

Statewide Effects of Transportation Policy

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The Task: Assembly Bill 2076

- Evaluate the likely economy wide effects of petroleum dependence reducing strategies in the context of projections for the California economy for 2000, 2020 and 2050.
- Method: EDRAM, a computable general equilibrium model for the California economy.

DRAM & EDRAM

- Models of the entire California Economy.
- DRAM is used to evaluate proposal with large fiscal impact.
- EDRAM is a derivative model with pollution coefficients and more detail about industrial sectors.

History of DRAM

- In August, 1994 SB 1837 was enacted requiring the Department of Finance to perform dynamic revenue analysis for proposed legislation having a revenue impact of ten million dollars or more.
 - Open source model.
 - Team from DOF (headed by B. Smith) and UCB.
 - In continuous use.

Documentation

- The model is in the public domain.
- Maintained by CA DOF.
- Full DRAM model and documentation:
 - http://134.186.99.249/html/fs_data/dyna-rev/dynrev.htm.
- ARB version differs in having engine and consumer chemicals sectors.
- ARB version includes pollution emissions data.
- ARB version documents:
 - <http://are.berkeley.edu/~phess>

Uncertainty in Model

- 1998 base from 1992 IO table
- Migration data
- Trade elasticities
- Petroleum elasticity of subs between capital and labor

Sources

- The sources are fully documented.
- Input Output table is the primary source for industry intermediate requirements.
- Demand was estimated from Consumer Expenditure Survey for the West.
 - Demand elasticity for fuel = $-.2$
- Most parameters (e.g., elasticity of substitution) taken from literature.

General Equilibrium

- The model solves for the prices of goods and services and factors of production that make quantity demanded and supplied equal.
- Both physical goods and money are conserved.

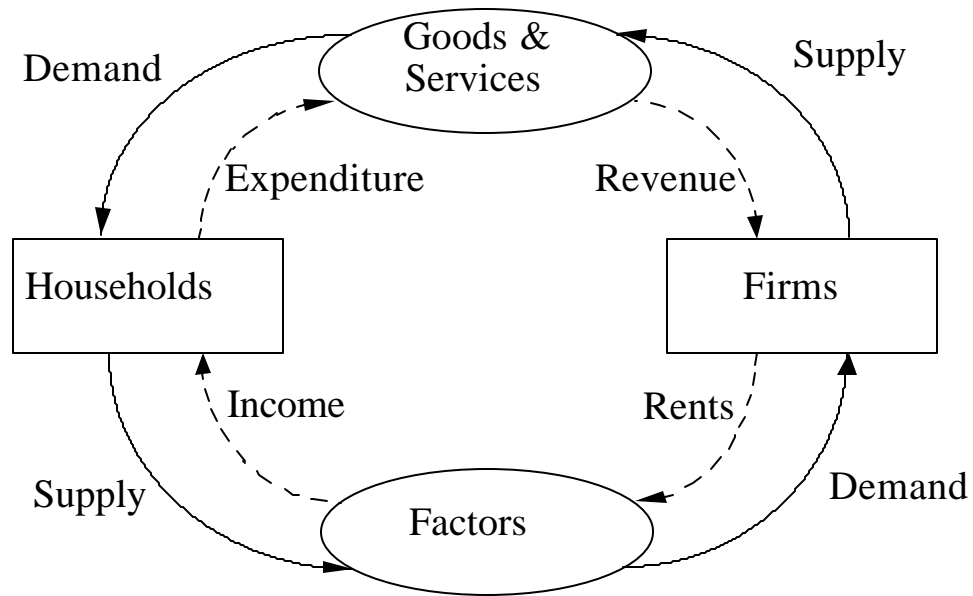
Structure of E-DRAM

- 102 distinct sectors:
 - 29 industrial sectors,
 - 9 consumer sectors,
 - two factor sectors (labor and capital),
 - seven household sectors,
 - one investment sector,
 - 45 government sectors, and
 - one sector that represents the rest of the world.

Where is Petroleum?

