530-295-2999 facsimile

PECHAN

3622 Lyckan Parkway
Suite 2002
Durham, NC 27707

919-493-3144 telephone
919-493-3182 facsimile

5528-B Hempstead Way
Springfield, VA 22151

703-813-6700 telephone
703-813-6729 facsimile

P.O. Box 1345
El Dorado, CA 95623

530-295-2995 telephone

EGAS 5.0 REGRESSION ANALYSES

FINAL
TECHNICAL MEMORANDUM

Prepared for:

Aaiysha Khursheed
Innovative Strategies and Economics Group
Office of Air Quality Planning and Strategies
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Prepared by:

Andy Bollman
E.H. Pechan & Associates, Inc.
3622 Lyckan Parkway, Suite 2002
Durham, NC 27707

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CONTENTS

TABLES

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CHAPTER I. INTRODUCTION

Credible emission growth factor projections are a vital input into a variety of regulatory analyses completed by the United States Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards (OAQPS). In order to produce these emission growth factors, EPA requires an accessible and flexible tool for translating forecasts of economic activity into projected air pollutant emissions growth. The Emissions Monitoring and Assurance Division (EMAD) developed the Economic Growth Analysis System (EGAS) to serve this purpose and to replace the use of Bureau of Economic Analysis (BEA) growth rates for the purpose of projecting emissions for regulatory support. Several versions of EGAS have been developed over the years; the latest version (4.0) was released in 2001. The purpose of this memorandum is to describe the regression analyses performed to develop emission activity growth equations for EGAS 5.0. The memorandum also provides a discussion of potential future improvements to the EGAS 5.0 regression analyses and equations.

CHAPTER II. SUMMARY OF REGRESSION ANALYSES PERFORMED IN SUPPORT OF EGAS 5.0

A. OVERVIEW

For EGAS 4.0, regression analysis categories were identified based on total criteria pollutant annual emissions from the 1996 National Emission Inventory (NEI). [For this effort, total criteria pollutant emissions included emissions from volatile organic compounds (VOCs), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter of 10 microns or less (PM_{10}).] The EPA identified these priority categories to reflect the largest contributing activities to total 1996 criteria pollutant emissions. The first step in identifying these activities was to sum the 1996 NEI emissions by source classification code (SCC) for SCCs that are assigned Regional Economic Models, Inc. (REMI) indicator growth factors in the EGAS 4.0 Crosswalk. These SCCs were then organized into common emission activities.[1] Next, EPA computed the emission activity-level emissions from the SCC-level emissions in the NEI. Finally, the emission activities were sorted by total emissions to identify the emission activities for which regression analyses were conducted.

For EGAS 5.0, EPA requested that new regression analyses be performed for these EGAS 4.0 emission activities, incorporating additional historical activity data and updated REMI economic models/data. The following sections describe the procedures and results of these new analyses.

B. METHODOLOGY

Pechan performed analyses that regressed national emission activity data against national data for variables identified as potentially correlated with the activity. Because of the constraints of the methodology (e.g., sole reliance on variables available from economic models developed by REMI), the regression analysis was not always successful in identifying variables that strongly correlated with emission activity levels. These instances are described in Section C.

1. Compile Emission Activity Data

The first step in conducting the EGAS 5.0 regression analysis was to compile available emissions activity data over the last three decades. Table II-1 identifies the emission activities included in the scope of this study and the data source(s) that were used to compile national annual data for each activity.

In some cases, Pechan was unable to obtain data for each year for the entire 30-year study period. For carbon black, for example, consistent annual production information was only available starting in

[1] The term "emission activity" refers to emission sectors that employ the same data to estimate emissions. Emission activities include the number of acres of agricultural fields burned, the number of barrels of crude oil refined, and the number of tons of steel produced.

1992. In these cases, Pechan utilized data in the regressions beginning with the first year for which a continuous series of data were available.

