Module 3: Input-Output Analysis

- Overview
- Background
- Foundation
- Key Components of Input-Output Analysis
- Advantages and Challenges of Using Input-Output Analysis

As part of this module you will ….

- Learn to identify different components of input-output analysis
- Understand how input-output analysis can help industry better identify impacts of regulations given specific inter-industry interactions
- Understand how to use multipliers to estimate impacts to industry sectors
- Identify data needed for input-output analysis
- Learn the benefits and limitations of input-output analysis

Overview

Input-output overview

- Input-output tables provide an accounting framework structure that is representative of a regional economy **describing flows to and from industries, institutions, and households**
  - Industries purchase from other industries
  - Industries sell to other industries
  - Industries sell outside the local economy
  - Industries buy from outside the local economy
- Transparency of the framework **helps us track the flow of money** between entities
- Input-output analysis can be used to measure impacts to overall economic activity resulting from changes in policy or regulations

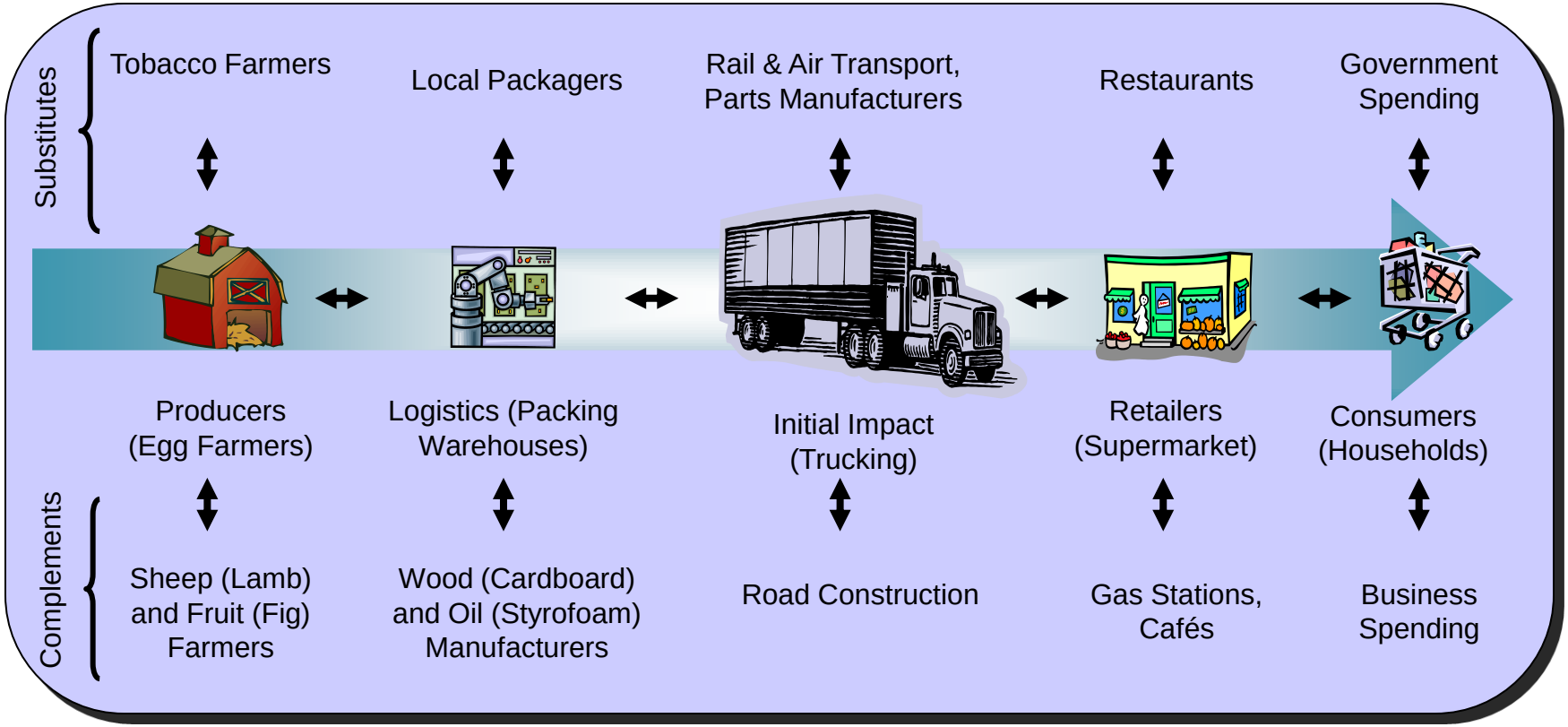
Input-output analysis augments traditional Cost Benefit Analysis (CBA)

