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Regional economic and emissions implication of oil palm development scenarios: A dynamic inter-regional CGE analysis for Indonesia

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Abstract

Using a dynamic multi-regional CGE model for Indonesia, IndoTERM, we simulate scenarios of oil palm development toward 2030. In particular, we simulate a cap, starting in 2014, on land used to grow oil palms, greatly reducing growth in oil output. The cost to Indonesia is not large, when compared to expected income gains over the period 2014-2030. However, growth rates are more seriously affected for Sumatra and West Kalimantan (centres of palm oil production).

1 Introduction

1.1 Development of Indonesian palm oil sector (1960-2011)

Palm oil is extracted from the bunches of plum-sized fruit borne by oil palm trees, which grow mostly in Malaysia or Indonesia[1]. Output has grown rapidly since the 1960s and it is now the world's highest-volume vegetable oil, used for food, fuel and other industrial purposes. For Indonesia, it is an important export-oriented industry. In 1961, Indonesia harvested 70 thousand hectares of oil palm. In 1980 the government opened up plantation schemes, formerly monopolized by *Perkebunan Besar Negara* (PBN, State-own Plantation Company) to now include *Perkebunan Besar Swasta* (PBS, Private Plantations) and *Perkebunan Rakyat* (PR-smallholder plantations), resulting in an increase in plantation area.

Nationally, production of palm oil in Indonesia is mostly located in Sumatra, with harvested area and production in 2012 reaching 65% and 73% respectively of the national total. Within Sumatra, Riau is the province with the greatest planted area and production. This province has 1.9 million ha (21.2% of the national oil palm plantation area) with a production of 5.8 million tons (24.8% of national palm oil production).

Kalimantan (Borneo) is also important, contributing 31% to national harvested area and 23% to production. The Government has also promoted oil palm in the eastern part of Indonesia. Over the last five years, oil palm plantations in Central Sulawesi and Southeast Sulawesi grew 17.8% and 15.4% annually.

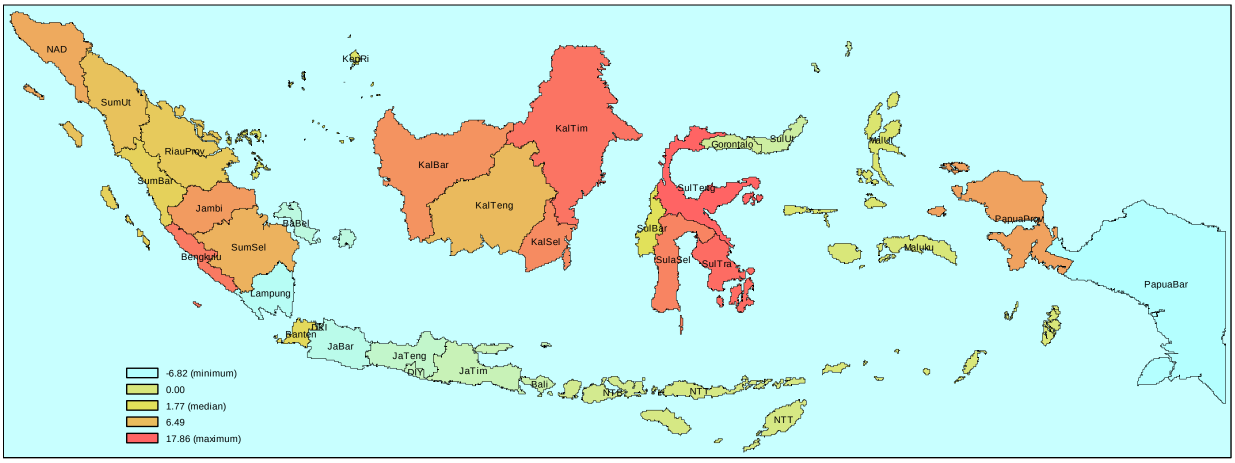

Figure 1. The average growth of oil palm harvested area, 2008 – 2012
Source: Directorate General of Estate Crops, 2012

[1] See http://www.palmoilworld.org/about_malaysian-industry.html

Figure 2 shows that increases in palm oil output have mainly come through increased planting area (rather than productivity growth). The figure suggests that Malaysia has increased productivity in recent years -- but the offelow, it can be seen that the development of oil palm plantations in Indonesia tend towards extensification. To increase production, Indonesia is still focused by increasing its plantation land. From 204 thousand hectares in 1980 to 6.09 million hectares in 2011 with hardly changes in its productivity. Although it was increased to 20.05 tons/ ha in 2005, the productivity of Indonesian oil palm plantation in 2011 only amounted to 16.7 tons/ ha.

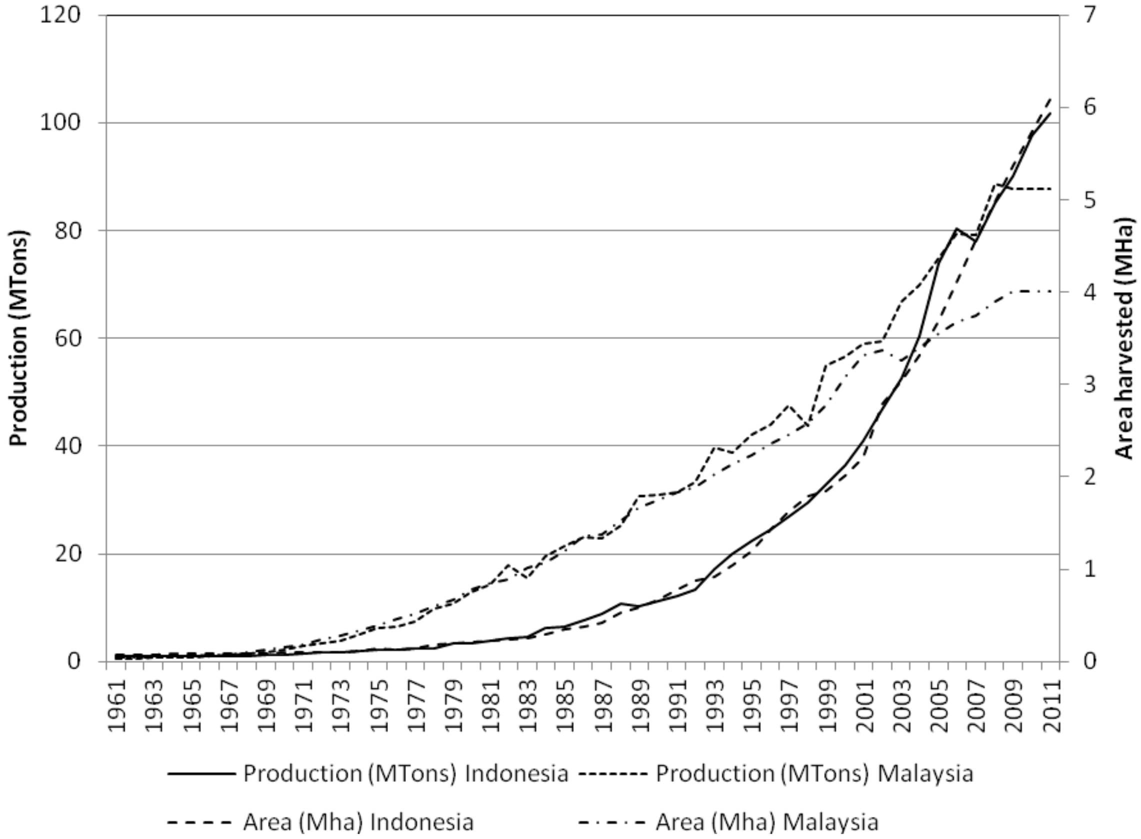

Figure 2. Area harvested and production of palm oil plantation, Indonesia and Malaysia
Source: FAO Database

