Comparison of Methods for Computing Yearly Growth Rates from Weekly and Monthly Data, 1978 to 2005

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Keywords: Growth Rates; Time Series; Petroleum; Establishment Surveys; Seasonality

Abstract

The Energy Information Administration (EIA) collects weekly and monthly data on volumes for a variety of petroleum products. Monthly data generally come from a census of appropriate companies. Weekly data are from samples of these companies. Estimates of total volume are then formed from these data.

The approximate release times of the estimates are:
Monthly estimates based on weekly data (called Monthly-from-Weekly and abbreviated MFW)---11 days
Preliminary estimates from the monthly census---60 days
Final reported volumes that include late submissions and resubmissions---September of the following year.

The gold standard for computing yearly growth rates in this paper is the final reported volume for a particular time period divided by the final reported volume for that same time period in the previous year. However, EIA customers, such as financial analysts and industry experts, want estimates of yearly growth quickly. So, oftentimes, the gold standard is not practical.

This study focused on constructing practical alternatives to the gold standard. The questions investigated were:

1. If MFW or preliminary estimates are used as the numerators, what are the best denominators to use?
2. If cumulative volumes for 3-, 6-, or 9-months or an entire year based on MFW or preliminary estimates are used as numerators:
    a. What are the best denominators?
    b. Is there seasonality in the growth rates?

The criteria for deciding between the alternative ratios were the differences in means and standard deviations, mean square error, and correlations with the gold standard. Ratios were further compared on percentage of times they were within 1% and 2% or in the same direction (both positive or both negative) as the gold standard. Data from 1978 through 2005 were used. The focus of this paper is the total volume supplied of all grades and types of finished motor gasoline. Similar results were obtained when total volume for all types of distillate fuel oil was used.

Although different methods did better on certain criteria, overwhelmingly the best denominator in all cases was the preliminary estimate. No seasonality or other patterns were found in the growth rates, even though there is seasonality (periodicity of 12 months) in the monthly volumes used to compute the ratios.

Introduction

Statement of Purpose

This paper is part of a bigger project to compare the congruence of the monthly volumes for finished motor gasoline supplied, distillate fuel oil supplied, and total product supplied as reported in various publications of the Petroleum Division of the Energy Information Administration (EIA). The focus of this paper is to compare six methods of computing yearly growth rates using data from 1978 to 2005 for finished motor gasoline supplied. The ideal ratio or gold standard (which will

also be called Method A) is formed using the final reported volumes from *Petroleum Supply Annual* (*PSA*) for a certain time period in one year divided by the *PSA* reported volumes for the previous year during the same time period.

Each of the growth rates methods, including Method A, is based on either monthly-based estimates and/or weekly-based estimates. The monthly-based estimates used in computing these growth rates are the preliminary estimates from *Petroleum Supply Monthly* (*PSM)* and the final reported volumes from *PSA*. The *PSA* reported volumes are updates of the preliminary PSM values and include late submissions and resubmissions with corrections.

Although there are multiple approaches for deriving monthly estimates from weekly data, based on earlier work (Blumberg, 2007; Kirkendall & Martin, 1993) it was decided to use only the monthly-from weekly (MFW) approach. The MFW estimates are weighted means of the weeks that have any days within a particular month. Some of this earlier work, that will be described further below, showed that, when yearly growth rates comparing a month from one year to that same month in a previous year, the differences are meaningfully insignificant between the different methods of computing monthly volumes from weekly data. The MFW was chosen because it is the one used in *Weekly Petroleum Status Report* (*WPSR*) and in *PSM*. As its title implies, *WPSR* is published weekly (usually on Wednesdays) and uses the weekly samples of companies as its data source for product supplied volumes. A week is defined by EIA for product supplied volumes as starting on a Friday at 7:01 a.m. and ending the next Friday at 7 a.m..

The reason that comparing growth rates based on weekly data, monthly data as reported in *PSM*, and monthly data as reported in *PSA* is important is that the weekly-based estimates for a month are available approximately 11 days of the end of the month while the *PSM* and *PSA* data take longer to be released. The *PSM* data are available within 60 days of the end of month. For example, the *PSM* that included data through March 2007 was released on May 30, 2007. The *PSA* values are released approximately nine months after the end of the calendar year that they cover.

Since the weekly-based estimates are based on samples and the *PSM* and *PSA* measurements are based on censuses of the same populations, the *PSM* and *PSA* data are generally more accurate, with the *PSA* measurements being more accurate than the *PSM* measurements due to corrections made between the publication of the *PSM* values and the *PSA* values. So, the question of main interest here is whether growth rates using weekly-based estimates and/or *PSM* values can mirror closely the growth rates computed using the *PSA* numbers as both the numerator and the denominator.

This paper will be divided into five major parts. The first part is this introduction. The second part will summarize earlier work done by the author when one-month periods were examined. The third part will investigate what methods best approximate Method A for computing yearly growth rates when three-month periods are used. The fourth part will investigate what methods best approximate Method A when computing cumulative growth rates based on the first 3 months, first 6 months, first 9 months, and/or an entire year are used. The fifth part takes some of the inconclusive results from the second, third, and fourth parts and studies those results further to be able to make better conclusions.

Definitions

Product Supplied
Product Supplied is defined by EIA as equal to (Field Production + Refinery and Blender Net Production + Imports + Adjustments) – (Stock Change + Refinery and Blender Net Inputs + Exports).

Monthly-from-Weekly Estimates
The monthly-from-weekly (MFW) estimates are weighted averages of the weeks that contain the days of a certain month. For example, for April 2007, the weighted average was {5*(data reported for 4/6/07) + 7*(data reported for 4/13/07) + 7*(data reported for 4/20/07) + 7*(data reported for 4/27/06) + 4*(data reported for 5/4/07)}/30.

Gold Standard (Method A)
This paper will take as the "gold standard" the year-to-year growth rate as defined by
$A(Period,t) = \left(\frac{Period_{PSA}(t)}{Period_{PSA}(t-1)} - 1 \right) * 100\%$ where Period is defined by the cumulative number of months under consideration (either 1, 3, 6, 9 or 12 months for this paper) and t = number of years since 1978 and where *PSA* is the volume reported in *Petroleum Supply Annual*. This method will be abbreviated throughout the paper as Method A. Method A will be compared to the following five other methods of defining year-to-year growth rates.

Method 1

Method 1 uses $\left(\frac{Period_{PSM}(t)}{Period_{PSA}(t-1)}-1\right)*100\%$ where *PSM* = the volume reported in *Petroleum Supply Monthly*. This is the method used by EIA's *Short-Term Energy Outlook (STEO)* when preparing Figure 8 (U.S. Petroleum Products Consumption Growth.)

Method 2

Method 2 uses $\left(\frac{Period_{PSM}(t)}{Period_{PSM}(t-1)}-1\right)*100\%$. Method 2 is presently not used in any EIA publications.

Method 3

Method 3 uses $\left(\frac{Period_{MFW}(t)}{Period_{MFW}(t-1)}-1\right)*100\%$. Method 3 is presently not used in any EIA publications.

Method 4

Method 4 uses $\left(\frac{Period_{MFW}(t)}{Period_{PSM}(t-1)}-1\right)*100\%$. Method 4 is presently not used in any EIA publications, although a slight variant of it is used in Table 1 of *WPSR*.

Method 5

Method 5 uses $\left(\frac{Period_{MFW}(t)}{Period_{PSA}(t-1)}-1\right)*100\%$. Method 5 is presently not used in any EIA publications.

Table 1 shows the relationships between the 6 methods.

Table 1. Relationships Between the 6 Methods

		Numerator	
Denominator	***PSA***	***PSM***	**MFW**
PSA	Method A	Method 1	Method 5
PSM		Method 2	Method 4
MFW			Method 3

Data Source

The monthly values for the *PSA*, *PSM*, and MFW are regularly extracted from the publication files of the appropriate publications and put into an Excel file by colleagues at EIA. This Excel file was used as the data source for this paper. The Excel file is in thousand barrels per day. It was decided to convert the data to million barrels per month so that cumulative volumes supplied over the different portions of the year would be easier to examine. It should be noted that the data in the Excel file are rounded to whole numbers. The conversion to million barrels per month caused some loss of precision, but this loss was slightly less than if the means in thousand barrels per day over the 3-, 6-, 9-, and 12-month periods had been computed.

Descriptive Statistics for the Raw Data

Descriptive statistics for the raw data may be needed by the reader to help interpret some of the results in this paper. These statistics are given in Tables 2 and 3. Table 2 is for 1- and 3-month periods. Table 3 is for 6-, 9-, and 12-month periods. The

major things to notice are that the means, medians, and standard deviations for *PSA*, *PSM*, and MFW are very close to each other for all sub-tables within Tables 2 and 3. Further, the standard deviations are close across all 3-month periods and across both 6-month periods, even though the means change due to seasonal demand. Further, the *PSA* means are greater than the *PSM* means and both are, in general, greater than the *MFW* means. Although not shown here, the distribution of the raw data for each of the three measurements (*PSA*, *PSM*, and MFW) for all months over the 28 years (n = 336) is approximately normally distributed.

Table 2. Descriptive Statistics for Finished Motor Gasoline Supplied for One-Month and Three-Month Periods, 1978-2005 (million barrels)

Measurement	Mean	Standard Deviation	Median	Minimum	Maximum	Percent of the Time Greater Than PSA	Percent of the Time Greater Than PSM	Percent of the Time Greater Than MFW
All Months Individually (n=336)								
PSA	232.06	27.15	227.57	168.00	295.65	--	62.20	61.90
PSM	231.54	26.80	227.35	168.61	293.07	34.82	--	55.36
MFW	231.10	27.01	227.12	168.00	293.32	37.80	44.35	--
First 3 Months (January to March) (n=28)								
PSA	658.65	71.97	638.61	558.69	805.87	--	75.00	64.29
PSM	657.25	71.16	638.22	558.06	799.13	25.00	--	60.71
MFW	657.02	73.21	635.69	554.52	802.92	35.71	39.29	--
Second 3 Months (April to June) (n=28)								
PSA	706.17	73.13	686.60	608.58	842.63	--	75.00	75.00
PSM	703.83	71.88	684.24	608.15	842.27	25.00	--	67.86
MFW	699.13	73.39	678.16	583.83	849.18	25.00	32.14	--
Third 3 Months (July to September) (n=28)								
PSA	717.27	78.18	694.43	610.30	858.24	--	71.43	53.57
PSM	715.75	76.80	693.33	610.02	852.60	28.57	--	53.57
MFW	716.64	75.52	701.02	606.50	848.70	46.43	46.43	--
Fourth 3 Months (October to December) (n=28)								
PSA	702.41	77.78	681.83	598.43	841.71	--	75.00	57.14
PSM	701.45	76.98	681.80	597.60	840.02	25.00	--	53.57
MFW	700.07	78.67	678.10	588.49	841.46	42.86	46.43	--
All 3 Month Periods Individually (n=112)								
PSA	696.13	77.60	681.70	558.69	858.24	--	74.11	62.50
PSM	694.57	76.57	681.62	558.06	852.60	25.89	--	58.93
MFW	693.21	77.43	678.16	554.52	849.18	37.50	41.07	--

Notes:
(1) *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* MFW = Monthly estimates based on weekly data.

