Impact of Global Crude Oil Price Shocks on Indonesia Economy **- a CGE Analysis**

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Outline

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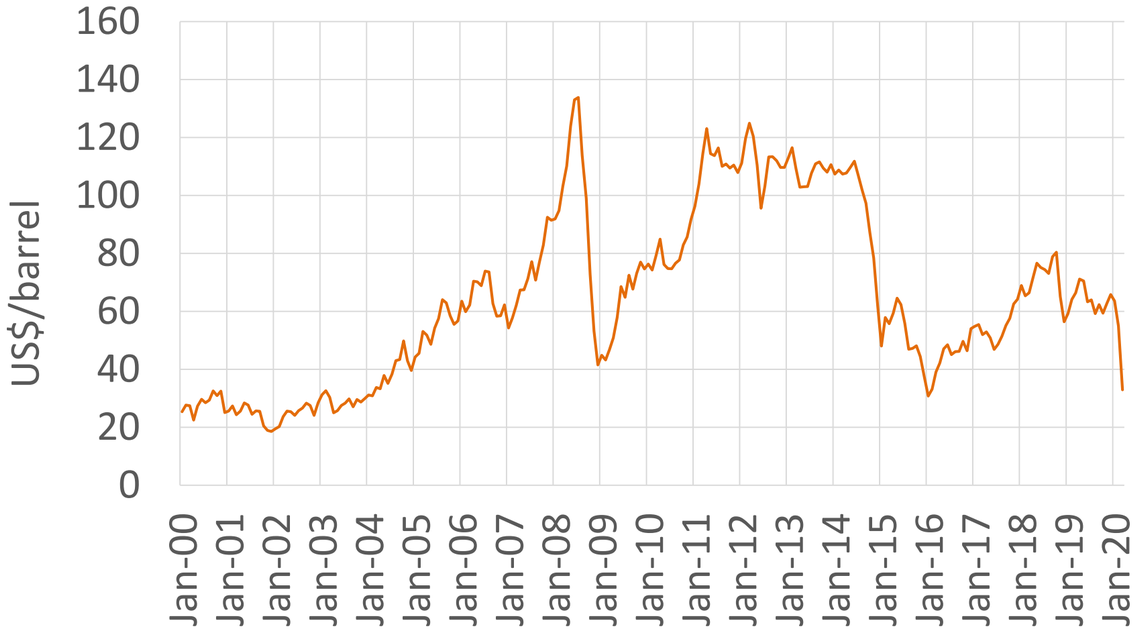
Introduction

Global crude oil price volatility overview:



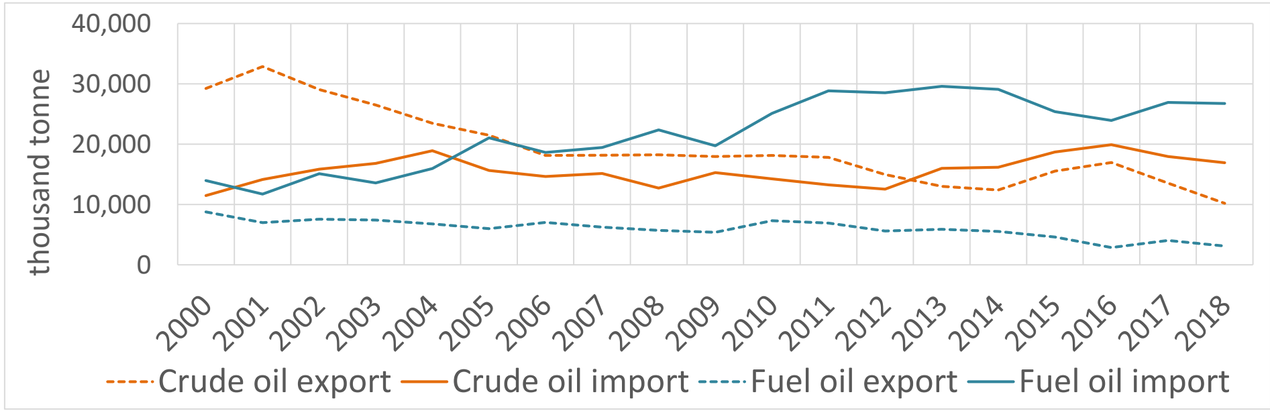
Dated Brent, Source: IndexMundi, 2020

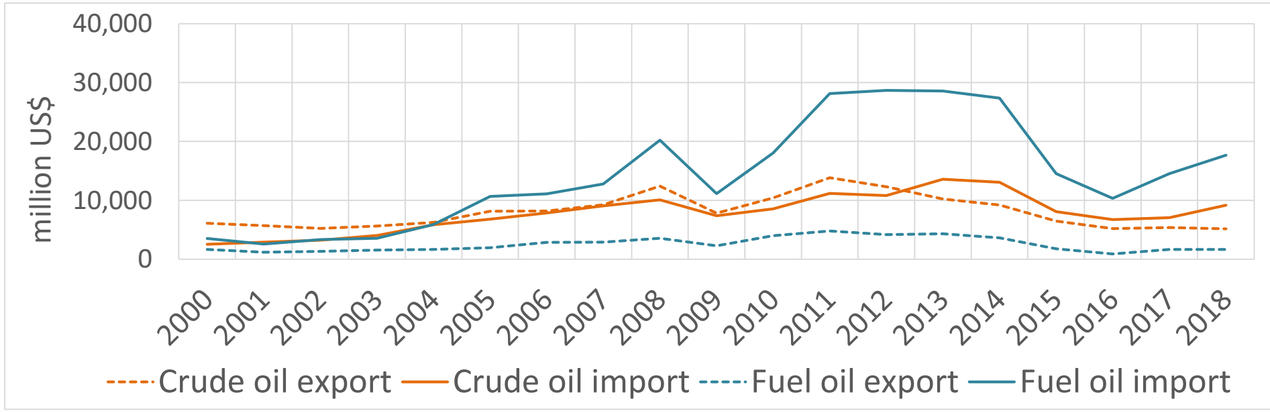
Several factors:

market mechanism, crisis incidents, high levels of oil production countries (OPEC), geopolitics

Role of crude oil commodities in Indonesia:

portion of the petroleum in primary energy consumption (own calculation from BP, 2019 data) in 2018:
Indonesia = 44.96% ; world = 33.62% ; APAC = 28.32%





Source: BPS, 2018

Theoretical Framework

Main concept and theory:
Based on Kilian (2014), effects of an exogenous global crude oil prices (p^{W}_{OIL}) shock on real GDP:

- **Direct effects**:
  1. Supply channel of transmission
     $\downarrow p^{W}_{OIL} \rightarrow \downarrow$ cost of producing domestic output (terms-of-trade shocks);
  2. Demand channel of transmission
     $\downarrow p^{W}_{OIL} \rightarrow \uparrow$ purchasing power of domestic households & firms;

  both causing economic expansion.
- **Indirect effects**:
  1. Reallocation effects: sectoral shift;
  2. Uncertainty effects: delay investments;

  asymmetric effects.

Literature review on the impact of crude oil price shocks to the country economy:

- Econometrics model: VAR linear or non-linear models (asymmetric/structural)
- **Computable General Equilibrium (CGE)**
  - GE → entire economy with many interacting markets (Léon Walras)
  - based on microeconomic theory
  - discuss efficiency of resource allocation or trade-off issue

  \+ relatively small data
  \+ allows static & dynamic data
  \+ mainly focuses on real side of economy

Theoretical Framework

Indonesia CGE model:
start 1980's, WAYANG (1999), Indonesia-E3 (2008), INDOFISCAL (2011), CGE Fiscal 4.0 (2018), etc.