- Traditional CBAs can only address visibly ***known*** (Direct) impacts and tend to ignore secondary and tertiary impacts
  - **Direct Impacts** are changes in the industry used to describe the events being analyzed

- Input-output analysis augment this process to capture comprehensive effects to include indirect and induced impacts
  - **Indirect impacts:** e.g., reflect changes in inter-industry purchases as they respond to the new demand of the directly affected industries
  - **Induced impacts:** e.g., reflect changes in spending from households as income/population increase/decreases due to changes in production

- Some practical uses include:
  - **Descriptive**: Can reveal knowledge about the relationships that make up an area's economy that would be impossible to obtain otherwise
  - **Forecasting**: Estimate total impact of policy changes
  - **Assessment**: Evaluate and assess specific goals, scenarios, etc.

For example, we can assess impacts across a product's supply chain using input-output analysis especially unintended costs or benefits



Background

History of input-output analysis

- **François Quesnay** (1694-1774), a French physician turned economist was the first to use a type of IO system to describe the economy
  - *Le Tableau Économique* (1758), contained an early, much less sophisticated version of a multi-sector input-output system
  - Show diagrammatically the flow of money in a primarily agrarian economy
- Wasn't until the late 1930's that **Wassily Leontief** (1906-1999), a Russian-born American economist, developed the analytical framework that would become modern input-output analysis
  - He was awarded the Nobel Prize in Economic Science in 1973 for this substantial contribution to the field of economics
- Input-output analysis has been around for nearly **70 years** and is a core methodology used in the worldwide research community
  - Recently there seems to have been a notable increase in the use of input-output tables in empirical analyses addressing a wide range of **policy issues**
  - This is partly due to the improved availability and quality of national input-output tables as well as modern IT capabilities allowing more complex analyses

Input-output analysis defined

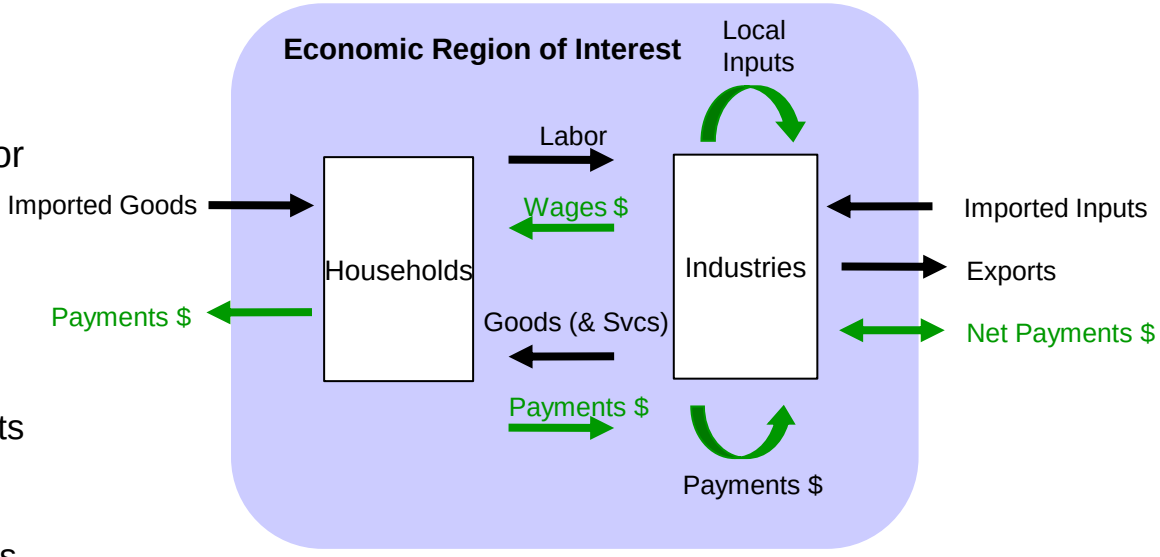
- *Basic*:
  - Large tables of data that describe the interconnectedness of industries, households, and government entities in an economy where the **output** of an industry will appear as the **input** to other industries
  - This helps us to track the flow of money in a **production process or supply chain**
- *Complex*:
  - Input-Output Analysis can describe both the transactions between the region and the rest of the world among activities within the region
  - These models produce a multiplier index that **measures** the total effect or impact of an increase in demand on employment or income
  - They can be used for **predicting** and **forecasting** the impacts of potential **future performance** of a regional economy and changes in inter-industry transactions

