Application of a Price-Sensitive Supply-Side Input-Output Model to an Examination of the Economic Impacts of Hurricanes Katrina and Rita's Disruptions of the U.S. Oil-Industry

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Issues

- Man-made or Natural Disasters
- Regional Scientists and Economic Impacts Analyses
- IO models as Tools Estimating Socioeconomic Impacts
- The application of input-output analysis to the study of economic impacts (actual and hypothetical) has led us to a number of discoveries and innovations.

Issues (Continued)

- Then, have our analytic tools really improved?
- Yes, in aspects of better data, better software and hardware than ever.
- Not much, in aspects of extensions in the traditional IO model.

Issues (Continued)

Traditional one-region IO Approach

- No Spatial Information
- No Resilience and No Substitutions

Why?

- Data problem
- Difficulties to apply methodologies

Issues (Continued)

- Why?

→Data Problem.

i. Industry Code incompatibility.

ii. Incomplete commodity trade flows between states.

iii. No information on service trade flows.

Issues (Continued)

- Why?

→ Methodology Application.

i. Chenery-Moses-type Multiregional Input Output Model (MRIO).

ii. Theoretical Support on the Supply-driven approach.

iii. No Model on the Temporal Extensions.

Supply-driven Model

- Ghosh’s suggestion of the supply-driven IO model in 1958.
- Application to impact analyses, especially of Giarratani (1976) and Davis and Salkin (1984).
- A consecutive debate over its plausibility

  -> Criticism (Oosterhaven, 1988; 1989)

  -> Defense (Gruver (1989) and Rose and Allison (1989))
- Dietzenbacher’s (1997) splendid interpretation: Equivalent to Leontief’s price model

Supply-driven Model (Continued)

- Unresolved implausibility.
- Problem to extend the supply-driven IO model to impact analyses.
- Theoretical support to apply the supply-driven IO model to the impact analyses, by introducing a four-quadrant space of economic situations.

Supply-driven Model (Continued)

Figure 1. General Expanded National Input Output Flow Matrix

$z_{11}\ \ z_{12}\ \cdots\ z_{1N}$ $z_{21}\ \ddots$ $\vdots\ \ z_{ij}\ \ddots$ $z_{N1}\ \ z_{NN}$ (Z)	$y_{11}\ \ y_{12}\ \cdots\ y_{1K}$ $y_{21}\ \ddots$ $\vdots\ \ y_{ik}\ \ddots$ $y_{N1}\ \ y_{NK}$ (Y)	$x^d_1 (= \sum_j \sum_k (z_{1j} + y_{1k}))$ $x^d_2 (= \sum_j \sum_k (z_{2j} + y_{2k}))$ $\vdots$ $x^d_N (= \sum_j \sum_k (z_{Nj} + y_{Nk}))$ (X^d)
$v_{11}\ \ v_{12}\ \cdots\ v_{1N}$ $v_{21}\ \ddots$ $\vdots\ \ v_{ij}\ \ddots$ $v_{L1}\ \ v_{LN}$ (V)	-	$\bar{v}_1 (= \sum_j v_{1j})$ $\bar{v}_2 (= \sum_j v_{2j})$ $\vdots$ $\bar{v}_L (= \sum_j v_{Lj})$ $(\bar{V})$
$x^s_1\ \ x^s_2\ \cdots\ x^s_N$ [1] (X^s)	$\bar{y}_1\ \ \bar{y}_2\ \cdots\ \bar{y}_K$ [2] $(\bar{Y})$	-

$$\Delta \mathbf{X^{s}}^{\mathbf{T}} = (\mathbf{I}-\mathbf{A})^{-1}\Delta \mathbf{Y_k}, \mathbf{A} = \mathbf{Z}(\hat{\mathbf{X}}^{\mathbf{s}})^{-1}$$: demand-side IO

$$\Delta \mathbf{X^{d}}^{\mathbf{T}} = \Delta \mathbf{V_l}(\mathbf{I}-\mathbf{B})^{-1}, \mathbf{B} = (\hat{\mathbf{X}}^{\mathbf{d}})^{-1}\mathbf{Z}$$: supply-side IO

*R*einterpretation (Continued)

