World Bank and TGO

Guide to the economics of the E3-Thailand model

Project: Impacts of carbon pricing instruments on national economy and contribution to NDC – Thailand

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Introduction to the E3-Thailand model

- An advanced software tool that can be used to assess energy-environment-economy linkages in Thailand
- The model consists of collections of stochastic behavioural equations and accounting identities
- Based on an accounting framework and designed for projections for business and policy analysis

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E3-Thailand Key Features

Detailed Coverage

- 70+ economic sectors and 35+ consumption categories
- 24 fuel users of 5 fuels

Comprehensive

- whole energy, environment and economy system
- two way feedbacks between each module
- many policy instruments

Highly Empirical

- 1970-2016 database
- 16 stochastic equations
- relationships validated from data
- econometrics allows for short-medium and long term analysis

Consistent

- based on system of national accounting
- input-output tables

Forward Looking

- annual projections to 2040
- behavioural equations with effects from previous outcomes
- ex-ante scenario analysis (ex-post is also feasible)

Modular

- E3: Energy, Environment, and Economy modules
- power generation sub-module*
- research can be decentralised

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Features of the E3-Thailand model

- Structural
  - disaggregation of variables
- Organized around a Social Accounting Matrix
  - i.e. on accounting principles, e.g. System of National Accounts
- Dynamic
  - behavioural equations with effects from previous outcomes: i.e. history matters
- Estimated on cross-section & time-series data
  - identifies current-year responses and long-term trends
  - allows sectoral and regional differences

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Feature of the E3-Thailand model (cont)

- Open as regards economic policy, i.e. no assumptions of full employment, budget balance, or balance of payments equilibrium
- “Scenario” approach:
  - computation of many scenarios with comparisons of policy packages and provides quantified explanation of results
- Treatment of uncertainty
  - in parameter estimates (econometric estimation of error distribution)
  - in assumptions and policies (by scenario analysis)

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Theoretical background

- institutional behaviour (e.g. of an industry) is specific to a region over a time period
- demand-led: consumer demand made effective by income
- production assumed to be in conditions of uncertainty, institutional rules, imperfect competition and variable returns to scale
- demands for labour, investment, energy in production process are derived indirectly from consumers' demand

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CGE

- perfect competition
- constant returns to scale
- equilibrium solution
- full employment
- projection based on one year's data
- guess-estimated parameters

E3-Thailand

- varying competition
- varying returns to scale
- demand driven
- unemployment
- projection based on 40+years' data
- parameters validated from history

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The stochastic equation sets

	Short Name	Description
1	BFR0	Aggregate Energy Demand
2	BFRC	Coal Demand
3	BFRO	Heavy Oil Demand
4	BFRG	Natural Gas Demand
5	BFRE	Electricity Demand
6	BRSC	Aggregate Consumption
7	BCR	Disaggregate Consumption
8	BKR	Industrial Investment
9	BQRM	Imports
10	BQRX	Exports
11	BPYH	Industrial Prices
12	BPQX	Export Prices
13	BPQM	Import Prices
14	BYRE	Industrial Employment
15	BYRW	Industrial Average Earnings
16	BLRP	Labour Participation Rate

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Example of stochastic equations in the model

Table C.14: Employment equations

Co-integrating long-term equation:

LN(YRE(.))			[total employment]
	=	BYRE(.,6)	
	+	BYRE(.,7) * LN(YR(.))	[real output]
	+	BYRE(.,8) * LN(LYLC(.))	[real wage costs]
	+	ECM	[error]

Dynamic equation:

DLN(YRE(.))			[change in total employment]
	=	BYRE(,.1)	
	+	BYRE(,.2) * DLN(YR(.))	[real output]
	+	BYRE(,.3) * DLN(LYLC(.))	[real wage costs]
	+	BYRE(,.4) * DLN(YRE)(-1)	[lagged change in employment]
	+	BYRE(,.5) * ECM(-1)	[lagged error correction]

Identity:

LYLC	=	(YRLC(.)/PYR(.)) / YREE(.)	[real labour costs]

Restrictions:

BYRE(.,2 .,7) >= 0	['right sign']
BYRE(.,3 .,8) <= 0	['right sign']
0 > BYRE(.,5) > -1	['right sign']

Definitions:

BYRE	is a matrix of parameters
YRE	is a matrix of total employment by industry, in thousands of persons
YR	is a matrix of gross output by industry, m $ at 2010 prices
YRLC	is a matrix of employer labour costs (wages plus imputed social security contributions) by industry, $ at current prices
PYR	is a matrix of output prices by industry, 2010=1.0
YREE	is a matrix of wage and salary earners, in thousands of persons

- derived demand
- sectors x regions
- unemployment = labour force – employment + adjustment
- employment demand = f(output, wage)