- Stimson, R.J., Stough, R.R., Roberts, B.H. (2002) **Regional Economic Development: Analysis and Planning Strategy**
- Springer-Verlag Berlin Heidelberg

Foundation

Input-output models track purchases of and expenditures of goods and services

- Changes in purchases of goods and services for final consumption drive the analysis
- Each industry that produces goods and services generates demands for other goods and services
- ***Multipliers*** describe these interactions
  - **Direct effects**: changes in the industry used to describe the events being analyzed
  - **Indirect effects**: e.g., reflect changes in inter-industry purchases as they respond to the new demand of the directly affected industries
  - **Induced effects**: e.g., reflect changes in spending from households as income/population increase/decreases due to changes in production



Multipliers inform us on how much of an increase in total regional income (or sales, jobs) to expect as a result of each additional dollar of sales or income etc.

General structure of an input-output model used for analysis

- Intermediate demand: Quadrant I represents flows of products, which are both produced and consumed in the process of production of goods
  - These flows are called *inter-industry flows or intermediate demand*

		Intermediate demand															Final demand											
		1	2	3	4	5	6	7	8	9	10	11	12	13	Sub-total	a	b	c	d	e	f	Subtotal	g	h	k	l
Intermediate Inputs	01 Agriculture, forestry and fishery	15585	5	84272	1521	0	90	0	1	21	0	21	13317	0	114832	912	38747	0	1935	7737	720	50051	164883	−21186	143697	27953
	02 Mining	2	35	73572	6739	20192	0	0	0	0	0	6	40	10	100597	−4	−67	0	−47	−111	109	−120	100477	−86691	13787	−86806
	03 Manufacturing	24627	931	1228672	215789	16803	31926	12629	1622	60937	4619	28966	282348	3837	1913708	33376	615966	4592	397219	−6354	465864	1510663	3424371	−342759	3081612	1134528
	04 Construction	809											13804	0	89792	0	0	0	683313	0	0	683313	773105	0	773105	683313
	05 Electricity, gas and water supply	919											54850	667	181024	50	80829	7852	0	0	310	89040	270064	−20	270044	88970
	06 Commerce	6659											83464	841	345688	19205	458620	45	106602	1174	44917	630563	976250	−6774	969476	604584
	07 Finance and insurance	5025											58349	9558	276382	3	104860	0	0	0	3955	108818	385200	−3705	381495	105110
	08 Real estate	61											26690	493	91278	0	567048	178	0	0	30	567255	658533	−7	658527	567248
	09 Transport	6193											41989	2081	305255	5430	147333	−419	7388	321	42608	202660	507915	−28846	479069	168385
	10 Communication and broadcasting	120											48510	1180	141987	2219	77931	0	0	0	522	80672	222659	−1264	221395	77189
	11 Public administration	0	0	0	0	0	0	0	0	0	0	0	0	7088	7088	0	7352	347820	0	0	0	355171	362259	0	362259	355171
	12 Services	2136	624	230602	63979	27543	63452	49975	17041	66840	36407	27588	192686	3499	782372	130522	710919	496995	103711	0	15626	1457774	2240145	−47869	2192276	1279383
	13 Activities not elsewhere classified	811	204	16686	3078	1439	6269	2571	2702	1909	1016	179	7179	0	44045	0	364	0	0	0	206	569	44614	−2491	42123	−1922
	Sub-total	62949	7221	2015303	408523	117156	283110	121233	92129	250145	88483	95313	823226	29255	4394046	191712	2809902	857062	1300121	2767	574867	5736431	10130476	−541612	9588865	5003107
	[illegible] outside households	973	692	56080	12883	5406	23417	12545	2261	10128	13575	6041	46765	946	191712											
Gross Value Added	Operating surplus	46707	1560	168599	14004	35107	99802	90169	296311	25935	15438	0	167220	4384	965237											
	Depreciation of fixed capital	14972	1238	166769	40591	50306	48018	34324	206675	30462	38096	94791	203001	4257	933500											
	Indirect taxes	7137	686	149749	32552	17444	44886	14692	39536	16471	7283	604	68766	587	400393											
	(Less) Current subsidies	−1795	−99	−5975	−3402	−2530	−2323	−16400	−2046	−2148	−79	0	−15097	−22	−51915											
	Sub-total	80748	6566	1066309	364582	152888	686367	260262	566397	228924	132912	266946	1369050	12868	5194819											
Domestic production		143697	13787	3081612	773105	270044	969476	381495	658527	479069	221395	362259	2192276	42123	9588865											
(Ref)	Net domestic product at factor cost	59461	4048	699686	281959	82262	572370	215100	319972	174011	74036	165510	1065615	7100	3721129											
	Gross domestic product	79776	5874	1010229	351699	147482	662950	247717	564137	218796	119336	260905	1322286	11922	5003107											