(2) The complementary percentages in the "Percent of the Time Greater Than …" columns for the "All Months Individually" portion of the table do not add to 100 percent since in a few instances the *PSA*, *PSM* or MFW monthly values were equal to each other.

Table 3. Descriptive Statistics for Finished Motor Gasoline Supplied for Six-Month, Nine-Month, and Twelve-Month Periods, 1978-2005 (million barrels)

Measurement	Mean	Standard Deviation	Median	Minimum	Maximum	Percent of the Time Greater Than PSA	Percent of the Time Greater Than PSM	Percent of the Time Greater Than MFW
First 6 Months (January to June) (n=28)								
PSA	1364.64	144.50	1319.75	1174.99	1643.89	--	67.86	75.00
PSM	1360.90	142.47	1317.44	1173.33	1639.14	32.14	--	60.71
MFW	1355.99	145.82	1311.12	1138.22	1651.90	25.00	39.29	--
Second 6 Months (July to December) (n=28)								
PSA	1419.68	155.91	1375.17	1209.16	1699.95	--	75.00	67.86
PSM	1417.20	153.70	1374.22	1207.62	1690.96	25.00	--	57.14
MFW	1416.71	153.78	1375.51	1194.99	1688.20	32.14	42.86	--
All 6 Month Periods Individually (n=56)								
PSA	1392.16	151.51	1353.15	1174.99	1699.95	--	71.43	71.43
PSM	1389.05	149.56	1350.55	1173.33	1690.96	28.57	--	58.93
MFW	1386.35	151.61	1342.05	1138.22	1688.20	28.57	41.07	--
First 9 Months (January to September) (n=28)								
PSA	2082.09	222.22	2014.35	1788.44	2500.91	--	67.86	67.86
PSM	2076.82	218.69	2010.52	1787.54	2491.93	32.14	--	50.00
MFW	2072.79	220.57	2009.97	1744.84	2498.84	32.14	50.00	--
Entire Year Total (January to December) (n=28)								
PSA	2784.07	299.69	2694.65	2386.46	3342.18	--	78.57	78.57
PSM	2777.83	295.31	2691.38	2385.06	3329.90	21.43	--	60.71
MFW	2772.40	298.60	2683.07	2332.90	3340.02	21.43	39.29	--

Note:
PSA = Petroleum Supply Annual; *PSM = Petroleum Supply Monthly;* MFW = Monthly estimates based on weekly data.

Evaluation Criteria for Comparing the Methods

For Study 1, Study 2, and Study 3 the methods are compared first using the descriptive statistics of the mean, standard deviation, mean square error and correlations with the "gold standard" of Method A. Also, the growth rates given by Method A and by the other methods are compared using paired (matched) t-tests. Next, the other methods are compared in terms of the percentage of the time that they are within 1% and within 2% of Method A. Further, the other methods are compared to Method A in terms of the percentage of the time that they give growth rates in the same direction (that is, both give positive growth rates or both give negative growth rates) as Method A. For Study 4, the above criteria will be used to compare directly to each other the methods that looked most promising from the first three studies.

STUDY 1
Comparison of Growth Rates Based on One-Month Periods

Study 1 was a preliminary study and used data only from 1995 through 2004. It compared 15 methods of using the monthly data from *PSA* and *PSM* and the weekly data from *WPSR* to form year-to-year growth rates. In addition to the gold standard of Method A and the five methods described in the introduction to this paper, growth rate ratios were also formed using two other approaches of computing monthly estimates from weekly data. These other two approaches were (i) computing the mean of the four weeks preceding the last Friday of the month and (ii) computing the mean of the four weeks that contain the most days of the month. When the values computed using these two other approaches replaced the MFW values it was found that there were no statistically significant or meaningfully significant differences between the use of MFW and these other two approaches. So, it was decided to use only MFW to compute monthly estimates from weekly numbers in Study 2, Study 3, and Study 4. Further, some methods were tried that used *PSM* values as the denominator for the first six months of the year and *PSA* values as the denominator for the last six months of the year. These "hybrid" methods did not perform well. Hence, it was decided not to look at these "hybrid" methods in further investigations. See Blumberg (2007) for details.

Table 4 provides a summary of the comparisons of Methods 1 to 5 to Method A when one-month periods are used. It was found that Method 2, that has *PSM* for the present year in the numerator and *PSM* for the previous year in the denominator, is the best method to use to approximate growth rates as calculated by Method A. It has descriptive statistics that are the closest of all 14 methods to Method A. Its correlation with Method A is .905. Further, its year-to-year growth rates are within 2% of Method A more often than other methods. Finally, far less of the time, it gives a different direction for year-to-year growth rates than Method A does as compared to the other methods (except for Method 1.) It can also be seen that Method 3 does the worst and that Methods 4 and 5 do about the same as compared to Method A.

STUDY 2
Comparison of Growth Rates Based on Three-Month Periods

For this study, quarters are defined in the usual way as: first quarter = January to March; second quarter = April to June; third quarter = July to September; and fourth quarter = October to December. The 1978 data were used only in the denominators for the 1979 growth rate ratios.

Descriptive Statistics

Table 5 gives the means, standard deviations, and correlations with Method A along with the other major evaluation criteria statistics for the six growth rate methods. Table 6 gives more details about the descriptive statistics, including means, standard deviations, medians, minimums, maximums, and ranges of the growth rate methods.

The methods that use *PSM* as the numerator have high correlations with Method A of .982 (Method 2) and .986 (Method 1) and their standard deviations, minimums, maximums and ranges are extremely close to that of Method A (see Table 5.) Method 1 (*PSM/PSA*), however, has a lower mean than Method A in all four quarters separately and combined (see Table 6.) Method 2 (*PSM/PSM*) has means fairly close to Method A.

The three methods that use MFW as the numerator have good correlations with Method A between .802 and .877 (R^2 between .643 and .769) and their standard deviations are close to that of Method A for all quarters separately and combined. Method 3 (MFW/MFW) has a higher mean overall than Method A. It also has higher means for each quarter separately, except for the third quarters where Method 3's mean is lower than Method A's. Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) have lower means overall than Method A and this holds true for all quarters separately, except for third quarters where Method 4 has a lower mean than Method A and Method 5 has a higher mean than Method A.

Table 4. Major Statistics Used to Evaluate the Year-to-Year Growth Rate Methods for Finished Motor Gasoline Supplied when Monthly Periods are Used, 1995-2004

Method Number	Method in Symbols	Mean	Standard Deviation	Correlation with Method A	Difference in Mean from Method A	p-value for the Difference	Percent of Time Within 1% of Method A	Percent of Time Within 2% of Method A	Percent of Time in Same Direction
A	**PSA/PSA**	**1.846**	**1.892**	**--**	**--**	**--**	**--**	**--**	**--**
1	PSM/PSA	1.442	1.974	0.941	0.404	<.0001	83.33	96.67	95.00
2	PSM/PSM	1.819	1.907	0.905	0.028	0.716	80.83	97.50	92.50
3	MFW/MFW	1.852	2.155	0.438	-0.005	0.978	34.67	69.17	76.67
4	MFW/PSM	1.840	2.137	0.665	0.006	0.971	44.17	75.00	85.00
5	MFW/PSA	1.463	2.154	0.721	0.383	0.007	44.17	78.33	83.33

Notes:

(1) All statistics in this table are based on 120 observations (12 months for each of the years 1995 to 2004.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular month in a particular year for the measure listed and the symbols in the denominator represent the value from the same month in the previous year. *PSA = Petroleum Supply Annual*; *PSM =Petroleum Supply Monthly;* MFW = Monthly estimates based on weekly data.

(3) The values in the third, fourth, and sixth columns are year-to-year growth rates expressed as percentages. For example, the mean year-to-year growth rate using Method A for the 120 months from January 1995 to December 2004 was 1.846 percent and the standard deviation was 1.892 percent.

(4) The symbol -- in the Method A row represents "Not Applicable".

(5) The correlations reported here are Pearson Product-Moment correlations of the year-to-year growth rates determined by Methods 1 to 5 with the year-to-year growth rates for Method A. All correlations have a probability value (p-value) of <.0001.

(6) The percentages reported in the sixth column are mean differences in year-to-year growth rates. For example, the mean difference between Method A for year-to-year growth rate for the 120 months and the *PSM/PSM* ratio (Method 2) for year-to-year growth rate for the 120 months is 0.028 percent (that is, Method A's mean is 0.028 percent higher.)

(8) The percentages reported in the eighth and ninth columns are the percentage of times that each method gives an answer within 1% (eighth column) or 2% (ninth column) of the ratio defined by Method A. For example, for Method 2, 80.83 percent of the time it gives a year-to-year growth rates within 1% of the growth rate given by Method A and 97.50 percent of the time it is within 2% of the Method A growth rate.

(9) The last column gives the percentage of times that each method gives a growth rate in the same direction as Method A. That is, it is the percentage of the time that each method and Method A both give positive growth rates or both give negative growth rates. For example, 92.50 percent of the time Method 2 and Method A are either both positive or both negative.

