Social Accounting Matrix (SAM) – A Modelling Tool for Impact Evaluation

Presented at the –

UNFCCC In-forum training workshop on use of economic modelling tools related to economic diversification and just transition of workforce

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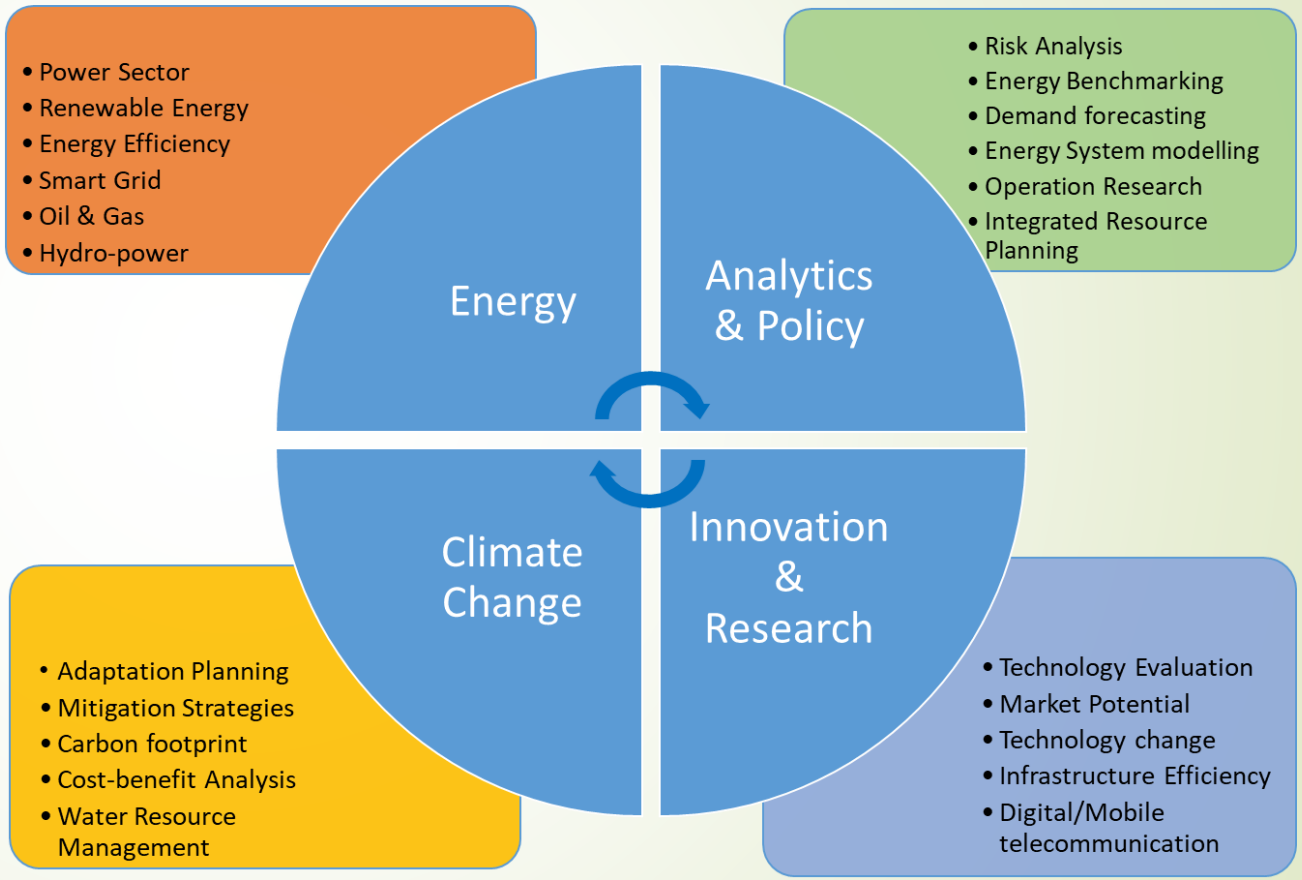
About Us

MZSPL began operations in June 2016. We offer research & consulting services in Energy & Water Sector and Climate Change Adaptation and Mitigation. MZSPL's solutions cut across other sectors of the economy like the industrial, agriculture, commercial, residential, transport and municipality

Our Mission:
Smart and sustainable energy solutions for all.



