

APPENDIX B

THE REMI MODEL

Introduction

Framework of the REMI Model

Assumptions of the REMI Model

Verification of the Model

Enhancements to the Model

INTRODUCTION

At the March 17, 1989 Air Quality Management Plan (AQMP) adoption hearing, the District's Governing Board adopted a resolution calling for the incorporation of an analysis of impacted industries, range of control costs, cost-effectiveness, and public health benefits into the evaluation of economic impacts of all proposed rules. Since then, the District has provided an analysis of socioeconomic impacts for each proposed rule.

In an effort to expand socioeconomic impact assessments for proposed rules and AQMP revisions, the District has purchased a computerized economic model from Regional Economic Models, Inc. (REMI) for the counties of Los Angeles, Orange, Riverside, and San Bernardino. The structure and assumptions of the model are briefly described below.

FRAMEWORK OF THE REMI MODEL

The District's REMI model links the economic activities in the counties of Los Angeles, Orange, Riverside, and San Bernardino. The model is comprised of a standard module, a demographic/migration module, and an input-output module. The standard module has 53 industries (2-digit SIC) or 214 industries (3-digit SIC), 94 occupations, and 25 final demand sectors. The demographic/migration module captures population changes due to births, deaths, and migration; and has 202 age/sex cohorts. The input-output module contains detailed inter-industry relationships for 466 sectors. The input-output module is used to assess the detailed inter-industry effects of a policy change. The effects are then fed into the standard module to allow for the assessment of total effects.

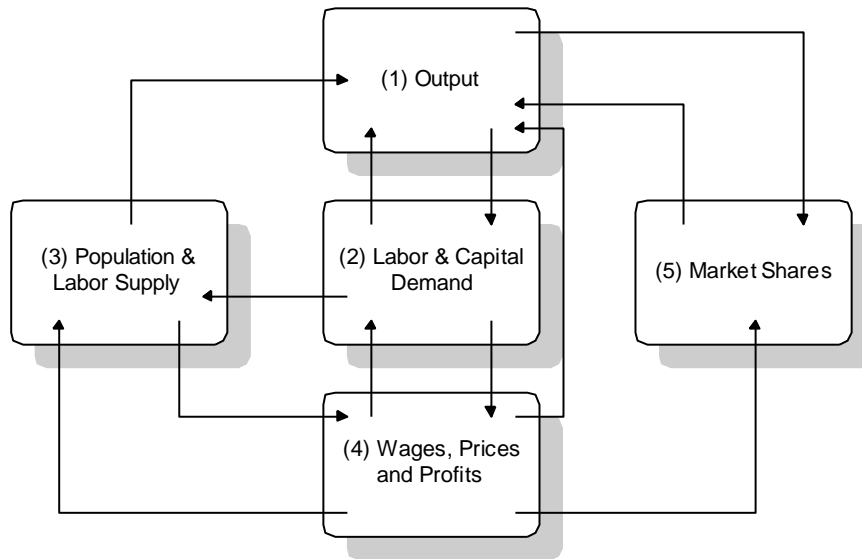
The standard module can be divided into the following five components: (1) production (output); (2) labor and capital demand; (3) population and labor supply; (4) wages, and prices, and profits; and (5) market share. These five components are interrelated and the linkages are depicted in Figure B-1.

Each component is built upon a two-step process. First, producers and consumers throughout all regions of the country have similar behavioral characteristics. Because of these similarities, statistical techniques can be used to estimate economic responses based on studies done throughout the United States. The second step of the modeling process is region specific, and involves calibration of the model based on region-specific historical data.

ASSUMPTIONS OF THE REMI MODEL

The REMI model has been built based on well-established economic theory and is updated regularly to incorporate new findings in economic theory and new historical data. Major assumptions behind the REMI model fall into the following three categories: overall, production, and population and labor. The major assumptions behind the REMI model are as follows.