2. Identify/Compile Data for Potential Explanatory Variables

Pechan selected potential independent variables for the regression analyses from the variables available from economic models (version 5.5) produced by REMI (Houyoux, 2004). Table II-2 presents the REMI variables identified as potentially correlated to emission activity levels. The first row in each section of this table identifies the emission activity; subsequent rows display the REMI variables that were evaluated in the regression analyses. These variables, which mostly consist of industry sector output (sales), employment, and value added, were tested for their ability to explain the variance in the historical trend in national emission activity. Additional independent variables that were incorporated into some of the analyses included population, real disposable personal income, and gasoline and oil expenditures. Next, Pechan compiled national REMI data for the Table II-2 variables for the years of interest from version 5.5 of REMI's economic models (Houyoux, 2004).

3. Perform Analyses

Pechan regressed each emission activity against the potential REMI explanatory variables listed in Table II-2. Pechan also tested a one-period lagged dependent variable in the regression analyses. Linear, squared, and cubic equation forms were tested. The analyses were initially performed on the full series of data. If these analyses did not result in an equation representing a strong correlation with emission activity, Pechan conducted additional regression analyses using data starting in 1990 to reflect the potential impact of the 1990 Clean Air Act Amendments on emission activity trends. Pechan identified the equation representing the best statistical fit by selecting the equation with the highest adjusted coefficient of determination (i.e., R^2), while ensuring that the absolute value of the t-statistic for each independent variable was greater than 2.0.

It was also necessary to investigate whether autocorrelation was a problem. Autocorrelation, which exists when error terms corresponding to different points in time are correlated, results in misleadingly high R^2 values. Autocorrelation is a particular concern when performing regression analysis on time series data. The Durbin-Watson (D-W) statistic is calculated and compared to acceptable upper and lower limits to identify the presence of positive or negative autocorrelation. In many cases, the D-W test indicated the presence of autocorrelation for the best fit equation developed from the initial regression analyses. In these cases, Pechan conducted additional regression analyses after stationarizing the variables (i.e., converting the emission activity and REMI values into first differences or logarithms). Pechan also included one-period lagged independent variables in each analysis conducted on the first difference and log variables. Linear, squared, and cubic equation forms were tested on the series of variables and the best functional form was selected.

C. RESULTS

Table II-3 presents the best-fit emission activity estimation equation for each source category as determined from a review of adjusted R^2, t-statistic, and D-W values. Because the results of the regression analyses were not entirely successful for each emission activity with data, EGAS 5.0 will not incorporate equations for the emission activities that are shaded in Table II-3.

For some categories, Pechan developed regression equations at a more aggregate level than the emission activity because of concerns over extrapolating past historical relationships over a long time-frame. The major concern that this separate approach is designed to address is the likelihood that negative growth factors will result for categories for which a significant downward trend in activity was observed over the past couple of decades.

For these activities, the emission activity will be separated into two components: (1) aggregate activity (to which we correlate a REMI variable); and (2) the change in the emission activity of interest relative to this aggregate activity (which is not correlated to a REMI variable). For example, although architectural coating solvent consumption has decreased significantly in the recent historical period, this has not been a result of a reduction in use of architectural coatings, but rather a shift away from higher to lower solvent content coatings due to emission control requirements. In order to not continue to project this category based on the negative correlation between architectural coating solvent consumption and housing expenditures observed over the historical period, this activity will be separated into (1) an equation that estimates total architectural coating consumption (by regressing historical architectural coating demand against historical housing expenditure levels); and (2) an adjustment factor that accounts for the projected proportion of total coating consumption from solvent-based coatings. This two-step procedure will eliminate the possibility of negative growth factor results, and allows EPA to utilize projections that are available for the solvent-based coating adjustment factor.

Table II-4 presents the activities that will use this two-step forecasting approach. This table identifies the emission activities, the dependent variable included in the regression analyses, and the proposed adjustment to the regression equation output to yield the emission activity projections.