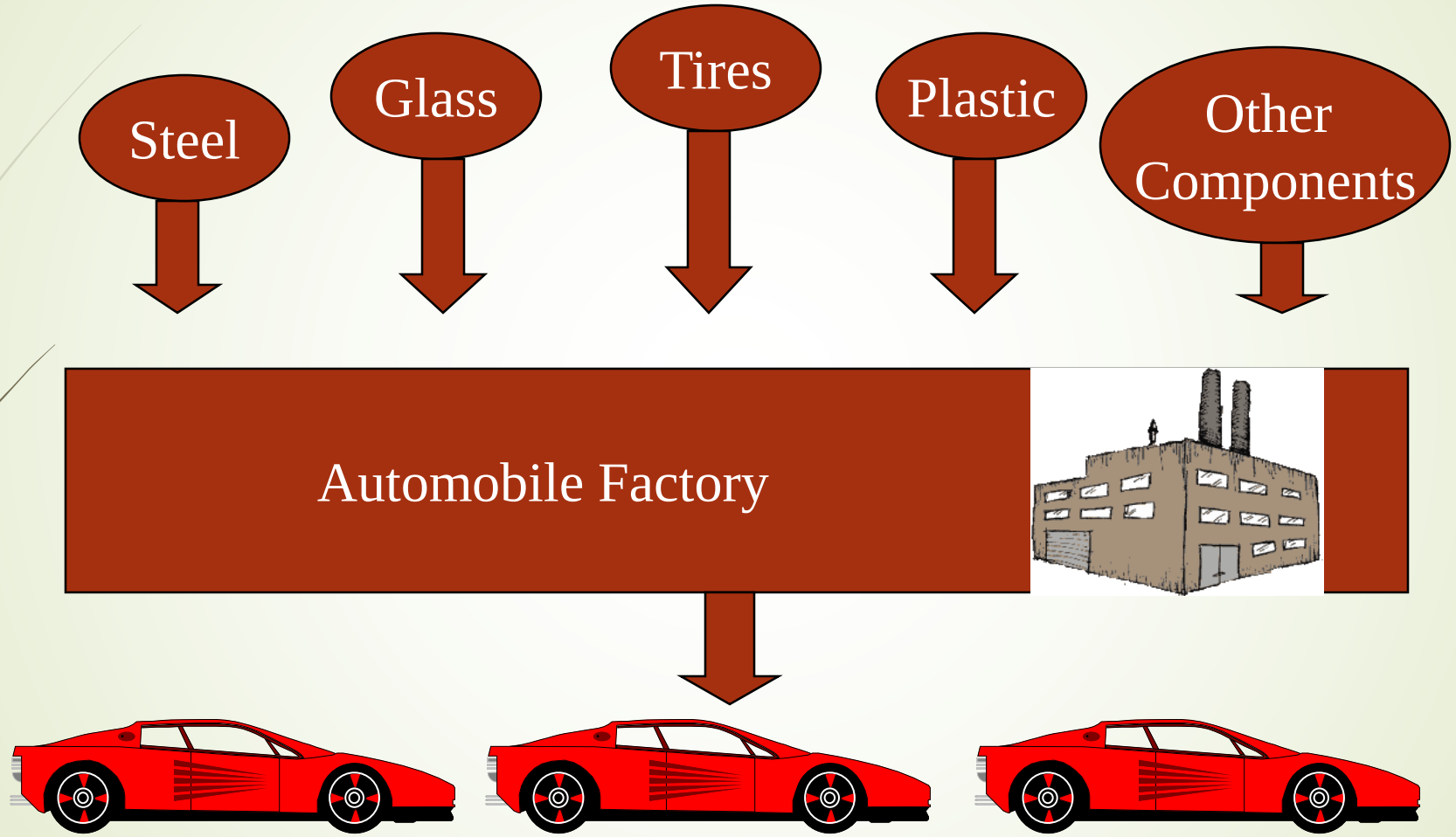
Contents

- Introduction to Input-output model – this brings out the inter-dependency of different sectors.
- Impact analysis using input-output model.
- Multi-regional input-output model.
- Introduction to SAM, which is an extension of Input-output model.
- SAM multipliers.

INPUT-OUTPUT MODELS

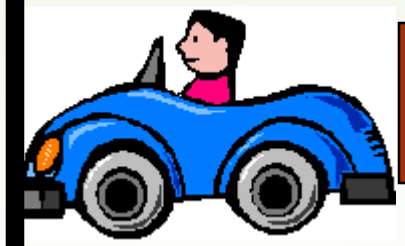
- An input/output table quantifies the transactions between sectors in an economy.
- It's a "snap-shot" of the economy for a one-year period.
- By understanding these linkages, we are able to predict how a change in one sector will affect the other sectors.
- Multipliers can be estimated - Multipliers measure total change throughout the economy from one unit change for a given sector.