Literature review on the impact of crude oil price shocks to **Indonesia** using **CGE**:

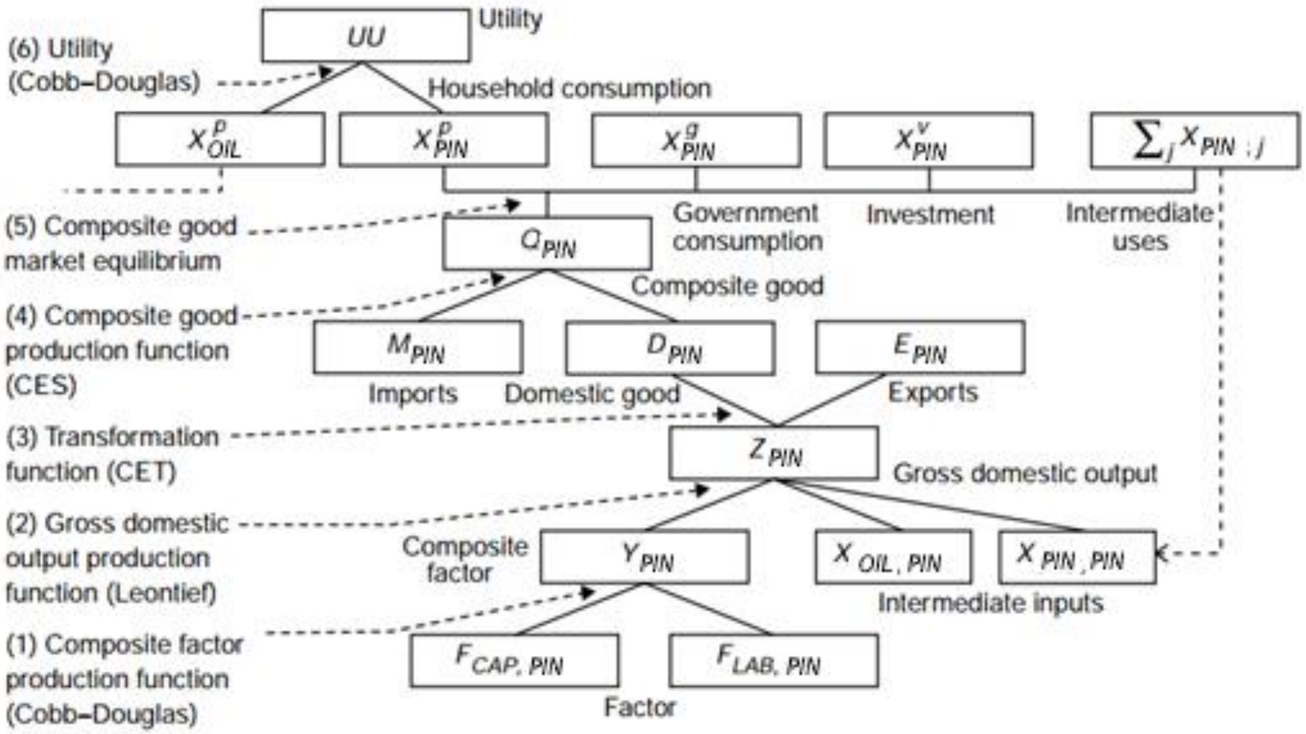
- Ezaki (1989), crude oil price shock decline in 1980 and 1985 → negative impact (wholly dependent on the crude oil)
- Asmara - Oktaviani - Kuntjoro - Firdaus (2011), volatility → contraction effect

Hypothesis

- if Indonesia is a net exporter of crude oil, Indonesia will get disadvantages of the fall in global crude oil prices shocks; or
- if Indonesia is a net importer of crude oil, Indonesia will get advantages of the fall in global crude oil prices shocks.

