CGE modelling of the resources boom in Indonesia and Australia using TERM

Glyn Wittwer and Mark Horridge[1]
Centre of Policy Studies

Paper presented at the 51st annual conference of AARES, Queenstown, New Zealand, February 14-16, 2007.

Abstract

The sharp increase in Australia's terms of trade since 2003-04 has dramatic regional and sectoral implications. Mining-intensive regions have gained from the jump in export prices. Import-competing sectors have faced greater competition both from falling import prices and due to rising demand for domestic factors from the mining sectors. The drought of 2006 will widen the gap between winning and losing regions.

In Indonesia, even if we assume that the oil extraction sector is facing resource depletion, a long-run terms-of-trade improvement may result in aggregate consumption increasing should real GDP fall relative to the base case.

The TERM framework is highly suitable for modelling Brazil and China, each with around 30 regions.

Contents

[1] The authors are grateful to AusAID for PSLP funding used to develop *IndoTERM* in conjunction with Center for Economics and Development Studies (CEDS) at Padjadjaran University, Bandung, West Java. The authors also acknowledge the funding of the Productivity Commission used to develop the 2001-02 multi-regional database for Australia, and funding from CSIRO and the Australian Research Council for various enhancements to TERM.

1. TERM as a tool for sub-national CGE modelling

Policy analysis increasingly concerns the regional dimension. Real GDP remains an important indicator of economic growth. Simulations using single country CGE models have been used since the late 1970s to examine the winners and losers from policy changes or changes in global economic conditions (see Dixon et al, 1982). In the Australia context, the resources boom and droughts of this millennium have contributed to wide disparities in growth rates between regions.

The first objective of this paper is to provide a brief overview of various applications of **T**he **E**normous **R**egional **M**odel (TERM). Then two variants of TERM, representing the economies of Australia and Indonesia, are used to analyse the impacts of the recent improvement in the terms-of-trade faced by each country.

TERM is increasingly becoming the CGE model of choice for sub-national multi-regional modelling. In Australian applications, variants of TERM have proliferated to undertake different applications:

- The impact of the 2002-03 drought on Australia (Horridge *et al*., 2005) [comparative static].
- Modelling of water trading scenarios (Wittwer, 2003; Peterson et al., 2005) and future rural-urban water requirements (Young *et al*., 2006)) [comparative static with water accounts, projections of the database ahead 25 years in the case of Young *et al*.].
- The economic impacts of improved weeds management (Wittwer *et al*., 2005), plant disease outbreaks (Wittwer *et al*., 2006), natural disasters and telecommunications upgrades (CoPS studies for clients) [dynamic].

We are undertaking further work at CoPS to enhance TERM's capabilities in water-related scenarios (Dixon *et al*., 2005). And a little known variant of TERM is able to model economic scenarios that present changes in real income by federal electorate (see http://monash.edu.au/policy/archivep.htm#tpmh0074).

2. Why TERM is quicker

The advantage of TERM over predecessors, notably MMRF (Naqvi and Peter, 1996), is its ability to handle a greater number of sectors and regions while still being able to solve relatively quickly. In TERM, the user, the regional source and the regional destination for each commodity are not detailed in a single huge matrix. Rather, two much smaller matrices separately provide data on (1) the user by regional destination and (2) the regional source and regional destination for each commodity. A common-sourcing assumption (i.e, all users of a given commodity source it in common proportions from different regions in each destination) results in two matrices that together are many-fold smaller than the single matrix that is otherwise required, thereby greatly reducing the number of equations required to solve the model. The advantage of using the common sourcing assumption increases with the number of regions in the database.

3. TERM goes international

The experience of the authors is that interest in TERM as a policy analysis tool is growing globally, as policy debate turns increasingly towards disparities between regions, and economic issues with a regional dimension such as transport and water infrastructure. Other countries for which versions of TERM have been devised include Brazil, China, Finland, Japan and Indonesia. Preparation of a database with 30+ regions has become relatively straightforward within the TERM methodology but remains onerous with other approaches. Brazil, China and Indonesia appear as obvious candidates for the TERM, as each has approximately 30 provinces. In the case of China, the authors plan to develop a 137 sector, 31 region SinoTERM database during 2007. This will be based on the 122 sector Chinese input-output table released by China's National Bureau of Statistics. The 137 sector version will include additional detail in agricultural and food sectors, which are under-represented in the published table yet account for substantial shares of rural employment.