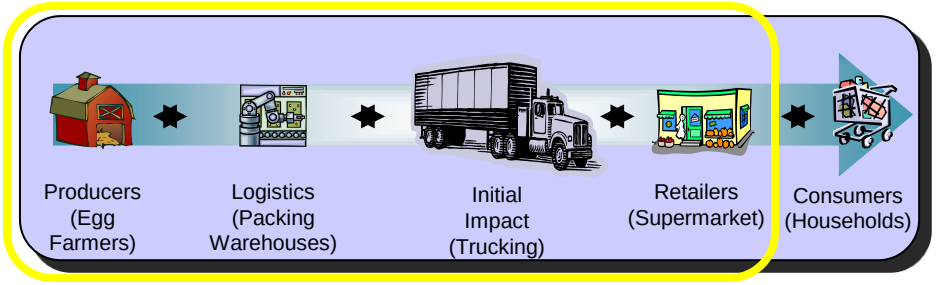
Notes :

Quadrant I – Intermediate Demand

Total Output

Total Input

Column Codes are:
- a : Consumption expenditure outside households
- b : Consumption expenditure (private)
- c : Consumption expenditure of general government
- d : Gross domestic fixed capital formation
- e : Increase in stocks
- f : Exports
- g : Total demand
- h : (Less) Imports
- k : Domestic production
- l : Gross domestic expenditure



General structure of an input-output model used for analysis

- Final demand: Quadrant II contains data of *final demand for the output of each producing* industry, i.e. demand of non-industry consumers like households, government or exports
  - Final demand is the demand for goods, which are *not used* to produce other goods (as opposed to intermediate demand)
  - Final demand columns show the sales by each industry to a final market, such as consumption, investment, government purchases, and net exports

