UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

June 27, 2012

Memorandum

SUBJECT: **Peer Review of Multimarket Model**

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

FROM: **Robin Langdon, Larry Sorrels, Tom Walton, OAQPS, Air Economics Group**

TO: **EPA Council for Regulatory Environmental Modeling**

The Air Economics Group (AEG) of the U.S. EPA Office of Air and Radiation's Office of Air Quality Planning and Standards (OAQPS) is responsible for developing analytical guidance and tools and conducting regulatory impact analyses. AEG uses many modeling tools, including partial equilibrium, two-market, multimarket and general equilibrium models.

In accordance with the Office of Management and Budget Final *Information Quality Bulletin for Peer Review* and the U.S. EPA *Peer Review Handbook*, AEG undertook a peer review of the Multimarket Model (MM) in September 2011. The peer review was conducted by five independent reviewers to assess the appropriateness of the model for conducting regulatory analyses, as well as address specific charge questions. The peer review was not designed and conducted as a consensus review by a peer review panel.

The peer review was managed by EC/R Incorporated. Please see the attached report prepared by EC/R Incorporated, which includes related background materials provided to the peer reviewers, as well as copies of email exchanges between EC/R Incorporated and the peer reviewers. The peer reviewers' comments on the MM are included in the report as Attachment 4. The peer reviewers offered positive and constructive feedback on the MM and made a number of suggestions for improvement.

This memorandum is intended to summarize the peer reviewers' comments and suggested remedies and is not intended to provide an exhaustive discussion. For the detailed peer review comments see Attachment 4 of the report. The remainder of this memorandum highlights, by technical topic area, specific points raised by the peer reviewers along with their suggested remedies, primarily for comments where the suggested remedy may not follow directly from the comment. By technical topic area, the peer reviewers' comments and suggested remedies are summarized in tables and EPA's responses are provided below the tables. The peer review feedback aids EPA to better clarify the limitations of the MM (e.g., short-run versus long-run elasticity availability and use, cross price elasticities, manner in which model is shocked, and the Leontief production function), as well as guide future use of the model.

Elasticities

The following highlights comments and suggested remedies on the MM's application and use of elasticities.

Reviewers' Feedback	Reviewers' Suggested Remedies
The MM does not include cross price elasticities	Consider other types of production functions
The use of export elasticities as supply elasticities was not justified	Conduct explicit supplemental analysis on significance of export markets
Respond to question from peer reviewer on why US supply is less elastic than rest-of-world	Review justification and related literature
Use of long-run elasticity given short-run application	Review suggested Houthakker et al. paper for possible approach to relate long-run and short-run elasticities; this should enable calculation of short-run elasticities that are consistent with long-run estimates

Depending on availability of resources and potential future application of the MM, EPA will consider a range of elasticities to test sensitivity, conduct explicit supplemental analysis on the significance of export markets, and review the suggested paper to consider the approach for relating long-run elasticities for short-run elasticity application.

Levels of Sectoral Aggregation

The following highlights comments and suggested remedies on the MM's levels of sectoral aggregation.

Reviewers' Feedback	Reviewers' Suggested Remedies
Too many sectors, which can make interpretation of results challenging	If the Agency wanted to examine the effects of a particular regulation, the Agency could build a model that focuses on the markets that will be most strongly affected by the regulation. Could use the MM (100 markets) and compare results those of a fewer-market model

Depending on availability of resources and potential future application of the MM, EPA may consider using EMPAX-CGE, the CGE model developed and used by EPA/OAQPS, for certain analyses.

Market Structure

The following highlights comments and suggested remedies on the MM's market structure.

Reviewers' Feedback	Reviewers' Suggested Remedies
Evaluate role of imperfect competition, or other variance from perfect competition, when sufficient data is available to do so	Could use the MM and compare results to a model with a few markets where imperfect competition is known to exist (e.g., cement manufacturing)
Need to consider regional issues, e.g., electricity markets and transportation	Different regional electricity markets could be built into MM with appropriate links to downstream industries based on geographic concentrations of the downstream industries to test assumption of a uniform national market for all sectors

Depending on availability of resources and potential future application of the MM, EPA could work to get some additional detail in the underlying engineering cost analyses. With respect to considering regional issues, because a lot of additional data would be required, it would be difficult to address inter-regional trade within the model structure. In addition, because of potential regional cost differences and the challenges of using the MM[1] to address those differences, EPA may consider using EMPAX for certain analyses.

Surplus or Welfare Measures

The following highlights comments and suggested remedies on the MM's use to estimate surplus or welfare measures.

Reviewers' Feedback	Reviewers' Suggested Remedies
Lumps export demand and consumer demand into one equation	Need to pull apart pieces of final demand to make rough estimate of consumer welfare
Surplus changes are likely to be an underestimate for the regulated sector and an overestimate for the rest of the economy	*Reviewers did not provide direct, specific remedies.*
If an intervention in one market were to increase employment in another, the increase in employment in the other market generates welfare gains that are not captured in the surplus measure from the intervened-in market	Include a representation of labor supply and demand.
If there are basic inputs that are not intermediate,	Specification for calculating producer surplus

[1] The MM reflects national markets and it would be challenging to use the MM to address questions about regional market differences.

Reviewers' Feedback	Reviewers' Suggested Remedies
there should be supply curves for those inputs and the equilibrium changes in prices of such inputs induced by regulation should be calculated	needs to be examined to help clarify interpretation of surplus as measured with respect to supply curves
Constant elasticity form for rest-of-world excess supply seems unnecessary because they likely can't be statistically distinguished from linear forms and linear forms are easier to work with	Specify rest-of-world supply and demand separately

EPA had been considering not using the MM to estimate changes in welfare. The peer review confirmed that the Agency should not use the model to estimate surplus or welfare changes.

Factor Demands/Production Function

The following highlights comments and suggested remedies on the MM's representation of factor demands and the related question of the way industry production functions are represented in the model.

Reviewers' Feedback	Reviewers' Suggested Remedies
From an income standpoint, we don't have the budget constraints of households in the model.	Incorporate household budget constraint.
Could look more closely at industry sector(s) where value added represents high portion of demand (labor and capital intensive markets)	Could develop table for screening purposes that (i) shows which industries are labor and capital intensive, and (ii) shows industry(ies) where labor demand is small but the sector is large part of economy
Limitation is representation of factor demands because the factor shares are held constant; prices of goods and services adjust and are passed through economy but factor demands do not. MM does not capture factor substitution in downstream markets MM does not account for pre-existing distortions away from economic efficiency in factor markets caused by pre-existing taxes, regulations or non-competitive behavior	Could build in an indicator[2] for when the possibility for incremental adjustments across a number of sectors might aggregate to large changes in factor markets

[2] The objective of the indicator would be to help identify when certain caveats are appropriate and/or when additional analyses may be needed.

With respect to more accurately representing factor demands, depending on availability of resources and potential future application of the MM, EPA may consider use of a secondary model to capture factor substitution changes. The additional model would provide information about how to change fixed coefficients. In addition, EPA could provide statistics or some analysis of the impacts of the regulatory action on a specific, related industry (e.g., for an electric utility regulation, Agency could analyze lime industry (lime is a "factor" used in scrubbers) to determine whether the regulation is significant enough to impact national lime market). EPA should also clarify that households' labor/leisure trade off is not explicitly accounted for in the MM by design.

Intermediate Goods

The following highlights comments and suggested remedies on the MM's representation of intermediate goods.

Reviewers' Feedback	Reviewers' Suggested Remedies
The MM does not capture factor substitution in downstream industries	Solve a PE model for the downstream industries using engineering economics models and tally the process changes and factor substitutions that might occur, and augment the RIAs for a rule with that information
Imposing labor and capital costs of compliance as a unit cost is reasonable, it is not a reasonable way to treat the purchase of intermediate goods	Those can be treated within model framework as modification of the IO matrix that underlies intermediate demand
Assumption that intermediate inputs are combined in fixed proportions is a logically consistent way to think about inter-market linkages, but misses some substitution possibilities with a given capital stock and misses more possibilities if the capital stock adjusts If there are basic inputs that are not intermediate, there should be supply curves for those inputs	*Reviewers did not provide direct, specific remedies.*

Depending on availability of resources and potential future application of the MM, EPA may explore introducing compliance costs as a modification of the IO matrix.

Shocking the Model

The following highlights comments and suggested remedies for how to consider shocking the MM.

Reviewers' Feedback	Reviewers' Suggested Remedies
One downside of the MM is that it may be easy to	You really need to think about the process by

Reviewers' Feedback	Reviewers' Suggested Remedies
stick in some parameter values and then start the model running. When this is done without thinking in detail about how the regulation affects the industry's cost structure, then the model is producing answers that may not have a lot of value	which the regulation raises the costs of production; need to know how the particular regulation affects the entire marginal cost curve in a particular industry
Effects are not properly accounted for in the MM	Couple MM with offline analysis to assess aggregate effects on labor supply, vendor queues, employment market queues, etc Explicitly account for in the model any cost premiums that might result

EPA appreciated the comments on how to shock the MM and believes that many of the comments can be addressed by better linking changes in factor demands forecast by partial equilibrium or engineering models to changes in factor demands in the MM.

General

The following highlights general comments and suggested remedies for improving the MM.

Reviewers' Feedback	Reviewers' Suggested Remedies
There are concerns regarding decreased data quality as the number of sectors is increased	Documentation should be clearer about how basic output numbers were assembled
While the documentation provides equations, it would have been easier to figure out the model if a mathematical presentation was included as appendix	Include model written down formally in an appendix to documentation
Assumptions about how regulations will shift the input demand and output supply curves seem fairly arbitrary	Review literature discussing how supply should be assumed to shift after a technological change, whether in a parallel, pivotal, or some other fashion (c.f., Lindner and Jarret 1978, 1980; Rose 1980; Wise and Fell 1980, Norton and Davis 1981; Voon and Edwards 1991; Haung and Sexton 1996; Edwards and Voon 1997; Wohlgenant 1997). Also review Alston, Norton, and Pardey (1994, pp. 63-64) – they recognize and discuss the challenge of making the proper assumption about the character of the supply shift

Review was difficult to carry out because it was difficult to fully engage in the structure of the model	Recommend small scale version of the model described in full detail, from the most primary inputs to final goods

Depending on availability of resources and future use of the MM, EPA will improve the documentation as follows: correct typographical errors and provide a diagram to show how the 35 sectors in EMPAX are disaggregated to the 100 sectors in MM. EPA may also include description of the partial equilibrium and engineering economic models that are used to identify and estimate compliance costs in regulated industries.

MEMORANDUM

Date: March 30, 2012

To: Robin Langdon, U.S. EPA/HEID

From: Stephen Edgerton, EC/R Incorporated

Subject: Final Report
Peer Review of the Multimarket Model
EPA Contract No. EP-D-06-119, Work Assignment No. 4-05

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1. Introduction

This memo constitutes the final report of the peer review of the U.S. Environmental Protection Agency's (EPA's) Multimarket Model conducted by EC/R under the subject work assignment. It describes and documents the peer review process and provides information on the selected expert reviewers. The review charge to the reviewers and the comments on the model submitted by the reviewers are attached.

2. Purpose

The purpose of this peer review was to provide the EPA with an objective peer review of the Multimarket Model to assess the appropriateness of the model for conducting regulatory analyses. The Multimarket Model is a relatively new economic model developed by the EPA's Office of Air Quality Planning and Standards. The model provides analysis that is focused on a time horizon 3 or 4 years after a new regulation and is designed to be used as a transparent economic impact tool that can respond quickly to requests about how stakeholders in 100 U.S. industries might respond to a new environmental policy.

3. Peer Review Process

EC/R received the subject work assignment on August 29, 2011. After fulfilling the contractual requirements to prepare and submit a work assignment work plan and cost estimate, we received work plan approval on September 23. Table 1 describes the process and time line for the peer review. Attachments 1 through 3 contain materials documenting the peer review process as described in Table 1.

4. Results

The results of the peer review are the comments on the Multimarket Model submitted by the reviewers, which are compiled in Attachment 4. The technical nature and varied organization of the comments preclude summarization by EC/R as we are not experts in the field of economic modeling.

Table 1. Peer Review Process and Time Line

Date	Action	Notes
11/16 through 11/22	**Identification of the pool of potential reviewers.** Worked with EPA to identify the necessary qualifications and to identify and rank a list of qualified potential reviewers.	
11/22 through 12/6	**Recruitment of the panel of five expert reviewers.** Contacted the pool through email and by telephone to discuss availability, interest, potential for conflicts of interest, and compensation.	Attachment 1 contains CVs for the five expert reviewers.
12/9	**Initiation of the review.** Issued Purchase Orders and Conflict of Interest (COI) Certification forms to reviewers and transmitted review charge and the model documentation.	Attachment 2 contains the reviewers' signed COI Certifications. Attachment 3 contains an example transmission email with attachments.
12/19	**Conference call between reviewers and EPA modelers.** Reviewers and EPA to took part in a conference call during which the reviewers asked clarifying questions.	
12/19 through 12/22	**Transmission of additional materials.** Sent additional materials related to the review to the reviewers.	Attachment 3 contains transmission emails with attachments.
1/13 through 1/20	**Receipt of review comments.**	
1/23	**Transmission of compiled comments to EPA.**	Attachment 4 contains the compiled comments.
3/30	**Transmission of the report of the peer review to EPA.** This report, which describes and documents the process and review comments.	

Attachments

Attachment 1

Reviewers' Curricula Vitae

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March 29, 2012

CURRICULUM VITAE

Name: Peter Berck

Addresses:

Work

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Home

1048 Keith Street
Berkeley, CA 94708

Position: S.J. Hall Professor, Agricultural and Resource Economics

Birthplace: New York, NY

Birth date: 1950

Education

Degree	Institution and Field	Date
A.B.	University of California, Berkeley, Economics and Mathematics	1971
Ph.D.	Massachusetts Institute of Technology, Economics	1976

Honors

Filosofie Hedersdoktor	Universitet Umea, Honorary degree	2002
Fellow of the American Agricultural Economics Association		2008

Academic Experience

1972-1976: Research and Teaching Assistant, Department of Economics, Massachusetts Institute of Technology, Cambridge.

1976-1982: Assistant Professor, Department of Agricultural and Resource Economics, University of California at Berkeley.

1982-1991:	Associate Professor, Department of Agricultural and Resource Economics, University of California at Berkeley.
1983 (Spring):	Visiting Scholar, Department of Economics, Harvard University, Cambridge, Massachusetts.
1983 (July):	Visiting Professor, Department of Economics, Ben Gurion University, Beersheba, Israel.
1991- :	Professor, Department of Agricultural and Resource Economics and Policy, University of California at Berkeley.
2005-06	Visiting Professor, Umeå University, Sweden.
2007-	Research Associate of the Environment for Development Program, University of Gothenburg.
2010-	Research Fellow of the Center for Agricultural Economics Research, Hebrew University

University and Professional Service

Member and Vice Chair, Committee on Rules and Elections, UC Merced 2010-

Member, Washington State University School of Economic Sciences Advisory Committee

Chair and member, CNR Courses and Curriculum Committee, 2006-2008, Chair 2009-

Special Editor, Editors' Manuscripts, *American Journal of Agricultural Economics*, 2005- .

Advisor, California Air Resources Board, 2003-5 .

Founding Member, Global Environment House Advisory Board, 2003- .

Head Graduate Advisor 2003- 4, and 2006-.

Reviewer, Department of Environmental Science, Policy, and Management, 2002.

Secretary, Systemwide Senate, 2002- 2003, 2004-2010 .

Universitywide Task Force on Instructional Activities, 2002-03.

Chair and Member, University of California, Merced, Task Force, 2001-2004.

College of Natural Resources Committee on Courses of Instruction, 2001-2003.

Merced Representative to Academic Council, 2001-2004.

Editor, Giannini Foundation Monograph Series, 2000- .

Editor, *American Journal of Agricultural Economics*, 2000-2004.

Chair, Committee on Educational Policy, 1999-2000.

Member, Academic Council, 1999-2000.

Universitywide Task Force on Copyright, 1998-2001.

Vice Chair, Committee on Educational Policy, 1998-1999.

Association of Environmental and Resource Economists Workshop Committee, 1997-1999.

Educational Finance Model Steering Committee (Universitywide), 1996-1998.

Chair, Committee on Educational Policy, Berkeley Division, 1996-1998.

Committee on Educational Policy, 1996-1998.

Divisional Council, 1996-1998.

Academic Planning Board, 1996-1998.

Chair, Student-Faculty Relations Committee, College of Natural Resources, 1995.

Chair, Space Committee, College of Natural Resources, 1995-1996.

Chair, Computer Committee, College of Natural Resources, 1994-1996.

Committee on Educational Policy, Berkeley Division, 1993-1998.

Editor, *Natural Resource Modeling*, 1991-1996 and 1999.

Chair of the Faculty, College of Natural Resources, 1990.

Editorial Board, *Journal of Environmental Economics and Management*, 1987-1995.

Executive Committee, College of Natural Resources, 1987-88.

Board of Directors, Association of Environmental and Resource Economists, 1986-87.

Chancellor's Committee on Instruction in Economics, 1985.

Vice Chair, Department of Agricultural and Resource Economics, 1984-1988.

General Associate Editor, *American Journal of Agricultural Economics*, 1983-1986.

Nominating Committee, Association of Environmental and Resource Economists, 1982.

Associate Editor, *Hilgardia/Bulletins* (University of California, Agricultural Sciences Publications), 1982.

Awards Committee, Western Agricultural Economics Association, 1981.

Chair of the Faculty, College of Natural Resources, 1980-81.

Working Group Leader, Canadian-U.S. Spruce Bud Worm Project, 1978-1983.

Chair, College of Natural Resources and Department of Agricultural and Resource Economics Computer Committee, 1978-1981.

Executive Committee, College of Natural Resources, 1978-1980.

Reviewer for *American Journal of Agricultural Economics; Econometrica; American Economic Review; The Bell Journal of Economics; Johns Hopkins University Press; Journal of Economic Dynamics and Control; National Science Foundation; Journal of Political Economy; Resources for the Future; Journal of Environmental Economics and Management; Journal of Economic History;* and *Forest Science* among others.

Consulting and Nonacademic Positions

Consultant on Environmental Project, Public Interest Economics—West.

Consultant, Chicago Mercantile Exchange.

Consultant, U.S. Forest Service.

Consultant and Expert Witness, U.S. Department of Justice.

Consultant, Hammon, Jensen, and Wallen.

Consultant, McKinsey & Company.

Consultant, Coffee, Sugar, and Cocoa Exchange, Inc.

Consultant and Expert Witness, Sierra Club Legal Defense Fund.

Consultant, Heins, Mills, and Olson.

Consultant, M Cubed.

Consultant, Del Norte County.

Consultant, Natural Resource Modeling Corporation.

Advisory Board Member, Governor Wilson's California Israel Exchange.

Expert Witness, Hersh and Hersh.

Expert Witness or Consultant, Market share of an ethical pharmaceutical (several cases), Valuation of the Redwood National Park, Valuation of the Headwaters Forest, Anti-trust case concerning travel agent fees, and Market-share case for polluted ground water.

Expert Witness, Bingham, McCutcheon.

Expert Witness, State of California. Green Mountain Chrysler v. Crombie. United States District Court for the District of Vermont (2007)

Ph.D. Directorships

John Siebert, "Almonds, Bees, and Externalities," December, 1978.

Anthony Nakazawa, "Consumer Preferences for Housing by Tenure and Structure Type," June, 1979.

Nancy Gallini, "Research and Development of an Exhaustible Resource Substitute," June, 1980.

Michael Arnold, "Higher Energy Prices and the Obsolescence of Capital Stock," December, 1982.

Amnon Levy, "Equity and Efficiency in Agricultural Land Allocation," June, 1982.

Mary Cleveland, "Consequences and Causes of Unequal Distribution of Wealth," June, 1984.

Karen Dvorak, "Soil Fertility as a Natural Resource," December, 1984.

Nancy Williams, "Iterative Planning with Incentive Compatible Control: The Case of the USDA Forest Service," December, 1984.

Grace Johns, "Modelling Bioeconomic Behavior in the Pacific Halibut Fishery: An Application of the Kalman Filter," 1986.

Peter Parks, "The Influence of Economic and Demographic Factors on Forest Land Use Decisions," 1987.

Gloria Helfand, "Standards versus Standards: The Incentive and Efficiency Effects of Pollution Control Restriction," 1988.

Diana Marie Burton, "National Forest Policy and Employment in Oregon," 1991.

Scott Templeton. "A Theoretical Analysis of the Role of Consumption Risk and Empirical Analysis of Non-Paddy Terracing in the Philippines," December, 1993.

Jacqueline Geoghegan. "The Road Not Taken: Environmental Congestion Pricing on the San Francisco-Oakland Bay Bridge," 1994.

Anni Huhtala. "Is Environmental Guilt a Driving Force? An Economic Study on Recycling" (Co-Chair), 1994.

Jonathan Lipow. "Lies, Distortions, and Half-Truths: Three Essays in Economics," 1994.

Christopher Dumas. "Cross-Media Pollution and Common Agency," 1997.

Andrew Lebugoi Dabalen. "Essays on Labor Markets in Two African Economies," 1998.

Ethan Daniel Chorin. "Von Clausewitz Meets Sea-Air: Examining the Link Between Internal Transportation, Infrastructure, Transshipment and Income Growth in the Republic of Yemen," 2000.

Christopher Costello. "Renewable Resource Management with Information on a Random Environment," 2000.

Michael Roberts. "Hotelling Reconsidered: The Implications of Asset Pricing Theory on Natural Resource Price Trends," 2000. (Winner of the American Agricultural Economics Association's Best Dissertation Award.)

H. Peter Hess. "Hedonic Estimation and Economic Geography," 2001.

Atanu Dey. "The Universal Service Obligation Imposed Cross Subsidies: The Effect on the Demand for Telecommunications Access in India," 2002.

David Newburn. "Spatial Economic Models of Land Use Change and Conservation Targeting Strategies," 2002.

Anna I. Gueorguieva. "The Social Effects of Macroeconomic Shocks: Analysis of Structural Adjustment and the Asian Crisis," 2003.

Stephen Stohs. "A Bayesian Updating Approach to Crop Insurance Ratemaking," 2003.

Ralf Steinhauser. (2007) Emissions Forecasting and Voluntary State and Firm Level Reductions. (co-chair)

James Manley. "Essays in Health and Development Economics," 2008.

Lyngun Nie. "Essays on son preference in China during modernization, 2008."

Currently chair of dissertation committee for four students.

Research Grants

U.S. Forest Service, Mineral Economics, 1976.

U.S. Forest Service, Regional Demand, 1977.

U.S. Forest Service, Aggregation Bias on Regional Forest Demand, 1978.

U.S. Forest Service, Copper Development, 1980.

U.S. Forest Service, Overbid and Futures Prices, 1981.

U.S. Forest Service, Modeling the Western Forest Land Base, 1984-1987.

Giannini Foundation of Agricultural Economics, Database Project, 1983-1985.

Giannini Foundation of Agricultural Economics, Waste Water in the San Joaquin, 1985-1988.

California Energy Commission, Permit Trading, 1994.

California Air Resources Board, Guidelines for Economic Analysis, 1994.

California Department of Finance, Dynamic Tax Analysis, 1995, 1996, 1997.

California Environmental Protection Agency Air Resources Board, Developing a Methodology for Assessing the Economic Impacts of Large-Scale Environmental Regulations, 1998-99.

California Department of Finance, Dynamic Revenue Analysis Model Elements to Interstate and International Trade, 1998-99, 1999-2000.

California Department of Forestry and Fire Protection, Development and Application of a Methodology to Manage Fiscal and Green Waste Impacts of Pitch Canker, 1999-2000.

Committee on Research, Farmer's Consumption and Agricultural Risk, 1999-2000.

College of Natural Resources Faculty Committee on Research, Regulation and the Environment, 1999-2003.

Agricultural Experiment Station, Agricultural Water Management Technologies, Institutions and Policies Affecting Economic Viability and Environmental Quality, 1999-2004.

Giannini Foundation, Predicting Vineyard Expansion and Its Environmental Consequences, 1999-2001.

University of California, San Diego, IGCC/California Sea Grant College Fellowship in International Marine Policy, 1999-2000.

California Department of Conservation, California Beverage Container Recycling and Litter Reduction Study, 2000-2003.

California Department of Finance, Dynamic Revenue Analysis Model (DRAM), 2000-01.

Committee on Research, Measuring Amenity Values in the Labor and Housing Markets, 2000-01.

California Environmental Protection Agency Air Resources Board, The Economic-Wide Effects of Air Quality Regulation, 2001-2005.

U.S. Environmental Protection Agency, Integrating Economic and Physical Data Across the Landscape to Forecast Land Use Change and Environmental Change, 2002-2004.

College of Natural Resources Faculty Committee on Research (AES), Regulation and the Environment, 2003-04.

College of Natural Resources Faculty Committee on Research (AES), Water Conservation, Competition and Quality in Western Irrigated Agriculture, 2003-04.

Committee on Research, The Market Value of the California Tax Revenue Stream, 2003-04.

U.S. Department of Agriculture, Economic Research Service, Land Use and the Environment at the Extensive Margin, 2003-04.

Committee on Research, The Economics of Total Nutrient Management, 2004-05.

Giannini Foundation, Total Nutrient Management, Pollution, and California Dairy Farming, 2004-05.

College of Natural Resources Faculty Committee on Research (AES), The Cost of Environmental Regulation, 2004-2008.

College of Natural Resources Faculty Committee on Research (AES), Rural Communities, Rural Labor Markets and Public Policy, 2004-2008.

Committee on Research, Determinants of Rural Land Use, 2005-06.

Haas School of Business (Fisher Center Grant), To Support a Postdoc, 2005-06.

California Environmental Protection Agency Air Resources Board, Technical Assistance for Climate Change Forecasting, 2005-. ($75,000)

USDA. The Effect of Commodity Food Prices on Firms' Pricing and Consumer Expenditure. 2009-2009. (co PI with Villas-Boas $30,000)

Committee on Research, 2006-08.

Energy Biosciences Institute… Life-cycle Environmental and Economic Decision-Making for Alternative Biofuels. Co-operating investigator. 2008-2010. (approximately $70,000)

Energy Biosciences Institute The Econometrics of Land Use Change and Biofuels $140,900. (PI with co PI Max Auffhammer) 2010-2012

Southern California Edison. California Needs Assessment of Workforce Issues for Energy Efficiency, Demand-side Management, Renewable Energy and the Green Energy. (cooperating investigator. approximately $10,000 out of 2,000,000) 2009-2010.

Giannini Foundation of Agricultural Economics. Demand in California: Estimating a Non-linear I(1) System. 2010-2011. ($14,000)

Giannini Foundation of Agricultural Economics. 2011-2012. ($25,000) and Fisher Center for Real Estate Research ($12,000) "Energy Efficiency and the Landlord-Tenant Problem in California's Commercial Buildings."

ERS/USDA. 2011-2012. ($35,000) Estimating Food Attributable Fractions of Foodborne Illness from Time Series Data.

Publications

Journals

Domar, E.; Siegel, J.; and Berck, Peter. "Stability Without Planning." *United Malayan Banking Corporation Economics Review*, Vol. X, No. 2 (1974), pp. 45-62.

Berck, Peter. "Hard Driving and Efficiency: Iron Production in 1890." *Journal of Economic History*, Vol. XXXVIII, No. 4 (December, 1978), pp. 879-900.

_____. "Open Access and Extinction." *Econometrica*, Vol. 47, No. 4 (July, 1979), pp. 877-882.

_____. "The Economics of Timber: A Renewable Resource in the Long Run." *The Bell Journal of Economics* (Fall, 1979), pp. 447-462.

_____. "The Supply of Douglas Fir and Its Potential for Biomass Utilization." *Bioresources Digest*, Vol. 2, No. 2 (April, 1980), pp. 98-108.

_____. "Optimal Management of Renewable Resources with Growing Demand and Stock Externalities." *Journal of Environmental Economics and Management*, Vol. 8, No. 2 (June, 1981), pp. 105-117.

_____. "Portfolio Theory and the Demand for Futures: Case of California Cotton." *American Journal of Agricultural Economics*, Vol. 63, No. 3 (August, 1981), pp. 466-474.

Berck, Peter, and Hihn, Jairus M. "Using the Semivariance to Estimate Safety-First Rules." *American Journal of Agricultural Economics*, Vol. 64, No. 2 (May, 1982), pp. 298-300.

Berck, Peter, and Perloff, Jeffrey M. "An Open-Access Fishery with Rational Expectations." *Econometrica*, Vol. 52, No. 2 (March, 1984), pp. 489-506.

Berck, Peter, and Bible, Thomas. "Solving and Interpreting Large-Scale Harvest Scheduling Problems by Duality and Decomposition." *Forest Science*, Vol. 30, No. 1 (1984), pp. 173-182.

Berck, Peter. "A Note on the Real Cost of Tractors in the 20s and 30s." *Journal of Agricultural History* (January, 1985), pp. 66-71.

Berck, Peter, and Perloff, Jeffrey M. "The Commons as a Natural Barrier to Entry: Why There Are So Few Fish Farms." *American Journal of Agricultural Economics*, Vol. 67, No. 2 (May, 1985), pp. 360-363.

Berck, Peter, and Cecchetti, Stephen. "Portfolio Diversification, Futures Markets, and Uncertain Consumption Prices." *American Journal of Agricultural Economics*, Vol. 67, No. 3 (August, 1985), pp. 497-507.

Berck, Peter, and Perloff, Jeffrey M. "A Dynamic Analysis of Marketing Orders, Voting, and Welfare." *American Journal of Agricultural Economics* (August, 1985), pp. 487-496.

Berck, Peter, and Bible, Thomas. "Wood Products Futures Markets and the Reservation Price of Timber." *Journal of Futures Markets*, Vol. 5, No. 3 (1985), pp. 311-316.

Berck, Peter, and Johns, Grace. "Policy Consequences of Better Stock Estimates in Pacific Halibut Fisheries." *Journal of the American Statistical Association.* Proceedings for the Business Economics and Statistics section (1985), pp. 139-145.

Berck, Peter, and Levy, Amnon. "The Costs of Equal Land Distribution: The Case of the Israeli Moshavim." *American Journal of Agricultural Economics*, Vol. 68, No. 3 (August, 1986), pp. 605-614.

Liebhold, Andrew; Berck, Peter; Williams, Nancy; and Wood, David L. "Estimating and Valuing Western Pine Beetle Impacts." *Forest Science*, Vol. 32, No. 2 (1986), pp. 325-338.

Lord, Janet P.; Portwood, Margaret M.; Lieberman, James S.; Fowler, William M., Jr.; and Berck, Peter. "Upper Extremity Functional Rating for Patients with Duchenne Muscular Dystrophy." *Archives of Physical Medicine and Rehabilitation*, Vol. 68 (1986), pp. 151-154.

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Berck, Peter, Sofia Tano and Olle Westerlund The determinants of the choice of location among young adults: evidence from Sweden

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Arizona State University, B.A. (Economics/Latin American Studies), 1982
La Universidad Autónoma de Nuevo León, Monterrey, Mexico, Exchange Student (Economics), 1981

Employment

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Teaching Experience

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Bullock, D.S. "Simulating the Effects of Supply and Demand Elasticities on Political-Economic Equilibrium." Working paper, University of Illinois Department of Agricultural and Consumer Economics, 2009.

Brouhle, Keith, and D.S. Bullock. "Measuring Welfare Effects of Uncertain Changes in Quality of Credence Goods under Partial or Exaggerated Information." Working paper, University of Illinois Department of Agricultural and Consumer Economics, 2009.

Bullock, D.S. "Should We Expect Government Policy to Be Pareto Efficient?: The Consequences of and Arrow-Debreu Economy with Violable Property Rights." Work in progress, University of Illinois Department of Agricultural and Consumer Economics, 2009.

Scholarships, Honors

Outstanding Student in Economics (Arizona State University, 1982).

Graduated *summa cum laude* (Arizona State University), G.P.A. 3.98/4.00, 1982.

National Science Foundation Award, Honorable Mention (Economics), 1983.

University of Chicago general fellowship, 1984-1985 (Awarded to the 35% of first-year Economics Department graduate students who passed qualifying examinations)

University of Chicago Pew Teaching Fellowship, 1986-1987, 1987-1988.

Included on the **Incomplete List of Instructors Ranked as Excellent by Their Students**:

ACE 356 "Agricultural and Food Policies and Programs": F99
ACE 453 "Applied Welfare and Policy Economics," : S92, S93*, S94*, S95*, S98, F99
ACE 456 "Economic Policy in a Global Economy II" : S91*, F93*, F94*, F95*, F96*
ACE 503 "Market Equilibrium and Welfare" : S02*, S03, S04, S05*, S06, S07*, S08, S09*, S11*
ACE 556 "International Food Policy II": F04, S09*, S11*
ACE 592-BTP "Biotechnology and Policy": S05*

* "Outstanding"

2012 Senior Faculty Award for Excellence in Teaching, University of Illinois College of Agricultural, Consumer, and Environmental Sciences.

Outstanding Graduate Faculty Award, Department of Agricultural Economics, University of Illinois, 1992, 2000, 2004, 2007.

University of Illinois Campus Award for Excellence in Graduate and Professional Teaching (Honorable Mention), March 2003.

American Agricultural Economics Association, **Quality of Communication Award** for Professional Excellence (Honorable Mention), Aug. 1, 2000.

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February 2012

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Ph.D., Economics, University of Michigan, 1989.

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B.S., Community Economic Development, University of California, Davis, 1980.

Areas of Specialization:

Environmental Policy, Public Finance, Industrial Organization, Applied Game Theory.

Professional Activities:

Senior Fellow, Resources for the Future, Quality of the Environment Division. (1998-present)

Fellow, Resources for the Future, Quality of the Environment Division. (1989-1998)

Consultant to state and federal agencies, electricity companies, environmental organizations and international lending and economic assistance institutions.

Previous Experience:

Professional Lecturer in International Relations, Energy, Environment, Science and Technology. Johns Hopkins SAIS University. (1993-1999).

Adjunct Professor, Department of Economics, Georgetown University. (1998).

Instructor, University of Michigan: Introductory Microeconomics.
Teaching Assistant, University of Michigan: Operations Research.
Teaching Assistant, University of Michigan: Law and Economics. (1984-1989).

Economic Analyst, Pacific Gas and Electric Company. (1984)

Program Manager, SolarCal Local Government Commission on Conservation and Renewable Resources, State of California. (1981-1982).

PUBLICATIONS

"Soft and Hard Price Collars in a Cap-and-Trade System: A Comparative Analysis," 2012 (with Harrison Fell, Richard D. Morgenstern and Karen L. Palmer), *Journal of Environmental Economics and Management,* forthcoming.

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"Tradable Standards for Clean Air Act Carbon Policy," 2012 (with Art Fraas and Nathan Richardson), *Environmental Law Reporter,* forthcoming.

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"Greenhouse Gas Regulation under the Clean Air Act: A Guide for Economists," 2011 (with Art Fraas and Nathan Richardson), *Review of Environmental Economics and Policy*, 5 (2) 293-313.

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"Renewables from Another Angle," 2000, *Electric Perspectives,* (with James McVeigh, Joel Darmstadter, and Karen Palmer). Vol. 25, No. 2, 10-20. See: "Winner, Loser, or Innocent Victim: Has Renewable Energy Performed As Expected?"

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Title: Ben Hill Griffin, Jr. Eminent Scholar and Professor, Food and Resource Economics, University of Florida, 1994-present
Research Professor, University of California at Berkeley, 1994-present
Adjunct Professor, University of Saskatchewan, 1986-present
Honorary Chair, Centre for the Study of Agriculture, Law, and the Environment, University of Saskatchewan, 2001-2003

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Birthplace: Central Butte, Saskatchewan, Canada

Date of Birth: October 5, 1940

EDUCATION

Institution	Degree	Year	Field
University of Saskatchewan	B.S.A.	1963	Agricultural Economics
University of Saskatchewan	M.Sc.	1964	Agricultural Economics
University of Wisconsin	M. A.	1966	Economics
University of Wisconsin	Ph.D.	1968	Economics
University of Saskatchewan	D.Litt.	1999	Agricultural Economics

THESIS AND DISSERTATION

M.S. thesis, University of Saskatchewan, 1964. "Function Analysis of Agriculture Resource Utilization in Saskatchewan's Census Division Sixteen."

Ph.D. dissertation, University of Wisconsin, 1968. "An Economic Analysis of the World Wheat Economy in 1980."

TEACHING AND RESEARCH INTERESTS

International trade; marketing; cost benefit; and anti-trust economics.

FARMING INTERESTS

Dr. Schmitz was raised on a farm near Central Butte, Saskatchewan, Canada. He continues to maintain an active interest in the operation and management of Schmitz Farms, located in the three municipalities of Chaplin, Enfield and Moose Jaw, of which he is part owner. Schmitz Farms specialize in durum and spring wheat production and beef cattle. Schmitz also has farming interests in Iowa and in California.

FACULTY POSITIONS HELD

Professor, University of California at Berkeley, 1968-1994 (excluding 1974, 1982-1983 and 1986-1988 at the University of Saskatchewan).

Adjunct Professor, Department of Agricultural Economics, University of Saskatchewan, 1986-present.

Chair, Department of Agricultural and Resource Economics, University of California at Berkeley, 1989-1993.

Eminent Scholar and Professor, Food and Resource Economics Department, University of Florida, 1994-present.

AWARDS AND HONORS (EXCLUDING UNDERGRADUATE)

Master's Thesis Award for the best thesis in Agricultural Economics in Canada, 1964.

Harold Groves Doctoral Dissertation Award for the best thesis in the Department of Economics, University of Wisconsin, for the period 1967-1968; submitted in the Irving Fisher Award competition.

American Agricultural Economics Association Award for Best Published Research, 1970 *(The World Sugar Economy)*.

American Agricultural Economics Association Award for Outstanding Article in *The American Journal of Agricultural Economics*, 1970 ("Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester").

American Agricultural Economics Association Award for Best Published Research, 1978 ("Storage and Price Uncertainty in International Trade").

American Agricultural Economics Association Award for Quality of Communication, 1979 (*International Trade Arrangements*).

Western Agricultural Economics Association Award for Best Published Research, 1980 (*Consumer's Surplus, Price Instability, and Consumer Welfare*).

American Agricultural Economics Association Award for Best Published Research, 1981 (*Grain Export Cartels*).

American Agricultural Economics Association Award for Research of Enduring Quality, 1981 (*Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester*).

Special Recognition given to Andrew Schmitz as "An Outstanding Contributor," in *Agricultural Economics and Agribusiness*, Second Edition, (Gail L. Cramer and Clarence W. Jones, editors, John Wiley and Sons, New York, NY, 1982.

The J.C. Snyder Memorial Lecture at Purdue University, 1983 (*North America's Agricultural Trade and the Policy Debate*).

Fellow of the American Agricultural Economics Association, 1985 (August).

George W. and Elsie M. Robinson Endowed Chair in Agricultural Economics, University of California, March 1986 – June 1994.

The Anderson Scholar Lecture at Ohio State University, 1986 (*Grain Cartels and Agricultural Trade*).

Outstanding Graduate Award, College of Agriculture's 75th Anniversary, University of Saskatchewan, Saskatoon, Canada, 1986 (July).

Van Vliet Endowed Chair, University of Saskatchewan, 1986-1988.

American Agricultural Economics Association Award for Research of Enduring Quality, 1987 ("Concept of Economic Surplus").

Fellows Address, American Agricultural Economics, 1989. (*GATT: The Role of Special Interest Groups*).

American Agricultural Economics Association Award for Research of Enduring Quality, *Applied Welfare Economics and Public Policy,* Prentice Hall, Englewood Cliffs, NJ, 1994.

Ben Hill Griffin, Endowed Chair and Eminent Scholar, University of Florida, June 1994.

Currie M., J. Murphy, and A. Schmitz. "The Concept of Economic Surplus and Its Use in Economic Analysis," 1966 (*The Economic Journal*, Awarded a Classic by the Royal Academy of Sciences, London, England).

American Agricultural Economics Association Waugh Medal and Lecture, "Boom Bust Cycles and Ricardian Rents," 1995 (August).

American Agricultural Economics Association, Babcock, B. and A. Schmitz, "Look for Hidden Costs: Why a Direct Subsidy Can Cost Us Less Than a 'No Cost' Trade Barrier," 1996 (*The Best of Choices 1986-1996*).

L. Tweeten Distinguished Lecture at Ohio State, "Canada-U.S. Trade Disputes," 1996.

M.L. Wilson Distinguished Lecture at Montana State, 1996 (*Grain Marketing and Trade: Where Are They Headed?*).

Invited Lecture, 1996 ("The Adaptation of New Technologies in Agriculture," 100th Anniversary, University of Vicosa, Brazil).

Earned Doctors of Letters Degree, University of Saskatchewan, 1999.

Outstanding Publication Award, "Canadian Wheat Board: Marketing in the New Millennium," 2001 (The Saskatchewan Book Writers Guild).

Member of National Research Council Food Safety Committee, National Academy of Sciences, July 2000 to present.

Lifetime Achievement Award, Southern Agricultural Economics Association, 2003.

Research Fellow, Rural Development Research Consortium, University of California, Berkeley, CA, 2003.

Enduring Research Quality Award-American Agricultural Economics Association, G. Feder, R. Just, and A. Schmitz, "Futures Markets and the Theory of the Firm under Uncertainty," 2003.

Outstanding Contribution in Research Award, Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, 2003-2004

Who's Who in America Award, 2004.

PROFESSIONAL CONSULTING ACTIVITIES (1968 TO PRESENT)

LEGAL CONSULTATIONS

Legal Firms (Including)
Alioto and Alioto, San Francisco, California
Hawkins and Norris, Des Moines, Iowa
Keker and Brockett, San Francisco, California

Donald Martin, Thunder Bay, Ontario, Canada
McKercher and McKercher, Saskatchewan, Canada
Tuttle and Taylor, Los Angeles, California
Lubé and Lewis, Oakland, California
Ardent and Fox, Washington, DC
Beard and Associates
Cohen, Milstein Hausfeld & Toll, P.L.L.C.
Levin, Middlebrooks, Thomas, Mitchell, Echsner. Proctor & Papantonio, P.A.
Bartlit, Beck, Herman, Palenchar, and Scott, L.L.P.
Barnes, Richardson, and Colburn
Devine Goodman

Companies and Government Agencies (Including)
Attorney General's Office, Arizona
Peat, Marwick, San Francisco, California
Wells Fargo Bank, Oakland, California
U.S. Department of Justice
Canadian Department of Justice

Other Consultations (Including)
American Enterprise Institute
Armour and Company
Marv Anderson and Associates
Canada Agriculture
Canadian Wheat Board
Environmental Protection Agency
Food West Resource Consultants
The Ford Foundation
Government of Saskatchewan
Hall Commission
International Food Policy Research Institute
International Trade Commission
Lawrence Livermore Laboratory
Meat Price Investigators, Inc.
National Grain and Feed Association
Potash Corporation of Saskatchewan
Prairie Farm Rehabilitation Authority, Ottawa, Canada
Resources and Development Corporation
Sugar Users Group, Washington, D.C.
Sunkist Growers, Inc.
Teknekron, Inc.
U.S. Central Intelligence Agency
U.S. Department of Agriculture
Canada Grains Council
U.S. Department of Transportation
U.S. General Accounting Office

U.S. Office of Technology Assessment
U.S. Tariff Commission
Uppsala University, Sweden
The World Bank
Mac Arthur Foundation
Food and Agriculture Organization of the United Nations

International Consulting and Other International Activities (selected activities)

1. The World Bank
   — Analyze food aid and food security of less developed countries and the impact of food storage on income and price instability.
   — Analyze world grain trade, with specific emphasis on the market structure.
   — Analyze optimal world grain stocks.

2. International Trade Consortium
   — A founding member in late 1970s. Group meets twice annually at international locations, averaging 150 to 200 participants. Membership includes Agriculture Canada and ERS/USDA.

3. Technokron
   — Copper industry dynamics in Zaire. Analyze long-run factors affecting copper production, and develop copper price forecasting models.

4. Economic Council of Canada
   — Project director of Economic Council of Canada study on the future of Prairie agriculture, 1986-1989 (most of work done while at the University of Saskatchewan, 1986-1988, as Van Vliet Endowed Chair). Competed for a research grant from Economic Council of Canada for about $500,000, and co-authored two major reports).

5. Sweden
   — Invited by various groups in Sweden to give lectures at the University of Uppsala and to organize and lead a workshop on Cost Benefit Analysis.

6. U.S. Feed Grain Association
   — Market comparisons between the United States and Canada. “The Market Demand for Feed Grains in Latin America” paper was presented in Venezuela.

7. Van Vliet Endowed Chair, Agricultural Economics, University of Saskatchewan.
   — Along with several others, was instrumental in getting the University of Saskatchewan in cooperation with the Government of Saskatchewan to endow the Chair for $1 million (Professor Van Vliet was foremost in directing my professional career).

8. Geneva Delegation (1990)
   — Part of a U.S. delegation, including Mark Ritchie (U.S. Delegation Coordinator), that met with GATT Director Arthur Dunkel and others, including Dr. Mansholt (Former

President, European Commission), to express concerns on the direction of the GATT Agriculture Trade Negotiations. Also met in Germany and Holland.

9. U.S. Information Agency (Bulgarian Project)
   — Wrote book on privatization of Bulgarian agriculture, with specific emphasis on grains and livestock, including poultry. Spent time in Bulgaria on research that was the basis for a book. We received a competitive grant for an amount exceeding $100,000.

10. Supply Management in Canada
   — Supply management project. Received substantial funding on a competitive basis to research Canadian supply management. (Funding obtained from several groups, including National Farm Products Council, Agriculture and Agri-Food Canada, and Canadian Dairy Commission.) Major paper presented in Ottawa. Later organized a conference at MacDonald Campus of McGill University in Québec (June 1994), which led to a book, *Regulation and Protectionism under GATT*.

11. Big Green Initiative
   — A major player in international work on the use of alternative pesticide technologies. This resulted in a major research output, including our paper in *Science* with Professor Zilberman from the University of California at Berkeley.

12. Saskatchewan Agricultural Development Fund
   — Received several large grants with Professors Furtan and Rosaasen (University of Saskatchewan).
      a. Feed grain study on a comparison of feed grain prices and efficiency of feed grain markets in both the United States and Canada.
      b. Study on implications of prairie farmers pulling out of Canadian Supply Management.
      c. The role of Parastatals in world agricultural trade and their effects on Canadian single desk selling entities.

13. U.S. Corn Growers' Economic Expert
   — Canadian dumping case against shipments of U.S. corn into Ontario.

14. USAID Sri Lanka Project (Received grant from USAID in an open bid process.)
   — Estimating the impact of Title III grain shipments to Sri Lanka, both in terms of their effect in eliminating malnutrition and in terms of privatization activities.
   — Established private grain auctions in Bangladesh.

15. MacArthur Foundation
   — Received significant grant with Professor Zilberman from the University of California at Berkeley to organize and participate at the IICA Conference, San Jose, Costa Rica.
   — My research dealt with GATT, Trade, and the Environment.

16. Israel (Bard Project)
   — Grain storage in less developed countries.

17. United States Beef Export Opportunities in Japan.
    — Extensive work in Japan sponsored by several groups, including private cattle sector.

18. Canadian Economic Development (CEDA)
    — Received funding under a competitive grant from CEDA. Project on the Caribbean (potential for agricultural exports and development).

19. The USDA Embargo Study (1985)
    — Conducted major research for Congress-mandated analysis of two controversial aspects of U.S. agricultural trade policy: embargoes and surplus disposal programs.

20. Canada Grains Council
    — Participated in an international effort with Doug Campbell and others on the impact of U.S. trade and agricultural policies on world grain trading nations.

21. The Association of Regulated Importers (Canada)
    — Expert witness on the effect of replacing poultry quotas in Canada with tariffs.

22. International Water Consortium
    — This group came about while I was Chair at the University of California at Berkeley. Participants included various Israeli groups and the University of Florida, University of California, and Australia. Meetings are held at various locations around the world.

23. Canadian Department of Justice
    — Major expert witness on economic performance of the Canadian Wheat Board (CWB) pertaining to Charter Case (Calgary, Alberta, October of 1996). I was selected by the Canadian Department of Justice through consultations and recommendations from the CWB. Report submitted to the Justice Department entitled *The Economic Performance of the Canadian Wheat Board: Myth or Reality* (testimony given in Calgary).

