Linking MARKAL/TIMES with REMI Policy Insight

IEA-ETSAP
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Presentation Outline

- Short Description of REMI and Its Use
- REMI-Energy Concept and Organization
- R2M Linkage Approach
- M2R Linkage Approach
- Status and Plans
**REMI Key Model Features**

- Includes all inter-industry linkages
- Is based on Economic Theory
- Includes New Economic Geography Theory
- Is calibrated and estimated using data for the region(s) being modeled
- Is dynamic and simulates the timing of economic impacts
- Is the leading Policy Analysis model in the U.S.

**Short Description of REMI**

The REMI-PI model integrates aspects of several economic modeling tools:

<table>
<thead>
<tr>
<th>Module</th>
<th>Aspect</th>
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<tbody>
<tr>
<td>I/O</td>
<td>Inter-industry processing sector (173X173 matrix)</td>
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<tr>
<td></td>
<td>13 consumer expenditures</td>
</tr>
<tr>
<td>CGE</td>
<td>Equilibrium ‘tendencies’ in factor and material input markets.</td>
</tr>
<tr>
<td>Econometric</td>
<td>Estimates derived from panel data</td>
</tr>
<tr>
<td>Economic Geography</td>
<td>Labor and product agglomeration. Lags in labor and plant mobility</td>
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<td>Instantaneous equilibrium of capital</td>
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</tbody>
</table>
REMI Model Linkages

REMI Model Linkages (Excluding Economic Geography Linkages)

State and Local Government Spending

(1) Output

Investment

Consumption

Real Disposable Income

(2) Labor & Capital Demand

Employment

(3) Demographic

Population

(4) Wages, Prices, and Production Costs

Employment Opportunity

Wage Rate

Real Wage Rate

Composite Wages

Composites

Deflator

(5) Market Shares

Domestic Market Share

International Market Share

Intermediate Input

Productivity

Intermediate Inputs

Commodity

Access Index

Output Block

(1) Output

Economic Geography Linkages

(2) Labor & Capital Demand

Employment

(3) Demographic and Labor Supply

Economic Migrants

(4) Wages, Prices, and Production Costs

Production Costs

Composite Prices

(5) Market Shares

Domestic Market Share

International Market Share

(1) Output

(2) Labor & Capital Demand

Employment

Commodity

Access Index

Intermediate Input

Productivity

Intermediate Inputs

(1) Output Block

Economic Geography Linkages (Cont.)
**REMI Applications - Energy**

What would be the effect of electric utility restructuring and the associated price change of electricity on the Wyoming economy?

**Policy Variables Used**
- In-state rate changes by customer class
- Export of Electricity estimates

**Key REMI Results**
- Employment, personal income, and population impacts

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**REMI Applications - Transportation**

What are the impacts of a high-speed rail link between San Diego & San Francisco?

**Policy Variables Used**
- Construction and operation spending
- Highway, conventional rail, and aviation savings
- Gasoline tax
- Housing cost change
- Consumer and government spending

**Key REMI Results**
- Effects of tax, spending, and cost changes
- Housing cost impacts drive the results
- Benefit/cost and net present value measures show feasibility
REMI Applications - Environment

What will be the effect of proposed air pollution control regulations on the Los Angeles area?

Policy Variables Used
• Cost of equipment
• Spending
• Non-pecuniary benefits of better health

Key REMI Results
• Economic effects of costs, spending, and amenities
• Employment increase and real income per capita decrease

MARKAL/TIMES Links to REMI Model Inputs

- Direct demand changes by industry for investment, operation, changes in fuel use, and maintenance from service industry
- Cost of fuel, operations, maintenance, and investment (annualized) for purchasing industries
- Direct consumption changes due to new technologies (reallocations of total shifts)
- Wages, Costs & Prices
- International imports and exports
**REMI-Energy Concept**

- 2-way linkage between REMI-Insight and MARKAL/TIMES
- REMI provides economic parameters for MARKAL/TIMES reference scenario
- MARKAL/TIMES simulates specific energy/environmental policies
- REMI calculates detailed economic impacts of MARKAL/TIMES results