Indeed, although the oil palm produces much more oil per hectare than other oil-bearing crops, it is striking that output-per hectare has grown much more slowly than for most crops. Possible reasons are:

- As a tree crop, it has a 30-year life cycle, with slower genetic progress than annual crops.
- Maximum yields are obtained frorm years 10 to 20 of tree life; younger, less productive, plants have formed a greater share during the recent period of rapid growth.
- Small-scale producers, promoted for social reasons, are typically far less efficient than large plantations.

Figure 3 below shows a range of per-hectare productivities; in 2011, Indonesian productivity was on average 75% of that achieved by Malaysia.

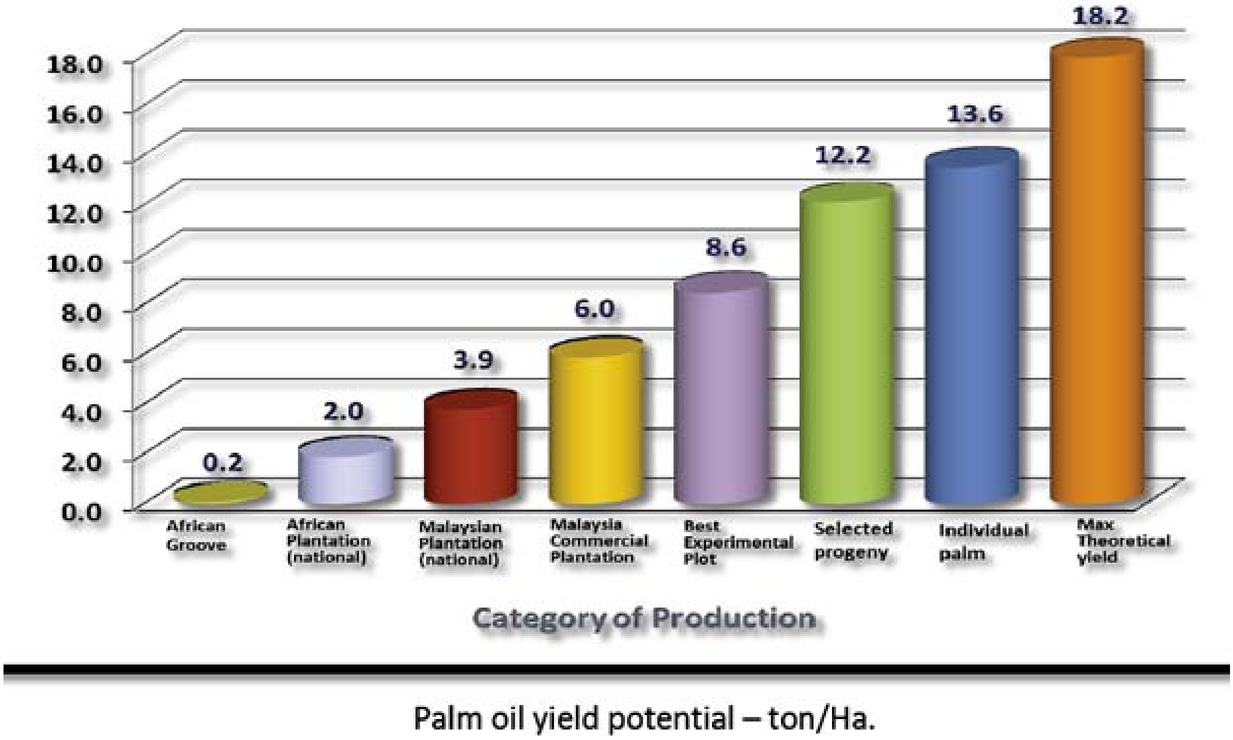

Figure 3. Palm oil productivity comparisons

Source: Malaysian Palm Oil Board (MPOB): http://www.palmoilworld.org/about_malaysian-industry.html

The problems of low productivity cannot be separated from the smallholder plantations which comprised 42% of total palm oil area in 2010 (Burke & Resosudarmo, 2012). On one hand, small plantations can increase community involvement and provide economic benefits to rural communities, especially those in Sumatra and Kalimantan (Burke & Resosudarmo, 2012). However, small plantations typically have below-average productivity (Burke & Resosudarmo, 2012; Rudel, Defries, Asner, & Laurance, 2009).