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Summary for equation specifications in E3-Thailand

Econometric equation	Main explanatory variables
Consumer spending (total)	real disposable income, interest rates, unemployment rates, inflation
Disaggregated consumer spending	real disposable income, relative prices of consumer products
Investment (by sector)	industry output, relative price of investment, future expected production, interest rate
International imports (by sector)	domestic demand, import price, domestic price, exchange rate, technology
International exports (by sector)	Global demand, export price, competing prices, exchange rate, technology
Employment (by sector)	industry output, wages, technology
Wages (by sector)	wage rates elsewhere, unemployment rate, benefit rates, expected inflation, expected production
Labour participation rate (by gender)	total output, average wage rate, unemployment rate
Output prices (by sector)	unit costs (materials, labour and taxes), competing import prices, technology, expected production
International import prices	export prices from trading partners, exchange rate, technology
International export prices	unit cost, other region export prices, exchange rate, technology

E3-Thailand econometric specification

- Cointegration (long-run) and error-correction (short-run) methodology
  - particularly as promoted by Engle and Granger (1987) and Hendry et al (1984)
  - estimate using 2SLS method
- Error correction term is a key variable (IV)
  - ECM coefficient determines speed and type of return to equilibrium following an external shock to the system
- This makes E3-Thailand suitable for both short, medium and long-term analysis

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Data sources

Variable	Sources
GDP	NESDB
GVA by sectors	NESDB
IO table by sector	NESDB
Consumer spending by consumer sectors	NESDB
Investment by sectors	NESDB
Import and export by sectors	WTO
Import and export by sectors (services)	World Bank
Population by age and gender	UN
Employment by sector	LFS - TNSO
Compensation of employees by sector	NESDB
Labour force by age and gender	ILO
VAT	World Bank
Income tax	NESDB
Social security	NESDB
Benefit rate	NESDB
Income distribution	NESDB
Interest rate (base rate)	BOT
Government final spending by government sector	NESDB
Energy demand by energy types and users	DEDE IEA Energy balance
Energy price by energy types and users	EPPO IEA
CO2 emissions by users	EPPO
Other GHG emissions (preferably by users)	WB
Electricity capacity/generation by technology	EGAT

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Exogenous variables

- Population
- Natural resources (coal, oil and natural gas, raw commodity price)
- Global GDP trends (split by Thailand main trading partners)
- Current and capital spending of government
- Tax rates and allowances
- Exchange rates
- Short- and long-term interest rates

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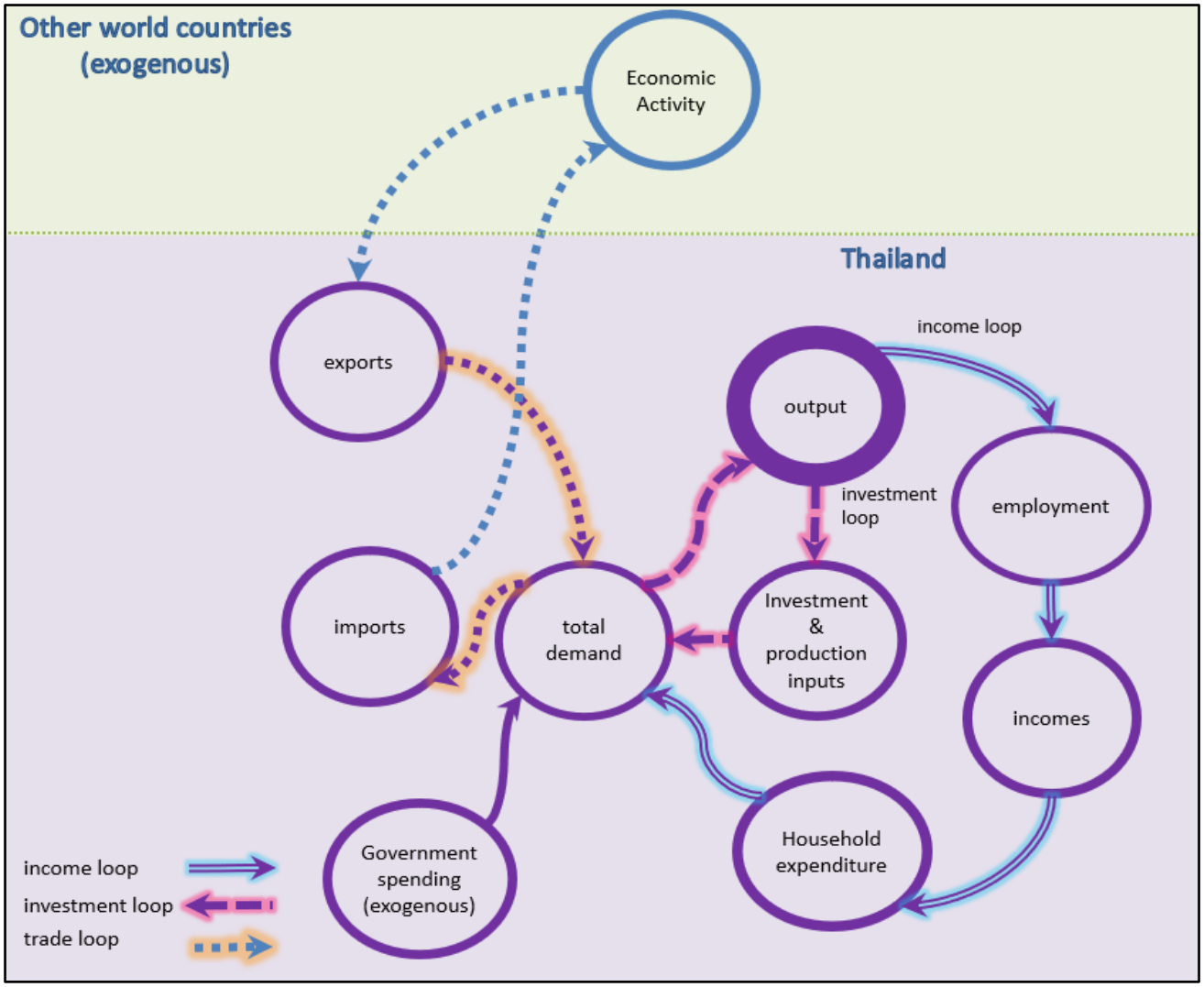
The determination of output



