Regression Project on the Quarterly Revenue of Adobe Inc.

By Palash Saha

Appendix 1: Company Profile- Adobe Inc.

Adobe Inc. is a technology business that provides a variety of digital marketing solutions, digital media products, and software services. The organization operates in three divisions: Digital Media, which enables users to download and install applications such as Adobe Photoshop, Illustrator, InDesign, and Acrobat; Digital Experience provides analytics, media optimization, social marketing, and other cloud-based business management applications; and Publishing, which provides products for the preparation of technical documents, online application development, printing, and e-learning solutions. It operates in the Americas, Europe, the Middle East, and Africa (EMEA), and Asia-Pacific (APAC) regions. The organization is based in San Jose, California, in the United States.

John Warnock and Charles Geschke, both former employees of Xerox Corporation's Research Center in Palo Alto, California, started Adobe in 1982. Warnock conducted interactive graphics research at Xerox, whilst Geschke managed computer science and graphics research as the Imaging Sciences Laboratory manager. Warnock later remembered that he and Geschke were dissatisfied with Xerox's inability to advance their products past the research phase (Hoover's Company Records;Fort Mill, 2022). They left Xerox to form their own company, naming it after a creek that ran near their houses in Los Altos, California, because they believed an independent endeavor would be profitable.

Adobe Inc. is a Publicly Traded Company. Aside from the Adobe corporate office in San Jose, California, the company also has a total of 67 locations across the globe with more than 25,988 employees. Shantanu Narayen is the Chairman, President and CEO of Adobe Inc since December 2007 and owns about 329,792 shares of Adobe Inc (ADBE) stock worth over $110 Million. The ticker symbol of Adobe Inc. is (NasdaqGS: ADBE). Adobe Inc falls in SIC CODE 7371 - Computer Programming Services and NAICS CODE 541511 - Custom Computer Programming Services.

The major competitors of Adobe Inc. include Autodesk, Google, Salesforce, SAP, Microsoft, DocuSign, Oracle, and IBM. Top shareholders of Adobe Inc are The Vanguard Group, Inc. ($11.85 billion), BlackRock Fund Advisors ($7.43 billion), SSgA Funds Management, Inc. ($5.93 billion), Fidelity Management & Research Company ($4.17 billion) (Geode Capital Management LLC ($2.98 billion), Fisher Asset Management LLC ($1.63 billion) (Cable News Network. 2022).

Adobe Inc. and M-Files formed a partnership in November 2022 to improve integration to expedite document E-signatures. In March 2021, Adobe Inc. partnered with Walmart to provide its technologies and capabilities to businesses and brands in the United States. Adobe Inc. and Microsoft have partnered with Walgreens Boots Alliance Inc to build the digital experience and consumer analytics platform in June 2020. Adobe achieved record revenue of $4.43 billion in its third quarter of fiscal year 2022, which represents 13 percent year-over-year growth or 15 percent in constant currency.

References:

"Adobe Inc. - Company profile". (n.d.). Retrieved December 12, 2022, from https://www.gale.com/c/business-insights-essentials

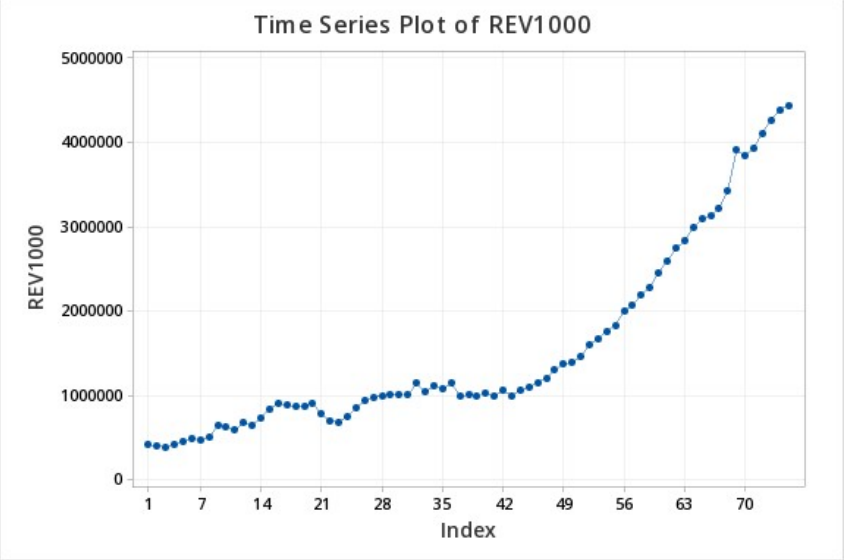
Cable News Network. (2022, November 14). *ADBE*. CNNMoney. Retrieved December 11, 2022, from https://money.cnn.com/quote/shareholders/shareholders.html?symb=ADBE&subView=institutional