1. Weak Correlations/Inconclusive D-W Values

The regression analyses were not always successful in identifying variables that strongly correlated with emission activity levels. This problem occurred for primary aluminum and carbon black, where the adjusted R^2 values indicate that only 64 percent of the variation in primary aluminum production and carbon black production is explained by each category's equation. For primary aluminum, the equation relies on employment in the Primary Nonferrous Smelting and Refining sector (standard industrial classification [SIC] code 333), and the carbon black equation relies on value added in the Chemicals and Allied Products sector (SIC code 28).

For the Industrial Adhesives category, the initial best fit equation indicated a high adjusted R^2 value (89 percent). However, this equation exhibited autocorrelation. When the dependent and independent variables were transformed to eliminate this problem, the new best fit equation (using output in the

Miscellaneous Chemical Products sector [SIC code 289]) resulted in an adjusted R^2 value of only 68 percent.

The problems above are indicative of the limitations of the forecast variables available from REMI's economic models. The low explanatory power of these equations is likely caused by the lack of specificity of the REMI variables with respect to each emission process. In addition, price information, which is an important potential determinant of emission activity, is not available from the models. Therefore, it is not always possible to estimate an equation that explains a large proportion of the variation in each emission activity.

In addition, for several source categories, the D-W values were inconclusive, but alternative transformations were unable to improve upon these values. For example, the D-W for the structure fires category (1.25) fell within the inconclusive range at a 5 percent level of significance.

2. Use of Regional Data

It is important to note that there is one EGAS 5.0 category for which the best fit equation REMI indicator may be a poor indicator of local growth trends. For the Commercial Pesticide Application category, the best fit equation relies on employment in the Agricultural Chemicals sector (SIC code 287). Although a correlation holds at the national level between pesticide application and employment in this sector, it is not expected to hold in areas of the country where no or small amounts of pesticides are produced, but large amounts are used (and vice-versa). For this sector, it is more defensible to use the estimated equation at the national level, and then adjust the national growth rate based on local growth relative to national growth for employment in the farm sector, which should better correlate with where pesticides are applied.

D. RECOMMENDATIONS

Pechan has identified a number of recommendations for EPA consideration. These recommendations are described in the following sections.

1. Extend Regression Approach to Additional Emission Activities

Pechan recommends that EPA consider reviewing both the hazardous air pollutant (HAP) and criteria pollutant components of the 2002 National Emission Inventory (NEI) to identify major emitting activities for additional regression analyses. The list of activities for which regression analyses have been performed is based on the 1996 criteria pollutant NEI. Therefore, it is not clear that the major HAP-emitting sectors are covered by the existing regression equations or that the same set of major criteria pollutant categories exists in 2002 as 1996. However, the current budget for this assignment does not provide funding for this additional activity.

In addition, Pechan is currently supporting the Lake Michigan Air Directors Consortium (LADCO) in evaluating alternative emission activity growth methodologies. As part of this effort, Pechan conducted regression analyses for a set of priority source categories with the highest emissions in the states in the

Midwest Regional Planning Organization (RPO) region. When regional data were available, Pechan conducted the analyses using data specific to the Midwest RPO region. Because regional data were not available for every priority source category, some regression analyses were conducted using national data. For these source categories, which are identified below, Pechan will incorporate the regression analysis equations into EGAS 5.0. Table II-5 displays these source categories and the equations that will be incorporated.

2. Incorporate Two-Step Projection Approach for Additional Categories

It is important to note that each emission activity estimation equation was developed using National data. Because EGAS 5.0 will incorporate State forecast data into these equations, EGAS 5.0 assumes that the relationship observed at the national level holds in each region of the country. As noted in Table II-4, Pechan has developed a two-step procedure for estimating activity levels for categories with a consistent decline over the historical period. Depending on the values for the State-level REMI data that are input into the equation, it is possible that additional categories will yield negative values. Pechan recommends that EPA consider a two-step emission activity estimation procedure for additional categories for future versions of EGAS to the extent that any State-level REMI data results in negative growth factors for these categories.