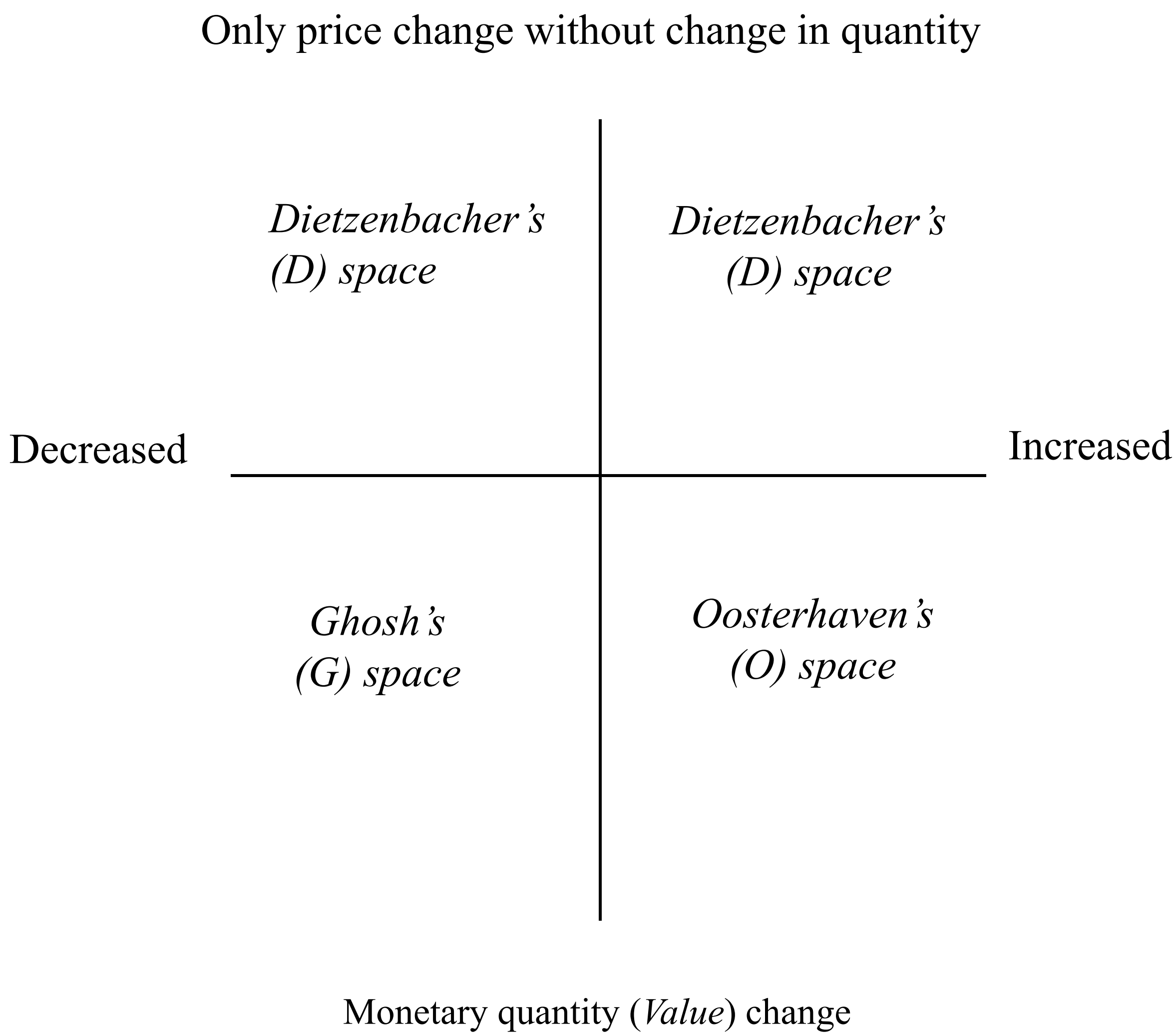


Figure 2. Four possible cases according to the change of value added factors

*R*einterpretation (Continued)

- The lower left quadrant

  ->For the above three quadrants, the supply-driven model is surely applicable using the Ghoshian price-model, as Dietzenbacher interpreted.

  ->Observe that a sudden decrease in the monetary value added factors will decrease the absolute price of total output losses.

  ->This result is wholly opposite to actual experience, because a sudden decease in valued added sectors induces decreases in total output for the sector and hence the absolute price for the sector generally would increase.

  ->The exceptional economic situation of sudden monetary value added losses (such caused by terrorist attacks or unexpected natural disasters), requires the restricted conditions for an impact analysis.

