DO FIRMS SHIFT DEMAND IN RESPONSE TO HIGH PRICES? AN EMPIRICAL ANALYSIS

EXPERT REPORT OF

ANINDYA SEN

Associate Professor,
Department of Economics
University of Waterloo
200 University Avenue West
Waterloo, Ontario
Canada N2L 3G1

Qualifications

1. The following is a summary of my qualifications in the area of economics and advanced statistical approaches to analyzing economic questions in the fields of industrial organization, health economics, and public finance.

2. I am currently an Associate Professor of Economics at the University of Waterloo in Canada. My research interests involve the use of advanced statistical and econometric techniques aimed at addressing public policy questions. I have published articles relevant to these fields in various peer reviewed academic journals.

3. Over the past three years I have been responsible for teaching advanced statistics (econometrics) courses to third and fourth year undergraduate (economics) honors students.

4. I also possess expertise as an economics/statistics consultant with respect to a diverse array of empirically oriented projects. Recent consulting assignments involve: quantifying the economic impacts of the Canadian marine transport industry; evaluating the likely impacts of introducing an emissions trading program in Ontario; understanding the determinants of Canadian retail gasoline prices; and assessing the effects of hedging on international gold prices. These projects have been conducted for public as well as private sector clients.

5. A full version of my *curriculum vitae* is contained at Appendix I.

Scope of Report

6. I have been asked by AITIA Analytics Inc. on behalf of its client, the Association of Major Power Consumers in Ontario, to evaluate empirically whether firms, on average, shift their demand for electricity to periods of lower prices (non-peak hours) in response to high prices during hours of peak consumption (peak hours) .

7. All data used in the analysis were obtained from the Independent Electricity Supply Operator (IESO). The electricity demand data were derived from metered hourly Allocated Quantities of Energy Withdrawn (AQEW) as defined by the IESO, aggregated by five industry sectors: (1) metal smelting and refining, (2) iron and steel manufacturing, (3) pulp and paper manufacturing, (4) petroleum products refining and (5) motor vehicle manufacturing. The data provided by the IESO represents consumption only by industrial customers served at transmission voltage, i.e., connected to the IESO-administered grid. Price data were derived from the Hourly Ontario Energy Price (HOEP) published by the IESO.

Empirical Model

8. I employ the following simple empirical specification;

Hourly Demand$_t$ averaged over a 12 hour period = b_0+ b_1 Hourly Ontario Electricity

Price$_t$ (HOEP) averaged over a 12 hour period + b_2 Hourly Ontario Electricity

Price$_t$ (HOEP) averaged over the previous 12 hours + Month Dummy Variables + e_t (1)

9. The above is an example of a multivariate regression model. Multivariate regression analyses essentially involves fitting a straight line to data points represented by a dependent (y) variable and a single or several independent (x) variables. In other words a linear relationship is assumed between a dependent and a single or several independent variables. This methodology reveals not only whether the relationship between the y and a specific x variable is statistically significant, controlling for other factors, but also gives information on the magnitude of the specific relationship through a coefficient estimate. In the above specification each of the 'b' coefficient estimates gives the marginal impact of a 1 unit increase in the 'x' variable with respect to the dependent variable, holding the effects of other possible determinants as constant.

10. The above model is what is known as a 'reduced-form approach' and is a standard approach to estimating the impacts of prices on demand. Instead of relying on hourly demand and prices, we have constructed two averages of each variable for each day. One average is computed from 7 a.m. to 7 p.m., which the current transmission tariff defines as the hours representing peak consumption. The second daily average is computed from 8 p.m.- 12 a.m and captures off-peak demand. Therefore, each day in the data set consists of two average observations constructed from hour specific data. [1]

11. The motivation for this approach is to evaluate whether average demand during off-peak hours is higher when average prices during peak hours are high, controlling for prices during the off-peak time period. Therefore, we are attempting to evaluate whether firms actually shift electricity demand from hours in which prices are high (peak demand) to hours where prices are lower (off-peak demand). If such shifting does occur, we would expect an increase in peak prices to be significantly associated with more consumption during off peak hours.