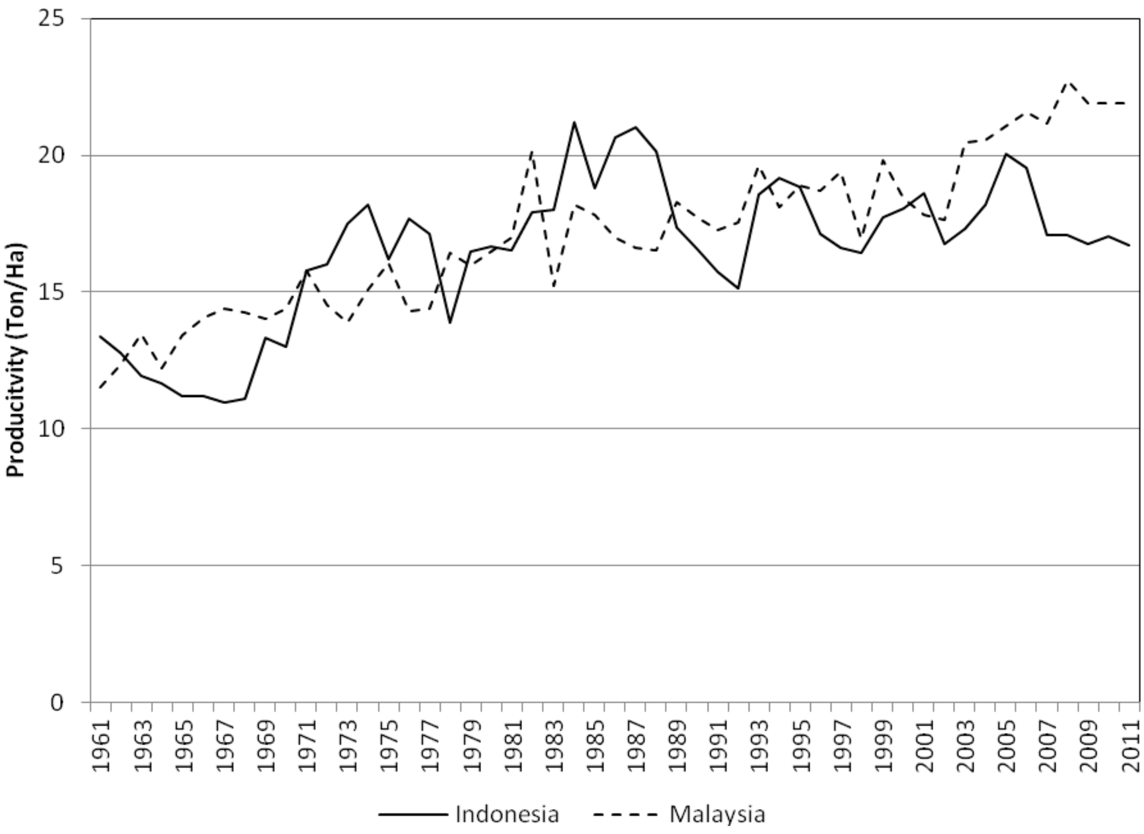

Figure 4. Productivity per ha (Source: FAO Database)

Processed palm oil is one of Indonesia's main exports. In the last few years, Indonesia has experienced a significant increase in the palm oil sector, by becoming the world's largest exporter of the commodity (Burke & Resosudarmo, 2012). In 2010 exports of Indonesian palm oil products reached 16.3 million tones or about 13.4 billion US$. This palm oil boom is very important for the economy, as being one of the main drivers of Indonesia’s export in recent years. Together with coal, the contribution of exports of these two products to merchandise exports reached 21.9% in 2011, up from only 3.8% in 2000 (Burke & Resosudarmo, 2012).

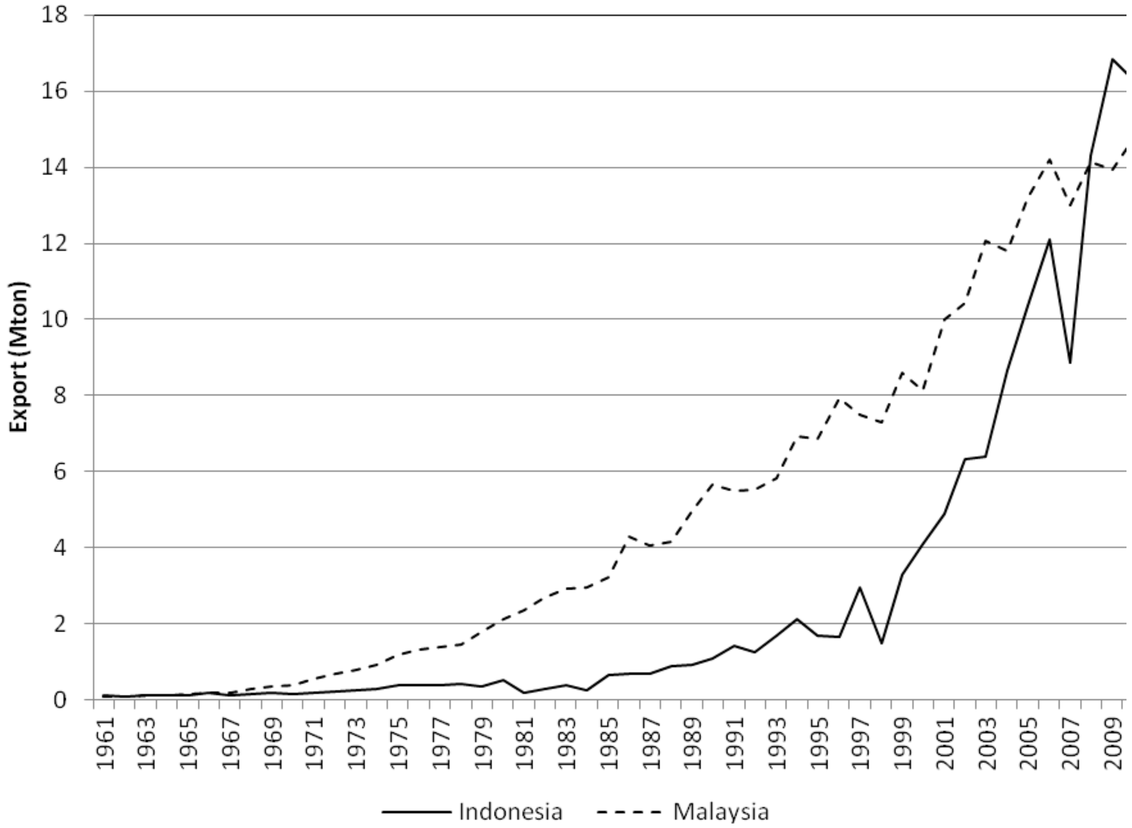

Figure 5. Export of palm oil (Tons), Malaysia and Indonesia (Source: FAO Database)

1.2 Indonesian oil palm sector and carbon emissions\

Palm oil is mainly used for food, but its high yield, about 4.2 tonnes / ha / year, makes it an attractive candidate material for biodiesel (Tan, Lee, Mohamed, & Bhatia, 2009). But while increased production comes mainly through area increase, the land use change may damage the environment, by releasing greenhouse gases and damaging forest ecosystems (Burke & Resosudarmo, 2012; Carlson et al., 2012; Rudel et al., 2009; Tan et al., 2009). Since Indonesia is one of the world's largest GHG emitters, land conversion for palm oil plantations is problematic. The Ministry of Forest estimated the deforestation in 2011 to be 0.45 million Ha (0.5% of Indonesia’s forest) of which palm oil plantations were the main cause.

A recent calculation found that the 2010 – 2020 net cumulative GHG emission from palm oil plantation is projected to reach 1.52 GtC (Carlson et al., 2012). They also projected that during the same period, the carbon emission from oil palm plantation in Kalimantan would rise by 284% , contributing 27% of Indonesia’s projected 2020 land-based emission. This contradicts the Government effort to reduce GHG emission by 26% relative to BAU by 2020. Considering the whole plantation area, the emission from oil palm alone would prevent reaching the 2020 target by 2020.

2 Methodology: IndoTERM

We explore the regional economic and emissions implication of various oil palm scenarios until 2030 using IndoTERM, a large CGE model of Indonesia.