24. World Trade Conference (Ankara, Turkey, 1997)
    — Helped organize and participate in a conference on Global World Agricultural Trade.

25. WTO and GATT Conferences (Saskatoon, SK, Canada)
    — I, along with Professor Grey (University of Saskatchewan) and T. Harasym (Saskatchewan Wheat Pool) organized a conference in Saskatoon on GATT and Agriculture, June of 1994. I was also an invited speaker.
    — Invited Speaker (WTO and GATT Conference, Saskatoon, Canada, October of 1997).

26. Beijing, China, 1997
    — Participated in meetings under Parastatal Project (University of Saskatchewan).

27. Turkish Agricultural Economics Research Institute, Ankara, Turkey, 1998
    — Research Director on “Marketing Orders and State Trading in Turkish Agriculture” project with Professors Erol Cakmak (Middle East Technical University), Richard

Gray (University of Saskatchewan), and Troy Schmitz (Arizona State University).

28. USAID Project in Guyana (in conjunction with Chemonics), 1999
    — Research Director on "Marketing Orders and State Trading in Turkish Agriculture" project with Professors Erol Cakmak (Middle East Technical University), Richard Gray (University of Saskatchewan), and Troy Schmitz (Arizona State University).
    — Project evaluating effectiveness, Guyana's Ministry of Trade, Industry, and Tourism.

PUBLICATIONS

BOOKS/BOOK CHAPTERS

1. Schmitz, A. (1966). *Functional Analysis of Agricultural Resource Use in North Western Saskatchewan*. Saskatchewan, Canada: Canadian Center for Community Studies.

2. Schmitz, A. and D.L. Bawden. (1973). "A Spatial Price Analysis of the World Wheat Economy: Some Long-Run Predictions." In *Studies in Economic Planning over Space and Time*, edited by G. Judge and T. Takayama. Amsterdam: North-Holland Publishing.

3. Hertford, R. and A. Schmitz. (1976). "Measuring Economic Returns to Agricultural Research." In *Resource Allocation and Productivity in National and International Agricultural Research*, edited by T. Arndt, D. Dalrymple, and V. Ruttan. Minneapolis, MN: University of Minnesota Press.

4. Schmitz, A. and A.F. McCalla. (1978). "The Canadian Wheat Board." In *Marketing Boards: An International Perspective*, edited by S. Hoos. Cambridge, MA: Ballinger Press.

5. Chambers, R.G., J.M. Letiche, and A. Schmitz. (1979). "The Gains from International Trade." In *International Trade and Agriculture: Theory and Policy*, edited by J. Hillman and A. Schmitz. Boulder, CO: Westview Press.

6. Hillman, J.S. and A. Schmitz, editors. (1979). *International Trade and Agriculture: Theory and Policy*. Boulder, CO: Westview Press.

7. Letiche, J.M., R.G. Chambers, and A. Schmitz. 1979. "The Development of Gains from Trade Theory: Classical to Modern Literature." In *Economic Perspectives: An Annual Survey of Economics*, edited by M. Ballabon. NY: Gordon and Bresch Publishing.

7. Schmitz, A. (1979). "Research in International Trade: Methods and Techniques with Emphasis on Agricultural Trade." In *International Trade and Agriculture: Theory and Policy*, edited by J. Hillman and A. Schmitz. Boulder, CO: Westview Press.

8. Rausser, G., A. de Janvry, A. Schmitz, and D. Zilberman. (1981). "Principal Issues in the Evaluation of Public Research in Agriculture." In *Evaluation of Agricultural Research*, edited by B. Sundquist. St. Paul, MN: University of Minnesota Press.

9. Sarris, A.H. and A. Schmitz. (1981). "Price Formation in International Agricultural Trade." In *International Agricultural Trade and Imperfect Markets*, edited by A. McCalla and T. Josling. Montclair, NJ: Allanheld, Osmun, and Company.

10. Schmitz, A. and A.F. McCalla. (1981). "Analysis of Imperfections in International Trade: The Case of Grain Export Cartels." In *Imperfect Markets in Agricultural Trade*, edited by A. McCalla and T. Josling. Montclair, NJ: Allanheld, Osmun and Company.

11. Schmitz, A., A.F. McCalla, D. Mitchell, and C. Carter. (1981). *Grain Export Cartels*. Cambridge, MA: Ballinger Press.

12. Chambers, R.G., R.E. Just, L.J. Moffitt, and A. Schmitz. (1982). "An Empirical Investigation of Disequilibrium in the U.S. Beef Import Market." In *New Directions in Econometric Modeling and Forecasting in U.S. Agriculture*, edited by G. Rausser. NY: Elsevier North-Holland, Inc.

13. Just, R.E., D.L. Hueth, and A. Schmitz. (1982). *Applied Welfare Economics and Public Policy*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

14. Letiche, J.M., R.G. Chambers, and A. Schmitz. (1982). "The Development of Gains from Trade Theory: Classical to Modern Literature." In *International Economic Policies and Their Theoretical Foundations*, edited by J. Letiche. NY: Academic Press.

15. McCalla, A.F. and A. Schmitz. (1982). "State Trading in Grains." In *State Trading in International Markets: Theory and Practice of Industrialized and Developing Countries*, edited by M. Kostechi. NY: The Macmillan Company.

16. Doering, O., A. Schmitz, and J. Miranowski. (1983). "Farm Costs and Exports." *Increasing Understanding of Public Problems and Policies*. Oak Brook, IL: The Farm Foundation.

17. Berck, P. and A. Schmitz. (1984). "Price Supports in the Context of International Trade." In *International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability*, edited by G. Storey, A. Schmitz, and A. Sarris. Boulder, CO: Westview Press.

18. Schmitz, A. (1983). "Canada's Agricultural Trade and Growth Potential." In *Transforming Western Canada's Food Industry in the 1980s and 1990s*, edited by B. Sadler. Calgary, Canada: University of Calgary Press.

19. Schmitz, A. (1984). "Prospects for Change in Livestock Production and Trade." In *World Agricultural Policies and Trade*, edited by G.E. Lee, pp. 134-162. Saskatoon, Canada: University of Saskatchewan.

20. Storey, G.C., A. Schmitz, and A.H. Sarris, editors. (1984). *International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability*. Boulder, CO: Westview Press.

21. Young, L. and A. Schmitz. (1984). "Storage under a Cartel." In *International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability*, edited by G. Storey, A. Schmitz, and A. Sarris. Boulder, CO: Westview Press.

22. Hueth, D.L. and A. Schmitz. (1985). "Rates of Return to Research from Joint Investment: Public and Private." In *Economics of Agricultural Research in Canada*, edited by K. Klein and W. Furtan. Calgary, Canada: University of Calgary Press.

23. Schmitz, A., R. Allen, and G-J Leu. (1985). "The U.S. Sugar Program and Its Effects." In *Alternative Agricultural and Food Policies and the 1985 Farm Bill*, edited by G. Rausser and K. Farrell (Giannini Foundation of Agricultural Economics, Division of Agriculture and Natural Resources). Berkeley, CA: University of California at Berkeley.

24. Ulrich, A., H. Furtan, and A. Schmitz. (1985). "Public and Private Returns From Joint Venture Research in Agriculture: The Case of Malting Barley." In *Economics of Agricultural Research in Canada*, edited by K. Klein and W. Furtan. Calgary, Canada: University of Calgary Press.

25. Schmitz, A. (1986). *The U.S. Sugar Program under Price Uncertainty*. Washington, D.C.: American Enterprise Institute.

26. Schmitz, A. (1986). *Wheat Trade and Trade Policy*. Saskatoon, Canada: University of Saskatchewan and Modern Press.

27. Paarlberg, P., A. Schmitz, and A. McCalla. (1987). "The Economics of Export Subsidies." Chapter 18, in *Embargoes, Surplus Disposal, and U.S. Agriculture* (Agricultural Economics Report 564). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

28. Schmitz, A. and C. Carter. (1987). "A Sectoral Perspective: Agriculture." In *Perspectives on a U.S.-Canadian Free Trade Agreement,* edited by R. Stern, P. Trezise, and J. Walley, 245-259. Washington, D.C.: The Brookings Institution.

29. Schmitz, A. and A.F. McCalla. (1987). "Embargoes: A Review of Conceptual, Theoretical, and Empirical Analyses." Chapter 8, in *Embargoes, Surplus Disposal, and U.S. Agriculture* (Agricultural Economics Report 564). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

30. Hayes, D. and A. Schmitz. (1988). "The Price and Welfare Implications of Current Conflicts between the Agricultural Policies of the United States and the European Community." Chapter 3, in *Issues in U.S.-E.C. Trade Relations,* edited by R. Baldwin, C. Hamilton, and A. Sapier. Chicago, IL: The University of Chicago Press.

31. Schmitz, A., G.C. van Kooten, and W.H. Furtan. (1988). "Issues in Commodity Trade: Implications for Natural Resources." Chapter 10, in *Agricultural Trade and Natural Resources*, edited by J. Sutton. Boulder, CO: Lynne Rienner Publishers.

32. Carter, C., A.F. McCalla, and A. Schmitz. (1989). *Canada and International Grain Markets: Trends, Policies, and Prospects*. Ottawa, Canada: Economic Council of Canada, Canadian Government Publishing Centre (107pp).

33. Fulton, M., K. Rosaasen, and A. Schmitz. (1989). *Canadian Agricultural Policy and Prairie* Agriculture. Ottawa, Canada: Economic Council of Canada, Canadian Government Publishing Centre.

34. Just, R.E. and A. Schmitz. (1989). "The Effect of U.S. Farm Programs on Diversification." Chapter 9, in *Free Trade and Agricultural Diversification: Canada and the United State*, edited by A. Schmitz. Boulder, CO: Westview Press.

35. Schmitz, A. (1989). "Agricultural Diversification Strategies: Canada and the United States." Chapter 2, in *Free Trade and Agricultural Diversification: Canada and the United States*, edited by A. Schmitz. Boulder, CO: Westview Press.

36. Schmitz, A., editor, (1989). *Free Trade and Agricultural Diversification: Canada and the United States.* Boulder, CO: Westview Press.

37. Schmitz, A. (1989). "Trade in Primary Products: Canada, the United States, and Japan." Chapter 2, in *Trade and Investment Relations among the United States, Canada, and Japan*, edited by R. Stern. Chicago, IL: The University of Chicago Press.

38. Carter, C., R. Stern, and A. Schmitz. (1990). "The Potato War and U.S.-Canada Agricultural Trade." Chapter 8, in *Canadian Agricultural Trade: Disputes, Actions, and Prospects*, edited by G. Lermer and K. Klein. Calgary: University of Calgary Press.

39. Schmitz, A. (1990). "Price Discovery in the U.S. Beef Industry." Chapter 6, in *Competitive Issues in the Beef Sector: Can Beef Compete in the 1990s?*, edited by D. Johnson, J. Connor, T. Josling, A. Schmitz, and G. Schuh. Minneapolis, MN: Hubert Humphrey Institute of Public Affairs, University of Minnesota.

40. Schmitz, A. and D. Sigurdson. (1990). "Stabilization Programs and Countervailing Duties: Canadian Hog Exports to the United States." Chapter 5, in *Canadian Agricultural Trade: Disputes, Actions, Prospects*, edited by G. Lermer and K. Klein. Calgary, Canada: University of Calgary Press.

41. Becker, T., R. Gray, and A. Schmitz, editors. (1992). *Improving Agricultural Trade Performance under the GATT*. Kiel, KG: Wissenschaftsverlag Vauk.

42. McGarry, M.J. and A. Schmitz, editors. (1992). *The World Grain Trade: Grain Marketing, Institutions, and Policies.* Boulder, CO: Westview Press

43. Wahl, T., D. Hayes, and A. Schmitz. (1992). "Agriculture and Trade in the Pacific: Toward the Twenty-first Century." In *The Japanese Beef Policy: Political Preference Function*. Boulder, CO: Westview Press.

44. Cochran, N., A. Schmitz, and S. Bojnec. (1994). "Agriculture Diversification and Productivity." In *Privatization of Agriculture in New Market Economies: Lessons from Bulgaria*, edited by A. Schmitz, K. Moulton, A. Buckwell, and S. Davidova. Norwell, MA: Kluwer Academic Publishers.

45. Meekhof, R., A. Schmitz, and I. Penov. (1994). "The Grain Sector: Wheat Is King." In *Privatization of Agriculture in New Market Economies: Lessons from Bulgaria,* edited by A. Schmitz, K. Moulton, A. Buckwell, and S. Davidova. Norwell, MA: Kluwer Academic Publishers.

46. Moulton, K., A. Schmitz, A. Buckwell, and R. Trendafilov. (1994). "Agricultural Transformation: An Overview." In *Privation of Agriculture in New Market Economies: Lessons from Bulgaria*, edited by A. Schmitz, K. Moulton, A. Buckwell, and S. Davidova. Norwell, MA: Kluwer Academic Publishers.

47. Moulton, K., A. Schmitz, and A. Simova. (1994). "Liquidation Committees, Land Commission and No Fruit." In *Privation of Agriculture in New Market Economies: Lessons from Bulgaria*, edited by A. Schmitz, K. Moulton, A. Buckwell, and S. Davidova. Norwell, MA: Kluwer Academic Publishers.

48. Schmitz, A., R.E. Just, and W.H. Furtan. (1994). "Crop Insurance in the Context of Canadian and U.S. Farm Programs." In *Economics of Agricultural Crop Insurance: Theory and Evidence*, edited by D. Hueth and W. Furtan, 167-201. Boston, MA: Kluwer Academic Publishers.

49. Schmitz, A., K. Moulton, A. Buckwell, and S. Davidova, editors. (1994). *Privatization of Agriculture in New Market Economies: Lessons from Bulgaria.* Norwell, MA: Kluwer Academic Publishers.

50. Schmitz, A., K. Moulton, R. Trendafilov, and J. Slavova. (1994). "The Cotton Industry in Decay." In *Privation of Agriculture in New Market Economies: Lessons from Bulgaria,* edited by A. Schmitz, K. Moulton, A. Buckwell, and S. Davidova. Norwell, MA: Kluwer Academic Publishers.

51. Schmitz, A. and T. Schmitz. (1994). "Tariffication and Canadian Supply Management." In *World Agriculture in a Post-GATT Environment: New Rules! New Strategies!*, edited by R. Gray, T. Becker and A. Schmitz. Saskatoon, Canada: University Extension Press, University of Saskatchewan.

52. Schmitz, A. and T. Schmitz. (1994). "Tariffs and Trade." In *Encyclopedia of Agricultural Sciences*, Volume 4. Manhattan, KS: Academic Press, Inc.

53. Schmitz, A. (1995). "Political Economic Analysis in Agricultural Trade and Competitiveness." In *Agricultural Competitiveness: Market Forces and Policy Choice*. Dartmouth, CT: Dartmouth Publishing Company.

54. Schmitz, A. and J. Vercammen. (1995). "Efficiency of Farm Programs and Their Trade-Distorting Effects." In *GATT Negotiations and the Political Economy of Policy Reform*, edited by G. Rausser. Amsterdam: *Springer-Verlag Publishers.*

55. Schmitz, A. (1996). "Introduction: Trade and Regulations in Transition." In *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*, edited by A. Schmitz, G. Coffin, and K. Rosaasen, 3-19. Boulder, CO: Westview Press.

56. Schmitz, A. and D. Christian. (1996). "The US Sugar Industry: The Free Trade Debate." In *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*, edited by A. Schmitz, G. Coffin, and K.A. Rosaasen, 180-202. Boulder, CO: Westview Press.

57. Schmitz, A., G. Coffin, and K.A. Rosaasen, editors. (1996). *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*. Boulder, CO: Westview Press.

58. Schmitz, A, H. de Gorter, and T.G. Schmitz. (1996). "Consequences of Tariffication." In *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*, edited by A. Schmitz, G. Coffin, and K. Rosaasen, 37-50. Boulder, CO: Westview Press.

59. Vercammen, J.A. and A. Schmitz. (1996). "Imports into Canada: Why Have They Remained Low?" In *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*, edited by A. Schmitz, G. Coffin, and K. Rosaasen, 64-77. Boulder, CO: Westview Press.

60. Schmitz, A., E. Cakmak, T. Schmitz, and R. Gray. (1998). "Policy, State Trading, and Cooperatives in Turkish Agriculture." Ankara, Turkey: Agricultural Research Institute.

61. Schmitz, A. and W.H. Furtan. (1998). "State Trading, Trade Distortions and GATT." In *World Agricultural Trade*, edited by T. Yildirim, A. Schmitz, and W. Furtan, 255-279. Boulder, CO: Westview Press.

62. Yildirim, T., A. Schmitz, and W.H. Furtan, editors. (1998). *World Agricultural Trade*. Boulder, CO: Westview Press.

63. Casey, F., A. Schmitz, S. Swinton, and D. Zilberman. (1999). *Flexible Incentives for the Adoption of Environmental Technology in Agriculture*. Amsterdam: Kluwer Publishing.

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INVITED PRESENTATIONS (1970 TO PRESENT)

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2. Bieri, J. and A. Schmitz. (1970). "Time Series Modeling of Economic Phenomena." Paper presented at the American Agricultural Economics Association Meeting, Columbia, MO (August).

3. Schmitz, A. (1970). "Priorities in Agricultural Economics for the 1970s." Paper presented at the American Agricultural Economics Association Meeting, Columbia, MO (August).

4. Bieri, J., A. de Janvry, and A. Schmitz. (1970). "Agricultural Technology and the Distribution of Welfare Gains." Paper presented at the American Agricultural Economics Association Meeting, Gainesville, FL.

5. Chen, D., R. Courtney, and A. Schmitz. (1971). "A Distributed Lag Analysis of Milk Production Response." Paper presented at the Western Agricultural Economics Association Meeting, Corvallis, OR.

6. Schmitz, A. (1973). "The Role of Government in the Buying and Selling of Grain." Paper presented to the International Grains Institute, Winnipeg, Manitoba, Canada (October).

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8. Schmitz, A. (1975). "Trade Liberalization: Obstacles and Prospects." Paper presented at the Western Agricultural Economics Association Meeting, Reno, NV (July).

9. Schmitz, A. (1976). Private vs. Public Grain Marketing." Paper sponsored by the Winnipeg Chamber of Commerce and the University of Manitoba, Department of Agricultural Economics, Winnipeg, Canada (December).

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12. Schmitz, A. (1977). “The Role of Market Intermediaries.” Paper presented at the University of California at Davis, Davis, CA (May).

13. Schmitz, A. (1997). “Instability in Agricultural Prices.” Paper presented at the American Farm Bureau Federation Conference, San Francisco, CA (June).

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15. Schmitz, A. (1977). “Quantitative Agricultural Policy.” Paper presented at the American Statistical Association Meeting, Chicago, IL (July).

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50. Schmitz, A., R.S. Firch, and J.S. Hillman. (1980). "Exports of Mexican Winter Vegetables to the U.S.: A Case Study of Dumping." Paper presented at the Trade Symposium, University of Minnesota, Duluth, MN (June).

51. Shalit, H. and A. Schmitz. (1980). "On Farmland Accumulation and Farmland Prices." Paper presented to the Fourth World Congress of the Econometric Society, Aix-en-Provence, France (August).

52. Schmitz, A. (1980). "Cooperative Marketing." Paper presented to the California Farm Bureau Federation, Sacramento, CA (November).

53. Schmitz, A. (1980). "Grain Export Cartels." Paper presented at the University of Manitoba, Winnipeg, Canada (November).

54. Schmitz, A. (1980). "Rates of Return from Research." Paper presented at the University of Saskatchewan, Saskatoon, Canada (November).

55. Schmitz, A. (1980). "Comparative Advantage of U.S. Agriculture in World Trade." Paper presented at the Farm Leadership Conference, University of California at Davis, Davis, CA (December).

56. Schmitz, A. (1980). "Exchange Rate Fluctuations and Trade." Paper presented at the International Trade Conference, Tucson, AZ (December).

57. Schmitz, A. (1981). "Issues Facing Agriculture in the 1980s." Paper presented at the Agricultural Conference, Banff, Alberta, Canada (April).

58. Schmitz, A. (1981). "Estimating and Evaluating Import Demand Functions." Paper presented at the U.S. Department of Agriculture, Washington, D.C. (June).

59. Schmitz, A. and A. Sarris. (1981). "Optimal U.S. Agricultural Trade Policy." Paper presented at the American Agricultural Economics Association Meeting, Clemson, SC (July).

60. Schmitz, A. (1981). "Agricultural Dumping in International Trade." Paper presented at the University of Ontario, Guelph, Canada (November).

61. Schmitz, A. (1981). "Effects of Labor Unions in Agriculture." Paper presented at the University of Ontario, Guelph, Canada (November).

62. Schmitz, A. (1981). "Grain Export Cartels." Paper presented at the University of Ontario, Guelph, Canada (November).

63. Schmitz, A. (1981). "Social and Private Rates of Return from Aggregate Investment." Paper presented at the University of Ontario, Guelph, Canada (November).

64. Schmitz, A. (1981). "Social and Private Rates of Return from Agricultural Research." Paper presented at the University of Manitoba, Winnipeg, Canada, (November).

65. Schmitz, A. (1982). "Grain Export Cartels." Paper presented at the Farm Conference, University of California at Davis, Davis, CA (February).

66. Schmitz, A. (1982). "The Income Position of U.S. Farmers." Paper presented at the Farm Conference, Great Falls, MT (February).

67. Schmitz, A. (1982). "U.S. Policy Response to Agricultural Trade Barriers." Public Lecture, University of Minnesota, Minneapolis, MN (February).

68. Schmitz, A. (1982). "The Use of Voluntary Quotas in Trade." Paper presented to the World Affairs Council, San Francisco, CA (March).

69. Schmitz, A. (1982). "A Retaliatory U.S. Agricultural Trade Policy." Paper presented at the University of Uppsala, Uppsala, Sweden (April).

70. Schmitz, A. (1982). "Optimal Trade Instruments." Paper presented to the International Law Society, University of Wisconsin, Madison, WI (April).

71. Schmitz, A. (1982). "Appropriate Technology for U.S. Agriculture." Paper presented at the Appropriate Technology Conference, University of California at Santa Barbara, Santa Barbara, CA (May).

72. Schmitz, A. (1982). "Grain Export Cartels." Paper presented at the University of Kiel, and at the University of Gottingen, Germany (May).

73. Schmitz, A. (1982). "The Subsidy Component of U.S. Agricultural Export." Paper presented at the Hebrew University of Jerusalem, Rehovot, Israel (May).

74. Schmitz, A. (1982). "The Cost of U.S. Exports." Paper presented at the Trade Conference, St. Louis, MO (June).

75. Schmitz, A. (1982). "Price Supports in the Context of Trade." Paper presented at the American Agricultural Economics Association Meeting, Logan, UT (August).

76. Schmitz, A. (1982). "International Capital Movements." Paper presented at the Trade Conference, sponsored by the Interdependence Center, St. Paul, MN (September).

77. Schmitz, A. (1982). "Demand Enhancement Programs." Paper presented at the Trade Conference sponsored by the Canadian Wheat Board, Winnipeg, Manitoba, Canada (October).

78. Schmitz, A. (1982). "Grain Exporter Cooperation." Paper presented to the Saskatchewan Wheat Pool Delegation Meeting, Regina, Canada (November).

79. Schmitz, A. (1982). "Price Instability—The Theoretical Foundation." Paper presented at The World Bank, Washington, D.C. (December).

80. Schmitz, A. (1982). "The Gains from Trade Revisited." Paper presented at the University of Maryland, College Park, MD (December).

81. Schmitz, A. (1982). “The Impact of Export Instability.” Paper presented at the University of Maryland, College Park, MD (December).

82. Schmitz, A. (1983). “The Gains from Trade: The Case of Agriculture.” Paper presented to the National Association of Wheat Growers, Houston, TX (January).

83. Schmitz, A. (1983). “North America’s Agricultural Trade and the Policy Debate.” Paper presented at the Ninth James C. Snyder Memorial Lecture in Agricultural Economics, Purdue University, West Lafayette, IN (February).

84. Schmitz, A. (1983). “The Marketing Challenge.” Paper presented at the Agricultural Conference, Saskatoon, Saskatchewan, Canada (February).

85. Schmitz, A. (1983). “Wheatpec and Canada's Foreign Trade.” Public Lecture sponsored by the Canadian Institute of National Affairs, Winnipeg, Manitoba, Canada (February).

86. Schmitz, A. (1983). Lectures in “Welfare Economics.” University of Uppsala, Uppsala, Sweden (April).

87. Schmitz, A. (1983). “North America's Agricultural Trade—The Grain Cartel Debate.” Paper presented to the International Students' Association, University of Idaho, Moscow, ID, and at Montana State University, Bozeman, MT (July).

88. Schmitz, A. (1983). “Public and Private Rates of Return to Agricultural Research.” Paper presented at the Conference on Agricultural Productivity in Canada, University of Lethbridge, Alberta, Canada (September).

89. Schmitz, A. (1984). “The Structure of U.S. Agriculture and Policy Response.” Paper presented at the University of Missouri, Columbia, MO (October).

90. Schmitz, A. (1984). “Prospects for Change in Livestock Production and Trade.” Paper presented at the University of Saskatchewan, 75th Anniversary Conference, Saskatoon, Canada (November).

91. Schmitz, A. (1985). “The World Grain Trade.” Paper presented at the Managing Farm Technology Conference, Regina, Saskatchewan, Canada (February).

92. Schmitz, A. (1985). “The U.S. Farm Policy Debate.” Paper presented at the University of Oklahoma, Stillwater, OK (March).

93. Schmitz, A. (1985). “World Trade in Sugar.” Paper presented at the International Sugar Conference, Palm Springs, CA (March).

94. Schmitz, A. (1985). “Canadian-U.S. Agricultural Trade.” Paper presented at Texas A&M University, College Station, TX (April).

95. Schmitz, A. (1985). “The Competitive Nature of U.S. Agriculture.” Paper presented at the Congressional Hearings, Washington, D.C. (April).

96. Schmitz, A. (1985). “Trade Implications for Natural Resource Based Industries.” Keynote Address, Western Agricultural Economics Meetings, University of Saskatchewan, Saskatoon, Canada (July).

97. Schmitz, A. (1986). “International Agricultural Trade.” Paper presented at the International School for Agricultural and Resource Development, Colorado State University, Fort Collins, CO (January).

98. Schmitz, A. (1986). “Marketing Institutions in International Commodity Markets.” Invited Address, Southern Agricultural Economics Association, Orlando, FL (February).

99. Schmitz, A. (1986). “Grain Cartels and Agricultural Trade.” Anderson Scholar Lecture, Ohio State University, Columbus, OH (March).

100. Schmitz, A. (1986). “New Market Opportunities for Red Meat.” Paper presented at the Alberta Cattle Feeders' Association Meeting, Calgary, Alberta, Canada (March).

101. Schmitz, A. (1986). “The Impact on Trade of the U.S. 1985 Farm Bill.” Paper presented to the Western Grain Growers' Association, Calgary, Alberta, Canada (March).

102. Schmitz, A. (1986). “Wheat Trade and Trade Policy.” Paper presented at the Canadian Wheat Production Symposium, Saskatoon, Saskatchewan, Canada (March).

103. Schmitz, A. (1986). “Sectoral Issues in a U.S.-Canadian Trade Agreement.” Paper presented at the workshop, U.S.-Canadian Relations, University of Western Ontario, London, Canada (April).

104. Carter, C. and A. Schmitz. (1986). “Instability, Uncertainty, and Agricultural Trade.” Paper presented at the American Enterprise Policy Conference, Washington, D.C. (May).

105. Hayes, D. and A. Schmitz. (1986). “The Price and Welfare Implications of Agricultural Policies of the United States and the European Community.” Paper presented at NBER and at the Center for European Policy Studies, Brussels, Belgium (June).

106. Schmitz, A. (1986). “International Implications of National Policy Development: Canada.” Paper presented to the Conference on Pacific Economic Cooperation, Massey University, Palmerston North, New Zealand (July).

107. Schmitz, A. (1986). “Canada-U.S. Free Trade and the Implications for Grains.” Paper presented at Brandon University, Brandon, Manitoba, Canada (November).

108. Schmitz, A. (1986). “The Future of the Red Meat Industry.” Invited paper, Farm Foundation Symposium, Atlanta, GA (November).

109. Schmitz, A. (1986). “Is There a Future for the Red Meat Industry?” Paper presented to Canadian Cattlemen’s Association, Saskatoon, Saskatchewan, Canada (November).

110. Schmitz, A. (1986). “The Future Prospects for Red Meat Industry.” Paper presented at Agricultural Outlook Conference, Ottawa, Canada (December).

111. Schmitz, A. (1986). “The Growth and Demand for Fertilizers.” Paper presented at Western Fertilizer Association Meetings, Vancouver, British Columbia, Canada (December).

112. Schmitz, A. (1987). “The Future Demand for Fertilizers in North American Agriculture.” Simplot Inc., Brandon, Manitoba, Canada (January).

113. Schmitz, A. (1987). “The Future Outlook for Grain.” Paper presented to Western Wheat Growers, Saskatoon, Saskatchewan, Canada (January).

114. Schmitz, A. (1987). “International Trade in Agriculture and Resource Use.” Invited paper, U.S. Department of Agriculture, Washington, D.C. (April).

115. Schmitz, A. (1987). “Trade in Primary Products: U.S., Canada and Japan.” Invited paper, University of Michigan, Ann Arbor, MI (April).

116. Schmitz, A. (1987). “The Future Demand for World Feed Grains.” Paper presented to Canadian Feed Grains Council, Saskatoon, Saskatchewan, Canada (June).

117. Schmitz, A. (1987). “Canada-U.S. Free Trade in Agriculture.” Invited paper, Springhill Center, St. Paul, MN (July).

118. Schmitz, A. (1987). “Elasticities in International Agricultural Trade.” Invited paper, Dearborn, MI (July).

119. Schmitz, A. (1987). “The Financial Crisis in North American Agriculture.” Paper presented at Finance Conference, Regina, Saskatchewan, Canada (November).

120. Schmitz, A. (1987). “The Implications of the U.S. Agricultural Policy on World Agriculture.” Invited paper, Springhill Center, St. Paul, MN (November).

121. Schmitz, A. (1987). “Key Issues in Canadian Agriculture.” Invited paper, Canadian Women's Institute, Saskatoon, Saskatchewan, Canada (November).

122. Schmitz, A. (1987). “Less Developed Countries and the Demand for U.S. Feed Grains.” Invited paper, U.S. Feed Grains Council, Caracas, Venezuela (November).

123. Schmitz, A. (1987). "Finance for Beginning Farmers." Paper presented to Saskatchewan Department of Agriculture, Swift Current, Saskatchewan, Canada (December).

124. Schmitz, A. (1987). "The Interface Between Livestock and Grain Producers." Invited paper, W-177 and Regional Directors, Tucson, AZ (December).

125. Schmitz, A. (1987). "Land Values, Wealth, and the Impact of Government Policies." Invited paper, Economic Council of Canada, Ottawa, Canada (December).

126. Schmitz, A. (1988). "The Outlook for Grains." Paper presented at Australian Agricultural Outlook Conference, Canberra, Australia (January).

127. Schmitz, A. (1988). "Market Pricing Strategies in World Grain Markets." Keynote Address, Australian Agricultural Economics Meetings, LaTrobe University, Melbourne, Australia (February).

128. Schmitz, A. (1988). "Predicting Land Markets in North America." Paper presented at the Royal Bank Conference, Regina, Saskatchewan, Canada (February).

129. Schmitz, A. (1988). "The Role of Fertilizers and Chemicals in the Agricultural Complex." Paper presented at Western Fertilizer and Chemical Dealers Associations Conference, Regina, Saskatchewan, Canada (February).

130. Schmitz, A. (1988). "Border Disputes Between Canada and the United States: Case Studies on Pork Products and Potatoes." Paper presented at the University of Lethbridge Agriculture Conference, Lethbridge, Alberta, Canada (March).

131. Schmitz, A. (1988). "Canadian Agriculture and GATT." Invited paper, Canadian Federation of Agriculture, Winnipeg, Manitoba, Canada (March).

132. Schmitz, A. (1988). "The U.S. Agriculture and GATT." Invited paper, Department of Agricultural Economics, Michigan State University, East Lansing, MI (April).

133. Schmitz, A. (1988). "Redesigning Agricultural Policy." Paper presented at the AIC Conference, Calgary, Alberta, Canada (June).

134. Schmitz, A. (1988). "The Role and Impact of Crop Insurance." Invited paper, U.S. Department of Agriculture, Washington, D.C. (June).

135. Schmitz, A. (1988). "The Imperfect Nature of World Grain Markets." Invited Keynote Address, Western Agricultural Economics Association Meetings, Honolulu, HI (July).

136. Schmitz, A. (1988). "Measuring Trade Distortions." Canadian Agricultural Economics Association, Montreal, Quebec, Canada (July).

137. Schmitz, A. (1988). “GATT and Special Interest Groups.” Fellows Address, American Agricultural Economics Association Meetings, Knoxville, TN (August).

138. Schmitz, A. (1988). “The Future of the Prairie Grain Economy.” Invited paper, Economic Council of Canada, Ottawa, Canada (September).

139. Schmitz, A. (1988). “The Future Role of Bio-Technology in Development.” Invited paper, University of Trinidad, Trinidad, Jamaica (October).

140. Schmitz, A. (1989). “Commodity Futures and Financial Management.” Paper presented at the Mt. Lucas Management Conference, New York, NY (March).

141. Schmitz, A. (1989). “Efficient Pricing of Wheat.” Invited paper, Canadian Wheat Board, Tokyo, Japan (March).

142. Schmitz, A. (1989). “Futures Demand for Farm Inputs.” Invited paper, Esso Canada, Edmonton, Alberta, Canada (April).

143. Schmitz, A. (1989). “Efficiency of U.S. Farm Programs and PSE Measures.” Invited paper, Office of the Trade Representative, Washington, D.C. (July).

144. Schmitz, A. (1989). “Price Discovery in the U.S. Beef Industry.” Paper presented at the National Cattlemen's Association Meetings, Columbus, OH (July).

145. Schmitz, A. (1989). “Can Beef Compete in the 1990s?” Invited paper, Manitoba Cattlemen's Association Conference, Manitoba, Canada (November).

146. Schmitz, A. (1989). “The Impact of GATT Negotiations.” Invited paper, Southern Regional Research Group, New Orleans, LA (November).

147. Schmitz, A. (1990). “Efficiency of Farm Programs and Trade Distortions.” Invited paper, Iowa State University, Ames, IA (February).

148. Schmitz, A. (1990). “The Impact of GATT on North American Agriculture.” Invited paper, GATT Secretariat, Geneva, Switzerland (February).

149. Schmitz, A. (1990). “U.S. and Canadian Farm Programs: Similarities and Differences.” Paper presented at the Saskatchewan Crop Insurance Conference, Saskatchewan, Canada (March).

150. Schmitz, A. (1990). ‘Do Farmers Practice Moral Hazard When Participating in Crop Insurance Contracts.” Paper presented at the Saskatchewan Crop Insurance Conference, Saskatchewan, Canada (March).

151. Schmitz, A. (1990). “Crop Market Prospects.” Television interview, University of California at Berkeley, Berkeley, CA (March).

152. Schmitz, A. (1990). "The World Sugar Economy and U.S. Sugar Programs." Paper presented at the U.S. State Department Conference, Washington, D.C. (May).

153. Schmitz, A. (1990). "Trade: Lessons to be Learned." Paper presented at the Agricultural Extension Training Seminar, Davis, CA (June).

154. Schmitz, A. (1990). "Production Controls in Import Concessions." Paper presented at the Western Economics Meetings, San Diego, CA (June).

155. Schmitz, A. (1990). "Forming Effective Coalitions in Agriculture." Paper presented at the 64th Annual Convention of the North Dakota Farmers Union, Fargo, ND (December).

156. Schmitz, A. (1990). "Land Use Implications of Canadian Crop Insurance." Paper presented at the Maryland/Saskatchewan Conference for the Improvement of Agricultural Crop Insurance. Saskatchewan, Canada (April).

157. Schmitz, A. (1990). "Monopoly Power and International Trade." Paper presented at a seminar in the Department of Economics, Iowa State University, Ames, IA (February).

158. Schmitz, A. (1990). "Commodities Important to the Southern Region of the United States." Paper presented at the S-224 Meetings, New Orleans, LA (January).

159. Schmitz, A. (1990). "Developing Issues in North American Agriculture." Invited paper, Council of Economic Advisors, Washington, D.C. (December).

160. Schmitz, A. (1990). "International Agricultural Development." Paper presented at a USAID Workshop, Washington, D.C. (December).

161. Schmitz, A. (1990). "Cooperation in Canada Trade Relations." Paper presented at a conference organized by Governor Sinner. Bismarck, ND (October).

162. Schmitz, A. (1990). "Economic Development and Trade in the Pacific." Invited paper, University of Hawaii, Honolulu, HI (August).

163. Schmitz, A. (1990). "The Growth and Importance of Sugar Markets." Paper presented at the Conference on Sugar Markets in the 1990s, Washington, D.C. (May).

164. Schmitz, A. (1990). "The Importance of the Grain Sector in Latin America." Invited paper, World Bank, Washington, D.C. (September).

165. Schmitz, A. (1990). "The Gains from International Trade Under Distortions." Paper presented at the Conference on Mechanisms to Improve Agricultural Trade Performance under the GATT. Kiel, Germany (October).

166. Schmitz, A. (1991). "Policy Options for Prairie Agriculture in the 1990s." Invited paper, University of Saskatchewan, Saskatoon, Saskatchewan, Canada (January).

167. Schmitz, A. (1991). "Tariff and Non-Tariff Barriers in International Trade." Paper presented at the University of Florida Consortium on International Development, Gainesville, FL (Spring).

168. Schmitz, A. (1991). "The Importance of Water in Economic Development." Paper presented at the International Conference on Water Management for the Sustainable Environment, Saskatoon, Saskatchewan, Canada (June).

169. Schmitz, A. (1991). "Maximizing the Potential from Forage Production." Paper presented at the American Alfalfa Symposium, Reno, NV (February).

170. Schmitz, A. (1992). "Negative Externalities in Agricultural Trade." Paper presented at the Conference on Resource and Environmental Management in an Interdependent World, Washington, D.C. (January).

171. Schmitz, A. (1992). "The Evaluating Impacts of CUSTA." Invited paper, North American Free Trade Agreement, Los Angeles, CA (March).

172. Schmitz, A. (1992). "Farm Debt in Canadian Agriculture." Invited paper, Regina, Saskatchewan, Canada (February).

173. Schmitz, A. (1992). "Alternative Agricultural Technologies." Invited paper, Institute for Alternative Agriculture, Inc., Baltimore, MD (March).

174. Schmitz, A. (1992). "The New Supply Management." Invited paper, Faculty of Agricultural and Environmental Sciences, McGill University, Quebec, Canada (April).

175. Schmitz, A. (1992). "New Directions in International Trade Theory." Paper presented at the 67th Annual WEA International Conference, San Francisco, CA (July).

176. Schmitz, A. (1992). "Can Farmers Survive Without Government Intervention?" Paper presented at the Executive Seminar on Agricultural Issues, Davis, CA (December).

177. Schmitz, A. (1992). "The Role of Farmer Cooperatives." Paper presented to Board of Directors Meeting, Harvest States, St. Paul, MN (December).

178. Schmitz, A. (1992). "The Gains from Agricultural Research under Distorted Trade." Paper presented at the International Agricultural Trade Research Consortium, Miami, FL (December).

179. Schmitz, A. (1993). "The World Grain Trade: Grain Marketing, Institutions, and Policies." Invited paper, World Bank, Washington, D.C. (June).

180. Schmitz, A. (1993). “International Grains in the 21st. Century.” Paper presented at the International Grains and Livestock Outlook Conference, Winnipeg, Manitoba, Canada (January).

181. Schmitz, A. (1993). “Structural Changes in North America Agriculture.” Paper presented at the National Forum for Agriculture, Des Moines, IA (March).

182. Schmitz, A. (1993). “Where’s Agriculture Headed?” Paper presented at a Marketing Symposium, Imperial Oil, Edmonton, Alberta, Canada (March).

183. Schmitz, A. (1993). “Is Prairie Agriculture Sustainable?” Invited paper, Regina District Association of Rural Municipalities, Regina, Canada.

184. Schmitz, A. (1993). “The Mechanics of COPF: Competitive Pricing for the 1990s.” Invited paper, National Farm Products Council, Chateau Laurier, Ottawa, Canada (June).

185. Schmitz, A. (1993). “Using Institutions to Create a Stronger Agricultural Industry for Saskatchewan.” Invited paper, University of Saskatchewan, Saskatoon, Saskatchewan, Canada (June).

186. Schmitz, A. (1993). “Implications for 1862 Land Grant Universities.” Paper presented at the Second National Workshop, Stone Mountain, GA (December).

187. Schmitz, A. (1994). “GATT and the Environment.” Paper presented at the Pesticide Economics Conference in Memory of Carolyn R. Harper, University of Massachusetts, Boston, MA (April).

188. Schmitz, A. (1994). “Supply Management and GATT.” Paper presented at the Conference on World Agriculture in a Post-GATT Environment: New Rules, New Strategies, Saskatoon, Saskatchewan, Canada (June).

189. Schmitz, A. (1994). “Power Relationships in the Political Process.” Paper presented at the Conference on Supply Management in Transition towards the 21st. Century, MacDonald Campus of McGill University, Saint-Anne-de-Bellevue, Quebec, Canada (June).

190. Schmitz, A. (1994). “Are We in for More U.S./Canada Trade Disputes?” Paper presented at the North American Agricultural Policy Research Consortium, Vancouver, British Columbia, Canada (May).

191. Schmitz, A. (1994). Policy paper presented to Canadian senators at the Diefenbaker Center, Saskatoon, Saskatchewan, Canada.

192. Schmitz, A. (1994). Invited paper at the International Agricultural Economics Association Conference, Africa (August).

193. Schmitz, A. (1994). Invited address to the Standing Committee on Agriculture and Agri-food, Ottowa, Ontario, Canada (September).

194. Schmitz, A. (1994). Invited paper on international trade and environmental policies at the International Conference on Coordination and Decentralization and Water Resources Management at the Hebrew University of Jerusalem, Rehovot, Israel (October).

195. Schmitz, A. (1994). Invited paper on livestock production for sustainable rural communities (paper dealt with anti-trust issues and concentration in the beef-packing industry), Center for Rural Affairs, Kansas City, MO (October).

196. Schmitz, A. (1994). Main speaker at the 1994 International Citrus Industry Economic Outlook Conference, sponsored by the Association of Citrus Economists and Allied Professionals, Orlando, FL (October).

197. Schmitz, A. (1994). Invited seminar at the Department of Agricultural Economics, University of Arkansas, Lafayette, AR (December).

198. Schmitz, A. (1994). Invitation to Winrock International to present seminar, Morrilton, AR. (December).

199. Schmitz, A. (1994). Invited paper at the International Agricultural Trade and Research Consortium, Washington, D.C. (December).

200. Schmitz, A. (1995). Invited paper at the Foreign and Domestic Market Development Conference, sponsored by the Food and Agricultural Marketing Consortium, Orlando, FL (January).

201. Schmitz, A. (1995). Paper presented on trade expansion, Fort Pierce, FL (June).

202. Schmitz, A. (1995). Keynote address presented at the 12th International Sweetener Symposium, sponsored by the American Sugar Alliance, Washington, D.C. (June).

203. Schmitz, A. (1995). Invited paper on the Economics of Rent-Seeking at the Canadian Agricultural Economics Association meetings, Ottowa, Ontario, Canada (July).

204. Schmitz, A. (1995). Presentation of the Waugh lecture, American Agricultural Economics Association Conference, Indianapolis, IN (August).

205. Schmitz, A. (1995). Paper presented on regulation and its impact on the Florida dairy industry at the American Agricultural Economics Association Conference, Indianapolis, IN (August).

206. Schmitz, A. (1995). Invited paper at the Institute of Agricultural Economics, Bulgaria (October).

207. Schmitz, A. (1995). Invited paper on rates of return to research at the International Trade Research Consortium meetings, Tucson, AZ (December).

208. Schmitz, A. (1996). "Transitional Economies." Paper presented at Allied Social Science Meetings, San Francisco, CA (January).

209. Schmitz, A. and C. Moss. (1996). "Boom Bust Cycles." Paper presented at Reno, NV (January).

210. Schmitz, A. (1996). "The Impact of Technology on the Structure of Agriculture." Paper presented at the National Forum for Agriculture, Ames, IA (March).

211. Schmitz, A. (1996). "Canada-U.S. Trade Dispute: The Wilson Lecture Series." Paper presented at the University of Montana, Bozman, MT (April).

212. Schmitz, A (199). *Privatization in Eastern European Agriculture*. Paper presented at Wye College, England, United Kingdom (April).

213. Schmitz, A. (1996). "Free Trade in Sugar: Myth and Reality." Paper presented at the FAO, Rome, Italy (April).

214. Schmitz, A. (1996). "Canada-U.S. Trade Disputes." Tweeten Lecture Series. Paper presented at Ohio State University, Columbus, OH (June).

215. Moss, C.B., J.S. Shonkwiler, and A. Schmitz. (1996). "A Historical Examination of Certainty Equivalence for Agricultural Assets: 1910-1992." Paper presented at Agricultural Economics Meetings, San Antonio, TX (July).

216. Schmitz, A. and C.B. Moss. (1996). "Aggregate Evidence of Boom/Bust Cycles in Domestic Agriculture." Paper presented at Agricultural Economics Meetings, San Antonio, TX (July).

217. Ervin, D.E. and A. Schmitz. (1996). "A New Era of Environmental Management in Agriculture?" Paper presented at Agricultural Economics Meetings, San Antonio, TX (July).

218. Schmitz, A. (1996). "The Impact of R and D in Agriculture Productivity." Paper presented at the University of Vicosa, Vicosa, Brazil (October).

219. Schmitz, A. (1997). "New Dimensions in Water Policy." Paper presented at the World Water Conference, Baltimore, MD (February).

220. Schmitz, A. (1997). "WTO and the New Trade Order." Paper presented at the Farming for Profit Conference, Moose Jaw, Canada (June).

221. Schmitz, A. (1997). “Further Comments on Boom-Bust Cycles.” Paper presented at the American Agricultural Economics Association Meetings, Toronto, Canada (July).

222. Schmitz, A. (1997). “The Economics of State Trading.” Paper presented at the Conference on World Trade, Ankara, Turkey (September).

223. Schmitz, A. (1997). “State Trading in Grains.” Paper presented at the WTO and GATT Conference, Saskatoon, Saskatchewan, Canada (October).

224. Schmitz, A. (1997). “The Impact of Single Desk Buyers on World Trade.” Paper presented to COFCO, Beijing, China (October).

225. Schmitz, A. (1997). “Manufactured Price Instability and State Trading Organizations.” Paper presented at International Trade Conference Meetings, San Diego, CA (December).

226. Schmitz, A. (1998). “State Trading in China.” Paper presented at Conference on Chinese Agricultural Trade, Honolulu, HI (February).

227. Schmitz, A. (1998). “Alternative Forms of Agricultural Cooperation between Canada and the United States.” Invited paper, North Dakota State University, Fargo, ND (September).

228. Schmitz, A. (1998). “Rent Seeking in Turkey's Agriculture.” Paper presented at International Economic Conference, Mid-East Technical University, Ankara, Turkey (September).

229. Schmitz, A. (1998). “Anti-Dumping Measures and Canada/U.S. Trade Conflicts.” Invited paper, University of Maryland, Columbia, MD (December).

230. Schmitz, A. (1999). “The Economics of Rent Seeking.” Invited paper, University of California at Berkeley, Berkeley, CA (February).

231. Schmitz, A. (1999). “The Changing Dynamics of U.S. Sugar Policy.” Invited paper, Veracruz, Mexico (March).

232. Schmitz, A. (1999). “The Role of Less Developed Countries in the WTO.” Invited paper, Guyana. (July).

233. Dumas, C., C. Moss, and A. Schmitz. (1999). “Carbon Sequestration in U.S. Agriculture.” Paper presented at Climate Change Conference, University of Florida, Gainesville, FL (September).

