Working Paper
in Economics and
Development Studies

Department of Economics
Padjadjaran University

No. 200607

The Impacts of Higher Energy Prices on Indonesia's and West Java's Economies using INDOTERM, a Multiregional Model of Indonesia

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August, 2006

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ABSTRACT

Indonesia's national and regional/local policy makers are becoming increasingly concerned with disparities between regions. Aggregate incomes and expenditures in one region may change proportionally more than national changes.

This paper contains a technical summary of the structure and special features of INDOTERM model, a member of the TERM family (TERM = The Enormous Regional Model). It treats West Java and the rest of Indonesia as separate economies. We discuss the data required to prepare a version of INDOTERM that represents all the provinces of Indonesia. Finally, we present a long-run simulation of the impacts of the recent hike in global energy prices on the Indonesian economy combined with possible depletion of Indonesia's crude oil supplies.

The special features for future development of INDOTERM are multiple household incomes and expenditures and a "top-down" extension representing sub-provincial municipalities.

Nationally, Indonesia's real income losses due to resource depletion are more than compensated by the sharp increase in the terms of trade arising from the increase in global demand for energy. West Java and the rest of Indonesia fare similarly, as a large proportion of the composite region consists of the remaining provinces of Java which have a similar economic structure to West Java. The relatively sparsely populated outer islands that are relatively rich in mineral resources are not represented separately. Using a "top-down" extension of West Java's 25 municipalities and districts in INDOTERM, the simulation shows that Kabupaten Indramayu fares best. This local region also 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.

Keywords: Computable General Equilibrium, Resource Economies and Regional Development.

1. Introduction

INDOTERM[1], a member of the TERM family (TERM = The Enormous Regional Model), is a "bottom-up" CGE model of Indonesia which treats West Java and the rest of Indonesia as separate economies. The TERM approach was created specifically to deal with highly disaggregated regional data while providing a quick solution to simulations. This makes TERM models useful for examining the regional impacts of shocks that may be region-specific.

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). For example, if the rest of world reduced tariffs on Indonesian textiles and clothing, this would raise the export price faced by Indonesian

[1] INDOTERM is the result of a collaboration between the Centre of Policy Studies, Monash University (Melbourne), and the Center for Economics and Development Studies, Padjdjaran University (Bandung), funded by an AUSAID public-sector linkage project.

producers. Textiles and clothing sectors in Indonesia would gain in such a scenario. But other industries might lose their share of employment and investment in the long run, and shrink relative to the base case.

A regional model can go a step further. Some regions contain high concentrations of industries that are directly affected by a policy. A regional model might show that aggregate incomes and expenditures in these regions change proportionally much more than national changes. Such information may be helpful to policy makers who are becoming increasingly concerned with disparities between regions. In many countries in the world, capital cities and coastal regions are booming yet inland regions are struggling to participate in national growth.

China is the obvious example of a booming economy in which inland provinces have yet to participate significantly. This is most evident in the flood of migrants over the past few decades from the countryside to eastern cities. This reflects relative employment opportunities and relative lack of transport, health and education infrastructure away from the cities. In the TERM type of model, differences in transport costs between regions are modelled. TERM models therefore might be helpful in estimating the regional economic impacts, for example, of improving transport infrastructure within a nation. Initiatives of this nature might be helpful to remote regions.

Not all recent global economic developments are unfavourable to relatively remote regions. Despite some stark differences in geography and culture, a large fraction of the exports of both Indonesia and Australia are of minerals. The booming economies of China and India have fuelled a rapid rise in global mineral prices over the past couple of years. The effect of such a prices boom might be to accelerate growth in mineral producing regions, which often are remote. As long as the current commodity boom continues, TERM simulations of the impact of the boom on the respective Indonesian and Australian economies will be of particular interest in regional policy analysis.

