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Journal of Policy Modeling 27 (2005) 285–308

Journal of Policy Modeling

# The impact of the 2002–2003 drought on Australia

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Received 1 February 2004; received in revised form 1 December 2004; accepted 2 January 2005
Available online 29 January 2005

## Abstract

TERM (The Enormous Regional Model) is a "bottom-up" CGE model of Australia which treats each region as a separate economy. TERM was created specifically to deal with highly disaggregated regional data while providing a quick solution to simulations. This makes it a useful tool for examining the regional impacts of shocks that may be region-specific. We include some details of how we prepared the TERM database, using a national input–output table, together with regional data showing output (for agriculture) and employment (in other sectors) for each of 144 sectors and 57 regions (the Australian statistical divisions). Using a 38-sector, 45-region aggregation of the model, we simulate the short-run effects of the Australian drought of 2002–2003, which was the most widespread for 20 years. The effects on some statistical divisions are extreme, with income losses of up to 20%. Despite the relatively small share of agriculture in Australian GDP, the drought reduces GDP by 1.6%, and contributes to a decline in unemployment and to a worsening of the balance of trade.


*JEL classification:* D58; R13; N57; O13

*Keywords:* CGE modelling; Regional economics; Agriculture

## 1. Progress in Australian regional economic modelling

The ORANI model (Dixon, Parmenter, Sutton, & Vincent, 1982), which distinguished over 100 sectors, introduced large-scale computable general equilibrium modelling in 1977.

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doi:10.1016/j.jpolmod.2005.01.008

Since then, related models have developed in several new directions. ORANI's solution algorithm combined the efficiency of linearised algebra with the accuracy of multi-step solutions, allowing the development of ever more disaggregated and elaborate models. The GEMPACK software developed by Ken Pearson (1988) and colleagues in the mid-1980s simplified the specification of new models, while cheaper, more powerful computers allowed the development of computer-intensive multi-regional and dynamic models. On the demand side, these advances have been driven by the appetite of policy-makers for sectoral, temporal, and social detail in analyses of the effects of policy or external shocks. Since regions elect parliamentary representatives, demand for regional detail is particularly strong.

To meet this need, even early versions of ORANI (see Dixon, Parmenter, & Vincent, 1978) included a "top-down" regional module to work out the regional consequences of national economic changes: national results for quantity variables were broken down by region using techniques borrowed from input–output analysis. From 8 to 100 regions could easily be distinguished. Region-specific demand shocks could be simulated, but, since price variables were not given a regional dimension, there was little scope for region-specific supply shocks.[1] On the other hand, the "top-down" approach did not need much extra data or computer power.

A second generation of regional CGE models adapted ORANI by adding two regional subscripts (source and destination) to most variables and equations. In this "bottom-up" type of multi-regional CGE model, national results are driven by (i.e., are additions of) regional results. Liew (1984), Madden (1990) and Naqvi and Peter (1996) describe several Australian examples. Dynamic versions of such models have followed (Giesecke, 1997). The best-known example of this type of regional model is the Monash Multiregional Forecasting model, MMRF (Adams, Horridge, & Wittwer, 2002).

Bottom-up models allow simulations of policies that have region-specific price effects, such as a payroll tax increase in one region only. They also allow us to model imperfect factor mobility (between regions as well as sectors). Thus, increased labour demand in one region may be both choked off by a local wage rise and accommodated by migration from other regions. Unfortunately models like MMRF pose formidable data and computational problems—limiting the amount of sectoral and regional detail. Only 2–8 regions and up to 40 sectors could be distinguished.[2] Luckily, Australia has only eight states, but size limitations have hindered the application of similar models to larger countries with 30–50 provinces, and have hitherto prevented us from distinguishing smaller, sub-state regions.

Finer regional divisions are desirable for several reasons. Policy-makers who are concerned about areas of high unemployment or about disparities between urban and rural areas desire more detailed regional results. Environmental issues, such as water management, often call for smaller regions that can map watershed or other natural boundaries more closely. Finally, more and smaller regions give CGE models a greater sense of geographical realism, closing the gap between CGE and LUTE (Land Use Transportation Energy) modelling.

[1] Such limitations could be partially circumvented: see Higgs, Parmenter, and Rimmer (1988).

[2] More precisely, these second-generation models (like MMRF) become rather large and slow to solve as the product: (number of regions) × (number of sectors) exceeds 300. TERM raises this limit to about 2500.

This paper outlines a new model with greater disaggregation of regional economies than previously available. The bottom-up TERM (The Enormous Regional Model) model allows us to analyse effects for each of 57 statistical divisions within Australia. Our application of the model in this paper is not to a policy scenario, but rather to a depiction of the Australian drought of 2002. Although widespread, the severity of the drought varied greatly between regions: rainfall ranged from 80 to 5% of the norm. As each region within the model has its own input–output database and agricultural product mix, TERM is uniquely equipped to estimate the varying impact of the drought on different regions. Our simulation depicts short-run effects; the drought broke in 2003 for most regions.

## 2. The structure of TERM

The key feature of TERM, in comparison to predecessors such as MMRF, is its ability to handle a greater number of regions or sectors. The greater efficiency arises from a more compact data structure, made possible by a number of simplifying assumptions. For example, TERM assumes that all users in a particular region of, say, vegetables, source their vegetables from other regions according to common proportions. The data structure is the key to TERM's strengths.

Fig. 1 is a schematic representation of the model's input–output database. It reveals the basic structure of the model. The rectangles indicate matrices of flows. Core matrices (those stored on the database) are shown in bold type; the other matrices may be calculated from the core matrices. The dimensions of the matrices are indicated by indices (c, s, i, m, etc.) which correspond to the following sets:

The sets DST, ORG and PRD are in fact the same set, named according to the context of use.

The matrices in Fig. 1 show the value of flows valued according to 3 methods:

1) Basic values = Output prices (for domestically-produced goods), or CIF prices (for imports);
2) Delivered values = Basic + Margins;
3) Purchasers' values = Basic + Margins + Tax = Delivered + Tax.

The matrices on the left-hand side of the diagram resemble (for each region) a conventional single-region input–output database. For example, the matrix USE at top left shows the delivered value of demand for each good (c in COM) whether domestic or imported (s in SRC) in each destination region (DST) for each user (USER, comprising the industries, IND, and four final demanders: households, investment, government, and exports). Some typical elements of USE might show:

- USE ("Wool","dom","Textiles","North"): domestically-produced wool used by the textile industry in North;
- USE ("Food","imp","HOU","West"): imported food used by households in West;
- USE ("Meat","dom","EXP","North"): domestically-produced meat exported from a port in North. Some of this meat may have been produced in another region;
- USE ("Meat","imp","EXP","North"): imported meat re-exported from a port in North.