Hoover's Company Records; Fort Mill. (2022, July). *Adobe Inc. Profile*. www.proquest.com. https://www.proquest.com/marketresearch/docview/1860762203/70454CBD324F4A48PQ/1?accountid=14690

Appendix 2: Dependent Variable Description—

The dependent variable is Sales Revenue for Adobe Inc per quarter (in 1000's of $). The sample includes data from the 1st quarter of 2004 through the 3rd quarter of 2022 for a total of 75 observations. The mean quarterly revenue during this time period was $1,552,007,000 ($1.552 billion) and the time series plot shows a little variation from quarter to quarter (standard deviation of $1.116 billion). Quarterly revenues exhibited an upward trend from the 4th quarter of 2004. It also exhibits little variation in its upward trend till 3rd quarter of 2014. After this time, revenues showed a constant upward trend until the 1st quarter of 2021. In this quarter Adobe Inc experienced a jump in its revenue followed by a slight drop in its revenue in the 2nd quarter of 2021.

Revenue tends to be highest in the 3rd quarter of each year. The means revenue in the 3rd quarter is $1.59 billion which is the highest of all the quarters. On the other hand, revenue tends to be lowest during the 1st quarter of each year (mean revenue in 1st quarter is $1.52 billion). The sample of data was obtained from S&P Capital IQ Database, Chart Builder. https://www.capitaliq.com/CIQDotNet/Charting4/ModernBuilder.aspx



Descriptive Statistics for Adobe Inc. Revenue (in 1000's of $)

Statistics

Variable	Total Count	Mean	StDev	Minimum	Maximum
REV1000	75	1552007	1116712	403713	4433000

Descriptive Statistics for Adobe Inc. Revenue (in 1000's of $) by Quarter

Statistics

Variable	Quarter	Total Count	Mean	StDev	Minimum	Maximum
REV1000	Q1	19	1522611	1143727	423281	4262000
	Q2	19	1561555	1159854	410085	4386000
	Q3	19	1592364	1192426	403713	4433000
	Q4	18	1530358	1053548	429502	4110000

Appendix 3: Independent Variable Descriptions

Data was collected for the following independent variables quarterly over the same time period as the sample of Adobe Inc Revenue data (from 1st quarter of 2004 through the 3rd quarter of 2022 for a total of 75 observations).

- **ADV1000 =** quarterly selling and general administrative expenses for Adobe Inc (in 1000's of $) obtained from S&P Capital IQ Database, Chart Builder; https://www.capitaliq.com/CIQDotNet/Charting4/ModernBuilder.aspx

- **INCPC1000 = quarterly real disposable income per capita (in 1000's of 2012 dollars) obtained from** U.S. Bureau of Economic Analysis, Real Disposable Personal Income: Per Capita [A229RX0Q048SBEA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/A229RX0Q048SBEA, November 14, 2022.

- **PPISP = Quarterly Producer Price Index for Software Publishers (in points) obtained from** U.S. Bureau of Labor Statistics, Producer Price Index by Industry: Software Publishers [PCU511210511210], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PCU511210511210, October 17, 2022.

