## Input Output Analysis

## A Tool for Modeling the Economic Impacts of Regional Biomass Feedstock Production

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### Goals

- Briefly explain input-output models as a class - basics, strengths, weaknesses
- Introduce major "off the shelf" modeling options; focus on Minnesota IMPLAN Group's product
- Discuss applications for regional biomass feedstock production

## What is basic I-O analysis?

- A quantitative estimate of change in the levels of economic activity throughout a regional economy that occurs as a result of assumed - often policy driven - changes in the levels one or more individual economic activities.
- Changes are usually measured in politically salient units: dollars of output, returns to business owners, income to labor, JOBS, even tax revenues
  - Typical headlines based on I-O studies
    - "Superhospital Study Projects \$28-million Annual Gain"
    - "University Study Shows California Parade To Be Economic Gem"
    - "Power Project Would Employ 700, Have a Huge Economic Impact"
  - Typical goal of (nonacademic?) I-O study sponsor
    - Headline using phrase "huge economic impact"

## What is basic I-O analysis? (II)

- Starts from empirical, quantitative summary measurements of the way goods and services in an economy are *produced* and *consumed* by each sector of the economy.
- Measures these relationships as the amount of the *inputs from* each economic sector that are used to produce the *outputs of* each economic sector.
  - Measurement can be in physical units, but is generally measured as a dollar amount (price times a physical quantity).
  - So far, strictly descriptive no behavioral/theoretical assumptions

## What is basic I-O analysis? (III)

- Transformation from descriptive set of double entry bookkeeping accounts into an impact model when simplistic but useful assumptions are made
  - The empirical ratios of inputs to outputs, which reflect production technologies at a given point in time, are assumed to be stable or unchanging as selected levels of economic activity are decreased or increased
  - Some users or consumers of goods and services are assumed to be exogenous to the economy being modeled (e.g. export purchasers) and to "shock" the regional economy by changes in their level of "final demand" for one or more goods and services
  - Still no behavioral assumptions like utility/profit maximization)
- Enables calculation of *economy wide* changes resulting from *sector specific, exogenously determined,* shocks to be calculated through the solution of a set of simultaneous linear equations

### Transactions Table

#### > I/O Tables - Transactions

Transactions Table (\$millions)

**Purchasing Sectors** 

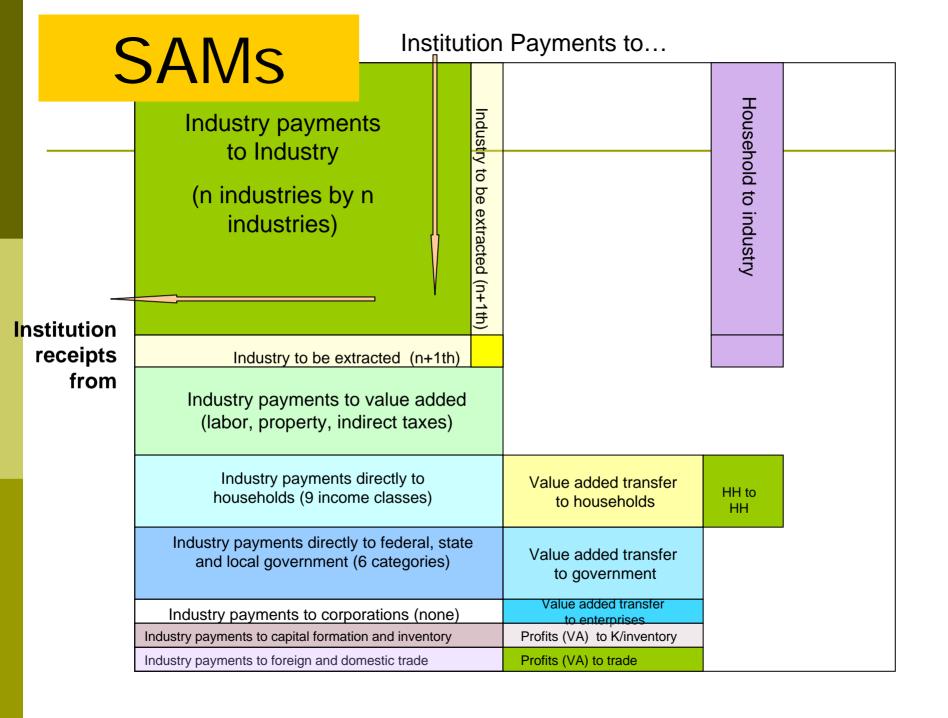
Processing				Final	Total
Sectors	<b>Agriculture</b>	Manufacturing	Services	Demand	Output
Agriculture	10	6	2	18	36
Manufacturing	4	4	3	26	37
Services	6	2	1	35	44
Payments	16	25	38	0	79
Total Outlay	36	37	44	79	196