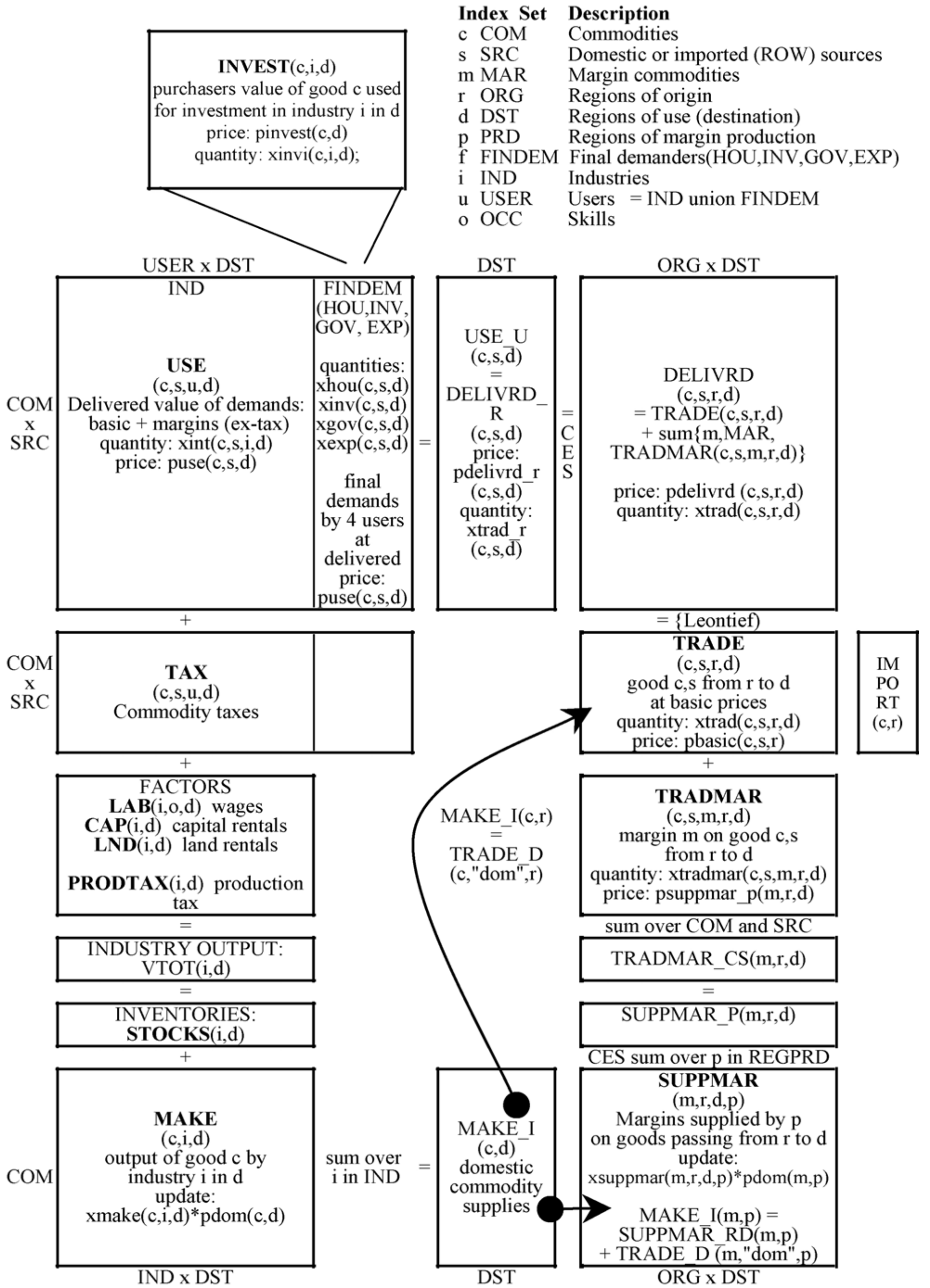


Fig. 1. The TERM flows database.

As the last example shows, the data structure allows for re-exports (at least in principle). All these USE values are "delivered": they include the value of any trade or transport margins used to bring goods to the user. Notice also that the USE matrix contains no information about regional sourcing of goods.

The TAX matrix of commodity tax revenues contains an element corresponding to each element of USE. Together with matrices of primary factor costs and production taxes, these add to the costs of production (or value of output) of each regional industry.

In principle, each industry is capable of producing any good. The MAKE matrix at the bottom of Fig. 1 shows the value of output of each commodity by each industry in each region. A subtotal of MAKE, MAKE_I, shows the total production of each good (c in COM) in each region d.

TERM recognizes inventory changes in a limited way. First, changes in stocks of imports are ignored. For domestic output, stock changes are regarded as one destination for industry output (i.e., they are dimension IND rather than COM). The rest of production goes to the MAKE matrix.

The right hand side of Fig. 1 shows the regional sourcing mechanism. The key matrix is TRADE, which shows the value of inter-regional trade by sources (r in ORG) and destinations (d in DST) for each good (c in COM) whether domestic or imported (s in SRC). The diagonal of this matrix (r = d) shows the value of local usage, which is sourced locally. For foreign goods (s = "imp") the regional source subscript r (in ORG) denotes the port of entry. The matrix IMPORT, showing total entry of imports at each port, is simply an addup (over d in DST) of the imported part of TRADE.

The TRADMAR matrix shows, for each cell of the TRADE matrix the value of margin good m (m in MAR) which is required to facilitate that flow. Adding together the TRADE and TRADMAR matrix gives DELIVRD, the delivered (Basic + Margins) value of all flows of goods within and between regions. Note that TRADMAR makes no assumption about where a margin flow is produced (the r subscript refers to the source of the underlying basic flow).

Matrix SUPPMAR shows where margins are produced (p in PRD). It lacks the good-specific subscripts c (COM) and s (SRC), indicating that, for all usage of margin good m used to transport any goods from region r to region d, the same proportion of m is produced in region p. Summation of SUPPMAR over the p (in PRD) subscript yields the matrix SUPPMAR_P which should be identical to the subtotal of TRADMAR (over c in COM and S in SRC), TRADMAR_CS. In the model, TRADMAR_CS is a CES aggregation of SUPPMAR: margins (for a given good and route) are sourced according to the price of that margin in the various regions (p in PRD).

TERM assumes that all users of a given good (c,s) in a given region (d) have the same sourcing (r) mix. In effect, for each good (c,s) and region of use (d) there is a broker who decides for all users in d whence supplies will be obtained. Armington sourcing is assumed: the matrix DELIVRD_R is a CES composite (over r in ORG) of the DELIVRD matrix.

A balancing requirement of the TERM database is that the sum over user of USE, USE_U, shall be equal to the sum over regional sources of the DELIVRD matrix, DELIVRD_R.

It remains to reconcile demand and supply for domestically-produced goods. In Fig. 1 the connection is made by arrows linking the MAKE_I matrix with the TRADE and SUPPMAR matrices. For non-margin goods, the domestic part of the TRADE matrix must sum (over d in DST) to the corresponding element in the MAKE_I matrix of commodity supplies. For margin goods, we must take into account both the margins requirement SUPPMAR_RD and direct demands TRADE_D.

At the moment, TERM distinguishes only four final demanders in each region:

(a) HOU: the representative household;
(b) INV: capital formation;
(c) GOV: government demand;
(d) EXP: export demand.

For many purposes it is useful to break down investment according to destination industry. The satellite matrix INVEST (subscripted c in COM, i in IND, and d in DST) serves this purpose. It allows us to distinguish the commodity composition of investment according to industry: for example, we would expect investment in agriculture to use more machinery (and less construction) than investment in dwellings.

MMRF includes SAM-like modelling of regional governments' income and expenditure. For the Australian[3] version of TERM, the 57 regions correspond to 'statistical divisions' (see Fig. 2), which do not entirely correspond with administrative regions. Hence, regional government finances are not modelled in this version of TERM.

### 2.1. TERM sourcing mechanisms

Fig. 3 illustrates the details of the TERM system of demand sourcing. Although the figure covers only the demand for a single commodity (Vegetables) by a single user (Households) in a single region (North), the same diagram would apply to other commodities, users and regions. The diagram depicts a series of 'nests' indicating the various substitution possibilities allowed by the model. Down the left side of the figure, boxes with dotted borders show in upper case the value flows associated with each level of the nesting system. These value flows may also be located in Fig. 1. The same boxes show in lower case the price (*p*. . .) and quantity (*x*. . .) variables associated with each flow. The dimensions of these variables are critical both to the usefulness of the model and to its computational tractability; they are indicated by subscripts c, s, m, r, d and p, as explained in Table 1. Most of what is innovative in TERM could be reconstructed from Figs. 1 and 3.

At the top level, households choose between imported (from another country) and domestic vegetables. A CES or Armington specification describes their choice—as pioneered by ORANI and adopted by most later CGE models. Demands are guided by user-specific purchasers' prices (the purchasers' values matrix PUR is found by summing the TAX and USE matrices of Fig. 1). Two is a typical value for the elasticity of substitution.

Demands for domestic vegetables in a region are summed (over users) to give total value USE_U (the "_U" suffix indicates summation over the user index u). The USE_U matrix is measured in "delivered" values—which include basic values and margins (trade and transport), but not the user-specific commodity taxes.

[3] TERM has also been applied to Brazil and Indonesia.