Data & Methodology

‘Standard CGE model’
follows Hosoe et al. (2010)



set of equations: 23 equations

Data: Input-Output table

- Indonesia IO table 2010 published by BPS-Statistics Indonesia
- 185 products aggregated → 8 products

SAM (Social Accounting Matrix) construction

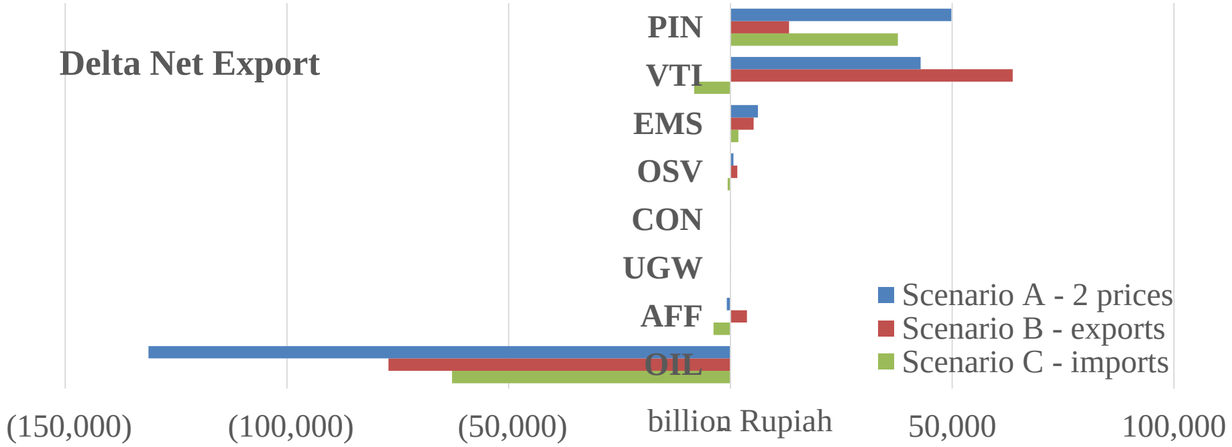
- row-sum and column-sum equality rule
- extra data from national account tables

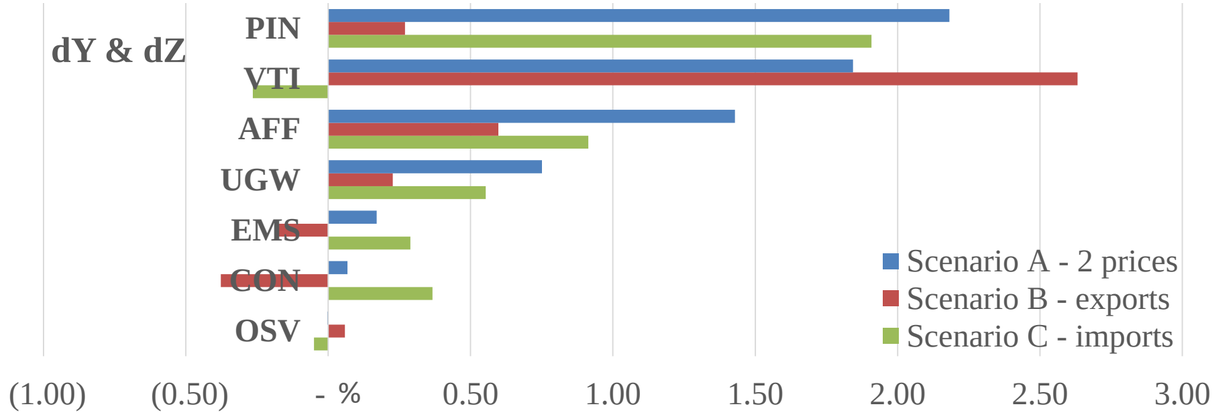
CGE model simulation using GAMS IDE

- calibration: estimate parameter
- optimization of non-linear programming (NLP)
- compare base run & counterfactual equilibrium → level of change in welfare
- 3 scenarios: crude oil price reduced by 30%
  - Scenario A - 2 price
  - Scenario B - exports
  - Scenario C - imports

Result, Discussion & Conclusions

Simulation results and interpretation





Hicksian EV: Scenario A: 11,005 ;
Scenario B: -9,189 ; Scenario C: 18,087

Discussion

- Indonesia benefits from ↓ p^{W}_{OIL}
- imports prices and activities are influential
- processing industry (PIN) & vehicle trade, transportation and warehousing, accommodation, food and beverage, information and communication services (VTI) sectors are the 2 sectors most affected

Suggestions for further research

detail of sectors, recent data, division of variables

Conclusions

↓ p^{W}_{OIL} → Indonesia got advantages, although as net exporter; fit in with direct effects theory

Thank you.