234. Moss, C.B. and A. Schmitz. (1999). “The Changing Agenda for Agribusiness: Sweetener Alliances in the 21st. Century.” Paper presented at Sweetener Markets in the 21st. Century Conference, Miami, FL (November).

235. Schmitz, A. (1999). "The Dominance of Brazil in the World Sugar Market." Paper presented at FAO Sugar Conference, Cuba (December).

236. Schmitz, A. (2000). "Price Discrimination and State Trading Enterpises." Paper presented at International Trade Conference, Saskatoon, Canada (March).

237. Schmitz, A. (2000). "Compatibility between U.S. and Canadian Farm Policies." Paper presented at Southern Agricultural Economics Association (SAEA) Meetings, Lexington, KY (March).

238. Schmitz, A. (2000). "Decoupling and the New U.S. Farm Program." Paper presented at International Trade Forum, New Orleans, LA (May).

239. Schmitz, A. (2000). "The Application of E Commerce in Agriculture." Paper presented at CARD Symposium, Iowa State University, Ames, IA (May).

240. Schmitz, A., and C. Moss. (2000). "Coalitions and Agricultural Policy." Paper in Honor of Luther Tweeten, Ohio State University, Columbus, OH (September).

241. Schmitz, A. (2000). "Product Differentiation in International Markets." Invited paper, Vera Cruz, Mexico (September).

242. Schmitz, A. (2000). "CUSTA and NAFTA: Good or Bad?" Paper presented at the International Trade Conference, North Dakota State University, Fargo, ND (October).

243. Schmitz, A. (2000). "Can Farm Subsidies Possibly Be Decoupled?" Invited paper, Alberta Agriculture (Edmonton, Alberta) and Department of Rural Economy, University of Alberta, Edmonton, Canada (October).

244. Schmitz, A. (2001). "International Trade and Beef and Countervailing Duties." Invited paper, Auckland, New Zealand (January).

245. Schmitz, A. (2001). "State Trading and Sugar." Invited paper, Queensland Sugar Corporation, Brisbane, Australia (February).

246. Schmitz, A. (2001). "Rent Seeking Behavior and Agricultural Policy." Invited paper, Purdue University, West Lafayette, IN (March).

247. Schmitz, A. (2001). "Agricultural Policy in the 21st Century." Invited paper, University of Nebraska, Lincoln, NE (April).

248. Schmitz, A. (2001). "Targeting Agricultural Subsidies." Invited paper, Kansas State University, Manhattan, KS (April).

249. Schmitz, A. (2001). "Agricultural Policy and the Theory of Public Choice." Invited paper, University of Georgia, Athens, GA (May).

250. Schmitz, A. (2001). "E-Commerce: Its Importance for Agriculture." Invited paper, Economic Research Service, USDA, Washington, D.C. (May).

251. Schmitz, A., and Richard Gray. (2001). "The Divergence between U.S. and Canadian Agricultural Policy." Paper presented at American Agricultural Economics Association Conference, Chicago, IL (August).

252. Moss, C., T. Schmitz, and A. Schmitz. (2001). "E Commerce and the Walrasian Auctioneer." Paper presented at American Agricultural Economics Association Conference, Chicago, IL (August).

253. Schmitz, A. (2001). "Gainers and Losers from Trade Liberalization." Paper presented at First International Agricultural Trade & Policy Conference (IFAS, FRE and IATPC), Gainesville, FL (November).

254. Schmitz, A., C. Moss, and T. Schmitz. (2001). "The Cost of Market Segmentation for Genetically Modified Crops." Paper presented at International Trade Consortium Meetings, Tucson, AZ (December).

255. Schmitz, A., T. Schmitz, and C. Moss. (2002). "The Significance of E Commerce in the Marketing of Agricultural Products." Paper presented at E-Commerce and Agriculture Conference, San Diego, CA (January).

256. Schmitz, A. (2002). "The Role of the WTO in Freeing-up Agricultural Trade." Paper presented at International Trade Conference, San Antonio, TX (May).

257. Moss, C.B. and A. Schmitz. (2002). "New Institutional Economics, Bureaucratic Rent Seeking, and the Potential Role of State Trading Enterprises in Coffee Markets" Paper presented at the XVI International Congress in Agribusiness, National Autonomous University, San Lois Potosi, Mexico (May).

258. Schmitz, A. and R. Just. (2002). "The Economics of Farmland Values." Paper presented at Government Policy and Farmland Markets: Implications of the New Economy Conference, ERS/USDA, Washington, D.C. (May).

259. Moss, C.B., T.G. Schmitz, A. Kagan, and A. Schmitz. (2002). "New Institutional Economics, Schumpeter and the Emergence of the Internet in Agriculture: Fad or Innovation?" Paper presented at the International Conference on Financial Engineering, E-Commerce & Supply Chain, and Strategies of Development, Piraeus Greece (June).

260. Moss, C.B., T.G. Schmitz, and A. Schmitz. (2002). "Differentiating GMOs and Non-GMOs in a Marketing Channel." Paper presented at the International Consortium on Agricultural Biotechnology Research, Ravello, Italy (July).

261. Schmitz, A. (2002). "Brazil as a Dominant Player in the World Sweetener Market: Do Prices Matter?" Paper presented at FAO/Mozambique Third International Sugar Conference, Maputo, Mozambique, Africa (October).

262. Schmitz, A. (2002). "The Impact of U.S. Farm Policy on Less Developed Countries." Invited paper, University of Zimbabwe, Zimbabwe, Africa (October).

263. Schmitz, A. (2002). "Trade Distortions and Impacts on Exports." Invited paper, University of Cape Town, Cape Town, Africa (October).

264. Schmitz, A. (2002). "International Trade & Policy Dimensions: The Case of Sugar." Paper presented at Second International Agricultural Trade & Policy Conference (IFAS, FRE and IATPC), Gainesville, FL (November).

265. Schmitz, A. (2003). "Frontiers in Agricultural Policy Research". Paper presented at Southern Agricultural Economics Association (SAE) Conference, Birmingham, AL (February).

266. Schmitz, A. (2003). "New Dimensions in Trade and Countervail Cases." Paper presented at International Agricultural Trade Disputes: Case Studies in North America Conference, Gainesville, FL (March).

267. Schmitz, A. and H. Furtan. (2003). "Canada/U.S. Agricultural Trade and Future Growth." Paper presented at Canada-United States Business Conference, Bloomington, IN (April).

268. Schmitz, A. (2003). "Liberalized Agricultural Trade: Prosperity for All?" Paper presented at Agricultural Competitiveness and World Trade Liberalization Conference, Fargo, ND (May).

269. Schmitz, A. (2003). "The Farm Crisis?" Paper presented at The Farm Crisis Conference, Baton Rouge, LA (May).

270. Schmitz, A. (2003). "Comparison of EU and U.S. Agricultural Polices." Paper presented at Farming For...Profit? Conference, Moose Jaw, Saskatchewan, Canada (June).

271. Schmitz, A. (2003). "World Trade and Hidden Subsidies." Paper presented at Sugar Cane League Conference, Destin, FL (June).

272. Schmitz, A., C.B. Moss, and T.G. Schmitz. (2003). "Market Segmentation and GMOs." Paper presented at Western Agricultural Economics Association (WAEA) Conference, Denver, CO (July).

273. Schmitz, A. (2003). "WTO and State Trading Enterprises." Paper presented at American Agricultural Economics Association (AAEA) Conference, Montreal, Quebec, Canada (July).

274. Schmitz, A., C.B. Moss, and T.G. Schmitz. (2003). "StarLink Corn and Structural Demand Changes." Paper presented at The Role of GMOs in Trade Disputes Conference, San Antonio, TX (October).

275. Schmitz, A. and H. Furtan. (2003). "Policy under Uncertainty." Paper presented at Conference in Honor of Professor Daryl Kraft, Winnipeg, Manitoba, Canada (October).

276. Schmitz, A. (2004). "Sugar and Water Use." Paper presented at Agricultural Production Trends and the Future of the Trans-boundary Rio Grande/Rio Bravo Basin Conference, San Antonio, TX (May).

277. Schmitz, A. (2004). "Farmers and Rent Seeking Behavior." Paper presented at Moose Jaw Annual Farm for Profit? Conference, Moose Jaw, Canada (June).

278. Schmitz, A. (2004). "Agricultural Trade Policy Issues in a Global Context." Paper presented at Agricultural Trade Cooperation in Southeast Europe Conference, Bucharest, Romania (June).

279. Schmitz, A., T.G. Schmitz, and C.B. Moss. (2004). "The Impact of StarLink Corn." Paper presented at American Agricultural Economics Association (AAEA) Conference, Denver, CO (July).

280. Schmitz, A. (2004). "Sugar Trade Liberalization Closely Examined: Who Wins? Who Loses? Paper presented at Twenty-first International Sweetener Symposium, Vail, CO (August).

281. Schmitz, A. (2004). "Cotton Policy and the WTO." Invited lecture, Louisiana State University, Baton Rouge, LA (September).

282. Schmitz, A. (2004). "The Future of Agricultural Policy." Paper presented at Canadian Agri-Food Policy Institute Conference, Toronto, Canada (September).

283. Schmitz, A. (2004). "Competitiveness in the U.S. Farm Sector under Globalization: Are We Less Competitive?" Paper presented at Agricultural Competitiveness and Change under Globalization Conference, Fargo, ND (October).

284. Schmitz, A. (2004). "Modeling the Impact of Agricultural Policy." Invited lecture, University of Tennessee, Knoxville, TN (November).

285. Powell, S.J. and A. Schmitz. (2004). "The WTO's Cotton subsidies Decision: The Agreement on Agriculture Takes a Bite out of U.S. Agricultural Policy." Paper presented at UF/IFAS International Agricultural Trade and Policy Center Conference, University of Florida, Gainesville, FL (December).

286. Schmitz, A. (2005). Television Interview for the *Farmgate Show* that was aired on CTV on January 22, 2005 at 12:30PM. Saskatoon, Saskatchewan, Canada.

287. Schmitz, A. and J.L. Seale, Jr. (2005). "Chinese Cotton and the Impact of U.S. Cotton Subsidies." Invited Paper, WERA Annual Meeting, University of Reno, Reno, NV (April).

288. Schmitz, A. (2005). "The Current State of the FTAA Negotiations." Paper presented at Sugar and Ethanol Brazil Conference, Sao Paulo, Brazil (March 14–16).

289. Powell, S. and A. Schmitz. (2005). "The WTO's Cotton Subsidies Decision: The Agreement on Agriculture Takes a Bite Out of U.S. Agricultural Policy." Paper presented at MABM Conference, Mississippi State University, MS.

290. Schmitz, A. (2005). "Forced Evolution of the U.S. Sugar Program." Panelist, International Sweetener Colloquium, Westin La Paloma, Tucson, AZ (February 6–9).

291. Schmitz, A. (2005) "Litigation of Agricultural Subsidies: The Cotton Case." Panelist, *International Agricultural Trade Research Consortium Summer Symposium*, Seville, Spain (June 19–21).

292. Schmitz, A. (2005). "Across the Border: U.S.-Canadian Agricultural Policies and Issues." Midwest Council of State Governments, Agriculture and Natural Resources Committee, Regina, Saskatchewan, Canada (July 31–August 3).

293. Schmitz, Andrew, T.G. Schmitz, and F. Rossi. (2006). 'Are Agricultural Policies Efficient?" Paper presented at The Allied Social Sciences Meetings, Boston, MA (January).

294. Schmitz, A. and J. Javelosa. (2006). "Human Rights and Agricultural Trade." Paper presented at Southern Agricultural Economics Association Meetings, Orlando, FL (February).

295. Moss, C.B. and A. Schmitz. (2006). "Rates of Return to Agricultural Research." Paper presented at R&D Conference, Jekyll Island, GA (March).

296. Schmitz, A. and J. Javelosa. (2006). "R&D in Improved Nutrition." Paper presented at R&D Conference, Jekyll Island, GA (March).

297. Schmitz, A. (2006). "Decoupling Agricultural Programs." Paper presented at Cost Benefit Conference, University of Washington, Seattle, WA (May).

298. Schmitz, A. and C.B. Moss. (2006). "Farmland Markets, Boom Bust Cycles, and Farm Size." Paper presented at IAMO Forum, Halle, Germany

299. Schmitz, A. (2006). "U.S. Agriculture Policy and the WTO." Invited paper, The Agricultural Institute, Prague, Czech Republic (July).

300. Schmitz, A. and R. Gray. (2006). "Marketing Boards: Canada-U.S. Agricultural Trade." Invited paper, Winnipeg, Manitoba, Canada (September).

301. Moss, C.B. and A. Schmitz. (2006). "International Trade and the New Institutional Economics." Paper presented at Trade Consortium Meetings, Orlando, FL (December).

302. Schmitz, A. (2007). "New Directions in Cost Benefit Analysis." Paper presented at the Cost Benefit Analysis Conference, University of Washington, Seattle, WA (May).

303. Schmitz, A. (2007). "Rates of Return to Agricultural Research." Paper presented at Conference of Biotechnology, University of Saskatchewan, Saskatoon, Canada (May).

304. Schmitz, A. (2007). "The European Union and the United States: Agricultural Policy Convergence or Divergence." Paper presented at the Agricultural Policy Changes: Canada, European Union, and the World Trade Organization Conference, Victoria, British Columbia, Canada (September).

305. Schmitz, A. (2007). "Ethanol: No Free Lunch." Paper presented at the Domestic and Trade Impacts of U.S. Farm Policy: Future Directions and Challenges Conference, Washington, D.C. (November).

306. Schmitz, A. (2007). "The New U.S. Farm Bill?" Lecture presented at Arizona State University, Phoenix, AZ (November).

307. Schmitz, A. (2007). "Future Directions in U.S. Agricultural Policy." Paper presented at the APAS Annual Conference, Regina, Saskatchewan, Canada (December).

308. Schmitz, A. (2008). "U.S. and EU Agricultural Policy: Divergence or Convergence?" Paper presented at the II AIEA2-USDA International Conference (The Economic Impact of Public Support to Agriculture), Bologna, Italy (June).

309. Schmitz, A. (2009). Paper presented to the Canola Growers Association, Toronto, Ontario, Canada (January).

310. Schmitz, A. (2009). Paper presented at the Moose Jaw Farming for Profit? Conference, Moose Jaw, Saskatchewan, Canada (June).

311. Schmitz, A. (2009). Paper presented at the Benefit-Cost Analysis Conference, Washington, D.C. (October).

312. Schmitz, A. (2009). Paper presented at the Alternative Energy Conference, Orlando, FL (November).

313. Schmitz, A. (2009). Paper presented at Invited Seminars, Arizona State University, Phoenix, AZ (December).

JOURNAL ARTICLES

1. Schmitz, A. (1965). "Agricultural Resource-Use Efficiency in North Western Saskatchewan." *Canadian Journal of Agricultural Economics* 13(2):34-46. (Master's Thesis Award, 1964).

2. Schmitz, A. (1967). "Production Function Analysis as a Guide to Policy in Low Income Farm Areas." *Canadian Journal of Agricultural Economics* 15(1):100-111.

3. Schmitz, A. (1968). "Canadian Wheat Acreage Response." *Canadian Journal of Agricultural Economics* 16(2):79-86.

4. Schmitz, A. (1968). "Production Function Analysis as a Guide to Farm Policy—A Reply." *Canadian Journal of Agricultural Economics* 16(2):130.

5. Schmitz, A., R.H. Courtney, and J. Bieri. (1969). "World Trade and United States Commercial Agriculture." *Proceedings of the Western Agricultural Economics Association*:100-105.

6. Bjarnason, H.F., M.J. McGarry, and A. Schmitz. (1969). "Converting Price Series of Internationally Traded Commodities to a Common Currency Prior to Estimating National Supply and Demand Equations." *American Journal of Agricultural Economics* 51(1):188-192.

7. Bieri, J. and A. Schmitz. (1970). "Time Series Modeling of Economic Phenomena." *American Journal of Agricultural Economics* 52(5):805-813.

8. Leuthold, R.M., A.J.A. MacCormick, A. Schmitz, and D.G. Watts. (1970). "Forecasting Daily Hog Prices and Quantities: A Study of Alternative Forecasting Techniques." *Journal of the American Statistical Association* 65(329):90-107.

9. Schmitz, A. (1970). Book review of *The Impact of Trade Liberalization* by Gerald I. Trant *et al*. *Canadian Journal of Agricultural Economics* 18(3):208-209.

10. Schmitz, A. (1970). Book review of *International Financial Decisions* by Sune Carlson. *Journal of the American Statistical Association* 65(331):1407-1408.

11. Schmitz, A. (1970). "Discussion: Priorities in Agricultural Economics Programs in the 1970s." *American Journal of Agricultural Economics* 52(5):840-841.

12. Schmitz, A. (1970). "The Impact of Trade Blocs on Foreign Direct Investment. *Economic Journal* 80:723-731.

13. Schmitz, A., D. Chen, and J. Murphy. (1970). "The Allocation of Research, Teaching, and Extension Personnel in the United States Colleges of Agriculture: Comment." *American Journal of Agricultural Economics* 52(1):161-163.

14. Schmitz, A. and P. Helmberger. (1970). "Factor Mobility and International Trade: The Case of Complementarity." *American Economic Review* 60(4):761-767.

15. Schmitz, A. and D. Seckler. (1970). "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester." *American Journal of Agricultural Economics* 52(4):569-577.

16. Schmitz, A. and D.G. Watts. (1970). "Forecasting Wheat Yields: An Application of Parametric Time Series Modeling." *American Journal of Agricultural Economics* 52(2):247-254.

17. Currie, J., J. Murphy, and A. Schmitz. (1971). "The Concept of Economic Surplus and Its Use in Economic Analysis." *Economics Journal* 81(324):741-799.

18. Bieri, J., A. de Janvry, and A. Schmitz. (1972). "Agricultural Technology and the Distribution of Welfare Gains." *American Journal of Agricultural Economics* 54(5):801-808.

19. Chen, D., R. Courtney, and A. Schmitz. (1972). "A Polynomial Lag Formulation of Milk Production Response." *American Journal of Agricultural Economics* 54(1):77-83.

20. Hueth, D.L. and A. Schmitz. (1972). "International Trade in Intermediate and Final Goods: Some Welfare Implications of Destabilized Prices." *Quarterly Journal of Economics* 84(3):351-365.

21. Schmitz, A. (1972). "Tariffs and Declining-Cost Industries." *Economica* 39(156):419-426.

22. Schmitz, A. and J. Bieri. (1972). "0EEC Tariffs and U.S. Direct Investments." *European Economic Review* 3(3):259-270.

23. Bieri, J. and A. Schmitz. (1973). "Export Instability, Monopoly Power, and Welfare." *Journal of International Economics* 3(4):389-396.

24. Schmitz, A. (1973). Book review of *International Mobility and Movement of Capital*, edited by Fritz Machlup, Walter S. Salant, and Lorie Tarshis. *American Journal of Agricultural Economics* 55(4):690-692.

25. Schmitz, A. (1973). "Distortions and Product Specialization in International Trade." *Economic Record* 49(126):263-269.

26. Bieri, J. and A. Schmitz. (1974). "Market Intermediaries and Price Instability: Some Welfare Implications." *American Journal of Agricultural Economics* 56(2):280-285.

27. Feder, G. and A. Schmitz. (1976). "Learning by Doing and Infant Industry Protection: A Partial Equilibrium Approach." *Review of Economic Studies* 43(1):175-178.

28. Schmitz, A. (1976). "Instability in International Grain Markets." *International Trade Digest* 1:1-7.

29. Feder, G., R.E. Just, and A. Schmitz. (1977). "Storage with Price Uncertainty in International Trade." *International Economic Review* 18(3):553-568.

30. Just, R.E., E. Lutz, A. Schmitz, and S.J. Turnovsky. (1977). "The Distribution of Welfare Gains from International Price Stabilization Under Distortions." *American Journal of Agricultural Economics* 59(4):652-661.

31. Schmitz, A. and R.E. Just. (1977). "Semi-price Discrimination." *Economic Record* 53(144):559-564.

32. Just, R.E., E. Lutz, A. Schmitz, and S.J. Turnovsky. (1978). "The Distribution of Welfare Gains from Price Stabilization: An International Perspective." *Journal of International Economics* 8(4):551-563.

33. Konandreas, P.A. and A. Schmitz. (1978) "Welfare Implications of Grain Price Stabilization: Some Empirical Evidence for the United States." *American Journal of Agricultural Economics* 60(1):4-84.

34. Carter, C. and A. Schmitz. (1979). "Import Tariffs and Price Formation in the World Wheat Market." *American Journal of Agricultural Economics* 61(3):517-522.

35. Hall, L., A. Schmitz, and J. Cothern. (1979). "Beef Marketing Margins and Concentration." *Economica* 46(183):295-300.

36. Just, R.E., A. Schmitz, and D. Zilberman. (1979). "Price Controls and Optimal Export Policies Under Alternative Market Structures." *American Economic Review* 69(4):706-714.

37. Just, R., A. Schmitz, and D. Zilberman. (1979). "Technological Change in Agriculture." *Science* 206(4424):1277-1280.

38. McCalla, A.F. and A. Schmitz. (1979). "Grain Marketing Systems: The Case of the United States versus Canada." *American Journal of Agricultural Economics* 61(2):199-212.

39. McCalla, A.F., A. Schmitz, and G.C. Storey. (1979). "Australia, Canada, and the United States: Trade Partners or Competitors." *American Journal of Agricultural Economics* 61(5):1022-1029.

40. Carter, C., N. Gallini, and A. Schmitz. (1980). "Producer-Consumer Trade-Offs in Export Cartels: The Wheat Cartel Case." *American Journal of Agricultural Economics* 62(4):812-818.

41. Carter, C. and A. Schmitz. (1980). "Import Tariffs and Price Formation in the World Wheat Market: Reply." *American Journal of Agricultural Economics* 62(4):823-825.

42. Feder, G., R. Just, and A. Schmitz. (1980). "Futures Markets and the Theory of the Firm under Price Uncertainty." *Quarterly Journal of Economics* XCIV(2):317-328.

43. Turnovsky, S.J., H. Shalit, and A. Schmitz. (1980). "Consumer's Surplus, Price Instability, and Consumer Welfare." *Econometrica* 48(1):135-152.

44. Carter, C.A., D.L. Hueth, J.W. Mamer, and A. Schmitz. (1981). "Labor Strikes and the Price of Lettuce." *Western Journal of Agricultural Economics* 6(1):1-14.

45. Chambers, R.G., R.E. Just, L.J. Moffitt, and A. Schmitz. (1981). "Estimating the Impact of Beef Import Restrictions in the U.S. Import Market." *Australian Journal of Agricultural Economics* 25(2):123-133.

46. Sarris, A.H., and A. Schmitz. (1981). "Toward a U.S. Agricultural Export Policy in the 1980s." *American Journal of Agricultural Economics* 63(5):832-839.

47. Schmitz, A., R.S. Firch, and J.S. Hillman. (1981). "Agricultural Export Dumping: The Case of Mexican Winter Vegetables in the U.S. Market." *American Journal of Agricultural Economics* 63(4):645-655.

48. Schmitz, A., H. Shalit, and S.J. Turnovsky. (1981). "Producer Welfare and Price Instability." *American Journal of Agricultural Economics* 63(1):157-160.

49. Shalit, H. and A. Schmitz. (1982). "Farmland Accumulation and Prices." *American Journal of Agricultural Economics* 64(4):710-719.

50. Allen, R., C. Dodge, and A. Schmitz. (1983). "Voluntary Export Restraints as Protection Policy." *American Journal of Agricultural Economics* 65(2):291-297.

51. Carter, C.A., G.C. Rausser, and A. Schmitz. (1983). "Efficient Asset Portfolios and the Theory of Normal Backwardation." *Journal of Political Economy* 91(2):319-332.

52. Schmitz, A. (1983). "Alternative Agricultural Trade Strategies." *Wisconsin International Law Journal* 1:57-69.

53. Schmitz, A. (1983). "Supply Management in Canadian Agriculture: An Assessment of the Economic Effects." *Canadian Journal of Agricultural Economics* 31:135-152.

54. La France, J., A. Schmitz, and D. Zilberman. (1984). "Price Leadership and Market Shares." *Economic Record* 60(July):160-164.

55. Shalit, H. and A. Schmitz. (1984). "Farmland Price Behavior and Credit Allocation." *Western Journal of Agricultural Economics* 9(2):303-313.

56. van Kooten, G.C. and A. Schmitz. (1985). "Commodity Price Stabilization: The Price Uncertainty Case." *Canadian Journal of Economics* 18(2):426-434.

57. Carter, C.A. and A. Schmitz. (1986). "Cattle Feeding in Western Canada: The Economics of Its Location." *Agribusiness* 2(1):119-135.

58. Schmitz, A. (1986). "Marketing Institutions in International Commodity Markets." *Southern Journal of Agricultural Economics* 18(1):41-48.

59. Schmitz, A. and R. Chambers. (1986). "Welfare and Trade Effects of Deficiency Payments." *Journal of Agricultural Economics* XXXVII:37-43.

60. Schmitz, A., D. Sigurdson, and O. Doering. (1986). "Domestic Farm Policy and the Gains from Trade." *American Journal of Agricultural Economics* 68(4):820-827.

61. Ulrich, A., H. Furtan, and A. Schmitz. (1986). "Public and Private Returns from Joint Venture Research: An Example from Agriculture." *Quarterly Journal of Economics* CI(1):103-129.

62. Bredahl, M., A. Schmitz, and J.S. Hillman. (1987). "Rent Seeking in International Trade: The Great Tomato War." *American Journal of Agricultural Economics* 69(1):1-10.

63. Carter, C., D.L. Hueth, J. Mamer, and A. Schmitz. (1987). "Agricultural Labor Strikes and Farmers' Income." *Economic Inquiry* XXV(1):121-133.

64. Hayes, D. and A. Schmitz. (1987). "Hog Cycles and Countercyclical Production Response." *American Journal of Agricultural Economics* 69(4):762-770.

65. Leu, G-J, A. Schmitz, and R.D. Knutson. (1987). "Gains and Losses of Sugar Program Policy Options." *American Journal of Agricultural Economics* 69(3):591-602.

66. Ulrich, A., W.H. Furtan, and A. Schmitz. (1987). "The Cost of a Licensing System Regulation: An Example from Canadian Prairie Agriculture." *Journal of Political Economy* 95(1):160-178.

67. Schmitz, A. (1988). "GATT and Agriculture: The Role of Special Interest Groups." *American Journal of Agricultural Economics* 70(5):994-1005.

68. Schmitz, A. (1988). "United States Agricultural Trade: Where Are the Gains?" *Western Journal of Agricultural Economics* 13(2):357-364.

69. van Kooten, G.C., A. Schmitz, and W.H. Furtan. (1988). "The Economics of Storing a Non-Storable Commodity." *Canadian Journal of Economics* XXI(3):579-586.

70. Tewari, D.D., S.N. Kulshreshtha, and A. Schmitz. (1989). "Impacts of Energy Prices and Trade-Demand Elasticities on Saskatchewan Agriculture." *Energy* 14(11):737-746.

71. Babcock, B.A., C.A. Carter, and A. Schmitz. (1990). "The Political Economy of U.S. Wheat Legislation." *Economic Inquiry* 18(2):335-353.

72. Picketts, V.J., A. Schmitz, and T. Schmitz. (1991). "Rent Seeking: The Potash Dispute between Canada and the United States." *American Journal of Agricultural Economics* 73(2):255-265.

73. Vercammen, J. and A. Schmitz. (1992). "Supply Management and Import Concessions." *Canadian Journal of Economics* 25:957-971.

74. Murphy, J.A., W.H. Furtan, and A. Schmitz. (1993). "The Gains from Agricultural Research under Distorted Trade." *Journal of Public Economics* 51:161-172.

75. Gray, R., A. Ulrich, and A. Schmitz. (1993). "The Continental Barley Market: Where Are the Gains?" *CJAE* 41:257-270.

76. Schmitz, A., H. Furtan, P. Kuch, and A. Guzel. (1994). "North American Agriculture: Its Contribution to the Greenhouse Effect." *International Journal of Environment and Pollution* 4(1&2):75-96.

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79. Schmitz, A. (1995). "Boom-Bust Cycles and Ricardian Rent." *American Journal of Agricultural Economics* 77:1110-1125.

80. Schmitz, A., W. Boggess, and K. Tefertiller. (1995). "Regulations: Evidence from the Florida Dairy Industry." *American Journal of Agricultural Economics* 77:1166-1171.

81. Ervin, D.E. and A. Schmitz. (1996). "A New Era of Environmental Management in Agriculture?" *American Journal of Agricultural Economics* 78(5):1198-1206.

82. Moulton, K. and A. Schmitz. (1996). "Learning by Doing: Lessons from Bulgaria's Transition." *Choices* 11(4, Fourth Quarter):21-26.

83. Schmitz, A. (1996). "Further Comments on Booms and Busts." *Choices* (Second Quarter):_____.

84. Schmitz, A. (1997). "Supply Management and GATT: The Role of Rent Seeking." *Canadian Journal of Economics* 43:581-586.

85. Schmitz, T.G., A. Schmitz, and C. Dumas. (1997). "Gains from Trade, Inefficiency of Government Programs and the Net Economic Effects of Trading." *Journal of Political Economy* 105(3):637-647.

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87. Schmitz, A., H. Furtan, and K. Baylis. (1999). "State Trading and the Upcoming WTO Discussions." *Choices* (Second Quarter):_____.

88. Rimal, A. and A. Schmitz. (1999). "Freeze Risk and Technology Adoption by Orange Producers." *Journal of Agribusiness* 17(2):93-103.

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90. Schmitz, A. and R. Gary. (2000). "The Canadian Wheat Board and Feed Barley." *Agribusiness: An International Journal* 16:491-501.

91. Schmitz, A. and C. Moss. (2001). "Vertical Integration in Production and Marketing: The Case of Sugar in the United States." *International Sugar Journal* CIII(1234):443-461.

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Education

Ph.D., Economics, University of Chicago, 1984.
M.S., Economics, Montana State University, 1977.
B.A., Environmental Studies, Utah State University, 1976.

Experience

William Neal Reynolds Professor of Agricultural & Resource Economics, N.C. State University, 2007 to present.
Professor of Agricultural & Resource Economics, 1994 to present, Assistant and Associate Professor from 1984-1994.
Professor of Economics, N.C. State University, 1994 to present.
Editor of the American Journal of Agricultural Economics, 2006-2010.
Senior Fellow of the Property and Environment Research Center, 2003 to present.
Associate Director of PERC's Enviropreneur Institute, 2005-2010.
Visiting Professor, Dept. of Ag. Econ. and Econ., Montana State University, 2002.
Director of Economics Graduate Program, N.C. State University, 1996-1999.
Visiting Lecturer, University of Waikato in Hamilton, New Zealand, 1990.
Instructor, Loyola University of Chicago, 1982-1983.
Research Associate, RCF Inc., Chicago, 1981-1982.
Research Staff, Standard Oil of Indiana, 1980.

Research and Teaching Fields

Agricultural and natural resource economics, econometrics, welfare economics

Awards and Honors

Harris Distinguished Visiting Professor of Economics, Clemson University, 2011
Fellow of the Agricultural and Applied Economics Association, 2010
Julian Simon Fellow, Summer 2003, Property and Environment Research Center
Quality of Research Discovery Award, American Agricultural Economics Association, 1996
First recipient of the American Agricultural Economics Association Outstanding Graduate Instructor Award (10 or more years experience), 1996
First recipient of the NCSU College of Agriculture and Life Sciences Outstanding Graduate Instructor Award, 1994-1995.

Working Papers

"Internalizing Reciprocal Benefits: The Economics of Honey Bee Pollination Markets" (with Randy Rucker and Michael Burgett).

"Location, Location, Location: The Budgetary Effects of Priority Area Designation in the Conservation Reserve Program" (with Keri Jacobs).

"The Basis Effects of Failures to Converge," with Berna Karali and Kevin McNew.

Publications - Refereed Journal Articles

Moore, Christopher, Daniel J. Phaneuf, and Walter N. Thurman, "A Bayesian Bioeconometric Model of Invasive Species Control: the Case of the Hemlock Woolly Adelgid," forthcoming, Environmental and Resource Economics, 2011.

Parker, Dominic P. and Walter N. Thurman, "Crowding Out Open Space: Federal Land Programs and Their Effects on Land Trust Activity," Land Economics, 87(2011): 202-222.

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Murray, Brian C., Walter N. Thurman, and Andrew Keeler, "Tax Interaction Effects, Environmental Regulation, and 'Rule of Thumb' Adjustments to Social Cost," Environmental and Resource Economics 30(2005): 73-92.

Park, Hoanjae, Walter N. Thurman, and J.E. Easley, Jr., "Modeling Inverse Demands for Fish: Empirical Welfare Measurement in Gulf and South Atlantic Fisheries," Marine Resource Economics 19(2004): 333-351.

Muth, Mary K., Randal R. Rucker, Walter N. Thurman, and Ching-Ta Chuang, "The Fable of the Bees Revisited: Causes and Consequences of the U.S. Honey Program," Journal of Law and Economics 46(2003): 479-516.

Thurman, Walter N., Tyler J. Fox, and Tayler H. Bingham, "Imposing Smoothness Priors in Applied Welfare Economics: An Application of the Information Contract Curve to Environmental Regulatory Analysis," Review of Economics and Statistics 83(2000): 511-522.

Park, Hoanjae and Walter N. Thurman, "On Interpreting Inverse Demand Systems: A Primal View of Scale Flexibilities and Income Elasticities," American Journal of Agricultural Economics 81(1999): 950-958.

Robenstein, Rodney G. and Walter N. Thurman, "Health Risk and the Demand for Red Meat: Evidence from Futures Markets," Review of Agricultural Economics 18(1996): 629-641.

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Thurman, Walter N. "Unconditional Asymptotic Results for Simple Linear Regression," The American Statistician 43(1989): 148-152.

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Publications - Books and Monographs

Thurman, Walter N., Assessing the Environmental Impact of Farm Policies, AEI Press, Washington, D.C., 1995.

Publications - Other Journal Articles

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Caron, Dewey, Michael Burgett, Randal Rucker and Walter Thurman, "Honey Bee Colony Mortality in the Pacific Northwest: Winter 2008/2009" American Bee Journal (March 2010): 265-270.

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Tolley, G., J. Hodge, J. Oehmke and W.N. Thurman, "A Framework for Evaluation of Research and Development Policies," Chapter 1 in The Economics of Research and Development Policy, Praeger Publishers, 1984.

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Parker, Dominic P. and Walter N. Thurman, "The Private and Public Economics of Land Trusts," NC State Economist, July/August 2004.

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Chvosta, Jan, Randal R. Rucker and Walter N. Thurman, "Texas Post-FAIR: The Big Get Bigger and the Small Decline" The Peanut Farmer, May 2001.

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Knoeber, Charles R. and Walter N. Thurman, "Broiler Contracting: Smooths Grower Incomes, Shifts Price Change Risk, but Critics Maintain Gains Accrue Largely to Integrators," N.C. State Economist, September 1994.

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Thurman, Walter N. "Reasons Debated for Consumption Pattern Changes," N.C. State Economist, April 1993.

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Thurman, Walter N. "Chicken Cycles," Tar Heel Economist, May 1988.

Popular Press - continued

Thurman, Walter N., "Effects of the Peanut Program," Tar Heel Economist, February 1988.

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Thurman, Walter N. and James E. Standaert, "Reasons for Changes in Meat Consumption Composition," Tar Heel Economist, February, 1986.

Thurman, Walter N. "Why Has Poultry Consumption Doubled?" Breakthrough (published by the N.C. State Univ. Dept. of Poultry Science), December 1985.

Presentations

Thurman, Walter N., "On Markets," the 2011 Harris Lecture at Clemson University, the John E. Walker Department of Economics.

Discussant at the American Enterprise Institute Farm Bill Workshop, Washington D.C., December 2010.

Karali, Berna, Kevin Mcnew, and Walter Thurman, "The Basis Effects of Failures to Converge," presented at the 2010 meetings of the NCCC-134 Committee on Applied Commodity Price Analysis, Forecasting, and Market Risk Management in St. Louis, Missouri.

Rucker, Randal R., Walter N. Thurman, and Michael Burgett, "The Economic Consequences of Colony Collapse Disorder," presentation at 2009 Agricultural and Applied Economics Association in Milwaukee, Wisconsin.

Thurman, Walter N. "Pollination Economics," the 2009 Rod Zeimer Lecture at the University of Georgia Department of Agricultural & Applied Economics.

Parker, Dominic P. and Walter N. Thurman, "Crowding Out Open Space: Federal Land Programs and their Effects on Private Land Trust Activity," 2004 meetings of the American Agricultural Economics Association, Denver. Also presented at Montana State University, Michigan State University, and the University of Illinois in summer and fall 2004.

Thurman, Walter N. "A Classical Liberal View of Land Trusts," presented at the biennial international meeting of the Mont Pelerin Society Meetings in Salt Lake City, August 2004.

Rucker, Randal R., Walter N. Thurman, and Michael Burgett, "The Internalization of Reciprocal Benefits: An Analysis of Honeybee Pollination Markets," presented at U. of Maryland, Montana State, UC-Davis, Utah State, Washington State, and Oregon State Universities, spring and summer 2002, Clemson University and the University of Maryland, 2003.

Chvosta, Jan, Walter N. Thurman, and A. Blake Brown, "The Economic Effects of Recent Change in Federal Peanut Policy," presented at American Peanut Research and Education Society meetings in Raleigh, North Carolina, July 20, 2002.

Walter N. Thurman and A. Blake Brown, "The Economic Consequences of the Elimination of the Tobacco Program," presented at the Tobacco Workers Conference in Pinehurst, North Carolina, January 15, 2002.

Presentations - continued

Rucker, Randal R. and Walter N. Thurman, "An Empirical Analysis of Honeybee Pollination Markets," presented at the 2001 summer meetings of the American Agricultural Economics Association in Chicago, IL.

Chvosta, Jan, Randal R. Rucker, and Walter N. Thurman, "Peanut Quota Markets and Peanut Production after FAIR," presented at the 2001 summer meetings of the American Agricultural Economics Association in Chicago, IL.

Rucker, Randal R., Jonathon K. Yoder, and Walter N. Thurman, "An Economic Analysis of the Determinants of Lumber Futures Price Movements," presented at the 1999 summer meetings of the American Agricultural Economics Association in Nashville, Tennessee.

Thurman, Walter N., Tyler Fox and Tayler Bingham, "Imposing Smoothness Priors in Applied Welfare Economics: An Analysis of Environmental Regulation in the Pulp and Paper Industry," presented to the U. of Arizona Econometrics Workshop, Tucson AZ, April 23, 1999.

Thurman, Walter N. and Francis G. Scrimgeour, "Agricultural Marketing Boards: The Structure of Rent Dissipation in New Zealand," presented at the meeting of the International Agricultural Trade Research Consortium, Washington, D.C., December 15, 1996.

Muth, Mary, Randal R. Rucker, Walter N. Thurman, and Ching-Ta Chuang, "A Post Mortem of the U.S. Honey Program," presented at Kansas State University's Department of Agricultural Economics, March 22, 1996.

Muth, Mary, Randal R. Rucker, Walter N. Thurman, and Ching-Ta Chuang, "A Post Mortem of the U.S. Honey Program," presented at Tulane University's Department of Economics, February 23, 1996.

Park, Hoanjae and Walter N. Thurman, "On Interpreting Inverse Demand Systems: A Primal View of Scale Flexibilities and Income Elasticities," paper presented at the NCSU Agricultural Economics Workshop, February 13, 1996.

Muth, Mary, Walter N. Thurman, and Ching-Ta Chuang, "A Post Mortem of the U.S. Honey Program," presented paper at the 1996 meetings of the Southern Agricultural Economics Association in Greensboro, North Carolina.

Thurman, Walter N., "The Environmental Effects of Agricultural Policy," paper presented at an American Enterprise Institute conference, "Future Directions in Agricultural Policy," held in Washington, D.C. on November 3-4, 1994.

Presentations - continued

Thurman, Walter N., "Restricting the Market for Quota: An Analysis of Tobacco Production Rights with Corroboration from Congressional Testimony," presented at the Brigham Young University Department of Economics, June 21, 1994.

Borges, Robert B. and Walter N. Thurman, "Production Quotas and Random Yields: The Marginal Effects of Inframarginal Subsidies on Peanut Production," at the presented at the annual meetings of the American Agricultural Economics Association in Orlando, Florida, August 1993.

Robenstein, Rodney and Thurman, Walter N., "Health Risk and the Demand for Red Meat: Evidence from Futures Markets," presented at the annual meetings of the American Agricultural Economics Association in Orlando, Florida, August 1993.

Morales, Roberta and Thurman, Walter N., "Welfare Analysis in a Market with Multiple Distortions: The Case of Salmonella enteritidis in Eggs," presented at the annual meetings of the American Agricultural Economics Association in Orlando, Florida, August 1993.

Easley, J.E., Jr. and Walter N. Thurman, "Valuation of Commercial Harvest: Practical considerations for Fishery Management of the General Equilibrium Derived Demand and a Recent Application," presented at the International Conference on Fisheries Economics, Centre for Fisheries Economics, Norwegian School of Economics and Business Administration, Bergen, Norway, May 1993.

Thurman, Walter N. "Imposing Priors in Applied Welfare Analysis: Applications of Leamer's Information Contract Curve," seminar presented at the University of California-Davis Department of Agricultural Economics, June 7, 1993.

Thurman, Walter N. "Applied General Equilibrium Welfare Analysis," presented at the annual meetings of the American Agricultural Economics Association in Manhattan, Kansas, August 1991.

Thurman, Walter N. and Randal R. Rucker, "The Side Effects of Supply Controls," presented at the annual meetings of the American Agricultural Economics Association in Manhattan, Kansas, August 1991.

Rucker, Randal R., Walter N. Thurman, and Daniel A. Sumner, "The Economic Effects of Transferability Restrictions on Tobacco Quota," presented at the 1991 annual meetings of the American Agricultural Economics Association in Vancouver, British Columbia, August 1990.

Presentations - continued

Thurman, Walter N. "The Welfare Significance of General Equilibrium Supply and Demand Curves," The University of Waikato, Hamilton, New Zealand, September 1990 and Lincoln University, New Zealand, December 1990.

Thurman, Walter N. "On The Welfare Significance of General Equilibrium Demand and Supply Curves," UNC-Wilmington Dept. of Economics and Finance workshop, December 1989.

Thurman, Walter N. "Two Illustrations of the Welfare Significance of a General Equilibrium Demand Curve," NCSU Natural Resource Economics workshop, August 22, 1989.

Thurman, Walter N. and Michael K. Wohlgenant, "Consistent Estimation of General Equilibrium Welfare Effects," presented at the annual meetings of the American Agricultural Economics Association in Knoxville, Tennessee, August 1988.

Thurman, Walter N. "The Welfare Significance of General Equilibrium Demand Curves and their Consistent Estimation," NCSU Department of Statistics workshop, Sept. 20, 1988.

Hakeem, Salih A. and Walter N. Thurman, "Futures-based Price Forecasts When Futures Markets Don't Exist," presented at the annual meetings of the American Agricultural Economics Association in Knoxville, Tennessee, August 1988.

Thurman, Walter N. "Risk in Broiler Production," presented at the annual meeting of the Southern Agricultural Economics Association in New Orleans, February 1988.

Thurman, Walter N. "Apple Prices and Storage Technology," meeting of the Southern Agricultural Economics Association in Nashville, Tenn., February 1987.

Thurman, Walter N. "Have Meat Price and Income Elasticities Changed? Their Connection with Changes in Marketing Channels," prepared for presentation at a symposium, "The Demand for Red Meat," sponsored by The Southern Regional Research Committee (S-165) and the Board of Agriculture of the National Research Council held October 20-21, 1986 in Charleston, South Carolina.

Thurman, Walter N. "Endogeneity Testing in Supply and Demand Systems with an Application to the Demand for Poultry Meat," presented at the 1985 American Agricultural Economics Association summer meeting in Ames, Iowa.

Professional and Department Service

Editor of the American Journal of Agricultural Economics, 2006-2010.
Member of the Publication of Enduring Quality Award Subcommittee for the Agricultural and Applied Economics Association, 2009-2012.
Member of Publications Committee for the AAEA, 2007-2010.
Organizer of "Contracting for Ecosystem Services," conference in Chapel Hill, North Carolina, sponosored by PERC, November 8-10, 2010.
Co-organizer of "Genetic Manipulation of Pest Species: Ecological and Social Challenges," an international conference held at NCSU March 2009.
External reviewer of the University of California, Davis graduate program in Agricultural & Resource Economics, January 2009.
External review panel member for the Department of Statistics, North Carolina State University, March 2004.
Invited participant in the Technical Assistant Visit (external review) of the U.S. Forest Service Southern Research Station, November 2003
Academic Review Team member for the Department of Agricultural and Resource Economics at the University of Arizona, 2001
Editorial Board member for Choices, 1998-2002
Agricultural Policy Topic Leader for Selected Papers for the annual meetings of the American Agricultural Economics Association, 2000
Member of Awards Committee for Quality of Communication for the American Agricultural Economics Association, 1999-2001
Member of Awards Committee for Quality of Teaching for the American Agricultural Economics Association, 1999-2001
Academic Consultant for the Casualty Actuarial Society and Society of Actuaries, 1994-present. Duties comprise advising the Society on the economics portion of their semi-annual examination.
Senior Associate Editor of the American Journal of Agricultural Economics, 1993-1997
Chair and member of the Awards Committee for Quality of Research Discovery for the American Agricultural Economics Association, 1993 (chair), 1992 (member)
Grant proposal reviewer for the National Science Foundation
Grant proposal reviewer for USDA National Research Initiative Grant Competition
Referee for:

American Economic Review, American Journal of Agricultural Economics, American Statistician, Australian Journal of Agricultural Economics, Canadian Journal of Agricultural Economics, Energy Journal, Environmental and Resource Economics, European Economic Review, European Financial Management, Journal of Agricultural & Resource Economics, Journal of Business and Economics Statistics, Journal of Economic Education, Journal of Economic Entomology, Journal of Environmental Economics and Management, Journal of Futures Markets, Journal of Law & Economics, Journal of Political Economy, Journal of Production Economics, Journal of Sports Economics, Land Economics, New Zealand Economic Papers, Oxford Economic Papers, Review of Financial Economics, Rand Journal of Economics, Review of Economics and Statistics, Scandinavian Journal of Economics, Southern Journal of Agricultural Economics, Western Journal of Agricultural Economics.

Professional and Department Service - continued

Committee work and other departmental and university service:

Chair of Kenneth Keller Graduate Research Award Committee, 2010
College of Ag. and Life Sciences Strategic Planning Study Group member, 2008
University Promotion and Tenure Committee, 2001-2001
Agricultural Economics Workshop Coordinator, 1999-2008
ARE Marketing and Development Committee Member, 1998-present
College of Ag. and Life Sciences Research Committee, 1999-2001
Departmental graduate admission committee, 1989-1993, 1996-2001, 2004-2006.
College of Ag. and Life Sciences Tenure and Promotion Committee, 1999-2001
Chair, economics graduate program admissions committee, 1996-1999
College of Ag. and Life Sciences Associate Dean search committee, 1998
Economics search committee, 1991-1993, 1995-1996, 2001-2002
Served as CALS representative at ITA English Proficiency Screenings, 1995-1996.
Chair of ARE committee to evaluate 9-month appointments, 1995-1996.
College of Ag. and Life Sciences long-range planning committee, 1995.
College of Ag. and Life Sciences grad. committee, 1991-1995.
Ag. and Resource Economics search committee, 1993-1994, 2001-2002
Ad hoc econometrics search committee, 1993-1994.
Ag. and Resource Economics CSRS Review Committee, 1993.
Preliminary exam committee Winter 1987 - Winter 1989, Summer 1991, Summer 1999-Summer 2001, Summer 2011-present
Undergraduate curriculum committee 1986-87, 1987-88, 1988-89.
Economics and Business search committee 1983-84 and 1984-85.