- Refining
- Crude Production
- Import and Export
 - Crude
 - Refined
- Intermediate good purchased by
 - Transportation
 - Other sectors
- Purchased by consumers
- Significant direct tax revenue
- Engines are needed to use petroleum

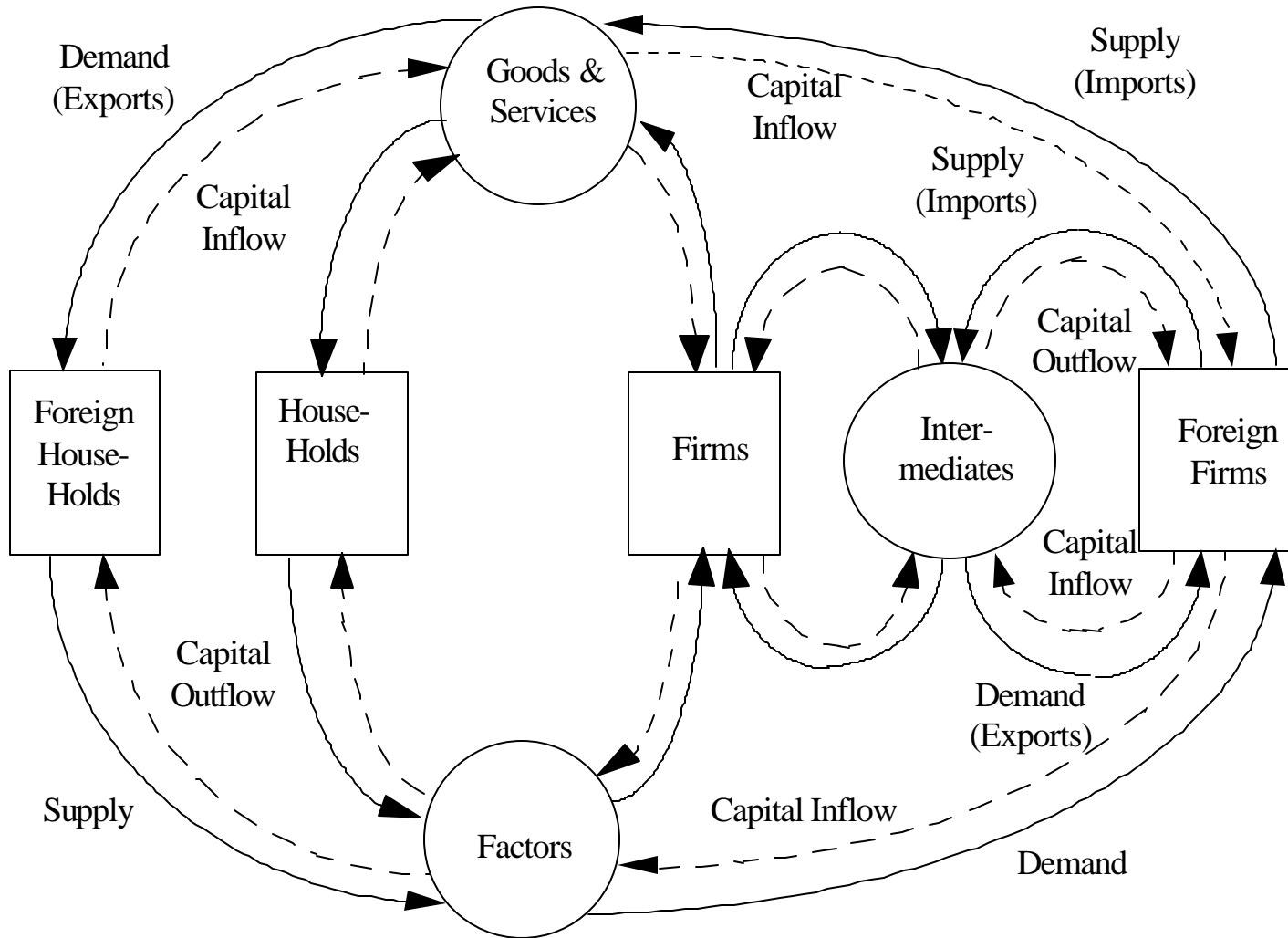
Goods and Services



29 different
goods and
services and 29
types of firms

Two Factors:
Capital and Labor

Trade and Intermediates



Investment and Migration

- Immigration and emigration respond to economic conditions.
- Investment and disinvestment respond to the rate of return.
- Model is equilibrium—takes 3-5 years to fully adjust to policy changes.

Equilibrium

- No modeling of transient phenomena
 - Temporary supply disruptions
 - Temporary price spikes
 - Cyclical unemployment and low capacity utilization
- Petroleum depletion accounted for only in terms of cost increases for imports

The Base Years

- 1998/99. EDRAM with the Petroleum sector modified to correspond to Energy Information Administration numbers and then balanced to produce consistent accounts.
- 2020. Matches projections for growth in population and state personal income.