IndoTERM is a multi-regional CGE model of Indonesia[2] that includes two dynamic mechanisms. Firstly, capital accumulates over time via the change in net investment. Employment temporarily responds to changes in real wages. Via this second mechanism we move the labour market from a typical short-run environment (real wages fixed, employment variable) to a long-run environment (employment fixed, real wages flexible).

IndoTERM treats each region as a separate economy. A feature of TERM-style models is their ability to deal with highly disaggregated regional data without excessive computational cost. This is made possible by a number of simplifying assumptions that creates a compact data structure (Horridge et al., 2003). For example, IndoTERM assumes that all users of a particular commodity (fish products) in a particular region, source their fish from other regions according to common proportions. Horridge et al. (2003) noted that finer regional and sectoral detail is desirable for a number of reasons. Firstly, TERM-style models are very useful for countries such as Indonesia, which is characterised by a large number of diverse regions. These regions vary in resource endowment and in the pattern of economic activity: policy intervention may be needed to ensure that the benefits of economic growth are shared equitably between regions. TERM allows events such as natural disasters to be modelled in a specific region. Secondly, policy-makers concerned with unemployment or urban-rural policy desire more detailed regional results. Thirdly, environmental issues, such as turning forests into farmland, call for smaller regions that can allow for natural boundaries to be mapped more accurately. Finally, smaller regions give CGE models a greater sense of geographical realism.

2.1 Basic structure of the static IndoTERM model

Figure 6 represents the model's input-output structure[3]. The rectangles indicate matrices of flows. Core matrices contained in the database are printed in bold while other matrices may be calculated from the core matrices. The dimensions of the matrices are indicated by indices corresponding to the sets listed at top right.

The matrices on the left-hand side of the diagram resemble (for each region) a conventional single-region input-output database.[4] 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("OilPalm","dom","EdibleOil","Sumatra"): domestically-produced OilPalm used by the EdibleOil industry in Sumatra.
- USE("OilGas","dom","EXP","Kalimantan") : domestically-produced OilGas exported from a port in Kalimantan.

The TAX matrix of commodity tax revenues contains elements 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.

The MAKE matrix at the bottom of Figure 2 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 commodity *c* each region *d*.

The right hand side of Figure 6 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 add-up (over *d* in DST) of the imported part of TRADE.

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[2] IndoTERM is based on the TERM (The Enormous Regional Model) of the Australian economy.

[3] This and the next subsection draw from Horridge et al. (2003).

[4] The matrices in Figure 2 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

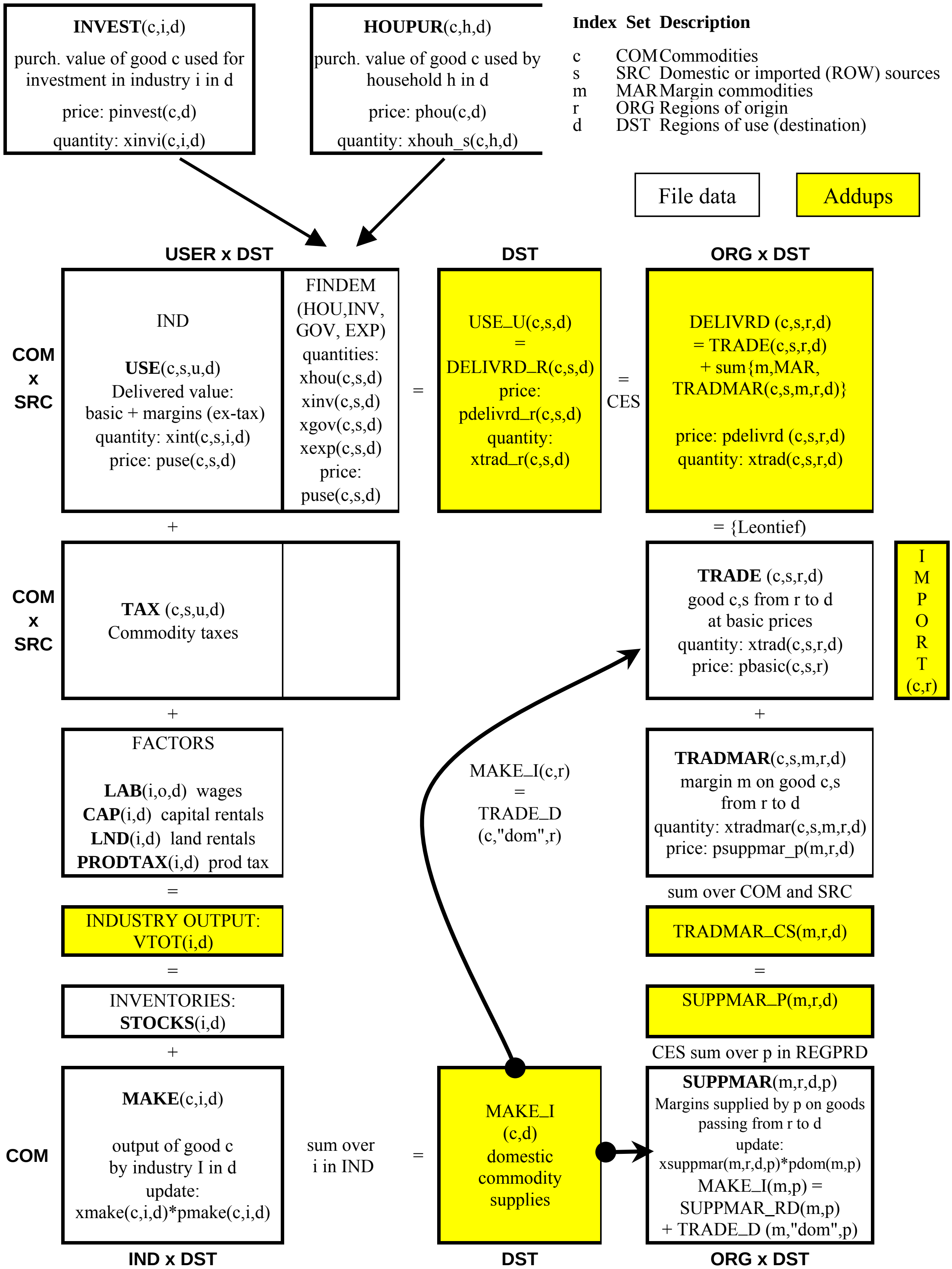

Figure 6: The INDOTERM flows database

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 Figure 2 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.

(a) At the moment, IndoTERM distinguishes only 4 final demanders in each region:

(b) HOU: the representative household

(c) INV: capital formation, distinguished by sector of use

(d) GOV: government demand

(e) EXP: export demand.