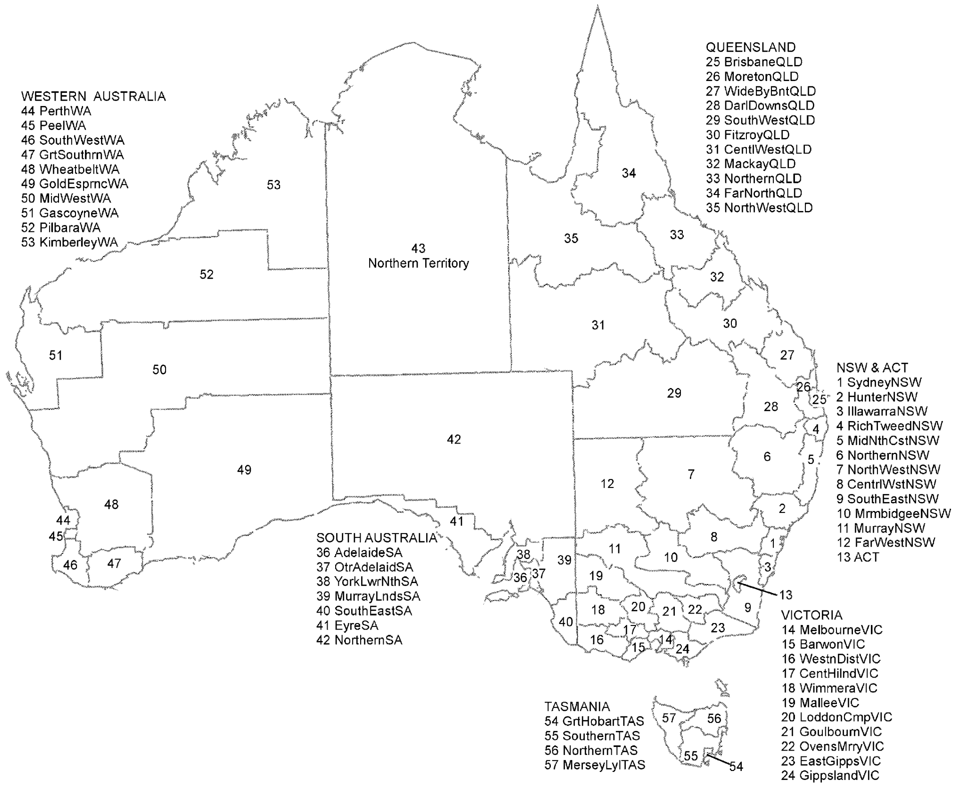


Fig. 2. Statistical divisions in Australia.

The next level treats the sourcing of USE_U between the various domestic regions. The matrix DELIVRD shows how USE_U is split between origin regions r. Again a CES specification controls the allocation; substitution elasticities range from 5 (merchandise) to 0.2 (services). The CES implies that regions which lower production costs more than other regions will tend to increase their market share. The sourcing decision is made on

Table 1
Main sets of the TERM model

| Index | Set name | Description | Typical size |
|---|---|---|---|
| s | SRC | (dom,imp) Domestic or imported (ROW) sources | 2 |
| c | COM | Commodities | 40 |
| m | MAR | Margin commodities (trade, road, rail, boat) | 4 |
| i | IND | Industries | 40 |
| o | OCC | Skills | 8 |
| d | DST | Regions of use (destination) | 30 |
| r | ORG | Regions of origin | 30 |
| p | PRD | Regions of margin production | 30 |
| f | FINDEM | Final demanders (HOU, INV, GOV, EXP) | 4 |
| u | USER | Users = IND union FINDEM | 44 |

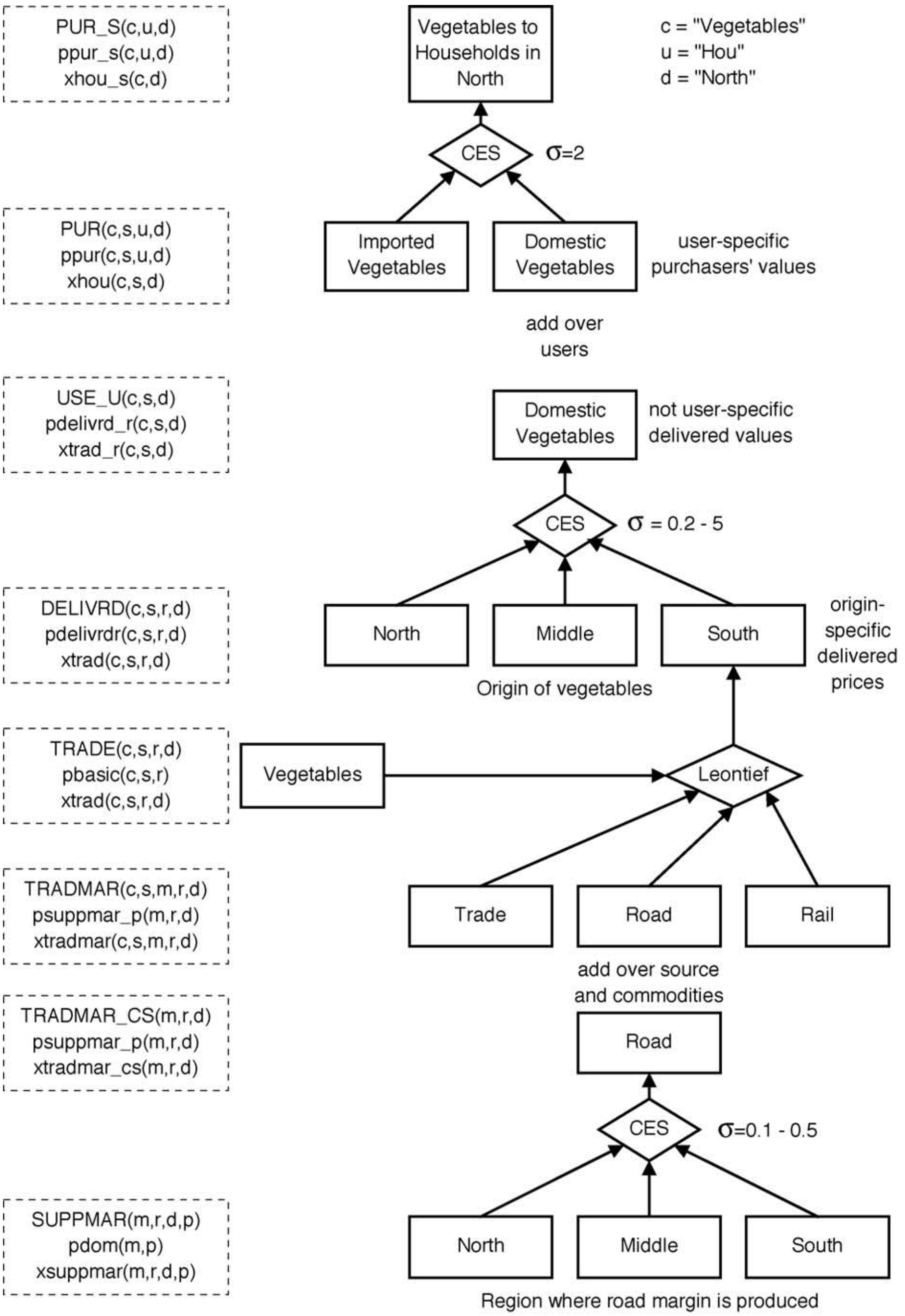


Fig. 3. Producing the TERM regional database.

the basis of delivered prices—which include transport and other margin costs. Hence, even with growers' prices fixed, changes in transport costs will affect regional market shares. Notice that variables at this level lack a user (u) subscript—the decision is made on an all-user basis (as if wholesalers, not final users, decided where to source vegetables). The implication is that, in North, the proportion of vegetables, which come from South is the same for households, intermediate, and all other users.

The next level shows how a "delivered" vegetable from, say, South, is a Leontief composite of basic vegetable and the various margin goods. The share of each margin in the delivered price is specific to a particular combination of origin, destination, commodity and source. For example, we should expect transport costs to form a larger share for region pairs, which are far apart, or for heavy or bulky goods. The number of margin goods will depend on how aggregated is the model database. Under the Leontief specification we preclude substitution between road and retail margins, as well as between road and rail. For some purposes it might be worthwhile to construct a more elaborate nesting, which accommodated road/Rail switching.

The bottom part of the nesting structure shows that margins on vegetables passing from South to North could be produced in different regions. The figure shows the sourcing mechanism for the road margin. We might expect this to be drawn more or less equally from the origin (South), the destination (North) and regions between (Middle), There would be some scope ($\sigma = 0.5$) for substitution, since trucking firms can relocate depots to cheaper regions. For retail margins, on the other hand, a larger share would be drawn from the destination region, and scope for substitution would be less ($\sigma = 0.1$). Once again, this substitution decision takes place at an aggregated level. The assumption is that the share of, say, Middle, in providing road margins on trips from South to North, is the same whatever good is being transported.