...Base Years

- 2050. Growth rates continued from 2020, except California oil production ends and refinery sector does not increase in capacity.

Key Base Statistics

	1998/99	2020	2050
SPI	\$892 b	\$2007 b	\$4319 b
POP.	34.7 m	45.5 m	68.2 m
Consump.	\$28.6 b	\$56.6 b	\$ 98.9 b
Production	\$32.4 b	\$52.4 b	\$52.5 b
Net Refined Imports	\$-3.8 b	\$4.1 b	\$ 46.4 b

Four Scenarios

- Fuel Efficiency
 - EEA/Duleep Fuel Economy Improvements
 - ACEEE-Advanced Fuel Economy Improvements
- Fuel Efficiency plus fuel displacement
 - ACEE-Moderate + Fuel Cell Vehicles
 - ACEEE-Full Hybrid Vehicles

Scenario 1: EEA/Duleep

	2020	2050
Light Duty Costs	1961	5712
Heavy Duty Costs	125	146
Fuel Sav.	3,264	14,617

All figures in millions of dollars.

Implementation of Scenario 1

- *The price of consumer transportation increases by 90% of \$1.961 billion cost.*
 - Price to consumers of transportation (net of fuel) increases by this fraction:
 - $(\text{Base transp. Expend.} + 0.9 * 1.961) / (\text{base transp. Expenditure})$ [11](#)
- *All industrial sectors require more of the ENGIN sector to produce a unit of their output.*
 - *Engin requirements increase to require 10% of the \$1.96 billion in costs in the base case plus the \$.125 billion for diesel.*
 - *ENGIN requirements increase by this factor:*
 - $(\text{Base expenditure on ENGIN} + .1 * 1.961 + .125) / (\text{base exp. on Engin.})$

Implementation... continued

- *90% of the \$3.264b fuel savings to consumers.*
 - Decreases effective fuel price to consumer by this fraction:
 - $(\text{base fuel expend.} - .9 * 3.264) / (\text{base fuel expend})$
- *10% of the \$3.264b fuel savings to industry*
 - Every unit of output for every industry requires less fuel input by this fraction
 - $(\text{base fuel expend.} - .1 * 3.264) / (\text{base fuel expend})$

Scenario 2: ACEE-Ad. Fuel

	2020	2050
Light Duty Costs	4,698	7606
Heavy Duty Costs	125	146
Fuel Sav.	9,284	19,746

All figures in millions of dollars.

Implementation

- Same structure as Scenario 1
 - Larger vehicle costs
 - Larger fuel savings

Scenario 3: Fuel Cell +

	2020	2050
Light Duty Cost	6123	10,785
Fuel Cell V.Cost	945	1,133
Heavy Duty Cost	125	146
H2 Costs	776	8,718
Fuel Save	8,269	26,170

All figures in millions of dollars.

Scenario 3

- Same structure as 1 plus
- Additional expenditure for hydrogen fuel
 - Purchased from the Chemical sector rather than ENMIN
 - \$776 Million in 2020
 - \$8.7 Billion in 2050
 - Applied as before increase in the percent of purchases by PETRO of CHEM
 - And a percentage decrease by PETRO of ENMIN

Scenario 4: Full Hybrid

	2020	2050
Light Duty Costs	13,534	21,908
Heavy Duty Costs	125	146
Fuel Sav.	12,533	29,896

All figures in millions of dollars.

Implementation of 4

- Scenario 4 has the same economic structure as scenario 1.

Output

2020	TODAY	SCN 1	SCN 2	SCN 3	SCN 4
OUTPUT (\$Bil.)	3078.02	3074.92	3070.02	3069.41	3062.49
% CHANGE		-0.1006%	-0.2600%	-0.2797%	-0.5047%
PI (\$Bil.)	2009.54	2009.52	2010.43	2006.54	2001.03
% CHANGE		-0.0008%	0.0444%	-0.1491%	-0.4236%
LABOR(MIL)	18.6605	18.6767	18.7119	18.6841	18.6726
% CHANGE		0.0868%	0.2754%	0.1263%	0.0648%