- **Q1 = 1 if the quarter is the 1st quarter of the year (December, January, February) and 0 otherwise**
- **Q2 = 1 if the quarter is the 2nd quarter of the year (March, April, May) and 0 otherwise**
- **Q3 = 1 if the quarter is the 3rd quarter of the year (June, July, August) and 0 otherwise**
- **Q4 = 1 if the quarter is the 4th quarter of the year (September, October, November) and 0 otherwise (OMITTED CATEGORY)**

Descriptive Statistics for Independent Variables:

Statistics

Variable	Total Count	Mean	StDev	Minimum	Maximum
ADV1000	75	609754	368837	159758	1585000
INCPC1000	75	40.824	3.690	35.927	52.201
PPISP	75	89.558	3.426	85.700	95.433
Q1	75	0.2533	0.4378	0.0000	1.0000
Q2	75	0.2533	0.4378	0.0000	1.0000
Q3	75	0.2533	0.4378	0.0000	1.0000
Q4	75	0.2400	0.4300	0.0000	1.0000

Appendix 4: Check for Outliers

Regression Equation

REV1000 = -5898406 + 3.0611 ADV1000 + 26383 INCPC1000 + 50579 PPISP - 22694 Q1 - 52383 Q2 - 15261 Q3

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-5898406	625427	-9.43	0.000
ADV1000	3.0611	0.0922	33.21	0.000
INCPC1000	26383	9469	2.79	0.007
PPISP	50579	4861	10.41	0.000
Q1	-22694	34239	-0.66	0.510
Q2	-52383	34264	-1.53	0.131
Q3	-15261	34256	-0.45	0.657

Model Summary

S	R-sq	R-sq(adj)
104075	99.20%	99.13%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	9.15449E+13	1.52575E+13	1408.62	0.000
Error	68	7.36543E+11	10831518468		
Total	74	9.22814E+13			

Fits and Diagnostics for Unusual Observations

Obs	REV1000	Fit	Resid	Std Resid		
40	1041699	1293910	-252211	-2.54	R	
41	1000120	1235542	-235422	-2.35	R	
43	1005409	1219241	-213832	-2.14	R	
69	3905000	3936725	-31725	-0.36		X
73	4262000	4047920	214080	2.30	R	
74	4386000	4352636	33364	0.38		X
75	4433000	4570698	-137698	-1.59		X

R Large residual
X Unusual X

The observations in the squared box above (#40, #41, #43 and #73) are considered outliers that are a violation of studentized residuals and are Response (Y) variables causing the issue. And the observations (#69, #74 and #75) are considered outliers that are a violation of Cook's D, and these are predictors (Xs) causing the issue.

After going through these outliers in the dataset I found no errors. Moreover, these are part of the target population that I am trying to analyze. Hence, I am keeping these in the sample.

Appendix 5: Check for Multicollinearity

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
104075	99.20%	99.13%	99.01%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-5898406	625427	-9.43	0.000	
ADV1000	3.0611	0.0922	33.21	0.000	7.89
INCPC1000	26383	9469	2.79	0.007	8.34
PPISP	50579	4861	10.41	0.000	1.89
Q1	-22694	34239	-0.66	0.510	~~1.54~~
Q2	-52383	34264	-1.53	0.131	~~1.54~~
Q3	-15261	34256	-0.45	0.657	~~1.54~~

The VIF's on ADV1000 and INCPC1000 are subsequently 7.89 and 8.34 which are greater than 5. These are the two variables that are highly correlated. Therefore, multicollinearity is a problem. As the VIF of INCPC1000 is higher than the VIF of ADV1000, I will remove INCPC1000 from dataset and again will recheck if Multicollinearity is still a problem or not.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
109056	99.11%	99.05%	98.94%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-4659980	461074	-10.11	0.000	
ADV1000	3.2870	0.0459	71.67	0.000	1.78
PPISP	47235	4936	9.57	0.000	1.78
Q1	-21196	35874	-0.59	0.557	~~1.54~~
Q2	-50713	35899	-1.41	0.162	~~1.54~~
Q3	-17018	35889	-0.47	0.637	~~1.54~~

All VIF's are below 5 for the continuous independent variables. Therefore, INCPC1000 will be removed as a predictor in our model going forward. Multicollinearity is no longer a problem.