The applications in this paper use two relatively new databases. The Australian version of TERM is based on the 2001-02 input-output table (ABS catalogue no. 5209.0.55.001). The Indonesian model *IndoTERM* entails a 175 sector, two region (West Java and rest) database based on the 2003 input-output table.[2]

4. Simulation of Australia's terms-of-trade improvement

Background

Australia's exports traditionally have been based on resource commodities, reflecting a comparative advantage as a land abundant, relatively labour-scarce nation. Since World War II, when agriculture accounted for over 25 percent of national GDP, agriculture's share of national income has declined and now sits at little more than 3 percent of GDP. In this period, Australia has experienced several mining booms, which have reinforced the resource-based component of the economy – at the same time as technological change and income growth have reduced the share of national income provided by agriculture. From 1945 to the late 1960s, manufacturing's share of national income plateaued at over 25 percent of GDP, aided in no small part by protectionist policies (Maddock and McLean, 1987). Thereafter, the rise of manufacturing in Japan, and the emergence of South Korea, Taiwan and, more recently, China, have, in combination with international

[2] The project's terms of reference stipulated the West Java was to be represented. The requirements to represent all the provinces of Indonesia although not onerous, were beyond the scope of the project.

trade liberalization under GATT and WTO, greatly increased the import competition faced by Australian manufactures. In the period from 1982 to 2004, manufacturing's share of GDP in Australia shrank from 19 percent to 12.5 percent. The sector of greatest decline was textiles, clothing and footwear (TCFs), shrinking from 1.4 percent to 0.4 percent in this time (ABS, 2006a).

Part of the relative decline of agriculture and manufactures reflects the emergence of services, both in domestic usage in a modern, increasingly knowledge-based economy, and the rise of international exports of tourism and education in Australia. Yet the trend towards globalization has resulted not only in increased exports of services. Now, in combination with rising energy scarcity due to burgeoning demand in east Asia and disruptions to supply and growing fears of resource diminution in the Middle East, demand for Australia's mineral resources has jumped since 2003-04.

The potential lasting structural changes to the Australia economy are not confined to resource exports. Although Australia is a significant exporter of crude oil, it also imports significant quantities of both crude oil and petroleum products (Table 2). The changes in the price of internationally traded goods between 2003-04 and March 2006 provide material for a short-run simulation using TERM (outlined in the next section) to examine the sectoral and regional impacts of movements in international demand and supply. In Table 3, we see how the composition of the economy varies between regions.[3] For example, in Mineral_QLD, Mineral_SA and Mineral_WA, mining's share of gross regional product (GRP) exceeds 30 percent. We would expect these regions to benefit in the short-run from the boom in minerals demand. The predominantly urban regions (designated by Urban_NSW, etc.) each earn more than 90 percent of total income from non-resource sectors, with one exception. That exception is Urban_WA.[4] Since the changes in trade prices shown in Table 2 have opposing effects on different sectors and regions, we have placed the impacts on Australia into four groups for the national results presented in Table 4. First, we isolate the impact of mineral export price shocks. Second, we present the remaining export price shocks, to various farm and food sectors. Next, the imported fuel shocks are isolated, and finally, the fourth group includes the impact mainly of the rising supply of manufactures from China.

Preparing the TERM database

In order to run TERM, we first had to prepare a national database and then gather and process regional data for use in the model. The TERM data process starts from the 2001-2 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 169. The selection of new sectors is based on our judgment as to which sectors are likely to be important in future modelling research. For example, we split the single health and single education sectors

---

[3] The column for agriculture includes fishing, forestry and food processing.
[4] UrbanWA's inhabitants rely to an unusual extent on mining income, due to fly-in, fly-out mining operations which result in employees spending non-working days in the urban region. This results in a significant exception to urban outcomes from our modeling, as shown in Table 6.

in the existing input-output table into four. Another reason for splitting published input-output sectors is so that different technologies can be applied to an industry in different regions later in the database process. For example, Victoria’s electricity generating industry uses brown coal while that in New South Wales uses black coal. Additional sectors black coal, brown coal, black coal electricity generation and brown coal electricity generation capture these known regional differences in technologies. The main source for the sectoral split is unpublished Australian Bureau of Statistics (ABS) commodity details data. Such data provide a split of sales for approximately 1,000 commodities to 107 industries, plus final users.

The preparation of the TERM database does not rely on gathering input-output tables for each region in the database. Rather, by assuming that the same technologies apply to a given industry in each region, it is sufficient to gather regional shares of national output for each industry. The next step therefore is to obtain, for each industry and final demander, an estimate of each statistical division’s share of national activity. To develop a full input-output table for each region, we required estimates of industry shares (ie, 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. Horridge et al. (2005) details the data sources.

These shares are used to split the national input-output table. Database preparation is undertaken at a maximum level of disaggregation, thereby enabling the practitioner to impose different technologies where necessary, as in the case of electricity generation.

Inter-regional trade matrices are computed on the basis of disaggregated regional demands and supplies. The gravity assumption (i.e., the volume of trade follows an inverse power of distance) is invoked for inter-regional trade using a distance matrix. Note that where ever 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. In addition, outside the capital cities, 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. For local commodities, we needed to ensure that local supplies were set equal to local demands. Otherwise, we would have generated implausible trades, such as inter-regional trade in childcare services.

The process of splitting the national database into more sectors, and then splitting the new national table into many regions is highly mechanised. This means that the methodology can be applied to new input-output tables as they appear, or to tables for different countries.