Courses Taught at NCSU

Undergraduate:

EC 201 - Principles of Microeconomics
EC 301 - Intermediate Microeconomics
ARE 311 - Agricultural Markets
EC/ARE 336 - Introduction to Environmental Economics

Graduate:

ECG 561/750 - Intermediate Econometrics
ECG 701 - Microeconomic Theory I
ECG 702 - Prices, Value, and Welfare (Microeconomic Theory II)
ECG 741 - Consumption, Demand, and Market Interdependency (Agricultural Economics Field Course)
ECG 751 - Econometric Methods

Graduate Student Advising

Ph.D. committees - graduated
(Economics unless otherwise indicated)

Committee chair or co-chair for the following students:

Borges, Robert
Butry, David
Chuang, Ted
Chvosta, Jan
Deese, William
Fatal, Shay
Ferrier, Peyton
Frechette, Darren
Hakeem, Salih Abdul
Jacobs, Keri
Karali, Berna
Kincaid, Joel
Maranakis, Kosmas
Martin, Laura
Markson, Kelly
Martinez, Miguel
Moore, Christopher
Morales, Roberta
Park, Hoanjae
Roka, Fritz
Schafer, Hartwig
Schuhmann, Peter
Seabolt, James
Wadood, Syed
Zulridah Mohd-Noor

Committee member for the following students:

Abdelmagid, Benaga
Ahrendsen, Bruce
Bauch, Simone (joint with Forestry)
Beach, Robert
Belasco, Eric
Boonsang, Tullaya

Committee member (continued)

Brester, Gary
Brimlow, Jacob
Brown, Blake
Brown, Greg
Brown, John William
Chang, Ruey-er
Chen, Ying-Erh
Clark, John Stephen
Collett-Schmit, Kristen
Courbois, Claude
Darwin, Robert
DaSilva, Orlando
Davis, George
DeJuan, Joseph
Domdom, Aleta
Eastwood, Brian - Statistics
Elsheimer, Bruce - Statistics
Evans, Barry - Statistics
Fontes, Rosa Maria Olivera
Frazao, Elizabeth
Fulcher, Charles
Girante, Joana
Ghosh, Sarbashis
Hegde, Aaron
Hossain
Houng, Shiou-Yin
Huang, Ju-Chin (Statistic co-major)
Huang, Yue-Qiu
Jajri, Idris
Jian, Jiang
Ker, Alan
Khalil, Tarek Mohamed - Statistics
Kianafard, Farid - Statistics
Koppit, Justin - Statistics
Lamb, Vivian

Lee, Jong-Hwa
Leegomonchai, Win

Ph.D. committee member (continued)

Lin, Jen-Hsiang
Long, Jonathan
Maia, Luiz Markson, Kelly
Marsoem, Bambang
McKenzie, Andrew
McDowell, Allen
McFall, Todd
McNew, Kevin
Mensah, Clifford
Metcalfe, Michael
Moerz, Armin (Civil Engineering)
Muth, Mary
Pope, Jaren
Reed, Albert John
Renkow, Mitchell Adam
Rezitis, Anthony
Roberts, Matthew C.
Schwabe, Kurt
Solakoglu, Nihat
Sung, Joo-Kyung
Wells, O. Fenton
Zeng, Tao
Zhen, Chen
Zhu, Ying

Master's committees - graduated

Committee chair or co-chair for the following Master's students:

Bruns, David - ME
Christoforidis, Andreas - ME
Depro, Brooks - ME
Eom, Young Sook - ME
Erickson, Jonathan - ME
Gallogly, Erin - ME
Knisely, Joseph - ME
Robenstein, Rody (MS Ag. Econ.)
Schafer, Hartwig - ME

Committee member for the following Master's students:

Borges, Robert B. - ME
Cotton, Steve - ME
Domdom, Aleta Catamora - ME
Duggan, Wesley - MS Ag. Econ.
Eccles, Bradley
Esya Eyvazova
Gregory, Linda Gail (MS Ag. Econ.)
Hilmer, Christiana - MS Statistics
Homsi, Ghada - ME
Kalinowski, Catherine - ME
Kincaid, Joel - ME
Metcalfe, Mark - MS Statistics
Lopez, Martha - ME
Plotnikova, Maria - ME
Roy, Debiprasad - ME
Roy, Priyanka - ME

Sierra, Jose Augusto - ME
Sabel, Thomas - ME
Smith, Salma - ME
Taylor, Ellis - ME
Wulan, Tririni - MS Ag. Econ.

Ph.D. committees - current

Committee chair or co-chair for the following Ph.D. students:

Dudley, Mitchell
Tsang, Steve
Li, Shu

Committee member for the following Ph.D. students:

Chen, Barbara
Furlong, Kevin
Onel, Gulcen
Qiu, Feng
Tran, Nam
Yu, Yanru
Zhan, Congnan
Zheng, Haiqing
Zhu, Qiuhong

Grants and Contracts

Title:	"A Fellowship Grant to Meet the National Need for Scientists Trained in Forest Products Marketing and Management"
Description:	USDA/CSREES National Needs Graduate Fellowship Grant, 2009-2012
PIs:	Walter N. Thurman, Barry K. Goodwin, and Raymond B. Palmquist
Amount:	$172,000

Title:	"Economic Implications of Colony Collapse Disorder"
Description:	Cooperative Agreement with USDA, 2008-2009
PIs:	Walter N. Thurman and Randal R. Rucker
Amount:	$25,000

Title:	"A Fellowship Grant to Meet the National Need for Scientists Trained in Forest Products Marketing and Management"
Description:	USDA/CSREES National Needs Graduate Fellowship Grant, 2005-2008
PIs:	Walter N. Thurman and Raymond B. Palmquist
Amount:	$280,000

Title:	"The Impact of a Tobacco Program Buyout"
Description:	North Carolina Tobacco Research Commission, 2005
PIs:	A. Blake Brown and Walter N. Thurman
Amount:	$29,000

Title:	"A Fellowship Grant to Meet the National Need for Scientists Trained in Forest Products Marketing and Management"
Description:	USDA/CSREES National Needs Graduate Fellowship Grant, 2002-2005
PIs:	Walter N. Thurman and Raymond B. Palmquist
Amount:	$276,000

Title:	"Externalities in Agriculture: The Economics of Pollination and Honey Markets"
Description:	USDA National Research Initiative (NRI) Competitive Grant, 2001-2003
PIs:	Randal R. Rucker (Montana State U.), Walter N. Thurman, and Michael Burgett (Oregon State Dept. of Entomology)
Amount:	$135,000

Title:	"An Economic Analysis of Tobacco Markets without the Tobacco Program"
Description:	North Carolina Tobacco Research Commission grant, 2001
PIs:	Walter N. Thurman and A. Blake Brown
Amount:	$5,000

Grants and Contracts - continued

Title:	"The Economic Effects of Restrictions on the Transfer of Marketing Quota"
Description	USDA National Research Initiative Grant, 1999-2000
PIs:	Randal R. Rucker and Walter N. Thurman
Amount:	$52,000

Title:	"Economic Analysis of Regulation to Control S. Enteritidis in Commercial Egg Production"
Description:	USDA National Research Initiative grant, 1996-1999
PIs:	Roberta A. Morales, Peter Cowen, Walter N. Thurman
Amount:	$160,000

Title:	"The Economics of Pathogen Control Using HAACP"
Description:	Cooperative Research Agreement with USDA, 1994-1997
PIs:	Walter N. Thurman and Jon Brandt
Amount:	$69,000 for 1994-1995, $174,000 total scheduled ERS contribution

Title:	"The South Atlantic and Gulf Snapper-Grouper Complex: Demand Estimation for Selected Individual Species and the Composite Species Complex"
Description:	National Marine Fisheries Service project, 1994-1995
PIs:	J.E. Easley, Jr. and Walter N. Thurman
Amount:	$110,000

Title:	"Bioeconomics of Commercial/Recreational Fishery Harvest Allocation"
Description:	UNC Seagrant project, 1994-1995
PIs:	J.E. Easley, Jr. and Walter N. Thurman
Amount:	$83,479

Title:	"Risk and Contracting in the Broiler Industry"
Description:	N.C. Poultry Federation Grant, 1993
PIs:	Walter N. Thurman and Charles R. Knoeber
Amount:	$3,000

Title:	"Improved Valuation of Fisheries Harvest: Application of the General Equilibrium Derived Demand"
Description:	UNC Seagrant project, 1991-1993
PIs:	J.E. Easley, Jr. and Walter N. Thurman
Amount:	$31,593

Grants and Contracts - continued

Title:	"Economics of Salmonella enteritidis Control in a Laying Flock"
Description:	Cooperative research agreement and cooperative education agreement with USDA to fund Roberta Morales' dissertation research, 1990-1992
PIs:	Walter N. Thurman and Frank Jones (NCSU Poultry Science)
Amount:	Cooperative education agreement - Two years of RA support for Morales Cooperative research agreement - $6,000

Title:	"The Impacts of Supply Controls and Related Programs: Empirical Analysis and Implications"
Description:	Cooperative research agreement with USDA, 1990-1991
PIs:	Walter N. Thurman, Randal R. Rucker, and Daniel A. Sumner
Amount:	$15,000

Professional Consulting

Analysis Group, 2002-present. Consult on agricultural and natural resource market issues. Named an Academic Affiliate of AG in 2005.

Research Triangle Institute, Center for Economics Research, 1993-present. Collaborate with RTI on EPA study of the pulp and paper industry as well as other projects on welfare analysis of environmental regulations.

Arthur D. Little/TIAX, 2001-2003. Collaborated on Dept. of Energy project on the market for platinum group metals and the impact of widespread adoption of fuel cell technologies.

Society of Actuaries/Casualty Actuary Society, 1996-2002. Academic consultant to the committees preparing certifying exams in economics for actuaries.

New Zealand Treasury, 1996-1997. Commissioned study titled "An Economic Analysis of Agricultural Marketing Structures in New Zealand."

Triangle Economic Research, 1995-1996. Econometric work forecasting recreational beach attendance in connection with oil spill litigation. Testified at trial as an expert witness.

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Attachment 2

Reviewers' Signed Conflict of Interest Certifications

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Dr. Peter Berck
PO3-NAR405-BER

CONFLICT OF INTEREST CERTIFICATION

I hereby warrant that, to the best of my knowledge and belief, no actual or potential organizational or personal conflicts of interest exist. I further warrant that if an actual or potential organizational or personal conflict of interest is identified during performance, I will immediately make full disclosure in writing to the E/CR in accordance with the appropriate clauses in EPA Contract EP-D-06-119.

(Authorized signature)

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Dr. David S. Bullock, University of Illinois
PO2-NAR405-BUL

CONFLICT OF INTEREST CERTIFICATION

I hereby warrant that, to the best of my knowledge and belief, no actual or potential organizational or personal conflicts of interest exist. I further warrant that if an actual or potential organizational or personal conflict of interest is identified during performance, I will immediately make full disclosure in writing to the E/CR in accordance with the appropriate clauses in EPA Contract EP-D-06-119.

(Authorized signature)

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Dr. Dallas Burtraw
PO5-NAR405-BUR

CONFLICT OF INTEREST CERTIFICATION

I hereby warrant that, to the best of my knowledge and belief, no actual or potential organizational or personal conflicts of interest exist. I further warrant that if an actual or potential organizational or personal conflict of interest is identified during performance, I will immediately make full disclosure in writing to the E/CR in accordance with the appropriate clauses in EPA Contract EP-D-06-119.

Dallas Burtraw

(Authorized signature)

12/19/11

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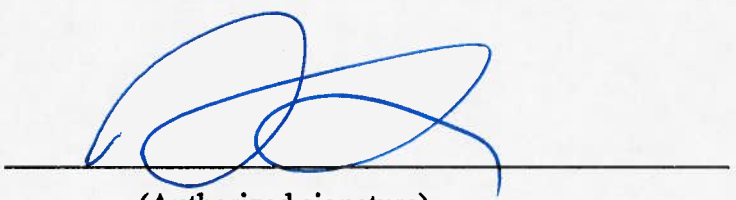
Prof. Andrew Schmitz
PO4-NAR405-SCH

CONFLICT OF INTEREST CERTIFICATION

I hereby warrant that, to the best of my knowledge and belief, no actual or potential organizational or personal conflicts of interest exist. I further warrant that if an actual or potential organizational or personal conflict of interest is identified during performance, I will immediately make full disclosure in writing to the E/CR in accordance with the appropriate clauses in EPA Contract EP-D-06-119.



(Authorized signature)

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Dr. Waltern N. Thurman, NCSU
PO1-NAR405-THU

CONFLICT OF INTEREST CERTIFICATION

I hereby warrant that, to the best of my knowledge and belief, no actual or potential organizational or personal conflicts of interest exist. I further warrant that if an actual or potential organizational or personal conflict of interest is identified during performance, I will immediately make full disclosure in writing to the E/CR in accordance with the appropriate clauses in EPA Contract EP-D-06-119.

Walter N. Thurman

(Authorized signature)

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Attachment 3

Materials Transmitted to the Reviewers and Example Transmission Email Messages

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Example email message of December 9, 2011 transmitting the review charge and model documentation (email addresses removed)

Hello Dr. Berck,

I hope the material with the purchase order was not too daunting. Please let us know if you have any questions.

I have attached the full charge and the documentation for the model. We will provide you with a temporary license so that you can review the code itself (in GAMS) when EPA has gotten that arranged.

We will be working to arrange a call with EPA for you to ask any clarifying questions that you have.

Thanks for agreeing to take part.

Stephen Edgerton
EC/R Incorporated
501 Eastowne Drive, Suite 250
Chapel Hill, NC 27514
(919) 433-8326

Email Attachments:

Peer Review Charge for MMM 12_05_2011.pdf
MMM Background Documentation 12_6_11.pdf

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Charge for Review of the Multimarket Model

December 6, 2011

Background

In conducting economic analyses related to regulatory actions, the U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) employs several modeling approaches over varying time horizons. The strictly partial equilibrium model tracks the effect of a regulatory action in a single market while ignoring all other possible market interactions. The strictly general equilibrium model tracks the effects of a regulatory action in all sectors of the economy with all inter-sectoral linkages included. In between these two modeling approaches are models that capture a finite set of predefined important market linkages, while ignoring effects in all other markets. Such a model that is between these two modeling approaches is the Multimarket Model, which is the subject of this peer review. (See Figure 1. *Modeling Choices for Economic Impact Analyses* in the OAQPS Multimarket Model Documentation for details on additional models used.)

The Multimarket Model is a relatively new addition to OAQPS's economic model tool kit and is a national multimarket, partial equilibrium model with linkages between energy-intensive manufacturing industries and energy producing sectors. The Model is designed to analyze large-scale policies that may affect a large number of industries or a substantial part of the whole economy to better understand economic incidence questions about how costs may be passed across sectors within the economy. In addition, the Multimarket Model is designed to be used as a transparent tool that can respond quickly to requests about how producers and consumers in 100 U.S. industry sectors might respond to new environmental policy.

Actions Requested

The peer review charge is to review the Multimarket Model and the Model's documentation and provide feedback and suggestions on the Model's structure and application. Specifically, the peer review should focus on considering and answering the questions provided below while reviewing the Model's structure.

Specific Questions for the Review

- Does the Multimarket Model fulfill the theoretical and practical expectations of a partial-equilibrium model?

- Historically, EPA has frequently used single or sometimes two-market partial-equilibrium models to estimate economic impacts of a new regulation. EPA plans to use the Multimarket Model to estimate market impacts from a regulation that may affect many industry sectors. Are there other regulatory scenarios where the Multimarket Model might

be more appropriate than a single or two-market partial-equilibrium model? Please comment on the advantages and disadvantages of the Multimarket Model versus single or two-market models.

- Distributional impacts are an important component of economic impact analysis in a regulatory setting. Is the number of sectors in the Multimarket Model sufficient to provide an understanding of the distribution of market impacts of any given regulation? In addition to commenting on the number of sectors, please comment on if there are other concerns with how the sectors are aggregated.

- How can the surplus changes coming from this model be interpreted?

- Is the treatment of imports and exports appropriately structured and parameterized for this type of economic model? Are there any significant shortcomings to this treatment that need to be addressed within EPA's plans for use of the Multimarket Model?

- Are the demand and supply elasticities used in the Multimarket Model appropriate for this model given its intended application? Please provide any suggestions to improve the elasticity estimates.

- EPA is interested in exploring different ways to use the model, either through enhancements in the model or innovations in how we represent the direct effects of a regulation in the model (i.e., how it is shocked). Please comment on the following ways to potentially enhance the model.
    - Alternatives to shock the model – beyond shocking the model through a cost per unit of output approach (i.e., "tax"), what other alternatives could you recommend to represent the impact of a regulation, given the current model structure? How can a regulatory shock that involves fuel switching be incorporated into the model?
    - Explicitly model the pollution control sector – what are your thoughts on how ancillary demand-side market changes can be reflected in the model (e.g., increased demand for pollution control equipment due to implementation of add-on controls)?

- Are there any components of the model documentation that you would recommend for further elaboration or clarification?

OAQPS Multimarket Model Documentation

December 2011

OAQPS Multimarket Model Documentation

Contract No. EP-W-11-029
Work Assignment Number: 0-06

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Air Economics Group
Research Triangle Park, NC 27711

CONTENTS

Section Page

1. Introduction 1

2. Overview of Features 3

3. Industry Sectors and Baseline Market-Clearing Conditions 5

4. Economic Behavior with Multiple Markets 6

4.1 U.S. Supply 6

4.1.1 Changes in U.S. Industry Supply Decisions and Pollution Abatement Costs 7

4.1.2 Accounting for Subsequent Factor Price Changes in an Industry's Supply Chain 8

4.2 Rest of World (ROW) Supply (U.S. Imports) 9

4.3 Demand 9

4.4 Model Price Elasticity Parameters 10

4.4.1 Supply Side: Own-Price Elasticities 11

4.4.1.1 Assignment Procedures and Assessments 11

4.4.2 Demand Side: Own-Price Elasticities 12

4.5 Method of Shocking the Model When Output Price Change Derived from a Partial Equilibrium Model 13

5. Partial Equilibrium Costs 13

5.1 Changes in Consumer and Producer Surplus 13

6. Model Uncertainties and Limitations 15

7. Conclusions 16

8. References 18

LIST OF FIGURES

Number		Page
1.	Modeling Choices for Economic Impact Analyses	20
2.	Direct Costs Reduce Production Rates at Baseline Prices	21
3.	Higher Energy and Intermediate Costs Further Reduce Production Rates at Baseline Prices	21

LIST OF TABLES

Number		Page
1.	Industry Sectors Included in Multimarket Model	22
2a.	2010: Baseline Data Set (billion 2006$)	27
2b.	2015: Baseline Data Set (billion 2006$)	33
2c.	2020: Baseline Data Set (billion 2006$)	38
2d.	2025: Baseline Data Set (billion 2006$)	43
2e.	2030: Baseline Data Set (billion 2006$)	48
3.	Supply Elasticities	54
4.	U.S. Demand Elasticities	58

1. Introduction

In conducting economic analyses related to regulatory actions, the U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) employs several modeling approaches (see Figure 1 on page 16 for a range of OAQPS modeling approaches and tools). A strictly partial equilibrium model tracks the effect of a regulatory action in a single market while ignoring all other possible market interactions. A strictly general equilibrium model tracks the effects of a regulatory action in all sectors of the economy with all inter-sectoral linkages included. In between these two modeling approaches are models that capture a finite set of predefined important market linkages, while ignoring effects in all other markets. Such a model that is between these two modeling approaches is the Multimarket Model, which is briefly described in the fourth column of Figure 1 and more completely in this documentation.

Because the scope of many of OAQPS's regulatory actions is industry specific and typically not large enough to substantially affect other sectors of the economy, partial equilibrium models have typically been employed to estimate the economic impacts. These partial equilibrium models have been either strictly partial (one product market) or have been extended to multiple markets when (a) more than one market is directly affected by a regulation and/or (b) other related product markets are potentially indirectly affected by the regulation. For example, the economic impact analysis conducted for the Pulp and Paper Cluster rule in 1998–1999 modeled the interactions between the directly affected markets for pulp inputs and the indirectly affected final paper and paperboard products markets (USEPA, 1997). Although these models may be extended to include multiple markets, they generally do not account for interactions within the entire U.S. economy, as the general equilibrium approach does.

The Multimarket Model described below is a relatively new addition to OAQPS's economic model tool kit. Before developing the Multimarket Model, OAQPS most frequently used partial equilibrium models developed for a specific regulation that affected a particular sector. However, some regulations affect multiple industry sectors and sector-specific partial equilibrium models are impractical. Although OAQPS uses the five region, 35 sector general equilibrium model, Economic Model for Policy Analysis (EMPAX)[1], for regulations with expected

[1] EMPAX-CGE is a peer-reviewed five region and 35 sector dynamic computable general equilibrium (CGE) economic model designed to estimate regional macroeconomic impacts of environmental regulations on the U.S. economy. Many major regulations directly affect a large number of industries and/or substantially impact

economy-wide effects or for regulations where the dynamic aspects are particularly important, the limited sectoral detail of perfect-foresight, dynamic CGE models (e.g., EMPAX) reduces their usefulness for many OAQPS regulations, especially when the Agency is interested in additional sectoral detail on price and quantity changes.

An example of a regulation that was not suited for analysis using a partial equilibrium model and that required more detailed sectoral analysis than EMPAX could provide is the industrial, commercial, and institutional (ICI) boiler regulations. These regulations were finalized early in 2011 and used the Multimarket Model for economic impact analysis (USEPA 2011a). These regulations affect several dozen or more industry sectors, and therefore needed a high degree of sectoral detail in the estimate of the market changes as a result of the rule. The structure of the Multimarket Model was developed for this type of analysis—an analysis of more than one sector, where the cost inputs are detailed. Besides its use for the ICI boiler regulations, the Multimarket Model was also used for the commercial, institutional, and solid waste incinerator regulations, the proposed Mercury and Air Toxics Standards (MATS), and the final Cross-State Air Pollution Rule (USEPA 2011b, USEPA 2011c, USEPA 2011d). For these last two regulations, the direct economic impact is on the electric power sector, but many sectors experience a secondary impact as a result of an increase in retail electricity prices. For these last two regulations, the direct impact on the electricity sector was modeled using the Integrated Planning Model (IPM) (see column five in Figure 1). Many sectors experience a secondary impact as a result of the retail electricity price increases and these secondary impacts are estimated by the Multimarket Model.

An economic impact analysis (EIA) provides information about a policy's economic costs; emphasis is also placed on how the costs are distributed among producers and consumers (EPA, 2010). In addition, large-scale policies that may affect a large number of industries or a substantial part of the whole economy require additional analysis to better understand economic incidence questions about how costs may be passed across sectors within the economy. The Multimarket Model is designed to respond quickly to requests about how producers and consumers in 100 U.S. industry sectors (versus EMPAX's 35 sectors) might

---

markets for key factors of production. In either case, substantial indirect impacts may result from changes in production, input use, income, and consumption patterns for directly affected markets. EMPAX-CGE offers the ability to trace economic impacts resulting from policies such as large-scale environmental regulations as the impacts are transmitted throughout the economy. This type of model provides critical insight to policy makers evaluating the magnitude and distribution of costs associated with environmental policies. This model became operational in 2004, and additional information on the model can be located at http://www.epa.gov/ttn/ecas/EMPAXCGE.htm.

respond to new environmental policy, and it is a national multimarket partial equilibrium model with linkages between energy-intensive manufacturing industries and the energy sector.

2. Overview of Features

The Multimarket Model contains the following features:

- Model scope
  - It includes 100 industry sectors within the United States ("markets").
  - It can be used to analyze market changes in a number of different years (2010, 2015, 2020, or 2025).
  - Supply curves reflect prices of inputs, underlying production assumptions, and have constant elasticities. Final demands are represented by constant elasticity demand curves. Intermediate demands are derived from supply functions.
  - The sectors represented in the model are linked with each other based on their use of energy and other nonenergy materials. Each sector's production technology reflects the purchase of energy and other intermediate goods made by other sectors included in the model. For example, the construction industry uses inputs from the petroleum, cement, and steel industries and is influenced by price changes that occur in each of those sectors. These market linkages allow EPA to consider how output and input price changes are transmitted across the sectors in the model.
  - Equilibrium baseline data for all sectors come from input-output information from IMPLAN 2007 as used in OAQPS's CGE model EMPAX.
  - International trade (imports/exports) is represented.
- Economic behavior
  - The model uses a market-clearing approach where the quantity supplied of each sector equals the quantity demanded. This condition must simultaneously hold for all of the sectors explicitly represented in the baseline (pre-policy) and scenario (post-policy).
  - U.S. industries respond to regulatory costs and price changes by changing production levels.

- U.S. industries also respond to price changes that occur within their supply chain (e.g., higher energy and other nonenergy material costs).
- International trade (imports/exports) responds to domestic price changes.
- Customers (U.S. and international households and industries only) reduce consumption when market prices increase, and vice versa.
- Markets are assumed to be perfectly competitive. Markets are also assumed to be national in scope.

- Short-term behavioral constraints
  - The model is static and changes are measured relative to its benchmark year (e.g., 2010, 2015, 2020, or 2025 as discussed below). No dynamic adjustment processes are depicted in the model.
  - Fixed production resources lead to an upward-sloping industry supply function.
  - U.S. industries cannot alter energy and intermediate input mixes. Said another way, and input substitution is not explicitly represented in the underlying production function.
  - Decisions are made in the context of a single period (the baseline year). Firms' and households' decisions are not influenced by expectations about policies and economic conditions in future years.
  - Investment and government consumption do not respond to price changes, and the quantities are fixed at baseline year levels.
- Labor and capital markets
  - The model excludes both a national labor and capital market.
  - Because the model excludes national labor and capital markets, we cannot use the model to estimate real wage changes, changes in labor/leisure choices, or savings and investment decisions within the model. Consequently, the Multimarket Model cannot consider whether policies interact with existing distortions, particularly distortions associated with the tax on labor income in ways that increase or decrease estimates of the social cost.

– Because savings and investment decisions are not modeled, social costs associated with capital stock changes are also not estimated.

3. Industry Sectors and Baseline Market-Clearing Conditions

The Multimarket Model is a simplified version of a subset of the U.S. economy. It includes 100 industry sectors and treats each sector as a U.S. market where buyers and sellers exchange goods and services. Exchange occurs in one of four selected "baseline" years (2010, 2015, 2020, and 2025).[2] Currently, analysis of intermediate years between the 5-year increments can be analyzed by assuming one of the baseline years approximates the baseline economic conditions. For example, the year 2020 may be selected to be representative of an intermediate baseline year of 2018.

The model statistics were derived from OAQPS's CGE model's (EMPAX-CGE) balanced social accounting matrix (SAM) for 35 industrial sectors. EMPAX-CGE relies on a wide variety of data sources to develop a SAM that characterizes the U.S. economy over time. The SAM combines information on the economy from Minnesota IMPLAN Group with several types of energy data available from the U.S. Energy Information Administration. The sources used in EMPAX-CGE, the methodology for integrating the economic and energy data, and the procedures for creating baselines for future baseline years can be found in Chapter 4 of the EMPAX-CGE model documentation.

After the EMPAX-CGE baseline for the five region, 35-sectors is developed, OAQPS extracts information for 2010, 2015, 2020, and 2025, aggregates it to a single U.S. region, uses a balancing procedure that expands the data set to 100 sectors and produces a consistent set of economic statistics that simultaneously satisfies the market-clearing condition in all 100 markets: the quantity of supply in each market equals the quantity of demand.

In the Multimarket Model, the following accounting identity holds for each sector (s):

$$\text{Output}_s + \text{Imports}_s = \text{Consumption}_s + \text{Investment}_s + \text{Government}_s + \text{Exports}_s. \quad (1)$$

Because all the baseline data are reported in value terms, we also use the common "Harberger convention," where we choose quantity units for which all 100 market prices are one in the baseline equilibrium (Shoven and Whalley, 1995). To illustrate, consider the iron and

[2] The Multimarket Model currently only has these four baseline years because, as discussed below, the model is calibrated to EMPAX. The current configuration in EMPAX has these four years as simulation years. If the simulated years in EMPAX were changed, the Multimarket Model baseline years could change.

steel sector in 2015. On the supply side, total U.S. production is valued at $174 billion and the total value of imports is $59 billion. Total U.S. market supply is $233 billion. On the demand side, $202 billion is bought by households and other sectors in the Multimarket Model. Government and investment uses account for $13 billion, and $18 billion is exported to the rest of the world. Total U.S. market demand is $233 billion.

4. Economic Behavior with Multiple Markets

A linked multimarket model is useful for evaluating relative market impacts across related markets. The Multimarket Model is shocked by imposing annual compliance costs across selected industries that are directly affected by the regulation. Changes in prices and output are estimated for the industries directly affected by the regulation, and then the price and quantity changes are propagated across the economy (in this case, the 100 sectors included in the model). Prices and quantities of certain final goods and factors adjust and come into a new equilibrium. Decisions across all markets within the model are determined simultaneously. Given the model structure, the subsequent reduction in consumer and producer surplus approximates the compliance cost estimate for the regulation in question, net of trade impacts yielding surplus changes outside of the United States.

4.1 U.S. Supply

The Multimarket Model characterizes supply decisions during the implementation period after EPA finalizes a new regulation. A typical implementation period is 3 to 5 years after a final regulation has been issued. During the period, the Multimarket Model assumes one or more production factors cannot be adjusted, while other production factors can be adjusted to meet the desired production levels. Under these conditions, the supply (that is, marginal cost) curves for the firms rise at higher output rates. As a result, the quantity of a good the industry is willing and able to supply to the market rises when the price of the good rises; we use a general form to describe the U.S. industry (s) supply function:[3]

$$Q_s = b_s \left(P_s\right)^{e_s} \tag{2}$$

where

Q_s = quantity supplied (s)

[3] We use the common functional form that is suggested in the *OAQPS Economic Analysis Resource Document* (EPA, 1999).

b_s = calibrated scale parameter for the supply price relationship

P_s = price for output (s)

ε_s = price elasticity of supply for output (s)

To calibrate the supply functions, parameters are chosen such that functional form and data are consistent, that is, they represent a solution to the model. Because we have selected units so that the baseline price is 1, the scale parameter is the baseline total value of output regardless of the elasticity selected.

4.1.1 Changes in U.S. Industry Supply Decisions and Pollution Abatement Costs

During the rulemaking process, the annualized compliance costs of a regulation are estimated through other modeling efforts. The costs represent engineering estimates of industry expenditures associated with the purchase of emission control equipment and other production inputs that would be needed to comply with the regulation. As a result of the regulation, industries supplying environmental protection goods or services will see increases in demand for their product as other industries make more environmental expenditures. In some cases, a sector may simultaneously be required to make environmental protection expenditures *and* experience increased demand for their output. For example, the electricity sector may have to incur more environmental protection expenditures and also supply additional electricity used by other sectors to meet environmental standards.

In addition to energy and intermediate inputs, labor and capital have historically represented a significant component of pollution control expenditures. For example, Nestor and Pasurka (1995 study of environmental protection expenditures across industries shows a significant share (in some cases over 50%) is associated with labor and capital expenditures. However, the existing Multimarket Model design does not include capital and labor where these expenditures can take place. Instead, the pollution control expenditures required for compliance with the regulation (i.e., those estimated outside of the Multimarket Model), are treated as an additional unit cost (c); the associated compliance expenditures ($c \times Q$) are withdrawn from the economy and are not returned to any of household, industry, or government.

In the Multimarket Model, annualized pollution control or abatement costs are assumed

to be variable factors of production.[4] Pollution abatement costs per unit of supply (*c*) alter production rates at baseline market prices (see Figure 2 on page 17). The cost per unit is approximated using the annualized compliance cost analysis and dividing it by the baseline value of output:

$$c_s \approx \text{annualized compliance costs}_s/\text{U.S. value of output}_s. \quad (3)$$

The pollution abatement costs shift the market (s) supply function as follows:

$$Q_s = b_s\left(P_s - c_s\right)^{\varepsilon_s}. \quad (3a)$$

4.1.2 Accounting for Subsequent Factor Price Changes in an Industry's Supply Chain

As shown in Figure 3 (on page 17), higher energy or intermediate good prices provide incentives to alter production rates at baseline market prices. The Multimarket Model considers how changes in all factor markets (g) and supply and demand conditions throughout an industry sector's supply chain (e.g., energy and other intermediate material prices) influence production decisions:

$$\sum_{i=1}^{n} \alpha_{sg}(P'_g - P_g). \quad (4)$$

The changes in factor (g) prices also shift the market (s) supply function as follows:

$$Q_s = b_s\left(P_s - c_s - \sum_{i=1}^{n} \alpha_{sg}(P'_g - P_g)\right)^{\varepsilon_s}. \quad (4a)$$

The SAM provides information about input (g) use by sector (s). The use ratio (α_{sg}) describes the dollar amount of an input that is required to produce a dollar of output. Higher ratios suggest strong links between two industries, while lower ratios suggest weaker links. We assume the input use ratio is fixed and industries cannot adjust their input mix during the period of analysis; this is a standard assumption in public and commercial input-output (IO) and SAM multiplier models (Berck and Hoffmann, 2002). Morgenstern and colleagues (2004) and Ho and colleagues (2008) also use this assumption when examining near-term effects of environmental policy.

[4] To the extent pollution abatement costs require equipment or other capital goods, this approach assumes the industry rents the equipment from a market that is not included in the Multimarket Model.

4.2 Rest of World (ROW) Supply (U.S. Imports)

U.S. import quantities respond to domestic price increases using a single supply function:[5]

$$Q_s' = r\left(P_s'\right)^{\varepsilon_g^{ROW}} \tag{5}$$

where

Q_s' = with-policy supply quantity (s)

r = calibrated scale parameter for the supply and price relationship

P_s' = with-policy U.S. price for output (s)

ε_s^{ROW} = price elasticity of supply of goods from the ROW to the United States (imports) (s)

The key supply parameter that controls the ROW supply adjustments is the price elasticity of supply (ε_g^{ROW}).

4.3 Demand

Uses for industry output are divided into four groups:

- domestic intermediate uses,
- other final use (domestic and exports),
- investment, and
- government use.

Intermediate use is determined by the input use ratios and the industry output decisions determined within the Multimarket Model:

$$Q_g' = \alpha_{sg} Q_s' \tag{6}$$

[5] We use the common functional form that is suggested in the *OAQPS Economic Analysis Resource Document* (EPA, 1999).

where

Q'_g = with-policy input demand quantity (g)

α_{sg} = input use ratio (input g used by s)

Q'_s = with-policy output quantity (s)

Other final use also responds to market price changes. Following guidance in the *OAQPS Economic Analysis Resource Document* (EPA, 1999), we use a general form for a "final use" demand function:

$$Q'_s = a\left(P'_s\right)^{\eta_s} \tag{7}$$

where

Q'_s = with-policy demand quantity (s)

a = calibrated scale parameter for the demand and price relationship

P'_s = with-policy price for output (s)

η_s = price elasticity of demand (s)

Given the model's decision making framework, the last two use groups (investment and government) are assumed to be fixed (i.e., the price elasticity of demand is zero).

4.4 Model Price Elasticity Parameters

To put the model into practice for past rulemakings, OAQPS had to quickly identify over 400 own-price elasticities in a relatively short period of time. We recognize that the choice of elasticity values is an important issue; a well-known result of partial equilibrium economic incidence literature suggests that the relative market price elasticities *determine* the distribution of market surplus changes across stakeholders.

The next sections describe and report the current values used in the model. EPA is currently trying to identify ways to improve the values and ways to characterize the uncertainty associated with the values.

4.4.1 Supply Side: Own-Price Elasticities

Broda and colleagues (2008a and 2008b) currently provide the empirical basis for all supply-side own-price elasticities. They estimate over 1,000 international trade elasticities that OAQPS organized to be comparable with the 100 industry sectors. The research design implies that the parameter estimates are inverse export supply elasticities. For example, a reported parameter estimate for an inverse export supply elasticity of 1.6 would imply an ROW supply elasticity of 1/1.6, or 0.6. A 1% increase in the domestic price leads to a 0.6% increase in the volume of goods supplied (i.e., exported) to the United States by other countries (p. 2043).

Absent better information, the Multimarket Model assumes the U.S. supply elasticity value is less than or equal to the supply of imports. For the 100 U.S. supply elasticities we assumed a domestic supply elasticity for each sector that was one standard deviation lower than the sample mean import supply elasticity. For sectors where only one observation was available, we assumed the domestic and import supply elasticities are the same.

4.4.1.1 Assignment Procedures and Assessments

Most of the Broda trade elasticities correspond with detailed North American Industry Classification System (NAICS) codes (5- and 6-digit level), while the multimarket industry sectors typically correspond with more aggregated sectors (NAICS 2-, 3-, or 4-digit levels). To adapt these values for the model, we organized the 5- and 6-digit NAICS codes under their 3- and 4-digit codes and calculated the sample mean elasticity value for all codes that fell within the aggregate industrial sector.[6] In some aggregated sectors, extremely high values are estimated for some NAICS codes. As a result, sample means may not be the best central tendency statistic for the aggregate sector. In fact, after applying the assignment procedures, EPA found some of the aggregate sector values may be more representative of long-run responses. As a result, the model may currently overstate responses to price changes, especially over shorter decision-making periods. OAQPS is currently reviewing whether the use of the sample median versus the sample mean would be a more appropriate approach.

Because Broda et al.'s articles focused on industrial production goods, their data set did not cover some of the industry sectors in the Multimarket Model (e.g., service industries, transportation, and energy sources). In order to fill the gaps, we turned to another source that

[6] In addition, we also restricted the elasticity sample to those that Broda et al. classify as "medium" and "low" categories because these categories tend to be inelastic and are more likely to be consistent over short periods of time. By using lower values, we were more likely to capture constraints in shorter periods where importers are likely to have less flexibility to respond to price changes.

reports substitution elasticities (Purdue University's Global Trade Analysis Project [GTAP]).[7] Although the substitution elasticities in the GTAP model are a different type of international trade elasticity and cannot be directly applied in the Multimarket Model (e.g., they are based on the Armington structure[8]), the parameters provide us with some additional information about the relative trade elasticity size differences between industry sectors. We used the GTAP information to develop practical ways of filling parameter gaps. To do this, we chose a base industrial sector (iron and steel) for which we had a parameter value from Broda et al. (2008b) (a value of 1.0). Next, we developed an industry-specific index for missing industries using the corresponding GTAP sector trade elasticities and the GTAP iron and steel sector. For example, the GTAP substitution elasticity for coal (6.1) is approximately 2.2 times the trade elasticity for iron and steel (2.95). As a result, the multimarket import supply elasticity for coal is computed as 2.2 (2.2 x 1.0).

4.4.2 Demand Side: Own-Price Elasticities

As noted in Section 4.3, uses for industry output are divided into four groups: domestic intermediate uses, other final uses (domestic and exports), investment and government uses. Intermediate demand is determined by the input use ratios and the industry output decisions; therefore, no price elasticity of demand parameter is required for this demand group. Instead, it is determined within the model (see equation 7 on page 9).

To approximate the response of final uses (η_g) to a change in price, we used demand elasticities reported in Ho, Morgenstern, and Shih (2008). To estimate the demand elasticities, Ho, Morgenstern, and Shih used a CGE model[9] and simulated the effects of placing a small tax (or, a small per-unit price increase) on output and recording the quantity change. The general equilibrium quantity change associated with the tax considers all price and income changes that led to the quantity change. As a result, the sector values are elastic and may overstate a final user's ability to respond to price changes especially over shorter decision-making periods. EPA continues to review alternative sources for demand parameters.

[7] See Chapter 14 of the GTAP 7 Database Documentation for the full description of the parameters at https://www.gtap.agecon.purdue.edu/resources/download/4184.pdf; see Table 14.2 for elasticities.

[8] Detailed documentation of the entire GTAP 7 Database is available at https://www.gtap.agecon.purdue.edu/databases/v7/v7_doco.asp. The GTAP also uses a unique system of categorizing commodities that does not match the NAICS or HS system exactly.

[9] The authors used the Adkins–Garbaccio CGE Model (Adkins, 2006).

4.5 Method of Shocking the Model When Output Price Change Derived from a Partial Equilibrium Model

EPA has used outputs of its Integrated Planning Model (IPM) to estimate the costs of complying with regulations on the electricity industry that are borne by the electric utility industry (USEPA, 2011e). To analyze the market changes induced by regulations that affect sectors such as electric utilities in the Multimarket Model, the change in the price of electricity due to the regulation as forecast by the IPM model is imposed on the electricity sector in the Multimarket Model, holding electricity generation fixed at the level of generation forecast by IPM. Prices and quantities of the final goods and factors represented in the Multimarket Model adjust and come into a new equilibrium in response to the change in the output price for electricity imposed on the model. The new model equilibrium is compared to the baseline model conditions to determine changes in prices and output for the electricity sector and price and quantity changes in other sectors not subject to the regulation, as a result of the regulation on the electricity sector propagating across the economy.

5. Partial Equilibrium Costs

The Multimarket Model also provides another measure of the overall burden to the economy using the idea of "partial equilibrium costs" (Pizer and Kopp, 2005). Partial equilibrium costs describe the proposed policy's economic burden once economic decisions have adjusted in the simulation and all the markets in the model have cleared. To measure partial equilibrium costs, the Multimarket Model approximates measures of consumer and producer surplus. The partial equilibrium cost estimates exclude losses or gains associated with preexisting tax distortions, balancing of the government's budget constraint, achievement of pollution reduction through different production technologies (e.g., substitution to less pollution-intensive and lower-priced inputs), and increased worker productivity that results from better air quality.

5.1 Changes in Consumer and Producer Surplus

In partial equilibrium analysis, the costs are estimated by measuring the changes in consumer and producer surplus, and the values can be determined using the market supply and demand model. The change in final consumer surplus in market (s) is associated with areas under the *final use* demand curves. A linear approximation for the surplus change is calculated as follows:

$$\Delta CS_s = -[\text{With Policy } Q_s \times \Delta p_s] + [0.5 \times \Delta Q_s \times \Delta p_s]. \quad (8)$$

Given the model's decision-making framework, investment and government consumption are assumed to be fixed (i.e., the price elasticity of demand is zero). With both quantities fixed, the change in surplus associated with government and investment consumption is approximated by the equilibrium change in market prices:

$$\Delta CS_s = -[\text{Baseline Government } Q \times \Delta p_s] - [\text{Baseline Investment } Q \times \Delta p_s]. \quad (9)$$

Although the consumption-related surplus changes in equations 8 and 9 "stay" in market (s), the change in intermediate consumption surplus "leaves" the market and *is separately accounted for* in the markets that use (s) as an intermediate input. By treating intermediate consumption surplus accounting this way, we avoid double counting consumption surplus losses associated with the consumption of (s).

On the seller side of each market (s), the lack of resource mobility associated with fixed production factors may cause sellers to suffer producer surplus losses. During the period of analysis (3 to 5 years after the regulation becomes final), the Multimarket Model assumes sellers are only able to pass through pollution abatement costs and other factor price changes to consumers to the extent the market conditions will allow. The change in producer surplus (U.S. and ROW) is measured as follows:

$$\Delta PS_s = [\text{With Policy } Q_s \times \Delta p_s] - [\text{With Policy } Q_s \times (c_s - \alpha_{gs}\, \Delta p_g)] -$$
$$[0.5 \times \Delta Q_s \times (\Delta p_s - c_s - \alpha_{gs}\, \Delta p_g)]. \quad (10)$$

Higher unit costs (abatement [c] and input prices [Δp_g]) and lower production levels reduce producer surplus in the short run. However, the losses are partially offset because market prices of (s) also tend to rise.

The total economic surplus changes described in equations 8 through 10 are summed over all the Multimarket Model markets to arrive at an estimate of the partial equilibrium costs.

$$\sum_{i=1}^{s} \Delta CS_s + \Delta PS_s. \quad (11)$$

Given the structure of the Multimarket Model and the way that the regulation is imposed in the model, the economy-wide partial equilibrium cost estimates derived from the model are similar in magnitude to the costs from engineering direct cost methods. However, we note that estimates of the direct cost of compliance (e.g., engineering costs) may overstate actual compliance costs because those methods often do not consider output or factor

changes. The Multimarket Model also considers additional losses associated with the foregone benefits associated with lower output levels (e.g., deadweight loss). In a perfectly competitive market without preexisting distortions, the foregone benefits are typically a small part of the total partial equilibrium costs.[10] A more detailed discussion of the economic costs of regulation is found in Chapter 8 of EPA (2010).

Unfortunately, there is no transparent rule of thumb that allows one to compare estimates of environmentally related private compliance cost or partial equilibrium cost estimates with true general equilibrium costs. Early CGE analyses demonstrate the difficulty of using such rules. Kokowski and Smith (1987) describe climate policy CGE experiments where errors in partial equilibrium cost measures were large. Murray et al. (2005) consider ad hoc tax interaction upward adjustments for partial equilibrium cost measures when a full CGE analysis is impractical. They conclude that the use of "rules-of-thumb" cost comparisons are not necessarily reliable and can be sensitive to model assumptions.

6. Model Uncertainties and Limitations

Some uncertainties and limitations associated with the Multimarket Model are included below.

- **Absence of explicit representations of labor and capital markets.** Unlike CGE models, the Multimarket Model does not include a national labor or capital market. As a result, we do not estimate real wage changes, changes in labor/leisure choices, or savings and investment decisions within the Model.

- **Absence of representation of taxes that influence market behavior.** For example, labor taxes are not represented in the model. Labor taxes have been shown to significantly affect the benefits and costs of environmental regulations. The absence of the effect is less of a limitation for the use of the Multimarket Model in analyses where changes in labor, leisure, and producer and consumer surplus are not estimated.

- **Leontief production relationship (fixed proportion) between factors of production.** Firms cannot alter production mixes, and there is no substitution between intermediate production inputs. This may lead to an underestimate of

[10] As a general rule, the absolute size of the deadweight loss estimate will be bigger when demand and supply elasticities used in the model are more elastic.

the change in the quantity demanded of intermediate goods and an overestimate of the change in the quantity supplied of final goods.

- **Absence of accounting for all effects of regulation on factor demands in regulated sector.** Given the type of regulatory shock that the Multimarket Model is currently designed to accept, the effect on net economic activity from pollution control expenditures is not accounted for in the model.

- **The Multimarket Model has the structure of a short-run, partial equilibrium model, but is parameterized with long-run elasticities.** Because these elasticities reflect adjustments made when all factors and all prices in the economy are variable, they may not be well suited for use in a model predicated on assumptions of fixed capital stocks. Consequently, use of these elasticities within the Multimarket Model may in some cases lead to overestimates of the decreases in output from domestic industries, overestimates the quantity of imports supplied, and underestimates of the price impacts relative to what would actually occur in the short-run, all other things being equal.

- **The Multimarket Model does not account for the impact of health benefit impacts** of an environmental policy on prices and outputs in other markets, although this is also a common limitation of CGE models and the majority of partial equilibrium models.

7. Conclusions

To assess the economic impacts of regulatory actions, there are trade-offs between using CGE models and single or two-market partial equilibrium models. CGE models track the effects of a regulatory action in all sectors of the economy with all between-sector linkages included and details on the impacts provided at an aggregated level; single or two-market partial equilibrium models track the effects of a regulatory action in a single or small number of markets with all other possible market interactions ignored and details on the impacts provided at a greater level of detail. In addition, the time horizons captured by the modeling approaches differ.

Historically, the scope of many of OAQPS's regulatory actions has been industry specific and typically not large enough to substantially affect the national economy or broad sectors thereof. Thus, OAQPS has employed partial equilibrium models to estimate economic impacts. More recently, however, OAQPS has had to analyze regulatory proposals that affect many or

several dozen industry sectors—an analysis that may not be appropriate for either the CGE or partial equilibrium modeling approaches. For example, the ICI boiler regulations finalized early in 2011 affected many sectors and required an economic modeling framework that fell somewhere between the CGE and partial equilibrium modeling approaches. The Multimarket Model was developed for this type of analysis—an analysis of many or several dozen industry sectors, for which results are not too highly aggregated and over a time horizon associated with the rule's implementation (typically 3 to 5 years from the promulgation of a new regulation).