3. Incorporate Additional Explanatory Variables

The current regression methodology only includes one REMI variable in each equation. In the future, Pechan recommends that EPA consider equations that utilize additional variables in an attempt to better characterize trends in emission activity levels. In particular, EPA should investigate the possibility of obtaining forecasts for additional explanatory variables (e.g., price) that would also assist in explaining trends in emission activity.

4. Update SCC Crosswalk

As part of the process of developing the emission activity growth indicator to SCC crosswalk required under Task 4, Pechan recommends that a review be conducted to ensure the validity of the current list of SCCs to which the regression equations should be applied, and to update the list for any SCCs that have been newly added to EGAS 5.0. In addition, Pechan has learned that it will not be possible at this time to incorporate the regression equations that include a lagged variable and/or that estimate emission activity differences rather than absolute emission activity levels (Khursheed, 2004). As part of the forthcoming SCC crosswalk, Pechan will identify the SCCs to which these equations would be applied in future versions of EGAS.

Table II-1. Emission Activities Included in Analysis

Emission Activity	Emission Activity Units	Years	Data Source(s)	Comments
Air Carrier	Landing and Take-Offs (LTOs)	All	FAA, 2004	
Aluminum	Thousand Tons	All	USGS, 2004a	
Architectural Coatings Paint Shipments	Thousand Short Tons	All	USCB, 2003	
Automobile Refinishing	Thousand Metric Tons	All	USCB, 2003	
Basic Oxygen Furnace	Million Short Tons	1972-1992	Pechan, 2001	
		1992-2002	USGS, 2004b USGS, 2004c	Values from these sources were applied to the 1992 value developed for EGAS 4.0
Blast Furnace	Thousand Metric Tons	All	USGS, 2004b	
Carbon Black	Thousand Short Tons	1992-1995	EPA, 2001	
		1996-2002	EPA 2004	These values were appended to the previous years' values
Cattle	Thousand Tons	1972-1993	BEA,1994	
		1993-2002	USDA, 2003a	Values from this source were applied to the 1993 value to project to 2002
Cement	Thousand Metric Tons	All	USGS, 2004d	
Commercial Pesticide Application	Millions of Pounds of Active Ingredient	All	EPA, 2002	
Commercial Vessel Diesel Fuel Consumption	Thousand Gallons	All	EIA, 2003a	
Construction	Thousand Acres	1974-1992	Pechan, 2001	
		1992-2002	NRCS, 2003	Values from this sources were applied to the 1992 value developed for EGAS 4.0
Crops Planted	Thousand Acres	All	USDA, 2003b	
Fluid Catalytic Cracking Units	Hundred Thousand Barrels	1972-1991	Pechan, 2001	
		1992-2002	OGJ, 2002; EIA, 2003b	These values were appended to the previous years' values
General Aviation	LTOs	All	FAA, 2004	
Industrial Adhesives Application	Thousand Short Tons	All	Pechan, 2001	
Military Aircraft	LTOs	All	FAA, 2004	
Sulfate Pulp Production	Thousand Short Tons	1972-1982	API, 1984	
	Thousand Short Tons	1983-1993	AF&PA, 1994	These values were appended to the previous years' values
	Thousand Short Tons	1994-2000	AF&PA, 2001	These values were appended to the previous years' values

Emission Activity	Emission Activity Units	Years	Data Source(s)	Comments
Railroad Diesel Fuel Consumption	Thousand Gallons	All	EIA, 2003a	
Stage II Gasoline	Thousand Barrels	All	EIA, 2003c	
Structure Fires	Thousand Tons	All	USCB, 2004.	