Köszönöm.
Terima kasih.

Indonesia Offshore Oil & Gas Rig

References:

Thesis references on ppt slide:

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- Hosoe, N. - Gasawa, K. - Hashimoto, H. (eds., 2010): *Textbook of computable general equilibrium modelling: programming and simulations*. Palgrave Macmillan.
- IndexMundi. (2020): *Crude oil (petroleum): 'Dated Brent' Monthly Price (US$ per barrel) 2000-2019*.
- Kilian, L. (2014): *Oil Price Shocks: Causes and Consequences*. Annual Review of Resource Economics, Vol. 6, pp. 133–154.

Cover & closing slide images sources:

- https://www.gettyimages.com/
- https://www.pngegg.com/en/png-zlrlm
- http://phe.pertamina.com/

Extra Slides

Table 3. Indonesia 2010 Social Accounting Matrix (SAM) constructed, in billion Rupiah

	AFF	OIL	EMS	PIN	UGW	CON	VTI	OSV	CAP	LAB	IDT	HOH	GOV	INV	EXT
AFF	64,002	-	77	697,881	-	37,162	81,724	14,110				393,323	-	156,249	38,317
OIL	-	16,337	13,900	193,044	69	10	87	168				-	-	3,735	101,182
EMS	3	23,352	46,609	244,971	38,301	85,320	136	1,377				-	-	8,884	301,574
PIN	99,971	7,951	54,082	1,460,592	47,165	899,197	599,266	235,701				1,962,103	15,154	447,763	1,081,838
UGW	543	1,368	484	49,165	145,355	3,798	21,380	10,788				54,048	228	57	592
CON	22,721	6,578	15,921	9,269	521	8,604	45,373	44,336				-	-	1,600,541	4,696
VTI	4,258	5,545	14,543	85,588	3,552	48,450	220,081	155,738				811,469	221	9,842	1,528,924
OSV	17,695	18,015	26,507	77,654	6,184	48,310	177,198	167,353				637,879	602,575	29,864	49,042
CAP	724,052	151,748	418,485	1,066,983	70,777	351,335	1,118,344	554,375							
LAB	246,581	18,280	95,450	472,878	20,745	237,196	494,084	584,862							
IDT	8,325	1,536	6,459	195,191	(50,977)	33,778	25,813	17,833							
HOH									4,456,099	2,170,076					
GOV											237,958	385,626			
INV												2,381,727	5,406		(130,198)
EXT	294,694	77,822	58,010	2,357,567	6,114	5,400	104,725	71,635							

Notes:

- AFF : Agriculture, forestry, and fisheries
- OIL : Crude oil
- EMS : Other energy & minerals commodities, and mining services
- PIN : Processing industry
- UGW : Utilities: electricity, natural/artificial gas products, steam / hot water supply, cold air & ice products, water supply, waste management & recycling
- CON : Construction
- VTI : Vehicle trade, transportation & warehousing, accommodation, food & beverage, information & communication services
- OSV : Financial, insurance, real estate, corporate, government, education, health, social, and other services
- CAP : Capital factor
- LAB : Labor factor
- IDT : Indirect tax
- HOH : Household
- GOV : Government
- INV : Investment
- EXT : External (import & export)

Extra Slides

Table 4. Percentage change of several Indonesian sector variables based on the counter-factual run (30% fall global crude oil price) Scenario A - 2 prices compared to base run simulation in %