Results

We now turn to the results of our simulation, consisting of the trade price shocks shown in table 1, in a short-run setting. The mineral price shocks alone have accounted for 26.3 percent out of a total 28.0 percent improvement in Australia's terms of trade between 2003-04 and March 2006 (Table 3, national results). The impact of the growth in demand for minerals for both export and import volumes is larger than the sum of all four groups of shocks. The second most significant row in table 3 is that for imported fuel shocks. The negative impact on Australia's real GDP almost completely offsets the impact of the mineral price shocks. The negative impact on the terms of trade (-7.3 percent) is smaller than the positive impact of the mineral shocks, consistent with Australia's status as a net exporter of mineral and energy products. Rising fuel prices acting alone have a negative impact on farm output. Farming regions are vulnerable to larger negative impacts from rising fuel prices than elsewhere. Yet the row showing farm and food shocks reveals that the most recent resources boom has not been entirely bad news for farmers, although the positive impacts at the national level are considerably smaller than the negative impacts of the imported fuel shocks. The final effect shown in table 3 is that of falling import prices, dominated by manufactures from China. Falling import prices since 2003-04 have had a positive effect on the terms of trade and trade volumes.

Table 1. Export and import shares (2001-02) and price shocks
(% change between 2003-04 and March 2006)

	Output $bn	Exports $bn	Import $bn	Export prices	Import prices
Livestock	19.7	2.7	0.1	19.1	0
Grains	9.6	5.0	0.0	11.6	0
Other Agriculture	17.1	2.5	0.6	5.4	0
Black Coal	14.9	12.9	0.0	100	0
Oil	9.7	5.6	7.2	120	120
Gas	5.5	3.3	0.1	17.7	0
Iron Ores	5.6	4.8	0.1	103	0
Other Metal Ores	8.6	4.2	2.4	81	-8.8
Meat Products	16.8	6.4	0.3	14	0
Dairy Products	9.1	3.1	0.7	19	0
Other Foods	40.3	8.7	6.4	11.5	6.9
TCFs	9.6	3.4	8.4	-22.3	-0.6
Wood and Paper	14.4	1.5	4.1	1.2	9.2
Petrol. & Coal Prods	18.4	1.7	2.9	66.7	120
Chemicals & Plastics	23.8	4.5	15.6	19.8	9.9
Cement & Glass	17.3	0.9	5.2	0	3.1
Iron & Steel	14.2	7.8	1.2	29.5	0
Non-ferrous Metals	24.4	13.3	2.2	59.8	37.4
Other Manufactures	78.2	15.9	70.1	3.7	-8.6
Other commodities	1080.0	29.2	23.0	14.5	-8.8

Data sources: ABS (2006b), ABARE (2006).

Table 2. Contribution of value-added to regional economy

	Mining $bn	Agriculture $bn	Other $bn	Mining (% of GRP)	Agriculture(% of GRP)	Other (% of GRP)	GRP (% of GDP)
Urban_NSW	1.2	3.5	141.6	0.8	2.4	96.7	21.8
Mineral_NSW	4.8	1.7	25.8	14.9	5.3	79.8	4.8
Other_NSW	2.4	10.6	35.2	4.9	22.0	73.0	7.2
Urban_VIC	4.2	4.4	114.3	3.4	3.6	93.0	18.3
Mineral_VIC	1.9	1.0	4.4	26.2	13.2	60.6	1.1
Other_VIC	2.0	8.0	25.2	5.6	22.8	71.6	5.2
Urban_QLD	1.3	1.6	51.6	2.4	3.0	94.6	8.1
Mineral_QLD	6.6	2.4	10.2	34.6	12.2	53.2	2.9
Other_QLD	2.9	5.7	39.7	6.1	11.8	82.1	7.2
Urban_SA	0.5	1.6	33.9	1.4	4.5	94.0	5.4
Mineral_SA	1.2	0.4	2.0	34.5	11.2	54.3	0.5
Other_SA	0.4	3.2	5.2	4.3	36.6	59.1	1.3
Urban_WA	4.3	1.3	41.3	9.1	2.7	88.2	7.0
Mineral_WA	11.8	4.7	12.0	41.4	16.6	42.0	4.2
Urban_TAS	0.1	0.4	5.2	2.5	6.3	91.2	0.9
Other_TAS	0.6	1.5	5.6	8.2	19.5	72.3	1.2
Mineral_NT	1.2	0.6	5.9	15.1	7.2	77.7	1.1
Urban_ACT	0.0	0.1	12.4	0.1	0.8	99.1	1.9

Table 3. Impact of change in international trade prices on major aggregates, national and selected regions *Percentage change relative to base case*

Effect	Real Household consumption	Real Investment	Real GDP	Export volumes	Import volumes	Terms of trade
National						
Mineral price shocks	0.19	0.00	0.19	7.81	8.47	26.30
Farm & food shocks	0.03	0.00	0.03	2.63	2.96	5.65
Imported fuel shocks	-0.18	0.00	-0.18	-4.43	-4.66	-7.34
Other import shocks	0.00	0.00	0.00	1.13	1.33	3.37
Total	0.04	0.00	0.04	7.15	8.09	27.99
Urban_SA						
Mineral price shocks	-1.22	-7.49	-0.50	-5.82	3.34	-
Farm & food shocks	0.09	0.67	0.08	5.33	3.10	-
Imported fuel shocks	-0.10	-0.03	-0.23	-2.52	-3.04	-
Other import shocks	-0.04	-0.34	-0.02	3.11	1.17	-
Total	-1.27	-7.19	-0.67	0.05	4.56	-
Mineral_WA						
Mineral price shocks	12.57	29.79	3.82	27.17	27.54	-
Farm & food shocks	-1.99	-4.71	-0.60	-0.53	0.58	-
Imported fuel shocks	-0.67	-0.49	-0.16	-15.87	-7.72	-
Other import shocks	0.19	1.12	0.06	0.14	2.27	-
Total	10.11	25.71	3.12	10.92	22.66	-