Appendix 6: Check for Curvilinearity

There are two continuous predictors (ADV1000 & PPISP). Hence, I need to run 4 models to check for curvilinearity. I select the model with the highest adj-R2 that has all squared terms with p-values < alpha. After running 4 models, I found that the X-squared variables of Model B, C, D have p-values >alpha. So, I eliminated these models and I select Model-A as the p-values of the continuous predictors of this model is less than alpha. Hence, Model-A is the best model for going forward.

Model-A

Model Summary

S	R-sq	R-sq(adj)
109056	99.11%	99.05%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-4659980	461074	-10.11	0.000
ADV1000	3.2870	0.0459	71.67	0.000
PPISP	47235	4936	9.57	0.000
Q1	-21196	35874	-0.59	0.557
Q2	-50713	35899	-1.41	0.162
Q3	-17018	35889	-0.47	0.637

Model-B

Model Summary

S	R-sq	R-sq(adj)
109038	99.12%	99.05%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-4047823	760678	-5.32	0.000
ADV1000	3.026	0.262	11.56	0.000
ADV1000_SQ	0.000000	0.000000	1.01	0.315
PPISP	41397	7593	5.45	0.000
Q1	-23454	35937	-0.65	0.516
Q2	-52653	35944	-1.46	0.148
Q3	-19979	36003	-0.55	0.581

Model-C

Model Summary

S	R-sq	R-sq(adj)
108192	99.14%	99.06%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-31931816	18796840	-1.70	0.094
ADV1000	3.2953	0.0459	71.86	0.000
PPISP	648712	414468	1.57	0.122
PPISP_SQ	-3312	2282	-1.45	0.151
Q1	-20788	35591	-0.58	0.561
Q2	-51242	35617	-1.44	0.155
Q3	-19511	35647	-0.55	0.586

Model-D

Model Summary

S	R-sq	R-sq(adj)
108650	99.14%	99.05%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-28113270	19758216	-1.42	0.159
ADV1000	3.120	0.272	11.47	0.000
ADV1000_SQ	0.000000	0.000000	0.65	0.515
PPISP	569617	433426	1.31	0.193
PPISP_SQ	-2898	2377	-1.22	0.227
Q1	-22348	35821	-0.62	0.535
Q2	-52473	35817	-1.47	0.148
Q3	-21179	35888	-0.59	0.557

Appendix 7: Check for Heteroscedasticity

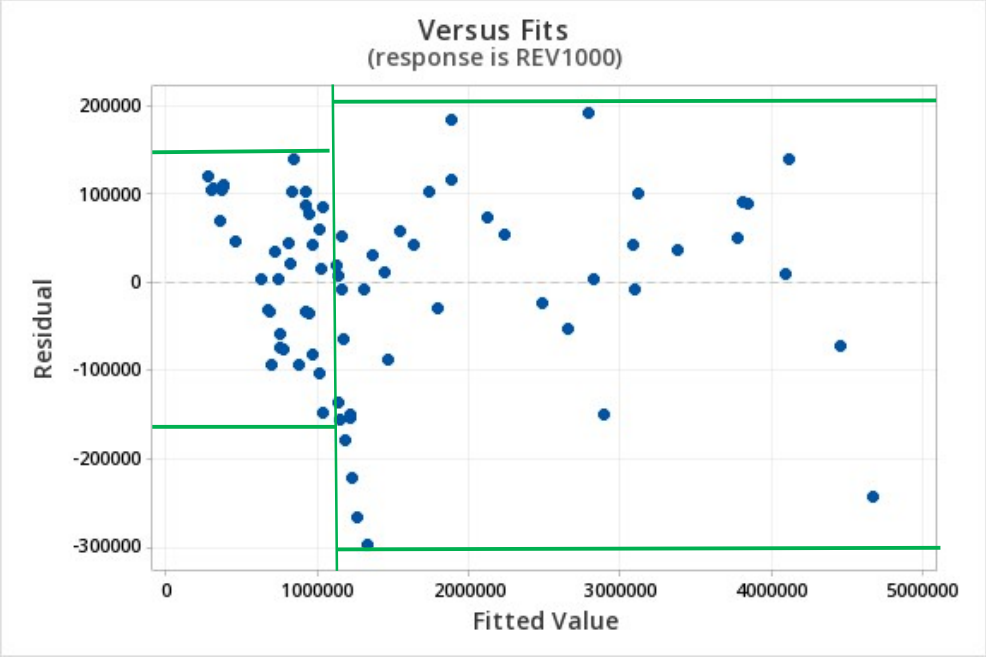
I will use Model-A from the previous appendix to check for heteroscedasticity using the residual vs. fit plot.