## Interindustry: Direct Requirements Coefficients

## > I/O Tables - Direct Requirements

Direct Requiren	nents Table						
·	Purchasing Sectors						
Processing Sectors	Agriculture	Manufacturing	Services	Final Demand	Total Output		
Agriculture	.27778	.16216	.04545				
Manufacturing	.11111	.10811	.06818				
Services	.16667	.05405	.02273				
				•	spent on input by agriculture,		
Payments	.44444	.67567	.86363		n ag inputs,		
Total Outlay	1.0	1.0	1.0	\$0.11 on manufacturing, \$0.17 on services, and			
				•	payments to s"/factors of		

production (eg labor, proprietors,gov't)





### What's in an IMPLAN<sup>©</sup> Data File

- For 9 Household Institutions:
  - <u>Personal Consumption Expenditures</u> (for 509 commodities)
- For 4 Government Institutions:
  - Government Consumption Expenditures (Federal Military & Non-Military, State & Local Government, Education & Non-Education for 509 commodities)
- For 4 Investment Institutions:
  - <u>Capital Formation & Inventory Additions</u>, <u>2 Government</u>
     <u>Investments</u> (for 509 commodities)
- For All Institutions:
  - Institutional Sales (HH used goods, Government sales sales of inventory)

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## What's in an IMPLAN© Data File (continued)?



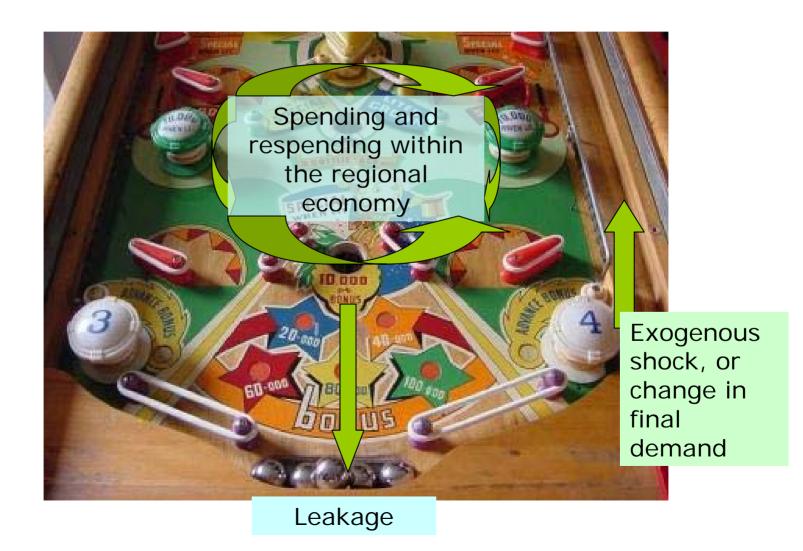
- □ Foreign Trade (with foreign countries):
  - Foreign Imports & Exports (for 509 commodities)
- Domestic Trade (within the US):
  - Regional Purchase Coefficients (econometric equations to estimate rate of local purchase of 509 commodities) – IMPLAN Version 2
  - Domestic Imports & Exports (estimated using MIG, Inc. National Trade Flow Model for 509 commodities among 3142 US counties)

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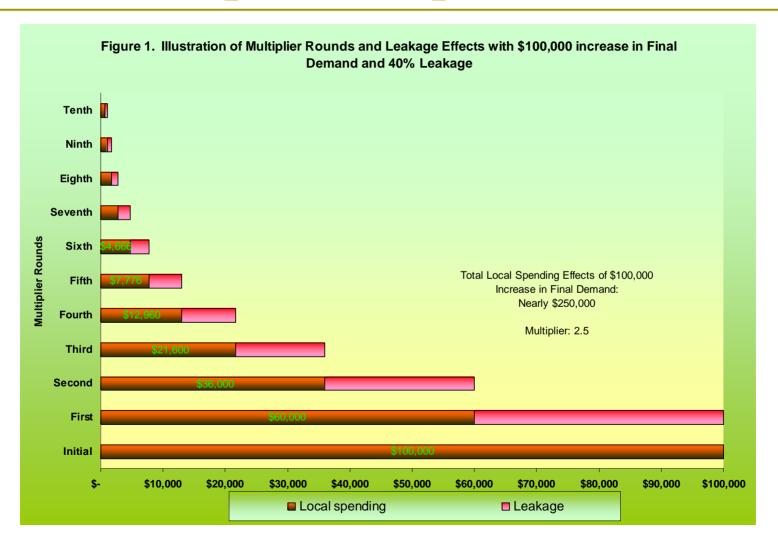
## Key Concepts in Impact Analysis