Table 4. Impact of change in international trade prices on major aggregates by region
Percentage change relative to base case

	Real Household consumption	Real Investment	Real GRP	Aggregate Employment	Real Wage Rate
Urban_NSW	-0.84	-6.86	-0.47	-0.50	-1.17
Mineral_NSW	0.37	7.45	0.23	0.10	-0.56
Other_NSW	-1.12	-3.30	-0.50	-0.64	-1.31
Urban_VIC	-0.59	-2.21	-0.26	-0.37	-1.04
Mineral_VIC	0.32	9.43	0.23	0.08	-0.59
Other_VIC	-1.58	-3.26	-0.65	-0.87	-1.53
Urban_QLD	-0.30	-5.13	-0.26	-0.23	-0.89
Mineral_QLD	5.36	26.07	1.80	2.56	1.88
Other_QLD	0.11	-2.07	-0.02	-0.02	-0.69
Urban_SA	-1.27	-7.19	-0.67	-0.72	-1.38
Mineral_SA	3.34	15.21	1.18	1.58	0.90
Other_SA	-1.64	-3.78	-0.62	-0.90	-1.57
Urban_WA	2.91	3.53	1.11	1.36	0.69
Mineral_WA	10.11	25.71	3.12	4.85	4.15
Urban_TAS	-0.11	-4.74	-0.04	-0.13	-0.80
Other_TAS	-0.61	1.47	-0.14	-0.39	-1.05
Mineral_NT	5.60	12.44	2.11	2.68	1.99
Urban_ACT	-0.62	-7.37	-0.44	-0.39	-1.05

In the short-run closure we have chosen, national aggregate investment is exogenous. However, investment shares can vary markedly between regions and sectors. This is evident both in the lower part of table 3 (showing a decomposition of outcomes for the biggest winner, Mineral_WA, and the biggest loser, Urban_SA) and in table 4, in which virtually all of the non-mining regions suffer a decrease in investment, while investment in mining-intensive regions booms. Mineral_WA and Mineral_QLD both experience an increase in investment exceeding 25 percent. Only four regions out of the 18 experience an increase in real wages. This is a highly relevant assumption of the simulation. In the minerals boom of the 1970s, economic gains to Australia were eroded by spiralling wages, so that unemployment increased despite the boom. Our assumption in the labour market is that national employment is fixed, with real before-tax wages allowed to vary nationally. At the regional level, we assume that labour is imperfectly mobile, with inter-regional migration partly, not completely, offsetting regional real wage differentials. Hence, real wages fall by 1.6 percent in Other_SA, while, at the other extreme, they rise by 4.2 percent in Mineral_WA.

Had we assumed that real before-tax wages were fixed, national employment would have fallen slightly, as most of the benefit of the terms of trade shock is in relatively capital-intensive sectors, whose output growth is hindered by our assumption that capital stocks are fixed in the short run. The state and Federal governments have had windfall gains from resource rents and increased company tax revenue due to the resources boom. Some of this revenue was given back to workers in the form of income tax reductions in the Federal May 2006 budget, so that it is possible that real after-tax wages could rise at the same time as real before-tax wages fall.

The contribution of broad sectors to regional income provides another way of presenting the winners and losers from the resources boom in the domestic economy. In the case of Urban_SA, more than the entire loss of income (-0.67 percent) is attributed to losses in TCFs (-0.10 percent) and other manufactures (-0.78 percent). Among the industries losing from rising import competition is the motor vehicles sector, which is relatively prominent in the Urban_SA economy. Other manufactures dominates the losing sectors in most regions, but in the minerals regions, these losses are overwhelmed by gains in resources. Urban_SA, as shown in table 3, loses from the minerals shocks (as labour is drawn to minerals regions); from the imported energy shocks (which impact negatively on all regions); and from the other import price shocks (which harm import-competing sectors, although lowering prices for households). The only group of shocks benefiting Urban_SA is farm and food export prices.