Basic Input-Output Logic



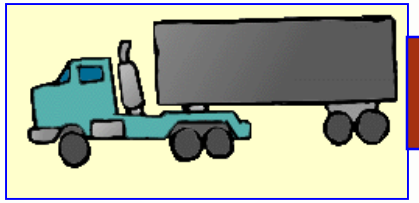
From the Tire Producer's Perspective

Tire Factory



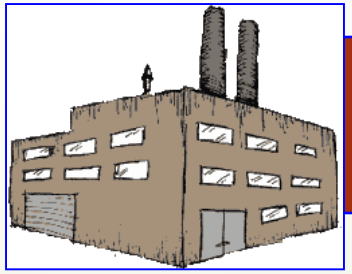
Individual Consumers

School Districts



Trucking Companies

FINAL DEMAND FOR TIRES



Automobile Factory

INTER-MEDIATE DEMAND FOR TIRES

Regional Input-Output Models

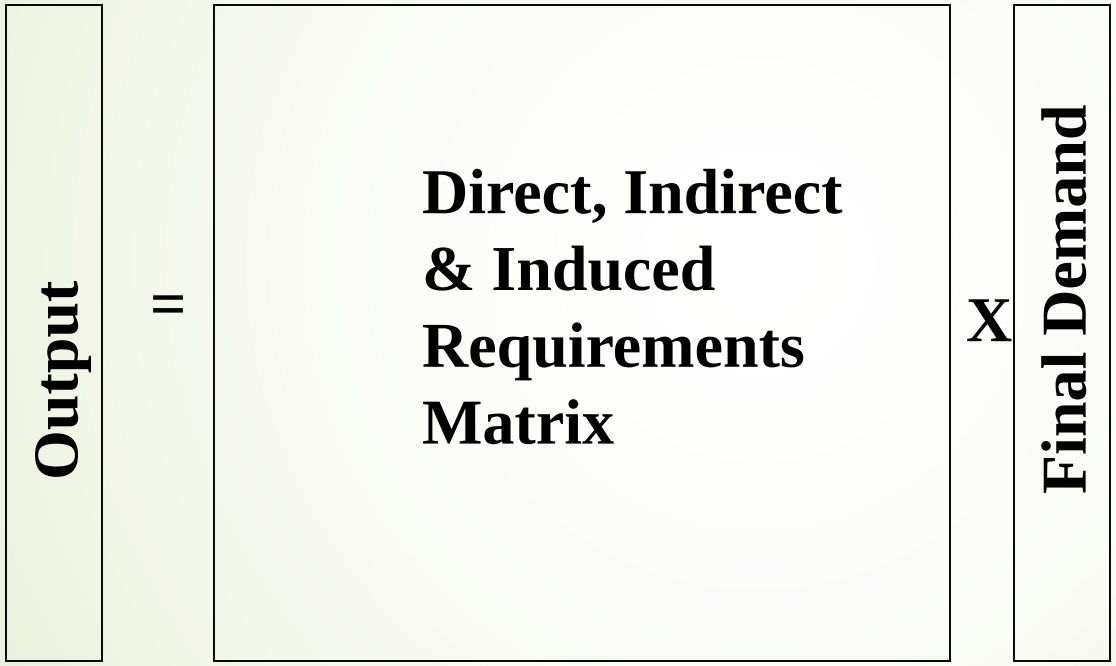
			Final Demand				
	Industry 1	Industry 2	Consump-tion	Invest-ment	Govt.	Exports	Total Sales
Industry 1							
Industry 2							
Labor Income							
Other Value Added							
Imports							
Total Purchases							

Total Sales = Total Purchases

Total Sales = Intermediate Sales + Final Sales

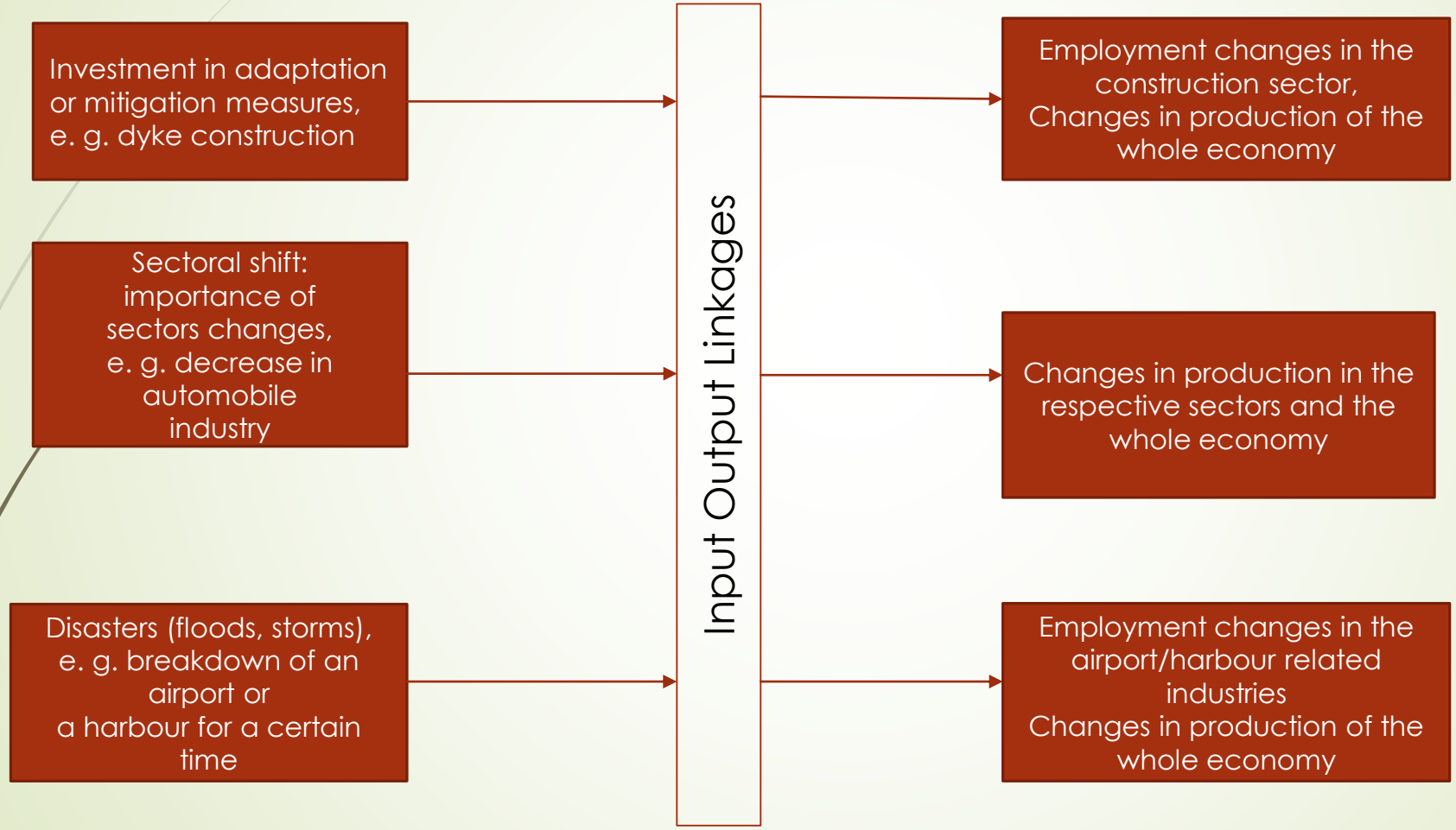
Total Purchases = Intermediate Purchases + Value Added + Imports

Impact Analysis Using I/O Models



Employment Impacts calculated from Output Impacts

Input Output Model Impacts



Multiplier models: how they work ...