Model Summary

S	R-sq	R-sq(adj)
109056	99.11%	99.05%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-4659980	461074	-10.11	0.000
ADV1000	3.2870	0.0459	71.67	0.000
PPISP	47235	4936	9.57	0.000
Q1	-21196	35874	-0.59	0.557
Q2	-50713	35899	-1.41	0.162
Q3	-17018	35889	-0.47	0.637



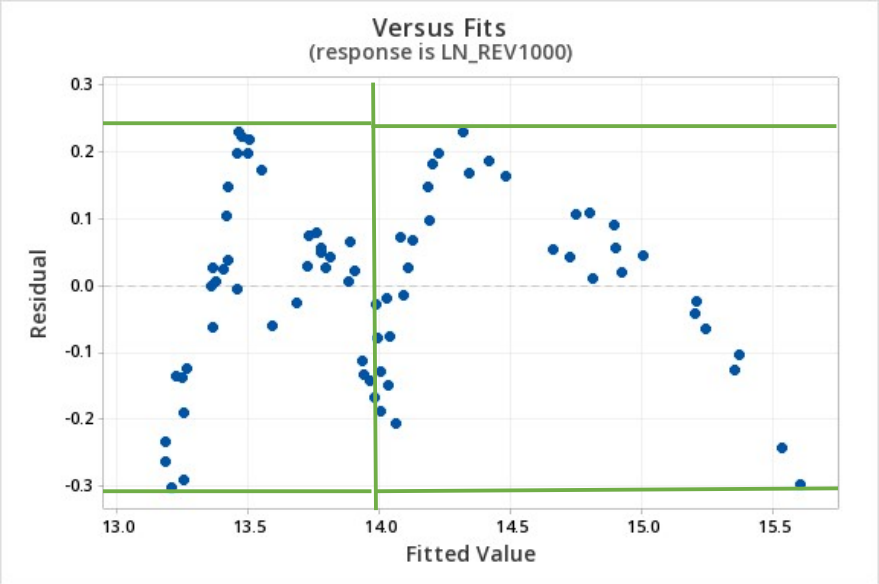
Heteroscedasticity is causing a potential problem in the model because the frame in the right side of the graph is wider than the frame in the left side of the graph. I will take an attempt to correct it by using natural log of Y variable= LN_REV1000.

Model Summary

S	R-sq	R-sq(adj)
0.142019	95.61%	95.29%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	15.537	0.600	25.88	0.000
ADV1000	0.000002	0.000000	26.10	0.000
PPISP	-0.02707	0.00643	-4.21	0.000
Q1	-0.0379	0.0467	-0.81	0.420
Q2	-0.0442	0.0467	-0.95	0.348
Q3	-0.0342	0.0467	-0.73	0.467



After running the model with natural log of Y variable= LN_REV1000, it is found in the Residual vs Fit Graph that the right frame of the graph is now more equal to the frame on the left side of the graph. The adj-R2 did not drop by more than 5 percentage points. I will keep LN_REV1000 as the response variable and now will check for curvilinearity using LN_REV1000 as the response variable.