Table 5. Contribution of broad sectors to regional income listed in order of negative GRP effects (% change in output)

	Agriculture	Black coal	Oil & gas	Metal oreas	Other mining	Food products	TCFs	Petrol. & coal products	Basic metals	Rest of manufactures	Services	Total
Urban_SA	0.03	0.00	0.00	0.00	0.12	0.08	-0.10	0.00	0.07	-0.78	-0.08	-0.67
Other_VIC	0.21	0.00	0.02	0.10	0.06	0.27	-0.16	0.03	0.43	-1.47	-0.14	-0.65
Other_SA	0.25	0.00	0.01	0.00	0.08	0.14	-0.02	0.01	0.42	-1.55	0.02	-0.62
Other_NSW	0.10	0.13	0.00	0.05	0.07	0.10	-0.10	0.01	0.26	-0.96	-0.17	-0.50
Urban_NSW	0.00	0.04	0.00	0.00	0.03	0.04	-0.15	0.00	0.04	-0.56	0.06	-0.47
Urban_ACT	0.00	0.00	0.00	0.00	0.02	0.02	-0.02	0.00	0.00	-0.27	-0.19	-0.44
Urban_VIC	0.01	0.00	0.27	0.01	0.03	0.08	-0.27	0.00	0.05	-0.51	0.08	-0.26
Urban_QLD	0.00	0.07	0.05	0.05	0.14	0.09	-0.07	0.00	0.14	-0.88	0.17	-0.26
Other_TAS	-0.05	0.00	0.00	0.30	0.04	0.02	-0.39	0.00	0.35	-0.24	-0.19	-0.14
Urban_TAS	0.00	0.00	0.00	0.01	0.01	0.01	-0.06	0.00	0.13	-0.10	-0.04	-0.04
Other_QLD	-0.14	0.14	0.06	0.30	0.14	0.06	-0.06	0.02	0.90	-1.20	-0.24	-0.02
Mineral_NSW	0.03	2.86	0.00	0.16	0.16	0.00	-0.10	-0.03	0.79	-2.40	-1.28	0.23
Mineral_VIC	0.46	0.00	4.32	0.05	0.32	0.60	-0.32	0.00	0.83	-4.55	-1.47	0.23
Urban_WA	-0.04	0.01	0.33	0.64	0.39	-0.03	-0.08	0.00	0.11	-0.58	0.35	1.11
Mineral_SA	-0.03	0.00	1.44	1.27	0.27	-0.04	-0.01	0.04	0.37	-1.91	-0.20	1.18
Mineral_QLD	-0.16	2.58	0.09	0.63	0.18	-0.12	-0.01	0.03	1.15	-1.15	-1.39	1.80
Mineral_NT	-0.05	0.00	0.65	2.32	0.16	-0.01	-0.01	0.00	0.07	-0.33	-0.66	2.11
Mineral_WA	-0.77	0.16	0.16	3.61	0.26	-0.15	-0.01	0.03	1.26	-1.15	-0.26	3.12
National	-0.02	0.27	0.16	0.31	0.11	0.06	-0.13	0.00	0.29	-0.89	-0.12	0.04

For the biggest winner, Mineral_WA, the contribution to GRP growth from mining is 3.9 percent (Table 5), reflecting both the magnitude of price shocks and the share of mining in Mineral_WA's economy: mining's value-added is $11.8 billion out of total regional value-added of $28.5 billion (Table 2). One curious result in the minerals regions is that the services sector makes a larger negative contribution to GRP than in other regions. This is because despite services being relatively income-elastic, and therefore in increased demand as income grows, the prices of labour-intensive services also rise with wages. Therefore, they will suffer larger cost increases than services in non-booming regions in which real wages are not rising—so users will source more of their services from cheaper, neighbouring regions. In the case of Mineral_WA, the negative contribution of services is tempered by fly-in, fly-out mining, which results in a smaller services sector in the region than otherwise, while boosting services in Urban_WA.

The bottom row in Table 5 shows the national results and indicates the extent of the structural change brought about even in the short run by the terms of trade improvement. Real GDP is virtually unchanged, as contributions are only coming from indirect taxes since primary factors are fixed in aggregate. Agriculture's share of national income shrinks slightly, by 0.02 percent. Mining's share of output rises by 0.85 percent, a substantial result given that the sector's share of national output pre-simulation was 7 percent (calculated from Table 2). In manufacturing, TCFs suffer a dramatic shrinkage. National output shrinks by more than 25 percent, which is equivalent to a fall in the sector's national income share of 0.13 percent.[5] Food and basic metal output shares increase. Other manufactures, hit hard by the falling prices of competing imports in the simulation period, fall as a share of national income by 0.89 percent. While manufacturing's total share loss is significant, the change in composition between manufacturing sectors is even larger.

Regional implications in the wake of south eastern Australia's 2006 drought

The drought of 2006, by being concentrated mainly in south eastern Australia, will have exacerbated some of the disparities in regional economic growth induced by the terms-of-trade boom. At the same time, the boom in the mining sectors may have offered some scope for labour to move from agriculture. If this is so, this will alleviate the negative short-run national employment effect that, according to our earlier study (Horridge *et al*., 2005) contributed 0.6 of the overall 1.6 percent loss in real GDP due to the 2002-03 drought. Without repeating the drought simulation for 2006, we can surmise that real GDP for 2006-07 will be 1.0 to 1.5 percent lower than budget projections, due to drought, indicating an eventual figure of 1.7 to 2.2 percent (the budget forecast was for 3.25 percent real GDP growth). At the same time, we might expect the state accounts to show widening disparities in growth, with mining contributing to relatively rapid growth in Western Australia, Northern Territory and Queensland, and the drought reinforcing slower growth elsewhere.