2.2 The IndoTERM sourcing mechanism

Figure 7 illustrates the details of the IndoTERM system of demand sourcing. Note that this figure covers only the demand for a single commodity (Vegetables) by a single user (Households) in a single region (Sumatra). 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 Figure 6. 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 at top right of Figure 6. Most key features of IndoTERM could be reconstructed from Figure 6 and Figure 7.

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 Figure 2).

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.

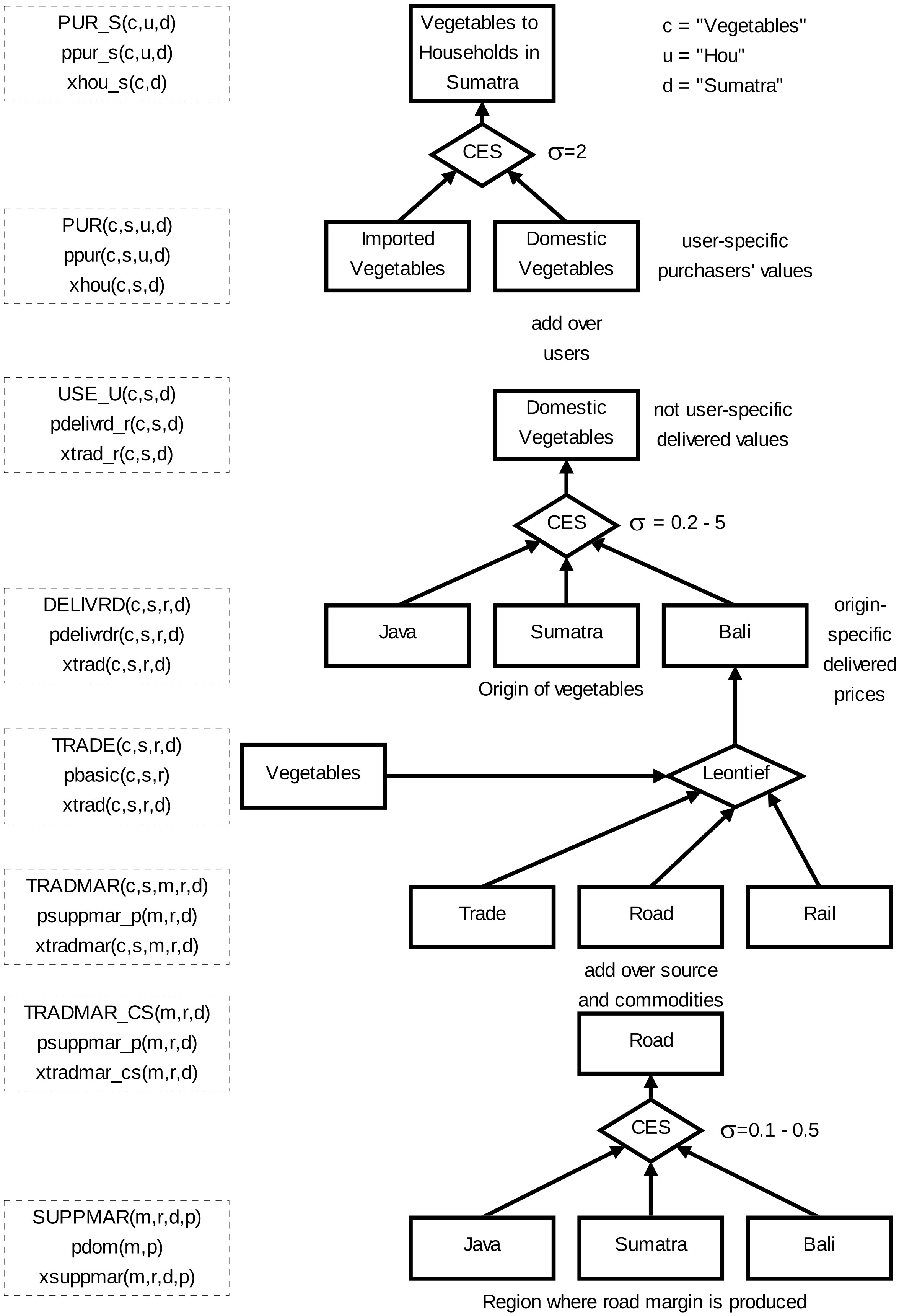

Figure 7: IndoTERM sourcing mechanisms

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 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 Sumatra, the proportion of vegetables which come from Bali is the same for households, intermediate, and all other users.

The next level shows how a "delivered" vegetable from, say, Bali, is a Leontief composite of basic vegetables 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 to Sumatra from Bali 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 (Bali), the destination (Sumatra) and regions between (Java). 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 Java in providing Road margins on trips from Bali to Sumatra, is the same whatever good is being transported.

Although not shown in Figure 7, a parallel system of sourcing is also modelled for imported vegetables, tracing them back to port of entry instead of region of production.

2.3 Dynamic equations

There are three dynamic mechanisms in IndoTERM[5]. They are:

- a stock-flow relation between investment and capital stock, which assumes a 1 year gestation lag.
- a positive relation between investment and the rate of profit.
- a relation between wage growth and employment.

For simplicity we have omitted industry and region subscripts in the details below.

2.3.1 Capital accumulation

Capital in each year grows by an amount equal to the rate of investment at the beginning of the period minus depreciation on existing capital stock.

$$K_1 = K_0+I_0-d*K_0 \qquad (E.1)$$

Thus,

$$\Delta K=I_0-d*K_0 \qquad (E.2)$$

where

K_1, K_0, ΔK is the capital stock at the end of period 1, capital stock at the start of the period and the change in capital stock respectively;

I_0 is the investment undertaken during the year;

d is the depreciation rate.

[5] This section relies on Horridge (2002).

Thus, a change in investment undertaken during year 1 affects the end-of-the-year capital stock and therefore the growth rate of capital not in this period but in the next.

Investment allocation has two parts, namely:

- investment/capital ratios are positively related to expected rates of return; and
- expected rates of return converge to actual rates of return via a partial adjustment mechanism.

We define the investment/capital ratios as:

G = XINV/XCAP (percentage change is gro=xinv – xcap) (E.3)

We define actual gross rate of return as:

R = PCAP/PINV (ordinary change Δgret = 0.01*GROR(pcap-pinv) (E.4)

where

G capital growth rate in the next period

XINV investment

XCAP capital stock

R actual gross rate of return

PCAP unit rental price of capital

PINV investment price index

E expected rate of return for the next period

Our theory that rates of growth of capital stock depend on expected rates of return may be expressed as:

$G = F(E)$ where $F_E > 0$ (E.5)

Notice that both G and R (and by extension E) must be > 0. In the case of R, this is guaranteed by other model equations — capital always earns a positive rent. For convenience, we have expressed (E.5) in terms of *gross* rather than *net* rates of growth and return.