Table 5. Major Statistics Used to Evaluate the Year-to-Year Growth Rate Methods for Finished Motor Gasoline Supplied Based on Quarterly Sums, 1979 to 2005

Method Number	Method in Symbols	Mean	Standard Deviation	Pearson Correlation with Method A	Difference in Mean from Method A	p-value for the Difference	Percent of the Time Within 2% of Method A	Percent of the Time in the Same Direction
A	**PSA/PSA**	**0.823**	**2.549**	**--**	**--**	**--**	**--**	**--**
1	PSM/PSA	0.600	2.525	0.986	0.223	<.0001	100.00	94.44
2	PSM/PSM	0.808	2.592	0.982	0.015	0.7526	100.00	96.30
3	MFW/MFW	0.837	2.865	0.802	-0.015	0.9302	83.33	80.56
4	MFW/PSM	0.599	2.640	0.877	0.224	0.0742	90.74	87.96
5	MFW/PSA	0.391	2.579	0.876	0.432	0.0006	90.74	85.19

Notes:

(1) All statistics in this table are based on 108 observations (four quarters for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The values in the third, fourth, and sixth columns are year-to-year growth rates expressed as percentages. For example, Method A over the 108 quarters from 1979 to 2005 has a mean ratio of 0.823 percent and a standard deviation of 2.549 percent.

(4) The symbol -- in the Method A row represents "Not Applicable".

(5) The correlations reported here are Pearson Product-Moment correlations of the year-to-year growth rates determined by Methods 1 to 5 with the year-to-year growth rates for Method A. All correlations have a probability value (p-value) of <.0001.

(6) The sixth column is mean differences in year-to-year growth rates. For example, the mean difference between Method A and Method 2 for the 108 quarters is 0.015 percent (that is, Method A's mean is 0.015 percent higher.)

(7) The percentages reported in the eighth column are the percentage of times that each method gives a growth rate within 2% of the growth rate given by Method A. For example, for Method 3, 83.33 percent of the time it is within 2% of the Method A growth rate.

(8) The last column gives the percentage of the time that each method gives a growth rate in the same direction as Method A. That is, it is the percentage of the time that each method and Method A both give positive growth rates or both give negative growth rates. For example, 80.56 percent of the time Method 3 and Method A are either both positive or both negative.

Table 6. Descriptive Statistics for the Year-to-Year Growth Rates (as Percentages) for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Mean	Standard Deviation	Median	Minimum	Maximum	Range
All Quarters (n = 108)							
A	**PSA/PSA**	**0.823**	**2.549**	**1.420**	**-8.320**	**5.173**	**13.493**
1	PSM/PSA	0.600	2.525	1.079	-8.566	4.459	13.025
2	PSM/PSM	0.808	2.592	1.326	-8.693	5.293	13.986
3	MFW/MFW	0.837	2.865	1.461	-7.899	5.378	13.277
4	MFW/PSM	0.599	2.640	1.381	-9.214	5.093	14.307
5	MFW/PSA	0.391	2.579	0.776	-9.088	5.058	14.146
First Quarters (n = 27)							
A	**PSA/PSA**	**0.960**	**2.780**	**1.845**	**-8.320**	**5.173**	**13.493**
1	PSM/PSA	0.744	2.675	1.303	-8.258	4.364	12.622
2	PSM/PSM	0.946	2.752	1.387	-8.550	5.293	13.843
3	MFW/MFW	1.004	3.140	1.318	-7.377	5.378	12.755
4	MFW/PSM	0.892	2.689	1.396	-5.604	4.244	9.848
5	MFW/PSA	0.692	2.650	0.412	-5.303	4.270	9.573
Second Quarters (n = 27)							
A	**PSA/PSA**	**0.757**	**2.456**	**1.062**	**-6.042**	**4.169**	**10.211**
1	PSM/PSA	0.422	2.392	0.625	-6.047	4.202	10.249
2	PSM/PSM	0.754	2.514	0.817	-6.112	4.897	11.009
3	MFW/MFW	0.809	2.911	1.575	-6.385	5.008	11.393
4	MFW/PSM	0.046	2.695	0.884	-6.729	3.987	10.716
5	MFW/PSA	-0.286	2.527	0.314	-6.664	3.619	10.283
Third Quarters (n = 27)							
A	**PSA/PSA**	**0.785**	**2.485**	**1.110**	**-7.590**	**4.100**	**11.690**
1	PSM/PSA	0.580	2.515	0.929	-7.822	4.459	12.281
2	PSM/PSM	0.760	2.540	1.036	-7.862	4.494	12.356
3	MFW/MFW	0.695	2.823	1.435	-7.899	5.163	13.062
4	MFW/PSM	0.859	2.378	1.429	-6.746	5.093	11.839
5	MFW/PSA	0.680	2.374	1.334	-6.705	5.058	11.763
Fourth Quarters (n = 27)							
A	**PSA/PSA**	**0.789**	**2.603**	**1.550**	**-8.307**	**3.974**	12.281
1	PSM/PSA	0.652	2.640	1.350	-8.566	3.485	12.051
2	PSM/PSM	0.771	2.697	1.489	-8.693	3.500	12.193
3	MFW/MFW	0.841	2.726	1.487	-7.842	4.307	12.149
4	MFW/PSM	0.598	2.840	1.467	-9.214	4.118	13.332
5	MFW/PSA	0.478	2.769	1.248	-9.088	4.099	13.187

Notes for Table 6:

(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The values in the third through eighth columns are year-to-year growth rates expressed as percentages. For example, Method A over the 108 quarters from 1979 to 2005 has a mean ratio of 0.823 percent and a standard deviation of 2.549 percent.

(3) Totals across components, where applicable, may not add due to independent rounding.

Effects of Outliers on the Results

The effects of outliers were considered carefully, since all of the methods being compared use ratio estimators. A growth rate that looks like a potential outlier may be caused by having a numerator or denominator that is larger or smaller than expected for the period under consideration. Sometimes the individual numerator and denominator may be outliers, but their ratio may not be an outlier. It was found that there were some outliers, but that these outliers had no meaningful effects on the results. The main effect of the outliers was to increase the standard deviations for all the methods. This actually made it easier to see patterns.

Significance Testing of Mean Differences in Growth Rates

The statistical tests for deciding whether there were significant differences between the mean growth rate using Method A and the other five methods are given in Table 7. The differences in means and the p-values are also given in Table 5. Paired (matched) t-tests were used since the growth rates are indexed by year and quarter. It needs to be remembered that growth rate differences, and not raw differences, are being tested here.

For the methods that use *PSM* as the numerator, Method 1's (*PSM/PSA*) mean difference from Method A is significant while Method 2's (*PSM/PSM*) mean difference from Method A is not significant across all quarters. However, the standard deviation of the differences is smaller for Method 1 than for Method 2. To see the combined influence of the bias (mean difference from Method A) and the variability (variance of the differences), the mean square error, defined by $(\text{bias})^2$ + $(\text{standard deviation of the differences})^2$ was computed. Based on the mean square errors, it is a tie between Method 1 and Method 2 at this point.

For the methods that use MFW as the numerator, Method 3 (MFW/MFW) has less bias than the Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*). But, Methods 4 and 5 have smaller standard deviations of the differences between them and Method A. So, to see the combined influence, mean square errors were computed. Based on the mean square errors, Method 3 is inferior to Method 4 and Method 5. However, the mean square errors are close for Method 4 and Method 5 for all quarters combined and for the four quarters separately.

Percentage of the Time Within 1% and 2% of the Method A Growth Rate

From Table 8 it can be seen that over all 108 quarters that 95.37 percent of the time the growth rates defined by Method 1 (*PSM/PSA*) or Method 2 (*PSM/PSM*) were within 1% of Method A and 100.00 percent of the time these two methods had growth rates within 2% of Method A. When MFW was used as the numerator, over all 108 quarters, Method 3 (MFW/MFW) was inferior to Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*). Method 3 was within 1% and 2% of Method A, 42.59 percent and 83.33 percent of the time, respectively. Methods 4 and 5 were tied and were within 1% and 2% of Method A, 58.33 percent and 90.74 percent of the time, respectively.

Table 7. Differences for Finished Motor Gasoline Supplied Between Method A and the Other Growth Rate Methods, 1979-2005

Method Number	Method in Symbols	Largest Under-estimate	Largest Over-estimate	Mean Difference	Standard Deviation of the Differences	t	p-value	Mean Square Error
All 108 Quarters								
1	PSM/PSA	-1.907	0.623	0.223	0.418	-5.546	<.0001	0.224
2	PSM/PSM	-1.759	1.890	0.015	0.489	-0.316	0.7526	0.239
3	MFW/MFW	-6.126	6.442	-0.015	1.731	0.088	0.9302	2.996
4	MFW/PSM	-5.391	2.716	0.224	1.292	-1.803	0.0742	1.718
5	MFW/PSA	-5.631	3.017	0.432	1.275	-3.518	0.0006	1.813
First Quarters (n =27)								
1	PSM/PSA	-1.259	0.623	0.216	0.413	-2.712	0.0117	0.217
2	PSM/PSM	-1.237	0.766	0.014	0.541	-0.136	0.8925	0.292
3	MFW/MFW	-4.793	2.350	-0.044	1.705	0.134	0.8947	2.910
4	MFW/PSM	-2.520	2.716	0.068	1.261	-0.280	0.7815	1.596
5	MFW/PSA	-2.675	3.017	0.268	1.297	-1.075	0.2921	1.754
Second Quarters (n = 27)								
1	PSM/PSA	-1.907	0.226	0.335	0.579	-3.009	0.0058	0.448
2	PSM/PSM	-1.759	1.890	0.003	0.622	-0.024	0.9811	0.387
3	MFW/MFW	-6.126	6.442	-0.052	2.208	0.122	0.9037	4.880
4	MFW/PSM	-5.391	1.457	0.712	1.522	-2.430	0.0223	2.824
5	MFW/PSA	-5.631	0.873	1.043	1.408	-3.850	0.0007	3.071
Third Quarters (n = 27)								
1	PSM/PSA	-1.173	0.359	0.204	0.353	-3.010	0.0057	0.166
2	PSM/PSM	-0.746	0.975	0.025	0.425	-0.304	0.7632	0.181
3	MFW/MFW	-3.220	4.139	0.090	1.700	-0.275	0.7856	2.897
4	MFW/PSM	-3.536	2.208	-0.074	1.211	0.319	0.7523	1.473
5	MFW/PSA	-3.828	1.966	0.105	1.231	-0.442	0.6618	1.527
Fourth Quarters (n = 27)								
1	PSM/PSA	-0.924	0.389	0.137	0.258	-2.746	0.0108	0.085
2	PSM/PSM	-0.844	0.602	0.018	0.352	-0.259	0.7980	0.124
3	MFW/MFW	-2.646	2.693	-0.053	1.281	0.213	0.8327	1.643
4	MFW/PSM	-2.027	1.729	0.191	1.060	-0.937	0.3575	1.160
5	MFW/PSA	-2.050	1.816	0.310	0.985	-1.636	0.1138	1.067

Notes:

(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The units for Largest Underestimate, Largest Overestimate, Mean Difference, and Standard Deviation of the Difference are percent. The units for Mean Square Error are percent squared.