Although not shown in Fig. 3, a parallel system of sourcing is also modelled for imported vegetables, tracing them back to port of entry instead of region of production.

### 2.2. Other features of TERM

The remaining features of TERM are common to most CGE models, and in particular to ORANI, from which TERM descends. Industry production functions are of the nested CES type: Leontief except for substitution between primary factors and between sources of goods. Exports from each region's port to the ROW face a constant elasticity of demand. The composition of household demand follows the linear expenditure system, while the composition of investment and government demands is exogenous. A variety of closures are possible. For the short-run simulation we describe below, industry capital stocks and land endowments were held fixed, whilst labour was fully mobile between sectors within a region and partially mobile between regions. At the regional level, household consumption tended to follow regional income.

### 2.3. Comparison with the GTAP model

GTAP (Hertel, 1997), a well-known model of the world economy, has a fairly similar structure to TERM. The "regions" of GTAP, however, are countries or groups of countries, whilst in TERM they are regions within a single country. In GTAP, regional trade deficits must sum to zero (the planet is a closed system) whilst in TERM a national trade deficit is possible. There are also differences in data structures: TERM models import/domestic substitution at the user level, whilst in GTAP this decision is modelled at a regional, all-user level. GTAP has a far more detailed representation of bilateral trade taxes than does TERM, reflecting the freer trade that is usually possible within a nation. TERM can accommodate commodity tax rates that vary between regions (North might tax whisky more than South) but it does not allow for regional tax discrimination (such as a tax, in North, that applied only to whisky from West).[4] Inter-regional labour movements, a rarity in GTAP, are usual in TERM. Finally, TERM has a particularly detailed treatment of transport margins.

## 3. Gathering data for 144 sectors and 57 regions

As formidable as the computational demands of regional CGE models, are the data requirements—which usually far exceed what is available. Regional input–output tables and trade matrices, as depicted in Fig. 1 are not available for Australia. Thus, a vital counterpart to TERM is a strategy, depicted in Fig. 4, to estimate its database from very limited regional data. The key features of this strategy are:

(a) The process starts with a national input–output table and certain regional data. The *minimum* requirements for regional data are very modest: the distribution between regions of industry outputs and of final demand aggregates. Additional regional detail, such as region-specific technologies or consumption preferences may be added selectively, when available.
(b) The process is automated, so that additional detail can easily be added at a later stage.
(c) The database is constructed at the highest possible level of detail: 144 sectors and 57 regions. Aggregation (for computational tractability) takes place at the end of the process, not at the beginning. Perhaps surprisingly, the high level of disaggregation is often helpful in estimating missing data. When aggregated, the model database displays a richness of structure that belies the simple mechanical rules that were used to construct its disaggregated parent. For example, even though we normally assume that a given disaggregated sector has the same input–output coefficients wherever it is located, aggregated sectors display regional differences in technology. Thus, sectoral detail partly compensates for missing regional data.

### 3.1. *The national input–output database*

As shown in Fig. 4, the TERM data process starts from the 1997 Australian input–output tables, distinguishing 107 sectors. Our first step was to convert these tables to the file format of ORANI-G, a standard single-country CGE model. Next, working at the national level, we expanded the 107 sectors to 144. In choosing to split sectors, we hoped to avoid infelicities of classification that have caused problems in the past (such as the lumping together of exports of sugar, cotton and prawns) and also to split up sectors which showed regional differences

[4] Australia's federal constitution requires free trade between the states.

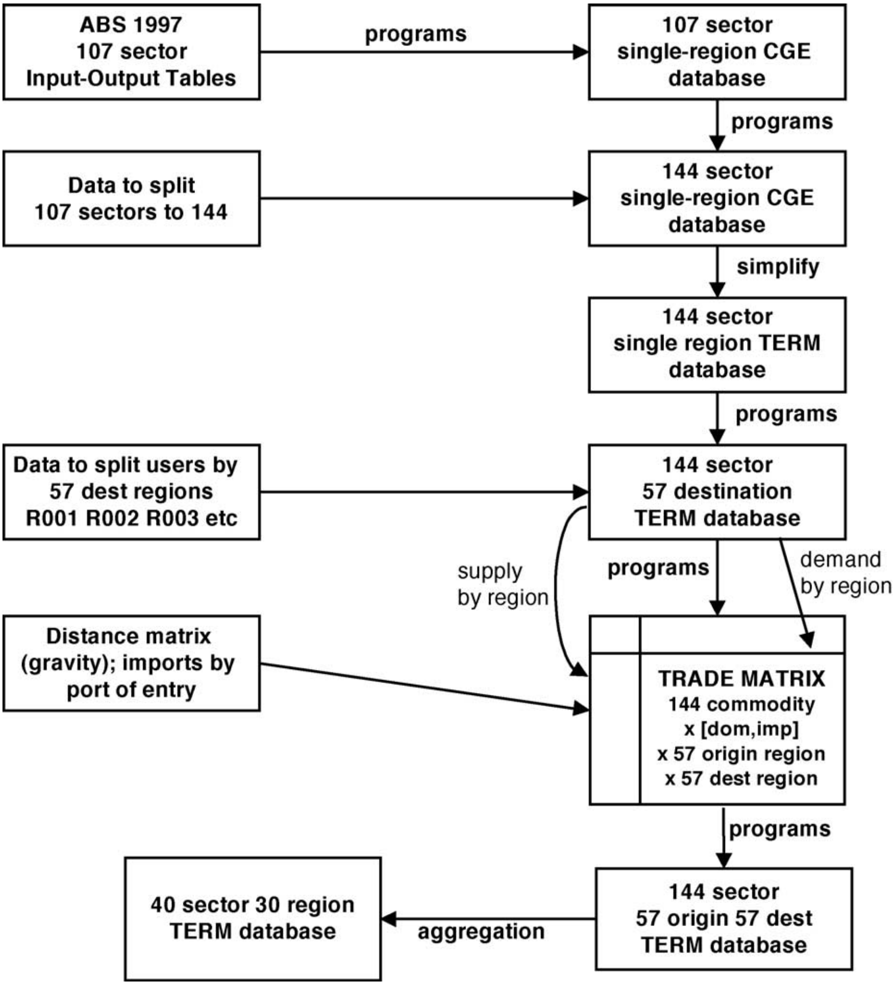


Fig. 4. TERM sourcing mechanisms.

in composition. For example, we split up electricity generation according to the fuel used (which differs among Australian regions) and added considerable agricultural detail.

The main source for the sectoral split was unpublished Australian Bureau of Statistics (ABS) commodity cards data. Such data provide a split of sales for approximately 1000 commodities to 107 industries, plus final users. However, the cards data do not always provide a desirable split from the 107 industries to the eventual 144 sectors of the disaggregated database. For example, there are significant sales of sugarcane to the other food products sector (107-sector aggregation). We allocated all sugarcane sales to refined sugar and zero sales to the seafood and other food products in our 144-sector disaggregation. When the intermediate sales split was less obvious, we used activity weights of the purchasing sectors for the split.

### 3.2. Estimates of the regional distribution of output and final demands

The next step was to obtain, for each industry and final demander, an estimate of each statistical division's share of national activity (these shares are the R001, R002, etc., of Fig. 4). To develop a full input–output table for each region, we required estimates of industry shares (i.e., each region's share of national activity for a given industry), industry investment shares, household expenditure shares, international export and import shares, and government consumption shares.

The main data sources for the industry split were:

- unpublished AgStats data from ABS, which details agricultural quantities and values at the statistical division level;
- employment data by industry by statistical division prepared by our colleague Tony Meagher from ABS census data and surveys;
- published ABS manufacturing census data (state level); and
- state yearbooks (for mining, ABS, 1998, 1999 and, for grapes and wine, ABS, 2002a).

Our sectoral split included a split of electricity into generation by fuel type plus a distribution sector. We relied on the internet sites of various electricity and energy agencies for capacity levels, on which shares of national activity were based.

Manufacturing, mining and services data disaggregated at the statistical division level were in quantities rather than values. These were adjusted to fit state account sector aggregates (ABS, 2002b), as wages and industry composition vary between states. Industry investment shares are similar to industry activity shares for most sectors. Exceptions include residential construction input shares, set equal to ownership of dwellings investment shares in each statistical division.