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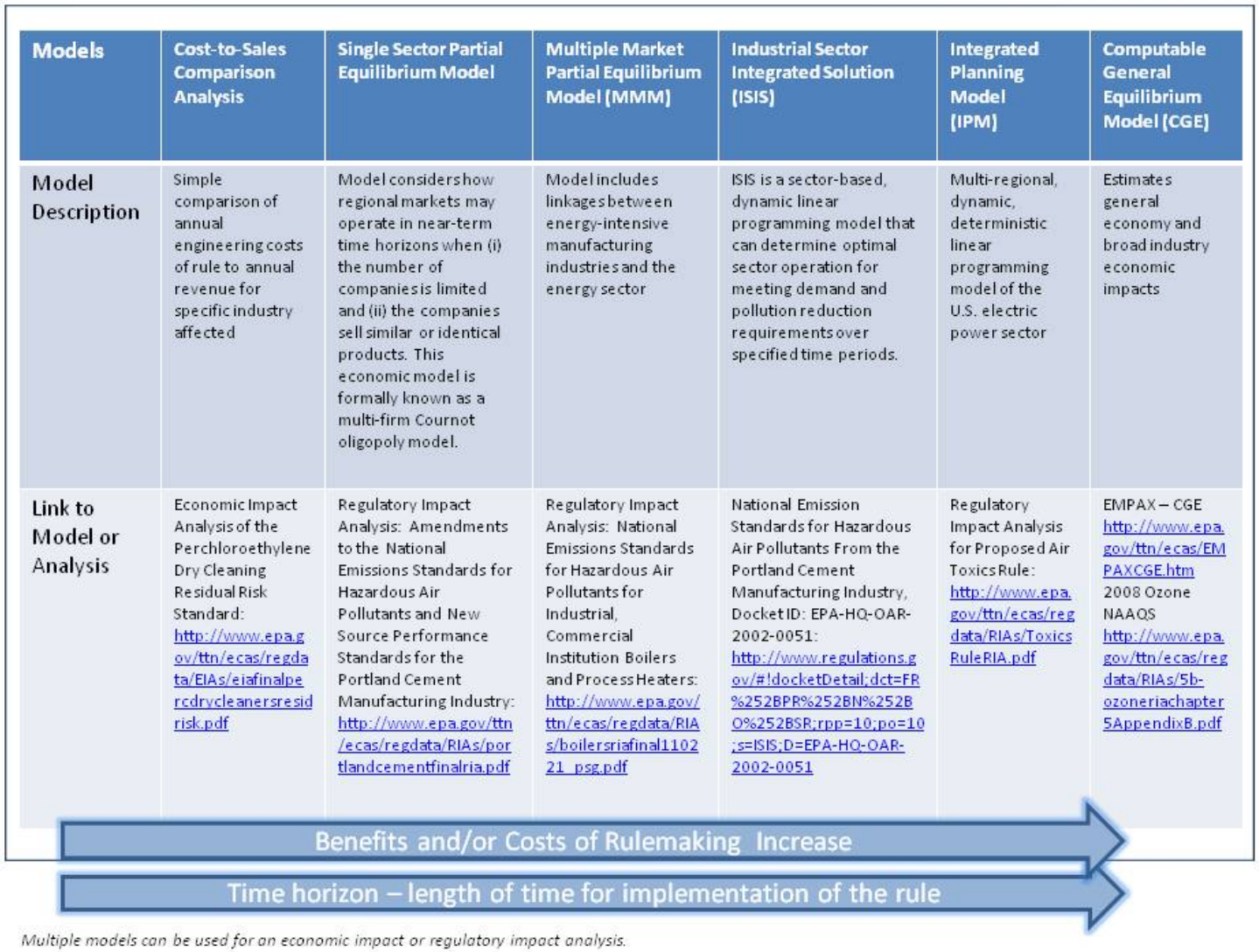

Models	Cost-to-Sales Comparison Analysis	Single Sector Partial Equilibrium Model	Multiple Market Partial Equilibrium Model (MMM)	Industrial Sector Integrated Solution (ISIS)	Integrated Planning Model (IPM)	Computable General Equilibrium Model (CGE)
Model Description	Simple comparison of annual engineering costs of rule to annual revenue for specific industry affected	Model considers how regional markets may operate in near-term time horizons when (i) the number of companies is limited and (ii) the companies sell similar or identical products. This economic model is formally known as a multi-firm Cournot oligopoly model.	Model includes linkages between energy-intensive manufacturing industries and the energy sector	ISIS is a sector-based, dynamic linear programming model that can determine optimal sector operation for meeting demand and pollution reduction requirements over specified time periods.	Multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector	Estimates general economy and broad industry economic impacts
Link to Model or Analysis	Economic Impact Analysis of the Perchloroethylene Dry Cleaning Residual Risk Standard: http://www.epa.gov/ttn/ecas/regdata/EIAs/eiafinalperc drycleanersresidrisk.pdf	Regulatory Impact Analysis: Amendments to the National Emissions Standards for Hazardous Air Pollutants and New Source Performance Standards for the Portland Cement Manufacturing Industry: http://www.epa.gov/ttn/ecas/regdata/RIAs/portlandcementfinalria.pdf	Regulatory Impact Analysis: National Emissions Standards for Hazardous Air Pollutants for Industrial, Commercial Institution Boilers and Process Heaters: http://www.epa.gov/ttn/ecas/regdata/RIAs/boilersriafinal110221_psg.pdf	National Emission Standards for Hazardous Air Pollutants From the Portland Cement Manufacturing Industry, Docket ID: EPA-HQ-OAR-2002-0051: http://www.regulations.gov/#!docketDetail;dct=FR%252BPR%252BN%252BO%252BSR;rpp=10;po=10;s=ISIS;D=EPA-HQ-OAR-2002-0051	Regulatory Impact Analysis for Proposed Air Toxics Rule: http://www.epa.gov/ttn/ecas/regdata/RIAs/ToxicsRuleRIA.pdf	EMPAX – CGE http://www.epa.gov/ttn/ecas/EMPAXCGE.htm 2008 Ozone NAAQS http://www.epa.gov/ttn/ecas/regdata/RIAs/5b-ozoneriachapter5AppendixB.pdf

Multiple models can be used for an economic impact or regulatory impact analysis.

Figure 1. Modeling Choices for Economic Impact Analyses

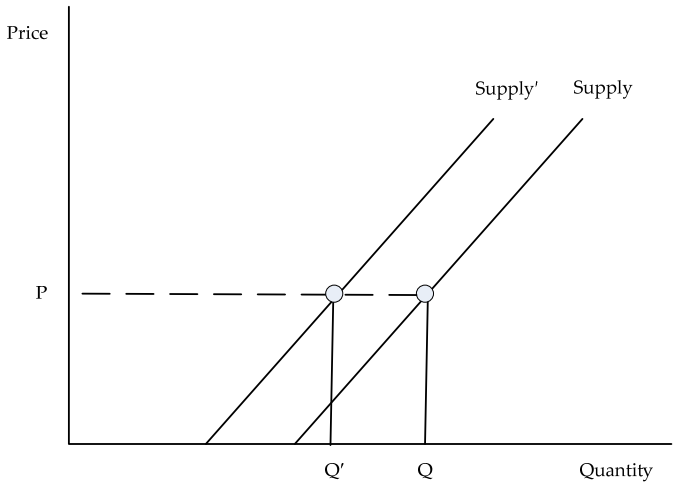

Figure 2. Direct Costs Reduce Production Rates at Baseline Prices

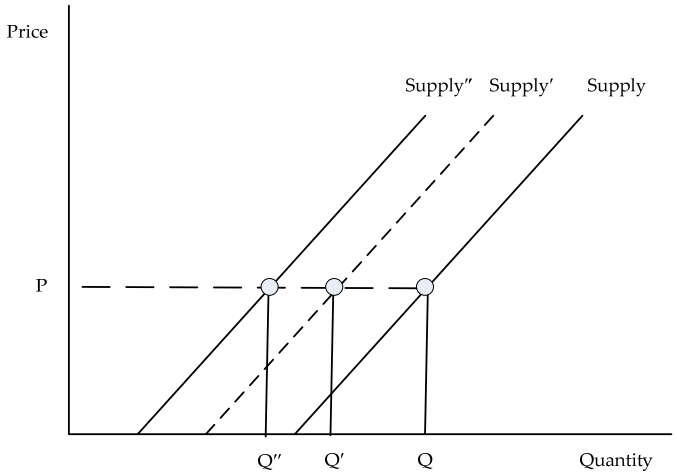

Figure 3. Higher Energy and Intermediate Costs Further Reduce Production Rates at Baseline Prices

Table 1. Industry Sectors Included in Multimarket Model

Industry Label	Description	Representative NAICS[a]
Energy Industries		
COL	Coal	2121
CRU	Crude Oil Extraction	211111 (exc. nat gas)
ELE	Electric Generation	2211
GAS	Natural Gas	211112 2212 4862
OIL	Refined Petroleum	324
Nonmanufacturing		
AGR	Agricultural	11
MIN	Mining	21 less others
CNS	Construction	23
Manufactured Goods		
Food, beverages, and textiles		
ANM	Animal Foods	3111
GRN	Grain Milling	3112
SGR	Sugar	3113
FRU	Fruits and Vegetables	3114
MIL	Dairy Products	3115
MEA	Meat Products	3116
SEA	Seafood	3117
BAK	Baked Goods	3118
OFD	Other Food Products	3119
BEV	Beverages and Tobacco	312
TEX	Textile Mills	313
TPM	Textile Product Mills	314
WAP	Wearing Apparel	315
LEA	Leather	316
Lumber, paper, and printing		
SAW	Sawmills	3211

(continued)

Table 1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Lumber, paper, and printing (continued)		
PLY	Plywood and Veneer	3212
LUM	Other Lumber	3219
PAP	Pulp and Paper Mills	3221
CPP	Converted Paper Products	3222
PRN	Printing	323
Chemicals		
CHM	Chemicals and Gases	3251
RSN	Resins	3252
FRT	Fertilizer	3253
MED	Drugs and Medicine	3254
PAI	Paints and Adhesives	3255
SOP	Soap	3256
OCM	Other Chemicals	3259
Plastics and rubber		
PLS	Plastic	3261
RUB	Rubber	3262
Nonmetallic minerals		
CLY	Clay	3271
GLS	Glass	3272
CEM	Cement	3273
LIM	Lime and Gypsum	3274
ONM	Other Non-Metallic Minerals	3279
Primary metals		
I_S	Iron and Steel	3311 3312 33151
ALU	Aluminum	3313 331521 331524
OPM	Other Primary Metals	3314 331522 331525 331528

(continued)

Table 1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Fabricated metals		
FRG	Forging and Stamping	3321
CUT	Cutlery	3322
FMP	Fabricated Metals	3323
BOI	Boilers and Tanks	3324
HRD	Hardware	3325
WIR	Springs and Wires	3326
MSP	Machine Shops	3327
EGV	Engraving	3328
OFM	Other Fabricated Metals	3329
Machinery and equipment		
CEQ	Construction and Agricultural Equipment	3331
IEQ	Industrial Equipment	3332
SEQ	Service Industry Equipment	3333
HVC	HVAC Equipment	3334
MEQ	Metalworking Equipment	3335
EEQ	Engines	3336
GEQ	General Equipment	3339
Electronic equipment		
CPU	Computers	3341
CMQ	Communication Equipment	3342
TVQ	TV Equipment	3343
SMI	Semiconductor Equipment	3344
INS	Instruments	3345
MGT	Magnetic Recording Equipment	3346
LGT	Lighting	3351
APP	Appliances	3352

(continued)

Table 1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Electronic equipment (continued)		
ELQ	Electric Equipment	3353
OEQ	Other Electric Equipment	3359
Transportation equipment		
M_V	Motor Vehicles	3361
TKB	Truck Bodies	3362
MVP	Motor Vehicle Parts	3363
ARC	Aircraft	3364
R_R	Rail Cars	3365
SHP	Ships	3366
OTQ	Other Transport Equipment	3369
Other		
FUR	Furniture	337
MSC	Miscellaneous Manufacturing	339
Services		
Wholesale and retail trade		
WHL	Wholesale Trade	42
RTL	Retail Trade	44–45
Transportation services		
ATP	Air Transportation	481
RTP	Railroad Transportation	482
WTP	Water Transportation	483
TTP	Freight Truck Transportation	484
PIP	Pipeline Transport	486
OTP	Other Transportation Services	485 487 488
Other services		
INF	Information	51
FIN	Finance and Insurance	52

(continued)

Table 1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Other services (continued)		
REL	Real Estate	53
PFS	Professional Services	54
MNG	Management	55
ADM	Administrative Services	56
EDU	Education	61
HLT	Health Care	62
ART	Arts	71
ACM	Accommodations	72
OSV	Other Services	81
PUB	Public Services	92

[a] NAICS = North American Industry Classification System. Industry assignments are based on data used in the EMPAX-modeling system, which relies on the commodity code system used in IMPLAN.

Table 2a. 2010: Baseline Data Set (billion 2006$)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
ACM	Accommodations	$830	$6	$18	$609	$1	$209
ADM	Administrative Services	$793	$35	$64	$56		$707
AGR	Agricultural	$311	$52	$5	$59	$30	$270
ALU	Aluminum	$64	$17	$4		$7	$69
ANM	Animal Foods	$45		$0	$13	$9	$23
APP	Appliances	$24	$19	$6	$21	$3	$13
ARC	Aircraft	$216	$51	$100		$107	$60
ART	Arts	$252		$3	$198	$3	$48
ATP	Air Transportation	$152	$27	$25	$86	$63	$5
BAK	Baked Goods	$61	$3	$2	$46	$0	$16
BEV	Beverages and Tobacco	$131	$48	$0	$145	$1	$34
BOI	Boilers and Tanks	$27	$2	$8		$2	$19
CEM	Cement	$9	$2	$0		$1	$9
CEM1	Other Concrete	$44	$1	$3		$2	$41
CEQ	Construction and Agricultural Equipment	$69	$24	$31		$15	$46
CHM	Chemicals and Gases	$281	$76	$10		$49	$298
CLY	Clay	$8	$4	$1		$2	$10
CMQ	Communication Equipment	$73	$35	$46	$4	$12	$45
CNS	Construction	$995	$74	$478		$0	$591
COL	Coal	$44	$2			$4	$42

(continued)

Table 2a. 2010: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
CPP	Converted Paper Products	$52	$2	$6	$12	$6	$30
CPU	Computers	$145	$66	$40	$28	$39	$104
CRU	Crude Oil Extraction	$66	$188				$254
CUT	Cutlery	$11	$5	$4	$8	$2	$0
EDU	Education	$974		$704	$248	$12	$9
EEQ	Engines	$34	$14	$5		$14	$29
EGV	Engraving	$20		$5		$7	$8
ELE	Electric Generation	$317	$0	$31	$136	$0	$149
ELQ	Electric Equipment	$33	$16	$16		$10	$23
FIN	Finance and Insurance	$2,013	$99	$41	$801	$131	$1,140
FMP	Fabricated Metals	$66	$1	$7		$2	$57
FRG	Forging and Stamping	$20	$0	$1		$2	$17
FRT	Fertilizer	$41	$5	$4		$11	$32
FRU	Fruits and Vegetables	$73	$12	$4	$49	$6	$26
FUR	Furniture	$65	$33	$12	$43	$2	$41
GAS	Natural Gas	$139	$33	$6	$41	$10	$115
GEQ	General Equipment	$53	$31	$23		$14	$47
GLS	Glass	$29	$0	$2		$10	$17
GRN	Grain Milling	$77	$9	$2	$16	$11	$56

(continued)

Table 2a. 2010: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
HLT	Health Care	$1,862		$20	$1,743	$20	$79
HRD	Hardware	$8	$4	$4		$3	$5
HVC	HVAC Equipment	$33	$8	$10		$6	$26
I_S	Iron and Steel	$121	$42	$10		$12	$140
IEQ	Industrial Equipment	$26	$14	$13		$11	$16
IFN	Information	$1,307	$74	$154	$347	$12	$868
INS	Instruments	$110	$38	$52	$6	$22	$68
LEA	Leather	$4	$26	$0	$28	$0	$1
LGT	Lighting	$12	$10	$5	$6	$1	$10
LIM	Lime and Gypsum	$7		$0		$5	$1
LUM	Other Lumber	$42	$2	$9		$3	$32
M_V	Motor Vehicles	$264	$163	$78	$186	$54	$109
MEA	Meat Products	$173	$10	$5	$90	$12	$76
MED	Drugs and Medicine	$253	$103	$18	$169	$27	$142
MEQ	Metalworking Equipment	$23	$10	$13		$4	$16
MGT	Magnetic Recording Equipment	$15	$2	$2		$2	$12
MIL	Dairy Products	$87	$3	$4	$39	$3	$44
MIN	Mining	$53	$2	$16		$12	$28
MNG	Management	$467	$0	$0		$97	$371
MSC	Miscellaneous Manufacturing	$178	$115	$52	$98	$47	$95
MSP	Machine Shops	$38	$2	$5		$3	$32

(continued)

Table 2a. 2010: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
MVP	Motor Vehicle Parts	$214	$65	$15	$6	$53	$204
OCM	Other Chemicals	$45	$2	$9	$4	$15	$19
OEQ	Other Electric Equipment	$30	$16	$7	$7	$11	$20
OFD	Other Food Products	$92	$7	$2	$50	$7	$40
OFM	Other Fabricated Metals	$55	$28	$21	$6	$12	$44
OIL	Refined Petroleum	$428	$107	$12	$271	$46	$206
ONM	Other Non-Metallic Minerals	$13	$5	$1		$2	$15
OPM	Other Primary Metals	$38	$26	$2		$12	$50
OSV	Other Services	$2,322		$577	$567	$282	$896
OTP	Other Transportation Services	$242		$17	$24	$18	$183
OTQ	Other Transport Equip	$22	$8	$10	$6	$6	$9
PAI	Paints and Adhesives	$35	$1	$3		$6	$27
PAP	Pulp and Paper Mills	$130	$21	$5	$9	$15	$122
PFS	Professional Services	$2,102	$77	$454	$166	$10	$1,549

(continued)

Table 2a. 2010: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
PIP	Pipeline Transport	$38	$80	$2		$8	$108
PLS	Plastic	$143	$14	$4	$13	$15	$124
PLY	Plywood and Veneer	$19	$8	$1		$1	$25
PRN	Printing	$51	$1	$11	$3	$6	$31
PUB	Public Services	$1,103	$22	$772	$65	$0	$289
R_R	Rail Cars	$11	$2	$4		$2	$7
REL	Real Estate	$2,711	$2	$104	$1,494	$34	$1,081
RSN	Resins	$105	$23	$6		$27	$96
RTL	Retail Trade	$1,439	$51	$78	$1,111	$0	$301
RTP	Railroad Transportation	$69	$0	$7	$10	$13	$40
RUB	Rubber	$37	$20	$14	$14	$7	$22
SAW	Sawmills	$29	$9	$1		$1	$36
SEA	Seafood	$13	$3	$1	$4	$1	$10
SEQ	Service Industry Equipment	$28	$22	$23	$9	$6	$13
SGR	Sugar	$34	$6	$2	$26	$3	$10
SHP	Ships	$36	$5	$25	$6	$0	$10
SMI	Semiconductor Equipment	$141	$61	$10		$45	$147
SOP	Soap	$80	$5	$3	$62	$9	$11
TEX	Textile Mills	$28	$9	$1	$3	$7	$26
TKB	Truck Bodies	$57	$11	$24	$9	$5	$29
TPM	Textile Product Mills	$26	$19	$4	$27	$2	$12

(continued)

Table 2a. 2010: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
TTP	Freight Truck Transportation	$296	$0	$28	$50	$46	$172
TVQ	TV Equipment	$18	$33	$3	$35	$2	$11
WAP	Wearing Apparel	$24	$92	$1	$113	$0	$2
WHL	Wholesale Trade	$1,309	$22	$167	$384	$145	$635
WIR	Springs and Wires	$5		$1		$3	$2
WTP	Water Transportation	$44		$11	$13	$19	$1

Table 2b. 2015: Baseline Data Set (billion 2006$)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
ACM	Accommodations	$940	$7	$20	$684	$2	$240
ADM	Administrative Services	$923	$39	$75	$66		$821
AGR	Agricultural	$349	$71	$6	$68	$26	$321
ALU	Aluminum	$81	$21	$4		$10	$88
ANM	Animal Foods	$50		$0	$15	$9	$26
APP	Appliances	$34	$26	$8	$30	$5	$17
ARC	Aircraft	$257	$57	$113		$131	$70
ART	Arts	$286		$3	$224	$4	$54
ATP	Air Transportation	$174	$34	$32	$99	$71	$6
BAK	Baked Goods	$68	$3	$3	$51	$0	$17
BEV	Beverages and Tobacco	$157	$56	$1	$172	$1	$40
BOI	Boilers and Tanks	$35	$3	$11		$3	$24
CEM	Cement	$12	$2	$0		$1	$13
CEM1	Other Concrete	$62	$2	$4		$2	$58
CEQ	Construction and Agricultural Equipment	$95	$31	$42		$22	$61
CHM	Chemicals and Gases	$355	$97	$11		$56	$384
CLY	Clay	$12	$6	$1		$3	$14
CMQ	Communication Equipment	$96	$43	$59	$5	$17	$58
CNS	Construction	$1,393	$107	$683		$0	$817
COL	Coal	$48	$2			$4	$46

(continued)

Table 2b. 2015: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
CPP	Converted Paper Products	$60	$2	$6	$13	$7	$36
CPU	Computers	$193	$82	$52	$35	$54	$134
CRU	Crude Oil Extraction	$75	$213				$289
CUT	Cutlery	$13	$6	$6	$10	$3	$0
EDU	Education	$1,122		$811	$286	$15	$10
EEQ	Engines	$46	$18	$7		$19	$37
EGV	Engraving	$26		$6		$10	$10
ELE	Electric Generation	$339	$0	$35	$144	$0	$160
ELQ	Electric Equipment	$46	$21	$22		$14	$31
FIN	Finance and Insurance	$2,345	$115	$48	$928	$154	$1,330
FMP	Fabricated Metals	$85	$1	$9		$3	$75
FRG	Forging and Stamping	$25	$0	$1		$2	$22
FRT	Fertilizer	$53	$6	$5		$14	$40
FRU	Fruits and Vegetables	$82	$14	$5	$56	$6	$29
FUR	Furniture	$78	$39	$14	$49	$2	$52
GAS	Natural Gas	$150	$34	$7	$44	$11	$122
GEQ	General Equipment	$72	$40	$30		$20	$62
GLS	Glass	$37	$0	$3		$13	$21
GRN	Grain Milling	$86	$10	$2	$18	$12	$64
HLT	Health Care	$2,154		$23	$2,020	$24	$87
HRD	Hardware	$10	$5	$4		$4	$7
HVC	HVAC Equipment	$46	$11	$13		$8	$35
I_S	Iron and Steel	$156	$53	$12		$16	$180

(continued)

Table 2b. 2015: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
IEQ	Industrial Equipment	$35	$18	$18		$15	$21
IFN	Information	$1,502	$84	$162	$404	$15	$1,004
INS	Instruments	$145	$47	$68	$8	$30	$86
LEA	Leather	$4	$25	$0	$27	$1	$1
LGT	Lighting	$16	$14	$7	$8	$2	$14
LIM	Lime and Gypsum	$9		$1		$7	$2
LUM	Other Lumber	$57	$2	$12		$3	$44
M_V	Motor Vehicles	$304	$180	$88	$210	$66	$120
MEA	Meat Products	$193	$11	$6	$102	$12	$84
MED	Drugs and Medicine	$318	$131	$22	$210	$35	$182
MEQ	Metalworking Equipment	$30	$13	$17		$5	$21
MGT	Magnetic Recording Equipment	$19	$2	$3		$3	$15
MIL	Dairy Products	$96	$4	$4	$44	$3	$49
MIN	Mining	$65	$3	$16		$15	$37
MNG	Management	$542	$0	$0		$113	$429
MSC	Miscellaneous Manufacturing	$213	$134	$62	$115	$58	$112
MSP	Machine Shops	$48	$2	$6		$3	$41
MVP	Motor Vehicle Parts	$246	$71	$16	$7	$63	$231
OCM	Other Chemicals	$56	$2	$11	$5	$19	$23
OEQ	Other Electric Equipment	$43	$22	$10	$10	$17	$28
OFD	Other Food Products	$102	$8	$2	$55	$7	$46

(continued)

Table 2b. 2015: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
OFM	Other Fabricated Metals	$71	$34	$26	$8	$16	$56
OIL	Refined Petroleum	$650	$171	$19	$405	$74	$323
ONM	Other Non-Metallic Minerals	$18	$7	$1		$3	$21
OPM	Other Primary Metals	$51	$34	$3		$16	$66
OSV	Other Services	$2,628		$612	$639	$337	$1,041
OTP	Other Transportation Services	$274		$20	$25	$18	$210
OTQ	Other Transport Equip	$26	$9	$11	$7	$7	$10
PAI	Paints and Adhesives	$44	$1	$3		$7	$34
PAP	Pulp and Paper Mills	$151	$24	$6	$10	$17	$143
PFS	Professional Services	$2,439	$87	$495	$194	$13	$1,824
PIP	Pipeline Transport	$44	$101	$1		$4	$139
PLS	Plastic	$173	$16	$5	$15	$18	$151
PLY	Plywood and Veneer	$26	$11	$1		$2	$34
PRN	Printing	$57	$1	$11	$3	$7	$35
PUB	Public Services	$1,248	$24	$877	$71	$0	$325
R_R	Rail Cars	$13	$2	$4		$3	$8
REL	Real Estate	$3,165	$2	$112	$1,753	$41	$1,261
RSN	Resins	$133	$29	$7		$34	$120

(continued)

Table 2b. 2015: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
RTL	Retail Trade	$1,688	$58	$82	$1,299	$0	$364
RTP	Railroad Transportation	$79	$0	$8	$10	$14	$47
RUB	Rubber	$45	$24	$17	$17	$9	$27
SAW	Sawmills	$40	$12	$1		$2	$50
SEA	Seafood	$14	$4	$1	$5	$2	$11
SEQ	Service Industry Equipment	$38	$29	$30	$12	$8	$17
SGR	Sugar	$38	$7	$2	$29	$3	$11
SHP	Ships	$43	$6	$30	$6	$0	$12
SMI	Semiconductor Equipment	$188	$75	$13		$64	$187
SOP	Soap	$100	$6	$4	$77	$12	$14
TEX	Textile Mills	$28	$9	$1	$3	$7	$26
TKB	Truck Bodies	$67	$12	$28	$10	$7	$34
TPM	Textile Product Mills	$26	$18	$3	$26	$2	$13
TTP	Freight Truck Transportation	$337	$0	$32	$53	$47	$205
TVQ	TV Equipment	$24	$40	$3	$45	$3	$13
WAP	Wearing Apparel	$23	$90	$1	$110	$0	$2
WHL	Wholesale Trade	$1,535	$24	$173	$441	$177	$768
WIR	Springs and Wires	$7		$1		$3	$2
WTP	Water Transportation	$50		$14	$14	$21	$1

Table 2c. 2020: Baseline Data Set (billion 2006$)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
ACM	Accommodations	$1,084	$8	$23	$793	$2	$274
ADM	Administrative Services	$1,061	$45	$86	$76		$943
AGR	Agricultural	$391	$96	$7	$77	$23	$380
ALU	Aluminum	$90	$23	$5		$11	$98
ANM	Animal Foods	$56		$0	$17	$10	$29
APP	Appliances	$42	$33	$10	$38	$6	$21
ARC	Aircraft	$280	$62	$122		$143	$76
ART	Arts	$330		$3	$259	$5	$62
ATP	Air Transportation	$198	$38	$35	$115	$80	$7
BAK	Baked Goods	$76	$4	$3	$57	$0	$19
BEV	Beverages and Tobacco	$181	$65	$1	$198	$1	$46
BOI	Boilers and Tanks	$38	$3	$11		$3	$27
CEM	Cement	$13	$2	$0		$1	$14
CEM1	Other Concrete	$67	$2	$4		$2	$62
CEQ	Construction and Agricultural Equipment	$110	$35	$49		$26	$70
CHM	Chemicals and Gases	$425	$113	$13		$67	$458
CLY	Clay	$13	$7	$1		$3	$16
CMQ	Communication Equipment	$115	$52	$72	$6	$20	$69
CNS	Construction	$1,496	$116	$730		$0	$883
COL	Coal	$50	$2			$4	$48

(continued)

Table 2c. 2020: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
CPP	Converted Paper Products	$68	$2	$7	$14	$8	$41
CPU	Computers	$234	$98	$64	$43	$65	$161
CRU	Crude Oil Extraction	$79	$219				$298
CUT	Cutlery	$15	$7	$6	$11	$4	$1
EDU	Education	$1,288		$930	$329	$18	$12
EEQ	Engines	$53	$21	$9		$23	$42
EGV	Engraving	$28		$6		$11	$11
ELE	Electric Generation	$370	$0	$41	$161	$0	$168
ELQ	Electric Equipment	$58	$27	$29		$18	$37
FIN	Finance and Insurance	$2,684	$130	$54	$1,064	$178	$1,518
FMP	Fabricated Metals	$94	$2	$9		$3	$83
FRG	Forging and Stamping	$28	$0	$1		$3	$24
FRT	Fertilizer	$63	$7	$6		$18	$47
FRU	Fruits and Vegetables	$93	$17	$6	$64	$7	$33
FUR	Furniture	$89	$45	$16	$58	$2	$58
GAS	Natural Gas	$173	$35	$8	$49	$16	$136
GEQ	General Equipment	$83	$47	$35		$23	$71
GLS	Glass	$42	$0	$4		$14	$24
GRN	Grain Milling	$96	$12	$2	$20	$12	$73
HLT	Health Care	$2,480		$26	$2,325	$28	$102
HRD	Hardware	$11	$6	$5		$4	$7
HVC	HVAC Equipment	$53	$13	$15		$10	$40
I_S	Iron and Steel	$174	$59	$13		$18	$202

(continued)

Table 2c. 2020: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
IEQ	Industrial Equipment	$41	$21	$20		$17	$24
IFN	Information	$1,724	$95	$184	$464	$17	$1,154
INS	Instruments	$174	$56	$84	$9	$36	$102
LEA	Leather	$4	$27	$0	$29	$1	$1
LGT	Lighting	$21	$18	$9	$11	$3	$16
LIM	Lime and Gypsum	$10		$1		$8	$2
LUM	Other Lumber	$61	$2	$12		$4	$48
M_V	Motor Vehicles	$325	$194	$93	$227	$72	$127
MEA	Meat Products	$216	$13	$6	$116	$12	$94
MED	Drugs and Medicine	$372	$153	$26	$247	$41	$212
MEQ	Metalworking Equipment	$35	$15	$20		$6	$23
MGT	Magnetic Recording Equipment	$23	$3	$4		$4	$18
MIL	Dairy Products	$108	$4	$5	$50	$3	$55
MIN	Mining	$71	$3	$17		$17	$41
MNG	Management	$621	$0	$0		$129	$492
MSC	Miscellaneous Manufacturing	$248	$154	$71	$134	$68	$129
MSP	Machine Shops	$53	$2	$6		$4	$45
MVP	Motor Vehicle Parts	$263	$76	$17	$8	$67	$247
OCM	Other Chemicals	$65	$2	$12	$6	$22	$27
OEQ	Other Electric Equipment	$54	$27	$14	$14	$22	$32
OFD	Other Food Products	$115	$9	$3	$62	$7	$52

(continued)

Table 2c. 2020: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
OFM	Other Fabricated Metals	$78	$38	$27	$8	$18	$63
OIL	Refined Petroleum	$731	$192	$22	$433	$87	$381
ONM	Other Non-Metallic Minerals	$20	$7	$1		$3	$23
OPM	Other Primary Metals	$59	$39	$3		$19	$77
OSV	Other Services	$3,033		$696	$747	$388	$1,202
OTP	Other Transportation Services	$312		$24	$31	$21	$236
OTQ	Other Transport Equip	$28	$10	$12	$8	$7	$11
PAI	Paints and Adhesives	$52	$1	$4		$9	$39
PAP	Pulp and Paper Mills	$170	$27	$6	$10	$19	$162
PFS	Professional Services	$2,801	$99	$565	$223	$15	$2,097
PIP	Pipeline Transport	$50	$113	$1		$5	$157
PLS	Plastic	$195	$18	$5	$17	$21	$170
PLY	Plywood and Veneer	$28	$12	$1		$2	$38
PRN	Printing	$63	$1	$12	$4	$8	$40
PUB	Public Services	$1,441	$28	$1,009	$83	$0	$376
R_R	Rail Cars	$14	$2	$4		$3	$9
REL	Real Estate	$3,631	$2	$126	$2,013	$49	$1,444

(continued)

Table 2c. 2020: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
RSN	Resins	$157	$33	$8		$42	$140
RTL	Retail Trade	$1,936	$66	$93	$1,496	$0	$412
RTP	Railroad Transportation	$90	$0	$9	$13	$16	$52
RUB	Rubber	$51	$27	$19	$19	$10	$30
SAW	Sawmills	$44	$14	$1		$2	$54
SEA	Seafood	$16	$5	$1	$5	$2	$13
SEQ	Service Industry Equipment	$44	$34	$35	$13	$10	$20
SGR	Sugar	$42	$8	$2	$33	$3	$13
SHP	Ships	$47	$6	$32	$7	$0	$14
SMI	Semiconductor Equipment	$229	$90	$16		$79	$224
SOP	Soap	$117	$7	$5	$89	$14	$16
TEX	Textile Mills	$30	$9	$1	$3	$7	$28
TKB	Truck Bodies	$72	$13	$30	$11	$7	$38
TPM	Textile Product Mills	$28	$19	$4	$27	$2	$14
TTP	Freight Truck Transportation	$383	$0	$37	$64	$56	$226
TVQ	TV Equipment	$29	$48	$4	$54	$4	$15
WAP	Wearing Apparel	$25	$96	$1	$118	$0	$2
WHL	Wholesale Trade	$1,759	$28	$195	$507	$204	$881
WIR	Springs and Wires	$7		$1		$4	$2
WTP	Water Transportation	$57		$16	$17	$24	$1

Table 2d. 2025: Baseline Data Set (billion 2006$)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
ACM	Accommodations	$1,257	$9	$26	$924	$2	$313
ADM	Administrative Services	$1,210	$51	$99	$87		$1,076
AGR	Agricultural	$444	$128	$8	$91	$20	$453
ALU	Aluminum	$98	$25	$5		$12	$107
ANM	Animal Foods	$62		$0	$19	$10	$33
APP	Appliances	$49	$39	$12	$45	$7	$24
ARC	Aircraft	$322	$71	$140		$164	$88
ART	Arts	$382		$4	$301	$5	$72
ATP	Air Transportation	$222	$42	$38	$130	$89	$8
BAK	Baked Goods	$85	$5	$3	$64	$0	$22
BEV	Beverages and Tobacco	$205	$74	$1	$225	$1	$52
BOI	Boilers and Tanks	$41	$3	$11		$3	$29
CEM	Cement	$13	$2	$0		$1	$15
CEM1	Other Concrete	$70	$2	$4		$2	$65
CEQ	Construction and Agricultural Equipment	$109	$35	$47		$27	$70
CHM	Chemicals and Gases	$472	$123	$13		$75	$506
CLY	Clay	$14	$7	$1		$3	$16
CMQ	Communication Equipment	$130	$59	$81	$7	$23	$78
CNS	Construction	$1,563	$124	$756		$0	$931
COL	Coal	$51	$2			$4	$48

(continued)

Table 2d. 2025: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
CPP	Converted Paper Products	$75	$3	$7	$15	$8	$47
CPU	Computers	$267	$111	$72	$48	$74	$183
CRU	Crude Oil Extraction	$79	$223				$302
CUT	Cutlery	$15	$8	$6	$12	$4	$1
EDU	Education	$1,480		$1,069	$378	$20	$13
EEQ	Engines	$52	$21	$9		$21	$44
EGV	Engraving	$30		$6		$11	$12
ELE	Electric Generation	$392	$0	$45	$175	$0	$171
ELQ	Electric Equipment	$68	$31	$36		$21	$41
FIN	Finance and Insurance	$3,067	$149	$62	$1,222	$202	$1,729
FMP	Fabricated Metals	$100	$2	$10		$3	$89
FRG	Forging and Stamping	$29	$0	$1		$3	$25
FRT	Fertilizer	$69	$8	$6		$20	$51
FRU	Fruits and Vegetables	$104	$20	$6	$72	$7	$38
FUR	Furniture	$102	$52	$19	$68	$3	$65
GAS	Natural Gas	$180	$37	$8	$49	$16	$144
GEQ	General Equipment	$82	$47	$34		$23	$72
GLS	Glass	$46	$0	$3		$16	$27
GRN	Grain Milling	$107	$14	$3	$23	$13	$82
HLT	Health Care	$2,851		$30	$2,670	$32	$120
HRD	Hardware	$11	$6	$5		$5	$8
HVC	HVAC Equipment	$53	$13	$15		$10	$41
I_S	Iron and Steel	$187	$63	$13		$20	$218

(continued)

Table 2d. 2025: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
IEQ	Industrial Equipment	$41	$21	$20		$17	$25
IFN	Information	$1,981	$109	$213	$533	$20	$1,324
INS	Instruments	$197	$64	$94	$10	$41	$115
LEA	Leather	$4	$28	$0	$30	$1	$1
LGT	Lighting	$24	$21	$11	$13	$3	$17
LIM	Lime and Gypsum	$11		$1		$8	$2
LUM	Other Lumber	$65	$3	$13		$4	$51
M_V	Motor Vehicles	$368	$222	$106	$259	$82	$143
MEA	Meat Products	$239	$15	$7	$130	$12	$105
MED	Drugs and Medicine	$404	$167	$28	$264	$44	$236
MEQ	Metalworking Equipment	$34	$14	$19		$6	$23
MGT	Magnetic Recording Equipment	$26	$3	$4		$4	$21
MIL	Dairy Products	$121	$5	$5	$55	$3	$62
MIN	Mining	$77	$3	$19		$18	$43
MNG	Management	$706	$0	$0		$148	$559
MSC	Miscellaneous Manufacturing	$285	$177	$82	$154	$78	$149
MSP	Machine Shops	$56	$2	$6		$4	$49
MVP	Motor Vehicle Parts	$297	$86	$19	$9	$76	$279
OCM	Other Chemicals	$71	$2	$13	$6	$25	$30
OEQ	Other Electric Equipment	$63	$32	$17	$17	$26	$35
OFD	Other Food Products	$128	$11	$3	$70	$7	$59

(continued)

Table 2d. 2025: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
OFM	Other Fabricated Metals	$83	$40	$28	$8	$19	$68
OIL	Refined Petroleum	$750	$197	$23	$435	$90	$400
ONM	Other Non-Metallic Minerals	$21	$8	$1		$3	$24
OPM	Other Primary Metals	$66	$44	$3		$21	$86
OSV	Other Services	$3,514		$810	$875	$448	$1,381
OTP	Other Transportation Services	$348		$27	$36	$24	$261
OTQ	Other Transport Equip	$32	$11	$14	$9	$8	$13
PAI	Paints and Adhesives	$56	$1	$4		$10	$43
PAP	Pulp and Paper Mills	$189	$31	$7	$11	$21	$181
PFS	Professional Services	$3,193	$114	$655	$256	$17	$2,380
PIP	Pipeline Transport	$57	$124	$1		$6	$174
PLS	Plastic	$215	$20	$6	$19	$23	$188
PLY	Plywood and Veneer	$30	$13	$1		$2	$40
PRN	Printing	$71	$1	$12	$4	$9	$46
PUB	Public Services	$1,671	$33	$1,168	$98	$0	$437
R_R	Rail Cars	$16	$3	$5		$4	$10
REL	Real Estate	$4,160	$2	$146	$2,307	$58	$1,652
RSN	Resins	$171	$36	$9		$46	$152

(continued)

Table 2d. 2025: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
RTL	Retail Trade	$2,206	$75	$108	$1,712	$0	$461
RTP	Railroad Transportation	$101	$1	$11	$15	$19	$56
RUB	Rubber	$56	$29	$20	$21	$11	$33
SAW	Sawmills	$46	$15	$1		$2	$58
SEA	Seafood	$18	$5	$1	$6	$2	$15
SEQ	Service Industry Equipment	$44	$34	$35	$13	$10	$20
SGR	Sugar	$47	$10	$2	$37	$3	$14
SHP	Ships	$54	$7	$38	$8	$0	$16
SMI	Semiconductor Equipment	$261	$101	$18		$91	$253
SOP	Soap	$128	$8	$5	$96	$16	$18
TEX	Textile Mills	$31	$10	$1	$3	$7	$30
TKB	Truck Bodies	$83	$15	$34	$13	$9	$43
TPM	Textile Product Mills	$29	$20	$4	$28	$2	$16
TTP	Freight Truck Transportation	$428	$0	$43	$75	$64	$246
TVQ	TV Equipment	$33	$53	$4	$61	$4	$17
WAP	Wearing Apparel	$26	$101	$1	$124	$0	$2
WHL	Wholesale Trade	$2,003	$32	$228	$584	$233	$991
WIR	Springs and Wires	$8		$1		$4	$3
WTP	Water Transportation	$64		$18	$19	$26	$1

Table 2e. 2030: Baseline Data Set (billion 2006$)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
ACM	Accommodations	$1,455	$10	$30	$1,077	$2	$356
ADM	Administrative Services	$1,371	$58	$113	$99		$1,217
AGR	Agricultural	$464	$177	$10	$105	$15	$511
ALU	Aluminum	$98	$25	$4		$12	$108
ANM	Animal Foods	$69		$0	$22	$10	$36
APP	Appliances	$53	$42	$13	$49	$8	$25
ARC	Aircraft	$342	$75	$148		$175	$94
ART	Arts	$442		$4	$349	$6	$83
ATP	Air Transportation	$247	$46	$43	$145	$98	$8
BAK	Baked Goods	$95	$6	$4	$72	$0	$25
BEV	Beverages and Tobacco	$233	$86	$1	$257	$1	$60
BOI	Boilers and Tanks	$41	$3	$10		$3	$31
CEM	Cement	$14	$3	$0		$1	$15
CEM1	Other Concrete	$73	$2	$4		$3	$69
CEQ	Construction and Agricultural Equipment	$93	$30	$38		$24	$60
CHM	Chemicals and Gases	$507	$129	$14		$81	$542
CLY	Clay	$14	$7	$1		$3	$17
CMQ	Communication Equipment	$134	$61	$82	$7	$24	$81
CNS	Construction	$1,642	$135	$785		$0	$991
COL	Coal	$53	$2			$4	$51

(continued)

Table 2e. 2030: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
CPP	Converted Paper Products	$82	$3	$8	$16	$9	$52
CPU	Computers	$277	$115	$74	$49	$78	$192
CRU	Crude Oil Extraction	$80	$231				$311
CUT	Cutlery	$15	$8	$6	$12	$4	$1
EDU	Education	$1,697		$1,228	$431	$23	$15
EEQ	Engines	$44	$19	$6		$17	$40
EGV	Engraving	$30		$6		$11	$13
ELE	Electric Generation	$424	$0	$51	$197	$0	$177
ELQ	Electric Equipment	$74	$33	$42		$24	$42
FIN	Finance and Insurance	$3,485	$170	$72	$1,396	$229	$1,958
FMP	Fabricated Metals	$100	$2	$8		$3	$90
FRG	Forging and Stamping	$29	$0	$1		$3	$25
FRT	Fertilizer	$73	$9	$7		$22	$53
FRU	Fruits and Vegetables	$117	$24	$7	$82	$8	$44
FUR	Furniture	$116	$60	$22	$80	$3	$72
GAS	Natural Gas	$201	$38	$9	$53	$21	$154
GEQ	General Equipment	$70	$40	$27		$20	$63
GLS	Glass	$49	$0	$3		$17	$29

(continued)

Table 2e. 2030: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
GRN	Grain Milling	$117	$17	$3	$27	$13	$92
HLT	Health Care	$3,257		$34	$3,046	$36	$141
HRD	Hardware	$11	$6	$4		$5	$8
HVC	HVAC Equipment	$46	$11	$11		$8	$38
I_S	Iron and Steel	$185	$63	$11		$20	$217
IEQ	Industrial Equipment	$36	$18	$16		$15	$23
IFN	Information	$2,263	$125	$252	$608	$23	$1,505
INS	Instruments	$203	$66	$95	$11	$43	$121
LEA	Leather	$4	$29	$0	$31	$1	$1
LGT	Lighting	$26	$23	$12	$15	$3	$18
LIM	Lime and Gypsum	$12		$1		$9	$2
LUM	Other Lumber	$69	$3	$13		$4	$54
M_V	Motor Vehicles	$386	$235	$110	$275	$88	$148
MEA	Meat Products	$262	$18	$8	$146	$11	$115
MED	Drugs and Medicine	$428	$177	$29	$273	$47	$256
MEQ	Metalworking Equipment	$29	$12	$15		$5	$21
MGT	Magnetic Recording Equipment	$27	$3	$4		$4	$22
MIL	Dairy Products	$134	$6	$6	$62	$3	$70
MIN	Mining	$82	$4	$20		$19	$45
MNG	Management	$798	$1	$0		$170	$628
MSC	Miscellaneous Manufacturing	$330	$203	$95	$177	$89	$172

(continued)

Table 2e. 2030: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
MSP	Machine Shops	$55	$2	$5		$4	$49
MVP	Motor Vehicle Parts	$311	$90	$20	$9	$79	$293
OCM	Other Chemicals	$75	$3	$14	$6	$26	$31
OEQ	Other Electric Equipment	$69	$35	$20	$20	$28	$37
OFD	Other Food Products	$142	$13	$3	$78	$8	$66
OFM	Other Fabricated Metals	$82	$40	$26	$8	$19	$69
OIL	Refined Petroleum	$796	$209	$25	$454	$97	$429
ONM	Other Non-Metallic Minerals	$22	$8	$1		$3	$25
OPM	Other Primary Metals	$68	$46	$3		$21	$89
OSV	Other Services	$4,061		$956	$1,017	$514	$1,574
OTP	Other Transportation Services	$387		$31	$42	$28	$286
OTQ	Other Transport Equip	$34	$12	$15	$9	$9	$13
PAI	Paints and Adhesives	$59	$1	$4		$11	$45
PAP	Pulp and Paper Mills	$206	$34	$7	$12	$22	$199
PFS	Professional Services	$3,615	$129	$765	$290	$19	$2,670

(continued)

Table 2e. 2030: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
PIP	Pipeline Transport	$63	$135	$1		$7	$190
PLS	Plastic	$230	$22	$6	$20	$24	$202
PLY	Plywood and Veneer	$32	$14	$1		$2	$43
PRN	Printing	$79	$1	$13	$4	$10	$52
PUB	Public Services	$1,934	$38	$1,352	$115	$0	$505
R_R	Rail Cars	$16	$3	$5		$4	$11
REL	Real Estate	$4,741	$3	$171	$2,626	$67	$1,881
RSN	Resins	$182	$37	$9		$49	$162
RTL	Retail Trade	$2,497	$85	$126	$1,940	$0	$515
RTP	Railroad Transportation	$112	$1	$13	$17	$22	$60
RUB	Rubber	$61	$31	$22	$23	$13	$34
SAW	Sawmills	$49	$16	$1		$2	$62
SEA	Seafood	$21	$6	$1	$7	$2	$17
SEQ	Service Industry Equipment	$37	$30	$29	$12	$9	$17
SGR	Sugar	$52	$12	$2	$42	$3	$16
SHP	Ships	$58	$8	$40	$9	$0	$17
SMI	Semiconductor Equipment	$271	$104	$18		$94	$264
SOP	Soap	$135	$8	$5	$100	$18	$20
TEX	Textile Mills	$32	$10	$1	$3	$7	$31
TKB	Truck Bodies	$88	$17	$35	$13	$9	$46
TPM	Textile Product Mills	$30	$21	$3	$28	$2	$17

(continued)

Table 2e. 2030: Baseline Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output (Domestic Supply)	Imports (International Supply)	Investment and Government	U.S. Consump-tion	Exports	Inter-mediate Demand
TTP	Freight Truck Transportation	$474	$0	$50	$88	$73	$263
TVQ	TV Equipment	$34	$54	$4	$62	$4	$17
WAP	Wearing Apparel	$27	$105	$1	$128	$0	$2
WHL	Wholesale Trade	$2,264	$36	$271	$671	$265	$1,094
WIR	Springs and Wires	$8		$1		$4	$3
WTP	Water Transportation	$72		$20	$21	$29	$1

Table 3. Supply Elasticities

Industry Label	Industry Description	Rest of World (ROW)	U.S.
ACM	Accommodations	0.7	0.7
ADM	Administrative Services	0.7	0.7
AGR	Agricultural	1.0	1.0
ALU	Aluminum	0.8	0.5
ANM	Animal Foods	1.1	0.8
APP	Appliances	0.9	0.8
ARC	Aircraft	0.9	0.6
ART	Arts	0.7	0.7
ATP	Air Transportation	0.7	0.7
BAK	Baked Goods	0.8	0.7
BEV	Beverages and Tobacco	2.9	2.9
BOI	Boilers and Tanks	1.1	0.8
CEM	Cement	0.9	0.7
CEQ	Construction and Agricultural Equipment	0.8	0.6
CHM	Chemicals and Gases	1.1	0.8
CLY	Clay	0.8	0.6
CMQ	Communication Equipment	2.5	1.0
CNS	Construction	0.7	0.7
COL	Coal	2.2	2.2
CPP	Converted Paper Products	0.9	0.7
CPU	Computers	1.0	0.7
CRU	Crude Oil Extraction	3.7	3.7
CUT	Cutlery	1.4	1.1
EDU	Education	0.7	0.7
EEQ	Engines	1.2	1.0
EGV	Engraving	1.1	0.8
ELE	Electric Generation	2.0	2.0

(continued)

Table 3. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
ELQ	Electric Equipment	0.8	0.6
FIN	Finance and Insurance	0.7	0.7
FMP	Fabricated Metals	1.2	1.1
FRG	Forging and Stamping	1.6	1.5
FRT	Fertilizer	1.0	0.7
FRU	Fruits and Vegetables	1.0	0.7
FUR	Furniture	1.9	1.9
GAS	Natural Gas	12.2	12.2
GEQ	General Equipment	1.0	0.7
GLS	Glass	0.8	0.6
GRN	Grain Milling	1.7	1.5
HLT	Health Care	0.7	0.7
HRD	Hardware	1.1	0.8
HVC	HVAC Equipment	0.9	0.6
I_S	Iron and Steel	1.0	0.6
IEQ	Industrial Equipment	0.9	0.6
INF	Information	0.7	0.7
INS	Instruments	0.9	0.6
LEA	Leather	0.9	0.7
LGT	Lighting	1.1	0.7
LIM	Lime and Gypsum	0.9	0.7
LUM	Other Lumber	0.9	0.7
M_V	Motor Vehicles	1.3	0.7
MEA	Meat Products	1.2	3.9
MED	Drugs and Medicine	1.3	1.0
MEQ	Metalworking Equipment	0.7	0.5
MGT	Magnetic Recording Equipment	1.0	0.7

(continued)

Table 3. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
MIL	Dairy Products	1.1	0.9
MIN	Mining	2.2	2.2
MNG	Management	0.7	0.7
MSC	Miscellaneous Manufacturing	1.0	0.8
MSP	Machine Shops	1.1	0.8
MVP	Motor Vehicle Parts	0.9	0.6
OCM	Other Chemicals	1.1	0.6
OEQ	Other Electric Equipment	1.0	0.7
OFD	Other Food Products	1.1	0.7
OFM	Other Fabricated Metals	0.9	0.6
OIL	Refined Petroleum	1.0	0.7
ONM	Other Non-metallic Minerals	1.5	0.7
OPM	Other Primary Metals	0.7	0.5
OSV	Other Services	0.7	0.7
OTP	Other Transportation Services	0.7	0.7
OTQ	Other Transport Equipment	1.0	0.7
PAI	Paints and Adhesives	1.0	0.7
PAP	Pulp and Paper Mills	1.1	0.7
PFS	Professional Services	0.7	0.7
PIP	Pipeline Transport	2.0	2.0
PLS	Plastic	1.0	0.7
PLY	Plywood and Veneer	1.3	1.3
PRN	Printing	1.0	0.7
PUB	Public Services	0.7	0.7
R_R	Rail Cars	1.8	0.7
REL	Real Estate	0.7	0.7
RSN	Resins	1.0	0.7

(continued)

Table 3. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
RTL	Retail Trade	0.7	0.7
RTP	Railroad Transportation	0.7	0.7
RUB	Rubber	1.3	1.1
SAW	Sawmills	0.8	0.6
SEA	Seafood	1.1	0.8
SEQ	Service Industry Equipment	0.8	0.6
SGR	Sugar	1.1	0.8
SHP	Ships	1.0	0.7
SMI	Semiconductor Equipment	1.2	1.0
SOP	Soap	0.8	0.6
TEX	Textile Mills	1.0	0.7
TKB	Truck Bodies	3.2	3.1
TPM	Textile Product Mills	0.8	0.6
TTP	Freight Truck Transportation	0.7	0.7
TVQ	TV Equipment	5.8	5.4
WAP	Wearing Apparel	1.2	0.8
WHL	Wholesale Trade	0.7	0.7
WIR	Springs and Wires	1.9	0.8
WTP	Water Transportation	0.7	0.7

Note: RTI mapped Broda et al. data for their industry aggregation to the multimarket model's 100 industries. Domestic supply elasticities are typically assumed to be within one standard deviation of the sample of supply elasticities used for the ROW. In selected cases where this information is not available, the U.S. supply elasticity was set equal to the ROW.