- **... Secondary effects:**
  - increase in supply of inputs (standard input-output multipliers)
- **Secondary effects: spending by households**
  - Factor income payments for factor services supplied (stemming from primary effects)
  - Spending out of income by households
- **Further secondary (i.e. multiplier) effects:**
  - Output effects
  - Income effects

Multiregional IO models

- For a country made up of several regions, any exogenous change in one region can be expected to have ramifications not only within the region (state, in this example) where the activity takes place, but also in other states.
- The one region of interest was essentially "disconnected" from the rest of the country within which it is located, in the sense that its production recipes are reflected in an intraregional matrix.
- This concept can also be expanded for multiple countries as we shall demonstrate in the subsequent slides.

Multiregional IO Models: Hypothetical example

For purposes of illustration, we consider a two-region economy. Using r and s, as before, for the two regions, let there be three producing sectors (1, 2, 3) in region r and two (1, 2) in region s. Suppose that one has information for region r on both intraregional flows, z_{ij}^{rr} , and interregional flows,z_{ij}^{sr} . There will be nine of the former and six of the latter. Suppose, further, that the same kind of information is available on the use of inputs by firms located in region s,z_{ij}^{rs} and z_{ij}^{ss}. This complete table of intraregional and interregional data can be represented as:

$$Z = \begin{bmatrix} z^{rr} & z^{rs} \\ z^{sr} & z^{ss} \end{bmatrix}$$

Multiregional IO table for hypothetical example in expanded form

Selling Sector		Purchasing Sector				
		Region r			Region s	
		1	2	3	1	2
Region r	1	z_{11}^{rr}	z_{12}^{rr}	z_{13}^{rr}	z_{11}^{rs}	z_{12}^{rs}
	2	z_{21}^{rr}	z_{22}^{rr}	z_{23}^{rr}	z_{21}^{rs}	z_{22}^{rs}
	3	z_{31}^{rr}	z_{32}^{rr}	z_{33}^{rr}	z_{31}^{rs}	z_{32}^{rs}
Region s	1	z_{11}^{sr}	z_{12}^{sr}	z_{13}^{sr}	z_{11}^{ss}	z_{12}^{ss}
	2	z_{21}^{sr}	z_{22}^{sr}	z_{23}^{sr}	z_{21}^{ss}	z_{22}^{ss}