(3) The method that Methods 1 to 5 are being compared to is Method A: $A(Quarter, t) = \left(\frac{Quarter_{PSA}(t)}{Quarter_{PSA}(t-1)} - 1 \right) * 100\%$. The percentages reported are differences in year-to-year growth rates. For example, the mean difference for year-to-year growth rates for the 108 quarters between Method A and Method 1 (*PSM/PSA*) is 0.223 percent (that is, Method A's mean is 0.223 percent higher.)

(4) Mean Square Error = $(\text{bias})^2 + (\text{standard deviation})^2$. Here, the bias = Mean Difference (the fifth column) and the standard deviation = Standard Deviation of the Differences (the sixth column.)

Table 8. Percentage of Time Each Year-to-Year Growth Rate Method is Within 1% and 2% of Method A for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Percent of the Time Within -1%	Percent of the Time Within +1%	Percent of the Time Within -2%	Percent of the Time Within +2%	Percent of the Time Within 1%	Percent of the Time Within 2%	Percent of the Time Not Within 2%
All 108 Quarters								
1	PSM/PSA	69.44	25.93	74.07	25.93	95.37	100.00	0.00
2	PSM/PSM	46.30	49.07	50.00	50.00	95.37	100.00	0.00
3	MFW/MFW	17.59	25.00	37.96	45.37	42.59	83.33	16.67
4	MFW/PSM	29.63	28.70	48.15	42.59	58.33	90.74	9.26
5	MFW/PSA	29.63	28.70	53.70	37.04	58.33	90.74	9.26
First Quarters (n =27)								
1	PSM/PSA	70.37	25.93	74.07	25.93	96.30	100.00	0.00
2	PSM/PSM	29.63	59.26	40.74	59.26	88.89	100.00	0.00
3	MFW/MFW	11.11	22.22	29.63	48.15	33.33	77.78	22.22
4	MFW/PSM	18.52	33.33	44.44	48.15	51.85	92.59	7.41
5	MFW/PSA	33.33	22.22	55.56	33.33	55.56	88.89	11.11
Second Quarters (n = 27)								
1	PSM/PSA	62.96	25.93	74.07	25.93	88.89	100.00	0.00
2	PSM/PSM	51.85	40.74	55.56	44.44	92.59	100.00	0.00
3	MFW/MFW	25.93	14.81	44.44	37.04	40.74	81.48	18.52
4	MFW/PSM	33.33	14.81	55.56	29.63	48.15	85.19	14.81
5	MFW/PSA	22.22	25.93	55.56	25.93	48.15	81.48	18.52
Third Quarters (n = 27)								
1	PSM/PSA	66.67	29.63	70.37	29.63	96.30	100.00	0.00
2	PSM/PSM	55.56	44.44	55.56	44.44	100.00	100.00	0.00
3	MFW/MFW	11.11	22.22	44.44	40.74	33.33	85.19	14.81
4	MFW/PSM	40.74	33.33	44.44	48.15	74.07	92.59	7.41
5	MFW/PSA	37.04	29.63	51.85	40.74	66.67	92.59	7.41
Fourth Quarters (n = 27)								
1	PSM/PSA	77.78	22.22	77.78	22.22	100.00	100.00	0.00
2	PSM/PSM	48.15	51.85	48.15	51.85	100.00	100.00	0.00
3	MFW/MFW	22.22	33.33	33.33	55.56	55.56	88.89	11.11
4	MFW/PSM	25.93	33.33	48.15	44.44	59.26	92.59	7.41
5	MFW/PSA	25.93	37.04	51.85	44.44	62.96	96.30	3.70

Notes:

(1) To interpret the "Method in symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The percentages reported are the percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method A of $A(Quarter,t) = \left(\frac{Quarter_{PSA}(t)}{Quarter_{PSA}(t-1)} - 1 \right) * 100\%$. For example, the first two entries for the Method 3 row for all 108 quarters mean that 17.59 percent of the MFW/MFW ratios are below the Method A ratios, but are still within 1% of them and that 25.00 percent of the MFW/MFW ratios are above the Method A ratios, but are still within 1% of them.

(3) Totals across components, where applicable, may not add to 100 percent due to independent rounding.

Occurrence of Reported Wrong Directions of Growth Rates

Sometimes for year-to-year growth rates it occurs that some methods yield a positive growth rate and other methods yield a negative growth rate for the same time period. This will occur especially when the growth rates are small (near 0 percent.) While the growth rates calculated by two different methods may be close to each other in their values, the fact that one is positive and one is negative is bothersome psychologically to the users of EIA data on volumes. This discrepancy in terms of sign is described in Table 9, where the "gold standard" of Method A was used and all other methods were compared to it. Because there are only 27 years of data, reporting the results separately for each quarter would be misleading.

As seen in Tables 5 and 9, Method 1 (*PSM/PSA*) and Method 2 (*PSM/PSM*) give the same direction as Method A does 94.44 percent and 96.30 percent of the time, respectively. Methods 3 (MFW/MFW) is not as good on this criterion. It gives the same direction as Method A does 80.56 percent of the time. Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) are in the middle. They give the same direction as Method A does 87.96 percent and 85.19 percent of the time, respectively.

Table 9. Occurrence of Reported Correct and Wrong Directions of Growth Rates for Finished Motor Gasoline, 1979 to 2005

Method Number	Method in Symbols	Percent of the Time Both Methods are Up	Percent of the Time Both Methods are Down	Percent of the Time Method A is Up and the Other is Down	Percent of the Time Method A is Down and the Other is Up	Percent of the Time that Method A and the Other Method are in the Same Direction
1	PSM/PSA	72.22	22.22	3.70	1.85	94.44
2	PSM/PSM	74.07	22.22	1.85	1.85	96.30
3	MFW/MFW	64.81	15.74	11.11	8.33	80.56
4	MFW/PSM	67.59	20.37	9.26	2.78	87.96
5	MFW/PSA	62.04	23.15	13.89	0.93	85.19

Notes:

(1) All statistics in this table are based on 108 observations (4 quarters for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method A of $\left(\frac{Quarter_{PSA}(t)}{Quarter_{PSA}(t-1)}-1\right)*100\%$. For example, the first two entries for the Method 2 row mean that 74.07 percent of the *PSM/PSM* ratios and Method A ratios are both positive (that is, indicate upward growth rates) and that 22.22 percent of the *PSM/PSM* ratios and Method A ratios are both negative (that is, indicate downward growth rates.)

(4) Totals across components, where applicable, may not add due to independent rounding.

Seasonality/Cyclic Patterns

In Tables 5 to 8, the results are given for all 108 quarters and for first quarters, second quarters, etc. separately. Although there are some minor perturbations, overall for all methods there is very little difference between the quarters. What differences do occur are not meaningful when looking at the big picture. To verify this statistically, a two-way ANOVA (analysis of variance) was done using the Methods and the Quarters as the main factors (see Table 10.)

Table 10. Analyses of Variance of Differences between Methods and Quarters, 1979-2005

Source of Variation	df	Sum of Squares	Mean Square	F	p-value
Method	5	102.3893	20.4779	0.62	0.6817
Quarters	3	151.4417	50.4806	1.54	0.2035
Method by Quarter Interaction	15	24.8223	1.6548	0.05	>0.99995
Error	624	20483.0221	32.8254		
Total	647	20761.6754			

Note: The six methods used in this analysis of variance are Method A and Methods 1 through 5. The four quarters used are January to March, April to June, July to September, and October to December.

As can be seen in Table 10, there are no significant differences for either of the main effect of Quarter or for the Method by Quarter interaction. The non-statistically significant result for Method is not in contradiction with the results discussed earlier in this paper. This non-significance is caused by the high correlations of the growth rates between the Methods and because of the relatively high within-cell (Method by Quarter) standard deviations (see Table 5) as compared to the differences in the means between the methods.

Time-series analyses using a multiple linear regression viewpoint (in the EViews software, Version 5.1) for both months and quarters as the base unit were also performed on the growth rates generated using Method A (the gold standard) as the dependent variable and time (in months or quarter starting January 1982) and indicator variables for the months/quarters as independent variables. The models showed neither a linear time trend nor any seasonality or other cyclic patterns. The regression results are in Table 11 (for months) and Table 12 (for quarters.) Method A growth rates from 1979 to 1981 were not used because the growth rates during that period were quite volatile, as compared to the period of 1982 to 2005, due to a gasoline shortage in the U.S. and other factors. Hence, it can be concluded that there is no significant seasonality in growth rates even though the monthly volumes show high seasonality (see Figure 1.)

Table 11: Regression Equation Results for Estimating Growth Rates for Method A from Months, 1982 to 2005.

Independent Variables	Coefficient	Standard Error	t	p-value
Intercept (Constant)	0.009492	0.005887	1.612426	0.1080
Linear Trend	0.000026	0.000017	1.499839	0.1348
January	-0.000420	0.006995	-0.059987	0.9522
February	0.000617	0.006994	0.088245	0.9297
March	0.001218	0.006994	0.174182	0.8619
April	-0.000190	0.006993	-0.027135	0.9784
May	0.000243	0.006993	0.034698	0.9723
June	-0.001777	0.006993	-0.254142	0.7996
July	0.000097	0.006993	0.013919	0.9889
August	0.001300	0.006992	0.185893	0.8527
September	-0.001698	0.006992	-0.242794	0.8083
October	-0.000747	0.006992	-0.106801	0.9150
November	0.000974	0.006992	0.139286	0.8893

$R^2 = .009757$ $F(12, 275) = .225803$ $p = .997091$

Notes:

(1) The dependent variable is the growth rates as computed using Method A of $A(Month, t) = \left(\frac{Month_{PSA}(t)}{Month_{PSA}(t-1)} - 1 \right) * 100\%$.