Checking for Curvilinearity

Model-A

Model Summary

S	R-sq	R-sq(adj)
0.142019	95.61%	95.29%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	15.537	0.600	25.88	0.000
ADV1000	0.000002	0.000000	26.10	0.000
PPISP	-0.02707	0.00643	-4.21	0.000
Q1	-0.0379	0.0467	-0.81	0.420
Q2	-0.0442	0.0467	-0.95	0.348
Q3	-0.0342	0.0467	-0.73	0.467

Model-B

Model Summary

S	R-sq	R-sq(adj)
0.0790646	98.66%	98.54%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	10.081	0.552	18.28	0.000
ADV1000	0.000004	0.000000	20.46	0.000
ADV1000_SQ	-0.000000	0.000000	-12.43	0.000
PPISP	0.02496	0.00551	4.53	0.000
Q1	-0.0178	0.0261	-0.68	0.498
Q2	-0.0269	0.0261	-1.03	0.306
Q3	-0.0078	0.0261	-0.30	0.767

Model-C

Model Summary

S	R-sq	R-sq(adj)
108192	99.14%	99.06%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-31931816	18796840	-1.70	0.094
ADV1000	3.2953	0.0459	71.86	0.000
PPISP	648712	414468	1.57	0.122
PPISP_SQ	-3312	2282	-1.45	0.151
Q1	-20788	35591	-0.58	0.561
Q2	-51242	35617	-1.44	0.155
Q3	-19511	35647	-0.55	0.586

Model-D

Model Summary

S	R-sq	R-sq(adj)
108650	99.14%	99.05%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	-28113270	19758216	-1.42	0.159
ADV1000	3.120	0.272	11.47	0.000
ADV1000_SQ	0.000000	0.000000	0.65	0.515
PPISP	569617	433426	1.31	0.193
PPISP_SQ	-2898	2377	-1.22	0.227
Q1	-22348	35821	-0.62	0.535
Q2	-52473	35817	-1.47	0.148
Q3	-21179	35888	-0.59	0.557

There are two continuous predictors (ADV1000 & PPISP). Hence, I need to run 4 models to check for curvilinearity. I select the model with the highest adj-R2 that has all squared terms with p-values < alpha. After running 4 models, I found that the X-squared variables of Model C, D have p-values >alpha. So, I eliminated these models. Of the remaining models, Model B has the highest adj-R2 (98.54%) and the X-squared variable (ADV1000_SQ) has p-values < alpha of 0.10. Therefore, Model-B is the best model after "checking" for curvilinearity.

Appendix 8: Check for Autocorrelation

The data is time-series data (revenue per quarter). Thus, it is necessary to check for autocorrelation. However, since the Durbin-Watson table is not available for a level of significance of 10%, the level of significance for this test will be 5%.

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	10.081	0.552	18.28	0.000
ADV1000	0.000004	0.000000	20.46	0.000
ADV1000_SQ	-0.000000	0.000000	-12.43	0.000
PPISP	0.02496	0.00551	4.53	0.000
Q1	-0.0178	0.0261	-0.68	0.498
Q2	-0.0269	0.0261	-1.03	0.306
Q3	-0.0078	0.0261	-0.30	0.767

Model Summary

S	R-sq	R-sq(adj)
0.0790646	98.66%	98.54%

Durbin-Watson Statistic

Durbin-Watson Statistic = 0.416137

H_o: There is no first order autocorrelation.
H_A: There is first order autocorrelation.
DW_c =0.416137
$D_{\alpha,k,n} = D_{0.05,6,75} \approx D_{0.05,5,75} \rightarrow D_L = 1.49 \; and \; D_U = 1.77$
Reject H_o; There is enough statistical evidence to show that there is POSITIVE first-order autocorrelation.