Source: Broda, C., N. Limao, and D. Weinstein. 2008a. "Export Supply Elasticities." http://www.columbia.edu/~dew35/TradeElasticities/TradeElasticities.html.

Table 4. U.S. Demand Elasticities

Industry Label	Industry Description	Demand Elasticity η_g
ACM	Accommodations	−0.7
ADM	Administrative Services	−0.7
AGR	Agricultural	−0.8
ALU	Aluminum	−1.0
ANM	Animal Foods	−0.6
APP	Appliances	−2.6
ARC	Aircraft	−2.5
ART	Arts	−0.7
ATP	Air Transportation	−0.8
BAK	Baked Goods	−0.6
BEV	Beverages and Tobacco	−0.6
BOI	Boilers and Tanks	−0.5
CEM	Cement	−0.8
CEQ	Construction and Agricultural Equipment	−1.7
CHM	Chemicals and Gases	−1.0
CLY	Clay	−0.8
CMQ	Communication Equipment	−2.6
CNS	Construction	−0.8
COL	Coal	−0.1
CPP	Converted Paper Products	−0.7
CPU	Computers	−2.6
CRU	Crude Oil Extraction	−0.3
CUT	Cutlery	−0.5
EDU	Education	−0.7
EEQ	Engines	−1.7
EGV	Engraving	−0.5

(continued)

Table 4. U.S. Demand Elasticities (continued)

Industry Label	Industry Description	Demand Elasticity η_g
ELE	Electric Generation	−0.2
ELQ	Electric Equipment	−2.6
FIN	Finance and Insurance	−0.7
FMP	Fabricated Metals	−0.5
FRG	Forging and Stamping	−0.5
FRT	Fertilizer	−1.0
FRU	Fruits and Vegetables	−0.6
FUR	Furniture	−0.7
GAS	Natural Gas	−0.3
GEQ	General Equipment	−1.7
GLS	Glass	−0.8
GRN	Grain Milling	−0.6
HLT	Health Care	−0.7
HRD	Hardware	−0.5
HVC	HVAC Equipment	−1.7
I_S	Iron and Steel	−1.0
IEQ	Industrial Equipment	−1.7
INF	Information	−0.7
INS	Instruments	−2.6
LEA	Leather	−1.1
LGT	Lighting	−2.6
LIM	Lime and Gypsum	−0.8
LUM	Other Lumber	−0.7
M_V	Motor Vehicles	−2.5
MEA	Meat Products	−0.6
MED	Drugs and Medicine	−1.0

(continued)

Table 4. U.S. Demand Elasticities (continued)

Industry Label	Industry Description	Demand Elasticity η_g
MEQ	Metalworking Equipment	−1.7
MGT	Magnetic Recording Equipment	−2.6
MIL	Dairy Products	−0.6
MIN	Mining	−0.6
MNG	Management	−0.7
MSC	Miscellaneous Manufacturing	−1.7
MSP	Machine Shops	−0.5
MVP	Motor Vehicle Parts	−2.5
OCM	Other Chemicals	−1.0
OEQ	Other Electric Equipment	−2.6
OFD	Other Food Products	−0.6
OFM	Other Fabricated Metals	−0.5
OIL	Refined Petroleum	−0.1
ONM	Other Non-metallic Minerals	−0.8
OPM	Other Primary Metals	−1.0
OSV	Other Services	−0.7
OTP	Other Transportation Services	−0.8
OTQ	Other Transport Equip	−2.5
PAI	Paints and Adhesives	−1.0
PAP	Pulp and Paper Mills	−0.7
PFS	Professional Services	−0.7
PIP	Pipeline Transport	−0.8
PLS	Plastic	−1.0
PLY	Plywood and Veneer	−0.7
PRN	Printing	−0.7
PUB	Public Services	−0.7

(continued)

Table 4. U.S. Demand Elasticities (continued)

Industry Label	Industry Description	Demand Elasticity η_g
R_R	Rail Cars	−2.5
REL	Real Estate	−0.7
RSN	Resins	−1.0
RTL	Retail Trade	−0.7
RTP	Railroad Transportation	−0.8
RUB	Rubber	−1.0
SAW	Sawmills	−0.7
SEA	Seafood	−0.6
SEQ	Service Industry Equipment	−1.7
SGR	Sugar	−0.6
SHP	Ships	−2.5
SMI	Semiconductor Equipment	−2.6
SOP	Soap	−1.0
TEX	Textile Mills	−1.1
TKB	Truck Bodies	−2.5
TPM	Textile Product Mills	−1.1
TTP	Freight Truck Transportation	−0.8
TVQ	TV Equipment	−2.6
WAP	Wearing Apparel	−2.4
WHL	Wholesale Trade	−0.7
WIR	Springs and Wires	−0.5
WTP	Water Transportation	−0.8

Note: RTI assigned an elasticity using the most similar industry from Ho and colleagues' industry aggregation.

Source: Ho, M. S, R. Morgenstern, and J. S. Shih. 2008. "Impact of Carbon Price Policies on US Industry." RFF Discussion Paper 08-37). Http://Www.Rff.Org/Publications/Pages/Publicationdetails.Aspx?. Publicationid=20680. Accessed August 2009. Table 8.A.6.

United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Air Economics Group Research Triangle Park, NC	December 2011

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Email message of December 19, 2011 transmitting links to examples of the EPA's use of economic modeling (email addresses removed)

Hello all,

The EPA has provided the following links to illustrate their use of, and discussion of, economic modeling for evaluating regulatory impacts. These are found on their Regulatory Impact Analysis (RIA) page:

http://www.epa.gov/ttn/ecas/ria.html

- Regulatory Impact Analysis: National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters:

Chapter 4 (example of use of Multimarket model)
http://www.epa.gov/ttn/ecas/regdata/RIAs/boilersriafinal110221_psg.pdf

- Regulatory Impact Analysis: Amendments to the National Emission Standards for Hazardous Air Pollutants and New Source Performance Standards (NSPS) for the Portland Cement Manufacturing Industry:

Chapter 3 (example of single market partial equilibrium model)
http://www.epa.gov/ttn/ecas/regdata/RIAs/portlandcementfinalria.pdf

- Economic Impact Analysis for the Gasoline Distribution Industry (Area Sources)

Chapter 4 (example of simpler partial equilibrium model for a smaller regulation not requiring a regulatory impact analysis) http://www.epa.gov/ttn/ecas/regdata/EIAs/gasoline_distribution_eia.pdf

Stephen Edgerton
EC/R Incorporated
501 Eastowne Drive, Suite 250
Chapel Hill, NC 27514
(919) 433-8326

Email message of December 20, 2011 transmitting the link to the baseline data files for the model and the text file of the model (email addresses removed)

Hello all,

Below is a link to an FTP site where the baseline data files for the Multimarket Model are posted. This is an 81 MB zip file that you can download. It is on an RTI site that I believe is cleared every Friday. Let us know if we need to get it re-posted next week.

ftp://ftp.rti.org/Public/mmm/

The attached file is the text file of the model. It can be opened in a text reader (e.g., WordPad).

In the next day or so we will get to you a few more items:

1. The temporary license for GAMS.

2. A slight elaboration on the first charge question to add a little more specificity.

3. A contact at EPA in case you have any questions on getting the model up and running.

Please let me know if there is anything else that you need.

Stephen Edgerton
EC/R Incorporated
501 Eastowne Drive, Suite 250
Chapel Hill, NC 27514
(919) 433-8326

Attachment:

mm.gms

```
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*U.S. Multi-Market Model
*May 11, 2011
*Developed by RTI International
*EPA Contract #
*WA 4-76
*RTI Project Number: 0209897.004.076
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

*--------------------------------------------------------------------------------------
---*
* May 2010
* Data included in this file:
*
*       AEO forecasts of employment             aeo_emp
*
* Last update: AEO 2009 Revised Case
*--------------------------------------------------------------------------------------
---*

$setglobal size 100sector

$if not setglobal year          $setglobal year         2015

$if not setglobal mmpe          $setglobal mmpe         1
$if not setglobal fshift        $setglobal fshift       0
$if not setglobal ipmon         $setglobal ipmon        1

**------ Time Periods ------**
set     t               years                           /2010*2050/;


**------ Regions ------**
set     r       Aggregated regions /
        NRTH    North East
        SOTH    South
        MIDW    Mid-West
        PLNS    Plains
        WEST    West /;

set st   all states /
        usa,ak,al,ar,az,ca
        co,ct,dc,de,fl
        ga,hi,ia,id,il
        in,ks,ky,la,ma
        md,me,mi,mn,mo
        ms,mt,nc,nd,ne
        nh,nj,nm,nv,ny
        oh,ok,or,pa,ri
        sc,sd,tn,tx,ut
        va,vt,wa,wi,wv,wy/;


**------ Households ------**
set     hh      All households /
        HH1     Households (0  - 15K)
        HH2     Households (15 - 30K)
```

```
        HH3     Households (30K - 50K)
        HH4     Households (50K + )     /;


**------ 101 Industries ------**
*broke CEM into 2 sectors 08/2010;

set     s       Sectors /

**--- Energy Industries---**
        COL     Coal                            NAICS 2121
        CRU     Crude Oil Extraction            NAICS 211111 (exc. nat gas)
        ELE     Electric generation             NAICS 2211
        GAS     Natural Gas                     NAICS 211112 2212 4862
        OIL     Refined Petroleum               NAICS 324

**--- Nonmanufacturing ---**
        AGR     Agriculture                     NAICS 11
        MIN     Mining                          NAICS 21 less others
        CNS     Construction                    NAICS 23

**--- Manufactured Goods ---**

* Food, beverages, and textiles
        ANM     Animal foods                    NAICS 3111
        GRN     Grain Milling                   NAICS 3112
        SGR     Sugar                           NAICS 3113
        FRU     Fruits and vegetables           NAICS 3114
        MIL     Dairy Products                  NAICS 3115
        MEA     Meat Products                   NAICS 3116
        SEA     Seafood                         NAICS 3117
        BAK     Baked goods                     NAICS 3118
        OFD     Other food products             NAICS 3119

        BEV     Beverages and Tobacco           NAICS 312
        TEX     Textile Mills                   NAICS 313
        TPM     Textile Product Mills           NAICS 314
        WAP     Wearing Apparel                 NAICS 315
        LEA     Leather                         NAICS 316

* Lumber, Paper, and Printing
        SAW     Sawmills                        NAICS 3211
        PLY     Plywood and Veneer              NAICS 3212
        LUM     Other Lumber                    NAICS 3219
        PAP     Pulp and Paper Mills            NAICS 3221
        CPP     Converted Paper Products        NAICS 3222
        PRN     Printing                        NAICS 323

* Chemicals
        CHM     Chemicals and gases             NAICS 3251
        RSN     Resins                          NAICS 3252
        FRT     Fertilizer                      NAICS 3253
        MED     Drugs and medicine              NAICS 3254
        PAI     Paints and adhesives            NAICS 3255
        SOP     Soap                            NAICS 3256
        OCM     Other chemicals                 NAICS 3259
```

* Plastic and Rubber

PLS	Plastic	NAICS 3261
RUB	Rubber	NAICS 3262

* Nonmetallic Minerals

CLY	Clay	NAICS 3271
GLS	Glass	NAICS 3272
LIM	Lime and Gypsum	NAICS 3274
ONM	Other Non-Metallic Minerals	NAICS 3279

* Primary Metals

I_S	Iron and Steel	NAICS 3311 3312 33151
ALU	Aluminum	NAICS 3313 331521 331524
OPM	Other Primary Metals	NAICS 3314 331522 331525 331528

* Fabricated Metals

FRG	Forging and stamping	NAICS 3321
CUT	Cutlery	NAICS 3322
FMP	Fabricated metals	NAICS 3323
BOI	Boilers and tanks	NAICS 3324
HRD	Hardware	NAICS 3325
WIR	Springs and wires	NAICS 3326
MSP	Machine shops	NAICS 3327
EGV	Engraving	NAICS 3328
OFM	Other fabricated metals	NAICS 3329

* Machinery and Equipment

CEQ	Construction and Ag Equipment	NAICS 3331
IEQ	Industrial Equipment	NAICS 3332
SEQ	Service Industry Equipment	NAICS 3333
HVC	HVAC Equipment	NAICS 3334
MEQ	Metalworking Equipment	NAICS 3335
EEQ	Engines	NAICS 3336
GEQ	General Equipment	NAICS 3339

* Electronic Equipment

CPU	Computers	NAICS 3341
CMQ	Communication Equipment	NAICS 3342
TVQ	TV Equipment	NAICS 3343
SMI	Semiconductor Equipment	NAICS 3344
INS	Instruments	NAICS 3345
MGT	Magnetic Recording Equipment	NAICS 3346
LGT	Lighting	NAICS 3351
APP	Appliances	NAICS 3352
ELQ	Electric equipment	NAICS 3353
OEQ	Other electric equipment	NAICS 3359

* Transport Equipment

M_V	Motor Vehicles	NAICS 3361
TKB	Truck Bodies	NAICS 3362
MVP	Motor Vehicle Parts	NAICS 3363
ARC	Aircraft	NAICS 3364
R_R	Rail Cars	NAICS 3365
SHP	Ships	NAICS 3366
OTQ	Other Transport Equip	NAICS 3369

```
* Others
        FUR     Furniture                       NAICS 337
        MSC     Miscellaneous Manufacturing     NAICS 339


**--- Services ---**

* Wholesale and Retail Trade
        WHL     Wholesale Trade                 NAICS 42
        RTL     Retail Trade                    NAICS 44-45

* Transportation Services
        ATP     Air transportation              NAICS 481
        RTP     Railroad transportation         NAICS 482
        WTP     Water transportation            NAICS 483
        TTP     Freight truck transportation    NAICS 484
        PIP     Pipeline transport              NAICS 486
        OTP     Other transporation services    NAICS 485 487 488

* Other Services
        IFN     Information                     NAICS 51
        FIN     Finance and Insurance           NAICS 52
        REL     Real Estate                     NAICS 53
        PFS     Professional Services           NAICS 54
        MNG     Management                      NAICS 55
        ADM     Administrative Services         NAICS 56
        EDU     Education                       NAICS 61
        HLT     Health Care                     NAICS 62
        ART     Arts                            NAICS 71
        ACM     Accomodations                   NAICS 72
        OSV     Other services                  NAICS 81
        PUB     Public Services                 NAICS 92

**--new cement industry--**
*       CEM     Cement                          NAICS 3273
        CEM     Cement manufacturing            NAICS 32731
        CEM1    Other concrete                  NAICS 32732 327331 327332
32739
        /;


**------ Trade (International and Domestic) ------**
set     trd     Trade Partners /
        ftrd    foreign trade
        dtrd    domestic trade /;

alias (g,s);

**------ Subsets ------**

set     col(s)  /col/
        cru(s)  /cru/
        ele(s)  /ele/
        gas(s)  /gas/
        oil(s)  /oil/
        cog(s)  /col,gas,oil/
```

```
        srv(s)
/whl,rtl,atp,rtp,wtp,ttp,pip,otp,ifn,fin,rel,pfs,mng,adm,edu,hlt,art acm,
                osv,pub/
;

alias (s,g),(g,gg),(hh,hhh),(r,reg);

**---- Data ---**
parameter
        y0(r,s)         Output
        cd0(r,hh,g)     Consumer demand for good g
        id0(r,g,s)      Intermediate demand of good g by industry s
        i0(r,g)         Investment goods
        g0(r,g)         Government purchases of good g
        x0(r,s,trd)     Exports by market (domestic and foreign)
        m0(r,g,trd)     Imports (domestic and foreign sources)
        id0_eia_100

        check1
;

$include data\balanced_mm_data_%year%.gms

*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
**New Multimarket Model Code Begins here
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%

*Elasticity Types
set elasttype /supply,demand/;

*Report Labels
set reportoutput        /supply0,pctdp,pctdq,pctds,pctdqi,pctdqx,
                        consumera,consumerd,consumerf,
                        producera,producerf,producerd,
                        cost,ish0,ish1,dshift,ishift,
                        supply,demand,ds,fs,dfix,ddadj,fdadj,id,vshf,
                        CO2eb,CO2ewr,empb,empwr,year/;

*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
*data qa/qc checks and processing
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%

*check #1:  Demand for commodity g = supply for commodity g

check1(g) =
100 * (sum(r,y0(r,g))-
sum(r,i0(r,g))-
sum(r,g0(r,g))-
sum((r,s),id0(r,g,s))-
sum((r,hh),cd0(r,hh,g))-
sum(r,x0(r,g,"ftrd"))+
sum(r,m0(r,g,"ftrd"))) / sum(r,y0(r,g));
```

```
check1(s) = round(check1(s),6);
display check1;


*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
*  MODEL INPUT DATA
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
set
        type                   input type /ds,fs,dd,fd/;

parameters

        ccxl(g,st)              compliance costs from xl spreadsheet (by
state)
        exl(g,type)             elasticities from xl spreadsheet
        empxl(g,*)              employment from xl spreadsheet
        id0US(g)                intermediate demand US
        io(g,s)                 input-output coefficient use of g by s
        io_rnw(s,g)             input-ouptut coefficient (renewable)
        ds0(g)                  domestic supply
        fs0(g)                  foreign supply (imports)
        dfix0(g)                fixed demand (investment govt tpt)
        dd0(g)                  fixed  adj  intermediate demand
        ddadj0(g)               domestic demand
        fdadj0(g)               foreign demand (exports)
        es(g)                   domestic supply elasticity
        efs(g)                  foreign supply elasticity (imports)
        ed(g)                   domestic demand elasticity
        efd(g)                  foreign demand elasticity (exports)
        emp(g)                  employees (1000)
        p0(g)                   normalized baseline price = 1
        dsK(g)                  domestic supply function constant
        fsK(g)                  foreign supply funciton constant
        ddK(g)                  domestic demand function constant
        fdK(g)                  foreign demand function constant
        eq_chk(g)               equilibrium check
;




*normalized price
p0(g) = 1;



*SAM data in (billion 2006$)
*---------------------------+

*USA baseline domestic supply
ds0(g) =
sum(r,y0(r,g));

*USA baseline foreign supply (imports)
fs0(g)=
```

```
sum(r,m0(r,g,"ftrd"));

*USA "fixed" domestic demand
dfix0(g)=
sum(r,i0(r,g))+
sum(r,g0(r,g));

*USA "adjustable" domestic demand (households)
ddadj0(g)=
sum((r,hh),cd0(r,hh,g));

*USA baseline foreign demand (exports)
fdadj0(g)=
sum(r,x0(r,g,"ftrd"));

fdadj0(g) = round(fdadj0(g),6);

*USA intermediate demand
id0US(g)= sum((r,s),id0(r,g,s));

dd0(g) = dfix0(g) + ddadj0(g) + id0US(g);

eq_chk(g) = ds0(g)+fs0(g)-dfix0(g)-ddadj0(g)-fdadj0(g)-id0US(g);
eq_chk(g) = round(eq_chk(g),6);

display eq_chk,p0, ds0, fs0, dfix0, ddadj0, fdadj0, id0US;




*----------Employment----------*
parameter
        raw_emp
        shr_emp
        aeo_emp
        empxl(g,*)              employment from xl spreadsheet
;

$libinclude xlimport empxl Data\emp_%size%.xls employees

raw_emp(g) = empxl(g,"emp");
shr_emp(g) = raw_emp(g) / sum(s, raw_emp(s));

*Update from AEO Table 20, Nonfarm + Manufacturing Employment (in thousands)
aeo_emp("2010") = (132.7 + 11.5)*1000;
aeo_emp("2015") = (143.9 + 12.0)*1000;
aeo_emp("2020") = (150.9 + 12.0)*1000;
aeo_emp("2025") = (157.6 + 11.6)*1000;
aeo_emp("2030") = (165.3 + 10.1)*1000;

emp(g) = aeo_emp("%year%") * shr_emp(g);

display emp;
*------------------------------*
```

```
*baseline data set
parameter bse(g,reportoutput);

bse(g,'ds')=ds0(g);
bse(g,'fs')=fs0(g);
bse(g,'dfix')=dfix0(g);
bse(g,'ddadj')=ddadj0(g);
bse(g,'fdadj')=fdadj0(g);
bse(g,'id')=id0US(g);
*bse(g,'vshf')=vshf(g);
bse(g,'empb')=emp(g);

$libinclude xlexport bse Results\mm_results_%size%_%year%.xls baselinex1


*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
*MODEL INPUTS
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%

*market supply and demand elasticities
$libinclude xlimport exl Data\elast_%size%.xls elast

*$ontext
*market parameters
es(g)=exl(g,"ds");
efs(g)=exl(g,"fs");
ed(g)=exl(g,"dd");
efd(g)=exl(g,"fd");
*$offtext


*IPM module ELEC adjustments:  ipmon == 1 yea*
*set elasticity so we approximate a horizontal supply segment
es("ele")$%ipmon%=50;
efs("ele")$%ipmon%=0;

*this is used to qa/qc tax incidence logic and CS/PS calcs
*only used to check model results
$ontext
es(g)=1;
efs(g)=1;
ed(g)=-1;
efd(g)=-1;
$offtext

*--------------------------------------------------
*FUNCTIONAL FORMS FOR SUPPLY AND DEMAND
*compute supply and demand function constants
*functional form assumes constant elasticity
dsK(g)$ds0(g)=ds0(g)/(p0(g)**es(g));
fsK(g)$fs0(g)=fs0(g)/(p0(g)**efs(g));

ddK(g)$ddadj0(g)=ddadj0(g)/(p0(g)**es(g));
fdK(g)$fdadj0(g)=fdadj0(g)/(p0(g)**efd(g));
```

```
*-------------------------------------------------

*compute input-output coefficients
*io(g,s)=
*sum(r,id0(r,g,s))/ds0(s);

io(g,s)=
*(sum(r,id0(r,g,s))+sum(r,id0_rnw(r,g)))/ds0(s);
sum(r,id0(r,g,s))/ds0(s);


*---------------------------------------------------------------------+
scalar inflationadjustment inflation adjustment $2007 /0.972307/;
*scalar inflationadjustment inflation adjustment $2006 /1/;
*note I used the CPI to adjust to $2006;

*regulatory program compliance costs (2006$)
$libinclude xlimport ccxl  Costs\cc_inputs_%size%_%year%.xls cc
display ccxl;


*ipm cost analysis (million $2006)
scalar ipmtotalcosts IPM total annual costs /9368/;
ipmtotalcosts = ipmtotalcosts*inflationadjustment;

*add residential or commercial costs ($2006) if applicable
scalar comin total annual costs commercial;
$libinclude xlimport comin  Costs\cc_inputs_%size%_%year%.xls com
display comin;

*distribute commercial costs across service sectors only
parameter comcc(g) total annual cost commercial by service sector;
scalar    checkcom checks com distribution;

comcc(g)$srv(g) =comin*inflationadjustment * ds0(g)/sum(s,ds0(s)$srv(s));
checkcom = sum(g,comcc(g));

scalar rescc total annual costs residential;
$libinclude xlimport rescc  Costs\cc_inputs_%size%_%year%.xls res

display comcc, rescc, checkcom;

parameter cc(g);
cc(g)=(((ccxl(g,"usa")+comcc(g))/1e+9)/ds0(g))*inflationadjustment;

*IPM alternative to reading in supply shifts from xl
*reset supply shifts to zero (blanks out XL inputs)
cc(g)$%ipmon%=0;


*IPM source:  Table 8-15 RIA Continental U.S. Average Retail Price
cc("ele")$%ipmon%=0.031;


display cc;

*---------------------------------------------------------------------*
```

```
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*  MODEL
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
positive variables
        p(g)            market clearing price
        ds1(g)          market clearing domestic supply quantities
        fs1(g)          market clearing imports
        dd1(g)          market clearing domestic demand quantities
        fd1(g)          market clearing exports;


equations
        dsupply(g)      domestic supply
        fsupply(g)      foreign supply
        ddemand(g)      domestic demand
        fdemand(g)      export demand
        equi(g)         market equilibrium conditions;


*supply provided by U.S. firms
dsupply(g)..

       ds1(g)=e=dsK(g)*(p(g)-cc(g)-sum(s,io(s,g)*(p(s)-1))*%mmpe%)**es(g);
*       ds1(g)=e=dsK(g)*(p(g)-cc(g))**es(g);


*supply provided by imports
fsupply(g)..
        fs1(g)=e=fsK(g)*(p(g)-cc(g)*%fshift%)**efs(g);

*U.S. demand
ddemand(g)..

        dd1(g)=e=(dfix0(g)+
                sum((r,s),id0(r,g,s)*(ds1(s)/ds0(s)))+
                        ddK(g)*p(g)**ed(g))*%mmpe% +
                ((dfix0(g) + ddadj0(g)+ id0US(g))*(1+ed(g)*(p(g)-1)))*(1-
%mmpe%);

*Export demand
fdemand(g)..
        fd1(g)=e=fdK(g)*p(g)**(efd(g));

*market clearing condition
equi(g)..
        ds1(g)+fs1(g)=e=dd1(g)+fd1(g);

*lower bound on price
p.lo(g)=0.90;

Model mm/All/;
option cns=path
Option Iterlim=1000000;
Solve mm using cns;
```

```
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
*MODEL RESULTS and REPORT WRITING
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
parameters

        pctdP(g)                pct change in price
        pctdQ(g)                pct change in mkt quantity
        pctds(g)                pct change in domestic supply
        pctdqi(g)               pct change in imports
        pctdqx(g)               pct change in expors
        leak(g)                 leakage rate (percent)

        dCS(g)                  change in consumer surplus($million)
        dCSd(g)                 change in domestic consumer surplus
($million)
        dCSf(g)                 change in domestic consumer surplus
($million)

        dPS(g)                  change in producer surplus ($million)
        dPSd(g)                 change in producer surplus domestic
($million)
        dPSf(g)                 change in producer surplus foreign ($million)
        cc0US(g)                total regulatory program costs ($million)
        temp(g,s)               indirect supply shifts;

*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
*MARKET
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%

*% Change In Price
pctdP(g)=p.l(g)-1;

*% Change In Quantity
*total US
pctdQ(g)=(dd1.l(g)+fd1.l(g))/(ds0(g)+fs0(g))-1;
pctds(g)=ds1.l(g)/ds0(g)-1;
pctdqi(g)$fs0(g)=fs1.l(g)/fs0(g)-1;
pctdqx(g)$fdadj0(g)=fd1.l(g)/fdadj0(g)-1;
leak(g)=(dd1.l(g)+fd1.l(g))/ds1.l(g)-1;

parameter usleak;

usleak = 1-
sum(g,
(dd1.l(g)+fd1.l(g))
-(dfix0(g)+ddadj0(g)+fdadj0(g)+id0US(g)))/
sum(g,ds1.l(g)-ds0(g));

display usleak;
```

```
display dd1.l, fd1.l, dd0, fdadj0;

*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
*WELFARE CALCULATIONS
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%

*Consumer Surplus Change ($million $2006)

*by region

dCSd(g) =
*domestic consumers
((-(ddK(g)*p.l(g)**ed(g)*pctdP(g)) +

0.5*(ddK(g)*p.l(g)**ed(g)-ddadj0(g))*pctdP(g)-

dfix0(g)*pctdP(g))*1e+3)*%mmpe% +

*qa/qc:  single market pe equilbrium
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
((-(dd1.l(g)*pctdP(g)) +
0.5*(dd1.l(g)-dd0(g))*pctdP(g))*1e+3)*(1-%mmpe%);
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


*foreign consumers

dCSf(g) =

(-(fd1.l(g)*pctdP(g)) +

0.5*(fd1.l(g)-fdadj0(g))*pctdP(g))*1e+3;

dCS(g) = dCSd(g) + dCSf(g);



*Producer Surplus Change ($million 2006)

dPSd(g) =

(ds1.l(g)*(pctdP(g)-cc(g)-sum(s,io(s,g)*(p.l(s)-1))*%mmpe%) -

0.5*(ds1.l(g)-ds0(g))*(pctdP(g)-cc(g)-sum(s,io(s,g)*(p.l(s)-
1))*%mmpe%))*1e+3;

*modify elec sector in IPM links
dPSd("ele")$%ipmon% = (ds1.l("ele")*(pctdP("ele")-sum(s,io(s,"ele")*(p.l(s)-
1))*%mmpe%) -

0.5*(ds1.l("ele")-ds0("ele"))*(pctdP("ele")-sum(s,io(s,"ele")*(p.l(s)-
1))*%mmpe%))*1e+3 -

(ipmtotalcosts)-ccxl("ELE","USA")/1e+6;
```

```
*qa/qc:  single market pe equilbrium
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*(ds1.l(g)*(pctdP(g)-cc(g)) -
*0.5*(ds1.l(g)-ds0(g))*(pctdP(g)-cc(g)))*1e+3;
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

dPSf(g) =

(fs1.l(g)*(pctdP(g)-cc(g)*%fshift%)-
0.5*(fs1.l(g)-fs0(g))*(pctdP(g)-cc(g)*%fshift%))*1e+3;


dPS(g) = dPSd(g)+ dPSf(g);


*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%
* REPORTS
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%

*Market Results
parameter mkttable(g,reportoutput);

mkttable(g,'supply0')=ds0(g)+fs0(g)*1/inflationadjustment;
mkttable(g,'pctdp')=pctdP(g);
mkttable(g,'pctdq')=pctdQ(g);
mkttable(g,'pctds')=pctds(g);
mkttable(g,'pctdqi')=pctdqi(g);
mkttable(g,'pctdqx')=pctdqx(g);
mkttable(g,'consumera')=dCS(g)*1/inflationadjustment;
mkttable(g,'consumerd')=dCSd(g)*1/inflationadjustment;
mkttable(g,'consumerf')=dCSf(g)*1/inflationadjustment;
mkttable(g,'producera')=dPS(g)*1/inflationadjustment;
mkttable(g,'producerd')=dPSd(g)*1/inflationadjustment;
mkttable(g,'producerf')=dPSf(g)*1/inflationadjustment;
mkttable(g,'cost')=(ds0(g)+fs0(g)*%fshift%)*cc(g)*1e+3*1/inflationadjustment;
mkttable("ele",'cost')$%ipmon%=ipmtotalcosts*1/inflationadjustment+ccxl("ELE"
,"USA")/1e+6;
mkttable(g,'ish0')=fs0(g)/(ds0(g)+fs0(g));
mkttable(g,'ish1')=(fs0(g)+fs1.l(g))/(ds0(g)+ds1.l(g)+fs0(g)+fs1.l(g));
mkttable(g,'dshift')=cc(g);
mkttable(g,'ishift')=sum(s,io(s,g)*(p.l(s)-1));
mkttable(g,'empwr')=emp(g)*(1+pctds(g));
;

$libinclude xlexport mkttable Results\mm_results_%size%_%year%.xls resultsx1

display mkttable;

parameter check;

check = sum(g,mkttable(g,"cost"));

display check;
```

```
* checks for new cement industry split:
$ontext
parameter
        cem_out
;
cem_out(cems,"pctdp") = pctdp(cems);
cem_out(cems,"pctdq") = pctdq(cems);
cem_out(cems,"pctds") = pctds(cems);
cem_out(cems,"pctdqi") = pctdqi(cems);
cem_out(cems,"pctdqx") = pctdqx(cems);

display cem_out;
$offtext
```

Email message of December 22, 2011 transmitting additional material for the peer review (email addresses removed)

Good morning everyone,

The EPA has received the temporary license for the GAMS software. It is in the attached text file dc9450.txt. If you wish to use it to run the model:

1. Download the most current version of the software at the GAMS website - http://gams.com/download/

2. Copy the 5 lines of text from the attached text file.

3. When you open the GAMS software, it will ask for your license. Paste in the 5 lines of text from the text file.

If you have difficulty in running the Multimarket Model, Alex MacPherson of EPA will be in the office on Thursday and Friday of next week. He has run the model and will be glad to help you get it going. His contact information is as follows:
Alex MacPherson

919-541-9770

Also attached to this message is a slightly revised set of questions for the review charge. The only revision is the addition of three sub-bullets under the first question to add greater specificity.

Please let me know if you need anything.

Stephen Edgerton
EC/R Incorporated
501 Eastowne Drive, Suite 250
Chapel Hill, NC 27514
(919) 433-8326

Email Attachments:

dc9450.txt *(not included in this document)*
Peer Review Charge for MMM 12_21_2011.pdf

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Charge for Review of the Multimarket Model

December 21, 2011

Background

In conducting economic analyses related to regulatory actions, the U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) employs several modeling approaches over varying time horizons. The strictly partial equilibrium model tracks the effect of a regulatory action in a single market while ignoring all other possible market interactions. The strictly general equilibrium model tracks the effects of a regulatory action in all sectors of the economy with all inter-sectoral linkages included. In between these two modeling approaches are models that capture a finite set of predefined important market linkages, while ignoring effects in all other markets. Such a model that is between these two modeling approaches is the Multimarket Model, which is the subject of this peer review. (See Figure 1. *Modeling Choices for Economic Impact Analyses* in the OAQPS Multimarket Model Documentation for details on additional models used.)

The Multimarket Model is a relatively new addition to OAQPS's economic model tool kit and is a national multimarket, partial equilibrium model with linkages between energy-intensive manufacturing industries and energy producing sectors. The Model is designed to analyze large-scale policies that may affect a large number of industries or a substantial part of the whole economy to better understand economic incidence questions about how costs may be passed across sectors within the economy. In addition, the Multimarket Model is designed to be used as a transparent tool that can respond quickly to requests about how producers and consumers in 100 U.S. industry sectors might respond to new environmental policy.

Actions Requested

The peer review charge is to review the Multimarket Model and the Model's documentation and provide feedback and suggestions on the Model's structure and application. Specifically, the peer review should focus on considering and answering the questions provided below while reviewing the Model's structure.

Specific Questions for the Review

- Does the Multimarket Model fulfill the theoretical and practical expectations of a partial-equilibrium model?
    - The documentation argues that the boiler MACT, affecting a number of industries, requires a model like the Multimarket Model to reflect the economic impacts. An alternative to the Multimarket Model is to use individual single sector partial equilibrium models or alternatively economy-wide general equilibrium models (comparative static CGE or dynamic CGE model). What is an appropriate way to

capture the economic impacts of the boiler rule (and other rules affecting more than one sector)?

- The Multimarket Model traded off the complexity of a CGE model for more sectoral detail. Some of the tradeoffs include using readily available long run elasticities; an inability to model the increase in spending for pollution abatement equipment and services; fixed proportions production functions; and omission of a labor market and other pre-existing distortions (e.g., taxes). Are these tradeoffs acceptable? Is the Multimarket Model an acceptable modeling approach for regulatory analysis of regulations that affect a sector like electricity (which passes on their costs to many other industrial sectors) or for regulations that affect multiple industrial sectors?
- The Multimarket Model uses fixed proportions production functions (suggesting a short run perspective, but the demand elasticities are long run elasticities). We also model the regulatory costs as all variable costs (the supply curve shifts up by the total "per unit" costs of the regulation). These assumptions were necessary to build this model. How should the results be interpreted?

- Historically, EPA has frequently used single or sometimes two-market partial-equilibrium models to estimate economic impacts of a new regulation. EPA plans to use the Multimarket Model to estimate market impacts from a regulation that may affect many industry sectors. Are there other regulatory scenarios where the Multimarket Model might be more appropriate than a single or two-market partial-equilibrium model? Please comment on the advantages and disadvantages of the Multimarket Model versus single or two-market models.

- Distributional impacts are an important component of economic impact analysis in a regulatory setting. Is the number of sectors in the Multimarket Model sufficient to provide an understanding of the distribution of market impacts of any given regulation? In addition to commenting on the number of sectors, please comment on if there are other concerns with how the sectors are aggregated.

- How can the surplus changes coming from this model be interpreted?

- Is the treatment of imports and exports appropriately structured and parameterized for this type of economic model? Are there any significant shortcomings to this treatment that need to be addressed within EPA's plans for use of the Multimarket Model?

- Are the demand and supply elasticities used in the Multimarket Model appropriate for this model given its intended application? Please provide any suggestions to improve the elasticity estimates.

- EPA is interested in exploring different ways to use the model, either through enhancements in the model or innovations in how we represent the direct effects of a regulation in the model (i.e., how it is shocked). Please comment on the following ways to potentially enhance the model.
  - Alternatives to shock the model – beyond shocking the model through a cost per unit of output approach (i.e., "tax"), what other alternatives could you recommend

to represent the impact of a regulation, given the current model structure? How can a regulatory shock that involves fuel switching be incorporated into the model?
    - Explicitly model the pollution control sector – what are your thoughts on how ancillary demand-side market changes can be reflected in the model (e.g., increased demand for pollution control equipment due to implementation of add-on controls)?

- Are there any components of the model documentation that you would recommend for further elaboration or clarification?

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Attachment 4

Reviewers' Comments on the Multimarket Model

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Comments of

Dr. Peter Berck
University of California, Berkeley

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Review of the OAQPS Multimarket Model

The OAQPS Multimarket Model, hereafter MM, is a large scale partial equilibrium model. The usefulness of this model relative to EMPAX-CGE a general equilibrium model also used by EPA, is to be able to break down the industrial classification to quite fine NAICS codes. The MM model has 100 sectors to the EMPAX's 35. The addition of extra sectors responds to a constant request from the policy side for narrowly defined sector specific information.

There are costs to the expansion to 100 sectors. The most obvious cost is the quality and quantity of the underlying data. As the size of an industry decreases (e.g. one uses 6 digit NAICS) the sample size that the IO table is based on also decreases. The documentation should be clearer about how the basic output numbers were assembled and whether any imputation was done by IMPLAN, relative to this being a straight read the original BEA data. If it is the latter, why use IMPLAN as an intermediary? If the former, please explain what was done by IMPLAN and why this should be viewed as a reliable estimate.

The use of the EIA data to supplement the input output data is necessary and reasonably well described in the EMPAX documentation. The whole procedure would be more transparent and could be presented in a way that another researcher could check if intermediate step of using IMPLAN were left out and the models were constructed directly from government data. Such a course of action would quickly reveal to the researcher whether the imputations being made were reasonable or beyond what the data can support. For instance, when using state data, imputations to 509 sectors would involve a massive leap of faith because employment at this level of disaggregation is not public information. Doing this part of the job in house would seem to be the appropriate step for a government agency interested in transparency that is making imputations about its own data.

Another cost of expansion to 100 sectors is that the demand system becomes very hard to work with. A full rank two system would require about 5,000 estimated parameters, which cannot be done with existing data, e.g. the consumer expenditure survey. So the demand system is going to be more and more assumed and less and less estimated as the number of sectors goes up. The same will happen for supply. Where it is feasible to estimate production functions for value added in the 20's of sectors (e.g. Jorgenson and Fraumeni), it seems hopeless with 100 sectors.

Final Demand Systems.

The MM specifies a demand system in the 100 goods considered. The system is a group of independent constant elasticity demand curves. It is written in terms of the goods in the model and lumps both the export demand and the consumer demand into one equation. In order to have a meaningful welfare analysis, these sources of final demand need to be taken back apart.

The EMPAX-CGE which this MM model draws upon has such a final demand specification, so this is not an impossible task.

Assuming that the government demands are fixed and that as in EMPAX the export demand elasticities are approximately unitary elasticity, we could in principle derive the MM model's implicit demand curves.

In order to do welfare analysis with the MM model, these demand curves must meet certain well known conditions. Although it is not clearly stated, I believe that this demand system is incomplete, that is there are goods and services consumed by households that are outside the scope of the model. LaFrance and Hanemann[1] give two sets of conditions for an incomplete demand system to yield a measure of welfare. The MM model's demand system may meet those conditions in that prices are divided by a price index, assuring homogeneity, and the demand curves slope down with no cross elasticities. However, there is no guarantee that the cost of the goods modeled does not exceed income. Consider an experiment that raised the prices of all goods inelastically demanded. Then the total expenditure would rise. It is an empirical question as to whether it would go up sufficiently to exhaust all the income of the households and then some.

Looking at the adding up and cross elasticity issues from a less theoretical standpoint, the model assumes that there is no cross elasticity of demand. This seems too restrictive largely because the MM model has such a large number of goods (and I assume a large percentage of expenditure accounted for.) It can't be that raising the price of energy intensive goods does nothing to the demand for other goods.

Using a CGE model as the source of the demand system, so as to make them general equilibrium demands, while clever, does really beg the issue. If one believed the demand system from the CGE model and wanted a partial equilibrium answer, then one should just use the demand system and impose unchanging income. If one wants a general equilibrium answer, then use EMPAX. There is also a logical inconsistency in the procedure. When done for one demand equation, it assumes that all the others have adjusted optimally. When done for two or more, call the two sectors A and B. The demand general equilibrium demand curve for A accounts for the optimal changes in B, yet B is present in the model. It seems like the CGE should be told not to let B adjust in order to get the general equilibrium demand curve for A without B adjusting.

[1] The Dual Structure of Incomplete Demand Systems Author(s): Jeffrey T. LaFrance and W. Michael Hanemann Source: American Journal of Agricultural Economics, Vol. 71, No. 2 (May, 1989), pp. 262-274

Supply

The specification of supply seems quite simplified relative to most CGE models. The supply specification shares the idea of having intermediate goods be demanded according to a Leontief system with all other large scale models I know. Usually (e.g. see EMPAX) value added is then modeled as a CES or other function of factors, at least labor and capital, and in this sort of application energy as well. The choice to suppress capital and labor and make output a function of value added price is not a bad solution in a multi-market model that abstracts from the labor market. Neither is the choice to make energy an intermediate good rather than a factor of production, provided that scenarios take advantage of the ability to change the energy intensity of goods. As written and used, however, no such changes seem to be made and the lack of any substitutability among the energy sectors seems to be a major limitation for the proposed use of the model.

Imposing the Policy

The documentation says:

> However, the existing Multimarket Model design does not include capital and labor where these expenditures can take place. Instead, the pollution control expenditures required for compliance with the regulation (i.e., those estimated outside of the Multimarket Model), are treated as an additional unit cost (c); the associated compliance expenditures ($c \times Q$) are withdrawn from the economy and are not returned to any of household, industry, or government.

While I do see why imposing the labor and capital costs of compliance as a unit cost is reasonable within the framework of a model that tracks neither labor nor capital, it is not a reasonable way to treat the purchase of intermediate goods. Those can easily be treated within the model framework as a modification of the IO matrix that underlies intermediate demand. One could probably capture all of the costs as intermediates with a judicious use of sectors like construction, which are themselves high labor intensity sectors. Using the intermediates instead of the unit cost approach would capture more of the economic activity within the model, which is desirable.

For instance, consider a policy that required more efficient boilers in powerplants and that the policy exactly paid for itself (to make the example easy). It could be modeled as requiring additional construction, steel, etc and requiring less coal. The current modeling would show this policy as doing nothing. Using intermediate goods would show the decrease in coal use and the increase in other intermediate usages.

Scope versus Specificity

I had expected to see the MM model as one with many fewer sectors and much more sector specific information. In fact, this model has much less energy specific modeling than its parent EMPAX model does. I find the model inferior to EMPAX in every way except its sectoralization. The assumptions underlying supply and demand are more ad-hoc than the CGE model.

Specific Questions for the Review

☐ Does the Multimarket Model fulfill the theoretical and practical expectations of a partial equilibrium model?