Layout of the 2005 Asian International Input-Output Table

		Intermediate Demand (A)										Final Demand (F)										Export (L)					
	code	Indonesia (AI)	Malaysia (AM)	Philippines (AP)	Singapore (AS)	Thailand (AT)	China (AC)	Taiwan (AN)	Korea (AK)	Japan (AJ)	U.S.A. (AU)	Indonesia (FI)	Malaysia (FM)	Philippines (FP)	Singapore (FS)	Thailand (FT)	China (FC)	Taiwan (FN)	Korea (FK)	Japan (FJ)	U.S.A. (FU)	Export to H.Kong (LH)	Export to India (LG)	Export to EU (LO)	Export to R.O.W. (LW)	Discrepancy (QX)	Total Outputs (XX)
Indonesia	(AI)	A^{II}	A^{IM}	A^{IP}	A^{IS}	A^{IT}	A^{IC}	A^{IN}	A^{IK}	A^{IJ}	A^{IU}	F^{II}	F^{IM}	F^{IP}	F^{IS}	F^{IT}	F^{IC}	F^{IN}	F^{IK}	F^{IJ}	F^{IU}	L^{IH}	L^{IG}	L^{IO}	L^{IW}	Q^{I}	X^{I}
Malaysia	(AM)	A^{MI}	A^{MM}	A^{MP}	A^{MS}	A^{MT}	A^{MC}	A^{MN}	A^{MK}	A^{MJ}	A^{MU}	F^{MI}	F^{MM}	F^{MP}	F^{MS}	F^{MT}	F^{MC}	F^{MN}	F^{MK}	F^{MJ}	F^{MU}	L^{MH}	L^{MG}	L^{MO}	L^{MW}	Q^{M}	X^{M}
Philippines	(AP)	A^{PI}	A^{PM}	A^{PP}	A^{PS}	A^{PT}	A^{PC}	A^{PN}	A^{PK}	A^{PJ}	A^{PU}	F^{PI}	F^{PM}	F^{PP}	F^{PS}	F^{PT}	F^{PC}	F^{PN}	F^{PK}	F^{PJ}	F^{PU}	L^{PH}	L^{PG}	L^{PO}	L^{PW}	Q^{P}	X^{P}
Singapore	(AS)	A^{SI}	A^{SM}	A^{SP}	A^{SS}	A^{ST}	A^{SC}	A^{SN}	A^{SK}	A^{SJ}	A^{SU}	F^{SI}	F^{SM}	F^{SP}	F^{SS}	F^{ST}	F^{SC}	F^{SN}	F^{SK}	F^{SJ}	F^{SU}	L^{SH}	L^{SG}	L^{SO}	L^{SW}	Q^{S}	X^{S}
Thailand	(AT)	A^{TI}	A^{TM}	A^{TP}	A^{TS}	A^{TT}	A^{TC}	A^{TN}	A^{TK}	A^{TJ}	A^{TU}	F^{TI}	F^{TM}	F^{TP}	F^{TS}	F^{TT}	F^{TC}	F^{TN}	F^{TK}	F^{TJ}	F^{TU}	L^{TH}	L^{TG}	L^{TO}	L^{TW}	Q^{T}	X^{T}
China	(AC)	A^{CI}	A^{CM}	A^{CP}	A^{CS}	A^{CT}	A^{CC}	A^{CN}	A^{CK}	A^{CJ}	A^{CU}	F^{CI}	F^{CM}	F^{CP}	F^{CS}	F^{CT}	F^{CC}	F^{CN}	F^{CK}	F^{CJ}	F^{CU}	L^{CH}	L^{CG}	L^{CO}	L^{CW}	Q^{C}	X^{C}
Taiwan	(AN)	A^{NI}	A^{NM}	A^{NP}	A^{NS}	A^{NT}	A^{NC}	A^{NN}	A^{NK}	A^{NJ}	A^{NU}	F^{NI}	F^{NM}	F^{NP}	F^{NS}	F^{NT}	F^{NC}	F^{NN}	F^{NK}	F^{NJ}	F^{NU}	L^{NH}	L^{NG}	L^{NO}	L^{NW}	Q^{N}	X^{N}
Korea	(AK)	A^{KI}	A^{KM}	A^{KP}	A^{KS}	A^{KT}	A^{KC}	A^{KN}	A^{KK}	A^{KJ}	A^{KU}	F^{KI}	F^{KM}	F^{KP}	F^{KS}	F^{KT}	F^{KC}	F^{KN}	F^{KK}	F^{KJ}	F^{KU}	L^{KH}	L^{KG}	L^{KO}	L^{KW}	Q^{K}	X^{K}
Japan	(AJ)	A^{JI}	A^{JM}	A^{JP}	A^{JS}	A^{JT}	A^{JC}	A^{JN}	A^{JK}	A^{JJ}	A^{JU}	F^{JI}	F^{JM}	F^{JP}	F^{JS}	F^{JT}	F^{JC}	F^{JN}	F^{JK}	F^{JJ}	F^{JU}	L^{JH}	L^{JG}	L^{JO}	L^{JW}	Q^{J}	X^{J}
U.S.A.	(AU)	A^{UI}	A^{UM}	A^{UP}	A^{US}	A^{UT}	A^{UC}	A^{UN}	A^{UK}	A^{UJ}	A^{UU}	F^{UI}	F^{UM}	F^{UP}	F^{US}	F^{UT}	F^{UC}	F^{UN}	F^{UK}	F^{UJ}	F^{UU}	L^{UH}	L^{UG}	L^{UO}	L^{UW}	Q^{U}	X^{U}
Freight and Insurance	(BF)	BA^{I}	BA^{M}	BA^{P}	BA^{S}	BA^{T}	BA^{C}	BA^{N}	BA^{K}	BA^{J}	BA^{U}	BF^{I}	BF^{M}	BF^{P}	BF^{S}	BF^{T}	BF^{C}	BF^{N}	BF^{K}	BF^{J}	BF^{U}						
Import from H. Kong	(CH)	A^{HI}	A^{HM}	A^{HP}	A^{HS}	A^{HT}	A^{HC}	A^{HN}	A^{HK}	A^{HJ}	A^{HU}	F^{HI}	F^{HM}	F^{HP}	F^{HS}	F^{HT}	F^{HC}	F^{HN}	F^{HK}	F^{HJ}	F^{HU}						
Import from India	(GH)	A^{GI}	A^{GM}	A^{GP}	A^{GS}	A^{GT}	A^{GC}	A^{GN}	A^{GK}	A^{GJ}	A^{GU}	F^{GI}	F^{GM}	F^{GP}	F^{GS}	F^{GT}	F^{GC}	F^{GN}	F^{GK}	F^{GJ}	F^{GU}						
Import from EU	(CO)	A^{OI}	A^{OM}	A^{OP}	A^{OS}	A^{OT}	A^{OC}	A^{ON}	A^{OK}	A^{OJ}	A^{OU}	F^{OI}	F^{OM}	F^{OP}	F^{OS}	F^{OT}	F^{OC}	F^{ON}	F^{OK}	F^{OJ}	F^{OU}						
Import from the R.O.W.	(CW)	A^{WI}	A^{WM}	A^{WP}	A^{WS}	A^{WT}	A^{WC}	A^{WN}	A^{WK}	A^{WJ}	A^{WU}	F^{WI}	F^{WM}	F^{WP}	F^{WS}	F^{WT}	F^{WC}	F^{WN}	F^{WK}	F^{WJ}	F^{WU}						
Duties & Import Taxes	(DT)	DA^{I}	DA^{M}	DA^{P}	DA^{S}	DA^{T}	DA^{C}	DA^{N}	DA^{K}	DA^{J}	DA^{U}	DF^{I}	DF^{M}	DF^{P}	DF^{S}	DF^{T}	DF^{C}	DF^{N}	DF^{K}	DF^{J}	DF^{U}						
Value Added	(VV)	V^{I}	V^{M}	V^{P}	V^{S}	V^{T}	V^{C}	V^{N}	V^{K}	V^{J}	V^{U}																
Total Inputs	(XX)	X^{I}	X^{M}	X^{P}	X^{S}	X^{T}	X^{C}	X^{N}	X^{K}	X^{J}	X^{U}																