I will attempt to fix Autocorrelation by adding a time trend as an additional predictor in the model:

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.899	0.641	15.45	0.000
ADV1000	0.000004	0.000000	9.34	0.000
ADV1000_SQ	-0.000000	0.000000	-7.71	0.000
PPISP	0.02715	0.00675	4.02	0.000
Q1	-0.0171	0.0262	-0.65	0.517
Q2	-0.0265	0.0262	-1.01	0.315
Q3	-0.0094	0.0264	-0.36	0.723
TIME	0.00189	0.00334	0.57	0.572

Model Summary

S	R-sq	R-sq(adj)
0.0794616	98.67%	98.53%

Durbin-Watson Statistic

Durbin-Watson Statistic = 0.416132

H_o: There is no first order autocorrelation.
H_A: There is first order autocorrelation.
DW_c =0.416132
$D_{\alpha,k,n} = D_{0.05,7,75} \approx D_{0.05,5,75} \rightarrow D_L = 1.49 \; and \; D_U = 1.77$
Reject H_o; There is enough statistical evidence to show that there is POSITIVE first-order autocorrelation.

The positive autocorrelation was not corrected by adding time. Next, autocorrelation will attempt to be corrected by adding both time and time-squared as predictors in the model.

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.534	0.652	14.62	0.000
ADV1000	0.000004	0.000000	9.21	0.000
ADV1000_SQ	-0.000000	0.000000	-6.55	0.000
PPISP	0.03059	0.00682	4.49	0.000
Q1	-0.0164	0.0256	-0.64	0.524
Q2	-0.0276	0.0256	-1.08	0.285
Q3	-0.0100	0.0258	-0.39	0.701
TIME	0.00784	0.00440	1.78	0.079
TIME_SQ	-0.000088	0.000044	-2.02	0.048

Model Summary

S	R-sq	R-sq(adj)
0.0777063	98.74%	98.59%

Durbin-Watson Statistic

Durbin-Watson Statistic = 0.468635

H_o: There is no first order autocorrelation.
H_A: There is first order autocorrelation.
DW_c =0.468635
$D_{\alpha,k,n} = D_{0.05,8,75} \approx D_{0.05,5,75} \rightarrow D_L = 1.49 \; and \; D_U = 1.77$
Reject H_o; There is enough statistical evidence to show that there is POSITIVE first-order autocorrelation.

The autocorrelation was not corrected by adding time and time-squared. Time and time squared will be used in going forward because the model with them has the highest adj-R2 and the p-values on time-SQ is lesser than alpha of 10%. **Note, that positive autocorrelation is still a problem in the model that was not corrected.**

Appendix 9: Check for Normality of Residuals

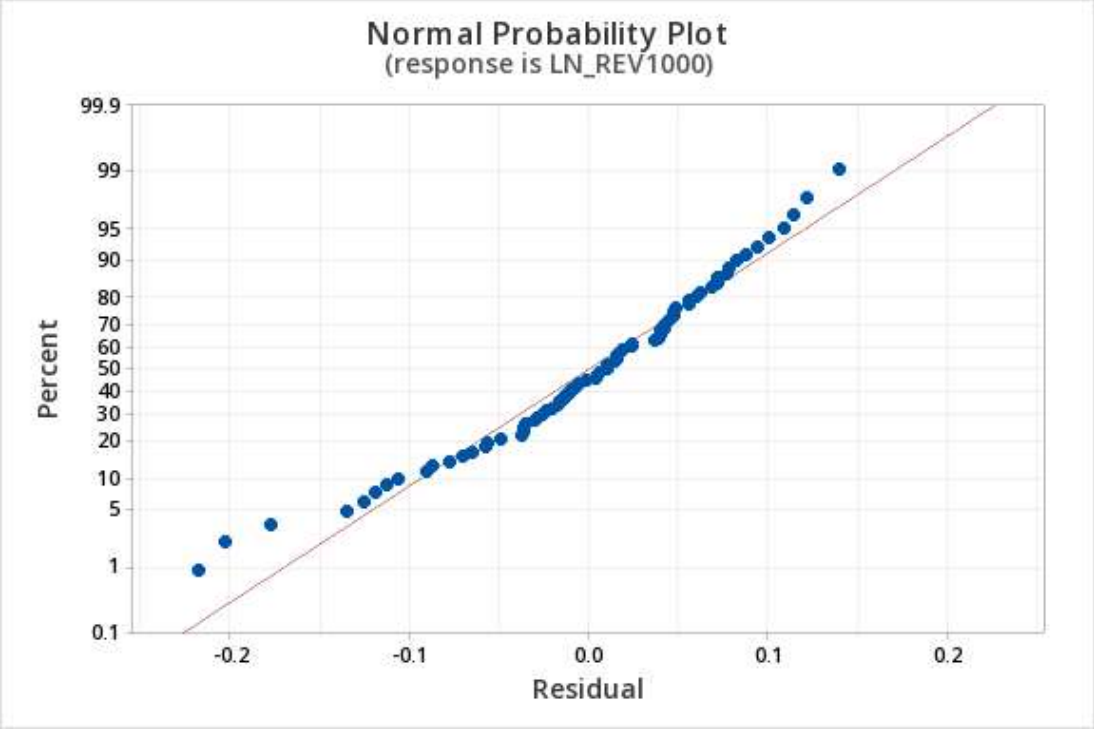
Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.534	0.652	14.62	0.000
ADV1000	0.000004	0.000000	9.21	0.000
ADV1000_SQ	-0.000000	0.000000	-6.55	0.000
PPISP	0.03059	0.00682	4.49	0.000
Q1	-0.0164	0.0256	-0.64	0.524
Q2	-0.0276	0.0256	-1.08	0.285
Q3	-0.0100	0.0258	-0.39	0.701
TIME	0.00784	0.00440	1.78	0.079
TIME_SQ	-0.000088	0.000044	-2.02	0.048