The current (first) version of INDOTERM identifies only two regions of Indonesia – West Java and the Rest. Potentially it could in future separately distinguish all the provinces. Our description of the model and database anticipates this possibility.

This paper continues with a technical summary of the structure of INDOTERM. This is followed by a discussion of the data requirements to prepare a version of INDOTERM that represents all the provinces of Indonesia. Next, a section outlines special features of the current version of the model. Finally, we present a simulation of the impacts of the recent hike in global energy prices on the Indonesian economy.

2. The structure of INDOTERM: a potential tool for covering all Indonesian provinces

The key feature of INDOTERM is its ability to handle a greater number of regions or sectors. This capability has not been fully exploited in the present version of INDOTERM, which includes only two regions but potentially could include all the provinces of Indonesia.[2] The greater efficiency arises from a more compact data structure relative to earlier multi-regional national models, made possible by a number of simplifying assumptions. For example, INDOTERM 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 INDOTERM'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:

[2] Daniel Pambudi completed his Ph.D. dissertation at the Centre of Policy Studies, Monash University, using EMERALD, a TERM-like model that represented each Indonesian province as a separate economy. He used a year 2000 database. References to earlier multiregional models include Madden (1990), Naqvi and Peter (1996), Adams et al. (2002) and Giesecke (1997)

Table 1: Main sets of the INDOTERM model

Index	Set name	Description	Typical size
s	SRC	(dom,imp) Domestic or imported (ROW) sources	2
c	COM	Commodities	175
m	MAR	Margin commodities (Trade, Road, Rail, Boat)	8
i	IND	Industries	175
o	OCC	Skills	4
d	DST	Regions of use (destination)	2
r	ORG	Regions of origin	2
p	PRD	Regions of margin production	2
f	FINDEM	Final demanders(HOU, INV,GOV, EXP);	4
h	HOU	Household type	8
u	USER	Users = IND + FINDEM	179

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 4 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

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.

INDOTERM 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 (ie, 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) 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).

INDOTERM 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 INDOTERM 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, INDOTERM distinguishes only 4 final demanders in each region:
(a) HOU: the representative household
(b) INV: capital formation
(c) GOV: government demand
(d) EXP: export demand.