(2) The coding used for the Linear Trend variable is 1=January 1982, 2=February 1982, … 13=January 1983, … 288=December 2005.

(3) The variables of January, February, … November are indicator variables. For example, the variable of February is coded 1 if the observed month was a February and is coded 0 otherwise.

Table 12: Regression Equation Results for Estimating Growth Rates for Method A from Quarters, 1982 to 2005.

Independent Variables	Coefficient	Standard Error	t	p-value
Intercept (Constant)	0.944620	0.495789	1.905289	0.0599
Linear Trend	0.007613	0.005964	1.276514	0.2050
Quarter 1	0.040626	0.467416	0.086916	0.9309
Quarter 2	-0.062620	0.467225	-0.134026	0.8937
Quarter 3	-0.017006	0.467111	-0.036407	0.9710

$R^2 = .018096$ $F(11, 84) = .419267$ $p = .794359$

Notes:

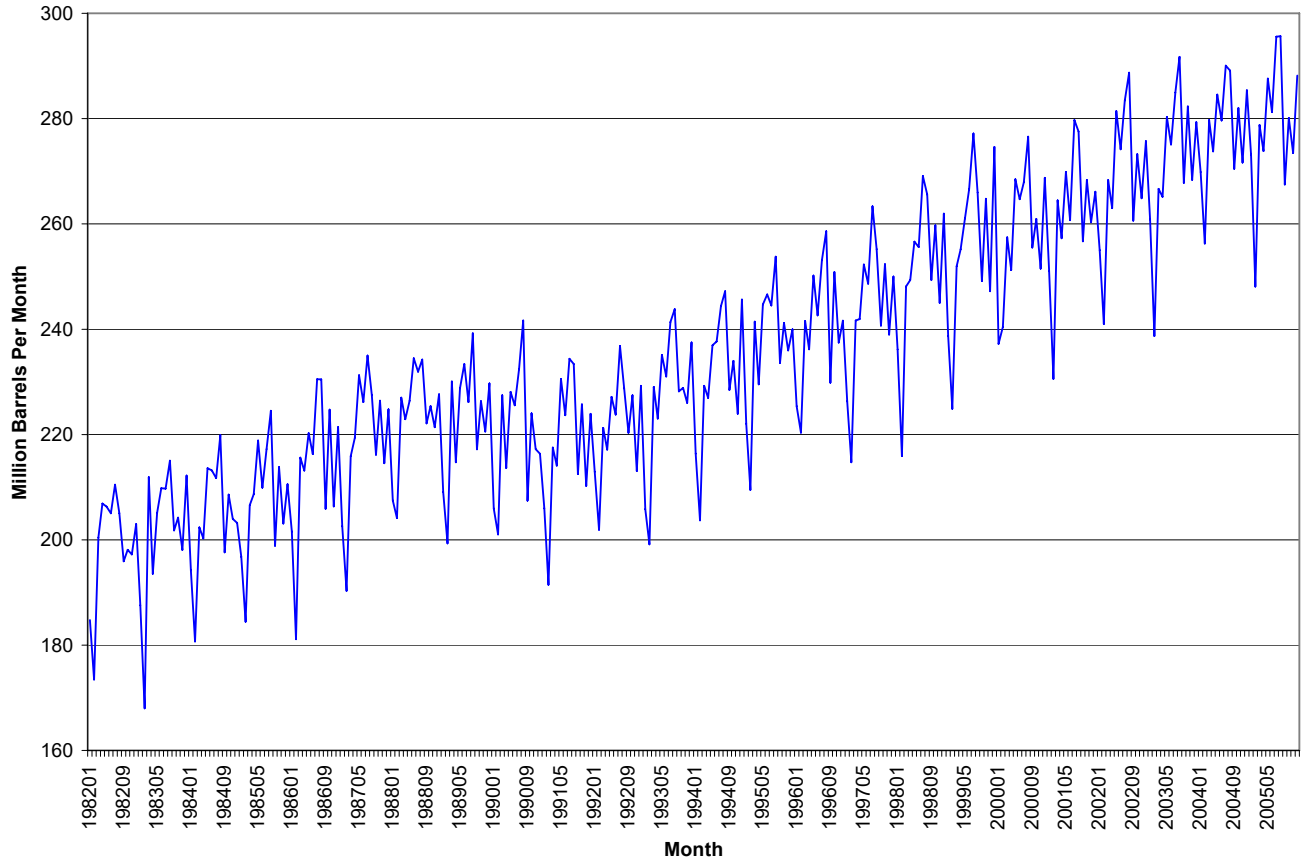
(1) The dependent variable is the growth rates as computed using Method A of $A(Quarter, t) = \left(\frac{Quarter_{PSA}(t)}{Quarter_{PSA}(t-1)} - 1 \right) * 100\% \cdot$

(2) The quarters are defined so that: first quarter is January, February and March; the second quarter is April, May and June; the third quarter is July, August, and September; and the fourth quarter is October, November, and December.

(3) The coding used for the Linear Trend variable is 1=first quarter 1982, 2=second quarter 1982, … 5=first quarter 1983, … 96=fourth quarter 2005.

(4) The variables of Quarter 1, Quarter 2, and Quarter 3 are indicator variables. For example, the variable of Quarter 2 is coded 1 if the observed quarter is the second quarter and is coded 0 otherwise.

Figure 1. Petroleum Supply Annual (PSA) Volumes of Finished Motor Gasoline Supplied, 1982 to 2005



Main Results from Study 2

- There does not appear to be any seasonality or other cyclic patterns for the growth rates.

- Using *PSM* as the numerator is much better than using MFW as the numerator.

- If the *PSM* measurement is used as the numerator, there is very little difference in all of the statistics for Method 1 (*PSM/PSA*) and Method 2 *(PSM/PSM*). However, when combined with the results of the previous study (Blumberg, 2007) and the results of Study 3, a more definite conclusion can be made that Method 2 is preferable to Method 1.

- If the MFW measurement is used as the numerator, then using MFW as the denominator (Method 3) is inferior to both Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*).

- No conclusion can be drawn from this study as to whether Method 4 or Method 5 is superior.

STUDY 3
Comparison of Cumulative Growth Rates Based on Different Length Time Periods

The purpose of this study was to see which of Methods 1 to 5 are best as compared to the gold-standard of Method A (*PSA/PSA*) when the volume of barrels supplied is accumulated for the first three months, first six months, first nine months or the entire year.

Descriptive Statistics

Table 13 gives the means, standard deviations, and correlations with Method A (along with the other major evaluation criteria statistics) for these time periods. Table 14 gives more details about the descriptive statistics, including means, standard deviations, medians, minimums, maximums, and ranges.

The methods that use *PSM* as the numerator (Method 1 of *PSM/PSA* and Method 2 of *PSM/PSM*) have high correlations with Method A of between .978 and .991 for all four time periods. For all time periods, the means for Method 2 are very close to those of Method A, while Method 1's means are lower than Method A's means.

For the 3-, 6-, and 9-month periods Method 3 (MFW/MFW) has correlations with Method A between .830 and .841 (R^2 between .689 and .707) while Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) have correlations with Method A between .878 and .894 (R^2 between .770 and .798.) When the volumes supplied are summed over the entire year, the correlations are slightly higher at .890 (for Method 3), .926 (for Method 4) and .932 (for Method 5.) For all time periods, the means for Method 3 are very close to those of Method A while those of Methods 4 and 5 are lower, with those of Method 5 being consistently the lowest. These differences in means will be discussed in more detail in the section on significance testing. The standard deviations are very close for Method A and all 5 methods within each time period, with the standard deviations being higher for the first 3 months then for the 6-month, 9-month, and entire year time periods.

Table 13. Major Statistics Used to Evaluate the Year-to-Year Growth Rate Methods for Finished Motor Gasoline, 1979 to 2005

Method Number	Method in Symbols	Mean	Standard Deviation	Pearson Correlation with Method A	Difference in Mean from Method A	p-value of the Difference	Mean Square Error	Percent of the Time Within 2% of A	Percent of the Time in the Same Direction
First 3 Months									
A	**PSA/PSA**	**0.960**	**2.780**	--	--	--	--	--	--
1	PSM/PSA	0.744	2.675	0.989	0.216	0.0117	0.217	100.00	96.30
2	PSM/PSM	0.946	2.752	0.981	0.014	0.8925	0.292	100.00	96.30
3	MFW/MFW	1.004	3.140	0.841	-0.044	0.8947	2.910	77.78	81.48
4	MFW/PSM	0.892	2.689	0.894	0.068	0.7815	1.596	92.59	88.89
5	MFW/PSA	0.692	2.650	0.887	0.268	0.2921	1.754	88.89	96.30
First 6 Months									
A	**PSA/PSA**	**0.847**	**2.255**	--	--	--	--	--	--
1	PSM/PSA	0.569	2.136	0.984	0.277	0.0016	0.245	100.00	96.30
2	PSM/PSM	0.837	2.229	0.978	0.009	0.9185	0.222	100.00	96.30
3	MFW/MFW	0.889	2.482	0.830	-0.042	0.8778	1.956	81.48	81.48
4	MFW/PSM	0.447	2.240	0.878	0.400	0.0729	1.397	88.89	92.59
5	MFW/PSA	0.179	2.128	0.887	0.668	0.0028	1.546	88.89	85.19
First 9 Months									
A	**PSA/PSA**	**0.821**	**2.164**	--	--	--	--	--	--
1	PSM/PSA	0.569	2.081	0.987	0.252	0.0011	0.192	100.00	92.59
2	PSM/PSM	0.806	2.143	0.981	0.015	0.8523	0.177	100.00	100.00
3	MFW/MFW	0.815	2.346	0.835	0.006	0.9807	1.707	85.18	96.30
4	MFW/PSM	0.583	2.025	0.886	0.239	0.2308	1.078	92.59	96.30
5	MFW/PSA	0.346	1.954	0.893	0.475	0.0177	1.178	92.59	96.30
Entire Year									
A	**PSA/PSA**	**0.812**	**2.203**	--	--	--	--	--	--
1	PSM/PSA	0.588	2.156	0.991	0.223	0.0007	0.142	100.00	92.59
2	PSM/PSM	0.796	2.213	0.988	0.016	0.8128	0.119	100.00	100.00
3	MFW/MFW	0.819	2.284	0.890	-0.007	0.9728	1.113	88.88	92.59
4	MFW/PSM	0.584	2.093	0.926	0.228	0.1667	0.742	96.30	100.00
5	MFW/PSA	0.377	2.026	0.932	0.435	0.0088	0.825	92.59	96.30

Notes for Table 13:

(1) All statistics in this table are based on 27 observations (1 data point for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular year for the measure listed and the symbols in the denominator represent the value from the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The values in the third, fourth, and sixth columns are year-to-year growth rates expressed as percentages. For example, for periods of the first 3 months, Method A has a mean of 0.960 percent and a standard deviation of 2.780 percent.