We also hypothesize that each industry has a long-run or normal rate of return R_{normal} and that when E, the expected rate, is equal to R_{normal} then $G = G_{trend}$ where G_{trend} is a normal or secular gross growth rate. That is,

$G_{trend} = F(R_{normal})$ (E.6)

We choose a type of logistic curve for the function F:

$G = Q.G_{trend}M^{\alpha}/(Q-1+M^{\alpha})$ where (E.7)

$M = E/R_{normal}$ (E.8)

if M = 1 then $G = G_{trend}$

if M is large then $G = QG_{trend} = G_{max}$ (Q = 5 in the database)

if M is 0 then G = 0

We postulate that end-of-period expected rates of return are an average of the initial (start-of-period) expected rate and the end-of-period actual rate of return. This implies that investors are both conservative and myopic—only past and current rates of return affect the expected rate for next period.

2.3.2 Real wage adjustment mechanism

In IndoTERM we allow for real wages to adjust to employment levels as follows: If end-of-period employment exceeds some trend level by x% then real wages will rise, during the period, by γ.x%. Since employment is negatively related to real wages, this mechanism causes employment to adjust towards the trend level, which may be thought of as the level of employment corresponding to NAIRU. We write this equation as:

$$\Delta W/W_0 = \gamma[(L_0/T_0)-1] + \gamma\Delta(L/T) \qquad \text{(E.9)}$$

where

L actual employment

T trend employment

W real wage

2.4 Multi-regional database

The key sources for the IndoTERM data are the BPS 2005 Indonesian national and inter-regional input-output tables, but several other sources have been used. Although the main IndoTERM database distinguishes 33 provinces and 179 sectors, simulations with this level of detail are slow to run. Hence for the simulations reported here, the data was aggregated to 12 regions and 41 sectors. See Appendix 1 for the mapping of 175 sectors to 41 sectors.

3 Baseline and policy forecast simulations

Using a dynamic CGE model to analyse a policy requires two simulations as illustrated in Figure 8 below. The first, baseline, forecast shows the development of the economy in the absence of the policy under consideration. The second, policy, simulation includes all the features of the baseline simulation and also a once-off policy shock in 2014. The new growth path would therefore move away from the baseline, making it possible to evaluate the impact of the policy. Policy effects are reported as percent deviations from the base forecast.

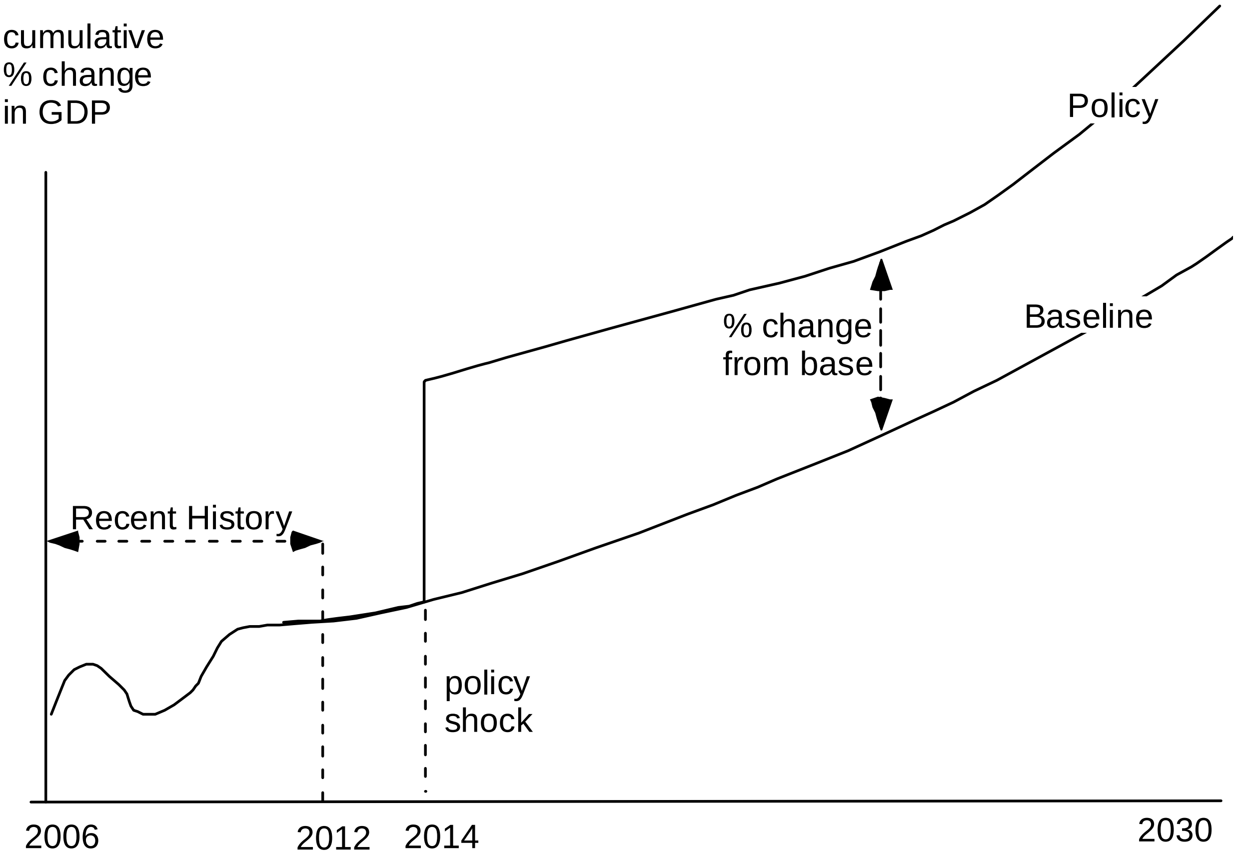

Figure 8: Baseline and policy simulations

Consistent with the picture above, the policy shock might be a 10% increase in demand (given fixed prices) for Indonesian exports in all periods after 2013. In such examples, endogenous variables tend to jump to the new level; then, after a few years of adjustment, settle down to a new path roughly parallel to that of the base forecast. Indeed, if the base forecast reflected perfect balanced growth, the new perturbed path would (after initial adjustment) be another parallel growth path, a fixed distance above (or below) the base path.

However, if the base forecast is NOT balanced growth, the perturbed path will not in general parallel the base. For example, suppose that in the base forecast the export share in GDP was growing over time. Then we should expect that percentage effect on GDP (due to the export demand increase) would also increase over time. The policy growth path would climb more steeply than the base.

3.1 Baseline forecast design

Our baseline forecast is driven by projected changes in population, labour force, productivity, and foreign demands that are roughly consistent with Indonesia's recent annual GDP growth rates of 6% p.a. We impose four sets of shocks uniformly over time:

- We assume that labour force and population grow respectively at 2.5 and 1.5 per cent p.a. over the entire simulation period. The higher growth rate for labour force reflects (a) the relative youth of

Indonesians, and (b) the idea that over time workers will migrate from informal to formal sectors, becoming more productive.