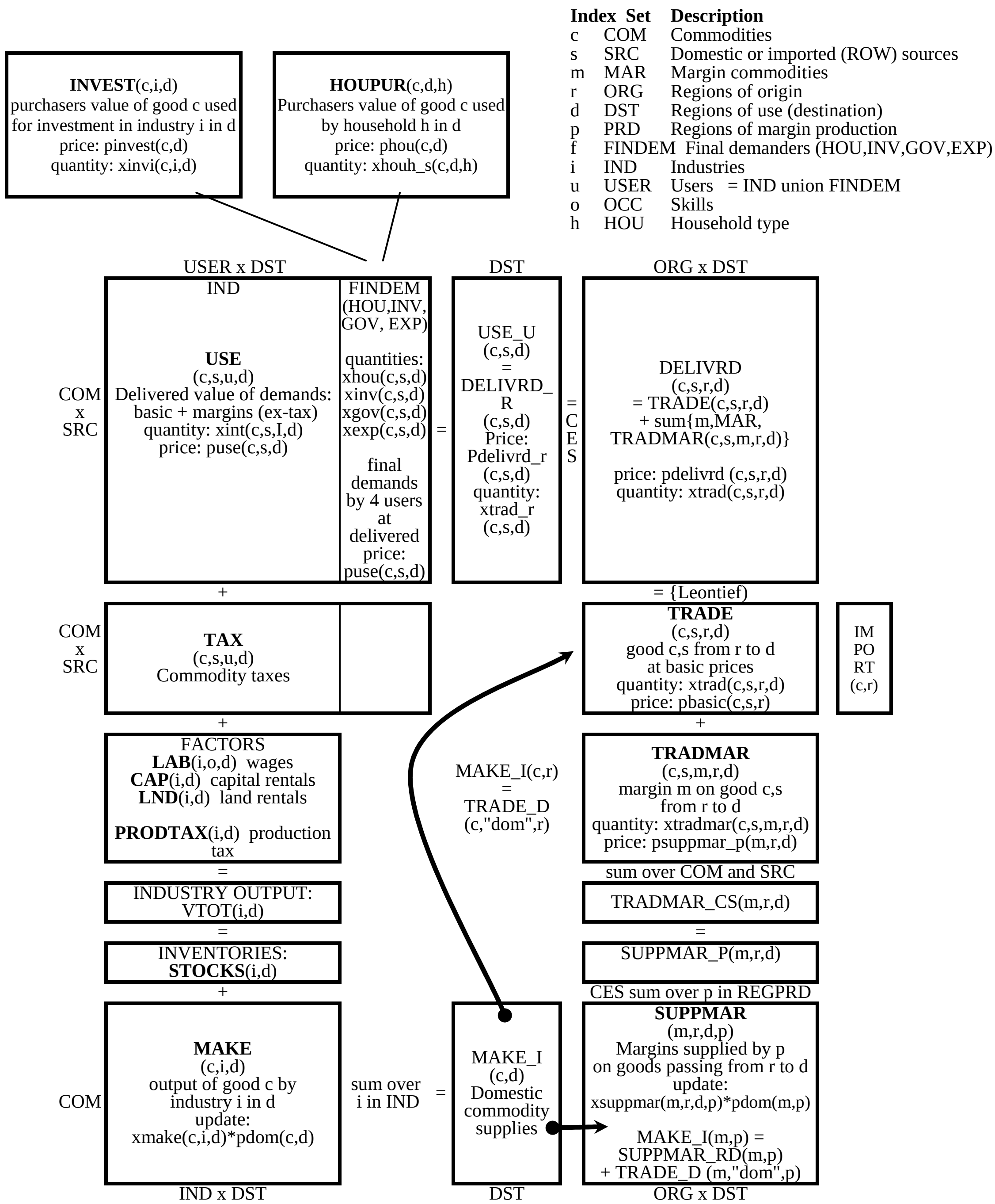

Fig. 1: The INDOTERM flows database

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.

A second satellite matrix, HOUPUR(c,h,d), allows the model to distinguish budget shares by household type h.

2.1. INDOTERM sourcing mechanisms

Fig. 2 illustrates the details of the INDOTERM 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 INDOTERM could be reconstructed from Figures 1 and 2.

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). 2 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.

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 10 (merchandise) to 1 (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 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 (i.e., constant proportion) 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 (σ=1) 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 (σ=0.2). 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. 2, a parallel system of sourcing is also modelled for imported vegetables, tracing them back to port of entry instead of region of production.