Prices

2020	Today	SCN 1	SCN 2	SCN 3	SCN 4
PRICE OF CFOOD	1.0001	1.0001	1.0002	1.0013	1.0026
PRICE OF CHOME	1.0000	1.0000	1.0001	1.0008	1.0018
PRICE OF CFUEL	1.0000	0.9687	0.9111	0.9215	0.8818
PRICE OF CFURN	1.0001	1.0001	1.0002	1.0011	1.0022
PRICE OF CCLOTH	1.0001	1.0001	1.0002	1.0011	1.0023
PRICE OF CTRANS	1.0000	1.0072	1.0171	1.0271	1.0513
PRICE OF CMED	1.0001	1.0002	1.0006	1.0020	1.0038
PRICE OF CAMUS	1.0000	1.0001	1.0002	1.0013	1.0027
PRICE OF COTHR	1.0000	1.0000	1.0001	1.0008	1.0017

2020	BAS E	S 1	S 2	S 3	S 4
PETRO					
OUTPUT (\$B)	39.30	37.69	34.73	35.39	33.52
% CHANGE		-4.11%	-11.64%	-9.97%	-14.73%
IMPORTS (\$)	15.68	15.56	15.35	15.40	15.28
% CHANGE		-0.76%	-2.15%	-1.81%	-2.56%
EXPORTS (\$B)	12.00	12.07	12.22	12.18	12.26
% CHANGE		0.63%	1.82%	1.52%	2.17%
ENMIN					
OUTPUT (\$B)	6.21	6.06	5.78	5.74	5.61
% CHANGE		-2.43%	-6.84%	-7.47%	-9.67%
IMPORTS (\$B)	36.01	34.83	32.67	32.59	31.83
% CHANGE		-3.28%	-9.28%	-9.49%	-11.60%
EXPORTS (\$B)	1.10	1.11	1.14	1.14	1.15
% CHANGE		1.43%	4.15%	4.25%	5.27%

Millions of dollars, pre-tax.

2020	BAS E	S 1	S 2	S 3	S 4
ENGINE					
OUTPUT (\$B)	40.47	40.58	40.63	40.67	40.80
% CHANGE		0.28%	0.41%	0.51%	0.83%
CHEMS					
OUTPUT (\$B)	30.28	30.65	31.31	32.07	31.67
% CHANGE		1.20%	3.39%	5.88%	4.57%
FOODS					
OUTPUT (\$B)	92.96	95.11	99.28	98.45	101.35
% CHANGE		2.32%	6.80%	5.91%	9.03%
APPAR					
OUTPUT (\$B)	25.95	26.50	27.63	27.13	27.51
% CHANGE		2.10%	6.47%	4.55%	6.00%
MOTOR					
OUTPUT (\$B)	18.22	18.16	18.08	18.01	17.86
% CHANGE		-0.35%	-0.81%	-1.15%	-2.02%

Imports, Production & GSP

2020	TODAY	SCN 1	SCN 2	SCN 3	SCN 4
OUTPUT (\$Bil.)	3078	3075	3070	3069	3062
Change in Output		3.098	8.004	8.610	15.536
Change in Petro Out.		1.61	4.57	3.92	5.79
% of CHANGE		52%	57%	46%	37%

2050	BASE	S 1	S 2	S 3	S 4
CA OUTPUT (\$B)	6569	6557	6553	6551	6538
% CHANGE		-0.17%	-0.23%	-0.26%	-0.46%
PERS INC.	4325	4330	4331	4330	4318
% CHANGE		0.10%	0.13%	0.12%	-0.16%
LABOR (Mil.)	27.97	28.03	28.05	28.08	28.04
% CHANGE		0.23%	0.31%	0.39%	0.25%

2050	BASE	S 1	S 2	S 3	S 4
PRICE OF CFOOD	1.0001	1.0000	1.0000	1.0013	1.0018
PRICE OF CHOME	1.0001	0.9999	0.9999	1.0008	1.0012
PRICE OF CFUEL	1.0000	0.9324	0.9088	0.8801	0.8636
PRICE OF CFURN	1.0001	1.0000	1.0000	1.0011	1.0015
PRICE OF CCLOTH	1.0001	1.0000	1.0001	1.0011	1.0016
PRICE OF CTRANS	1.0001	1.0095	1.0126	1.0208	1.0382
PRICE OF CMED	1.0001	1.0003	1.0004	1.0021	1.0029
PRICE OF CAMUS	1.0001	0.9999	1.0000	1.0012	1.0018
PRICE OF COTHR	1.0001	0.9999	1.0000	1.0008	1.0012