No, the MM model potentially loses the adding up property of demand (or requirement that income is greater than expenditure.) In all dimensions it is less well considered and more ad hoc than the EMPAX model from which it is derived. Given the usage, e.g. a boiler regulation, the energy sector needs close and realistic rather than broad brush modeling.

☐ Historically, EPA has frequently used single or sometimes two-market partial-equilibrium models to estimate economic impacts of a new regulation. EPA plans to use the Multimarket Model to estimate market impacts from a regulation that may affect many industry sectors. Are there other regulatory scenarios where the Multimarket Model might be more appropriate than a single or two-market partial-equilibrium model? Please comment on the advantages and disadvantages of the Multimarket Model versus single or two-market models.

The potential advantage of an MM model is lavish attention to the sectors of interest, which might be just the energy sector and the heavily energy using goods sectors. CGE's are regularly used to evaluate policies that affect many sectors, so I do not see that as a justification. If EMPAX seems sectored wrong for EPA's purposes, EPA should have it re-sectored and the regions collapsed into one. If general equilibrium effects were not wanted, CGE's admit to having many variables fixed. However the construction of the MM demand system was done precisely to get the general equilibrium effects back in the model. I do not see how EPA has made the case for the MM model.

☐ **Distributional impacts are an important component of economic impact analysis in a regulatory setting. Is the number of sectors in the Multimarket Model sufficient to provide an understanding of the distribution of market impacts of any given regulation? In addition to commenting on the number of sectors, please comment on if there are other concerns with how the sectors are aggregated.**

The sector aggregation is appropriate for this type of analysis. Leaving out cross elasticity of demand vitiates any attempt to make judgments as to sectoral impact.

☐ **How can the surplus changes coming from this model be interpreted?**

I outlined about how one would need to pull apart the pieces of final demand in order to make even a rough estimate of consumer welfare. The model should have a demand system that is known to be internally consistent and hence a sub-expenditure system. Then and only then can one make estimates.

☐ **Is the treatment of imports and exports appropriately structured and parameterized for this type of economic model? Are there any significant shortcomings to this treatment that need to be addressed within EPA's plans for use of the Multimarket Model?**

The treatment of imports is standard. Exports should be disaggregated from other final demand.

☐ **Are the demand and supply elasticities used in the Multimarket Model appropriate for this model given its intended application? Please provide any suggestions to improve the elasticity estimates.**

The use of the export elasticities as supply elasticities is not justified. They are not the same. A fundamental drawback of all large number of sector models is that the elasticities lose considerable precision as the number of sectors goes up.

o **Alternatives to shock the model – beyond shocking the model through a cost per unit of output approach (i.e., "tax"), what other alternatives could you recommend to represent the impact of a regulation, given the current model structure? How can a regulatory shock that involves fuel switching be incorporated into the model?**

See the comments above about using the I0 matrix for shocks.

o **Explicitly model the pollution control sector – what are your thoughts on how ancillary demand-side market changes can be reflected in the model (e.g., increased demand for pollution control equipment due to implementation of add-on controls)?**

I know this to be done by California ARB for every regulation they evaluate.

☐ **Are there any components of the model documentation that you would recommend for further elaboration or clarification?**

The model shares documentation with EMPAX, between the two and the code it is clear enough what has been done. As mentioned above, the SAM could be constructed in house using just government data with some increase in clarity and perhaps accuracy.

Comments of

Dr. David Bullock
University of Illinois

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Review of OAQPS Multimarket Model

David Bullock
University of Illinois Dept. of Agricultural and Consumer Economics

Answering your specific questions

Does the Multimarket Model fulfill the theoretical and practical expectations of a partial equilibrium model?

I think that the theoretical bases of this model have not been well thought-through, or at least are not thoroughly discussed in the documentation provided. In particular, you could do a better job of explaining why you make some the restrictive assumptions you make, and discussing the limitations of the model brought about the restrictive assumptions. I'd like to see further justification for

- The choice of constant-elasticity functional forms
- The way in which input prices come into the supply and input demand functions (Why do you use the $(P_g - P_g^0)$ formulation? Why not just make supply a function of prices, without baseline prices in the formulation?
- The assumption that inputs are perfect complements
- The assumption that input demands are constant fractions of supply
- The whole idea about there being "fixed inputs" that make the supply functions slope upward

As far as meeting practical expectations, I think that you are biting off a lot with this model, and you don't have very good econometric estimates of the parameters you need to know for your model to be reasonable tool for examining economic reality.

Historically, EPA has frequently used single or sometimes two-market partial-equilibrium models to estimate economic impacts of a new regulation. EPA plans to use the Multimarket Model to estimate market impacts from a regulation that may affect many industry sectors. Are there regulatory scenarios where the Multimarket Model might be more appropriate than a single or two-market partial-equilibrium model? Please comment on the advantages and disadvantages of the Multimarket Model versus single of two-market models.

In general, the bigger the model, the more difficult it may be to come up with sensible, intuitive interpretations of the model's results. At their worst, big CGE models are forced to use very stylized ways to model policy, and sometimes "strange" results come about because of the many cross-market effects, and it isn't possible to figure out *why* these results have come about. So, CGE models can be "black boxes." Your model, with 100 sectors, is not as complicated as large CGE models. And I don't think in general that you'll get a lot of results that you can't interpret. Basically input use is always going to be a constant fraction of supply. It should be relatively uncomplicated to figure out

which goods' production quantities have changed, and how that has changed demands for inputs, etc. So, you aren't going to have to keep track of the effects of cross-elasticities and feedback, and this should make interpretation much simpler.

But I think that the Multimarket Model is still weak in how it actually models regulation. It looks to me that, basically, you are getting some technical experts to give you an estimate of the total cost an industry to abide by a regulation imposed upon it. Then you take that number, and basically divide it by the quantity of production to get the cost of the regulation per-unit of production, and assume that this is also the vertical shift in the marginal cost schedule. The difficulty I see here is that you are assuming that the drop in average costs equal to drop in marginal costs. But, often, environmental regulations require a significant fixed cost to be paid. (For example, to purchase scrubbers for coal-burning electricity generators.) The cost of that scrubber will be spread out over many years—but your model is by design a short-run model. And, once the scrubbers are purchased, the marginal cost of using them might be fairly small. So you've got a challenge to account for investment in long-lived physical capital in a short-run model.

The advantage to using a model with just a few markets is that you can concentrate on getting the details of the model "right." You can think long and hard about how the regulation will affect the supply curve, and then use more complicated methods to try to model the regulation accurately. You can think long and hard about how prices in one market in your model will affect the few related markets in your model. In other words, with a smaller model, you can worry much more about the details of the modeling and the details of the results.

A difficulty in any model, whether a model of one market or a model of many related markets, is to properly interpret what the supply curves are, and what the geometric areas beneath them mean. If, when estimating a supply elasticity, prices of related markets are ignored, then one is estimating some version of an "equilibrium supply" elasticity. But the area under an equilibrium supply curve can represent the costs of not only producers in the industry, but also producers in industries that provide inputs to the sector. Often, with such equilibrium curves, geometric areas under and behind supply curves can reflect costs in markets that are horizontally-linked to the market being directly analyzed. But you need many hundreds of elasticity estimates to run your model. These estimates were gotten with different data sets, and estimated in different ways. Some may be estimates of "ordinary" supply elasticities, and some of "equilibrium" supply elasticities. Some may be "long-run" estimates, others short-run estimates. You will be applying common interpretations to all of these estimates, but theoretically, they do not represent the same things. In this way, it will be difficult to interpret just whose welfare is reflected in your ΔPS measure. When you use an agricultural supply elasticity, for example, is the ΔPS reflective of the changes in "farmer" well-being, or rather of the well-being of farmland owners? Your model tries to deal with this by including input markets. Nonetheless, you will need to be careful in your interpretations. In any case, when you are using a small model, with only a few markets, then inevitably your "supply curves" are going to be some type of "equilibrium" supply curve, and you need to take care in your interpretation of just who the "producers" are whose welfare is changing.

Distributional impacts are an important component of economic impact analysis in a regulatory setting. Is the number of sectors in the Multimarket Model sufficient to provide an understanding of the distribution of market impacts of any given regulation? In addition to commenting on the number of sectors, please comment on if there are other concerns with how the sectors are aggregated.

You are looking or a "happy medium" here, trying to limit the model's size in order to strengthen your ability to interpret the model's results. Ideally, if you wanted to examine the effects a particular regulation, you would build a model that focuses on the markets that will be most strongly impacted by the regulation. You would very carefully model those markets, and put less effort into modeling other markets that are related, but not strongly related, to the regulated market. But I doubt that you have the resources to look at individual regulations so carefully. You need a model that can estimate the effects of regulations in many parts of the economy.

Do I think that 100 is the correct number of markets to keep in your model? I really can't say, but my gut feeling is that 100 is too many. To the extent that your budget allows, I think you could learn more by examining the most important markets closely, than by using such a one-size-fits-all approach. Of course, the way to figure this out is to use your 100-market model, and compare its results to those of a few-market model. Do the results seem to be similar? Is the 100-market model telling your things that you could never get from a simpler model? If it is, then a 100-market model is a good thing. I think that you'll have to compare different models by applying different models. I don't think there's any other good way to get a decent intuitive feel for which models are best for which situations.

How can the surplus changes coming from this model be interpreted?

That's a great question. The answers to this questions can be found in Just, Hueth, and Schmitz, (2004, Chapter 9 and Appendix to chapter 9). I'm not going go into a detailed explanation in this short report, but I will high-light some issues in the JHS analysis that calls some of your welfare measures into account. Anyway, according to JHS, the answer to your question may depend on a number of things:

- It depends on which prices were ignored and which prices were accounted for in the original econometric study used to estimate the elasticities. This has to do with the degree to which the supply and demand curves you are estimating are "ordinary" curves or "equilibrium" curves. If an own-price elasticity was estimated for an output, but the econometrician did not account for input prices in the estimation procedure, then the "ΔPS" area shows the change in quasi-rents not only for the producers in the immediate market, but also for producers further up the supply chain—those who supply inputs to the market in focus. Similarly, the "change in consumer surplus" areas might represent some of the change in welfare of consumers not only in the market in focus, but of consumers in markets

for substitutes or complements. This reveals one of the problems of your big model: you will need to think a great deal, and use formal theory, to interpret the welfare implications of your geometric area. How to do this is known, and is discussed in the Just, Hueth, and Schmitz (2004) text. But frankly, not too many people understand the theory. Also, it's too involved for me to cover in detail in this report.

- I've thought pretty hard about your actual measure of producer surplus, which. As I explained in my Minor Points section, is incorrectly written in your equation (10) as

$$\Delta PS_s = \left[\text{With Policy } Q_s \times \Delta p_s\right] - \left[\text{With Policy } Q_s \times \left(c_s - \alpha_{gs}\,\Delta p_g\right)\right] - \left[0.5 \times \Delta Q_s\right] \times \left(\Delta p_s - c_s - \alpha_{gs}\,\Delta p_g\right).$$

Actually, I think that you meant to write

$$\Delta PS_s = \left[\text{With Policy } Q_s \times \Delta p_s\right] - \left[\text{With Policy } Q_s \times \left(c_s \underbrace{+}_{\textbf{note sign change}} \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)\right] - \left[0.5 \times \Delta Q_s \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)\right].$$

Rearranging,

$$\Delta PS_s = -\left[\text{With Policy } Q_s \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)\right] - \left[0.5 \times \Delta Q_s \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)\right]$$

$$= \left(\text{With Policy } Q_s - 0.5\Delta Q_s\right) \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)$$

$$= \left(\text{With Policy } Q_s - 0.5\left[\text{With Policy } Q_s - \text{Without Policy } Q_s\right]\right) \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)$$

$$= 0.5\left(\text{With Policy } Q_s + \text{Without Policy } Q_s\right) \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs}\Delta p_g\right)$$

In case, it's not clear to me that your formula is the way to go. The reason is that when multiple prices change, then lots of curves shift lots of times, and keep track of which geometric areas should be counted and which shouldn't can get pretty confusing. The work of Just Hueth, and Schmitz (2004) show that The change in profits of producers of good 1 (for notational convenience, I'm using s = 1. The formula for other s values are similar) is,

$$\underbrace{\Pi_1\left(P_1^1,P_2^1,...,P_n^1,c_1^1\right)-\Pi_1\left(P_1^0,P_2^0,...,P_n^0,c_1^0\right)}_{\Delta\Pi_1}=$$

$$\int_L\left(\sum_{i=1}^{n}\frac{\partial\Pi_1\left(P_1,P_2,...,P_n\right)}{\partial P_i}dP_1+\frac{\partial\Pi_1\left(P_1,P_2,...,P_n\right)}{\partial c_1}dc_1\right),$$

where L is an arbitrary path of integration between endpoints $\left(P_1^0,P_2^0,...,P_n^0,c_1^0\right)$ and $\left(P_1^1,P_2^1,...,P_n^1,c_1^1\right)$. Technically, it looks to me like the path you are trying to use in your measure is one that we might call a "shutdown price path." This is a path that moves the output price from its initial equilibrium value to zero, then changes all the other input prices, then changes the output price from zero to the subsequent equilibrium level.

$$\Delta\Pi_1=\int_0^{P_1^1}S_1\left(P_1,P_2^1,...,P_n^1,c_1^1\right)dP_1-\int_0^{P_1^0}S_1\left(P_1,P_2^0,...,P_n^0,c_1^0\right)dP_1$$

$$=\int_0^{P_1^1}\max\left\{0,b_s\left(\left(1-\alpha_{11}\right)P_1-c_1^1-\sum_{\substack{g=1\\g\neq1}}^{100}\alpha_{s,g}\left(P_g^1-P_g^0\right)\right)^{\varepsilon_s}\right\}dP_1-\int_0^{P_1^1}\max\left\{0,b_s\left(\left(1-\alpha_{11}\right)P_1-c_1^0\right)^{\varepsilon_s}\right\}dP_1$$

$$=\frac{b_s}{\left(\varepsilon_s+1\right)\left(1-\alpha_{11}\right)}\left(\left(1-\alpha_{11}\right)P_1-c_1^1-\sum_{\substack{g=1\\g\neq1}}^{100}\alpha_{s,g}\left(P_g^1-P_g^0\right)\right)^{\varepsilon_s+1}-\frac{b_s}{\left(\varepsilon_s+1\right)\left(1-\alpha_{11}\right)}\left(\left(1-\alpha_{11}\right)P_1-c_1^0\right)^{\varepsilon_s+1}$$

$$=\frac{\left(b_1\right)^{-\frac{1}{\varepsilon_s}}}{\left(\varepsilon_s+1\right)\left(1-\alpha_{11}\right)}\left(Q_1^1\right)^{\frac{1}{\varepsilon_s}+1}-\frac{\left(b_1\right)^{-\frac{1}{\varepsilon_s}}}{\left(\varepsilon_s+1\right)\left(1-\alpha_{11}\right)}\left(Q_1^0\right)^{\frac{1}{\varepsilon_s}+1}$$

$$\Delta\Pi_1=\frac{\left(b_1\right)^{-\frac{1}{\varepsilon_s}}}{\left(\varepsilon_s+1\right)\left(1-\alpha_{11}\right)}\left(\left(Q_1^1\right)^{\frac{1}{\varepsilon_s}+1}-\left(Q_1^0\right)^{\frac{1}{\varepsilon_s}+1}\right).$$

In contrast, your "change in producer surplus" measure is,

$$\Delta PS_1=-0.5\left(Q_1^1+Q_1^0\right)\times\left(\Delta p_1-c_1-\sum_{g=1}^{n}\alpha_{g1}\Delta p_g\right)$$

These formulas look pretty different to me. It would be interesting to use some numerical simulations to see if the different formulas give results that are very different. In any case, my formula is exact; there is no linear approximation.

Now, a more statistically reliable way to look at producer welfare change is to use a sequential integration method, which is also described in Just, Hueth, and Schmitz (2004,

chapters 8 and 9). This method has a significant statistical advantages over the shutdown price method.

$$\Delta\Pi_1 = \sum_{i=1}^{n} \int_{P_i^0}^{P_i^1} \frac{\partial \Pi_1}{\partial P_i}\left(P_1^1,...,P_{i-1}^1,P_i...,P_i^0,...,P_n^0,c_1^0\right)dP_i + \int_0^{P_1^1} \frac{\partial \Pi_1}{\partial c_1}\left(P_1^1,...,P_{i-1}^1,P_i...,P_i^0,...,P_n^0,c_1^0\right)dP_i$$

$$= \int_{P_i^0}^{P_i^1} S_1\left(P_1,P_2^0,...,P_n^0,c_1^0\right)dP_1 -$$

$$\sum_{i=2}^{n} \int_{P_i^0}^{P_i^1} X_{1i}^d\left(P_1^1,...,P_{i-1}^1,P_i...,P_i^0,...,P_n^0,c_1^0\right)dP_i + \int_0^{P_1^1} \frac{\partial \Pi_1}{\partial c_1}\left(P_1^1,...,P_{i-1}^1,P_i...,P_i^0,...,P_n^0,c_1^0\right)dP_i$$

$$= \int_{P_i^0}^{P_i^1} b_1\left(\left(1-\alpha_{11}\right)P_1 - c_1^0\right)^{\varepsilon_s} dP_1 - \int_{P_i^0}^{P_i^1} \alpha_{12} b_1\left(\left(1-\alpha_{11}\right)P_1^1 - c_1^0\right)^{\varepsilon_s} dP_1$$

I won't finish the formula here. But it's very figure-outable.

Is the treatment of imports and exports appropriately structured and parameterized for this type of economic model? Are there an significant shortcomings to this treatment that need to be addressed within the EPA's plans for use of the Multimarket model?

Your functional form for rest-of-world excess supply is constant-elasticity, and whether the excess supply is positive or negative depends on the size of the coefficient *r*. But since *r* cannot change sign, it seems to me that if the rest of the world is an importer in the baseline equilibrium, it has to be an importer in all equilibria. Wouldn't it be better to specify rest-of-world supply and demand separately, to avoid this problem. (Or else assume a linear functional form for rest-of-world excess supply. A linear functional form will allow excess supply to be negative.) It seems to me that policy makers would be very interested to know whether imposition of an environmental regulation would cause the U.S. to stop exporting a good and start importing it.

Are the demand and supply elasticities used in the Multimarket Model appropriate for this model given its intended application? Please provide any suggestions to improve the elasticity estimates.

You are facing the same problem that any model of this type faces: it's very hard to get a good, consistent estimations of multiple elasticities. To the extent that they were estimated econometrically, my guess is that many different methods and types of data were used in the estimations. As is usually the case with these types of models, it's not clear to me whether they are "ordinary" or "equilibrium" elasticities, or whether the are short-run or long-run elasticities. How we should interpret your welfare measures

depends very much on these factors. I always wish that there were some kind of reference where the authors would argue in detail what reasonable estimates of elasticities would be, and *why*: why should we expect the elasticity of supply of a particular industry be twice that of another industry? If good intuitive arguments were used to justify the elasticity values used, then it would be easier for all to judge how reasonable they think the model's results are. But as for just pulling elasticities from "the literature" without a good deal of intuitive reflection—I can't put much faith in that process.

EPA is interested in exploring different ways to use the model, either through enhancements in the model or innovations in how we represent the direct effects of a regulation in the model (i.e., how it is shocked). Please comment on the following ways to potentially enhance the model.

- *Alternatives to shock the model—beyond shocking the model through a cost per unit of output approach (i.e., "tax"), what other alternatives could you recommend to reperesnet the impact of a regulation, given the current model structure? How can a regulatory shock that involves fuel switching be incorporated into the model?*

I think that if you are going to study a particular regulation in a particular industry, then you need to *really* think about the process by which the regulation raises costs of production. Basically, your current methods are to interview experts, ask them how much the regulation will change costs of production as a whole, you divide that number by observed quantity, and assume that the marginal cost curve is shifted down by that amount. But it's so well known that technology change or regulation might shift the marginal cost schedule in a parallel manner, or with some kind of pivot, and that the size in the change in producer welfare highly depends on the assumed type of shift. What needs to be known is how the particular regulation affects the entire marginal cost curve in a particular industry. To get a handle on this sort of thing will take careful thought into how the regulation changes the industry's technology. So, I'm calling for careful thought about the effects of a regulation on real-world technology. One danger with having a model like yours is that it's just so easy to stick in some parameter values, and then start the computer program running. When this is done without thinking in detail about how the regulation affects the industry's cost structure, then the computer program is spitting out answers that don't mean a whole lot. So, study the institutional details, don't just turn the crank on the model.

- *Explicitly model the pollution control sector—what are your thoughts on how ancillary demand-side market changes can be relegated in the model (e.g.,, increased demand for pollution control equipment due to implementation of add-on controls)?*

As an example, let's say that a regulation requires the use of "scrubbers" in the production of electricity from coal. I think the first thing you do is to ask a lot of questions to engineers about how long it will to take to build a "scrubbers" factory, and whether demand of resources by scrubber producers will take up a very big market share

of aggregate demand for those resources. Basically, I'm suggesting that you think through the dynamics of the production process. I think this careful thought is the only way to go, because if a market for scrubbers doesn't exist before the regulation is implemented, you aren't going to be able to find out much with econometrics.

Are there any components of the model documentation that you would recommend for further elaboration or clarification?

I think that I was able to understand the model from your documentation. But it took more time than it needed to, because I never saw the whole thing just written out in front of me. I've discussed this in more detail above: I think that the model can be written down formally in about five equations:

(1) $Q_s^S = b_s\left(P_s - c_s - \sum_{g=1}^{100}\alpha_{s,g}\left(P_g - P_g^0\right)\right)^{\varepsilon_s}$, $s = 1,...,100$. (*U.S. supply function for final good s*)

(2) $Q_s^{Dconinvgov} = a_s\left(P_s\right)^{\eta_s}$, $s = 1,...,100$. (*U.S demand function for final good s by consumers, investors, and government*)

(3) $Q_s^{ESrow} = r_s\left(P_s\right)^{\varepsilon_s^{ROW}}$, $s = 1,...,100$. (*Rest-of-world excess supply of good s to the U.S.*)

(4) $X_{s,g} = \alpha_{s,g}Q_s^S$, $s = 1,...,100$; $g = 1,...,100$ (*Demand by the producers of s to use good g as an input*)

(5) $\sum_{g=1}^{100} X_{s,g} + Q_s^{Dconinvgov} = Q_s^S + Q_s^{ESrow}$, $s = 1,...,100$. (*World market clearing of good s*)

Minor Points

1. Figures 2 and 3 show supply curves as linear. But they are constant-elasticity supply curves. Why not show them as such in the diagrams?

2. You assume that marginal abatement costs are equal for every unit produced. But wouldn't there be a fair amount of fixed costs necessary to meet the standards? I'm concerned that your method of using expert advice to estimate how much your supply and input demand curves shift may not adequately distinguish between changes in average total costs and average variable costs. Length-of-run makes a big difference in the how far the ATC ad AVC curves are apart. In the short run, it might make sense for these firms to stay in business, and not reduce production. I think that you face a real challenge as you try to figure out just how much to shift your curves when the regulation changes.

3. It was not immediately clear to me what the α_{sg} parameter represented in equation 4. Nor was it clear what the *i* index was doing. (This should be a *g*, not an *i*.) I suggest that you discuss these parameters before presenting them instead of after.

4. You write on p. 8 that "The use ration (α_{sg}) describes the dollar amount of an input that is required to produce a dollar of output." That's true in the initial equilibrium, because by construction all prices there are one. But after an environmental regulation is imposed, prices change, while α_{sg} remains constant. It makes more sense to me to say that α_{sg} is how many units of input *g* are used in the production of one unit of output *s*. This is assumed to be a constant, and is independent of prices.

5. Typo in equation (4) and (4a). You want the summation to be from $g = 1, \ldots, n$, not from $i = 1, \ldots, n$. The index on α and on *P* is *g*, not *i*.

6. Typo in equation (5)? Should *r* have a subscript *s* on it? That is, *r* isn't the same number for each $s = 1, \ldots, n$, is it? It seems to me you want to use the notation r_s, not *r*. It may seem like I'm being picky here, and I suppose I am. But if you are going to document a model, you don't want to be negligent with the notation. Otherwise, ten years from now someone wanting to review what you did will spend a lot more energy trying to figure out what you meant in your documentation.

7. How do you handle industries in which the U.S. can change from an exporter to an importer in different equilibrium. Your functional form for rest-of-world excess supply is constant-elasticity, and whether the excess supply is positive or negative depends on the size of the coefficient *r*. But since *r* cannot change sign, it seems to me that if the rest of the world is an importer in the baseline equilibrium, it has to be an importer in all equilibria. Wouldn't it be better to specify rest-of-world supply and demand separately, to avoid this problem. (Or else assume a linear functional form for rest-of-world excess supply. A linear

functional form will allow excess supply to be negative.) It seems to me that policy makers would be very interested to know whether imposition of an environmental regulation would cause the U.S. to stop exporting a good and start importing it.

8. Typo in equation (5). You have ε_g, but you want ε_s.

9. I don't understand your notation in equations (4a), (5), and (7). In (4a), you use the term Q_s to mean "quantity of good *s* supplied." In equation (5), you are using Q_s' to mean "quantity of good *s* excess supply from the rest of the world to the U.S." In (7) you are using Q_s' to mean "quantity of good *s* demanded by U.S. producers and consumers." Quantity supplied, quantity demanded, and quantity of rest-of-world excess supplied are three very different concepts, and the variables representing them should have three distinct names. Below, I am using Q_s^D, Q_s^S, and Q_s^{ESF}, where "ESF" stands for "excess supply from foreigners."

10. Similarly, in equation (6), your notation Q_g is not sufficient. You need to put index *s* in there, because what you are talking about is the demand for input *g* by producers of output *s*. If you don't distinguish this from demand for input *g* by producers of other outputs, then you aren't being consistent with the notation, and you could easily mess up your computer code.

11. In (7), should parameter *a* have a subscript *s*? Isn't the value of this parameter dependent on the market? It seems to me you want to use the notation a_s, not *a*.

12. Page 10. You say that you needed to identify over 400 own-price elasticities. I only see 300: ε_s, ε_s^{ROW} and η_s. What are the others?

13. A lot of typos regarding which pages the figures are on, which pages referenced equations are on… Ex: On p. 12, you write, "see equation 7 on p. 9." But equation 7 is not on page 9 in your document.

14. On p. 14, you write that ΔPS_s includes the change in producer surplus in the U.S. and in the excess supplier of the rest-of-world. Why do you include the rest o the world in this measure? Wouldn't that part of the measure be pretty easy to take out?

15. In equation (10), is the expression correct? It seems to me that you need to sum over g, and also that you have dropped a sign in front of one of the α_{gs}. That is, you have for equation (10),

$$\Delta PS_s = \left[\text{With Policy } Q_s \times \Delta p_s\right] - \left[\text{With Policy } Q_s \times \left(c_s - \alpha_{gs}\Delta p_g\right)\right] - \left[0.5 \times \Delta Q_s\right] \times \left(\Delta p_s - c_s - \alpha_{gs}\Delta p_g\right).$$

But shouldn't it actually be,

$$\Delta PS_s = \left[\text{With Policy } Q_s \times \Delta p_s\right] - \left[\text{With Policy } Q_s \times \left(c_s \underbrace{+}_{\text{note sign change}} \sum_{g=1}^{n} \alpha_{gs} \Delta p_g \right)\right]$$

$$- \left[0.5 \times \Delta Q_s \times \left(\Delta p_s - c_s - \sum_{g=1}^{n} \alpha_{gs} \Delta p_g \right)\right] ?$$

I'm guessing that these are just typos in your report, and not the actual formulas you used in your GAMS program.

16. Section 4.5: I don't understand: "the change in the price of electricity due to the regulation as forecast by the IPM model is imposed on the electricity sector in the Multimarket Model, holding electricity generation fixed at the level of generation forecast by the IPM." Why do you need to use the IPM model here? Why does electricity generation have to be held constant?

17. It looks to me that in equations (8) and (9), you are using the term ΔCSs to mean two different things. In (8), you seem to be saying ΔCSs is the change in final consumer surplus in market s. In equation (9) you seem to be using ΔCSs to mean the changes in the expenditures of government and investors on good s. Why are you using the same piece of notation to mean two different things?

18. On p. 16, you state a concern that your elasticities are unrealistically large. Well, then why not assume smaller ones? What would be a reasonable assumption? That "short-run" elasticities are half of "long-run" elasticities? I'm sure there's empirical work done on this sort of thing reported in the literature.

Major Points

1. **I'd like to see stated more explicitly the reasons that your restrictive assumptions are necessary.**

To me, it seems that the documentation you provided us describes the model in a rather *ad hoc* manner, and with insufficient theoretical justification and intuitive explanation. You make some assumptions and statements without delving much into what they mean or why they are made. Here are some passages, quoted directly from the documentation, to illustrate my point:

> *"Fixed production resources lead to an upward-sloping industry supply function."*
>
> *"Because the model excludes national labor and capital markets, we cannot use the model to estimate real wage changes, changes in labor leisure choices, …"*
>
> *"During the period, the Multimarket Model assumes one or more production factors cannot be adjusted, while other production factors can be adjusted to meet desired production levels. Under these conditions, the supply (that is, marginal cost) curves for the firms rise at higher output rates."*

It's not clear to me that production resources have to be fixed for an industry supply curve to be upward sloping. We can get an upward-sloping industry supply curve by thinking that the supply of basic resources (like labor and human capital) comes about at increasing marginal opportunity cost, and that different individuals have different cost schedules for supplying those resources. I think that this assumption is more intuitively appealing than is the assumption of fixed resource supply.

> *"Input substitution is not explicitly represented in the underlying production function."*
>
> *"Intermediate use is determined by the input use ratios and the industry output decisions determined within the Multimarket Model: …* $Q_g' = \alpha_{sg} Q_s'$ *(6)."*

I think that you should state more explicitly why you are making this assumption about no input substitution and constant input/output ratios: because you don't have estimates of cross-price elasticities. After all, this assumption is quite restrictive and in some cases quite unrealistic.

2. **I'd like to see more of an explanation of why you choose the functional forms you choose. Actually, I think that some of your assumptions about functional form have made your model more complicated than it needs to be, and really haven't added value to the model.**

Your model defines the functional forms of supply and input demand curves in a rather *ad hoc* manner:

$$S_s\left(P_{1,},P_2,...,P_{100}\right)=b_s\left(P_s-c_s-\sum_{g=1}^{100}\alpha_{s,g}\left(P_g-P_g^0\right)\right)^{\varepsilon_s}$$

$$X_{s,g}^d\left(P_{1,},P_2,...,P_{100}\right)=\alpha_{s,g}b_s\left(P_s-c_s-\sum_{g=1}^{100}\alpha_{s,g}\left(P_g-P_g^0\right)\right)^{\varepsilon_s}.$$

Now, why use these particular functional forms? Obviously, given these forms, the market-clearing conditions give you a large set of non-linear equations to solve simultaneously. I will illustrate later why a system of linear equations would be much simpler to solve, and every bit as justifiable on a theoretical basis. In some sense, perhaps, having constant-elasticity functional forms looks better because it's more complicated. But I think that you are incurring costs and gaining little, if anything, by using the more complicated model.

3. **I'd like to see the model written down formally in an appendix.**

In the document, you write down the equations of your model, and provide discussion about those equations. This is fine, but it would have been easier for me to figure out the model if you had just presented it in Mathematical form in an appendix. I'm not saying that you should delete what you have now. But it would have been nice to just see the thing written down formally.

Here's how I would have done it. (Here I stick to with standard notation that I'm used to seeing, which is a little different from your notation.):

(1) $Q_s^S=b_s\left(P_s-c_s-\sum_{g=1}^{100}\alpha_{s,g}\left(P_g-P_g^0\right)\right)^{\varepsilon_s}$, $s=1,...,100$. (*U.S. supply function for final good s*)

(2) $Q_s^{Dconinvgov}=a_s\left(P_s\right)^{\eta_s}$, $s=1,...,100$. (*U.S demand function for final good s by consumers, investors, and government*)

(3) $Q_s^{ESrow}=r_s\left(P_s\right)^{\varepsilon_s^{ROW}}$, $s=1,...,100$. (*Rest-of-world excess supply of good s to the U.S.*)

(4) $X_{s,g}=\alpha_{s,g}Q_s^S$, $s=1,...,100$; $g=1,...,100$ (*Demand by the producers of s to use good g as an input*)

(5) $\sum_{g=1}^{100}X_{s,g}+Q_s^{Dconinvgov}=Q_s^S+Q_s^{ESrow}$, $s=1,...,100$. (*World market clearing of good s*)

4. Why not start out stating the assumptions explicitly, and creating a linear model?

Instead of assuming a constant-elasticity supply curve (which implicitly defines an assumed technology), you could make things a lot simpler, and I think every bit as realistic and defensible, if you began by assuming a particular functional form of the production function.

For notational simplicity, let's deal with the supply of good 1. (Goods 2, … , 99 could be treated similarly.) Let $v_{1,1}$, $v_{1,2}$, … , $v_{1,100}$ be the observed input demand variables, and let their obsered cost shares be: $\alpha_{1,1}$, $\alpha_{1,2}$, … , $\alpha_{1,100}$.. Also let there be some "owned factor" of production (perhaps labor or "management") that is not purchased in the market, but instead can be provided by the supplier of good 1. Call this owned factor $v_{1,0}$. Let the production function be,

$$f_1\left(v_{1,1}, v_{1,2}, ..., v_{1,100}, v_{1,0}\right) = Min\left\{\frac{v_{1,1}}{\alpha_{1,1}}, \frac{v_{1,2}}{\alpha_{1,2}}, ..., \frac{v_{1,100}}{\alpha_{1,100}}, v_{1,0}\right\}.$$

Here we have the perfect complementarity of inputs that you want in your model.

We assume that there are many firms that are able to produce good 1 according to the production function above. But we let firms differ in their cost schedules for supplying the owned-input, $v_{1,0}$. For a firm i, we let the opportunity cost of supplying the own-factor have a quadratic functional form:

$$C_i\left(v_{1,0}\right) = \frac{1}{2k_i} v_{1,0}^2.$$

Different firms can have different values of the parameter k_i. Firms with higher values of k_i have lower opportunity costs of supply the owned-input.

In order to make a firm's average cost curve U-shaped, we assume that if a firm wants to produce good 1, it must pay set-up costs C_1^{su}. The variable cost function for the specified technology is then,

$$VC_1^i\left(q_1, P_1, P_2, ..., P_{100}\right) \equiv C_1^{su} + \left(\alpha_{1,1}P_1 + \alpha_{1,2}P_2 + ... + \alpha_{1,100}P_{100}\right)q_1 + \frac{1}{2k_i}q_1^2.$$

Because of the way we've entered $v_{1,0}$ into the production function, we get a linear marginal cost function:

$$MC_1^i\left(q_1, P_1, P_2, ..., P_{100}\right) \equiv \left(\alpha_{1,1}P_1 + \alpha_{1,2}P_2 + ... + \alpha_{1,100}P_{100}\right) + \frac{1}{k_i}q_1.$$

Average variable cost is,

$$AVC_1^i\left(q_1, P_1, P_2, ..., P_{100}\right) \equiv \alpha_{1,1}P_1 + \alpha_{1,2}P_2 + ... + \alpha_{1,100}P_{100} + \frac{C_1^{su}}{q_1} + \frac{1}{2k_i}q_1.$$

Average cost equals marginal cost at q_1^{i*}, where

$$q_1^{i*} \equiv \sqrt{2k_i C_1^{su}}\,.$$

Thus, average variable cost at the bottom of the average variable cost curve is,

$$AVC_1^i\left(q_1^{i*}, P_1, P_2, ..., P_{100}\right) \equiv \frac{C_1^{su}}{\sqrt{2k_i C_1^{su}}} + \left(\alpha_{1,1}P_1 + \alpha_{1,2}P_2 + ... + \alpha_{1,100}P_{100}\right) + \frac{1}{2k_i}\sqrt{2k_i C_1^{su}}$$

$$\equiv \alpha_{1,1}P_1 + \alpha_{1,2}P_2 + ... + \alpha_{1,100}P_{100} + \sqrt{\frac{2C_1^{su}}{k_i}}.$$

Inverting the identity above, we get the firm's supply function:

$$S_1^i\left(P_1, P_2, ..., P_{100}\right) \equiv \begin{cases} 0, & P_1 < \sqrt{\dfrac{2C_1^{su}}{k_i}} \\ k_i\left(\left[1-\alpha_{1,1}\right]P_1 - \alpha_{1,2}P_2 - ... - \alpha_{1,100}P_{100}\right), & P_1 \geq \sqrt{\dfrac{2C_1^{su}}{k_i}} \end{cases}$$

The industry supply for good 1 is then

$$S_1\left(P_1, P_2, ..., P_{100}\right) \equiv \begin{cases} 0 \\ K\left(\left[1-\alpha_{1,1}\right]P_1 - \alpha_{1,2}P_2 - ... - \alpha_{1,100}P_{100}\right), where\ K = \sum_i k_i \end{cases}$$

Now we need to calibrate the value of *K*. As you discuss in the documentation, units are already adjusted such that in the initial equilibrium all prices are 1. Since you have the elasticity of supply, you can find

$$\varepsilon_1 = \underbrace{\frac{\partial S_1(1,...,1)}{\partial P_1}}_{K\left(1-\alpha_{1,1}\right)}\frac{1}{Q_1^0},$$

and so,

$$S_1\left(P_1, P_2, ..., P_{100}\right) \equiv \begin{cases} 0 \\ K\left(\left[1-\alpha_{1,1}\right]P_1 - \alpha_{1,2}P_2 - ... - \alpha_{1,100}P_{100}\right), where\ K = \sum_i k_i \end{cases}.$$

Plugging this result back into the supply function finishes the calibration.

$$S_1\left(P_1, P_2, ..., P_{100}\right) \equiv \begin{cases} 0, \\ \varepsilon_1 Q_1^0\left(1-\alpha_{1,1}\right)^{-1}\left(\left[1-\alpha_{1,1}\right]P_1 - \alpha_{1,2}P_2 - ... - \alpha_{1,100}P_{100}\right) \end{cases}$$

Demands for purchased inputs are proportional to supply:

$$v_{1g}^{d}\left(P_1,P_2,...,P_{100}\right)\equiv\begin{cases}0,\\ \alpha_{1,g}\varepsilon_1 Q_1^0\left(1-\alpha_{1,1}\right)^{-1}\left(\left[1-\alpha_{1,1}\right]P_1-\alpha_{1,2}P_2-...-\alpha_{1,100}P_{100}\right)\end{cases}$$

In more general terms, for any s, g = 1, …, 100,

$$S_s(\mathbf{P})\equiv\begin{cases}0, & P_1<\sqrt{\dfrac{2C_1^{su}}{k_{1,0}}}\\ \varepsilon_s Q_s^0\left(1-\alpha_{s,s}\right)^{-1}\left(P_s-\sum_{g=1}^{100}\alpha_{s,g}P_g\right), & P_1\geq\sqrt{\dfrac{2C_1^{su}}{k_{1,0}}}\end{cases}$$

$$v_{s,g}^{d}(\mathbf{P})\equiv\begin{cases}0, & P_1<\sqrt{\dfrac{2C_1^{su}}{k_{1,0}}}\\ \alpha_{s,g}\varepsilon_s Q_s^0\left(1-\alpha_{s,s}\right)^{-1}\left(P_s-\sum_{g=1}^{100}\alpha_{s,g}P_g\right), & P_1\geq\sqrt{\dfrac{2C_1^{su}}{k_{1,0}}}\end{cases}$$

The model I've given you is very much like the one described in your document, except for two differences:

- I've stated explicitly the theoretical details.
- My model is linear, making it much easier to solve. In fact, you could come up with analytical solutions to the equilibria, which would mean that you wouldn't need to solve the model numerically, and therefore wouldn't even need the GAMS software.

5. Returns to sector-specific resources (labor, capital) are implicit in the model.

You write in a number of places that returns to labor and capital are not dealt with in your model. Actually, I think that in some sense they are. Key here is how the upward-sloping supply curve was generated in the model I presented above. I didn't have to assume that factors of production were fixed for industries. Rather, I only had to assume that owned-resources were provided at increasing marginal costs. I think that this is often true for sector-specific capital, human capital and labor. If the price of an output rises, then it takes time for new firms to enter the market, and to duplicate the least-cost methods of existing firms. To put new buildings or factories into the production process, they often have to be taken from other uses, and the more that are taken, the greater the marginal opportunity cost of taking them. And training new people is more expensive the faster it has to be done. For all these reasons, increasing the price of an output attracts more resources into a sector, but at increasing marginal opportunity costs.

The question arises: What does "producer surplus" measure? In general, it measures the returns to owners of resources that potential competitors cannot obtain except at marginal costs greater than those of the firm earning the increased returns. Firms in an industry need not be identical. Some firms have big comparative advantages in the production of an output.

The claims I make in this point are pretty well established in the theoretical literature. I could give a more technical presentation of this material if needed.

6. **Especially "locally," the constant-elasticity form in not more justified than is the linear form**

The system of constant-elasticity supply and demand functions is more difficult to use than a linear system. Is it in some way superior, so as to justify its use? I don't think that it is. The conventional method of estimation of the producer welfare effects of a supply-curve-shifting policy (or technological change) is burdened by a well-recognized difficulty: the method usually requires extrapolation of the econometric estimation of the supply function to regions outside the range the data (Scobie 1976; Lindner and Jarett 1978; Rose 1980; Voon and Edwards 1991). Just, Hueth, and Schmitz (2004, pp. 284-290) provide a helpful discussion, which I draw upon in figure 1. The small circles in figure 1 represent observed (price, quantity) data points, and the means of the quantity and price data are shown at $\overline{q}$ and $\overline{p}$. (Note that we have price on the horizontal axis and quantity on the vertical axis.) If the linear functional form is assumed, and the estimated supply curve is $\hat{S}(p) = \hat{\alpha} + \hat{\beta}p$. However, if the constant-elasticity functional form is assumed, the estimated supply curve is $\tilde{S}(p) = \tilde{\alpha}p^{\tilde{\beta}}$. But $\hat{\alpha}$, $\hat{\beta}$, $\tilde{\alpha}$, and $\tilde{\beta}$ are estimates, and subject to statistical error. Moreover, *there is very little difference between the two estimated supply curves in the range of the data*. This means that it's not going to be possible to statistically figure out which of these curves is closer to the true supply curve. No statistical test is going to be able to test for functional form. In short, the econometrician isn't going to be able to reject one supply curve estimate for the other. The differences in the curves takes place at (p, q) points outside the range of the data.

In your model, you take hundreds of own-price supply elasticities, that have been estimated using a lot of different types of methods, and then you assume that all the supply curves have constant-elasticity functional forms. But very often the range of historical data is not wide enough to determine much about the global forms of the estimated functions.

When the case is as shown in figure 2, then as long as the price changes are not too big, the assumed functional form of supply might make very little difference to your point estimates of changes in producer welfare, anyway. I illustrate this point in figure 2. Assuming that a regulation in some other market shifts the demand for the shown market. Then the price rises from p^0 to p^1. If we estimate a linear functional form, the estimated change in producer surplus is the shaded area. If we estimate a constant-elasticity functional form, the estimated change in producer surplus almost identical. So, not only was rejection of the linear curve in favor of the constant elasticity curve not possible from the data, which curve we ultimately chose didn't end up making much difference. Under these circumstances, it seems to me that assuming the linear functional forms is every bit as valid as choosing the constant-elasticity forms. Further more, the linear functional forms are much easier to work with—you can solve for different equilibrium prices and quantities analytically, so you don't need the complicated GAMS program to find equilibria numerically.

7. **Your assumptions about how regulation will shift the input demand and output supply curves seem fairly arbitrary.**

There is a large and involved literature discussing how supply should be assumed to shift after a technological change, whether in a parallel, pivotal, or some other fashion (c.f., Lindner and Jarret 1978, 1980; Rose 1980; Wise and Fell 1980, Norton and Davis 1981; Voon and Edwards 1991; Haung and Sexton 1996; Edwards and Voon 1997; Wohlgenant 1997). Alston, Norton, and Pardey (1994, pp. 63-64) recognize and discuss the challenge of making the proper assumption about the character of the supply shift:

> *There has been a great deal of discussion in the literature about the effects of different types of research-induced supply shifts on the size and distribution of research benefits, and rightly so. This choice in the analysis is crucially important… Unfortunately, economic theory is not informative about either the functional form of supply and demand or the functional form (parallel, pivotal, proportional, or otherwise) of the research-induced supply shift. … We might hope to obtain plausible estimates of elasticities at the data means, but definitive results concerning functional forms are unlikely and it is impossible to get statistical results that can be extrapolated to the price or quantity axes (i.e., the full length of the function) with any confidence.*

Strong critiques about the dependence of producer welfare measures on assumptions about supply shifts have appeared in the literature. Beattie (1995, p. 1065) was in general complimentary in his review of Alston, Norton, and Pardey (1994), but he also wrote,

> *If total benefits from a research-induced supply shift are halved when that shift is deemed to be pivotal rather than parallel, and if producer benefits disappear when the supply shift is pivotal against an inelastic demand, then it seems to me that we have a rather big problem here.*

Your method of measuring the welfare effects of environmental regulation is, essentially, to assume that curves shift in a parallel fashion. I don't know that you can easily justify this particular assumption, and I think that this assumption can make a big difference in your ultimate measurements of welfare change. I think at the least, you need to explicitly recognize this difficulty when you report research results. It might also be a good idea to assume different types of shifts, and do sensitivity analysis.

8. **Elasticities, elasticities, elasticities**

I'm sure that you realize that your results will always be highly dependent on your elasticity estimates, and that your elasticity estimates probably aren't very good. Nor is it clear what kind of elasticities we're talking about. When the elasticities were estimated, which prices were conceptually held constant, and which prices

were allowed to change in equilibrium? This always seems to be a big issue with these types of models.