*R*einterpretation (Continued)

- The lower left quadrant (*continued*)

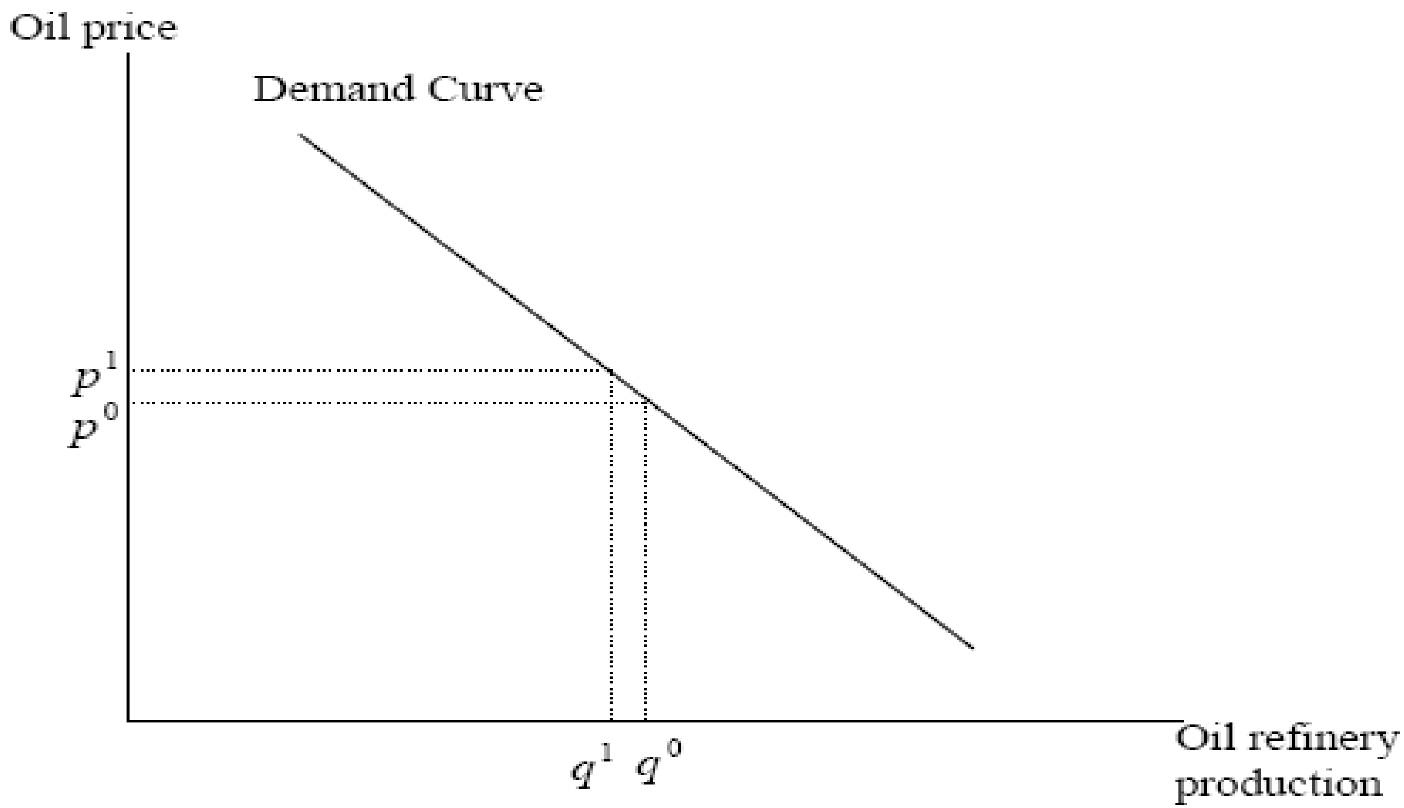
  ->While the basic interpretation of the supply-driven model might be focused on the price interrelations, under static market equilibrium, producers will not change their current technical rationing during the short term, after a man-made or natural disaster

  ->Only if suppliers expect final demand losses are higher than the lower-bounds requests, they will continue their sales until the market loses its power from other pressures.

  ->This examination of Ghosh's supply driven model shows a relation with monetary quantity losses and is theoretically applicable to the man-made or natural impact analyses under the conditions.

Price-sensitive Supply IO

If market system might react relatively fast, loosening one or two conditions among the verified conditions, is the supply model still useful?



Price-sensitive Supply IO (Continued)

->Using the price elasticity of demand, even in the case of loosening the conditions in the G-space, the supply-driven IO model still might be useful.

->The supply-driven model using a exogenous price elasticity of demand is not the quantity-type supply-driven model, but price-type supply-driven model, which is possibly converted from the quantity-type demand-driven model

->Therefore, even in the case that markets are out of equilibrium due to quantity losses caused by a disaster, the price-type supply-driven model can still be applied to G-space to estimate the total input losses for consumers due to the increase of prices if there is a vector of price elasticity of demands.