FIGURE B-1
Components of REMI Model



Overall

1. Production costs, such as capital equipment, labor and fuel, are allowed to be substituted based on the changes in relative costs of these inputs to those in the United States. Total production costs are the sum of input costs weighted by their usage.
2. Location of a firm is driven by profitability.
3. All industries sell to both local and national markets. The model calculates the proportions of local demand that an industry can satisfy and its export share. Exports are divided into shipments from one county to the remaining counties (e.g., counties of Los Angeles, Orange, Riverside, and San Bernardino) and sales outside of the four-county region.
4. For pricing purposes, industries are classified as national or regional. Goods sold in national markets must be priced at the average national price to be competitive. National industries, on average, supply more than 50 percent of their output to national markets. Regional industries sell more than 50 percent of their output locally. The national industries in the model are hotels and manufacturing sectors with the exception of stone, clay, and glass; printing and publishing; and petroleum and coal products. The regional industries consist of mining, construction, finance, wholesale and retail trade, services (except hotels), and agriculture.
5. The REMI model consists of exogenous and endogenous economic variables. Values of exogenous variables are determined outside of the model. Exogenous variables are a driving force of change in the regional economy. The resulting changes are

reflected in the values of endogenous variables calculated by the model. Therefore, policy changes can be simulated by changing exogenous variables whose values are developed by District staff as inputs to the REMI model. For example, increases in demand for control equipment due to a rule can be simulated by increasing the sales of the supplier of control equipment. The impact of such a policy change includes changes in employment, among others.

6. There will be two avenues for market expansion. First, as the cost of production decreases, firms become more competitive in the export market and more competitive with imports. Second, markets are assumed to expand as a region's economy grows.

Production

1. Production costs affect regional competitiveness which impacts the shares of local and export markets. As the relative production costs increase, there will be a reduction in the proportion of local demand which can be satisfied locally as imported goods are substituted for local goods.
2. Production levels drive labor demand which interacts with labor supply to determine wage rates. Combined with other production costs, e.g., capital and fuel costs, wages determine relative production costs in the four-county region compared to the rest of the United States.
3. Production levels are determined by the total demand which consists of consumption, investment, government spending, and net exports. Employment is determined by the level of production and labor intensity, i.e., number of employees per unit of production.
4. An increase in demand will increase production by a factor greater than one because of indirect impacts.

Population and Labor

1. There are four types of migrants: international migrants, retired migrants, former military personnel, and economic migrants. These economic migrants are individuals moving to the region for employment opportunities. They respond to both economic and amenity factors.
2. The demographic section of the model predicts the number of births and deaths that occur in the population. Labor supply is derived from the indigenous labor force and potential job migrants.
3. Labor is segmented by occupation as well as by industry. Employment within an industry is translated to occupation level employment through the use of occupational skill requirements by industry.

VERIFICATION OF THE MODEL

The District's version of the REMI model was independently evaluated by the University of Pittsburgh in 1989 to determine its forecasting and simulation capabilities. The model's performance was judged to meet accepted standards of practice (Cassing and Giarratani, 1992).

ENHANCEMENTS TO THE MODEL

The District's socioeconomic assessment process is an evolving one. The assessment has expanded from impacts on directly affected industries to include employment impacts on all industries. In 1992, enhancements were made to the REMI model to allow the assessment of impacts on different income groups and on low- versus high-wage groups.

Using the nationwide median weekly earnings of full-time workers from the 1993 Current Population Survey (CPS), 94 occupations in the REMI model were ranked in ascending order of earnings and divided into five equal (quintile) groups. Table B-1 shows how the 94 civilian occupations were ranked:

TABLE B-1
 Ranking of Occupational Earnings

Occupation	Median Weekly Earnings	Quintile Group
Private Household Workers	\$187	1
Cashiers	\$226	1
Food Prep. & Service Workers	\$243	1
Textile & Related Operators	\$247	1
Farm Occupations	\$248	1
Other Sales Workers, Nec.	\$268	1
Farm Operators & Managers	\$269	1
Fishers, Hunters, & Trappers	\$269	1
Other Agricultural-related Workers	\$269	1
Non-farm Gardeners	\$273	1
Non-farm Animal Care Workers	\$277	1