Published ABS data (Tables 4 and 5, ABS, 2000) provide sufficient commodity disaggregation for the task of splitting regional consumption aggregates into commodity shares. Such data also provide a split between capital city regions and other regions within each state.

In compiling international trade data by region, we first gathered trade data by port of exit or entry. For this task, we used both unpublished ABS trade data available for each state and territory plus the annual reports of various ports authorities. Queensland Transport's annual downloadable publication *Trade Statistics for Queensland Ports* gives enough data to estimate exports by port of exit with reasonable accuracy for that state. For other states, port activity is less complex; most manufacturing trade passes through capital city ports, and regional ports specialize in mineral and grain shipments.

State accounts data provide aggregated Commonwealth and state government spending in each region (ABS, 2002b). Employment numbers by statistical division for government administration and defence provide a useful split for these large public expenditure items. For other commodities, population shares by statistical division were used to calculate the distribution of Commonwealth and state government spending across regions.

By applying these shares to the national CGE database, we were able to compute the USE, FACTOR and MAKE matrices on the left-hand side of Fig. 1. None of these matrices distinguish the source region of inputs.

### 3.3. The TRADE matrix

The next stage was to construct the TRADE matrix on the right-hand side of Fig. 1. For each commodity either domestic or imported, TRADE contains a $57 \times 57$ submatrix, where rows correspond to region of origin and columns correspond to region of use. Diagonal elements show production, which is locally consumed. As shown in Fig. 4 we already know both the row totals (supply by commodity and region) and the column totals (demand by commodity and region) of these submatrices. For Australia, hardly any detailed data on inter-regional state trade is available. We used the gravity formula (trade volumes follow an inverse power of distance) to construct trade matrices consistent with pre-determined row and column totals. In defence of this procedure, two points should be noted:

- Wherever production (or, more rarely, consumption) of a particular commodity is concentrated in one or a few regions, the gravity hypothesis is called upon to do very little work. Because our sectoral classification was so detailed, this situation occurred frequently.
- Outside of the state capitals, most Australian regions are rural, importing services and manufactured goods from the capital cities, and exporting primary products through a nearby port. For a given rural region, one big city is nearly always much closer than any others, and the port of exit for primary products is also well defined. These facts of Australian geography again reduce the weight borne by the gravity hypothesis.

For a particular commodity the traditional gravity formula may be written:

$$V(\mathrm{r,\,d}) = \lambda(\mathrm{r})\mu(\mathrm{d})V(\mathrm{r},*)\frac{V(*,\mathrm{d})}{D(\mathrm{r,\,d})^2} \quad \mathrm{r} \neq \mathrm{d}$$

where $V$(r,d) is the value of flow from r to d (corresponding to matrix TRADE in Fig. 1); $V$(r,*), production in r (known); $V$(*,d), demand in d (known); and $D$(r,d), distance from r to d.

The $\lambda$(r) and $\mu$(d) are constants chosen to satisfy:

$$\sum\nolimits_{\mathrm{r}} V(\mathrm{r,\,d}) = V(*,\mathrm{d}) \ \text{ and } \ \sum\nolimits_{\mathrm{d}} V(\mathrm{r,\,d}) = V(\mathrm{r},*).$$

For TERM, the formula above gave rather implausible results, especially for service commodities. Instead we set:

$$\frac{V(\mathrm{r,\,d})}{V(*,\mathrm{d})} \propto \frac{\sqrt{V(\mathrm{r},*)}}{D(\mathrm{r},*)^K} \quad \mathrm{r} \neq \mathrm{d}$$

where $K$ is a commodity-specific parameter valued between 0.5 and 2, with higher values for commodities not readily tradable. Diagonal cells of the trade matrices were set according to:

$$\begin{aligned}\frac{V(\mathrm{d,\,d})}{V(\mathrm{d},*)} &= \text{locally-supplied demand in d as share of local production}\\ &= \min\left\{\frac{V(\mathrm{d},*)}{V(*,\mathrm{d})}, 1\right\} F\end{aligned}$$

where $F$ is a commodity-specific parameter valued between 0.5 and 1, with a value close to 1 if the commodity is not readily tradable.

The initial estimates of $V$(r,d) were then scaled (using a RAS procedure) so that:

$$\sum_{\mathrm{r}} V(\mathrm{r},\mathrm{d}) = V(*,\mathrm{d}) \text{ and } \sum_{\mathrm{d}} V(\mathrm{r},\mathrm{d}) = V(\mathrm{r},*).$$

Transport costs as a share of trade flows were set to increase with distance:

$$\frac{T(\mathrm{r},\mathrm{d})}{V(\mathrm{r},\mathrm{d})} \propto \sqrt{D(\mathrm{r},\mathrm{d})}$$

where $T$(r,d) corresponds to the matrix TRADMAR in Fig. 1. Again, the constant of proportionality is chosen to satisfy constraints derived from the initial national IO table.

All these estimates are made with the fully-disaggregated database. In many cases, zero trade flows can be known a priori. For example, ABS data indicate that rice is grown in only four of the 57 statistical divisions. At a maximum disaggregation, the load born by gravity assumptions is minimized.

### 3.4. Aggregation

Even though TERM is computationally efficient, it would be slow to solve if a full 144-sector, 57-region database were used. The next stage in the data procedure is to aggregate the data to a more manageable size. The aggregation choice is application-specific. For the simulation reported below, we distinguished 45 regions but only 38 sectors. The sectoral aggregation was most detailed in the agricultural and agriculture-related sectors, while manufacturing and service industries were grouped broadly. A large number of regions is needed if supply-side shocks must be imposed which differ amongst regions. The latter requirement is exemplified by the drought simulation described next.

## 4. Background to the drought of 2002

Although the 2002 drought was widespread, the impact on farmers varied widely across regions. Rainfall deficits generally were worse in inland grain-growing regions than in coastal regions. This has meant a bleaker outlook for grains than some other crops, but it also has meant that the same agricultural product is likely to be affected differently in different regions. The level of industry and regional detail in the TERM model provides a unique tool for estimating both the regional and macroeconomic effects of the current drought. Regions are either statistical divisions or combinations of statistical divisions. Each region has its own CGE model; these are linked by matrices of trade flows. Of particular relevance for the current project was the formation of the agricultural component of the database, estimated using ABS agricultural output data at the statistical division level. The simulations reported here employ a 1996–1997 database. Nineteen of the 38 industries are in the agricultural sector.

Table 2
The extent of the drought

| Rank | 9-month period | Percentage of Australia below 10th percentile | Rank | 9-month period | Mean Australian percentile value |
|---|---|---|---|---|---|
| 1 | November 1901–July 1902 | 58.9 | 1 | April–December 2002 | 13.2 |
| 2 | April–December 2002 | 58.6 | 2 | March–November 1994 | 15.7 |
| 3 | March–November 1994 | 52.6 | 3 | April–December 1972 | 17.1 |
| 4 | March–November 1940 | 49.9 | 4 | March–November 1940 | 18.6 |
| 5 | July 1951–March 1952 | 49.4 | 5 | July 1951–March 1952 | 19.4 |

*Source*: Bureau of Meteorology (2003).

### 4.1. Estimating the direct impact of drought at the regional level

The Bureau of Meteorology (2003) recorded April to December 2002 as one of the most severe and widespread droughts on record for a 9-month period. In terms of the proportion of the nation recording rainfall below the 10th percentile for nine months, this period was the second worst on record. In terms of the mean percentile value, this period was the worst on record (Table 2). While few regions have registered record low rainfall totals, Fig. 5 shows that a large area of Australia suffered severe rainfall deficiencies in 2002.