Table II-2. REMI Variables Included in Regression Analyses

Air Carriers	Aluminum Prebake	Architectural Coatings	Auto Refinishing
Air Transportation - SIC 45 Output	Primary Nonferrous Smelting & Refining - SIC 333 Output	Paints and Allied Products - SIC 285 Output	Population
Air Transportation -SIC 45 Employment	Primary nonferrous smelting & refining - SIC 333 Employment	Paints and Allied Products - SIC 285 Employment	Automobile Parking, Repair, and Services - SIC 752 - 754 Output
Air transportation -SIC 45 Value Added	Primary Metals Industries - SIC 33 Value Added	Chemicals and Allied Products - SIC 28 Value Added	Automobile Parking, Repair, and Services - SIC 752 - 754 Employment
Real Disposable Personal Income		Population	Auto Repair, Services and Parking - SIC 75 Value Added
Population		Real Disposable Personal Income	Vehicle and Parts Expenditures
		Housing Expenditures	Gasoline and Oil Expenditures
		Construction- SIC 15, 16, 17 (Output, Employment, & Value Added)	Real Disposable Personal Income

Basic Oxygen Furnace	Blast Furnace	Carbon Black	Cattle
Blast Furnaces and Basic Steel Products - SIC 331 Output	Blast Furnaces and Basic Steel Products - SIC 331 Output	Miscellaneous Chemical Products - SIC 289 Output	Farm - SIC 01, 02 Value Added
Blast Furnaces and Basic Steel Products - SIC 331 Employment	Blast Furnaces and Basic Steel Products - SIC 331 Employment	Miscellaneous Chemical Products - SIC 289 Employment	Farm- SIC 01, 02 Employment
Primary Metals Industries - SIC 33 Value Added	Primary Metals Industries - SIC 33 Value Added	Chemicals and Allied Products - SIC 28 Value Added	Meat Products- - SIC 201 Output
			Meat Products - SIC 201 Employment

Cement Dry Process	Commercial Pesticides	Commercial Vessel- Diesel	Construction
Hydraulic Cement - SIC 324 Output	Agricultural Chemicals - SIC 287 Output	Water Transportation - SIC 44 Output	Construction - SIC 15, 16, 17 Output
Hydraulic Cement - SIC 324 Employment	Agricultural Chemicals - SIC 287 Employment	Water Transportation - SIC 44 Employment	Construction - SIC 15, 16, 17 Employment
Stone, Clay and Glass Products - SIC 32 Value Added	Chemicals and Allied Products - SIC 28 Value Added	Other Transportation and Transportation Services - SIC 44, 46, 47 Value Added	Construction - SIC 15, 16, 17 Value Added
Construction- SIC 15, 16, 17 Output	Farm- SIC 01, 02 - Value Added	Total GDP	Housing Expenditures
Construction- SIC 15, 16, 17 Employment	Farm- SIC 01, 02 Employment		Population
Construction- SIC 15, 16, 17 Value Added	Agricultural Services- SIC 07 (Output, Employment, & Value Added)		Total GDP
	Population		

Table II-2 (continued)

Farm	Fluid Catalytic Cracking Units	General Aviation	Industrial Adhesives
Farm- SIC 01, 02 Value Added	Petroleum Refining - SIC 291 Output	Air transportation -SIC 45 Output	Miscellaneous chemical products - SIC 289 Output
Farm- SIC 01, 02 Employment	Petroleum Refining - SIC 291 Employment	Air transportation -SIC 45 Employment	Miscellaneous chemical products - SIC 289 Employment
Agricultural Services - SIC 07 Output	Petroleum and Coal Products - SIC 29 Value Added	Air Transportation - SIC 45 Value Added	Chemicals and Allied Products - SIC 28 Value Added
Agricultural Services - SIC 07 Employment	Fuel Oil and Coal Expenditures	Population	Durables Manufacturing (Output, Employment, & Value Added)
Agricultural Services, Forestry, Fisheries and Other - SIC 07-09 Value Added	Gasoline and Oil Expenditures	Real Disposable Personal Income	Non-Durables Manufacturing (Output, Employment, & Value Added)
Population (inverse)			Total Manufacturing (Output, Employment, & Value Added)