(4) The symbol -- in the Method A row represents "Not Applicable".

(5) The correlations reported here are Pearson Product-Moment correlations of the year-to-year growth rates determined by Methods 1 to 5 with the year-to-year growth rates for Method A. All correlations have a probability value (p-value) of <.0001.

(6) The sixth column is mean differences in year-to-year growth rates. For example, the mean difference between Method A and Method 1 for first three months is 0.216 percent (that is, Method A's mean is 0.216 percent higher.)

(7) The mean square error in the eighth column is equal to (Difference in Mean from Method A)^2 + (Standard Deviation of the Difference from Method A from Table 15)^2. Its units are percent squared.

(8) The percentages reported in the ninth column are the percentage of times that each method gives an answer within 2% of Method A. For example, for Method 3 for the periods of the first three months, 77.78 percent of the time it is within 2% of the Method A growth rate.

(9) The last column gives the percentage of the time that each method gives a growth rate in the same direction as Method A. That is, it is the percentage of the time that each method and Method A both give positive growth rates or both give negative growth rates. For example, for the periods of the first three months, 81.48 percent of the time Method 3 and Method A are either both positive or both negative.

Significance Testing of Mean Differences in Growth Rates

The tests for deciding whether there were significant differences between the mean growth rate given by Method A and the other five methods are given in Table 15. The differences in means and the p-values are also given in this table. Paired (matched) t-tests were used since the growth rates are indexed by year. It needs to be remembered that growth rate differences, and not raw differences, are being tested here.

For the methods that use *PSM* as the numerator, Method 1's (*PSM/PSA*) mean difference from Method A is significant while Method 2's (*PSM/PSM*) mean difference from Method A is not significant across for all time periods. However, the standard deviations of the differences are smaller for Method 1 than for Method 2. To see the combined influence of the bias (mean difference from Method A) and the variability (variance of the differences), the mean square error, defined by (bias)^2 + (standard deviation of the differences)^2 was computed. The mean square error for the periods of first three months is less for Method 1 than for Method 2. But, the mean square errors for the other time periods are greater for Method 1 than for Method 2. None of the differences in mean square errors between the two methods are meaningfully significant. Further, the mean square errors for Methods 1 and 2 are much smaller than for Methods 3 to 5.

For the methods that use MFW as the numerator, Method 3 (MFW/MFW) has less bias than Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*). But, Methods 4 and 5 have smaller standard deviations of the differences between them and Method A than Method 3 does. Method 3 has a larger mean square error than Method 4 and Method 5. However, the mean square errors are close for Method 4 and Method 5 for all time periods.

Table 14. Descriptive Statistics for the Year-to-Year Growth Rates (as Percentages) for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Mean	Standard Deviation	Median	Minimum	Maximum	Range
First 3 Months							
A	**PSA/PSA**	**0.960**	**2.780**	**1.845**	**-8.320**	**5.173**	**13.493**
1	PSM/PSA	0.744	2.675	1.303	-8.258	4.364	12.622
2	PSM/PSM	0.946	2.752	1.387	-8.550	5.293	13.843
3	MFW/MFW	1.004	3.140	1.318	-7.377	5.378	12.755
4	MFW/PSM	0.892	2.689	1.396	-5.604	4.244	9.848
5	MFW/PSA	0.692	2.650	0.412	-5.303	4.270	9.573
First 6 Months							
A	**PSA/PSA**	**0.847**	**2.255**	**1.451**	**-7.114**	**3.617**	**10.731**
1	PSM/PSA	0.569	2.136	1.192	-7.083	3.289	10.372
2	PSM/PSM	0.837	2.229	1.366	-7.229	3.671	10.900
3	MFW/MFW	0.889	2.482	1.199	-6.182	4.415	10.597
4	MFW/PSM	0.447	2.240	0.816	-5.952	3.896	9.848
5	MFW/PSA	0.179	2.128	0.394	-5.804	3.513	9.317
First 9 Months							
A	**PSA/PSA**	**0.821**	**2.164**	**1.365**	**-6.656**	**2.903**	**9.559**
1	PSM/PSA	0.569	2.081	1.107	-6.650	2.881	9.531
2	PSM/PSM	0.806	2.143	1.363	-6.669	3.094	9.763
3	MFW/MFW	0.815	2.346	1.228	-5.678	4.373	10.051
4	MFW/PSM	0.583	2.025	0.898	-5.146	3.472	8.618
5	MFW/PSA	0.346	1.954	0.665	-5.127	3.221	8.348
Entire Year							
A	**PSA/PSA**	**0.812**	**2.203**	**1.381**	**-6.242**	**2.932**	**9.174**
1	PSM/PSA	0.588	2.156	1.191	-6.286	2.736	9.022
2	PSM/PSM	0.796	2.213	1.393	-6.237	3.018	9.255
3	MFW/MFW	0.819	2.284	1.586	-5.152	3.927	9.079
4	MFW/PSM	0.584	2.093	1.028	-4.879	3.168	8.047
5	MFW/PSA	0.377	2.026	0.672	-4.928	2.970	7.898

Notes:

(1) All statistics in this table are based on 27 observations (one for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The percentages reported in the third through eighth columns are for the year-to-year growth rates. For example, Method A for the data for the first 3 months for the 27 years from 1979 to 2005 has a mean growth rate of 0.960 percent and a standard deviation of 2.780 percent.

(4) Totals across components, where applicable, may not add due to independent rounding.

Table 15. Differences for Finished Motor Gasoline Supplied Between Method A and the Other Growth Rates, 1979-2005

Method Number	Method in Symbols	Largest Under-estimate	Largest Over-estimate	Mean Difference	Standard Deviation of Differences	t	p-value	Mean Square Error
First 3 Months								
1	PSM/PSA	-1.259	0.623	0.216	0.413	-2.712	0.0117	0.217
2	PSM/PSM	-1.237	0.766	0.014	0.541	-0.136	0.8925	0.292
3	MFW/MFW	-4.793	2.350	-0.044	1.705	0.134	0.8947	2.910
4	MFW/PSM	-2.520	2.716	0.068	1.261	-0.280	0.7815	1.596
5	MFW/PSA	-2.675	3.017	0.268	1.297	-1.075	0.2921	1.754
First 6 Months								
1	PSM/PSA	-0.162	1.538	0.277	0.411	3.514	0.0016	0.245
2	PSM/PSM	-1.344	0.992	0.009	0.471	0.103	0.9185	0.222
3	MFW/MFW	-3.104	2.678	-0.042	1.398	-0.155	0.8778	1.956
4	MFW/PSM	-1.258	3.008	0.400	1.112	1.869	0.0729	1.397
5	MFW/PSA	-1.309	3.256	0.668	1.049	3.308	0.0028	1.546
First 9 Months								
1	PSM/PSA	-0.127	1.412	0.252	0.358	3.663	0.0011	0.192
2	PSM/PSM	-1.218	0.816	0.015	0.421	0.188	0.8523	0.177
3	MFW/MFW	-3.357	2.177	0.006	1.307	0.024	0.9807	1.707
4	MFW/PSM	-1.510	2.846	0.239	1.010	1.227	0.2308	1.078
5	MFW/PSA	-1.529	3.210	0.475	0.976	2.532	0.0177	1.178
Entire Year								
1	PSM/PSA	-0.083	1.289	0.223	0.303	3.830	0.0007	0.142
2	PSM/PSM	-1.031	0.668	0.016	0.344	0.239	0.8128	0.119
3	MFW/MFW	-2.085	2.288	-0.007	1.055	-0.034	0.9728	1.113
4	MFW/PSM	-1.363	2.197	0.228	0.831	1.423	0.1667	0.742
5	MFW/PSA	-1.314	2.248	0.435	0.797	2.832	0.0088	0.825

Notes:

(1) All statistics in this table are based on 27 observations (one for each of the years 1979 to 2005.)

(2) To interpret the "Method in symbols" column, the symbols in the numerator represent the value from a particular month in a particular year for the measure listed and the symbols in the denominator represent the value from the same month in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The units for Largest Underestimate, Largest Overestimate, Mean Difference, and Standard Deviation of the Difference are percent. The units for Mean Square Error are percent squared.

(4) The method that Methods 1 to 5 are being compared to is Method A: $A(Period, t) = \left(\frac{Period_{PSA}(t)}{Period_{PSA}(t-1)} - 1 \right) * 100\%$, where Period = first 3 months, first 6 months, first 9 months, or the entire year. The percentages reported are differences in year-to-year growth rates. For example, the mean difference for year-to-year growth rate for the first 3 months for the 27 years of 1979 to 2005 between Method A and Method 1 (*PSM/PSA*) is 0.216 percent (that is, Method A's mean is 0.216 percent higher.)

(5) Mean Square Error = (bias)^2 + (standard deviation)^2. Here the bias = Mean Difference (the fifth column) and the standard deviation = Standard Deviation of the Differences (the sixth column.)

Percentage of the Time Within 1% and 2% of the Method A Growth Rate

Table 16 reports the percentages of the time that each method is within 1% and 2% of Method A. Methods 1 and 2 are within 1% of Method A almost all of the time (lowest percentage is 88.89 percent, which is 24 out of 27 years) and always within 2% of Method A. While the percentages differ slightly between the time periods for those methods that use MFW as the numerator, the patterns are the same: Method 3 (MFW/MFW) has a lower percentage of years that it is within 1% and within 2% of Method A than Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) do.