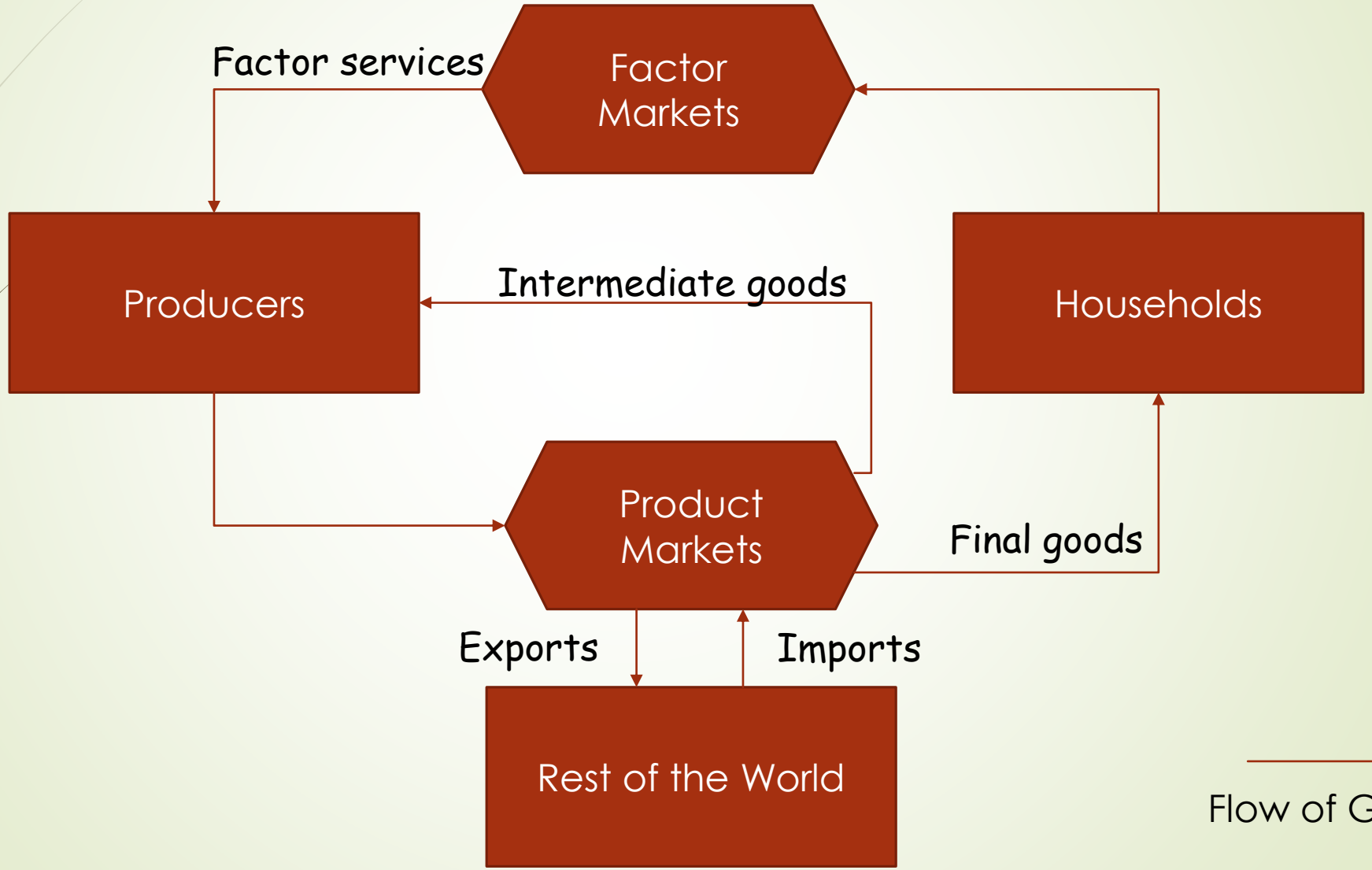
What is a SAM?

- A Social Accounting Matrix (SAM) is a square matrix that builds on the input-output table - but the SAM goes further
- A SAM considers not only production linkages, but tracks income-expenditure feedbacks (including institutions)
- Each "transactor" (such as factors of production, households, enterprises, the government and the ROW) has a row and a column – double entry national income accounting (row totals therefore equal to corresponding column total)
- A SAM is a consistent data system that provides a snapshot of the economy in a given year
- Note that the SAM reconciles data from different sources and we often talk about the SAM as consisting of two corresponding layers: the Macro-SAM and the Micro-SAM