		AFF	OIL	EMS	PIN	UGW	CON	VTI	OSV
ΔY (dY)		1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
ΔF (dF)	CAP	1.704	-46.518	0.369	2.518	0.995	0.5	2.177	0.547
	LAB	0.624	-47.087	-0.697	1.428	-0.078	-0.568	1.091	-0.521
ΔX (dX)	AFF	1.429		0.17	2.182		0.068	1.843	-0.003
	OIL		-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	EMS	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	PIN	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	UGW	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	CON	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	VTI	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
	OSV	1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
ΔZ (dZ)		1.429	-46.58	0.17	2.182	0.751	0.068	1.843	-0.003
ΔX_p (dXp)		0.029			0.313	0.269		0.594	-0.032
ΔX_g (dXg)					0.771	0.727		1.053	0.424
ΔX_v (dXv)		0.013	7.43	0.685	0.297	0.252	0.173	0.578	-0.048
ΔE (dE)		2.237	-73.291	1.462	3.782	1.921	1.046	2.725	0.536
ΔM (dM)		0.574	73.331	-3.075	-0.378	-0.41	-0.906	-1.16	-0.569
ΔQ (dQ)		1.233	-1.361	-1.123	0.845	0.724	0.063	0.615	-0.04
ΔD (dD)		1.402	-31.959	-0.832	1.681	0.749	0.066	0.764	-0.018
Δp_y (dpy)		-0.794	-0.949	-0.866	-0.737	-0.823	-0.636	-0.738	-0.518
Δp_z (dpz)		-0.813	-1.417	-1.055	-1.189	-0.991	-0.902	-0.847	-0.686
Δp_q (dpq)		-0.743	-7.596	-1.406	-1.024	-0.981	-0.902	-1.301	-0.683
Δp_e (dpe)		-0.419	-30.293	-0.419	-0.419	-0.419	-0.419	-0.419	-0.419
Δp_m (dpm)		-0.419	-30.293	-0.419	-0.419	-0.419	-0.419	-0.419	-0.419
Δp_d (dpd)		-0.826	11.258	-1.551	-1.432	-0.993	-0.903	-1.374	-0.693
ΔT_z (dTz)		0.604	-47.337	-0.886	0.967	-0.248	-0.834	0.981	-0.689

Table 5. Net export volume change of several Indonesian sector variables based on Scenario A - 2 price simulation in billion Rupiah

		AFF	OIL	EMS	PIN	UGW	CON	VTI	OSV
base-run	E	38,317	101,182	301,574	1,081,838	592	4,696	1,528,924	49,042
	M	294,694	77,822	58,010	2,357,567	6,114	5,400	104,725	71,635
	net E	(256,377)	23,360	243,564	(1,275,729)	(5,522)	(704)	1,424,199	(22,593)
counter-factual run	E	39,174	27,025	305,983	1,122,753	603	4,745	1,570,587	49,305
	M	296,386	134,890	56,226	2,348,655	6,089	5,351	103,510	71,227
	net E	(257,211)	(107,865)	249,757	(1,225,902)	(5,486)	(606)	1,467,077	(21,923)
delta net E		(834)	(131,225)	6,193	49,827	36	98	42,878	670

Scenario A – 2 prices

Table 6. Percentage change of several variables based on a counter-factual run (30% fall global crude oil price) compared to base run simulation

Δε (depsilon)		-0.419
ΔT_d (dTd)		-0.715
Δp_f (dpf)	CAP	-1.063
ΔS_p (dSp)		-0.715
ΔS_g (dSg)		-0.261
UU_0		1,092,518
ep_0		3,858,822
ep_1		3,869,827
EV		11,005

Scenario B - exports

Δε (depsilon)		0.309
ΔT_d (dTd)		-0.466
Δp_f (dpf)	CAP	-0.693
ΔS_p (dSp)		-0.466
ΔS_g (dSg)		-0.166
UU_0		1,092,518
ep_0		3,858,822
ep_1		3,849,633
EV		-9,189

Scenario C - imports

Δε (depsilon)		-0.657
ΔT_d (dTd)		-0.332
Δp_f (dpf)	CAP	-0.494
ΔS_p (dSp)		-0.332
ΔS_g (dSg)		-0.129
UU_0		1,092,518
ep_0		3,858,822
ep_1		3,876,910
EV		18,087

$$EV = ep(p^{q0}, UU^1) - ep(p^{q0}, UU^0)$$

Extra Slides

Set of equations:

- Domestic production:

$$Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \quad \forall j \quad \dots (1)$$

$$F_{h,j} = \frac{\beta_{h,j} p_j^y}{p_h^f} Y_j \quad \forall h, j \quad \dots (2)$$

$$X_{i,j} = ax_{i,j} Z_j \quad \forall i, j \quad \dots (3)$$

$$Y_j = ay_j Z_j \quad \forall j \quad \dots (4)$$

$$p_j^z = ay_j p_j^y + \sum_i ax_{i,j} p_i^q \quad \forall j \quad \dots (5)$$

- Government:

$$T^d = \tau^d \sum_h p_h^f FF_h \quad \dots (6)$$

$$T_j^z = \tau_j^z p_j^z Z_j \quad \forall j \quad \dots (7)$$

$$X_i^g = \frac{\mu_i}{p_i^q} \left(T^d + \sum_j T_j^z - S^g \right) \quad \forall i \quad \dots (8)$$

- Investment and savings:

$$X_i^v = \frac{\lambda_i}{p_i^q} (S^p + S^g + \varepsilon S^f) \quad \forall i \quad \dots (9)$$

$$S^p = ss^p \sum_h p_h^f FF_h \quad \dots (10)$$

$$S^g = ss^g \left(T^d + \sum_j T_j^z \right) \quad \dots (11)$$

- Household:

$$X_i^p = \frac{\alpha_i}{p_i^q} \left(\sum_h p_h^f FF_h - S^p - T^d \right) \quad \forall i \quad \dots (12)$$

- Export and import prices and the balance of payment constraint:

$$p_i^e = \varepsilon p_i^{We} \quad \forall i \quad \dots (13)$$

$$p_i^m = \varepsilon p_i^{Wm} \quad \forall i \quad \dots (14)$$

$$\sum_h p_i^{We} E_i + S^f = \sum_h p_i^{Wm} M_i \quad \dots (15)$$

- Substitution between imports and domestic goods (Armington composite):

$$Q_i = \gamma_i \left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i} \right)^{\frac{1}{\eta_i}} \quad \forall i \quad \dots (16)$$

$$M_i = \left[\frac{\gamma_i^{\eta_i} \delta m_i p_i^q}{p_i^m} \right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \quad \dots (17)$$

$$D_i = \left[\frac{\gamma_i^{\eta_i} \delta d_i p_i^q}{p_i^d} \right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \quad \dots (18)$$

- The transformation between exports and domestic goods:

$$Z_i = \theta_i \left(\xi e_i E_i^{\varphi_i} + \xi d_i D_i^{\varphi_i} \right)^{\frac{1}{\varphi_i}} \quad \forall i \quad \dots (19)$$

$$E_i = \left[\frac{\theta_i^{\varphi_i} \xi e_i (1 + \tau_i^z) p_i^z}{p_i^e} \right]^{\frac{1}{1-\varphi_i}} Z_i \quad \forall i \quad \dots (20)$$

$$D_i = \left[\frac{\theta_i^{\varphi_i} \xi d_i (1 + \tau_i^z) p_i^z}{p_i^d} \right]^{\frac{1}{1-\varphi_i}} Z_i \quad \forall i \quad \dots (21)$$

- Market-clearing conditions:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{i,j} \quad \forall i \quad \dots (22)$$

$$\sum_j F_{h,j} = FF_h \quad \forall h \quad \dots (23)$$

Extra Slides

GAMS syntax preview:

File Edit Search Windows Utilities Model Libraries Help

INA-en_scenA HadiPrasojo.gms

```
$title Indonesia-Energy Standard CGE Model
$onText
Make an Indonesia-Energy Standard CGE Model
based on Chapter 6 of Hosoe, N, Gasawa, K, and Hashimoto, H
Handbook of Computible General Equilibrium Modeling
University of Tokyo Press, Tokyo, Japan, 2004
SAM in billion Rupiah unit
$offText

Set
   u    'SAM entry' / AFF, OIL, EMS, PIN, UGW, CON, VTI, OSV, CAP, LAB, IDT, HOH, GOV, INV, EXT /
   i(u) 'goods'     / AFF, OIL, EMS, PIN, UGW, CON, VTI, OSV                                    /
   h(u) 'factor'    /                                  CAP, LAB                                 /;

Alias (u,v), (i,j), (h,k);

Table SAM(u,v) 'social accounting matrix'
          AFF      OIL      EMS      PIN      UGW      CON      VTI      OSV      CAP      LAB      IDT      HOH      GOV      INV      EXT
   AFF    64002        0       77   697881        0    37162    81724    14110                                 393323        0   156249    38317
   OIL        0    16337    13900   193044       69       10       87      168                                      0        0     3735   101182
   EMS        3    23352    46609   244971    38301    85320      136     1377                                      0        0     8884   301574
   PIN    99971     7951    54082  1460592    47165   899197   599266   235701                                1962103    15154   447763  1081838
   UGW      543     1368      484    49165   145355     3798    21380    10788                                  54048      228       57      592
   CON    22721     6578    15921     9269      521     8604    45373    44336                                      0        0  1600541     4696
   VTI     4258     5545    14543    85588     3552    48450   220081   155738                                 811469      221     9842  1528924
   OSV    17695    18015    26507    77654     6184    48310   177198   167353                                 637879   602575    29864    49042
   CAP   724052   151748   418485  1066983    70777   351335  1118344   554375
   LAB   246581    18280    95450   472878    20745   237196   494084   584862
   IDT     8325     1536     6459   195191   -50977    33778    25813    17833
   HOH                                                                            4456099  2170076
   GOV                                                                                      237958   385626
   INV                                                                                             2381727     5406          -130198
   EXT   294694    77822    58010  2357567     6114     5400   104725    71635                                                        ;
```

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INA-en_scenA HadiPrasojo.gms

```
Parameter
   alpha(i)  'share parameter in utility func.'
   beta(h,j) 'share parameter in production func.'
   b(j)      'scale parameter in production func.'
   ax(i,j)   'intermediate input requirement coeff.'
   ay(j)     'composite fact. input req. coeff.'
   mu(i)     'government consumption share'
   lambda(i) 'investment demand share'
   deltam(i) 'share par. in Armington func.'
   deltad(i) 'share par. in Armington func.'
   gamma(i)  'scale par. in Armington func.'
   xid(i)    'share par. in transformation func.'
   xie(i)    'share par. in transformation func.'
   theta(i)  'scale par. in transformation func.'
   ssp       'average propensity for private saving'
   ssg       'average propensity for gov. saving'
   taud      'direct tax rate';

alpha(i)  = Xp0(i)/sum(j, Xp0(j));
beta(h,j) = F0(h,j)/sum(k, F0(k,j));
b(j)      = Y0(j)/prod(h, F0(h,j)**beta(h,j));
ax(i,j)   = X0(i,j)/Z0(j);
ay(j)     = Y0(j)/Z0(j);
mu(i)     = Xg0(i)/sum(j, Xg0(j));
lambda(i) = Xv0(i)/(Sp0+Sg0+Sf);
deltam(i) = M0(i)**(1-eta(i))/(M0(i)**(1-eta(i)) + D0(i)**(1-eta(i)));
deltad(i) = D0(i)**(1-eta(i))/(M0(i)**(1-eta(i)) + D0(i)**(1-eta(i)));
gamma(i)  = Q0(i)/(deltam(i)*M0(i)**eta(i)+deltad(i)*D0(i)**eta(i))**(1/eta(i));
xie(i)    = E0(i)**(1-phi(i))/(E0(i)**(1-phi(i))+D0(i)**(1-phi(i)));
xid(i)    = D0(i)**(1-phi(i))/(E0(i)**(1-phi(i))+D0(i)**(1-phi(i)));
theta(i)  = Z0(i)/(xie(i)*E0(i)**phi(i)+xid(i)*D0(i)**phi(i))**(1/phi(i));
ssp       = Sp0/sum(h, FF(h));
ssg       = Sg0/(Td0+sum(j, Tz0(j)));
taud      = Td0/sum(h, FF(h));
```