**REMI-Energy Main Issues**

- Can REMI economic output be mapped to MARKAL demands?
- What parts of MARKAL output should be sent to REMI?
  - Convey all or most of MARKAL results
  - Avoid or reduce double-counting by REMI (e.g. if MARKAL calculates investments in energy techs, REMI should not further modify these investments)
- How to convey MARKAL results to REMI? (Policy variables, I/O coefficients, etc.). Devise semi-automatic interfaces between the two models
- Are iterations needed?
Components of the Linkage

- REMI-Energy “control center”
  - Oversees exchange and transformation of the outputs/inputs

- REMI-2-MT Workbook
  - R2MT Output to Sector (DM) mapping table
  - R2MT Output to Sector (DM) (de)coupling factors

- MT-2-REMI Workbook
  - MT2R technology group/mapping table
  - MT Results (from VEDA-BE)
    - Lumpsum and annualized investment
    - Operating and maintenance costs
    - Fuel expenditure
  - Relies on VEDA-BE “rules” and tables
REMI-PI Outputs to MArkAL Demands

REMI-EnergyR2M – REMI Outputs to MArkAL End-use Service Demands

Decoupling Factors
- Chemicals
- Iron and Steel
- Pulp and Paper
- Air Transport
- Marine Transport

Decoupling Factors
- Other Industrial
- Non-ferrous Metals
- Non-metal Minerals

Decoupling Factors
- 8 Residential Demands

Decoupling and Apportioning Factors
- 13 Commercial Demands
- Bus Transport
- Truck Transport
- Car Transport
- Rail Freight Transport
- Rail Passenger Transport

MARKAL Base Year Demands

MARKAL Future Year Demands

Use or Other Energy Data Source

R2M Matrix Mapping Sheet

R2M Coefficient Input Sheet

MARKAL Run Scripts

R2M Workbook

HALOA

REMI-PI Outputs to be Transferred to MArkAL {for REMI to do}

REMI PI Reference Forecast

170 Industry Categories

13 Consumption Category

170 Industrial Activity Outputs (Growth factors)

Household Budget Splits (13 categories)

Wages, Employment, Consumption, etc.

R2M Transformation Tool

Population Statistics

I/O Matrix of Coefficients

Bridge Matrix

Commodity Prices, including Final Energy Carriers

Demand Price and Other Elasticities
### Remi-2-Markal/Times Workbook – Mapping Table

<table>
<thead>
<tr>
<th>Industry Subsectors</th>
<th>Final Output Subsectors</th>
<th>MARKAL Demand Subsectors</th>
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### Remi-2-Markal/Times Workbook – Decoupling Matrix

<table>
<thead>
<tr>
<th>Group A: 1 to 1</th>
<th>R2M Decoupling Factors</th>
<th>Project</th>
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<th>Group B: Many to 1</th>
<th>R2M Decoupling Factors</th>
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<th>Group C: 1 to Many</th>
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<th>Group D: Many to Many</th>
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MARKAL/TIMES Results to REMI-PI

Reference Demands for each Energy Service

MARKAL Model Run

Anualized investment Cost for conversion, process and end-use technologies

Annual O&M cost for each conversion, process and end-use technology

Quantity of Energy carriers consumed by each conversion, process and end-use technology

Marginal Prices of Energy carriers

Resource supply Levels and Revenue

REMIEnergy

REMIEnergy M2R

REMIPolicy Variables and Other Inputs

GAMS Post-processor/VEDA-BE tables

REMIPolicy Variables and Other Inputs

REMIEnergy M2R

REMIEnergy M2R

REMIPolicy Variables and Other Inputs

MARKAL/TIMES Results to REMI_PI - Details

MARKAL Model Run

VEDA BE Tables

INVEST COST

ACINVEST

ACFuelup

ACCOM

ACRESOURCE

LRESOURCE

REMIEnergy M2R

REMIEnergy M2R

REMIPolicy Variables and Other Inputs

REMIPolicy Variables and Other Inputs

REMIEnergy M2R

REMIEnergy M2R

REMIPolicy Variables and Other Inputs

REMIPolicy Variables and Other Inputs
Current Status and Plans

- {TO BE ADDED by REMI 1st}

Final remarks

- Conceptual framework established, but full implementation pending a “client”
- Linkage to be re-assessed after experimenting current scheme
  - Harmonizing Reference Scenario assumptions
  - MARKAL outputs to send to REMI-PI
  - Need for iterations, convergence criterion