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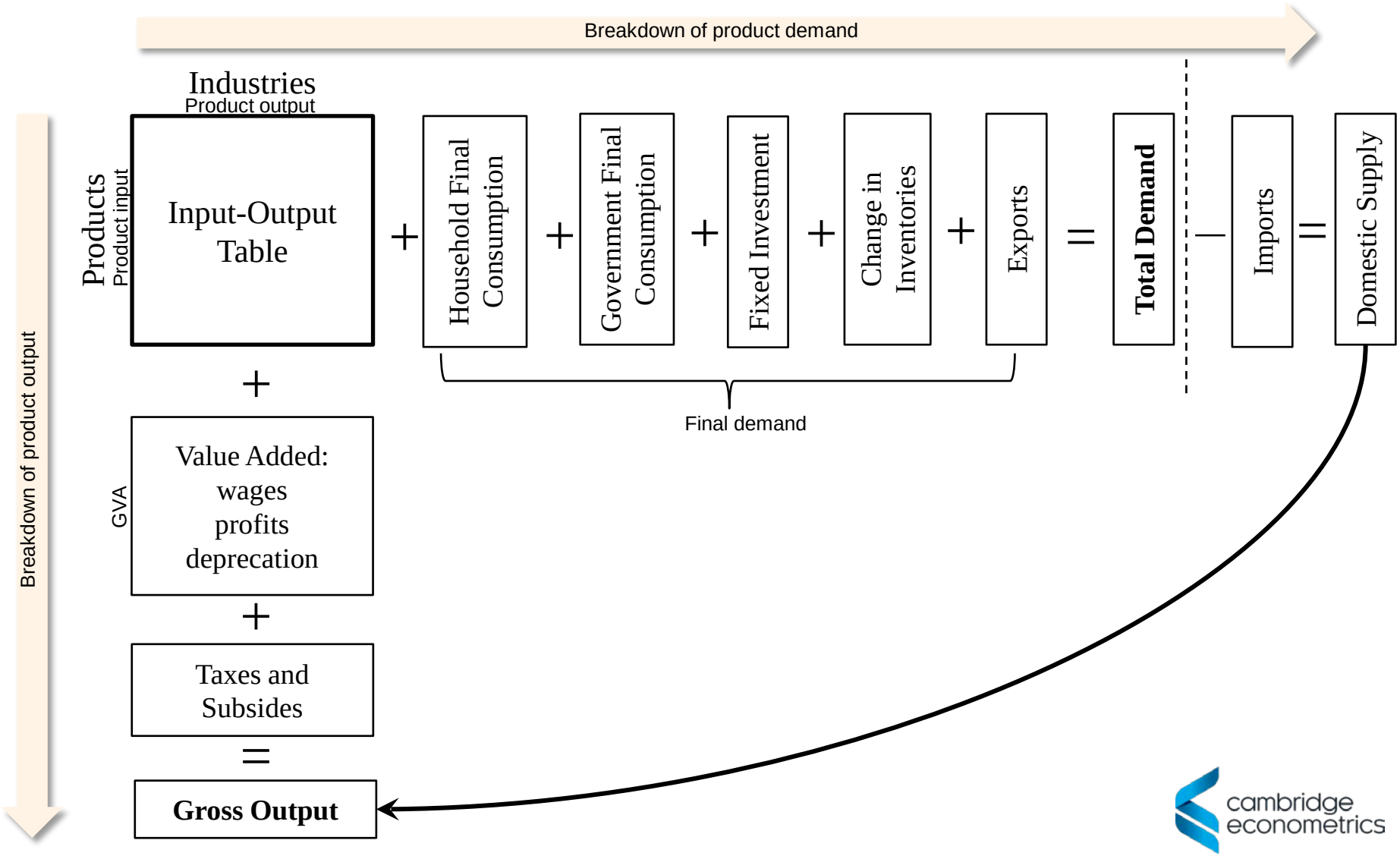
The core input-output structure