12. We use data for May, June, July, and August as these months are characterized by frequent price spikes during hours of peak demand. Further, in order to evaluate

[1] By using two daily averages, we are attempting to evaluate the short run effects of significant changes to prices. However, we did not obtain significantly different results by also including average prices and demand from 1 a.m. to 6 a.m., i.e., in all off-peak hours.

the sensitivity of our findings, we present estimates based on data from two separate years (2006 and 2007).

13. We employ a model that is straightforward and intuitive. Total average demand is assumed to be a function of hourly average price ($ per hour) calculated over the same time period as well as being determined by hourly average prices in the previous 12 hours. Finally, dummy or 1-0 variables are constructed for each month in order to control for the potentially confounding effects of other unobserved determinants of electricity demand that may occur within a specific month.

14. As is standard in the literature, we convert our hourly demand and price averages into natural logarithms. Therefore, our specification is a 'log-log' model which allows us to interpret the coefficient estimates as elasticities. Standard errors of coefficient estimates are clustered by day in order to account for within group correlations that could arise from differential loads contingent on the specific day.

Table 1: OLS estimates

	Pulp	*Metal*	*Iron*	*Motor*	*Petrol*
A. 2007					
Current HOEP	-0.226	-0.045	-0.0439	0.367	0.013
	(0.0219)a	(0.013)a	(0.017)a	(0.046)a	(0.009)
Average HOEP for past 12 hours	0.0969	0.058	0.025	0.151	0.016
	(0.0216)a	(0.011)a	(0.019)	(0.044)a	(0.009)b
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	244	244	244	244	244
R Square	0.2707	0.4775	0.4305	0.3665	0.9364
B. 2006					
Current HOEP	-0.259	-0.021	-0.037	0.386	-0.007
	(0.0201)a	(0.027)	(0.019)b	(0.056)a	(0.021)
Average HOEP for past 12 hours	0.133	0.097	0.097	0.158	0.0011
	(0.021)a	(0.027)a	(0.019)a	(0.062)a	(0.016)
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	244	244	244	244	244
R Square	0.5337	0.4981	0.3064	0.3397	0.7525

15. The above table contains Ordinary Least Squares (OLS) estimates of the effects of current and 12 hour lagged average electricity prices on electricity demand. 'a' denotes whether the coefficient estimate of an explanatory variable is statistically

significant at the 1% level. ‘b’ indicates that a covariate is statistically significant at the 5% level.

16. The first striking result is that in most cases, demand by industry is impacted by contemporaneous prices. Second, this relationship is most evident for the pulp, metal, and iron and steel industries. Third, we obtain quite comparable estimates across years. Specifically, our estimates suggest that a 10% increase in electricity prices is significantly associated (at the 1% level) with a 2.3-2.6% decline in demand by the pulp industry. In contrast, estimates with respect to the metals and iron industry imply that a 10% increase in prices is significantly correlated with a 0.2 to 0.45 percent decline in demand.

17. What is perhaps even more intriguing is that coefficient estimates of average prices in the previous 12 hours is significantly correlated with an increase in hourly demand across all industries. Further, the magnitudes of coefficient estimates are relatively large. Results with respect to the pulp and paper industry imply that a 10% increase in average prices 12 hours ago is significantly associated with a 1-1.3 percent increase in current demand, *controlling* for current prices.

18. In most cases, coefficient estimates of lagged prices are statistically significant and larger in magnitude than current prices for metal and iron. Specifically, our results indicate that a 10% increase in *lagged* 12 hour average prices is associated with a 0.6%-1% increase in *current* consumption. These findings offer evidence that some industries respond quite significantly in terms of their demand to expectations of price increases.