- changes in final demand
- The chain of spending and respending that is set into motion by an initial economic stimulus.
- "leakage" from a local economy when some purchases are spent on nonlocal goods and services or are not spent at all (savings)

## Key Concepts in Impact Analysis



## Key Concepts in Impact Analysis



## Input Output Strengths/Cautions

#### Basic I-O's strengths are

- ability to capture the extent of inter-connectedness, or linkages, between sectors (highly disaggregated) of the economy
- ability to calculate how a change in one part of the economy works its way through the rest of the economy
- conceptual simplicity/low cost (hundreds and thousands of \$)

#### Selected cautions

- Assumes average production relations, when marginal changes may deviate from average
- Linearity assumes production functions independent of scale
   infinitely elastic supplies (prices don't go up with demand)
- Better at analyzing small/marginal changes than large changes that shift prices and cause technology substitutions
- Static, single period, rather than dynamic feedbacks

## Off the shelf basic I-O data and modeling systems

Basic Input Output models – regional models adapted from national I-O surveys rather than costly primary data collection

- MIG/Implan
  - Analyst buys data for region/regions, and software system, then builds and manipulates models, offers full analytic flexibility
- RIMS BEA
  - Analyst purchases only output (multipliers) from a single model, uses this to calculate impacts

## Off the shelf more sophisticated models with I-O cores

- REMI's Policy Insight® and TranSight®
  - More sophisticated, more comprehensive, more theoretically satisfying, more costly – probably more accurate for *large* changes
    - dynamic model (year-by-year endogenous analysis)
    - I-O supplemented with Computable General Equilibrium (CGE), econometric estimations, and the New Economic Geography theory (agglomeration effects)

## ■ GTAP

 Ditto much of the above; a global computable general equilibrium model built on multiple national I-O data; uniqueness is capacity to model trade, international economic linkages

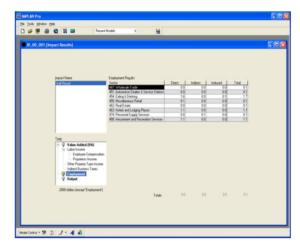
### IMPLAN© is used for

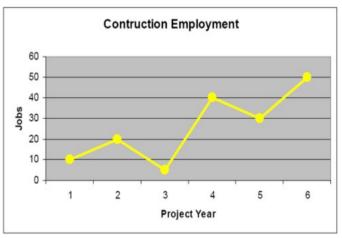


## ...Evaluating Economic Impacts

- Frame the issue
- Use IMPLAN® to estimate the distribution of economic impacts
- Evaluate the consequences of an issue/policy change

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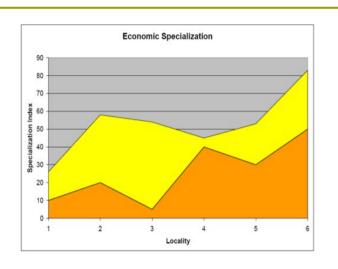




## IMPLAN© is used for



## ... Understanding Economies

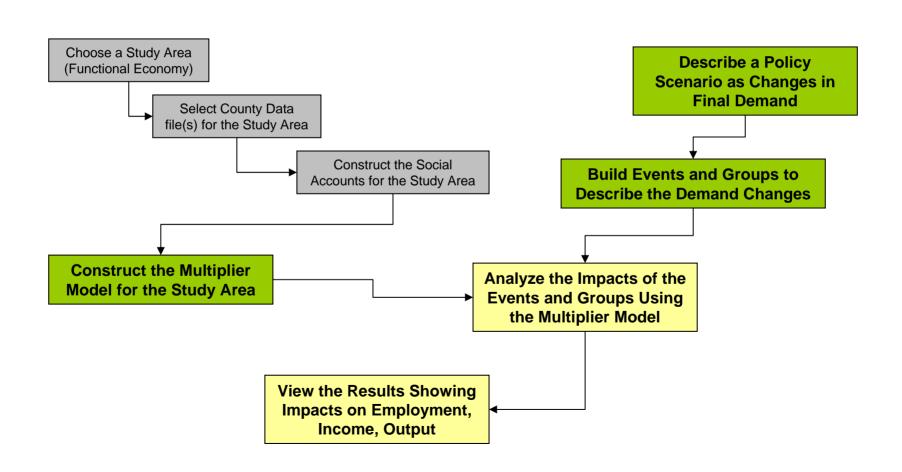




- Given sectors or policy of interest, investigate...
  - Economic Specialization & Diversity, Income Distributions
  - Backward and Forward Linkages
  - Keystone Sectors, Industrial Clusters
  - Trade Flows, Commuting Patterns, Balance of Payments