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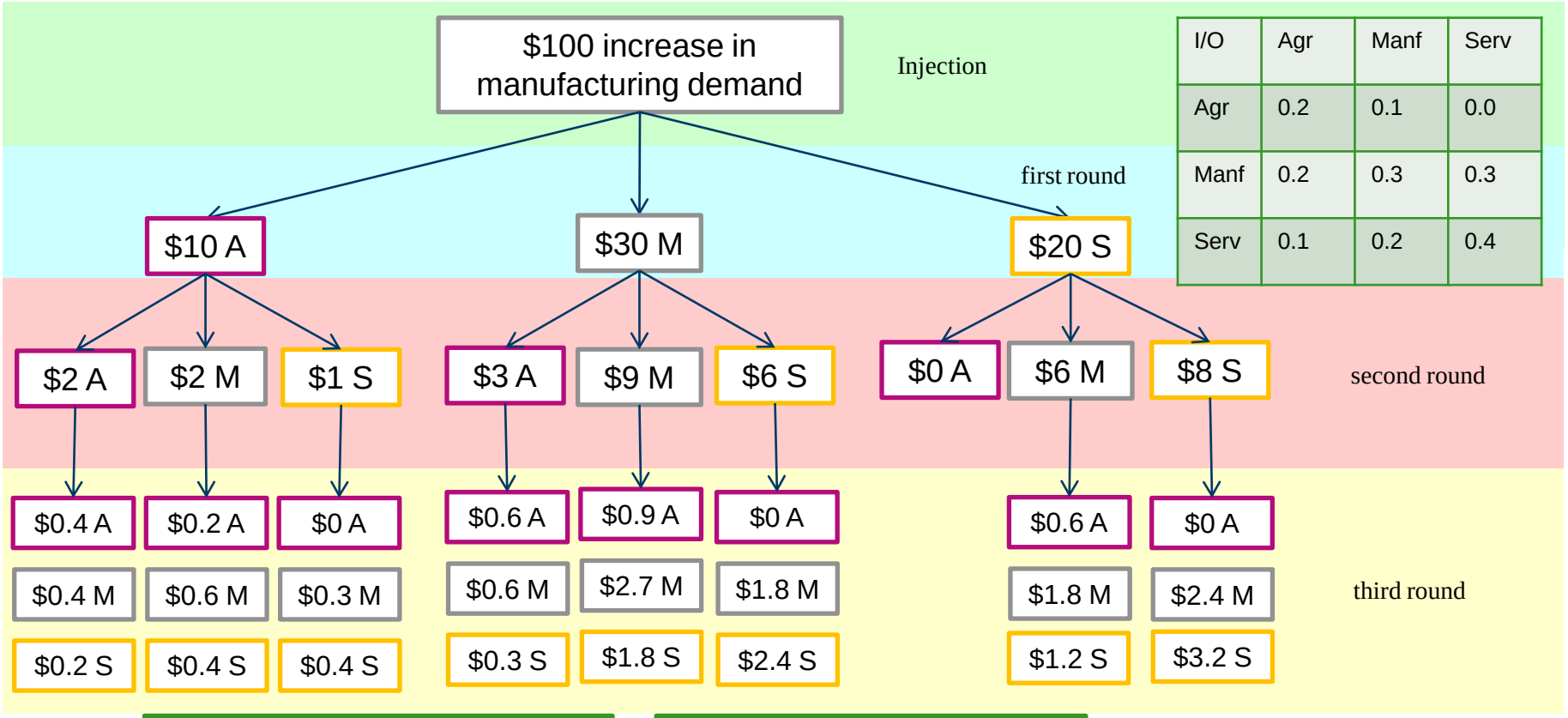
E3-Thailand: Multiplier



I/O	Agr	Manf	Serv
Agr	0.2	0.1	0.0
Manf	0.2	0.3	0.3
Serv	0.1	0.2	0.4

Injection: M=$100
First round: A=$10, M=$30, S=$20
Second round: A=$5, M=$17, S=$15
Third round: A=$2.7, M= $10.6, S= $9.9