Military Aircraft	Stage II Gasoline	Pulp	Rail Diesel	Structure Fires
Federal Government Military - SIC 945 and 971 Value Added	Gasoline & Oil Expenditures	Pulp, Paper, and Paperboard Mills - SIC 261 - 263 Output	Railroad Transportation - SIC 40 Output	Population
Federal Government Military - SIC 945 and 971 Employment	Population	Pulp, Paper, and Paperboard Mills - SIC 261 - 263 Employment	Railroad Transportation - SIC 40 Employment	Housing Expenditures
Population	Real Disposable Income	Pulp and Paper and Wood Products - SIC 24-27 Value Added	Railroad Transportation - SIC 40 Value Added	Real Disposable Personal Income
Total GDP	Petroleum Refining- SIC 291 Output		Total GDP	Construction- SIC 15, 16, 17 Output
	Petroleum Refining- SIC 291 Employment			Construction- SIC 15, 16, 17 Employment
	Vehicle and Parts Expenditures			Construction- SIC 15, 16, 17 Value Added

Table II-3. Regression Analysis Results

	Air Carrier	Aluminum	Arch Coatings	Auto Refinishing	Basic Oxygen Furnace
Years Analyzed	1972-2002	1972-2002	1981-2001	1972-2002	1972-2002
Equation	LOG(y) = b0 + b1*LOG(x) + b2*LAG(LOG(y)) + b3*LAG(LOG(x))	yDIF = b0 + b1*DIF(x) + b2*LAG(DIF(x))	y = b0 + b1*x + b2*LAG(y)	LOG(y) = b0 + b1*LAG(LOG(y)) + b2*LOG(x)	yDIF = b0 + b1*DIF(x) + b2*LAG(DIF(x))^2
coeff (y-int.)	-0.012	0.010	-0.017	0.087	0.022
coeff(b1)	0.429	2.273	0.614	0.542	1.944
coeff(b2)	0.556	-1.062	0.437	0.401	7.007
coeff(b3)	-0.272				
REMI Variable	Air Transportation-SIC 45, Employment	Primary nonferrous smelting and refining-SIC 333, Employment	Housing Expenditures	Automobile Parking, Repair and Services-SIC 752-754 Output	Blast Furnaces and Basic Steel Products-SIC 331, Employment
R2	0.965	0.659	0.964	0.813	0.778
R2 adjusted	0.961	0.635	0.959	0.799	0.761
R2 prediction	0.945	0.608	0.950	0.764	0.701
t-stat (x1)	3.85	7.32	2.84	3.64	8.95
t-stat (x2)	3.30	-3.47	2.29	2.14	4.95
t-stat (x3)	-2.55				
t-stat (b0)	-1.74	0.65	-0.23	2.97	1.90
F-stat	220.74	27.11	237.63	56.70	45.63
D-W	1.49	2.14	1.93	2.10	2.28

Table II-3 (continued)

	Blast Furnace	Carbon Black	Cattle	Cement	Commercial Pesticides[1]
Years Analyzed	1972-2002	1972-2002	1990-2002	1972-2002	1980-1999
Equation	LOG(y) = b0 + b1*LOG(x) + b2*LAG(LOG(x)) + b3*LOG(x)^2	y = b0 + b1*x^3 + b2*LAG(y)	y = b0 + b1*LAG(y) + b2*LAG(y)^2 + b3*x^3	y = b0 + b1*x	LOG(y) = b0 + b1*LAG(LOG(y)) + b2*LOG(x)
coeff (y-int.)	0.012	0.473	-16.352	0.339	-0.003
coeff(b1)	2.409	0.019	32.851	0.641	0.480
coeff(b2)	-1.328	0.447	-15.397		0.334
coeff(b3)	1.256		-0.047		
REMI Variable	Blast Furnaces and Basic Steel Products- SIC 331, Employment	Chemicals and Allied Products- SIC 28, Value Added	Farm SIC 01,02 Value Added	Total GDP	Agricultural Chemicals- SIC 287, Employment
R2	0.948	0.663	0.924	0.922	0.797
R2 adjusted	0.941	0.637	0.892	0.920	0.770
R2 prediction	0.915	0.586	0.754	0.909	0.712
t-stat (x1)	13.25	3.11	4.46	17.92	3.81
t-stat (x2)	-7.87	2.84	-4.36		2.61
t-stat (x3)	5.76		-3.06		
t-stat (b0)	1.15	3.34	-4.29	5.56	-0.32
F-stat	151.18	25.60	28.44	321.20	29.40
D-W	1.67	1.98	2.58	1.40	2.19