		Intermediate demand														Final demand										
		1	2	3	4	5	6	7	8	9	10	11	12	13	Sub-Total	a	b	c	d	e	f	Sub-Total	g	h	k	Y
Intermediate Inputs	01 Agriculture, forestry and fishery	15585	5	84272	1521	0	90	0	1	21	0	21	13317	0	114832	912	38747	0	1935	7737	720	50051	164883	−21186	143697	27953
	02 Mining	2	35	73572	6739	20192	0	0	0	0	0	6	40	10	100597	−4	−67	0	−47	−111	109	−120	100477	−86691	13787	−86806
	03 Manufacturing	24627	931	1228672	215789	16803	31926	12629	1622	60937	4619	28966	282348	3837	1913708	33376	615966	4592	397219	−6354	465864	1510663	3424371	−342759	3081612	1134528
	04 Construction	809	91	12871	1990	12587	5482	1503	28433	4791	1739	5691	13804	0	89792										5	683313
	05 Electricity, gas and water supply	919	431	63383	5393	16233	12262	2258	2195	8883	3183	10367	54850	667	181024										4	88970
	06 Commerce	6659	233	162559	49429	3919	14131	1909	627	16449	957	4511	83464	841	345688										6	604584
	07 Finance and insurance	5025	660	40186	8644	7612	49277	28720	32983	29330	5035	1001	58349	9558	276382										5	105110
	08 Real estate	61	123	8928	2691	2242	28616	6091	4078	7036	3762	466	26690	493	91278										7	567248
	09 Transport	6193	3794	82386	39884	7157	46409	7283	1465	50343	5042	11229	41989	2081	305255										9	168385
	10 Communication and broadcasting	120	90	11184	9386	1428	25196	8293	982	3606	26722	5288	48510	1180	141987										5	77189
	11 Public administration	0	0	0	0	0	0	0	0	0	0	0	0	7088	7088	0	7352	347820	0	0	0	355171	362259	0	362259	355171
	12 Services	2136	624	230602	63979	27543	63452	49975	17041	66840	36407	27588	192686	3499	782372	130522	710919	496995	103711	0	15626	1457774	2240145	−47869	2192276	1279383
	13 Activities not elsewhere classified	811	204	16686	3078	1439	6269	2571	2702	1909	1016	179	7179	0	44045	0	364	0	0	0	206	569	44614	−2491	42123	−1922
	Sub-total	62949	7221	2015303	408523	117156	283110	121233	92129	250145	88483	95313	823226	29255	4394046	191712	2809902	857062	1300121	2767	574867	5736431	10130476	−541612	9588865	5003107
	outside households	973	692	56080	12883	5406	23417	12545	2261	10128	13575	6041	46765	946	191712											
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	Depreciation of fixed capital	14972	1238	166769	40591	50306	48018	34324	206675	30462	38096	94791	203001	4257	933500											
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	Sub-total	80748	6566	1066309	364582	152888	686367	260262	566397	228924	132912	266946	1369050	12868	5194819											
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(Net)	Net domestic product at factor cost	59461	4048	699686	281959	82262	572370	215100	319972	174011	74036	165510	1065615	7100	3721129											
	Gross domestic product	79776	5874	1010229	351699	147482	662950	247717	564137	218796	119336	260905	1322286	11922	5003107											

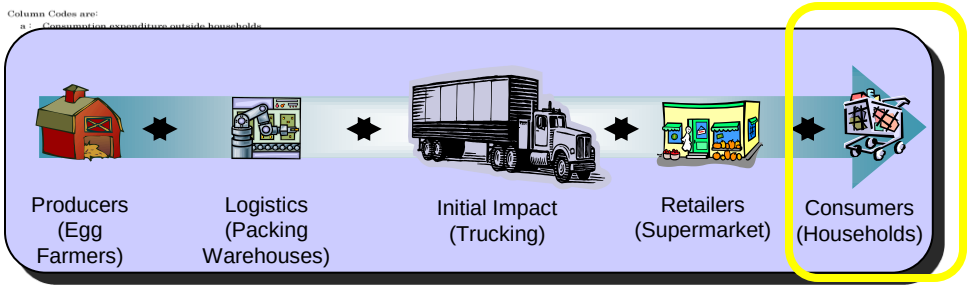
Notes :

Total Input

Quadrant II – Final Demand

Total Output

Column Codes are:
a : Consumption expenditures outside households



General structure of an input-output model used for analysis

- A full input-output model also includes additional value added rows: **Quadrant III**
  - Value added rows include information about the non-industrial inputs of production, such as labor

		Intermediate demand														Final demand											
		1	2	3	4	5	6	7	8	9	10	11	12	13	Sub-total	a	b	c	d	e	f	Sub-total	g	h	i	j
Intermediate Inputs	01 Agriculture, forestry and fishery	15585	5	84272	1521	0	90	0	1	21	0	21	13317	0	114832	912	38747	0	1935	7737	720	50051	164883	−21186	143697	27953
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	11 Public administration	0	0	0	0	0	0	0	0	0	0	0	0	7088	7088	0	7352	347820	0	0	0	355171	362259	0	362259	355171
	12 Services	2136	624	230602	63979	27543	63452	49975	17041	66840	36407	27588	192686	3499	782372	130522	710919	496995	103711	0	15626	1457774	2240145	−47869	2192276	1279383
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	Sub-total	62949	7221	2013303	408523	117156	283110	121233	92129	250145	88483	95313	823226	29255	4394046	191712	2809902	857062	1300121	2767	574867	5736431	10130476	−541612	9588865	5003107
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	Indirect taxes	7137										604	68766	587	400393											
	(Less) Current subsidies	−1795										0	−15097	−22	−51915											
	Sub-total	80748										569946	1369050	12868	5194819											
Domestic production		143697										662259	2192276	42123	9588865											
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- f : Exports
- g : Total demand
- h : (Less) Imports
- k : Domestic production
- l : Gross domestic expenditure