Occurrence of Reported Correct and Wrong Directions of Growth Rates

As discussed in Study 2, sometimes for year-to-year growth rates it occurs that some methods yield a positive growth rate and other methods yield a negative growth rate for the same time period. As seen in Tables 13 and 17, Method 1 (*PSM/PSA*) gives the same direction as Method A between 92.59 percent (25/27) and 96.30 percent (26/27) of the time. Method 2 (*PSM/PSM*) gives the same direction as Method A between 96.30 percent and 100.00 percent of the time. Methods 3 (MFW/MFW) is not as good on this criterion. It gives the same direction as Method A between 81.48 percent and 96.30 percent of the time. Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) are in the middle. They give the same direction as Method A between 85.19 percent and 100.00 percent of the time. These results must be interpreted carefully since there are only 27 observations for each time period

Main Results from Study 3

- Method 1 (*PSM/PSA*) and Method 2 (*PSM/PSM*) are preferable to all of the methods that use MFW as their numerator (Methods 3 to 5.) They have higher correlations with Method A; their standard deviations are closer to Method A's than those for Methods 3 to 5 are; their mean square errors are smaller; they are within 1% and 2% of Method A more often; and they give the correct direction slightly more often.

- It is hard to decide between Method 1 and Method 2 as to which is better. There is a slight preference for Method 2 since it has a lower mean square error for all time periods, except for the time period of the first 3 months.

- Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*) are preferable to Method 3 (MFW/MFW). They have higher correlations with Method A; their mean square errors are smaller; they are within 1% and 2% of Method A more often; and they give the correct direction slightly more often.

- It is hard to decide between Method 4 and Method 5 here. Method 5 has slightly lower correlations with Method A than Method 4 does. Also, Method 5 has lower p-values than Method 4 for the differences in means between it and Method A. Otherwise, there are no meaningful differences between Methods 4 and 5.

Table 16. Percentage of Time Each Year-to-Year Growth Rate Method is Within 1% and 2% of Method A for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Percent of the Time Within -1%	Percent of the Time Within +1%	Percent of the Time Within -2%	Percent of the Time Within +2%	Percent of the Time Within 1%	Percent of the Time Within 2%	Percent of the Time Not Within 2%
First 3 Months								
1	PSM/PSA	70.37	25.93	74.07	25.93	96.30	100.00	0.00
2	PSM/PSM	29.63	59.26	40.74	59.26	88.89	100.00	0.00
3	MFW/MFW	11.11	22.22	29.63	48.15	33.33	77.78	22.22
4	MFW/PSM	18.52	33.33	44.44	48.15	51.85	92.59	7.41
5	MFW/PSA	33.33	22.22	55.56	33.33	55.56	88.89	11.11
First 6 Months								
1	PSM/PSA	29.63	59.26	29.63	70.37	88.89	100.00	0.00
2	PSM/PSM	55.56	40.74	59.26	40.74	96.30	100.00	0.00
3	MFW/MFW	33.33	25.93	48.15	33.33	59.26	81.48	18.52
4	MFW/PSM	33.33	33.33	40.74	48.15	66.67	88.89	11.11
5	MFW/PSA	22.22	51.85	25.93	62.96	74.07	88.89	11.11
First 9 Months								
1	PSM/PSA	29.63	66.67	29.63	70.37	96.30	100.00	0.00
2	PSM/PSM	40.74	55.56	44.44	55.56	96.30	100.00	0.00
3	MFW/MFW	37.04	22.22	44.44	40.74	59.26	85.18	14.82
4	MFW/PSM	44.44	29.63	48.15	44.44	74.07	92.59	7.41
5	MFW/PSA	25.93	48.15	29.63	62.96	74.07	92.59	7.41
Entire Year								
1	PSM/PSA	18.52	77.78	18.52	81.48	96.30	100.00	0.00
2	PSM/PSM	48.15	48.15	51.85	48.15	96.30	100.00	0.00
3	MFW/MFW	40.74	29.63	44.44	44.44	70.37	88.88	11.12
4	MFW/PSM	40.74	40.74	44.44	51.85	81.48	96.30	3.70
5	MFW/PSA	18.52	62.96	22.22	70.37	81.48	92.59	7.41

Notes:

(1) All statistics in this table are based on 27 observations (one for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular month in a particular year for the measure listed and the symbols in the denominator represent the value from the same month in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method A = $\left(\frac{Period_{PSA}(t)}{Period_{PSA}(t-1)} - 1\right) * 100\%$, where Period = first 3 months, first 6 months, first 9 months, or the entire year. For example, the first two entries for the Method 3 row for first 3 months mean that 11.11 percent of the MFW/MFW ratios are below the Method A ratios, but are still within 1% of them and that 22.22 percent of the MFW/MFW ratios are above the Method A ratios, but are still within 1% of them.

(4) Totals across components, where applicable, may not add to 100 percent due to independent rounding.

Table 17. Occurrence of Reported Correct and Wrong Directions of Growth Rates for Finished Motor Gasoline Supplied, 1979 to 2005

Method Number	Method in Symbols	Percent of Time Both Measures Up	Percent of Time Both Measures Down	Percent of the Time Method A is Up and the Other is Down	Percent of the Time Method A is Down and the Other is Up	Percent of the Time that Method A and the Other Method are in the Same Direction
First 3 Months						
1	PSM/PSA	66.67	29.63	0.00	3.70	96.30
2	PSM/PSM	66.67	29.63	0.00	3.70	96.30
3	MFW/MFW	59.26	22.22	7.41	11.11	81.48
4	MFW/PSM	62.96	25.93	3.70	7.41	88.89
5	MFW/PSA	62.96	33.33	3.70	0.00	96.30
First 6 Months						
1	PSM/PSA	62.96	33.33	3.70	0.00	96.30
2	PSM/PSM	66.67	29.63	0.00	3.70	96.30
3	MFW/MFW	59.26	22.22	7.41	11.11	81.48
4	MFW/PSM	62.96	29.63	3.70	3.70	92.59
5	MFW/PSA	55.56	29.63	11.11	3.70	85.19
First 9 Months						
1	PSM/PSA	66.67	25.93	7.41	0.00	92.59
2	PSM/PSM	74.07	25.93	0.00	0.00	100.00
3	MFW/MFW	74.07	22.22	0.00	3.70	96.30
4	MFW/PSM	70.37	25.93	3.70	0.00	96.30
5	MFW/PSA	70.37	25.93	3.70	0.00	96.30
Entire Year						
1	PSM/PSA	66.67	25.93	7.41	0.00	92.59
2	PSM/PSM	74.07	25.93	0.00	0.00	100.00
3	MFW/MFW	70.37	22.22	3.70	3.70	92.59
4	MFW/PSM	74.07	25.93	0.00	0.00	100.00
5	MFW/PSA	70.37	25.93	3.70	0.00	96.30

Notes for Table 17:

(1) All statistics in this table are based on 27 observations (one for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular month in a particular year for the measure listed and the symbols in the denominator represent the value from the same month in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method A of $A(Period, t) = \left(\frac{Period_{PSA}(t)}{Period_{PSA}(t-1)} - 1 \right) * 100\%$, where Period = first 3 months, first 6 months, first 9 months, or the entire year. For example, the first two entries for the Method 3 row in the First 3 Months portion of the table mean that 59.26 percent of the MFW/MFW ratios and Method A ratios are both positive (that is, indicate upward growth rates) and that 22.22 percent of the MFW/MFW ratios and the Method A ratios are both negative (that is, indicate downward growth rates.)

(4) Totals across components, where applicable, may not add due to independent rounding.

STUDY 4
Comparing Method 4 and Method 5 Directly to Method 2

In Study 1, Study 2 and Study 3 it was concluded that using Method 2 (*PSM/PSM*) was the best approximation to Method A (PSA/PSA) and that no conclusion could be made as to whether Method 4 or Method 5 was the better approximation. Since it is expected that in the future, based on the results of these studies, Method 2 will be used more often by EIA and others for product supplied growth rates, it was decided to compare Method 4 and Method 5 directly to Method 2. By comparing Method 4 and Method 5 directly to Method 2, it was hoped that one of these two methods would be shown to be superior. One way of thinking of what is going on is that the previous work compared the other methods to a "gold standard" of Method A. This study compares Methods 4 and 5 to a "silver standard" of Method 2.

In order to compare Methods 4 and 5 to Method 2, tables similar to those from the previous studies were made. Tables 18 and 19 give summary statistics and paired t-test results for the differences between Methods 4 and 5 and Method 2. Tables 20 and 21 give the percentage of times that the growth rates computed by Methods 4 and 5 are within 1% and 2% of Method 2's growth rates. Table 22 gives the percent agreement in terms of direction (either positive or negative) of the Method 4 and 5 growth rates with those of Method 2.

From inspection of these tables it is now clear that Method 4 is preferable to Method 5. Method 4 has smaller mean square errors than Method 5 for all comparison periods. In terms of the percentage of times that each method is within 2% of Method 2, 75 percent of the time (6 out of 8 comparison periods) Method 4 has a higher percentage than Method 5 and 12.5 percent (1 out of 8 comparison periods) of the time is tied with Method 5. For 87.04 percent of the quarters from 1978 to 2005, Method 4 gives a growth rate in the same direction as Method 2 while Method 5 gives a growth rate in the same direction only 80.56 percent of the time.

Table 18: Differences Between Method 2 versus Method 4 and Method 5 for Quarterly Growth Rates for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Largest Under-estimate	Largest Over-estimate	Mean Difference	Standard Deviation of Differences	t	p-value	Mean Square Error
All 108 Quarters								
4	MFW/PSM	-5.472	2.946	0.209	1.234	-1.762	0.0810	1.567
5	MFW/PSA	-5.712	3.247	0.417	1.312	-3.303	0.0013	1.894
First Quarters (n =27)								
4	MFW/PSM	-1.779	2.946	0.054	1.212	-0.231	0.8193	1.472
5	MFW/PSA	-2.682	3.247	0.254	1.360	-0.971	0.3403	1.914
Second Quarters (n = 27)								
4	MFW/PSM	-5.472	1.553	0.709	1.472	-2.503	0.0189	2.668
5	MFW/PSA	-5.712	0.778	1.040	1.489	-3.630	0.0012	3.300
Third Quarters (n = 27)								
4	MFW/PSM	-3.346	2.445	-0.099	1.161	0.444	0.6605	1.358
5	MFW/PSA	-3.638	2.431	0.080	1.254	-0.331	0.7431	1.579
Fourth Quarters (n = 27)								
4	MFW/PSM	-1.965	1.850	0.174	0.951	-0.949	0.3515	0.934
5	MFW/PSA	-2.437	1.937	0.293	0.936	-1.625	0.1162	0.962

Notes:

(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The units for Largest Underestimate, Largest Overestimate, Mean Difference, and Standard Deviation of the Difference are percent. The units for Mean Square Error are percent squared.