19. We also obtain similar results for the motor vehicle industry as our estimates reveal that a 10% increase in *lagged* 12 hour average prices is associated with a 1.5% increase in *current* consumption. While we also obtain a positive correlation between *lagged* 12 hour average prices and *current* consumption for the petroleum industry, the corresponding elasticities are not as statistically precise.

APPENDIX 1

Dr. Anindya Sen
Department of Economics
University of Waterloo
200 University Avenue
Waterloo, Ontario
Canada N2L 3G1
Phone: (519) 888 4567 ext. 32123
Fax: (519) 725 0530
Email: asen@watarts.uwaterloo.ca

DATE OF BIRTH April 1st 1969

PLACE OF BIRTH Saskatoon, Canada

EMPLOYMENT

July 2005 to present: Associate Professor of Economics, University of Waterloo

Sept. 2002 to present: Affiliated Research Scientist, Center for Behavioral Research and Program Evaluation, Faculty of Health Sciences, University of Waterloo

Sept. 1999 – June 2005: Assistant Professor of Economics, University of Waterloo

June 1998 - Aug. 1999: Economist, Competition Bureau, Federal Government of Canada

EDUCATION

1998 Ph.D., Economics, University of Toronto.
1992 M.A., Economics, Concordia University
1990 B.A. (Hons.), Economics, University of Delhi

AWARDS

- Distinguished Teacher of the Year Award, 2004; given by the students of the Economics Society.
- Nominee, University Distinguished Teacher of the Year Award, 2004

GRANTS

External

- Principal Investigator (with Emma Pierard), "Maternal Smoking, Infant Birth Weight, and Cigarette Taxes", SSHRC Standard Research Grant, ($30, 000), 07/07 – 07/09

- Co-investigator, “Improving Access to Canadian Smoking Data”, Canadian Tobacco Research Initiative, ($1,500,000). 08/04-08/09
- Co-Investigator, “Improving the Population Impact of Telephone Counselling for the Treatment of Smoking”, Heart and Stroke Foundation, ($1,209,618) 08/01-06/06.

Internal

- Internal SSHRC 4A Award ($5,000), 2006-07
- CBRPE Faculty Award ($20,000), 2001-03
- New Faculty Research Award ($5,000), University of Waterloo, 2000

Work Published or Under Review at Refereed, Scholarly Journals

Industrial Organization

1. “Do price ceilings result in lower gasoline prices? Empirical evidence from Canada.”, under review, *Journal of Law and Economics* (with Dennis Lu and Anthony Clemente).

2. “Estimating the impacts of vertical integration on wholesale prices: empirical evidence from Canadian gasoline markets.”, under review, *Journal of Law, Economic, and Organization*.

3. “Estimating the impacts of outlet density on industry concentration, retail prices, and profitability: empirical evidence from Canadian retail gasoline markets.”, revised and resubmitted, *Journal of Economics and Management Strategy* with (Peter Townley).

4. Sen, Anindya, “Does increasing the market share of smaller firms result in lower prices?”, *Review of Industrial Organization*, 26(4), 2005, pp. 371-389.

5. Sen, Anindya, “Higher prices at the gas pump: international crude oil price fluctuations or local market concentration? An empirical investigation.”, *Energy Economics,* vol. 25, no. 3, May 2003, pp. 269-88.

6. Sen, Anindya and Ted Mallett, “Does local competition impact interest rates charged on small business loans? Empirical evidence from Canada”, *Review of Industrial Organization*, 19(4), December 2001, pp.435- 450.

7. Sen, Anindya, Ted Mallett, and Ruma Sondhi, “Jury still out on internet benefits: more branches keep bank's loan rates low”, *Canadian Business Economics* 8(3), February 2001, pp.21-29.

Public & Health Economics

8. "Estimating the impacts of household behavior on youth smoking: evidence from Ontario, Canada.", under review, *Review of Economics of the Household*.

9. "Do youth smokers respond to changes in cigarette prices? Empirical evidence from the 1994 reduction in Canadian excise taxes", under review, *Journal of Health Economics*.