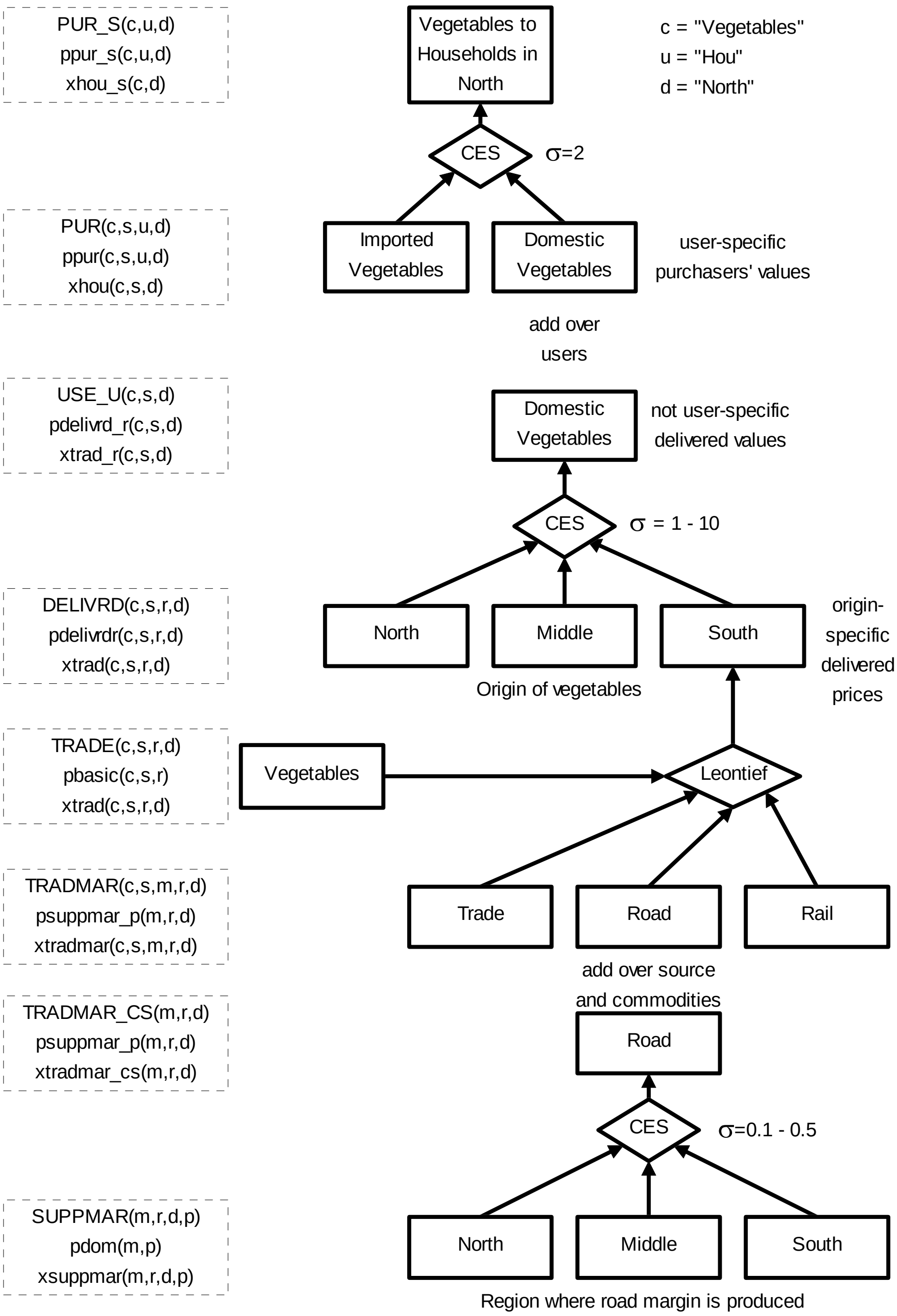

Fig. 2: INDOTERM sourcing mechanisms

3. Gathering data for 175 sectors and 30+ 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 available only with quite limited detail. Thus, a vital counterpart to Fig. 3, to estimate its database using these 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: 175 sectors and 30+ 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.