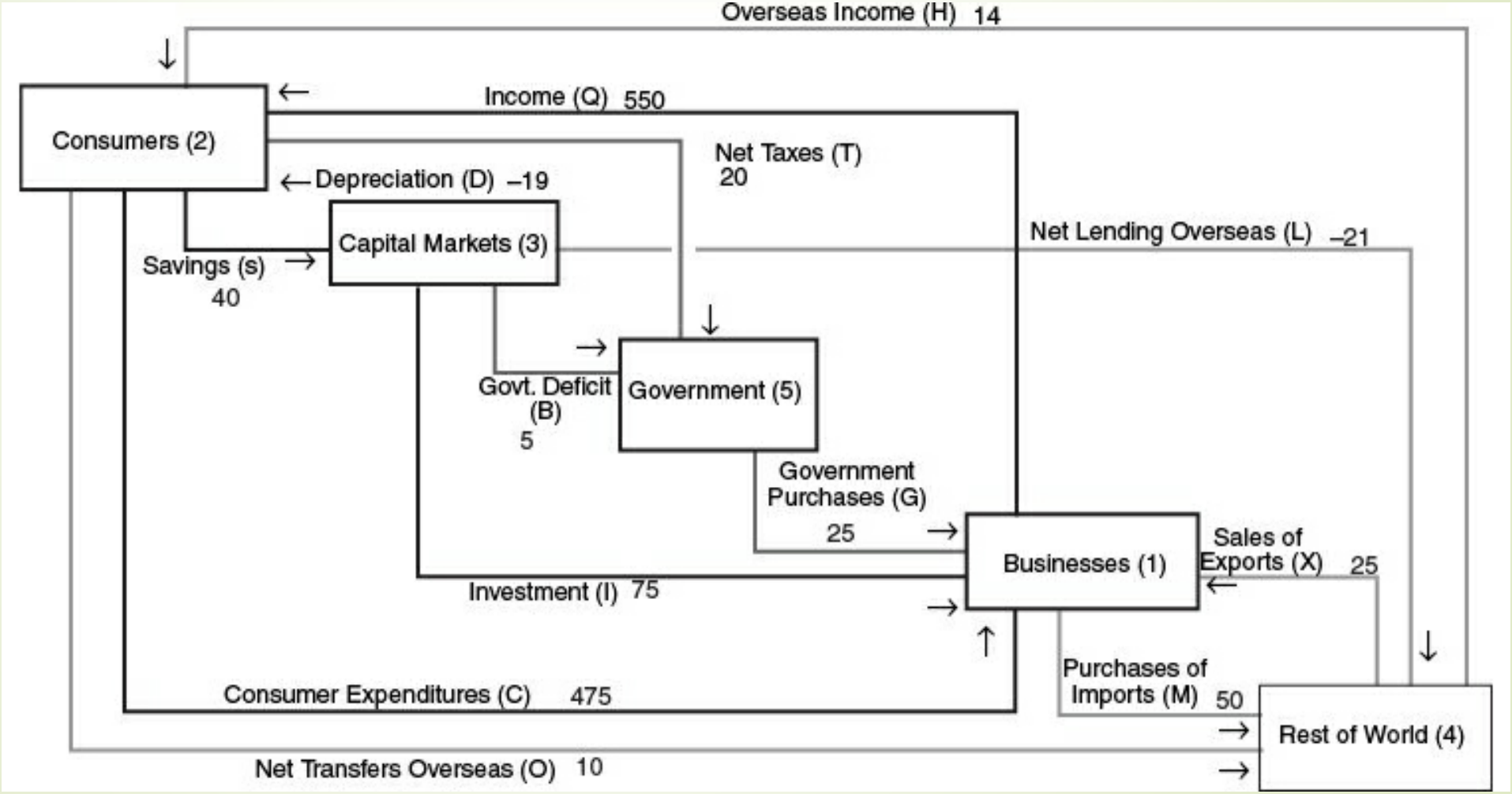
Why Build SAMs?

- SAM helps to understand the interactions of macro policy and I-O production structure as well as economic interactions between sectors and institutions of the economy and rest of the world (ROW).
- SAM Provides the framework (or accounting device) in which to organize structural and institutional data (households, firms and government).
- SAM can be supplemented with satellite tables to provide flexibility, yet consistent framework for socio-economic analysis.
- It can be used as the basis for simple modelling under certain assumptions.

Economy wide circular flow



Example of Circular Flow of Income and Expenditures



SAM-based multiplier models

- Aim is to capture the circular flow of income: producers to consumers and *vice-versa*.

- We need to distinguish between *endogenous* and *exogenous* accounts

- *Exogenous transactions*: usually defined as the income and outlays of government, capital investment and rest of the world

- *Endogenous transactions*: usually the production, factor and institution (households) accounts – capturing the circular flow of income

Unique features of SAM

Description

- Useful snapshot of economic structure

Construction

- Good organizing framework
- Draws together data from disparate sources

Basis for modelling

- Data for calibrating macro and macro-meso models
- Multiplier models capture structural features
- CGE models, microsimulation, etc.

Table 1: A Basic Social Accounting Matrix (SAM)

			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	TOTALS
Production	Products	(1)		Intermediate consumption		Household consumption		Government consumption	Fixed capital formation and change in stocks	Exports	Demand for products
	Activities	(2)	Domestic sales								Sales of commodities
Factors of production		(3)		Gross value added payments to factors						*Net* factor income from RoW	Factor income receipts
Institutions (Current accounts)	Households	(4)			Labour and mixed income	Inter-household transfers	Distributed profits to households	Current transfers to households		*Net* current transfers from RoW	Current household receipts
	Corporate enterprises	(5)			Operating surplus			Current transfers to enterprises		*Net* current transfers from RoW	Current enterprise receipts
	Government (&NPISHs)[1]	(6)	*Net* taxes on products			Direct taxes	Direct taxes			*Net* current transfers from RoW	Current government receipts
Combined capital accounts		(7)				Household savings	Enterprise savings	Government savings	Capital transfers	*Net* capital transfers from RoW	Capital receipts
Rest of World (RoW) (combined account)		(8)	Imports						Current external balance		Aggregate receipts from RoW
TOTALS			Supply of products	Costs of production activities	Factor income payments	Current household outlays	Current enterprise outlays	Current government outlays	Capital outlays	Aggregate outlays to RoW	

Table 2. SAM: Endogenous and Exogenous Accounts

ACCOUNT		Endogenous			Exogenous	TOTAL
		(1)	(2)	(3)	(4)	
Products	(1)	Intermediate consumption T_{11}		Household consumption expenditures T_{13}	Other final demands x_1	Total demands for products y_1
Factors	(2)	Value added T_{21}			Factor income from abroad x_2	Total factor income receipts y_2
Households	(3)		Factor income to households T_{32}	Inter-household transfers T_{33}	Non-factor income receipts x_3	Total household incomes y_3
Other accounts (exogenous)	(4)	Imports, indirect taxes l_1	Other factor payments l_2	Savings, etc l_3		Total exogenous receipts Σl
TOTAL		Total activity outputs y_2	Total factor income payments y_3	Total household outlays y_4	Total exogenous payments Σx	

SAM-based modelling

Multiplier models (fixed price models)

- many examples in development economics
- decomposition analysis is prominent

CGE models (flexible price models)

- many examples in development economics
- trade, income distribution and poverty analysis