5. An application to Indonesia using *IndoTERM*

IndoTERM is a member of the TERM family which treats West Java and the rest of Indonesia as separate economies. *IndoTERM* includes two features not present in the standard version of TERM, namely:

Multiple household types

[5] We were able to check our simulated result for TCFs with the sector's share of GDP in the national accounts (ABS 2006a). The average share in 2003-04 was 0.38%, falling to 0.27% in December 2005, close to our simulation result. The same impact is not as apparent for mining, as much of the increase in prices accrues to production taxes that are not identified separately for mining in the national accounts.

Using data from the 2003 BPS SAM, households are broken into 8 types, differentiated by income level and source. The composition of income and expenditure differs according to group. Thus, a fall in the price of, say, rice has offsetting effects on the poorest group (agricultural labourers). On one hand their cost of living falls (rice is a comparatively large share of their living costs); on the other hand, agricultural incomes fall, especially in rice-producing regions. The net effect is computed by the model.

Municipal top-down extension

Results for West Java are further broken down into 25 municipalities or districts.[6] There is only a little supporting data[7], so a simplified, "top-down" approach is used, which divides sectors into two groups:

(a) For most primary and manufacturing sectors we assume that output changes by the same percentage in each district. Nevertheless, district GDPs vary because expanding sectors are over-represented in some districts.

(b) For the other, mostly service, industries, we assume that output follows district demand. District household demand is in turn linked to district labour income. This gives rise to a fairly strong "local multiplier effect", which amplifies district GDP differences due to (a).

The scenario: declining proven oil reserves and rising global energy prices

Indonesia's proven oil reserves have declined by around 20 percent since the turn of the millennium. At the same time, there has been a sharp increase in oil prices. In 2003, oil prices were around $US30 per barrel and had risen to around $US55 per barrel in 2005. Though analysts may dispute how much more oil prices might rise, there is little dispute that rising energy demands in China and India – and an inability of many Western nations to reduce national oil consumption – are likely to underpin high oil prices for some time to come.

As has been the case in Australia, this is likely to provide mixed news for Indonesia. Consumers will continue to feel the pinch of rising oil prices. As a major oil producer, Indonesia may benefit from high prices, despite declining reserves.

Our application consists of two groups of shocks:

- Rising trade prices for key commodities; and
- Possible depletion of Indonesia's crude oil supplies[8].

The shocks given to import and export prices were as follows: crude oil (100%), natural gas(100%), basic chemicals (10%), fertilizer (18.5%), paints (14%), petroleum products (34%) and LNG (34%). The reason for the shocks to basic chemicals, fertilizer and paints reflects their reliance on fuel inputs. As energy prices rise, the global price of such commodities will also rise with the costs of production.

[6] A top-down extension for Australia versions of the model were developed subsequent to the Indonesian project, providing details at the statistical local area (SLA) level.

[7] BPS provided value-added by 9 broad sectors for each district.

[8] These simulations were undertaken using GEMPACK software. See Pearson (1988). Other applications using the TERM approach include Horridge *et al*. (2005), Wittwer (2003) and Wittwer *et al*. (2005).

The assumption of resource depletion, represented in the model as a 20% decline in crude oil productivity, is based on a perception that globally, crude oil resource depletion is moving ever closer. It might be that evidence of declining proven crude oil reserves in Indonesia is symptomatic of low investment in exploration and extraction in the 1990s. This was due to a combination of low crude oil prices at the time and the crisis of the late 1990s, in which investor confidence in Indonesia collapsed. It remains possible that with renewed exploration and development of new wells stimulated by high oil prices, Indonesia's crude oil productivity will not decrease.

For the simulation, we used a long run closure. On the income side, this assumes that national employment is fixed, and that all adjustment nationally occurs via changes in real wages relative to the base case. Concerning capital stocks, in the long run we assume that there is sufficient time for industry investment to respond fully to variations in industry rates of return from the base case. Therefore, all adjustment in the long run is in stocks of capital rather than rates of return on capital. On the expenditure side, we assume aggregate consumption is linked to nominal GDP via a consumption function. Government consumption is fixed. At the industry level, the investment to capital ratio is fixed, thereby determining investment. We assume that the trade balance as a share of GDP is exogenous.

Since we are using a multiregional model, there are several additional features in the macroeconomic behaviour of the model that operate at the regional level. We assume that migration between regions follows imperfectly elastic inter-regional demand for labour. That is, there is a migration response to differences in real wages between regions, but the response is not sufficient to eliminate inter-regional wage differences.

We present the results in separate columns for the two sets of shocks. We turn first to explaining the change in real GDP.