TABLE B-1

(Continued)

Occupation	Median Weekly Earnings	Quintile Group
Personal Service Workers	\$279	1
Retail Salespersons	\$281	1
Counter & Rent Clerks	\$288	1
Stock Clerks, Sales Workers	\$288	1
Health Service Workers	\$289	1
Cleaning Workers	\$291	1
Other Service Workers, Nec.	\$293	1
Precision Textile, Apparel Workers	\$298	1
Hand Helpers, Laborers	\$312	2
Mail Clerks & Messengers	\$324	2
Information Clerks	\$329	2
Comb. Machine Tool Operators	\$333	2
Machine Tool Cut & Form Operators	\$333	2
Metal Fabrication Machine Operators	\$333	2
Numerical Control Machine Tool Operators	\$333	2
Woodworking Machine Operators	\$333	2
Precision Woodworkers	\$340	2
Other Precision Workers, Nec.	\$348	2
Precision Assemblers	\$348	2
Precision Food Workers	\$348	2
Precision Print Workers	\$348	2
Forestry & Logging Occupations	\$356	2
Other Clerical Workers, Nec.	\$360	2
Other Machine Operators, Nec.	\$366	2
Hand Workers	\$376	2
Non-Financial Record Processing Workers	\$376	2
Financial Record Processing Workers	\$380	2
Communication Equipment Operators	\$385	3
Secretaries, Stenographers, & Typists	\$385	3
Recording, Scheduling, and Dispatching Workers	\$392	3
Supervisors, Farm, Forest, & Agriculture	\$401	3
Metal & Plastic Machine Operators	\$410	3
Adjustment, Investment, & Collections Occupations	\$412	3
Travel Agents	\$417	3
Printing, Binding & Related Workers	\$418	3
Computer & Related Equipment Operators	\$435	3
Motor Vehicle Operators	\$437	3
Material Moving Operators	\$440	3
Other Transportation Operators, Nec.	\$447	3
Health Technicians & Technology Occupations	\$458	3
Vehicle, & Mobile Equipment Mechanics	\$475	3
Soc., Recreation, & Religious Workers	\$492	3
Construction Trades Occupations	\$495	3
Other Mechanical, Installers, Nec.	\$496	3
Water & Liquid Waste Occupations	\$505	3
Communication Equipment Mechanics, Installers	\$510	3

TABLE B-1

(Continued)

Occupation	Median Weekly Earnings	Quintile Group
Machinery & Related Mechanics, Installers	\$510	3
Protective Services Occupations	\$511	4
Precision Inspectors, Testers	\$517	4
Precision Metal Workers	\$527	4
Engineering & Science Technicians	\$550	4
Insurance Sales Workers	\$565	4
Blue Collar Workers Supervisors	\$573	4
Writers, Artists, Entertainers	\$574	4
Postal Clerks, & Mail Workers	\$585	4
Teachers, Librarians, & Counselors	\$585	4
Management Support Occupations	\$597	4
Chemical Plant & System Operators	\$600	4
Electric Power Operators, Distribution Workers	\$600	4
Gas & Petroleum Plant Workers	\$600	4
Other Plant & System Operators, Nec.	\$600	4
Elec. Equip. Mechanics, Installers	\$603	4
Real Estate Agents	\$610	4
Life Scientists	\$626	4
Mining, Quarrying Occupations	\$643	4
Oil & Gas Extraction Occupations	\$643	4
Other Extraction Occupations, Nec.	\$643	4
Other Technicians	\$658	5
Managerial and Administrative Occupations	\$664	5
Social Scientists	\$670	5
Other Professional Workers, Nec.	\$682	5
Stationary Engineers	\$682	5
Health Assessment & Treatment Occupations	\$687	5
Architects & Surveyors	\$694	5
Water Transportation Workers	\$715	5
Physical Scientists	\$722	5
Rail Transportation Workers	\$722	5
Secur. & Fin. Svcs. Workers	\$783	5
Computer, Math., and Operations Research Analysts	\$816	5
Engineers	\$911	5
Health Diagnosing Occupations	\$994	5
Lawyers	\$1164	5
Judges, Magistrates	\$1170	5

Nec. means not elsewhere classified.