Price-sensitive Supply IO (Continued)

$$\Delta \mathbf{P}^{s^{\mathbf{T}}} = (\mathbf{I} - \mathbf{B})^{-1} \Delta \mathbf{P}^{\mathbf{Y_{oil}}}$$

$$\delta p^{oil} = \delta q^{oil} \pi^{oil}$$

where $\pi^{oil} = \dfrac{p^{oil}}{\bar{\varepsilon}_p^{oil} q^{oil}}$

is exogenous for the oil industry sector

$$\Delta \widetilde{\mathbf{P}}^{s^{\mathbf{T}}} = (\mathbf{I} - \mathbf{B})^{-1} \Delta \mathbf{Q}^{\mathbf{oil}} \mathbf{\Pi}^{\mathbf{oil}}$$

Economic Losses

<u>What happened in the Gulf of Mexico?</u>

- Two consecutive hurricanes devastated the coast of the Gulf of Mexico with huge economic losses and casualties
- The costliest natural disaster in U.S. history
- Estimated economic losses
  - $115 billion (Louisiana federal reimbursement report)
  - $92 billion (National Hurricane Center)
  - $62 billion (New Orleans port inoperability)
  - $4.8 billion (Oil-Refinery disruption in the PADD 3)

Economic Losses (Continued)

Table 1. Summary of Data Necessary to Estimate Total Output Vectors

Consumption Sector	Oil-Refinery Product Type	q^{oil}	p^{oil}	$\bar{\varepsilon}_p^{oil}$	π^{oil}	δq^{oil}	W[2)]	δp^{oil}	$W^* \delta p^{oil}$
Transportation	Finished Motor Gasoline	263272550	69.528	-0.0334	-0.000008	-37750	0.2696	0.298	0.0804
	Kerosene-Type Jet Fuel	48463714	65.382	-0.0017	-0.000792	-23989	0.1713	18.993	3.2543
	Distillate Fuel Oil	89976381	67.920	-0.0058	-0.000129	-42582	0.3041	5.504	1.6740
	Residual Fuel Oil	6732933	39.336	-0.0058	-0.001000	-4008	0.0286	4.009	0.1148
Residential	Distillate Fuel Oil	12403498	67.920	-0.0997	-0.000055	-5870	0.0419	0.322	0.0135
Commercial	Distillate Fuel Oil	7037068	67.920	-0.4135	-0.000023	-3330	0.0238	0.078	0.0018
	Propane	33689621	41.412	-0.4135	-0.000003	-8493	0.0607	0.025	0.0015
	Residual Fuel Oil	1331172	39.336	-0.4135	-0.000071	-792	0.0057	0.057	0.0003
Industrial	Distillate Fuel Oil	13083732	67.920	-0.2018	-0.000026	-6192	0.0442	0.159	0.0070
	Residual Fuel Oil	11764067	39.336	-0.2018	-0.000017	-7002	0.0500	0.116	0.0058
TOTAL		487754736				-140008	1.0000		**5.1534**
Unit		Barrel(B)[1)]	\$/B			1000B		\$/B	\$/B

$$\pi^{oil} = \frac{p^{oil}}{\bar{\varepsilon}_p^{oil} q^{oil}} \text{ and } W_c = \delta q_c^{oil} / \sum_c \delta q_c^{oil}$$

where subscript *c denotes Consumption Sector*

Economic Losses (Continued)

Results

- Direct economic losses the two consecutive hurricanes caused is $721.5 million for four months, based on 5.1534 $/Barrel and 140 million barrel losses during the four months.
- Indirect interindustry economic losses via USIO would be $815 million.
- Hence total economic disruptions would be $1.537 billion, of which loses were $1 billion from the oil industry.

Economic Losses (Continued)

Comparison

- Previous Approach using Flexible NIEMO
  - $4.8 billion for 13 months (Oil-Refinery disruption in the PADD 3)

  → $373 million per month averagely

Current result shows $384 million losses per month averagely.

Economic Losses (Continued)

Comparison

- Flexible NIEMO vs. Price-sensitive Supply IO model

  -Similar data sources

  -Different Methodology

  -Different Regional Size

  -Different Multipliers

  -Similar results

  -All kinds of resilience vs. Specific sectors e.g. oil industry

  -Coefficient changes vs. Direct losses changes

  -Long term vs. Short/Middle term

Conclusions

- Ghoshs' original position is most plausible in the downward direction: a *downward* shift in value added inputs *can* put limits on the forward transactions.
- Suggestion of new price-type supply-driven IO model, using price elasticity of demand.
- Empirical application of price-sensitive supply-driven IO model, based on the disruption of oil-refinery industry in U.S. during four months.
- Price-sensitive supply-side NIEMO and FlexNIEMO