Table 6: Indonesia's national real macroeconomic impacts of energy price and resource depletion shocks (% change from base case)

	Oil productivity	Trade price	Total
H'hold consumption	-1.24	1.53	0.28
Investment	-0.54	-4.46	-4.99
Govt consumption	0.00	0.00	0.00
Export Volumes	-1.75	-5.47	-7.22
Import volumes	-0.72	-1.08	-1.80
Real GDP	-1.28	-0.92	-2.20
Avg real wage	-0.34	-3.68	-4.01
Capital stocks	-0.95	-1.78	-2.72
CPI	-0.48	2.76	2.28
GDP price index	-0.43	5.31	4.88
Export price index	0.06	17.82	17.88
Import price index	0	8.74	8.74

Table 7. Decomposition of Indonesia's real GDP on income side (contribution %)

	Oil productivity	Trade price	Total
Land	0	0	0
Labour	0	0	0
Capital	-0.46	-0.86	-1.32
Technology	-0.78	0	-0.78
Production tax	0	0.01	0.01
Indirect tax	-0.04	-0.06	-0.11
Total	-1.28	-0.92	-2.20

First, we consider the impact of oil productivity on the economy. We can decompose the real GDP result by adding up changes in productive factors (land, labour and capital) net of changes in technology. There are three sources of real GDP or income loss from declining oil productivity. Capital income accounts for 49% of GDP in the base case, so that a decline in aggregate capital stocks of 0.95% (table 6, 1st column) reduces real GDP by 0.46% (= 0.49 x 0.95). Crude oil's productivity decline of 20% contributes to a decline in real GDP of 0.78%. And a decline in indirect tax income reduces real GDP by 0.04%. The three contributions sum to –1.28% (table 6, 1st column).

Under the column headed "trade price" in tables 6 and 7, we show the impacts of rising export and import prices for energy commodities. Higher energy prices lead to a decrease in aggregate capital stocks, as industries lower investment relative to the base case in order to restore rates of return to base case levels. The decline in aggregate capital stocks of 1.78% (table 6, 2nd column) contributes to a decrease in real GDP of 0.86% (table 7, 2nd column). The remaining 0.05% of the real GDP arises mainly from lower indirect tax income (table 3). Note from table 6 that export prices rise more than import prices. This terms-of-trade increase equals 8.4% (=(17.8-8.7)/1.087). We expect terms-of-trade improvements acting alone to increase the share of aggregate consumption in real GDP. This is because our consumption function links nominal consumption to nominal income or GDP. The consumer price index (CPI) includes the price of imports but not exports. The GDP price index or deflator includes the price of exports but not imports. Therefore, a terms-of-trade improvement results in the GDP deflator increasing by more than the CPI (table 2). Hence, if nominal consumption falls by the same percentage as nominal GDP, real consumption will fall by a smaller percentage than real GDP due to the terms-of-trade effect. In addition, aggregate investment falls (-4.5%, table 6, 2nd column) by a larger percentage than real GDP, making a larger share of national income available for household consumption. Note that although we assume that real government expenditure is exogenous, its share of GDP is substantially smaller than that of real investment. Since government spending accounts for only 7% of GDP, compared with 71% for aggregate consumption in the base data, reducing government spending in line with GDP would make little difference to aggregate consumption. The substantial improvement in the terms-of-trade results in an unusual result in the 2nd column of table 7: real household consumption increases by 1.53% despite real GDP falling by 0.92%.

Table 8. Indonesia's regional macroeconomic variables (% change from base case)

	West Java			Rest of Indonesia		
	Oil productivity	Trade price	Total	Oil productivity	Trade price	Total
H'hold consumption	-1.31	1.97	0.66	-1.23	1.45	0.22
Investment	-0.58	-4.53	-5.10	-0.53	-4.44	-4.97
Govt consumption	0	0	0	0	0	0
Export Volumes	-1.76	-7.04	-8.80	-1.75	-5.37	-7.12
Import volumes	-0.64	-1.76	-2.40	-0.74	-0.93	-1.67
Real GDP	-1.76	-0.67	-2.43	-1.19	-0.97	-2.16
Employment	-0.01	0.06	0.06	0.00	-0.01	-0.01
Avg real wage	-0.34	-3.62	-3.96	-0.33	-3.69	-4.02
Capital stocks	-1.03	-1.35	-2.38	-0.93	-1.86	-2.79
Export price index	0.09	16.28	16.36	0.05	17.91	17.97
Import price index	0.00	5.12	5.12	0.00	8.93	8.93

Table 8 shows the regional results of the simulation. Recall that the present version of *IndoTERM* contains only two regions, West Java and the rest of Indonesia. This representation results in two regions that are relatively similar, as a large proportion of the composite region consists of the remaining provinces of Java. These have similar endowments to West Java, unlike the relatively sparsely populated outer islands that are relatively rich in mineral resources. With representation of such provinces individually, we would expect to find significant differences between the macroeconomic changes between regions.