- We assume a continued increase in foreign demand for Indonesian commodities; export demand curves move to the right by 6 per cent p.a..
- We assume that labour productivity improves for all service industries by 3 per cent p.a. and for non-service industries by 6 per cent p.a..
- Shocks are imposed are imposed on the endowments and productivity of natural resources (called "Land" in the model, but including ore bodies, fish stocks, etc). These shocks differ between sectors, as shown in the table below.

Table 1: Productivity assumptions

	Labour productivity	Land productivity	Land quantity
OilPalm	6	3	3
Other Agriculture	6	3	0
OilGas	6	0	0
OtherExtractive	6	2	0
Manufacturing	6	n.a.	n.a.
Services	3	n.a.	n.a.

- Resource quantities are fixed, except that we allow oil palm land area to increase by 3% p.a. Indonesian policy is not to allocate more land to oil palm, but there are still substantial forest areas allocated for oil palm, but not yet actually converted. This (and perhaps flouting of the policy) allows palm area to rise.
- Land productivity rises by 3% p.a. in agriculture. This applies to oil palm also (although, as noted previously, historical gains have been less than this) and offers another way to increase oil palm output.
- Resource productivity in the extractive sector rises by 2% p.a., except for OilGas, which gets NO efficiency increase. This reflects our view that Indonesian oil reserves offer little scope for output increase.

The effect is that Mining and Agriculture (except OilPalm) grow more slowly than real GDP, so that shares in GDP of Manufacturing and Services increase over time. However, outputs of OilPalm and EdibleOils grow at 7.5% p.a. (which is less than recent growth rates).

3.2 Matching recent history in the base simulation?

Our initial database refers to 2005 -- some time in the past. Some macro data is available for the periods up to 2012 (which includes turbulence from the 2008 financial crisis). We attempt to incorporate this into our base forecast, so that the database for 2012 will appear more realistic.

3.2.1 How do we introduce historical data into the base forecast?

IndoTERM consists of a system of equations, where the number of variables exceeds the number of equations. The variables are divided between endogenous and exogenous variables. We can think of each equation in IndoTERM determining an endogenous variable. Variables not determined within the model are exogenous. The choice between endogenous and exogenous variables is called a closure. Natural exogenous variables include technological or behavioural parameters, tax rates and foreign prices.

We use a different closure for initial years of the baseline forecast, so that the forecast agrees either with recent historical data. Such data usually refer to naturally endogenous variables in the model. To accommodate these data, the naturally endogenous variables are swapped with naturally exogenous variables. This allows the newly exogenous variables to be shocked with the observed data. For example, we match recent actual government spending by endogenizing the (normally exogenous) ratio of government spending to GDP. The table below summarises the annual percentage change in the data imposed on macroeconomic variables.

Table 2: Percentage change in real GDP expenditure components (2006–2012)

Variable	2006	2007	2008	2009	2010	2011	2012
Gross domestic product	5.50	6.34	6.01	4.63	6.20	6.46	6.30
Real private consumption	3.17	5.01	5.34	4.86	4.74	4.71	5.28
Real gross fixed capital formation	2.60	9.32	11.89	3.29	8.48	8.82	9.76
Real public consumption	9.61	3.89	10.43	15.67	0.29	3.16	1.32
Real exports	9.41	8.54	9.53	-9.69	15.27	13.57	2.08
Real imports	8.58	9.06	10.0	-14.98	17.37	13.33	6.66

Source: Asian Development Bank (ADB).

3.3 Baseline Results

At a macro level, our simulation results show that real GDP growth slowly decelerates over the 25 year period from 6.3 per cent to 5 % p.a.. Over this period, real GDP nearly triples. This implies an average annual growth rate of 5.4 % p.a. over the period 2006 -2030. The reason for the gradual decline is that the factor share of total land increases from approximately 3.4 per cent in 2005 to 5.9 per cent in 2030. This increase in the factor share combined with the land productivity shocks partly explains this decline. Employment grows at a slower pace, at an annual average rate of 1.5 % p.a.. Recall from our baseline shocks that labour productivity in service industries, which employs approximately 56 per cent of those employed, increases by less that the productivity in non-service industries, which employs 44 per cent of all labour. The factor share of labour falls from 48 per cent in 2005 to 45.7 per cent in 2030. The capital stock grows at an annual average rate of about 5.5 % p.a.. The capital share in total factor use remains constant over the simulation period. Taken together, movements in these factors account for approximately 3.3 per cent of the annual average GDP growth (0.45*1.5+0.48*5.5=3.3). The remainder of GDP growth comes from technical progress and indirect taxes.

Table 3: Macro results - annual per cent growth rates

		2010	2015	2020	2025	2030	Average
1	GDP	5.95	5.44	5.20	5.06	4.98	5.4
2	Employment	1.76	1.28	1.32	1.38	1.41	1.5
3	Capital	6.22	5.73	5.26	5.01	4.89	5.5
4	Consumption	6.08	5.73	5.42	5.21	5.09	5.6
5	Investment	5.63	4.62	4.55	4.65	4.72	4.9
6	Public spending	5.99	5.67	5.37	5.17	5.05	5.5
7	Exports	5.73	5.40	5.34	5.31	5.33	5.5
8	Imports	5.76	5.49	5.46	5.47	5.50	5.6

Source: Model results

Over the simulation period there is very little change in the share of the expenditure components in GDP. There is a slight change in the share of investment and public spending between 2005 and 2030. The investment share falls slightly from 21.8 per cent to 20.2 per cent and the share of public spending increases from 7.1 to 8.9 per cent. All the expenditure components show strong annual average growth, similar to that of GDP growth.

As the economy grows, so too do all sectors in all regions, but at different rates. The Oil and Gas industry shows the lowest growth rates, averaging 0.5 per cent over the period 2006-2030. The main reason for the poor growth is that we assumed that oil extraction capacity was fixed. Less than 10 per cent of this industry's factor cost is labour, and therefore it does benefit from labour productivity. The oil and gas industry is followed by the Coal, Fishing, Forestry and Other mining industries that are also resource-constrained industries but they benefit from both the labour and land productivity improvement. The average growth rates of these industries range between 3.5 and 4.4 per cent. The industries that performed the best are EstateCrops and OilPalm with annual average growth rates of 9.4 and 8.3 per cent respectively. These industries are also land-using industries, but their share of labour in total factor cost is more than 75 per cent. Hence, they benefit from both labour and land productivity increases. Industries that use agricultural output as an intermediate input closely follow the output change of their primary input. For example, the EdibleOil industry is the third fastest growing industry with an annual average growth rate of 8.3 per cent. A large input to this industry is OilPalm which grows strongly throughout the simulation period.