Table II-3 (continued)

	Commercial Vessels	Construction	Farm	Fluid Catalytic Cracking Units	General Aviation
Years Analyzed	1972-2002	74,78,82,87,92,97,01,02	1972-2002	1972-2002	1990-2002
Equation	y = b0 + b1*LAG(y) + b2*x	y = b0 + b1*x	yDIF = b0 + b1*LAG(DIF(x)) + b2*DIF(x)^3	y = b0 + b1*LAG(y) + b2*x^3	yDIF = b0 + b1*LAG(DIF(x)) + b2*LAG(DIF(y))^2
coeff (y-int.)	-0.174	-0.724	0.007	0.512	0.015
coeff(b1)	0.528	1.783	1.221	0.660	-0.373
coeff(b2)	0.643		-347.306	-0.095	-22.147
coeff(b3)					
REMI Variable	Water Transportation-SIC 44 Output	Population	Farm- SIC 01, 02 Employment	Petroleum Refining-SIC 291 Employment	Air Transportation-SIC 45 Output
R2	0.839	0.974	0.733	0.954	0.791
R2 adjusted	0.826	0.970	0.712	0.950	0.739
R2 prediction	0.802	0.953	0.620	0.943	0.587
t-stat (x1)	3.55	15.03	6.40	8.74	-5.08
t-stat (x2)	2.51		-4.52	-4.48	-3.55
t-stat (x3)					
t-stat (b0)	-0.69	-5.14	1.61	4.71	2.88
F-stat	67.58	225.87	35.65	267.32	15.16
D-W	2.39	1.74	1.59	1.56	1.84

Table II-3 (continued)

	Industrial Adhesives[1]	Military Aviation	Sulfate Pulp	Railroad Diesel	Structure Fires	Stage II Gasoline
Years Analyzed	1990-2001	1990-2002	1971-2000	1972-2002	1985-2002	1990-2002
Equation	yDIF = b0 + b1*LAG(DIF(x))^3	LOG(y) = b0 + b1*LOG(x) + b2*LAG(LOG(x))^3	LOG(y) = b0 + b1*LAG(LOG(x))^3 + b2*LAG(LOG(y))	LOG(y) = b0 + b1*LOG(x) + b2*LOG(x)^3	y = b0 + b1*x + b2*x^3	LOG(y) = b0 + b1*LOG(x)^2
coeff (y-int.)	0.005	0.025	0.063	-0.03164	-0.007	0.006
coeff(b1)	-285.877	0.994	-21.562	0.564	1.136	7.419
coeff(b2)		-65.227	0.816	-1.009	-0.130	
coeff(b3)						
REMI Variable	Miscellaneous Chemical Products- SIC 289 Output	Federal Government Military- SIC 945 & 971 Value Added	Pulp, paper, and paperboard mills- SIC 261 Employment	Railroad Transportation- SIC 40 Employment	Housing Expenditures	Gasoline and Oil Expenditures
R2	0.718	0.825	0.961	0.900	0.987	0.901
R2 adjusted	0.683	0.781	0.958	0.893	0.985	0.890
R2 prediction	0.524	0.701	0.944	0.880	0.971	0.839
t-stat (x1)	-4.51	5.30	-2.25	9.67	7.49	9.05
t-stat (x2)		-6.07	11.98	-3.74	-3.94	
t-stat (x3)						
t-stat (b0)	0.19	2.26	2.94	-3.73	-0.06	2.22
F-stat	20.38	18.83	305.41	117.33	567.66	81.81
D-W	1.64	1.87	1.93	1.40	1.25	1.71