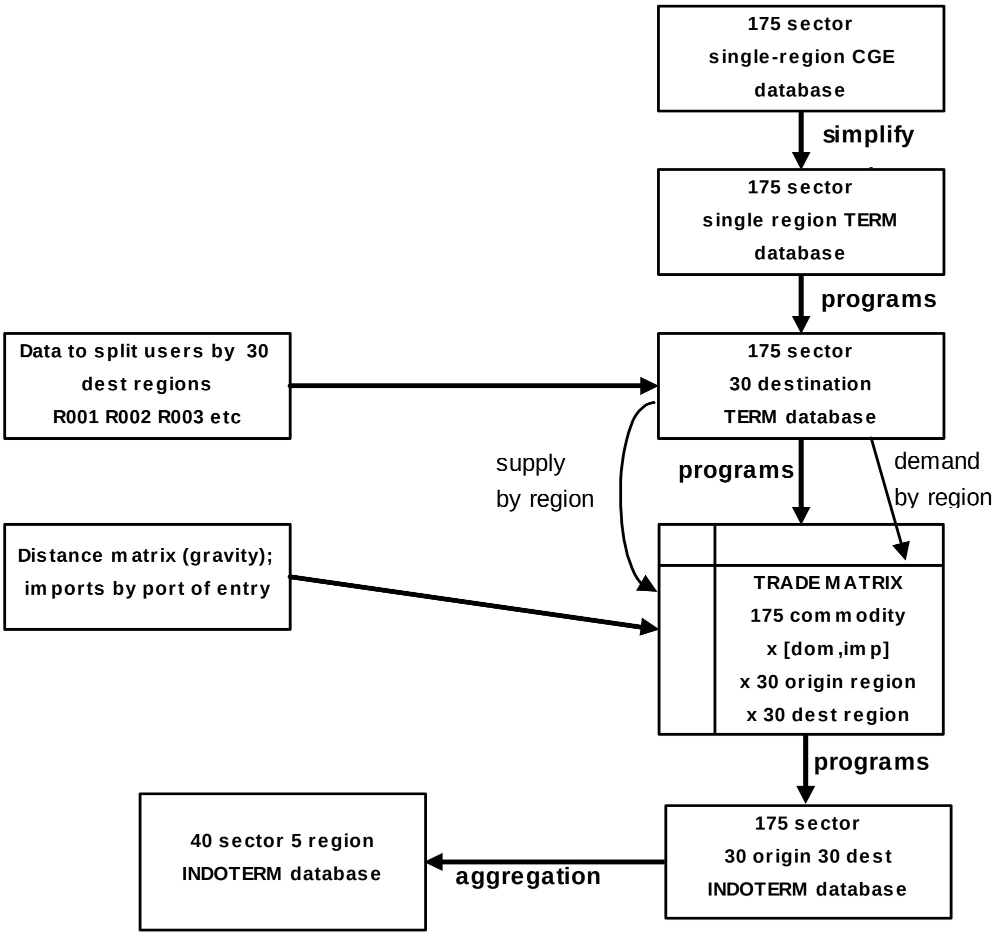

Fig. 3: Producing the TERM regional database

3.1. The national input-output database

As shown in Fig. 3, the TERM data process starts from the 2003 Indonesian input-output tables, distinguishing 175 sectors. Our first step was to convert these tables to the file format of ORANI-G, a standard single-country CGE model.

We also drew on a 23-sector national SAM for 2003, prepared by the BPS. This appears mostly consistent with the IO table. The SAM was used to provide detail about multiple household types and industry skill mix, both of which were lacking from the IO tables.

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

The next step is to obtain, for each industry and final demander, an estimate of each province's share of national activity (these shares are the R001, R002, etc, of Fig. 3. 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. The regional output shares were prepared by Professor Armida Alisjahbana.

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[3] is to construct the TRADE matrix on the right-hand side of Fig. 1. For each commodity either domestic or imported, TRADE contains a 30x30 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. 3, we already know both the row totals (supply by commodity and region) and the column totals (demand by commodity and region) of these submatrices. We use 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, note that:

- 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.

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

$$V(r,d) = \lambda(r).\mu(d).V(r,*).V(*,d) / D(r,d)^2 \qquad r \neq d$$

where

V(r,d) = 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)
D(r,d) = distance from r to d

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

$$\Sigma_r V(r,d) = V(*,d) \text{ and } \Sigma_d V(r,d) = V(r,*).$$

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

$$V(r,d)/V(*,d) \propto \sqrt{V(r,*)}/D(r,d)^k \qquad r \neq d$$

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:

$$V(d,d)/V(d,*) = \text{locally-supplied demand in d as share of local production}$$
$$= \text{MIN}\{ V(d,*)/V(*,d),1\} \times F$$

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:

$$\Sigma_r V(r,d) = V(*,d) \text{ and } \Sigma_d V(r,d) = V(r,*).$$

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

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

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, particular crops or minerals may be produced in only a few provinces. At a maximum disaggregation, the load born by gravity assumptions is minimized.