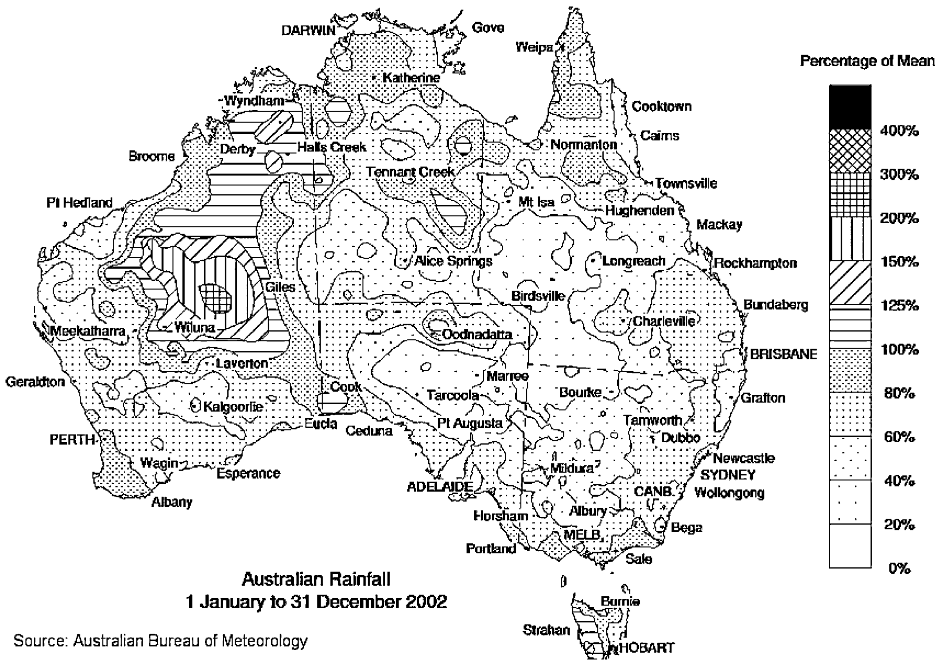


Fig. 5. Rainfall deficits in Australia, 2002.

In October the Australian Bureau of Agricultural and Resource Economics (ABARE, 2002a) issued a special drought issue of its crop report further revising downwards its expectations for winter crop output and warning of an inauspicious outlook for summer crops. The grim 2002–2003 outlook for Australian crops was confirmed in ABARE's (2002b) December crop report, with winter and summer crop output down on average on 2001–2002 output by 56 and 59%, respectively.

For the forecasting estimates reported above our concern was with such year-on-year estimates. In this section, however, we wish to compare the impact of the drought with what otherwise would have been the case. We assume the latter to be encapsulated in ABARE's earlier 2002–2003 forecasts published in the first part of 2002, before it became apparent that Australia was facing a severe drought.

To properly model the drought at the regional (statistical division) level it was important to make estimates of the direct effect of the drought on output for agricultural industries within individual statistical divisions. We did this by developing estimation formulae that computed productivity losses due to the drought for each agricultural industry in each region. The formulae related the productivity losses to rainfall deficits in individual regions, which in turn, were estimated from district rainfall deficit figures (for specific periods up to 31/10/02) available from the Bureau of Meteorology. Separate formulae were developed for different types of crops and for livestock. For example, for winter grains grown in southern Australia, we assumed that the productivity loss for the crop in a particular region was a progressively increasing function of the 3-month rainfall deficit, and was also affected to a lesser extent by the 6-month deficit. Thus, as the severity of the 3-month rainfall deficit increased, productivity losses were estimated to become increasingly greater at the margin. Other crops were either linearly or progressively related to combinations of 3-, 6- and 18-month rainfall deficits. In each case, regional industry productivity losses were adjusted so that the simulation result for the effect of the drought on the Australia-wide output of the industry coincided with the difference between the latest ABARE 2002–2003 output forecast and the Bureau's earlier forecast for the industry.

We made some allowance for herd dynamics. For cattle and sheep grazing, we used 18-month rainfall deficits to distribute output falls between regions. However, ABARE (2002c) forecast a modest overall increase above the 2001–2002 figure in the number of livestock slaughtered and also a small increase in meat produced. For the most severely-affected regions, we felt that de-stocking may have been the dominant response to the drought; so we adjusted the ABARE estimates to account for this, treating sales to abattoirs as disinvestment rather than contributions to industry output. Reduced herd numbers can be expected to have an effect on certain regions well beyond 2002–2003.

## 5. Impacts at the regional and national levels and a historical comparison

Table 3 shows the results for the macroeconomic effects of the drought generated by the TERM simulation. It can be seen from the first row of the final column that we expected the drought to lower Australian GDP by 1.6%. One percentage point of this relates to reductions in value added in the agriculture sector (row 2), while the remaining 0.6 percentage point (row 3) is contributed by other industries suffering negative multiplier effects.

The bottom two rows of Table 3 show that the drought was projected to have considerable adverse effects on the Australian labour market in 2002–2003. Note that the drought was projected to cause a reduction both in employment and in the national real wage rate of a little under 1%. This reflects our assumption that the temporary drought-induced reduction in the demand for labour would be shared between a decline in employment and a decline in real wages. Capital stocks are fixed in each sector in each region.

Our assumption regarding adjustment in the labour market limits the degree of multiplier effects of the drought. The fall in economy-wide employment accounts for only 0.4 percentage points of the projected negative effect of the drought on GDP, while reductions in the indirect tax base accounts for a further 0.2% reduction in GDP.

Both real investment and real household consumption were projected to suffer a smaller percentage reduction than GDP. Again this reflects our assumptions about the macroeconomic environment. In the case of household consumption we expected reductions in expenditure to be ameliorated by increased borrowing (particularly given the current low interest rates), increased government benefits (e.g. unemployment benefits and government relief schemes) and, for severely-affected farmers, deferrals in investments in machinery. Using these considerations we set a particular ratio for the percentage change in real household expenditure to the percentage change in gross regional product (GRP) for each of the 45 regions. Table 3 shows that the drought-induced percentage decline in real consumption is slightly under half the percentage decline in GDP.

The reduction in real investment of 0.9% is made up entirely of falls in investment in the agricultural sector, particularly the postulated reductions in investment in livestock in the sheep and cattle industries. We assume that, given widespread expectations that the drought will not continue very much longer, there will be no overall change in the non-agricultural level of real investment from what would otherwise have been the case.

The widespread nature of the drought can be seen through the substantial projected fall in gross state product (GSP) in all the mainland states. Queensland, New South Wales and South Australia were projected to experience reductions in real GSP of approximately 2%. New South Wales's agricultural sector was the hardest hit in percentage change terms with an overall agricultural production loss of around 45%. However, NSW was the state least intensive in agriculture in 2001–2002. Thus, the decline in agriculture had only the same

Table 3
Macroeconomic impacts of drought, 2002–2003 percentage change relative to base case

| | NSW | VIC | QLD | SA | WA | TAS | NT | ACT | Australia |
|---|---|---|---|---|---|---|---|---|---|
| Real GDP (total) | −1.9 | −1.2 | −2.0 | −1.9 | −1.5 | 0.3 | −0.1 | −0.1 | −1.6 |
| Agriculture contribution | −1.2 | −0.7 | −1.2 | −1.4 | −1.2 | 0.3 | −0.1 | 0.0 | −1.0 |
| Other industries contribution | −0.7 | −0.5 | −0.8 | −0.5 | −0.3 | 0.0 | 0.0 | −0.1 | −0.6 |
| Real consumption | −0.9 | −0.5 | −0.9 | −0.8 | −0.6 | 0.1 | 0.0 | −0.1 | −0.7 |
| Real investment | −1.6 | −0.7 | −1.2 | −1.6 | 0.3 | 1.6 | −0.5 | 2.1 | −0.9 |
| Export volume | −2.7 | −4.3 | −3.8 | −12.1 | −8.8 | −3.0 | 0.5 | −1.1 | −5.0 |
| Import volume | −0.4 | 0.1 | −0.4 | −0.4 | 0.1 | 1.3 | 0.3 | 0.5 | −0.2 |
| Export prices | 0.7 | 1.2 | 1.0 | 2.8 | 1.8 | 0.8 | −0.1 | 0.3 | 1.2 |
| Employment | −0.9 | −0.6 | −1.1 | −0.7 | −0.5 | 0.1 | −0.1 | −0.2 | −0.8 |
| Average wage rate | −1.2 | −0.7 | −1.3 | −0.8 | −0.6 | 0.2 | −0.1 | −0.2 | −0.9 |