Notes:

DIF - refers to difference between current year value and previous year value

LOG - refers to logarithm of value

LAG - refers to previous year's value

[grey shading] - The equation for this category will not be incorporated into EGAS 5.0 because adjusted R^2 value is less than 70%

[1] This equation should not be used at a subnational level

Table II-4. Two-Step Forecasting Procedure Emission Activities

Emission Activity	Dependent Variable in Equation	Adjustment to Regression Output	Source of Adjustment
Architectural Coating Solvents	Architectural Coating Shipments (gallons)	Solvent-based architectural coating shipments per total architectural coating shipments	Freedonia, 2002a: "Table V-8. Architectural Paint Shipments by Type & Application" [extrapolated beyond last (2011) year]
Commercial Pesticide Solvents	Active Pesticide Ingredients (pounds)	Pounds of solvents used in Pesticides per Dollar of Agricultural Chemical shipments (1996$)	Freedonia, 2002b: "Table IV-22. Agricultural Chemical Market for Solvents" [extrapolated beyond last (2011) year]
Structure Fires	Number of Housing Units	Number of fires per 10,000 housing units	Time series extrapolation of historical trend (will not use linear extrapolation to avoid zero/negative values)

Table II-5. LADCO Study National Regression Analysis Results

	Consumer Solvents: All Coatings	Consumer Solvents: All FIFRA Products	Electronic and Other Electrical Surface Coating	Miscellaneous Manufacturing Surface Coating	Sulfite Pulping
Years Analyzed	1993-2000	1990-1999	1993-2002	1993-2002	1990-2000
Equation	y = b0 + b1*x	LOG(y) = b0 + b1*LOG(x)^3 + b2*LOG(x)^2	LOG(y) = b0 + b1*LOG(x)^3	y = b0 + b1*x^3	y = b0 + b1*x
coeff (y-int.)	2.317	-0.005	-0.005	0.997	1.994
coeff(b1)	-1.111	2290.7	-204.01	-0.110	-1.022
coeff(b2)		-128.97			
coeff(b3)					
REMI Variable	Chemicals & Allied Products - SIC 28 Value Added	Population	Elect. Components & Accessories - SIC 367 Employment	Misc. Manuf. Industries - SIC 39 Value Added	Paper & Allied Prods. - SIC 26 Value Added
R2	0.918	0.944	0.757	0.824	0.886
R2 adjusted	0.902	0.926	0.722	0.799	0.873
R2 prediction	0.841	0.755	0.649	0.723	0.818
t-stat (x1)	-7.49	7.17	-4.67	-5.73	-8.36
t-stat (x2)		-8.20			
t-stat (x3)					
t-stat (b0)	13.74	-1.15	-0.11	24.44	14.55
F-stat	56.03	50.94	21.78	32.85	69.89
D-W	2.01	2.29	1.91	2.20	1.98

Table II-5. (continued)

	Wood Furniture Surface Coating	Waferboard
Years Analyzed	1993-2002	1990-2002
Equation	DIF(y) = b0 + b1*DIF(x)^3	y = b0 + b1*x
coeff (y-int.)	0.060	-1.869
coeff(b1)	3024.3	3.22
coeff(b2)		
coeff(b3)		
REMI Variable	Furniture Fixtures - SIC 25 Employment	Construction - SIC 15, 16, 17 Employment
R2	0.925	0.94
R2 adjusted	0.914	0.934
R2 prediction	0.891	0.909
t-stat (x1)	9.29	12.53
t-stat (x2)		
t-stat (x3)		
t-stat (b0)	2.43	-6.39
F-stat	86.37	157.05
D-W	1.94	1.31

CHAPTER III. REFERENCES

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