10. "Do lower cigarette taxes result in more smoking by women and poorer birth outcomes? Empirical evidence from Canada.", with Emma Pierard and Alan Wilson, under review, *Canadian Journal of Economics*.

11. "Estimating intergenerational correlations in educational attainment: empirical evidence from the 1986, 1994, and 2001 waves of the general social surveys.", with Anthony Clemente, under review, *Economics of Education Review*.

12. "Estimating the impacts of taxes on the initiation and persistence of youth smoking: empirical evidence from Ontario, Canada", with Tony Wirjanto, revision requested at *Health Economics*

13. Sen, Anindya with May Luong, "Estimating the impact of beer prices on STDs: empirical evidence from Canada.", with May Luong, forthcoming, *Contemporary Economic Policy*.

14. Sen, Anindya "Does increased abortion lead to lower crime? Evaluating the relationship between crime, abortion, and fertility," *The B.E. Journal of Economic Analysis & Policy* 7(1) (Topics), 2007.

15. Sen, Anindya and Brent Mizzen, "Estimating the impact of seat belt use on traffic fatalities: empirical evidence from Canada.", *Canadian Public Policy*, September 2007.

16. Sen, Anindya "Do stricter penalties or media publicity reduce alcohol consumption by drivers?", *Canadian Public Policy* 31(4), December 2005.

17. Sen, Anindya "Is health care a luxury? new evidence from OECD data", *International Journal of Health Care Finance and Economics* 5(2), June 2005, pp. 147-164.

18. Sen, Anindya, Jonathan Gruber, and Mark Stabile, "Estimating price elasticities when there is smuggling: the sensitivity of smoking to price in Canada." *Journal of Health Economics* 22(5), September 2003, pp. 821-42.

19. Sen, Anindya, "An empirical test of the offset hypothesis", *Journal of Law and Economics* 44(2), October 2001, pp.481-510.

20. Sen, Anindya, "Do stricter penalties deter drinking and driving? An empirical investigation of Canadian impaired driving laws", *Canadian Journal of Economics* 34(1), February 2001, pp. 149-164.

21. Sen, Anindya, "Will stricter penalties deter drunk driving?", *Policy Options* 20(7) 1999, pp. 54-57.

Work Published in Conference Proceedings

Sen, Anindya, "Traffic fatalities and seatbelt laws", Canadian Transport Research Forum Meetings.

Work in progress

Industrial Organization

22. "Do firms benefit from a significant horizontal merger? Evidence from the 1990 acquisition of Texaco by Imperial Oil.", with Mikko Packelen.

23. "Refinery fires, competition and retail prices.", with Wai Hong Choi

24. "Overshifting, collusion, and tax incidence in concentrated industries: empirical evidence from Canadian retail gasoline and cigarette markets.", with Derek Picard.

25. "Price dispersion, competition, and menu costs: empirical evidence from Canadian retail gasoline markets.", with J.P. Lam.

26. "Productivity, concentration, and free trade: empirical evidence from the Canadian manufacturing sector.", with Marc Duhamel.

27. "Profits and market concentration: empirical evidence from the Canadian manufacturing sector.", with Marc Duhamel.

Public & Health Economics

28. "Obesity, infant birth weight, and cigarette taxes: empirical evidence from the Canadian Community Health Surveys (CCHS)", with Mahdiyeh Entezarkheir and Alan Wilson

29. "Do taxes impact smoking? Evidence from Canada.",with Nigar Nargis.

30. "Estimating the impacts of minimum wage and government transfers on teen childbearing.", with Hideki Ariizumi.

31. “Evaluating the determinants of youth smoking: empirical evidence from the 1994 and 2002 youth smoking surveys.”, with Hideki Ariizumi and Daciana Driambe

32. “Infant health and maternal smoking: evidence from the national longitudinal surveys on children and youth.”, with Emanuelle Pierard and Alan Wilson.