Table 9. Industry national outputs, Indonesia (% change from base case)

	Oil productivity	Trade price	Total
Natural Gas	0.06	10.12	10.18
Private Health	-1.5	2.86	1.36
Private Educat	-1.46	2.53	1.07
Poultry Prd	-0.97	2.02	1.06
Restaurant	-0.89	1.81	0.92
Films	-0.57	1.46	0.89
PersHousSvc	-1.4	2.24	0.85
Hotel	-0.13	0.97	0.84
Animal Feed	-0.69	1.38	0.69
RecCultSvcPr	-0.66	1.32	0.66
Clay Cer Struc	1.51	-12.91	-11.4
Communic Equp	1.93	-13.45	-11.52
Plastcs Fibre	0.72	-13.04	-12.31
Iron Ore	0.36	-12.75	-12.39
Oth Chemicals	-0.12	-13.98	-14.1
Scientif Equp	1.68	-15.79	-14.11
Bas Ferr Prd	0.53	-15.99	-15.47
Sport Goods	1.88	-18.52	-16.64
Basic Ferrous	0.66	-18.23	-17.56
Oth Trans Equp	1.52	-21.13	-19.61

The biggest winners and losers at the national industry level are shown in table 9. Natural gas is the biggest winner, due to the doubling of the export price and the absence of any resource depletion shock for gas. The remaining industries that expand output do so simply because most of their sales are to households. Service industries tend to have relatively income-elastic household demand, and do well when aggregate household consumption increases. Among the losers, the pattern is that industries are reliant on energy inputs, or are export-oriented. The simulation favours exports of energy products at the expense of other exports.

IndoTERM also includes a top-down representation of the municipalities of West Java. The local region that fares best in West Java is the kabupaten of Indramayu. This is because it accounts for over 70% of crude oil and natural gas production in West Java. Indramayu loses from the decline in crude oil productivity, and indeed the output loss more than outweighs the increase in natural gas production for this effect. But it gains substantially from the energy price hikes: the increase in nominal income has a substantial positive effect on the municipality, with local industries, including trade and motor repairs experiencing output increases in excess of 40%. Overall, the municipality experiences a gain in factor income of 7.3%, whereas most other regions of West Java lose income in the scenario.

6. Conclusion: future directions for TERM variants

The Centre of Policy Studies receives constant requests to undertake modelling using TERM. In the Australian context, further theoretical modifications to the agricultural sectors are currently being undertaken to better reflect the mobility of factors on individual farms. This is part of project to improve the water accounts in TERM-water and to introduce more hydrological detail to a CGE model. While it may have been interesting to superimpose a series of drought shocks on the terms-of-trade shocks in this paper, further development is being undertaken to distinguish dryland from irrigated cropping. The extraordinary feature of the 2006 drought was that the entire Snowy Mountains region suffered record rainfall deficits. Enhancements to TERM in 2007 will better depict the impacts of this drought and of various policy simulations.

In the case of *IndoTERM*, the requirements of the funded project were for only two main regions. The additional data and effort to depict all 33 of Indonesia’s provinces instead of just two regions are not proportional to the increase in the number of regions. Particularly with a highly disaggregated national database, it is not difficult to surmise that many industries do not exist at all in a number of provinces. Agricultural and, to some extent, mining data are usually available at the provincial level. Resource sectors tend to contribute a relatively large proportion to the total economy of relatively remote provinces. Consequently, the task of representing all provinces by sector is not as daunting as it may first seem.

References

ABARE 2006, Market monitor, (accessed online 29 May 2006)

ABS (Australian Bureau of Statistics), (2006a and previous issues). Australian National Accounts: State Accounts, Catalogue 5220.0. ABS, Canberra.

ABS 2006b, International Trade Price Indexes, Australia, catalogue 6457.0, (accessed online 29 May 2006)

Dixon P, Parmenter B, Sutton J, Vincent D (1982) ORANI: A Multisectoral Model of the Australian Economy. North-Holland, Amsterdam.

Dixon, P., Schreider, S. and Wittwer, G. (2005). "Combining engineering-based water models with a CGE model", chapter 2 in Productivity Commission, *Quantitative tools for microeconomic policy analysis*, Conference Proceedings, 17-18 November, 2004, Canberra.

Horridge, M, Madden, J. and Wittwer, G. (2005), Using a highly disaggregated multi-regional single-country model to analyse the impacts of the 2002-03 drought on Australia, Journal of Policy Modelling 27(3):285-308, May.

Maddock R, McLean I (1987) The Australian economy in the very long run. In: Maddock, R., McLean, I., (Eds.), The Australian Economy in the Long Run. Cambridge University Press, Cambridge.

Naqvi F, Peter M (1996) A Multiregional, Multisectoral model of the Australian Economy with an Illustrative Application, Aust. Econ. Papers. 35(2), 94-113.

Peterson D, Dwyer G, Appels D & Fry J (2005) Water Trade in the Southern Murray-Darling Basin, The Economic Record 81(s1):s115-s127.

TERM website: (http://monash.edu.au/policy/term.htm

Wittwer G (2003) An outline of TERM and modifications to include water usage in the Murray-Darling Basin, Preliminary working paper (at http://monash.edu.au/policy/archivep.htm#tpgw0050).

Wittwer, G., Vere, D., Jones, R. and Griffith, G. (2005), Dynamic general equilibrium analysis of improved weed management in Australia's winter cropping systems, Australian Journal of Agricultural and Resource Economics, 49(4): 363-377, December.