In doing so, the percentage changes of a policy on each quintile of earnings can thus be reported for occupational wage rate, employment, and wage bill.

The ES-202 data (excluding self-employment) from the BLS for the four-county area provide the average annual wage per worker (full-time and part-time) for the 49 private non-farm industries at the 2-digit SIC level in the REMI model. By ranking the 49 industries in ascending order of the average annual wage per worker, we can divide them into five equal groups, as shown in Table B-2:

TABLE B-2
Ranking of Wages by Sector

Sector	SIC	Average Annual Wage	Quintile Group
Tobacco Manufacturing	21	\$8,989	1
Private Households	88	\$9,628	1
Personal Services & Repair	72,76	\$10,030	1
Real Estate	65	\$10,506	1
Eating & Drinking Places	58	\$10,844	1
Agri., Forest, Fish.,Hunt. Services	07-09	\$11,770	1
Rest of Retail	52-57,59	\$15,849	1
Apparel	23	\$16,615	1
Auto Repair/Services/Parking	75	\$16,783	1
Amusement & Recreation	79	\$16,941	1
Hotels	70	\$17,695	2
Local Transit/Interurban Transport.	41	\$17,775	2
Construction	15-17	\$17,803	2
Leather	31	\$18,613	2
Misc. Business Services	73	\$19,033	2
Education	82	\$19,472	2
Non-profit Organizations	83	\$19,612	2
Furniture	25	\$19,867	2
Misc. Manufacturing	39	\$20,861	2
Trucking	42	\$21,243	2
Textiles	22	\$23,254	3
Lumber	24	\$24,251	3
Rubber	30	\$25,933	3
Stone, Clay, etc.	32	\$26,752	3
Fabricated Metal	34	\$27,181	3
Other Transportation	46,47	\$28,500	3
Printing	27	\$28,540	3
Food	20	\$28,852	3
Primary Metals	33	\$30,580	3
Motor Vehicles	371	\$30,919	3
Medical	80	\$31,720	4
Wholesale	50,51	\$32,226	4
Mining, Oil/Gas Extraction	10-14	\$32,746	4
Misc. Professional Services	81	\$33,749	4
Insurance	63,64	\$34,464	4
Paper	26	\$35,440	4
Banking	60	\$35,507	4

TABLE B-2

(Continued)

Sector	SIC	Average Annual Wage	Quintile Group
Credit & Finance	61,62	\$37,559	4
Air Transportation	45	\$38,270	4
Electrical Equipment	36	\$39,511	4
Communications	48	\$40,962	5
Chemicals	28	\$41,157	5
Non-electrical Mach., Computers	35	\$41,447	5
Rest of Transportation Equipment	372-379	\$44,068	5
Instruments	38	\$45,234	5
Motion Pictures	78	\$45,631	5
Public Utilities	49	\$46,560	5
Railroad Transportation	40	\$55,777	5
Petroleum Products	29	\$61,420	5

The percentage change in employment, wage bill, and wage rate resulting from a policy can thus be reported for each quintile of wages, by sector.

The annual Consumer Expenditure Survey (CEX), published by the BLS, provides a continuous flow of information on the buying habits of American households. The CEX reports average annual expenditures and characteristics of households by income group. There are eight income groups: less than \$5,000; \$5,000 to \$9,999; \$10,000 to \$14,999; \$15,000 to \$19,999; \$20,000 to \$29,999; \$30,000 to \$39,999; \$40,000 to \$49,999; and \$50,000 and over.

By linking consumption expenditures in the REMI model with spending patterns of the eight income groups in the CEX, we can then develop a composite price change for consumer goods for each income group.