Agriculture: $17.7
Manufacturing: $57.6
Services: $44.9
Total: $120.2
Multiplier: $120.2/$100 = 1.202

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The treatment of the labour market

- Labour demand as derived from demand for products and affected by output, costs of labour relative to value of output produced, unemployment and benefit rates
- Labour markets disaggregated by industry and region with interactions across industries and regions in wage equations
- Labour supply from working age population and participation rates by gender (in turn affected by unemployment)
- Wage rates set in an employer-union bargaining model adapted to industry-region labour markets

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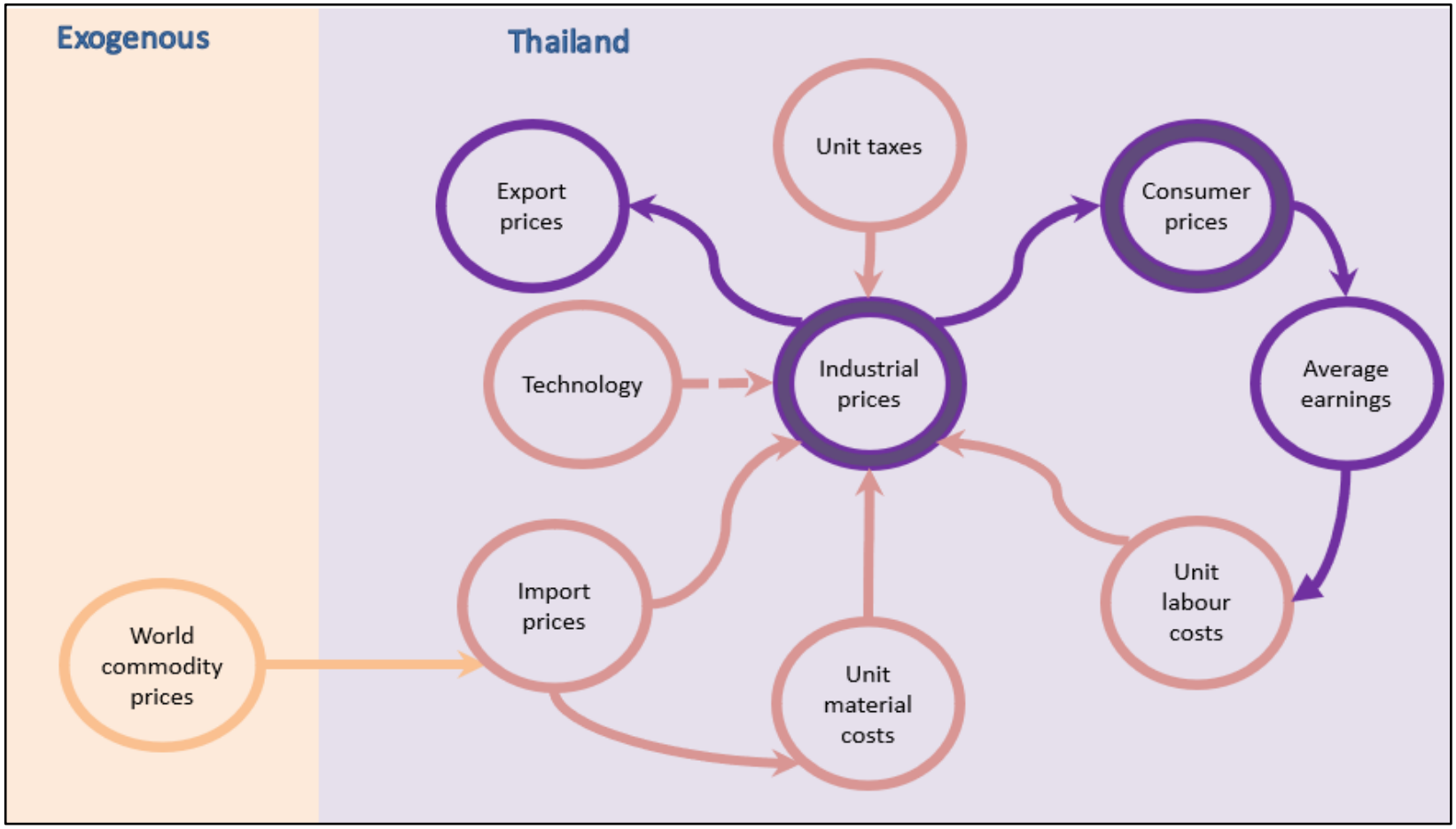
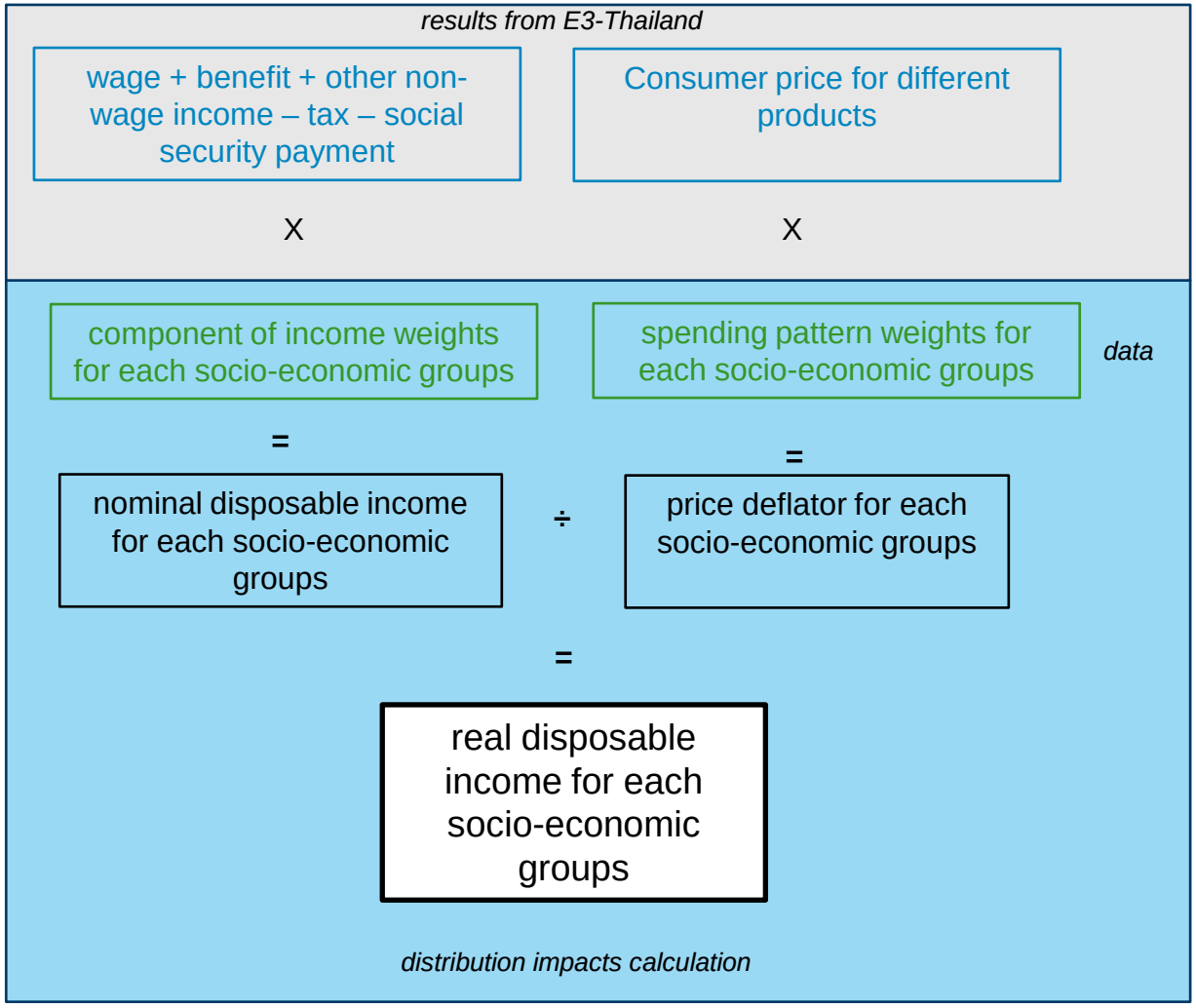
The determination of prices