Quadrant III – Value Added

Total Input

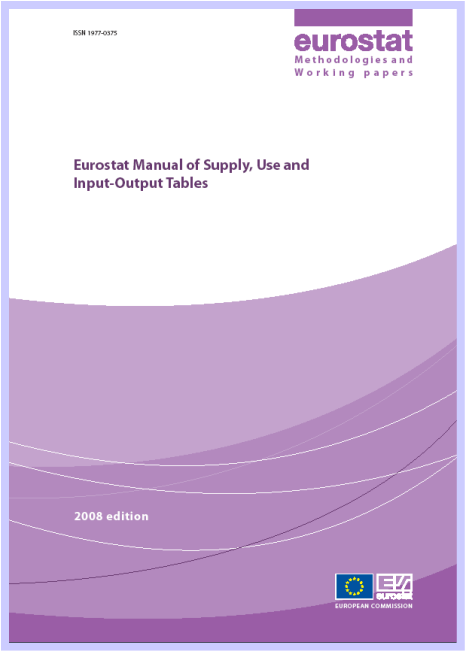
Total Output

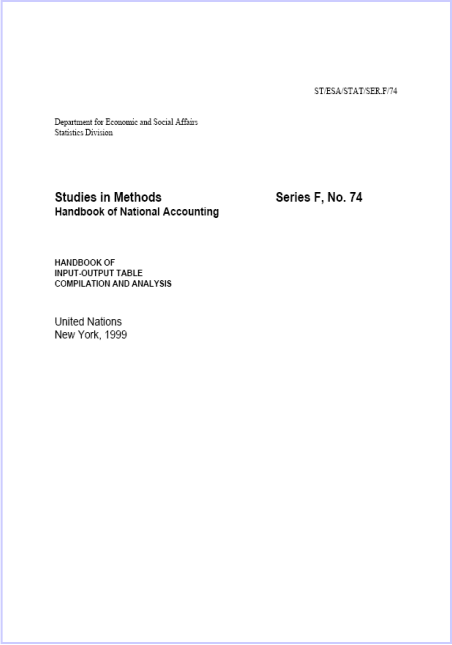
Key assumptions of input-output models

- **Constant returns to scale**
  - Production functions (an industry's list of expenditures) are assumed to have constant returns to scale
  - Production functions are considered linear; if additional output is required, all inputs increase proportionately
- **No supply constraints**
  - Supplies are assumed to be unlimited
  - Industry has unlimited access to raw materials and its output is limited only by the demand for its products
- **Fixed commodity input structure**
  - Price changes do not cause a firm to buy substitute goods
  - This structure assumes that changes in the economy will affect the industry
- **Homogenous (same production) sector output**
  - The proportions of all the commodities produced by that industry remain the same, regardless of total output
  - An industry wont increase the output of one product without proportionately increasing the output of all its other products
- **Industry technology assumption (same technology)**
  - Assumes the industry uses the same technology to produce all its products
  - The industry has a primary or main product and all other products are byproducts of the primary product

For more detailed input-output analysis information…

- European Union IO Manual
- United Nations IO Handbook





Key Components of Input-Output Analysis

There are three basic components of input-output models

- Transactions Table: shows the **monetary** flows of goods and services in a local economy
  - Total outlays = Total output
  - Intermediate purchases - goods and services purchased and used in the local production process
  - Final demands - purchases for final consumption
  - Final payments - payments for inputs outside intermediate production process
- Direct Requirements Table: the **purchases** of resources (inputs) by a sector from all sectors to produce one dollar of output
  - Creates a production “recipe”
- Total Requirements Table: the **multipliers** are drawn from this table

Transactions Table with households of a simple three sector economy

Selling Sectors ($ million)	Purchasing Sectors ($ million)					
	Agriculture	**Health**	**Services**	**Households**	**Final Demands**	**Total Output**
Agriculture	**10**	**6**	**2**	**2**	**16**	**36**
Health	**4**	**4**	**3**	**10**	**16**	**37**
Services	**6**	**2**	**1**	**7**	**28**	**44**
Households	**3**	**6**	**10**	**0**	**0**	**19**
Final Payments	**13**	**19**	**28**	**0**	**0**	**60**
Total Input	**36**	**37**	**44**	**19**	**60**	**196**