2050	BASE	S 1	S 2	S 3	S 4
PETRO					
OUTPUT (\$B)	39.25	32.66	30.41	27.66	26.46
% CHANGE		-16.8%	-22.5%	-29.5%	-32.6%
IMPORTS (\$B)	63.64	62.14	61.63	61.10	60.79
% CHANGE	0.0002	-2.35%	-3.15%	-3.98%	-4.47%
EXPORTS (\$B)	19.14	19.52	19.66	19.80	19.88
% CHANGE	-0.0002	1.99%	2.68%	3.42%	3.85%
ENMIN					
OUTPUT (\$B)	7.69	7.23	7.07	6.32	6.72
% CHANGE		-5.9%	-8.1%	-17.8%	-12.6%
IMPORTS (\$B)	57.41	52.27	50.53	43.54	47.54
% CHANGE	0.0008	-8.9%	-12.0%	-24.2%	-17.2%
EXPORTS (\$B)	2.64	2.75	2.78	2.96	2.85
% CHANGE		4.00%	5.47%	12.14%	8.16%

2050	BASE	S 1	S 2	S 3	S 4
ENGINE					
OUTPUT (\$BILLION)	87.03	87.22	87.24	87.15	87.47
% CHANGE OUTPUT		0.22%	0.23%	0.14%	0.50%
CHEMS					
OUTPUT (\$BILLION)	64.99	66.67	67.24	75.52	68.36
% CHANGE OUTPUT		2.58%	3.45%	16.20%	5.18%
FOODS					
OUTPUT (\$BILLION)	200.23	210.49	214.22	218.82	221.47
% CHANGE OUTPUT		5.12%	6.98%	9.29%	10.61%
APPAR					
OUTPUT (\$BILLION)	55.88	58.78	59.84	61.00	60.89
% CHANGE OUTPUT		5.19%	7.08%	9.16%	8.96%
MOTOR					
OUTPUT (\$BILLION)	39.35	39.15	39.08	38.87	38.69
% CHANGE OUTPUT		-0.50%	-0.68%	-1.20%	-1.68%

Sensitivity to World Price

- Increased world price of Petro and Crude increases benefits of scenarios and leaves their costs unchanged.
- 20% increase in price in 2020.
 - Personal income is increased over base in 3 of 4 scenarios and falls less in the fourth.
- As price increases, scenarios become clearly preferred to base

Sensitivity to Imports

- Decreasing the supply elasticity of imports accelerates the decline of the domestic industry.
- Conversely, increasing their elasticity moderates that decline.
- In the case of ENMIN it approx triples the decline to go from $e=2$ to $e=.1$

Sensitivity to Fuel Price Elas.

- If $e = -.77$ rather than $-.2$, the effects on state wide aggregates would be dampened.
 - Scen 4 2020: .2% output fall rather than .5%
 - Reason: consumers don't contract their fuel use as much—the lower effective price counters the technical efficiency

Conclusions

Consumers:

All the scenarios result in much lower effective fuel prices.

Prices for transport services are higher.

Savings from fuel are spent on other items including apparel and food

Consumers whose income is largely wages see an increase in their real incomes; this leads to a larger labor supply

Conclusions cont.

- As a result of fuel savings, the petroleum industry contracts in all scenarios, more in those scenarios where more fuel is saved.
- Energy minerals contracts for the same reason.
- Contraction of these sectors reduces non-wage payments to consumers.
- Consumers with a high fraction of income from capital see their real incomes decrease in many scenarios

Conclusions....cont

- As a result of these competing forces, personal income is mixed: In 2020 scenarios 1-3 PI changes by roughly the calibration error. In scenario 4 it is down by .4%.
- In 2050 personal income is never down by much more than the calibration error and increases in three scenarios.

Conclusions... cont.

- State Output falls, because of the contraction of the petroleum sector. In 2020 scenarios between 37% and 57% of the output decrease is directly attributable to the decrease in PETRO.
- Labor increases, because laborers are more sensitive to real wages than to returns to capital.
- The scenarios range from mild to very aggressive fuel saving scenarios and have only very modest effect upon the economy as a whole.
- An increase in oil prices makes all the scenarios more attractive in terms of PI, real wages, and GSP.