Table 4
Agriculture's share of state factor income

| | 1981–1982 | 1982–1983 | 1983–1984 | 2001–2002 | 2002–2003 (projected) | 2002–2003 (actual[a]) |
|---|---|---|---|---|---|---|
| NSW | 3.8 | 2.4 | 4.3 | 2.7 | 1.5 | 1.7 |
| VIC | 3.9 | 2.9 | 4.6 | 3.8 | 3.1 | 3.1 |
| QLD | 7.3 | 5.2 | 7.0 | 4.9 | 3.7 | 4.2 |
| SA | 8.2 | 4.9 | 7.3 | 7.5 | 6.2 | 5.4 |
| WA | 8.9 | 8.6 | 6.9 | 4.1 | 2.9 | 2.9 |
| TAS | 6.3 | 6.2 | 6.8 | 6.1 | 6.4 | 6.1 |
| Australia | 5.1 | 3.7 | 5.2 | 3.9 | 2.9 | 2.9 |

*Source*: ABS 5220.0; TERM projection.
[a] The 2002–2003 actual numbers come from ABS 5220.0, released November 2003—a year after the simulations were run. As can be seen, the TERM predictions have turned out to be fairly accurate. At the time, government forecasts of the drought's impact on GDP were only half as large as the TERM estimates.

impact on GSP as it did in Queensland, where we projected agriculture's output to fall by a quarter as a result of the drought. Queensland agriculture's 2001–2002 share of GSP was 4.7% compared with 2.5% for NSW. The estimated reduction in agricultural output in both South Australia and Victoria was a little under 20%, but their 2001–2002 shares in total state output were 7.2 and 3.6%, respectively. Hence, even a moderate drought would have significant negative impacts on the economies of South Australia and Victoria. Western Australia with a projected reduction in overall agricultural output of around 30% and a base-year agricultural share slightly above the Australian average of 3.6% was projected to experience the same fall in GSP directly through agriculture's contraction as NSW and Queensland. However, the negative flow-on effects to the Western Australian economy were projected to be substantially smaller than the other two states—mainly because mining, which makes up a very large proportion of WA output relative to other states, was projected to grow slightly as a result of the drought-induced decline in the real wage rate.

Tasmania was the only state not negatively affected by the drought. While the state is quite agriculture intensive (with an agricultural share in output of over 4%), it experienced a reasonable level of rainfall in 2002. Tasmania thus gained from the beneficial effects of agricultural price rises without suffering agricultural output falls. The ACT has virtually no agricultural industry and thus suffers little from the drought. While agriculture, consisting largely of beef cattle, comprises 2.7% of the Northern Territory economy, the rainfall deficit in the Territory was considered not to have had any major effect on that region's agricultural output.

A historical comparison of the effects of drought is shown in Table 4. In moving from 1982 to 1983, when drought had a marked effect on agricultural output in all states other than Western Australia, to a good year in 1983–1984, agriculture's contribution to GDP increased by 1.5%. Given that downstream sectors also benefited from a seasonal recovery, that recovery in 1983–1984 may have contributed as much as 2.5% to GDP. Our projection that real GDP declined by 1.6% reflects the smaller 2002 share of agriculture in national income.

In Table 5 we see that the effects of the drought are estimated to vary considerably across Australian regions. As expected, the largest negative effects of the drought are

Table 5
Impact of drought on major aggregates in selected regions

| | Real household consumption | Real investment | Real GRP | Aggregate employment | Real wage rate |
|---|---|---|---|---|---|
| New South Wales | | | | | |
| Sydney/Illawarra | −0.2 | 1.1 | −0.5 | −0.7 | −0.8 |
| Northern NSW | −8.0 | −12.7 | −15.4 | −2.9 | −3.7 |
| North West NSW | −9.6 | −19.3 | −18.4 | −5.1 | −6.3 |
| Central West NSW | −3.5 | −8.1 | −6.9 | −2.4 | −3.0 |
| Murrumbidgee | −5.8 | −10.8 | −11.4 | −2.7 | −3.4 |
| Murray NSW | −6.7 | −13.0 | −13.0 | −3.3 | −4.2 |
| Far West NSW | −2.8 | −4.8 | −5.5 | −2.0 | −2.5 |
| Victoria | | | | | |
| Melbourne/Barwon | −0.2 | 1.4 | −0.4 | −0.4 | −0.6 |
| Western District | −1.8 | −11.3 | −3.5 | −1.3 | −1.7 |
| Wimmera | −5.7 | −9.6 | −11.1 | −2.2 | −2.7 |
| Mallee | −8.1 | −13.1 | −15.5 | −3.3 | −4.1 |
| Goulburn | −2.6 | −6.9 | −5.1 | −1.4 | −1.8 |
| Ovens Murray | −0.8 | −1.6 | −1.7 | −0.7 | −0.9 |
| Queensland | | | | | |
| Brisbane | −0.3 | 0.8 | −0.6 | −0.8 | −1.0 |
| Darling Downs | −4.4 | −7.3 | −8.6 | −2.3 | −2.9 |
| South West QLD | −11.1 | −24.1 | −21.0 | −5.5 | −6.9 |
| Central West QLD | −7.3 | −19.0 | −14.0 | −4.6 | −5.7 |
| Mackay QLD | −1.8 | 0.8 | −3.5 | −1.6 | −2.0 |
| Northern QLD | −1.6 | 0.7 | −3.3 | −1.3 | −1.6 |
| South Australia | | | | | |
| Adelaide (and outer Adelaide) | −0.3 | 1.1 | −0.5 | −0.5 | −0.6 |
| Yorke and Lower North | −5.4 | −7.9 | −10.5 | −2.3 | −2.9 |
| Murray Lands SA | −5.0 | −5.8 | −9.7 | −1.3 | −1.6 |
| South East SA | −1.3 | −2.2 | −2.6 | −0.6 | −0.8 |
| Eyre SA | −6.8 | −11.3 | −13.2 | −3.5 | −4.3 |
| Northern SA | −1.6 | −1.7 | −3.1 | −1.3 | −1.6 |
| Western Australia | | | | | |
| Perth and SW WA | −0.2 | 1.4 | −0.3 | −0.4 | −0.5 |
| Great Southern WA | −3.7 | −9.0 | −7.3 | −2.3 | −2.8 |
| Wheatbelt | −8.7 | −11.7 | −16.6 | −2.6 | −3.2 |
| Goldfields Esperance | −1.0 | 0.5 | −2.1 | −0.5 | −0.6 |
| Mid West WA | −2.8 | −1.8 | −5.4 | −0.9 | −1.1 |

projected to occur outside the capital cities. Nevertheless, the capital cities are still affected by the drought, as the GRPs for Sydney/Illawarra, Melbourne/Barwon, Brisbane and Adelaide/Outer-Adelaide fall by around half a per cent.

While a small number of non-capital-city regions are projected to suffer smaller declines in their real GRP than the national GDP decline, rural Australia overall was projected to suffer severe output contractions in 2002–2003. Eighteen out of the 45 regions in the model suffered GRP declines of over 5%. A GRP reduction of greater than 10% is projected for eleven of these. The 17 worst-affected regions include all 14 of Australia's regions that had

20% or more of their output in the agricultural sector, reflecting the widespread nature of the drought.

The projected severity of the drought on a region can largely be explained as a combination of the region's reliance on agriculture and the severity of the drought in the region. The worst-affected regions are South West Queensland (with a −21% change in GRP), North West NSW (−18%), the WA Wheatbelt (−17%), the Victorian Mallee (−16%) and Northern NSW (−15%). The Wheatbelt has an agricultural share of output of 46%, compared to the mid to high 20 s for the other four regions. However, the other four regions have suffered an even more severe drought than the Wheatbelt.

The next most affected region is Central West Queensland with a projected GRP reduction of 14% relative to the base case in 2002–2003. It is likely that this region, among a number of other regions, will be slow to recover from the drought as its agricultural output consists of sheep and beef cattle, and it may therefore, have been subject to significant destocking.

## 6. Impacts at the sectoral level

In Table 6 we show the percentage changes in the output of 25 selected industries for each of the 18 regions worst-affected by the drought (in GRP terms) in 2002–2003. Outputs for a number of agricultural industries decline dramatically. Negative flow-on effects, although not as large, can also be seen in those industries that process agricultural products. There are negative effects on trade and transport sectors that supply both margin services on the sales of agricultural products and form part of farmers' consumption expenditure. The construction industry contracts in these regions as investors, at least temporarily, transfer their investment activities to non-agricultural regions.

For the agricultural industries the large negative effects on output are not matched by similar reductions in employment. Indeed, employment in the agricultural industries is projected to change little due to the drought, for reasons discussed in the next section. However, the processing and service-sector industries shown to lose output in Table 6 reduce their employment by a slightly greater percentage than their output. Thus, there are only seven regions for which more than a fifth of the total number of jobs lost in the region are in the agricultural sector.