Households distribution impacts



Households classification

1 All households
2 Farmer-Land owner
3 Farmer-rent
4 Farmer- others
5 Self-emp (non-farm)
6 Professional
7 Labourer (farm)
8 Labourer (logis &trans)
9 Services workers
10 Const & manuf workers
11 Inactive
12 Quintile 1
13 Quintile 2
14 Quintile 3
15 Quintile 4
16 Quintile 5

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E3-Thailand: Sectors

1 Agriculture
2 Forestry and logging
3 Fishing & aquaculture
4 Mining coal & lignite
5 Extraction oil & gas
6 Mining of metal ores
7 Other mining
8 Food products
9 Beverages
10 Tobacco products
11 Textiles
12 Wearing apparel
13 Leather products
14 Wood products
15 Paper products
16 Printing & publishing
17 Manufactured fuels
18 Chemicals products
19 Pharmaceutical
20 Rubber & plastics
21 Non-metallic minerals
22 Basic metals
23 Metal products
24 Computer & electronic
25 Electrical equipment
26 Other machinery
27 Motor vehicles
28 Oth transport equip.
29 Furniture
30 Other manufacturing
31 Repair & install
32 Electricity supply
33 Gas supply
34 Water supply
35 Private construction
36 Public construction
37 Sale of cars
38 Trade except cars
39 Land transport
40 Water transport
41 Air transport
42 Warehousing
43 Postal activities
44 Accommodation
45 Catering activities
46 Publishing activities
47 Motion pic & music
48 Program & broadcast
49 Telecommunications
50 Computer programming
51 Information services
52 Financial services
53 Insurance & pension
54 Finance auxiliary
55 Real estate activities
56 Imputed rents
57 Legal and accounting
58 Management consultant
59 Architect & engineer
60 Scientific R&D
61 Advertising
62 Other professionals
63 Veterinary
64 Rental and leasing
65 Employment activities
66 Travel agency etc
67 Security activities
68 Property maintenance
69 Office admin
70 Public admin & defense
71 Education
72 Health care
73 Arts & entertainment
74 Libraries & museums
75 Gambling & betting
76 Sport & recreation
77 Membership org.
78 Repair of HH goods
79 Other pers services
80 HH as employers

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E3-Thailand: Consumer spending groups

1 Food
2 Drink (no-alcohol)
3 Drink (alcoholic)
4 Tobacco
5 Clothing & footwears
6 Housing & water
7 Electricity
8 Gas
9 Other fuels
10 Furniture & text
11 HH equip & maintenance
12 Health
13 Cars
14 Petrol
15 Cars operation
16 Transport
17 Communication
18 Equipment
19 Other recreation
20 Books etc
21 Education
22 Restaurants& hotels
23 Personal care
24 Personal effects
25 Financial services
26 Other services n.e.c.
27 Health, education, social protection
28 Other services n.e.c.

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E3-Thailand: Other classifications

Government spending classification

1 Defense
2 Education
3 Health
4 Other
5 Unallocated

Global commodity classification

1 Food/Feed
2 Wood
3 Construction minerals
4 Industrial minerals
5 Ferrous metals
6 Non-ferrous metals
7 Energy- Coal
8 Energy- Brent oil
9 Energy- Gas
10 Others

Trading partners classification

1 China
2 USA
3 Japan
4 Vietnam
5 Malaysia
6 Indonesia
7 Rest of ASEAN
8 EU28
9 Rest of Annex I
10 Middle East
11 Africa
12 Rest of World

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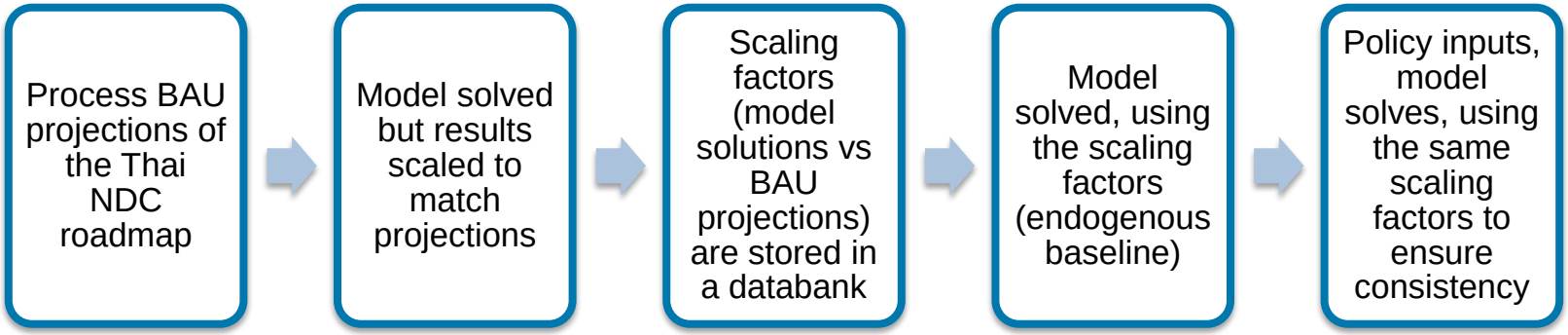
E3-Thailand model baseline