## Creating and Using a Multiplier Model





# IMPLAN© and Biomass Impacts

Suggestions for Impact Analysis

## Info Needed about the Bio-Fuel Firn



#### Input Budget/Production Function for Bio-Fuel Firm

- Sometimes possible to use IMPLAN sector to approximate an alternative fuels firm (eg, Distillery sector proxy for Ethanol plant)
- Otherwise use plant operations budget to create IMPLAN Group (materials inputs budget)
  - E.g. Analysis of the economic impacts from ethanol production in three New York State regions. Final report, Batista, J.C.; Boisvert, R.N.; Kalter, R.J. Nov 1982.
    - The study`s input-output analysis suggests that investment in a small cheese whey-ethanol plant would generate far more local employment, per gallon of annual capacity, than a large corn-based plant which would rely more heavily on feedstocks from the outside region.
    - In addition, a cheese whey ethanol plant`s impact on dairies in the region would have a greater effect on the local economy than the ethanol plant itself.

#### Biomass Inputs

- Typical focus on biomass input in physical units (eg, m³ of wood) with price per unit
- Cost/price of "green" biomass may vary by land ownership (eg, public vs private timber tracts) and/or tree species
- Total Sales from Production
- Payrolls
- Corporate Income
- Employment

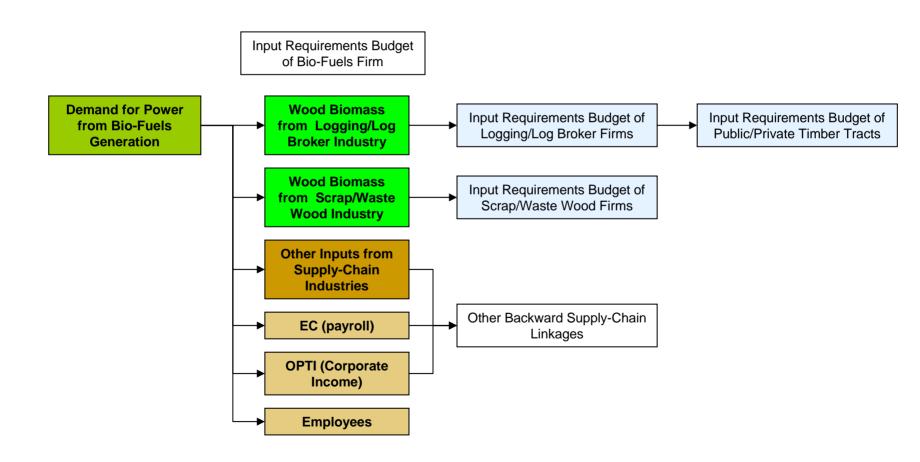


## Impact Analysis Considerations

- Separate the impacts of plant construction from the plant operations impacts
- Usually best to use IMPLAN "Analysis-By-Parts" protocol for Plant Operations, analyzing 3 "Parts":
  - Materials Inputs part
  - Payrolls part
  - Corporate income part
- Usually best to model the impacts of each of the firms in the biomass supply-chain separately, for example:
  - Wood Bio-Fuel Power Generation
  - Logging/Log Brokers
  - Timber Tracts by Ownership (and/or species, and/or Location)



## Stylized Backward Linkages (input purchases), Power Generation from Wood Biomass



## GIS and I-O Compatibility

- E.g. use GIS, other tools to determine the local feedstock that might be available for fuels that could displace electricity/fossil fuel imports to a region
- Use I-O to model economic impacts (e.g. jobs) associated with local production (import substitution)
- C.f. "Development of a Spatially Explicit Land Use/Economic Impact Assessment Tool" (Thurau et al. 2004)
  - Estimated current biomass production value by estimating farm/forest biomass yields by soil and crop/tree type at pixel level, multiplying by net income, aggregating to region. Redistributed land to different (income maximizing, could have been linked to energy development) crop/forest management scenario. Compared regional economic impacts of biomass production under current and income maximizing scenarios.