Table 4: Regional results- annual per cent growth rates

	2010	2015	2020	2025	2030	Average
Sumatra	5.57	5.18	5.09	5.05	4.98	5.26
Java	6.33	5.76	5.39	5.19	5.10	5.66
Kalimantan	5.24	4.81	4.73	4.75	4.75	4.94
Sulawesi	5.89	5.40	5.19	4.98	4.79	5.39
BaliTeng	5.42	4.78	4.71	4.64	4.47	4.95
PapuaMaluku	4.16	3.58	3.87	3.73	3.45	3.93

The percentage change in output by region is presented in Table 4. Our simulation results show that Java grows that fastest at an annual average of 5.66 % p.a. and PapuaMaluku region the lowest at an annual average of 3.9 % p.a.. The lower growth in the PapuaMaluku region is because they mainly produce output that does not benefit greatly from the productivity improvement. These industries include Coal and Other mining industries. Java grows the most over the period because this region hosts the majority of manufacturing and service industries. These industries show strong growth over the simulation period.

3.4 Simulation Scenarios

In the base scenario oilpalm grows around 8% pa, or 660% between 2006 and 2030. OilPalm is not exported directly, but passes through OilAndFat sector. In both base and policy scenarios, all Agricultural [including OilPalm] land usages are held fixed, and land productivity grows 6% pa. In the policy scenario, OilAndFat exports are frozen in 2016, leading to OilPalm output growing at only 3% thereafter (serving growing domestic market).

4 Results and Discussion

[incomplete]

In the base scenario real Indonesian GDP grows 292% between 2006 and 2030. In the policy scenario real Indonesian GDP grows 289% between 2006 and 2030, ie, around 1% below base level in 2030.

Regional effects are more noticeable -- growth rates of SumUt, SumSel, Kalbar, KalTeng down by 0.5 to 1% pa (from around 5% pa). Because labor relocates, some other regions do better.

4 Concluding remarks

In this paper we use a dynamic multi-regional model (IndoTERM) for Indonesia to construct a baseline simulation for the period 2006 - 2030. The baseline simulation reflects the business-as-usual scenario in the absence of a specific policy change under consideration. To create this baseline, we impose on IndoTERM our judgement about the future economic growth in Indonesia. We introduce four sets of shocks. These shocks include labour and land productivity improvements, labour force and population growth and finally, shocks relates to foreign demand for Indonesian commodities.

The objective of this paper is to explore the regional economic and emissions implication of various relevant scenario of oil palm development in Indonesia toward 2020. Using a dynamic multi-regional CGE model for Indonesia, IndoTERM, we simulate various relevant scenario of oil palm development toward 2030. The BAU scenario includes continued forestclearing. We also simulate a freeze on conversion of forest to oil palm plantations from 2014, leading to OilPalm output growing at only 3% thereafter (serving growing domestic market). Growth rates of SumUt, SumSel, Kalbar, KalTeng down by 0.5 to 1% pa (from around 5% pa). This lower growth rate derives from labor relocation and some other regions do better.

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Appendix 1: Mapping of 175 sectors to 41 sectors

	41 Sectors	175 Sectors
1	Paddy	Paddy
2	Crops	Maize, Cassava, SweetPotatos, OthRootCrops, Groundnut, Soybean, OtherBeans, Vegetables, Fruits, CerOthFoodCr
3	EstateCrops	Rubber, Sugarcane, Coconut, FibreCrops, Tobacco, Coffee, Tea, Clove, Cocao, Cashew, OthEstateCrp, OthAgric
4	OilPalm	OilPalm
5	Animals	Livestock, FreshMilk, PoultryPrd, OthLivestock
6	Forestry	Wood, OthForest
7	Fishing	SeaFish, InlandFish, Shrimp
8	Coal	Coal
9	OilGas	CrudeOil, NaturalGas
10	OtherMining	TinOre, NickleOrem BauziteOre, CopperOre, GoldOre, SilverOre, IronOre, OthMining, NMetalMinral, CrudeSalt, Quarrying
11	FoodProds	Meat, ProcessMeat, DairyPrds, CanFruitVeg, Copra, Rice, WheatFlour, OthFlour, BakeryPrds, Noodles, Sugar, PeeledGrain, Confectionry, ProcCoffee, ProcTea, SoyaBeanPrds, OthFoods, AnimalFeed, AlcoBeverage, SoftDrinks, TobaccoPrds, Cigarettes
12	FishProds	SaltDryFish, ProcFish
13	EdibleOil	EdibleOil
14	Textiles	Kapok, Yarn, Textile, NCloTextPrd, KnittingMill, CarpetRope, Clothing
15	Shoes	Leather, LeatherPrds, Footwear
16	WoodPrd	Swamill, Plywood, WoodBldngPrd, WoodFurnture, OthWoodPrd, NonPlasticr
17	PaperPrd	Pulp, PaperCard, PaperPrds, PrintPublish
18	Chemicals	BascChemical, Fertilizer, Pesticides, PlasticsFibre, Paints, Drugs, NativeMedicn, Soaps, Cosmetics, OthChemicals
19	PetrolRefin	PetrolRefPrd, LNG
20	RubbrPlastic	SmokedRubber, Tires, OthRubberPrd, PlasticPrd
21	OthManufact	Ceramics, GlassPrd, ClayCerStruc, OthNonFerPrd, OthNonFerPrd, ScientifEqup, Jewellery, MusicalInst, SportGoods, OthManufact
22	Cement	Cement
23	BasicMetals	BasicFerrous, BasFerrPrd, BasicNonFerr, BasNonFerrPr
24	FabMetalPrd	ToolsCutlery, MtlFurniture, StructMetlPr, OthMetalPrds
25	Machines	Engines, MachineryApp, ElecGenMotor, ElecMachiner, CommunicEqup, HholdElecApp, OthElecApp, Battery
26	TranspEquip	Ships, Trains, MotorVehicle, MotorCycle, OthTransEqup, Aircraft
27	ElecGas	ElecGasSupp
28	Water	WaterSupply
29	Construction	Building, AgrConstruct, PublicWorks, ConstUtilsCo, OthConstruct
30	Trade	Trade, MotorRepairs
31	RestrntHotel	Restaurant, Hotel
32	RailTrans	RailTrans
33	RoadTrans	RoadTrans
34	WaterTrans	SeaTrans, RiverTrans
35	AirTrans	AirTrans
36	TransSvc	TransSvc
37	Communicaton	Communicaton
38	Finance	AgricSvc, Banking, OthFinance, Insurance, BusinessSvc
39	RealEstateDo	RealEstateDo
40	GovServices	GeneralGov, GovEducSvc, GovHealthSvc, OthGovSvc
41	OthServices	PrivatEducat, PrivatHealth, OthPrCommun, Films, RecCultSvcPr, PerHousSvc, OthGoodsSvc