- Process of mapping model baseline to BAU of the NDC Roadmap



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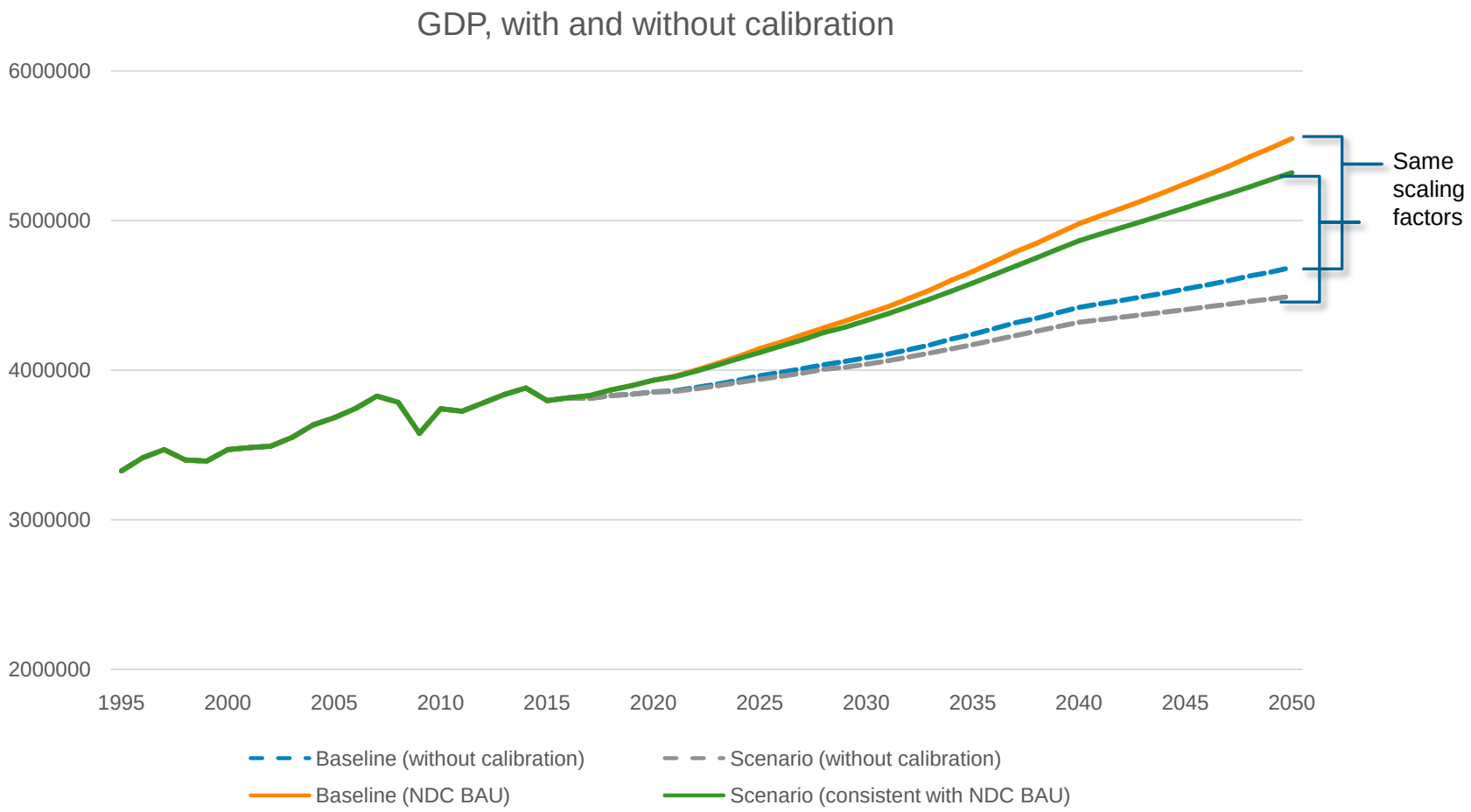
Calibrating the E3-Thailand baseline



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E3-Thailand applications

Energy & Climate

- ETS/ carbon market
- carbon/energy targets
- carbon/ energy tax
- ETR
- renewables energy
- power generation mix
- green jobs
- removal of harmful subsidies
- international energy prices

Economic/ Labour

- fiscal policies: government revenues and spending
- monetary policies
- labour supply and demand forecasts
- labour market policies e.g. improving female participation rate

Others

- sector specific studies e.g. aviation, water transport, engineering
- impacts of R&D and innovations

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Typical main outputs from E3-Thailand

Economy:	Labour market:	Energy & Environment:
✓ **GDP** and the **aggregate components** of GDP (household expenditure, investment, government expenditure and trade) ✓ **sectoral** output and GVA, prices, trade and competitiveness effects ✓ **consumer prices** and **expenditures**, and implied household **distributional** effects	✓ **sectoral employment** ✓ **labour force** and **participation rate** by gender and age groups ✓ **unemployment** rate and level ✓ **sectoral wage** rate ✓ **real income** of different **socio-economic** groups	✓ **energy demand**, by users and by fuel ✓ energy **prices** ✓ **power** sector detailed results ✓ **CO_2 emissions** by sector and by fuel ✓ **other** air-borne **emissions**

*all with **annual** results to **2040**

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E3-Thailand limitations

- Data
  - annual model
  - quality and availability of data
- Econometric
  - dealing with structural change
  - based on historical relationships (Lucas critique)
- Complexity
  - complex linkages between different part of models
- Treatment of financial markets

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