Pros and cons between multiplier and CGE models

- former are a special case of the latter
- advantages and disadvantages of both approaches
  - multiplier models offer simple insights and transparency
  - CGE attempt to capture more endogenous behaviour

Multiplier decomposition

Fixed price multipliers $dy = (I - C)^{-1} dx = M dx$

Pyatt-Round (P-R) multiplier decomposition

$$M = M_3 M_2 M_1$$

M_1: within-group effects

M_2 : cross-group effects

M_3 : between-group effects

Stone additive decomposition

$$M = I + (M_1 - I) + (M_2 - I) M_1 + (M_3 - I) M_2 M_1$$

Pyatt-Round decomposition: an extension

- aim is to show how the P-R decomposition can achieve the D-T decomposition objectives

- the method shows the contributions to an element of the total multiplier, m_{ij} due to different paths

- consider impact on income of HH *i* of unit increase in output of activity *j*

$$m_{IP.ij} = m'_{3.II.i}\, M_{2.IP}\, m_{1.PP.j}$$

- instead we form an 'rAs' transform based on $m'_{3.II.i}$ and $m_{1.PP.j}$

$$M_{IP.ij} = \hat{m}'_{3.II.i}\, M_{2.IP}\, \hat{m}_{1.PP.j}$$

Defourny-Thorbecke (D-T) decomposition

- argued that P-R has operational limitations: i.e. difficult to identify what are the *important* paths (loops) in the process

- use *structural path analysis* based on graph theory

- computes every conceivable loop in following through an exogenous injection and its resultant impact on endogenous accounts

- requires software to compute and rank all path multipliers (Direct influence, Total influence, Global influence)

- example based on SAM for Korea (EJ 1984)

Reflecting on fixed price multiplier models

- **Advantages**
  - Relatively simple to comprehend
  - Simple to compute (Excel, spreadsheet)
  - Based on structural features exhibited by base SAM
- **Disadvantages**
  - Responses at the margin might differ from those on average
  - Bottlenecks will mean multiplier effects are *overestimated*
  - Price effects might also mean effects are *overestimated*
  - Limited endogenous behaviour will mean effects are *underestimated*

SAMs: current work and in prospect

SAM construction

- mathematical balancing methods have predominated
- more work needed on basic surveys and data assembly

Design of SAMs

- current work on multipliers and the Stone phenomenon
- indicates that there is an ‘optimal’ design for distributional analysis

Environmental extensions

- environmental and satellite SAMs show much promise

Thank You

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The Leontief coefficients

Leontief, the innovator of input-output analysis, uses a special production function which depends *linearly* on the total output variables x_i. Using Leontief coefficients a_{ij}, we may manipulate our transactions information into what is known as an input-output table:

$$\begin{aligned} x_{11} &= a_{11}x_1 \\ x_{12} &= a_{12}x_2 \\ x_{13} &= a_{13}x_3 \\ x_{14} &= a_{14}x_4 \\ \vdots &= \vdots \end{aligned}$$

$$x_{ij} = a_{ij}x_j$$

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + c_1 &= x_1 \\ \vdots \qquad\qquad\qquad\qquad\quad &= \vdots \\ a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 + c_4 &= x_4 \end{aligned}$$

Next step

$$\begin{aligned} x_1 - a_{11}x_1 - a_{12}x_2 - a_{13}x_3 - a_{14}x_4 &= c_1 \\ \vdots & \vdots \\ x_4 - a_{41}x_1 - a_{42}x_2 - a_{43}x_3 - a_{44}x_4 &= c_4 \end{aligned}$$

Rewriting finally yields

$$\begin{aligned} (1 - a_{11})x_1 - a_{12}x_2 - a_{13}x_3 - a_{14}x_4 &= c_1 \\ \vdots & \vdots \\ -a_{41}x_1 - a_{42}x_2 - a_{43}x_3 + (1 - a_{44})x_4 &= c_4 \end{aligned}$$

One more step

Introducing matrix notation, we can see how a solution may be obtained. Let

$$x = \begin{pmatrix} x_1 \\ \vdots \\ x_4 \end{pmatrix}; \qquad c = \begin{pmatrix} c_1 \\ \vdots \\ c_4 \end{pmatrix};$$

$$I = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}; \qquad A = \begin{pmatrix} a_{11} & \cdots & a_{14} \\ \vdots & \ddots & \vdots \\ a_{41} & \cdots & a_{44} \end{pmatrix};$$

denote the total output vector, the final demand vector, the unit matrix and the input-output matrix, respectively.

Key result

$$
\begin{aligned}
Ax + c &= x \\
(I - A)x &= c \\
x &= (I - A)^{-1}c
\end{aligned}
$$

SAM equations

Production Account: $Q + M + T_I = U + F + I + X + G$

Consumption Account: $U + V + T_B = Q + D + H$

Capital Accumulation Account: $I + D + L + B = S + S_G + S_F$

"Rest of World" Account: $X + H + S_F = M + O + L$

Government Account: $G + P + S_G = T + B + T_B + T_I$

Household Account: $P + W = F + T + S + O$

Value Added Account: $V = W$

More applications of multiplier analysis ...

Ghana

- example of the Pyatt-Round decomposition to examine structure, using Stone additive method

- confirmed the Stone phenomenon

Korea

- Defourny-Thorbecke structural path analysis

- indirect effects may produce significantly larger impacts than direct (elementary) paths

More applications of multiplier analysis ...

Indonesia

- Keuning & Thorbecke used SAM multiplier analysis to trace through effects of government budget retrenchment (i.e. negative effects)

- ten household groups, effects on income distribution more sensitive to exogenous shocks

- also build in loss of imputed benefits due to reduction in health and education