(3) The method that Methods 4 and 5 are being compared to is Method 2 defined by $\left(\frac{Quarter_{PSM}(t)}{Quarter_{PSM}(t-1)}-1\right)*100\%$. The percentages reported in the fifth column are differences in year-to-year growth rates. For example, for First Quarters, Method 2's mean is .054 percent higher than Method 4's mean.

(4) Mean Square Error = $(\text{bias})^2 + (\text{standard deviation})^2$. Here the bias = Mean Difference (the fifth column) and the standard deviation = Standard Deviation of the Differences (the sixth column.)

Table 19: Differences Between Method 2 versus Method 4 and Method 5 for Growth Rates for 3-, 6-, 9-, and 12-month Periods for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Largest Under-estimate	Largest Over-estimate	Mean Difference	Standard Deviation of Differences	t	p-value	Mean Square Error
First 3 Months								
4	MFW/PSM	-1.779	2.946	0.054	1.212	-0.231	0.8193	1.472
5	MFW/PSA	-2.682	3.247	0.254	1.360	-0.971	0.3403	1.914
First 6 Months								
4	MFW/PSM	-3.122	1.487	0.391	1.121	-1.812	0.0816	1.409
5	MFW/PSA	-3.369	1.424	0.658	1.158	-2.954	0.0066	1.775
First 9 Months								
4	MFW/PSM	-2.793	1.522	0.223	0.990	-1.172	0.2519	1.031
5	MFW/PSA	-3.157	1.541	0.460	1.044	-2.290	0.0304	1.302
Entire Year								
4	MFW/PSM	-2.171	1.358	0.212	0.804	-1.368	0.1829	0.691
5	MFW/PSA	-2.241	1.309	0.419	0.844	-2.579	0.0159	0.887

Notes:

(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular time period in a particular year for the measure listed and the symbols in the denominator represent the value from the same time period in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The units for Largest Underestimate, Largest Overestimate, Mean Difference, and Standard Deviation of the Difference are percent. The units for Mean Square Error are percent squared.

(3) The method that Methods 4 and 5 are being compared to is Method 2 defined by $\left(\frac{Period_{PSM}(t)}{Period_{PSM}(t-1)} - 1\right) * 100\%$. The percentages reported in the fifth column are differences in year-to-year growth rates. For example, for periods of the First 3 Months, Method 2's mean is .054 percent higher than Method 4's mean.

(4) Mean Square Error = $(\text{bias})^2 + (\text{standard deviation})^2$. Here the bias = Mean Difference (the fifth column) and the standard deviation = Standard Deviation of the Differences (the sixth column.)

Table 20. Percentage of Time Methods 4 and 5 are Within 1% and 2% of Method 2 Over All Quarters for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Percent of the Time Within -1%	Percent of the Time Within +1%	Percent of the Time Within -2%	Percent of the Time Within +2%	Percent of the Time Within 1%	Percent of the Time Within 2%	Percent of the Time Not Within 2%
All 108 Quarters								
4	MFW/PSM	37.04	28.70	52.78	37.96	65.74	90.74	9.26
5	MFW/PSA	31.48	25.93	52.78	36.11	57.41	88.89	11.11
First Quarters (n =27)								
4	MFW/PSM	40.74	18.52	59.26	33.33	59.26	92.59	7.41
5	MFW/PSA	37.04	7.41	66.67	25.93	44.44	92.59	7.41
Second Quarters (n = 27)								
4	MFW/PSM	37.04	29.63	48.15	33.33	66.67	81.48	18.52
5	MFW/PSA	25.93	29.63	44.44	29.63	55.56	74.07	25.93
Third Quarters (n = 27)								
4	MFW/PSM	48.15	22.22	51.85	37.04	70.37	88.89	11.11
5	MFW/PSA	29.63	33.33	40.74	51.85	62.96	92.59	7.41
Fourth Quarters (n = 27)								
4	MFW/PSM	22.22	44.44	51.85	48.15	66.67	100.00	0.00
5	MFW/PSA	33.33	33.33	59.26	37.04	66.67	96.30	3.70

Notes:

(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular quarter in a particular year for the measure listed and the symbols in the denominator represent the value from the same quarter in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method 2 defined by $\left(\frac{Quarter_{PSM}(t)}{Quarter_{PSM}(t-1)} - 1\right) * 100\% \cdot$

(3) Totals across components, where applicable, may not add to 100 percent due to independent rounding.

Table 21. Percentage of Time Methods 4 and 5 are Within 1% and 2% of Method 2 Over 3-, 6-, 9- and 12-month Periods for Finished Motor Gasoline Supplied, 1979-2005

Method Number	Method in Symbols	Percent of the Time Within -1%	Percent of the Time Within +1%	Percent of the Time Within -2%	Percent of the Time Within +2%	Percent of the Time Within 1%	Percent of the Time Within 2%	Percent of the Time Not Within 2%
First 3 Months								
4	MFW/PSM	40.74	18.52	59.26	33.33	59.26	92.59	7.41
5	MFW/PSA	37.04	7.41	66.67	25.93	44.44	92.59	7.41
First 6 Months								
4	MFW/PSM	33.33	29.63	48.15	40.74	62.96	88.89	11.11
5	MFW/PSA	37.04	22.22	55.56	29.63	59.26	85.19	14.81
First 9 Months								
4	MFW/PSM	37.04	44.44	44.44	48.15	81.48	92.59	7.41
5	MFW/PSA	44.44	33.33	51.85	37.04	77.78	88.89	11.11
Entire Year								
4	MFW/PSM	44.44	37.04	55.56	40.74	81.48	96.30	3.70
5	MFW/PSA	48.15	29.63	59.26	33.33	77.78	92.59	7.41

Notes:
(1) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular time period in a particular year for the measure listed and the symbols in the denominator represent the value from the same time period in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(2) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method 2 defined by $\left(\frac{Period_{PSM}(t)}{Period_{PSM}(t-1)} - 1\right) * 100\%$.

(3) Totals across components, where applicable, may not add to 100 percent due to independent rounding.

Table 22. Occurrence of Reported Same and Different Directions for Growth Rates using Method 2, Method 4, and Method 5 over All Quarters for Finished Motor Gasoline Supplied, 1979 to 2005

Method Number	Method in Symbols	Percent of the Time Method 2 and the Other Method are Up	Percent of the Time Method 2 and the Other Method are Down	Percent of the Time Method 2 is Up and the Other is Down	Percent of the Time Method 2 is Down and the Other is Up	Percent of the Time that Method 2 and the Other Method are in the Same Direction
4	MFW/PSM	66.67	20.37	9.26	3.70	87.04
5	MFW/PSA	60.19	20.37	15.74	3.70	80.56

Notes:

(1) All statistics in this table are based on 108 observations (four quarters for each of the years 1979 to 2005.)

(2) To interpret the "Method in Symbols" column, the symbols in the numerator represent the value from a particular month in a particular year for the measure listed and the symbols in the denominator represent the value from the same month in the previous year. *PSA = Petroleum Supply Annual*; *PSM = Petroleum Supply Monthly;* and MFW = Monthly estimates based on weekly data.

(3) The percentages reported are percentage of times that each method gives an answer within 1% or 2% (depending on the column) of Method 2 defined by: $\left(\frac{Quarter_{PSM}(t)}{Quarter_{PSM}(t-1)} - 1\right) * 100\% \cdot$

(4) Totals across components, where applicable, may not add due to independent rounding.

Overall Main Results (The Big Picture)

- Method 2 using *PSM* for a given time period in one year divided by the *PSM* value for the same period in the previous year is preferable to Method 1 that uses *PSM* divided by *PSA*.

- Method 3 (MFW/MFW) is inferior to Method 4 (MFW/*PSM*) and Method 5 (MFW/*PSA*).

- Method 4 is preferable to Method 5, but it is a close call. This preference is based on the results of Study 4.

- The above three results when combined have a nice succinct conclusion when Method A is not possible to use. **That is, when Method A cannot be used, then always use *PSM* measurements from the previous year as the denominator when computing growth rates for any time period. This conclusion is for both *PSM* and MFW as the numerator.**

Limitations

- The analyses done were only for finished motor gasoline supplied and distillate fuel oil supplied, although only the ones for finished motor gasoline were discussed in this paper. Other product supply measures were not analyzed.

- The analyses of the growth rates from Blumberg (2007) with ratios of one-month time periods (summarized here as Study 1) only used data from the period of 1995 to 2004. These analyses need to be redone using the 27 years that were used in this paper.

Directions for Future Research

- Similar analyses should be carried out for the equivalent data from the Petroleum Marketing surveys and for other Petroleum Supply measures.

- An analysis of the different methods of estimating month-to-month growth rates between two consecutive months should be carried out using similar analyses to those used here.

- The rate of change of the growth rates (that is, the counterpart of the second derivative (concavity) when looking at continuous functions) may be worth investigating.

Acknowledgements

The idea for Study 1 came from John Cook, Director of the Petroleum Division. The ideas for Study 2 and Study 3 came from Joanne Shore. Both of them, as well as Carol French and Douglas MacIntyre, helped in the design of the methodology of these studies. Tammy Heppner and Bin Zhang provided the data needed to carry out this research.

References

Blumberg, Carol J. "Comparison of Different Methods of Computing Yearly Growth Rates for Petroleum Supply, 1995-2004." Unpublished paper prepared for the Spring 2007 meeting of the American Statistical Association Committee on Energy Statistics, April 5 to 6, 2007 (Washington DC, January 30, 2007.) Located at http://www.eia.doe.gov/smg/asa_meeting_2007/spring/files/comparemethods.pdf.

Kirkendall, Nancy and Donald Martin. "Comparison of Choletta-Chhab and MFW Methods." Unpublished paper prepared for the Spring 1993 meeting of the American Statistical Association Committee on Energy Statistics (Washington DC, February 23, 1993.)