The limited contraction in agricultural employment explains why the rural regions suffer a much smaller percentage reduction in total employment than in GRP, while there is a slightly greater percentage contraction in aggregate employment than in GRP in the capital city regions.

## 7. Modelling issues arising from this application

Intermediate input usage with CGE models typically follows a "Leontief" structure—that is, the physical quantity of intermediate inputs used per unit of output is, at a given technology, constant and independent of price. Therefore, for commodities sold entirely to other industries, demand is rather inelastic. Inelastic demands created a major modelling problem

Table 6
Effect of drought on selected industries for drier regions listed in order of negative GRP effects (% change in output)

| | Sheep | Barley | Wheat | Other broadacre | Beef cattle | Dairy cattle | Rice | Cotton | Fruit and nuts | Grapes | Multi-grape | Sugar cane | Pasture irrigation | Vegetables |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South West QLD | −38 | −63 | −66 | −42 | −37 | 1 | 0 | −71 | −36 | 0 | −37 | 0 | 4 | 7 |
| North West NSW | −30 | −64 | −67 | −43 | −29 | −41 | 0 | −67 | −34 | −32 | −36 | 0 | −36 | −34 |
| Wheatbelt | −11 | −36 | −41 | −24 | −11 | 0 | 0 | 0 | −19 | −9 | −21 | 0 | −22 | −20 |
| Mallee | −12 | −64 | −67 | −43 | −12 | −19 | −50 | 0 | −30 | −16 | −32 | 0 | −30 | −30 |
| Northern NSW | −8 | −42 | −47 | −28 | −7 | −14 | 0 | −66 | −22 | 11 | 0 | 0 | −24 | −22 |
| Central West QLD | −38 | 0 | 0 | 0 | −38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eyre SA | −5 | −41 | −45 | −27 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | −17 | 0 |
| Murray NSW | −14 | −65 | −68 | −44 | −14 | −23 | −50 | 0 | −33 | −20 | −35 | 0 | −33 | −33 |
| Murrumbidgee | −14 | −62 | −66 | −42 | −13 | −22 | −50 | 0 | −29 | −15 | 0 | 0 | −30 | −29 |
| Wimmera | −9 | −38 | −43 | −26 | −7 | 0 | 0 | 0 | −19 | −17 | 0 | 0 | −20 | 6 |
| Yorke, Lower North | −4 | −33 | −39 | −23 | −4 | −5 | 0 | 0 | −12 | −9 | 0 | 0 | −13 | 0 |
| Murray Lands SA | −9 | −55 | −59 | −37 | −8 | −15 | 0 | 0 | −24 | −1 | −6 | 0 | −25 | −24 |
| Darling Downs | −11 | −42 | −47 | −28 | −10 | −18 | 0 | −58 | −20 | −18 | −23 | 0 | −23 | −21 |
| Great Southern | −6 | −34 | −39 | −23 | −5 | −10 | 0 | 0 | −14 | −11 | 0 | 0 | −17 | −15 |
| Central West NSW | −12 | −64 | −67 | −43 | −12 | −20 | 0 | 0 | −30 | −27 | 0 | 0 | −31 | −31 |
| Far West NSW | −30 | −66 | −69 | 0 | −29 | 0 | 0 | −72 | −36 | 10 | −38 | 0 | 0 | 0 |
| Mid West WA | −9 | −17 | −24 | −14 | −8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Goulburn VIC | −12 | −40 | −45 | −27 | −11 | −19 | −50 | 0 | −22 | −17 | −25 | 0 | −24 | −23 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| South West QLD | −58 | −19 | −5 | 0 | 0 | 0 | −5 | −13 | −7 | −12 | −6 |
| North West NSW | −52 | −16 | −3 | −10 | 2 | −5 | −2 | −12 | −7 | −11 | −5 |
| Wheatbelt | −20 | −13 | 4 | −5 | 0 | 0 | 0 | −8 | −6 | −6 | −4 |
| Mallee | −31 | −15 | 4 | −9 | 0 | −5 | 0 | −8 | −8 | −10 | −4 |
| Northern NSW | −51 | −15 | 4 | −5 | 1 | 0 | 1 | −9 | −5 | −6 | −4 |
| Central West QLD | 0 | −18 | −7 | 0 | 0 | 0 | 0 | −6 | −5 | −9 | −3 |
| Eyre SA | −16 | −14 | 5 | 0 | −2 | 0 | 0 | −8 | −5 | −7 | −3 |
| Murray NSW | −34 | −14 | 1 | −10 | −1 | −5 | 0 | −7 | −5 | −9 | −3 |
| Murrumbidgee | −30 | −14 | 2 | −6 | −1 | −5 | −1 | −5 | −6 | −7 | −3 |
| Wimmera | −20 | −14 | 3 | −7 | 0 | −6 | 0 | −5 | −5 | −9 | −3 |
| Yorke, Lower North | −13 | −14 | 3 | 0 | −2 | −6 | −1 | −4 | −4 | −7 | −2 |
| Murray Lands SA | −25 | −15 | 1 | −9 | −2 | −5 | 0 | −4 | −5 | −7 | −2 |
| Darling Downs | −39 | −14 | −1 | −9 | −1 | 0 | −3 | −4 | −4 | −5 | −2 |
| Great Southern | −15 | −13 | 4 | −7 | 0 | −6 | 0 | −3 | −5 | −5 | −2 |
| Central West NSW | −32 | −15 | 0 | −9 | −2 | −7 | −2 | −3 | −4 | −5 | −2 |
| Far West NSW | 5 | −17 | −7 | 0 | 0 | −6 | 0 | −3 | −3 | −5 | −2 |
| Mid West WA | −15 | −14 | 2 | 0 | 0 | 0 | 0 | 0 | −4 | −7 | −1 |
| Goulburn VIC | −24 | −15 | 0 | −11 | −2 | −7 | −3 | −2 | −3 | −3 | −1 |

in our drought scenario, as we combine extraordinary supply shocks with these inelastic demands. This results in very large price increases, beyond what we observe in practice. To deal with this, we allowed some substitution between different intermediate inputs. It does not make intuitive sense to allow much substitution; that would imply that we could convert base metal ores into gold with sufficient relative price changes without changing the technology, or reduce the grape content of wine below legal limits. In another sense, a little “alchemy” is quite reasonable: when an input becomes very scarce, we may put extra effort into minimising wastage. In our modelling, we settled on an intermediate input substitution parameter of 0.15.

Another way we adapted the model for drought was to increase the magnitude of the Armington or import substitution elasticities. Grain imports in Australia are usually negligible due to quarantine restrictions. Late in 2002, quarantine restrictions were temporarily relaxed to allow the importation of feed grain. This provides a real world justification for greatly enlarging the relevant elasticity in the model to deal with a drought scenario.

## 8. Conclusions

Fifty years ago, agriculture’s share of GDP in Australia was around 20% (Maddock & McLean, 1987). Now, it is less than 4% (ABS, 2002a, 2002b). Despite the relative decline of agriculture, a widespread drought can still have observable impacts on Australia’s economy. Using a new CGE model of the statistical divisions of Australia, we have ascribed output shocks based on ABARE estimates, and productivity shocks related to rainfall deficits, in projecting the impacts on different regions of the Australian economy. The effect of the drought was to reduce severely agricultural output in most regions. On average, Australian agricultural output was reduced by the drought by slightly under 30%. Given agriculture’s share of 3.6% of Australian GDP, this projected contraction in agricultural reduced Australian GDP growth by 1 percentage point. A further 0.6 percentage was cut from GDP growth due to negative multiplier effects.

Our modelling indicates that Australian employment would be almost 0.8% lower on average in 2002–2003 than would have been the case in the absence of the drought. While the greatest employment contractions were projected for rural regions, the bulk of the jobs losses occur in non-agricultural sectors. Employment within the agricultural sector was not expected to change much, relative to the large output contractions, due partly to the nature of agricultural employment (i.e., a large proportion of owner-operators) and partly to the drought-induced reduction in the productivity of labour. This drought, unlike that of 1982–1983, came at a time when jobs growth was relatively strong, so that drought-induced employment losses did not cause a national jobs crisis.

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