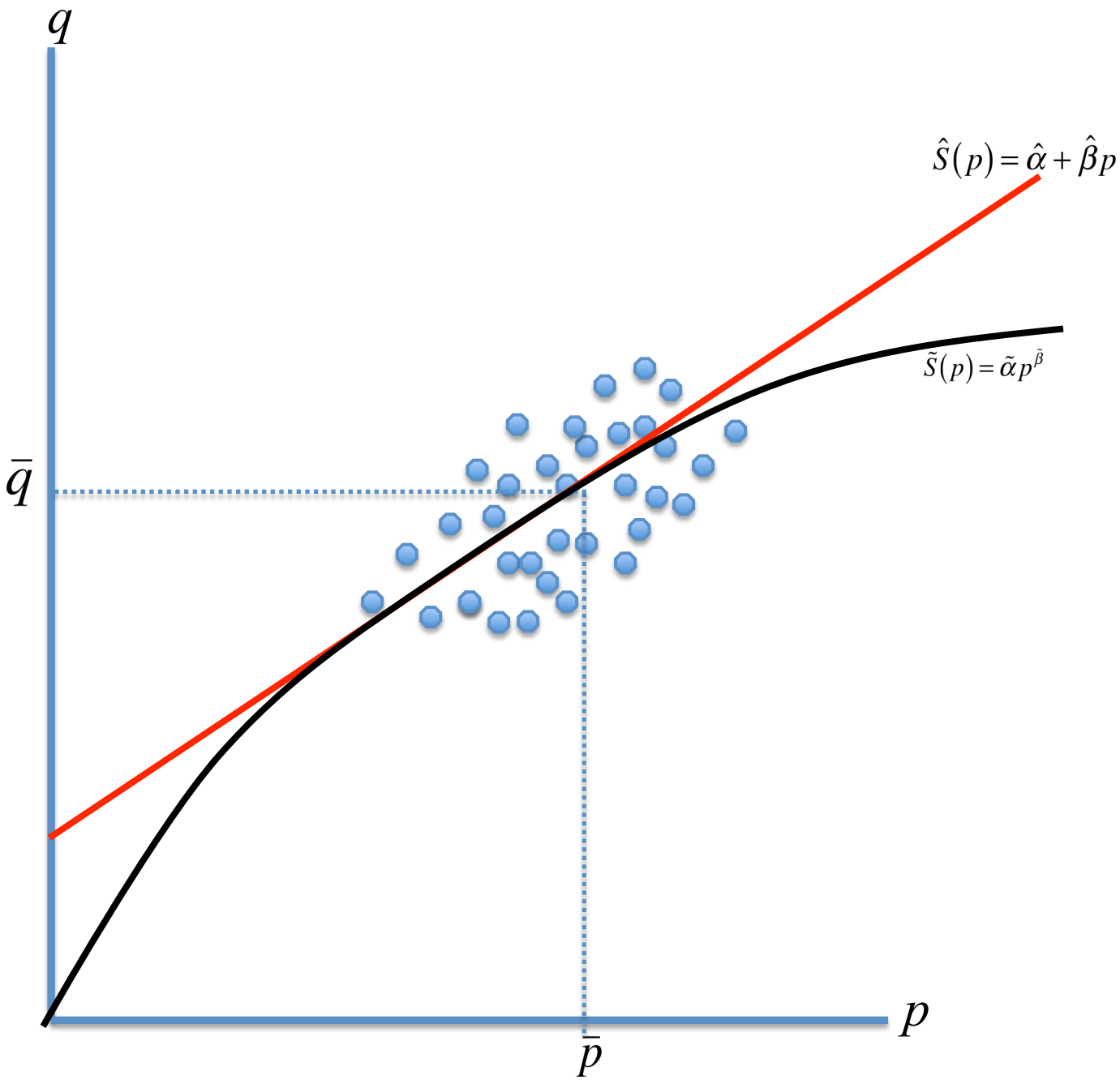

Figure 1. Range of data does not allow econometric distinction of two supply curves

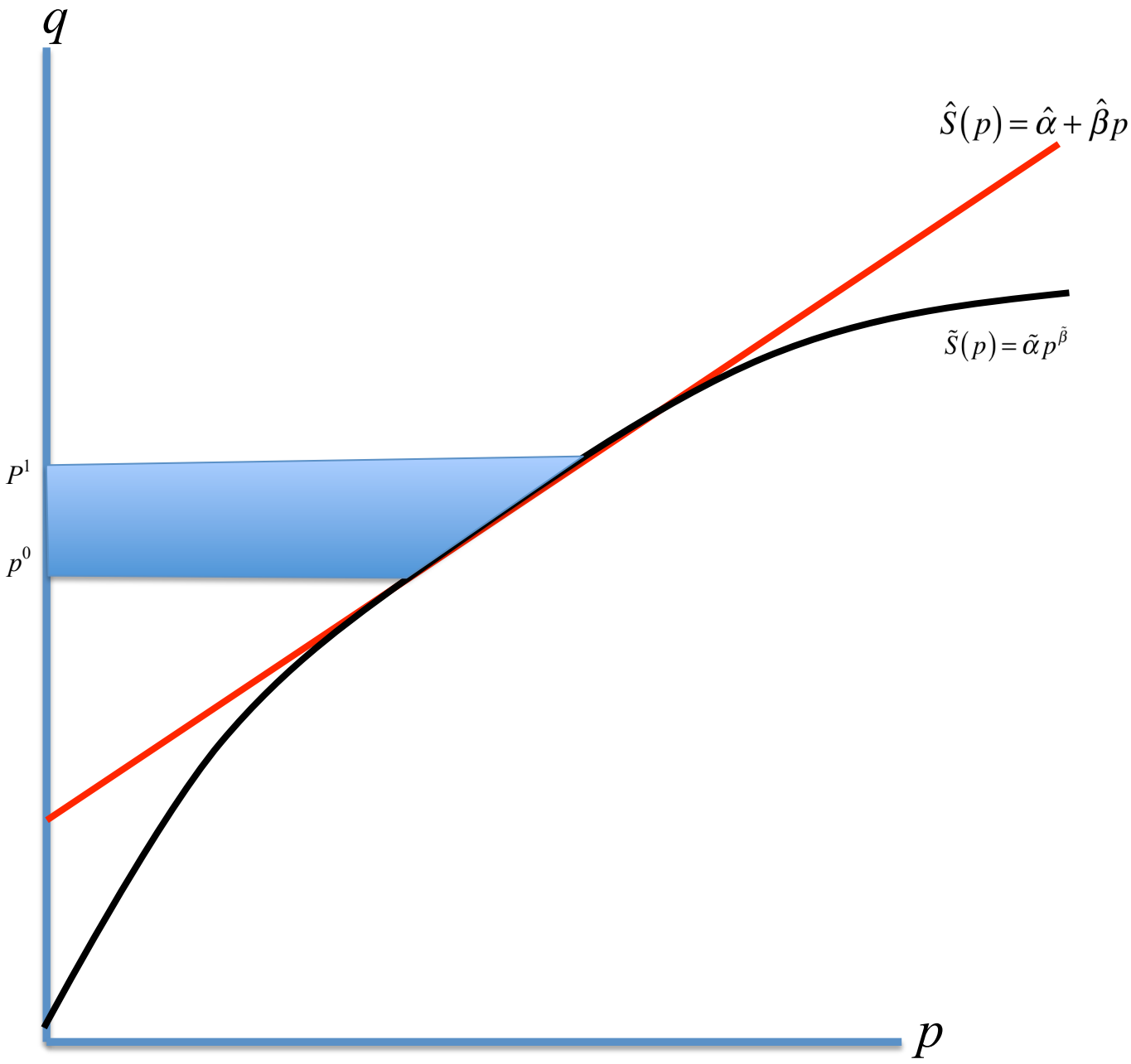

Figure 2. Assumed functional form for supply curve makes little difference for the estimate of the change in producer surplus.

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Comments of

Dr. Dallas Burtraw
Resources for the Future

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January 14, 2012

Review of EPA's Multimarket Model
Dallas Burtraw / Resources for the Future

These comments were prepared as part of a review of the EPA's Multimarket Model (MMM) which is used to estimate the costs of regulations. The model is one of many that can be aligned along a spectrum of models and approaches that vary from single market, partial equilibrium (PE) approaches to general equilibrium (GE), and from static analysis to dynamic. Along this spectrum the GE models typically provide relatively less specificity in elasticity estimates, technology characterizations and regional behavior and relatively greater internal consistency across elements of the economy. The multimarket model is a static PE model that links many markets and hence has characteristics of PE and GE models.

The intent of this report is to provide suggestions for model use and future development. First I provide an overview and general suggestions. Second, I address a series of charge questions provided by the EPA including comments on the documentation.

I. Model Use and Future Development

Although GE models get the prize for elegance and consistency, they are often not the most useful for analysis of individual regulations. GE models typically identify an outcome after the economy has thoroughly adjusted allowing for changes in factor shares in production and in capital stocks. Typically GE models identify a long run outcome displayed at a coarse level of geographic and sectoral resolution, Policy makers are often interested in the measure of costs in the transition period (when households and businesses may be most vulnerable because they have not had a chance to adjust capital stocks), and at the regional and sectoral level (which in some cases may be disproportionately affected by regulation). GE models can allow for adjustment costs and be solved for intermediate equilibria but they are less often used in this dynamic fashion, and the technical resolution within the model usually is further reduced to achieve model convergence in a dynamic model. Hence, the effort to build a model linking markets within a PE framework is relevant and potentially useful.

Most modelers understand that their models do not offer a crystal ball because models are inherently incomplete and also because the world will not stand still waiting for the equilibrium from one policy change to manifest. Consequently, policy analysis relies on changes from baseline within a model to evaluate the effect of a policy, with the anticipation that that relative effect will persevere through time even as the economy heads in various directions. Nonetheless, a limitation of any modeling exercise is that it presumes the economy remains otherwise unaltered from policy interventions. Consequently, the predicted long run adjustments may be intercepted by other influences that interact and alter the outcome of policy. This is another reason why an array of modeling tools is appropriate for policy analysis. MMM should be viewed in this context. Its results will differ from single market PE on the one hand, and GE on the other. Each contributes valuable information that should be understood in context.

At the outset of this report I want to highlight two specific areas for potential enhancement of MMM, or more accurately, for the analytical framework which is informed by MMM. (Specific suggestions are offset in bulleted format.)

One potentially important issue in MMM is the ***assumption of a uniform national market for all sectors***. This does not apply equally well for all sectors, and especially not well for electricity where regions rely on different technologies and fuels with different emissions profiles and subject to different costs from a given regulation. Moreover, these differences propagate through the industrial sectors which are large energy users. Consequently, electricity as an intermediate input to another manufacturing process may demonstrate substantially different changes in costs in various regions of the country, so the impact on a given downstream industry of a change in average electricity prices may be a poor representation of how that particular industry is affected, especially where it is concentrated regionally.

- The expansion of the model to include regional differences in a few industries, especially electricity and possibly other energy supply options, is a potentially important model development that can be readily accomplished.

The most immediate candidates would be electricity and other fuel markets, because they differ importantly across the nation. If other sectors rely on very different technologies in different regions they also would be candidates.

Another potentially important model enhancement would be to build some safeguards to alert the user that conditions are breaching the range in which the model results can be accepted without caveat. Specifically, the model algorithm could be enhanced to include ***internal validity checks***. I explain with example, based on my understanding of the following. Production costs are augmented by engineering estimates of abatement, process change and fuel substitution that may occur, but the actual ratio of inputs are not changed. Consequently the price of the produced good is augmented according to the change in the price of its inputs through inclusion of a shadow cost adder. Imagine that one particular abatement technology or fuel substitution is identified in the engineering models for a number of sectors. The change in an individual sector may not lead to major changes in factor prices. However, in the aggregate this could add up to a large substitution for the economy with potential changes in factor prices. This would not be apparent in MMM. An obvious example is if a response to regulation is substitution to greater use of natural gas in a number of sectors. In the current economy, this may not lead to changes in gas prices because of recent forecasts suggesting relatively elastic gas supply, but that has not always been the case and it may not hold for other factors. Similarly, substitutions away from a factor such as coal may, in the aggregate, lead to a reduction in coal prices that mitigates the cost of regulation.

- Can MMM build in an indicator for when the possibility for incremental adjustments across a number of sectors might aggregate to large changes in factor markets?

To do so would require accounting for factor substitution that is identified in engineering models that are used to parameterize MMM, and checking the aggregate changes in factor use as a sidebar element of the MMM algorithm. Although the effect may not lead to important changes in the cost estimates

from MMM, the benefit would be to provide confidence that the MMM algorithm attends to the possibility that the sum on incremental changes in many sectors could sum to a large effect in the aggregate, which is one example of how a model can provide an internal validity check that improves the usability of the model in general.

II. Comments on specific questions for review

1. Theoretical and practical aspects

1a. What is the appropriate way to capture impacts of the boiler rule and other rules affecting more than one sector?

There is no single appropriate way to capture the impacts of a regulation affecting multiple sectors. Each of the mentioned modeling approaches has limitations.

The methodology of MMM is calibrated to results from PE and engineering economic models. Each PE model is solved to find the change in costs when the sector optimizes with respect to technology choice, process changes, fuel choice, etc. A limitation of the documentation is a weak explanation of the models that are used in this regard and the information that they account for.

- Documentation would be enhanced through improved description of the PE and engineering economic models that are used to identify compliance costs in regulated industries. Since several models may be used, it is impractical to describe each one. But their characteristics should be described including the types of information they account for and the modeling technique that is used to identify the least cost compliance strategy.

This information is brought into MMM through calculation of the change in cost per unit of production and represented as a shadow cost adder. In this way MMM captures most of the contribution from the PE analysis. The limitation is the representation of factor demands because they are held constant. Hence the price of goods and services adjust and are passed through the economy but the factor demands do not. Revenues associate with the shadow cost adder disappear, which can be interpreted as payment to primary factors or deadweight loss.

A rule like the boiler rule that affects more than one sector requires more than one independent PE model analysis to account for market interactions. The change in costs in one sector affects the costs in another sector and the overall level of product and service demand, which is calculated in MMM.

However, MMM does not capture two important effects. One is the aggregate change in demand for factors summed across industries. Elsewhere in this report I suggest that offline accounting of the aggregate change in factor demand should be conducted and included in an regulatory impact assessment (RIA) for a rule such as the boiler rule.

The second effect not captured by MMM is factor substitution in downstream industries. For example, the change in costs of producing steel would raise costs of manufacturing cars, but MMM would not indicate a substitution to other materials in the production of cars. Demand for cars would be affected

in MMM by an estimate of the maximum possible change in costs for cars. It is the maximum because this option remains available even though car manufacturers would look for other production options.

An important caveat on this second identified limitation of MMM is that factor substitution in downstream production processes can take a long time, especially in the example I used about car manufacturing. So this limitation may be more or less significant depending on how MMM is used. In this report, I suggest that MMM is appropriate for short and intermediate run analysis, and less so for long run analysis.

The approach used in MMM is useful as long as it is clear that the cost estimates in downstream industries are an upper bound. On the other hand MMM does not account for pre-existing distortions away from economic efficiency in factor markets caused by pre-existing taxes, regulations, or noncompetitive behavior. This would lead MMM to be an underestimate. However, I feel the measures that come from distortions in factor markets are mostly appropriate for inclusion in long run analysis, and less so in short run analysis. For example, the "tax interaction effect" stemming from pre-existing labor taxes and substitutions away from labor supply depends on labor market equilibrium and full employment. That condition may characterize labor markets on average and in the long run but labor markets take time to adjust and labor supply is often not fully utilized in the short run, or in some strata of the economy. Regulatory changes that cause factor substitution may lead to decreases in labor demand in some sectors and the tax interaction effect, which hinges on inadequate labor supply, is not relevant in those sectors until labor markets adjust through movement of labor between industries, which takes some time to accomplish. For these reasons, the limitations of MMM seem especially important in the long run. In the short and intermediate run the limitations are mitigated by the usefulness of interpreting the MMM estimates as upper bound, or bookend estimates of costs.

A possible opportunity for improvement in MMM would be to solve a PE model for the downstream industries using engineering economics models. Then, one could tally the process changes and factor substitutions that might occur, especially the change in factor demand, and augment the RIAs for a rule with an accounting of that information.

In my discussion below I argue that GE models have the unique capability of accounting fully for factor substitution and changes in prices and downstream demand in a way that is not an upper bound. But GE models have their own set of stylized relationships that may represent the economy less well than MMM, depending on the purpose of the analysis. I feel a GE model is likely to be less well suited than MMM for analysis of the short and intermediate run.

In summary, with respect to this leading question about the appropriate way to capture the effects of a rule affecting more than one sector, I think the decision hinges on the timeframe for the analysis. I think analysis of the short and intermediate time horizon is most important, although not singularly so. For this reason, I think MMM is likely to be the most useful model of the three types of models I mention here. This does not include other engineering economic models such as ISIS, which seems to offer the promise of accounting for factor substitution in a short and intermediate time frame while doing much of what MMM is able to do.

I summarize other points I mention above in the following recommendations for possible ways to improve MMM:

- Account for changes in factor demand across the modeled sector and take this information offline for an evaluation of the possible magnitude of change in equilibrium prices. (For example, the possible change in the cost of natural gas as a result of wide-spread fuel switching.)
- Examine downstream sectors that might be affected importantly and incorporate that assessment into the RIA.

1b. Are the tradeoffs required to parameterize and operate MMM acceptable?

The tradeoffs listed in the charge questions include use of long run elasticity estimates, inability to account for factor substitutions, and omission of labor market distortions. These may in fact be only a subset of the limitations of MMM. Nonetheless imperfections characterize all modeling approaches. For example, computable GE models are typically constrained to use demand and substitution elasticities that are based on limited empirical information and less specific to individual sectors than what is used in MMM.

In this vein, the tradeoffs of MMM should be kept in mind and used to provide an interpretation of how results are used. For the purpose of a short or intermediate run analysis the tradeoffs are acceptable. However, as noted there are opportunities for improvement.

1c. How should results of MMM be interpreted?

The calibration of elasticities in MMM is calculated based on estimates empirically estimated for another purpose and in another context. It is thoughtful, but as acknowledged in the documentation, the elasticities should be interpreted as long run elasticities. This would tend to overestimate the impacts on demand and predict a change in economic activity in MMM that is likely greater than what should be expected in the short and intermediate run, which is the forecast horizon for MMM. Again, for this reason the model structure is providing an upper bound of likely costs and effects in the economy. Knowing this cost estimate and interpreting it as a bookend for the real cost is valuable given the wide range of uncertainties at play within and outside the model.

- Model results from MMM should be interpreted to be relevant to short and intermediate run perspectives. Analysis in support of regulation should be informed by contrasting results from other modeling frameworks including GE where possible.

The limitations with respect to use and interpretation of elasticities provide a potential opportunity to improve the model:

- Houthakker et al. (1974) develop an approach to account for the distinction between short run and long run elasticities stemming from the time it takes to make capital adjustments, etc. This framework provides a way to relate long run and short run elasticities and should enable a calculation of short run elasticities that are consistent with the long run estimates.

Reference:

Houthakker, H.S., P.K. Verleger, and D.P. Sheehan. 1974. "Dynamic Demand Analysis for Gasoline and Residential Electricity." American Journal of Agricultural Economics 56: 412–18.

2. What are regulatory scenarios where MMM might be more appropriate than a one or two-market PE model? Comment on advantages and disadvantages.

The MMM has distinct characteristics that should influence when it is more appropriate than other models, but the premise of this question suggests that MMM would be used in isolation from the underlying PE and engineering economic models that are solved to determine the shadow cost adder in MMM. I think this premise is flawed. MMM should be most useful when it is complemented by offline accounting to investigate the potential limitations coming from the representation of technological change as a shadow cost adder. The main limitation of MMM, compared to a one or two-market PE framework, is the inability to account for changes in relative factor use. However, MMM is able to account for the cost of those changes. Hence, it will not adequately signal the change in activity in various sectors on an idiosyncratic basis and may misrepresent distributional consequences both negative and positive affecting different sectors through changes in factor markets.

MMM should be relatively advantageous:

a) when, based on PE analysis, the main response to regulation is the installation of post-combustion controls;
b) when relatively greater changes in output prices are expected; and
c) because of the fixed coefficient representation in MMM, when there is relatively less factor substitution (process change) between industry categories.

3. Is the number of sectors in MMM sufficient to understand distributional impacts? Are there other concerns about how sectors are aggregated?

Distributional effects fall generally into two categories. One is the change in the expenditure burden based on household consumption patterns. This is likely to occur on a national basis, without regional differences except for the market-basket basis of regional consumption patterns. For example, if the cost of potatoes is affected through regulation of a fungicide, the national potato price is affected, and households are equally affected except if there is a difference in the relative expenditure share based on differences in income, region or other demographic characteristic.

The other is the effect that stems from sector-based economic activity, which is more likely to have a distinct regional characteristic. For example, if the potato industry is negatively affected, negative employment effects will be concentrated where potatoes are grown and where food processing occurs. This type of distributional impact is probably the focus of attention for most regulations.

The answer to the question hinges on the specific regulation under consideration. In general, it should be possible to conduct a preliminary assessment of the sectors involved in a regulation and assess whether MMM has appropriate disaggregation before conducting the modeling. However, in practice it

may be costly, time consuming or impractical given resources to adjust the model. I do not have sufficient expertise to be able to anticipate the outcome of such an assessment.

Generically, I suggest there is one way that the model sector aggregation could be changed to better assess the distributional (and efficiency) impacts of a regulation. While most sectors serve national markets at uniform costs except for differences in transportation costs that are relatively minor, some sectors have explicit regional scope. Cement is one example. The ISIS model is especially careful in this regard. Another is the electricity sector, which provides an important input to many other sectors. Moreover, the regional electricity industry is characterized by large differences in technology and fuel use. Regions are likely to be affected from direct regulation in different ways, and more importantly the regions may be affected by indirect regulation on downstream industries in different ways. Electricity provides a possible substitute energy source, for example, for industrial boilers. Wholesale electricity prices differ by a factor of two or more in different regions. This leads to the suggestion:

- Different regional electricity markets might be built into MMM, with appropriate links to downstream industries based on the geographic concentrations of the downstream industries, even if those industries are characterized as a single national sector. Similar regional approaches should be considered for other energy options and potentially other industries with strong regional characteristics.

4. How can surplus changes in MMM be interpreted?

Surplus changes in MMM are likely to be an underestimate for the regulated sector and an overestimate for the rest of the economy. This results from the inability of downstream industries to substitute away from products from the regulated sector. Consequently, demand changes in the regulated sector are mitigated in MMM. At the same time, that inability to substitute away from products from the regulated sector implies a maximal estimate of cost change in final goods and services, where demand elasticities are at play. Consequently, there will be a high estimate of contraction in the rest of the economy.

The model construction passes forward most of the cost of the policy to downstream consumers in the regulated industries. This is mitigated only by the response of demand to a change in prices. The model does not explicitly account for the share of total incidence that falls on owners of capital or resources, or labor, due to changes in demand for those factors and/or changes in their wage. Consequently distributional effects that are reflected in MMM are approximate. I think that in most industries, most costs would be passed downstream, so the distributional implications embodied in MMM are useful. The fact that demand elasticities are interpreted as long run mitigates the effect of this model structure, but distributional implications with respect to the impacts on consumers versus producers (or owners of factors) should be interpreted with care or not cited. Distributional effects across industries are probably useful as a first order approximation.

5. Is the treatment of imports and exports appropriate?

I do not have any suggestions about how this could be done differently.

6. Are demand and supply elasticities in MMM appropriate? Are there suggestions for improvement?

As noted above, the demand and supply estimates are flawed but if they are understood and characterized properly, and the MMM results interpreted properly, the elasticities provide useful information. Because they are long run elasticities, the resulting estimates in MMM can be viewed as an upper bound on costs.

I provide a specific suggestion above about how the elasticity estimates might be improved. Please see Houthakker et al. (1974) for illustration of an approach to account for the distinction between short run and long run elasticities stemming from the time it takes to make capital adjustments, etc. This framework provides a way to relate long run and short run elasticities and should enable a calculation of short run elasticities that are consistent with the long run estimates on which the model is currently based.

7. Comment on different ways to use the model.

7a. What are alternative ways to represent the impact of a regulation in the model? How can fuel switching be incorporated into the model?

I have suggested previously that effects that are not properly accounted for in MMM could and should be incorporated through complementary offline analysis. This should include an accounting for changes in factor demand across the modeled sector and take this information offline for an evaluation of the possible magnitude of change in equilibrium prices in factor demands (for example, the price of natural gas). Secondly, the analysis should include an offline examination of downstream sectors that might be affected importantly and incorporate that assessment into the RIA. This analysis should evaluate ancillary issues such as the impact on vendors, the ramp up capability of vendors and skilled labor, and the supply queue. Where the queue is long, one could expect a cost premium. MMM would not capture this and it should be accounted for separately, or added explicitly to MMM as part of the shadow price adder.

To repeat and extend the previous suggestions, I enumerate them further here:

- Couple MMM with offline analysis to assess the aggregate effects on factor supply, vendor queues, employment market queues, etc. Explicitly account for cost premiums that might result in the model.
- Evaluate the potential role of imperfect competition where it is supported by empirical data, regulatory information or economic investigations. Add a premium to the cost of changes in supply from those industries.
- Account for regional markets on a case-by-case basis. Explicitly model regional electricity industries and potentially other industries as separate industries in MMM.

7b. How can MMM explicitly model the pollution control sector? How can increased demand for pollution control equipment be reflected in the model?

As suggested above, the pollution control sector may be capital or labor constrained resulting in cost premiums. This should be evaluated empirically and in the context of engineering economic PE models and reflected in the shadow price adder that is included in MMM.

Because of its fixed factor ratios, MMM will overstate the overall cost to the economy outside the regulated sector because it will yield a high estimate of the overall change in prices for final goods and services. Concurrently, it will not reflect changes in economic activity across sectors.

I do not see a way to improve this within MMM except through the calculation of alternative coefficients of factor inputs. To accomplish this, one might disaggregate the pollution control industry as much as possible and solve PE model(s) to conjecture the response to regulation. Then one might rebalance the factor coefficients in MMM to accommodate the response to the regulation. This could be interpreted as an arbitrary exercise, so one would have to proceed cautiously.

8. Are there components of model documentation that could be improved?

One leading suggestion for improvement to the documentation:

- The documentation needs further explanation of how sector specific PE models and engineering economic models are used to calculate the shadow price adder that is brought into MMM to represent sector-specific costs of conforming to the regulation. The way this is done, and potential improvements in this area, may be even more important than the other suggestions for improvements to MMM. I could not ascertain the process or level of sophistication involved based in the documentation for MMM.

p. 4: "…another way, <delete "and"> input substitution…

P 4: "Decisions are made in the context of a single period…decisions are not influenced by expectations about …future years." I understand this to be true in MMM but is it necessarily true in the engineering models and single market PE models that are used to parameterize MMM? For example, IPM is used to parameterize electricity sector changes. IPM is a forward looking model, so regulation in the electricity sector or regulation affecting demand for electricity could affect investment and retirement in IPM with an associated effect on price changes that are brought into MMM as part of the systematic response to the regulation. Hence, it may be more accurate to say that estimates of abatement costs are forward looking only partially.

P. 9: Equation 5: is this elasticity term ε_g^{ROW} the elasticity for input goods (g) or imports (s)? I think it is a typo in the equation, but the symbol explanation and following sentence do not seem to agree in any case.

P. 11: "equal to the supply <elasticity> of imports.

P. 11: same paragraph. I am confused about the "standard deviation" that is mentioned. Is this the SD of the Broda trade elasticities across subgroups after they are aggregated to a MMM group?

However, the next paragraph (subsection 4.4.1.1) describes a sample mean value, rather than use of one SD below the mean.

In any event, I found these paragraphs confusing and there may be an opportunity to improve the exposition here.

P. 13, section 4.5: "…the *change* in the price of electricity due to the regulation…is imposed…holding electricity generation fixed at the *level* of generation forecast…" Is this the baseline level?

P. 14, top: "…investment and government consumption are assumed to be fixed…" It might be helpful to indicate here that expenditures to maintain this level of consumption are affected, and this is assumed to pass through fully as a change in consumer surplus.

P. 14, equation 10: Is this a typo in the equation? Should the term be:
"$...-[\text{With Policy } Q_S \times (C_s + \alpha_{gs}\Delta p_g)]...$"?

P.15, paragraph 2: "...with true <?> general equilibrium costs <estimates>." Describing general equilibrium model results as "true" is inappropriate. They are internally consistent but based on assumptions that may not be consistent with the economy. This really is a dangerous perspective that should be reconsidered if it was inserted here intentionally.

Comments of

Dr. Andrew Schmitz
University of Florida

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Review of the Multimarket Model

Professor Andrew Schmitz

University of Florida

January 18, 2012

Questions and Answers:

- Theoretical and practical expectations—No (as discussed later).
- Advantages of multimarket models—Multimarket models have the advantage of incorporating general equilibrium effects that partial market models cannot.
- Distributional impacts—The number of markets is sufficient. Here the modelers might want to look at a recent paper by Schmitz and Schmitz (2010) where they do a case study of the distributional impacts of terminating the peanut program.
- Surplus changes—My major concern is that this model does not adequately account for negative externalities. If there were no negative externalities, EPA would have no need or justification to introduce regulations. Consider the discussion below. In Figure 1, *S* is supply and *D* is demand. The competitive price is p_0 and the quantity is q_0. Note that in Figure 1, the social marginal cost is identical to the private cost. Now suppose that EPA introduces a regulation that reduces quantity to q_1 that raises price to p_1. Note that the regulation creates a net welfare loss, so why would it be introduced? The social loss is given by triangle *abc* as consumers lose p_1p_0ca and producers gain p_0p_2bc.

  Consider Figure 2 where separation is made between the private marginal cost curve (S_p) and the social marginal cost curve (S_s). The market equilibrium with

externalities corresponds to p_0 and $q0$. If EPA imposed an optimum regulation to correct for the externality, the quantity would be reduced to q_1 and price would rise to p_1. Now note that society loses from the regulation if only measured in the market depicted in Figure 2. This is because consumers lose p_1p_0ab from the regulation and the net effect on producers is $p_1cb - p_0ca$.

From a practical standpoint, it is very difficult to determine the optimal size of the regulation to correct for negative externalities. For example, in Figure 2, a regulation that reduces quantity below q_1 is too restrictive, but one that leaves output greater than q_1 is not restrictive enough. I suspect that, in many cases, the relationship between the size of regulation and its effect on a negative externality is nonlinear.

The correct model is given in Figure 3. The model in Figure 2 corresponds to Panel A. In Panel B (Figure 3), the supply for environmental services is given by S_E and demand by D_E. A movement from q_0 to q_1 (Panel A) through regulation generates a surplus of abc (Panel B). This positive surplus will exceed the net loss in surplus in Panel A from a regulation. Hence there will be a net gain from the regulation. So, unless Panel B is adequately taken into account, regulation will generate a negative gain in economic surplus (these results can be generated from the well-known textbook on this subject by Just, Hueth, and Schmitz [2005]).

- International trade—I had a hard time following how the model generates surplus results along the standard method of modeling trade impacts. For example, in Figure 4, the world price is given by p_w and exports are given by q_wq_0. At the extreme, a regulation that shifts supply to S' would cause exports to cease. The loss is given by $abcd$. However, if

one assumes a large-country effect, p_w will change once a regulation is introduced. One has to test a priori which sectors fit the large-country category and those that do not, so that the terms of trade effect can be handled properly. Then it is necessary, as before, to account for the gains from removing negative externalities that are not taken into account in the market represented in Figure 4.

- Supply and demand elasticities—Unfortunately, economists have stopped estimating elasticities for most commodities and sectors. The elasticities look okay. EPA may want to test their model to a range of elasticities (this is a common procedure, see Schmitz and Schmitz 2010).
- Shocking the model—For the sake of analysis, it seems that the tax approach is appropriate. On fuel switching, if there are added costs, the supply curve merely switches to the left. In terms of add-on costs, increased demand for pollution control equipment can be factored into the supply curve for the product that will shift the supply curve leftward or it can be added to the supply of services (Panel B, Figure 3).
- Further comments—My major concern is the treatment of negative externalities (see discussion above). Unless negative externalities are properly accounted for the results are going to show that regulations create net welfare losses (this has to be the case given the economic surplus approach that underlies this type of model). You may want to get some others involved who have had a considerable amount of experience in incorporating negative externalities into general equilibrium models.

References

Just, R., D. Hueth, and A. Schmitz. 2005. *The Welfare Economics of Public Policy: A Practical Approach to Project and Policy Evaluation*. Cheltenham, UK:: Elgar Publishing.

Schmitz, A. and T.G. Schmitz. 2010. Benefit-cost analysis: distributional considerations under producer quota buyouts. *Journal of Benefit-Cost Analysis* 1(1):Article 2. http://www.bepress.com/jbca/vol1/iss1/2 (DOI: 10.2202/2152-2912.1002).

Figures

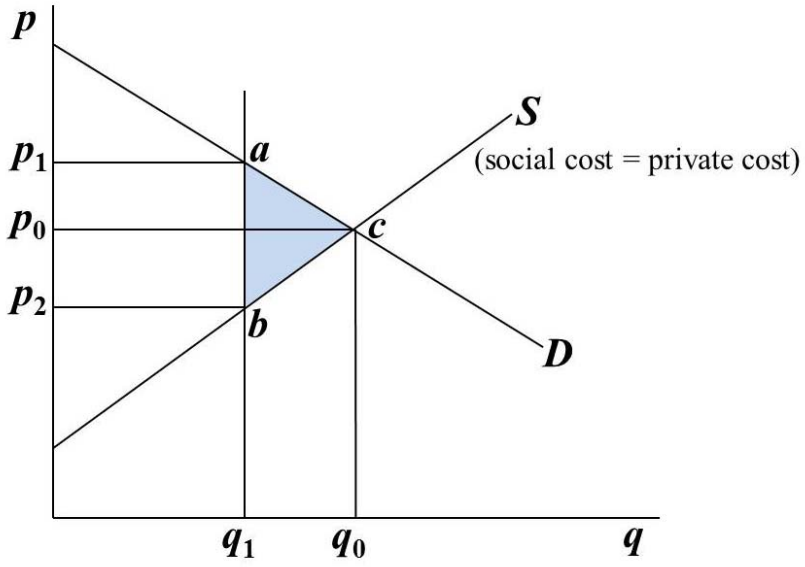

Figure 1

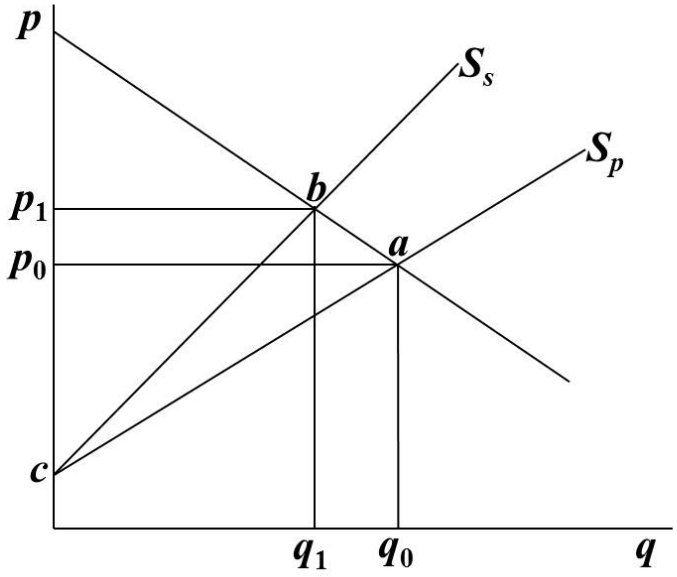

Figure 2

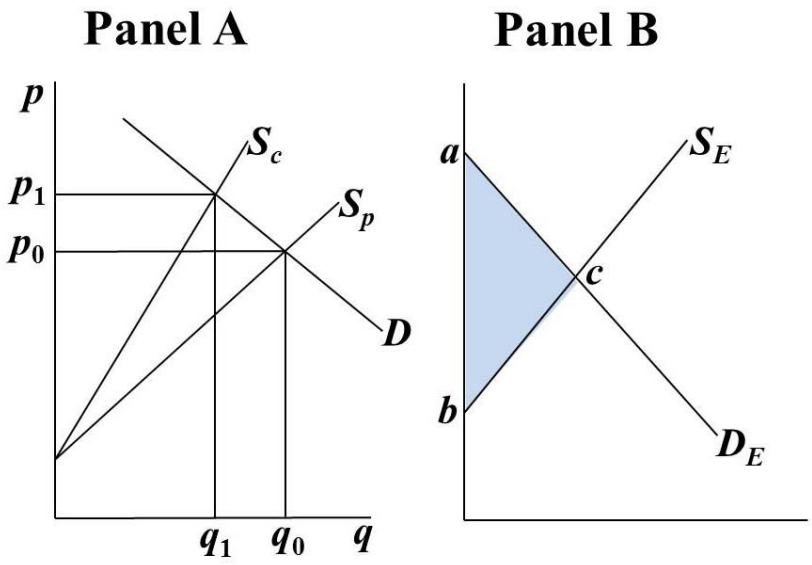

Figure 3

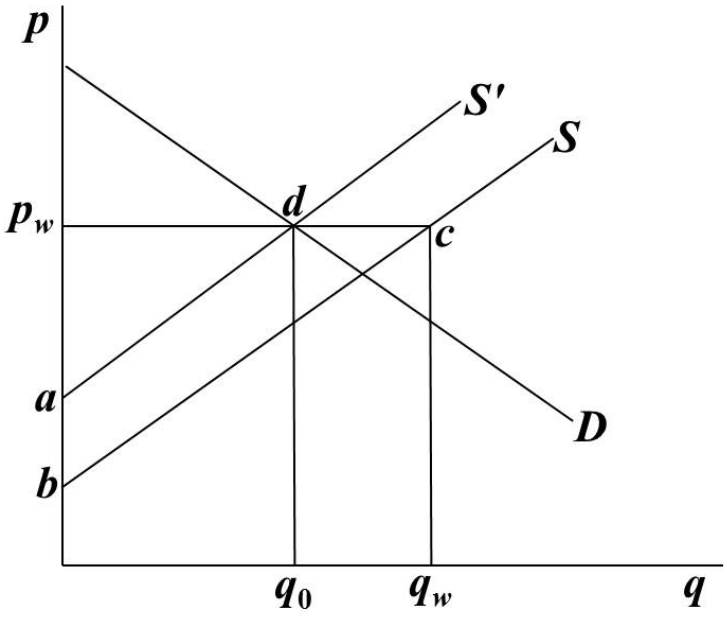

Figure 4

Comments of

Dr. Walter Thurman
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General Comments on the OAQPS Multimarket Model

Introduction

The work embodied in the multimarket model is impressive and high quality. Further, I am enthusiastically sympathetic with the goal of defensible benefit-cost analysis of EPA regulations in ways other than the simplest of supply-and-demand models or the most general and comprehensive of computable general equilibrium models. Use of the former begs the question of how to interpret the single-market supply and demand relations and how effectively other-market effects are represented in the one market. Use of the latter, while intellectually satisfying from a modeling perspective, entails guessing at system-wide parameters that typically are placeholders.

There is much to like about the model I reviewed. It is a comprehensive and painstaking effort to logically identify all the equilibrium effects of a regulation. My comments below tend to emphasize my concerns and questions about the model. Given my appreciation for the importance of the problem and for the quality of the work done in developing the model, my overall favorable opinion should not be lost sight of. I should also stress that several of the concerns I raise below are not easily addressed. They inhere in the economic problems that the multimarket model addresses.

In addition to reviewing the document "OAQPS Multimarket Model Documentation," I reviewed three applications of regulatory impact analysis by the EPA: (1) the 2011 RIA of boilers and heaters, (2) the 2007 impact analysis for the gasoline distribution industry, and (3) the 2010 analysis for the portland cement industry. The last two are not directly relevant to an understanding of the multimarket model (the gasoline distribution analysis was carried out within a partial equilibrium framework; the portland cement study was partial equilibrium and modeled imperfect competition) but were examined for guidance on the kinds of applications relevant to the EPA's analysis.

Finally, I found the review difficult to carry out because I found it difficult to fully engage in the structure of the model. The summary document goes into detail in some places and summarizes broadly in others. I think I finally understood what the model is doing, but if it were to be written again I would recommend that a small-scale version of the model be described in full detail, from the most primary inputs to final goods. For example, what would the model look like if there were only two intermediate and two final products? I think that such a version of the model would be simple enough to manipulate analytically–even graphically–but would communicate better the nature of the actual, much larger, model. This would be most helpful for those who come to the model in the future and wish to understand it and interpret its output. This comment is likely the most valuable one I will make.

General perspective

Ultimately all costs are borne by consumers, either through changes in prices or changes in incomes. The multimarket model appropriately measures all consumer costs at the final good level. "Consumer" surplus losses with respect to derived demands for intermediate inputs are appropriately ignored to avoid double counting.

The supply price of an intermediate input is determined by the costs of the inputs acquired from upstream markets, but also by the rate of production. The elasticity of supply can be thought of as capturing the marginal-cost-increasing effects of higher rates of output that ultimately derive from fixed factors. Either the factors directly involved in production are fixed–and those fixities give rise to rising marginal costs–or there are factors not explicitly priced in the model, but as output expands they can only be acquired at increasing prices (or lower qualities).

The description of the model is explicit about its assumption that intermediate inputs are combined in fixed proportions. To the extent that this is so, the only demand response to an increased input price is through the effect on output price, which causes a decrease in the quantity demanded of the final product. Thus, all derived demand effects are scale effects, and none are substitution. This is a logically consistent way to think about inter-market linkages, but it surely misses some substitution possibilities with a given capital stock, and misses more substitution possibilities if the capital stock actually adjusts.

The hierarchical structure of the model

The model documentation discusses final consumer demands and intermediate input supplies. Consumer surplus changes measured with respect to the final goods demand curves capture welfare changes due to regulation through changes in ultimate consumption value. Changes in producer surplus at intermediate and final levels capture changes in quasi-rents to factors fixed in the short run. But what of the most upstream inputs? Are there inputs that are less than perfectly elastically supplied to the model economy, but the production of which doesn't require inputs from further upstream levels of production?

If there are such basic inputs that are not intermediate, then there should be supply curves for those inputs. Equilibrium changes in the prices of such inputs induced by regulation should be calculated, and producer surplus changes should be measured with respect to their supply curves to capture changes in rents induced by regulation. Perhaps such input supply curves are special cases of the one given in equations (2) and (4a). If so, then my comment is more about the documentation than the model.

If there are not such inputs, then the most upstream outputs take as given prices that the model has no way of adjusting in equilibrium. Perhaps it is an assumption of the model that there are internationally traded inputs whose prices are fixed with respect to the interventions considered

by EPA policy. If so, that should be made explicit in the documentation and the reasonableness of those assumptions should be assessed.

The functional form of the supply relation

Equation (2) gives the supply relation in industry s as:

$$(2) \quad Q_s = b_s(P_s)^{\varepsilon_s} \quad ,$$

implying a functional form for MC (equal to price in a competitive industry) of:

$$(2') \quad P_s = MC_s = (Q_s/b_s)^{1/\varepsilon_s} \quad .$$

In subsequent analysis, the shift in the supply curve represented by regulation and the ensuing changes in factor prices is given by:

$$(4a) \quad Q_s = b_s(P_s - c_s - \sum_{i=1}^{n} \alpha_{sg}(P_g{}' - P_g))^{\varepsilon_s} .$$

Equation (4a) implies the following expression for industry marginal cost in the perturbed equilibrium:

$$(4a') \quad P_s = MC_s = (Q_s/b_s)^{1/\varepsilon_s} + c_s + \sum_{i=1}^{n} \alpha_{sg}(P'_g - P_g) .$$

I have a hard time reconciling equations 2' and 4a'. The former accounts for initial equilibrium input prices with the multiplicative constant b_s. The latter suggests that the functional form for MC adjusts for changes in prices additively. Expression 4a' suggests that the specification of the initial equilibrium might better be written as:

$$(i) \quad P_s = (Q_s/b_s)^{1/\varepsilon_s} + \sum_{i=1}^{n} \alpha_{sg} P_g$$

or

$$(ii) \quad Q_s = b_s (P_s - \sum_{i=1}^{n} \alpha_{sg} P_g)^{\varepsilon_s} \quad .$$

I can't tell exactly how the model is calibrated to the baseline year, but it seems to me that calibrating according to (ii) would give different results than calibrating according to (2).

Focusing on how the model specifies marginal cost is helpful in interpreting the surplus changes measured with respect to the calibrated supply curves. Equation (i) makes it clear that marginal cost is composed of two pieces: one reflecting a constant returns-to-scale combination of intermediate inputs at prices P_g and another reflecting the costs of using another factor, which is either fixed or purchased at prices that increase with production. Measuring producer surplus changes behind such a curve is a measurement of the changes in economic quasi-rents to factors that are fixed in the length of run considered.

Pre-existing distortions in other markets

Harberger (1971) and others (e.g., Just, Hueth, and Schmitz, 1982) have noted that partial equilibrium welfare analysis is complete only to the extent that allocations are efficient in related markets that are affected by the interventions (regulations) under consideration. That is, surplus measures behind an appropriately equilibrium demand curve–along which prices of substitutes vary as they do in equilibrium in other markets–will capture all extra-market gains *as long as there are no distortions in the other markets*. As was argued in the tax-interaction-effect literature, an extra-market distortion that is hard to ignore is the income tax. The income tax creates a wedge between the marginal value of leisure to workers and the value of their marginal product in employment. Thus, if an intervention in one market were to increase the employment of labor in another, the increase in employment in the other market generates welfare gains–welfare gains that are not captured in the surplus measure from the intervened-in market alone.

The model documentation specifically notes that these general equilibrium measures are not captured by the multimarket model. But noting that doesn't correct for the omission.

Values for elasticities

U.S. industry supply elasticities are benchmarked to supply elasticities for the same goods from the rest of the world. It is argued that U.S. supply is likely to be less elastic. I'm not sure why this should be the case. Further, the method of making U.S. supply less elastic is arbitrary. In the boiler report (p. A-21), it is stated that:

> "When we aggregated and averaged the original elasticities to the 3- and 4-digit NAICS level for our foreign supply elasticities, we also calculated the standard deviation of each 3- and 4-digit NAICS sample. By adding the standard deviation to the corresponding foreign supply and then taking the inverse, we were able to calculate a domestic supply elasticity for each sector that was lower than its foreign counterpart while maintaining the structure of the original elasticities."

This method has the advantage of being algorithmic, hence reproducible. But I cannot divine the

logic in adding the standard deviation. If domestic supply elasticities are less elastic than their import counterparts, why would the extent of the difference be related to the dispersion in supply elasticities in a particular industry grouping? And behind it all, what economic logic or empirical basis supports the claim that domestic supplies are less elastic than import supplies?

Geography

Industry models often have no spatial dimension, and the multimarket model also doesn't explicitly represent geography. The extent to which this omission is problematic relates to the importance of transportation costs relative to the value of output. For commodity markets, such as many grains and foodstuffs and some metals, the value per unit weight is low and transportation costs have important effects on prices. For example, changes in the cost of barge services on the Mississippi river have dramatic effects on the difference between the price of corn in the interior of Iowa and the price of corn ready for export in New Orleans. Thus, a change in barge rates due, say, to an increase in fuel prices can drive regional differences in output prices. If regulations in a market that is importantly affected by transport costs are geographically concentrated, the price effects will be different in different locations, even for otherwise identical production units facing a national market for output.

Particular applications of the multimarket model to situations where transportation costs were important could accommodate such spatial price linkages with equilibrium conditions that prices at receiving locations equal prices at producing locations plus transport costs. Transport costs themselves could be specified as depending upon quantities shipped and fuel costs.

In connection with the above I note that Food Manufacturing is an important industry in the boiler analysis, which includes Grain and Oilseed Milling as an industry group.

The 2011 boiler and heater analysis distinguishes between changes in employment that represent opportunity costs of labor displaced from other uses–when labor is fully employed–and changes in employment with lower opportunity costs–when there is substantial unemployment. These effects will be differentiated by geography due to spatial variation in the unemployment rate. This concerns more the particular boiler and heater application than the multimarket model, though the multimarket model might also be used to represent the effects of changes in employment as well.

Specific comments on the review document, "OAQPS Multimarket Model Documentation"

page, para, line	
1, 3, 4-5	Why are sector-specific equilibrium models impractical. Is it because it is expensive to continually reinvent the same wheel? Or does this statement refer to something else?
2, 2, last sentence	Wouldn't *all* sectors experience impacts from electricity price increases? The fact that the sentence says only that many sectors experience the secondary impact makes me think I might not understand the procedure being described.
4, 1, 1-2	Is "within their supply chain" synonymous with "for their inputs"? The supply chain terminology is not clear to me.
4, 3, 1	Why does the word "only" appear in the parenthetical phrase? Perhaps the statement refers to the assumed inelasticity of demand from government and investment. The statement could be more clear.
4, 10	The statement that "the model excludes both a national labor market and capital market" is hard to interpret. I think it means that neither demand for labor nor capital is explicitly modeled. I think that this means that the supply and demand relationships are general equilibrium with respect to wage rates and interest rates–they vary along the curves as prices change. Whether or not my interpretation is correct, the statement raises more questions than it answers.
5, 4	Can more be said about how the 35 sectors from the EMPAX-CGE model are expanded into the 100 sectors of the Multimarket model? It strikes me as an important implementation detail.
6, eq 2	Where are input prices in the supply model? Changes in input prices are incorporated into the post-regulatory shifts in supply curves, so their levels logically should appear in the specification of the pre-regulatory supply curve, even if they are absorbed into calibrating constants. At this point in my review, I'm not sure if this point is merely notational or more substantive. (More on this is said in my General Comments.)
8, eq 4a	Are factor prices, P_g, set equal to one in the baseline as output prices are?
9, eq 5	I think the supply elasticity should have an "s" subscript, not "g."
9, eq 6	If I understand the model, Q_g should be subscripted as Q_{sg}.

11, 1	Are the elasticities of import supply conceived of as net of U.S. exports to the rest of the world? Is that how Broda et al. conceived them?
11, 2	The bench marking of U.S. supply elasticities to import supply elasticities isn't clear. Over what set of observations are the mean and standard deviation referred to calculated?
12, 3, 6-8	In the typical cases that I can think of, general equilibrium (multimarket) demand curves will be less elastic than their partial equilibrium counterparts, not more elastic as is claimed in the text.

References

Harberger, Arnold, "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," *J. of Econ. Lit.* (1971).

Just, Richard, Darrell Hueth, Andrew Schmitz, *Applied Welfare Analysis and Public Policy*, 1982, Prentice-Hall, Englewood Cliffs, NJ.