3.4. Aggregation

Solution time for models of the TERM type is roughly proportional to [$NREG^2 * NSEC^2$]. With only 2 regions, INDOTERM is quick to solve for 175 sectors – so no sectoral aggregation is needed. However, even though TERM is computationally efficient, it would be slow to solve if a full 175-sector, 30-region database were used. In that case, the next stage in the data procedure

[3] With two regions, the TRADE matrix is rather simple to construct, and the gravity assumption is not needed. Nevertheless we include here a description of the process needed if there was more than 2 regions.

would be to aggregate the data to a more manageable size. An aggregation facility is built into the data process. The aggregation choice (which sectors or regions should be combined) is application-specific.

4. Special features of INDOTERM

INDOTERM includes two features not present in the standard version of TERM, namely:

4.1. Multiple household types

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.

4.2. Municipal top-down extension

Results for West Java are further broken down into 25 municipalities or districts. There is only a little supporting data[4], 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).

5. The impacts of higher energy prices on Indonesia’s economy

Sustained rapid growth in China and India has fuelled rising demand for resources globally. This has been observed most obviously in rising world prices for crude oil and petroleum products. This is of particular relevance to Indonesia, given that energy-related products are prominent in both exports and imports. Our application consists of two groups of shocks:

- Rising trade prices for key commodities; and
- Possible depletion of Indonesia’s crude oil supplies[5].

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.

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

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

[5] 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).

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 2: 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

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 2) 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 3).

Table 3: Decomposition of 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

Under the heading "trade price" in tables 2 and 3, 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 2) contributes to a decrease in real GDP of 0.86% (table 3). The remaining 0.05% of the real GDP arises mainly from lower indirect tax income (table 3). Note from table 2 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 2, 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 2: real household consumption increases by 1.52% despite real GDP falling by 0.92%.

Table 4: 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 4 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.

The biggest winners and losers at the national industry level are shown in table 5. 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.

Table 5: National output (% 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

Table 6: Municipal factor income (% change from base case)

	Oil productivity	Trade price	Total
KabBogor	-0.10	-2.99	-3.09
KabSukabumi	-0.84	1.42	0.58
KabCianjur	-0.77	0.21	-0.56
KabBandung	-0.17	-2.72	-2.88
KabGarut	-0.45	-0.67	-1.12
KabTasikm	-0.65	-0.42	-1.07
KabCiamis	-0.87	-0.41	-1.28
KabKuning	-0.83	0.53	-0.30
KabCirebon	-0.69	-0.49	-1.19
KabMaja	-0.75	0.63	-0.12
KabSumeda	-0.47	-1.31	-1.78
KabIndra	-1.68	9.02	7.34
KabSubang	-1.30	4.99	3.69
KabPurwakt	-0.32	-2.50	-2.82
KabKarawang	-0.31	-0.97	-1.28
KabBekasi	0.09	-3.76	-3.67
KotBogor	-0.91	-1.28	-2.19
KotSukabumi	-0.98	-0.63	-1.61
KotBandung	-0.54	-2.20	-2.75
KotCirebon	-0.22	-3.36	-3.58
KotBekasi	-0.07	-3.79	-3.85
KotDepok	-0.19	-3.45	-3.63
KotCimahi	0.05	-4.32	-4.27
KotTasik	-0.83	-1.26	-2.09
KotBanjar	-0.78	-0.47	-1.24

In summary, as a nation abundant in energy commodities, Indonesia's real income losses due to resource depletion are more than compensated by the sharp increase in the terms of trade arising from the increase in global demand for energy.

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