Direct Requirements Table of a simple three sector economy

Selling Sectors	Purchasing Sectors: Agriculture	Health	Services
Agriculture	**0.278**	**0.162**	**0.045**
Health	**0.111**	**0.108**	**0.068**
Services	**0.167**	**0.054**	**0.023**
Final Payments	**0.444**	**0.676**	**0.864**
Total	**1.000**	**1.000**	**1.000**

Total Requirements Table with households of a simple three sector economy

Selling Sectors	Purchasing Sectors: Agriculture	Health	Services	Households
Agriculture	1.536	0.369	0.197	0.429
Health	0.386	1.370	0.318	0.879
Services	0.388	0.256	1.203	0.619
Households	0.279	0.311	0.341	1.319
Total	2.589	2.307	2.059	3.245

For example: Given a $1.00 change in final demand sales in agriculture in the local economy, the total direct, indirect, and induced impacts are $2.589

Multipliers are useful to inform the magnitude of a potential policy implications

Selling Sectors	Purchasing Sectors: Agriculture	Health	Services	Households
Agriculture	**1.536**	**0.369**	**0.197**	**0.429**
Health	**0.386**	**1.370**	**0.318**	**0.879**
Services	**0.388**	**0.256**	**1.203**	**0.619**
Households	**0.279**	**0.311**	**0.341**	**1.319**
Total	**2.589**	**2.307**	**2.059**	**3.245**

- The total multipliers are different for each sector where “households” reflect the **largest** multiplier and “services” has the **smallest** multiplier
- Multipliers are specific to each sector as supply chain, inputs to production, and labor differ from sector to sector
- These multipliers represent the total (direct, indirect, and induced) impacts of a change in final demand for any of the three sectors

Caution when using multipliers

- Multiplier values **include** direct effects
- Cannot aggregate **sector** multipliers to derive an aggregate multiplier
- Be cautious of large multipliers – check the calculations or data
- Be cautious in using a multiplier from an other study area
  - e.g. cannot use Lebanon's multipliers for Egypt

Advantages and Challenges of Using Input-Output Models

Advantages and challenges of using input-output models

- **Advantages**
  - Provides descriptive analytical power with predictive capabilities by:
    - Presenting an extensive quantity of information in a concise, orderly, and easily understood fashion
    - Providing a comprehensive picture of the inter-industry structure of an economy
    - Highlighting key, strategic importance of various industries and sectors
    - Highlighting possible opportunities for strengthening income and employment

- **Challenges**
  - *Data needs* and *complexity*: IO models are *tremendously complex* and *very data hungry*. This typically places these models in the hands of experts
  - *Time/Data issues*: Usually a single year's data are used to develop the Total Requirements Table; however, purchases may actually reflect a longer term investment and short term trends may impact the data
  - *Restrictions of assumptions*:
    - Technology changes, prices change, and demand changes, all affecting the explanatory power of the Total Requirements Table
    - Assumes a linear relationship between increasing demand for inputs and outputs which assumes away possibility of externalities and increasing/ decreasing returns to scale
    - Assumption that each industry has a single, homogeneous production function and each produces one product which may not reflect the real economy accurately

As part of this module you learned….

- How to identify different components of input-output analysis
- How input-output analysis can help industry better identify impacts of regulations given specific inter-industry interactions
- How to use multipliers to estimate impacts to industry sectors
- To identify data needed for input-output analysis
- The benefits and limitations of input-output analysis

Given the limitations of input-output analysis, econometric models can be used to supplement

- **There are challenges and limitations in using I-O analysis**
  - input-output analysis is **one of the methods** which can be used to assess the impact of change in the economy or a regulation at a certain time
  - input-output analysis is **static** (results can only be attained for one year at a time), and is incapable of looking accurately at changes over time
  - at times of significant changes in the global economy, or one country's economy, this can present a major challenge in obtaining accurate estimates of impacts
- **Econometric models can help**
  - Dynamic macroeconomic models can complement by **capturing comprehensive effects more accurately as they do so over time** to allow analysts to think through the less obvious interconnections associated with regulations