33. “More cops less crime? Evidence from Canadian cross-province and time-series data”, with Christine O’ Neill.

Labor Economics

34. “Estimating the welfare effects of an increase in minimum wages: evidence from Canada.”, with Corey Van de Waal.

35. “Wages and industrial concentration: evidence from the Canadian Manufacturing sector.”, with Becky Shi and Marc Duhamel.

36. “Do better publications result in higher salaries for academics? Empirical evidence from the Ontario Salary Disclosure Act.”, with Mikal Skuterud.

Current Ph.D. Supervision

Wai Hong Choi, “Essays in Retail Competition and Prices.” (Ongoing)

Becky Shi, “Labor markets and Industrial Concentration.” (Ongoing)

Consulting Reports

“Wages and industrial concentration: evidence from the Canadian Manufacturing sector.” for Industry Canada.

“Productivity, concentration, and free trade: empirical evidence from the Canadian manufacturing sector.” report for Industry Canada.

“What determines the profitability of a retail gasoline outlet? A study for the competition bureau of Canada.” http://www.competitionbureau.gc.ca/PDFs/RetailGasolineOutlet-e.pdf, (2006).

“Estimating the economic benefits of the marine transport industry in Canada”, (with Peter Dungan and LECG LLC), report for Transport Canada (http://www.cmc-ccm.com/acrobat/MIBS-FinalReport.pdf), 2004.

“A cost benefit analysis of the multi jurisdictional disclosure system”, (with Poonam Puri and LECG LLC), report for the Ontario Securities Commission (http://www.osc.gov.on.ca/Regulation/Confidence/pic_20030627_cba-disclosure-system.pdf), 2003.

"Estimating the impact of mergers among bread manufacturers in Canada", report for the Competition Bureau, Industry Canada, 2001.

"Competition and gasoline prices in Eastern Canada", report for the Competition Bureau, Industry Canada, 2000.

PRESENTATION OF RESEARCH

At Conferences

Canadian Economics Association Meetings, 2007, 2006, 2005, 2004, 2003, 2002; Interdisciplinary Conference Sponsored by the National Cancer Institute of Canada, University of Waterloo, 2001; Canadian Law and Economics Association Meeting, 2000, 1999; International Business and Economics Society Meetings, 1999; Canadian Transport Research Forum Meetings, 1999.

Invited Presentations at Universities

2007 McMaster University, University of Toronto, York University
2005 University of Western Ontario
2004 University of Guelph, McMaster University.
2001 Ryerson University, York University, University of Toronto, University of Western Ontario.
2000 McMaster University, Faculty of Health Studies, University of Waterloo.

Other

- "Evaluating the Economic Impact of the Marine Transport Industry", presented to Transport Canada, 2004.
- "Inferring the Presence of Market Power from Tax Hikes", presented to the Competition Bureau, Industry Canada, 2003.
- "Estimating the Impact of Mergers among Bread Manufacturers", presented to the Competition Bureau, Industry Canada, 2001.
- "Competition and Gasoline Prices in Eastern Canada", presented to the Competition Bureau, Industry Canada, 2000.
- Expert Testimony on the Causes of Rising Gas Prices, House of Commons Industry Committee, 1999.

TEACHING

Courses Taught

Undergraduate: ECON 361 (Cost Benefit Analysis), ECON 341 (Public Expenditure), ECON 321 (Econometrics), ECON 201 (Microeconomics)

Graduate: Public Finance, Health Economics

SERVICE

Department Level

Director, Seminar Series, 2000-01, 2003-04
Member, Graduate Committee, 1999-2005 – part of committee that designed and introduced the Ph.D. program

Refereeing

Journal of Political Economy, Canadian Journal of Economics, Journal of Health Economics, Journal of Public Economics, Review of Industrial Organization, Journal of Risk and Insurance, Economic Inquiry, Social Science and Medicine, Journal of Policy Analysis and Management, Contemporary Economic Policy, Southern Economic Journal.