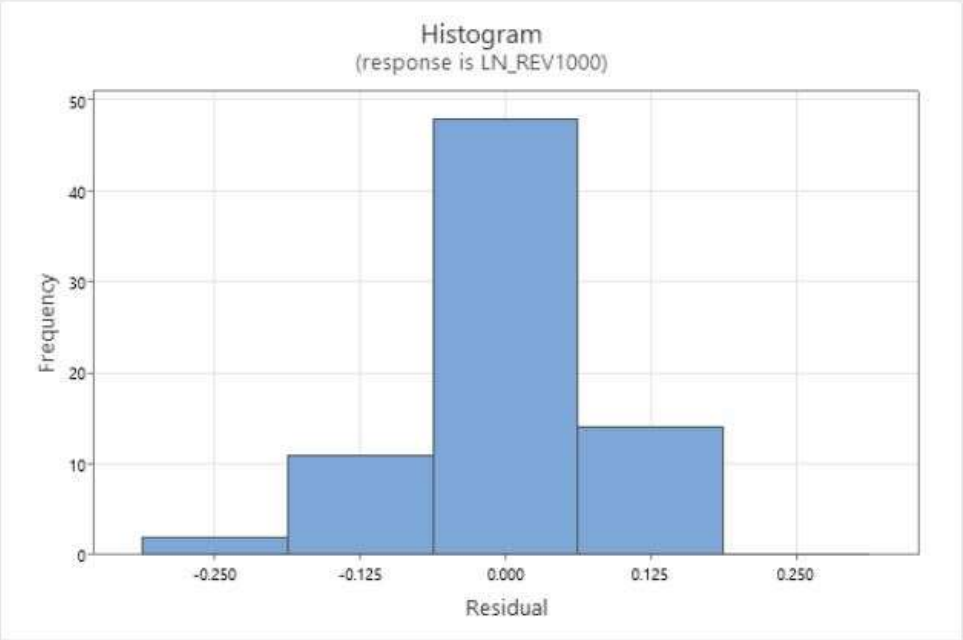
Model Summary

S	R-sq	R-sq(adj)
0.0777063	98.74%	98.59%

Majority of the points lie on the red line or close to the red line indicating the residuals are normally distributed. There are six extreme points that do not follow this pattern.



The histogram of residuals is centered around 0 (highest bar at 0) and almost symmetric (slightly skewed to the right) indicating a mostly normal distribution of residuals.



Appendix 10: Hypothesis TEST of Significance for Each Independent Variable in Your Final Model.

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.534	0.652	14.62	0.000
ADV1000	0.000004	0.000000	9.21	0.000
ADV1000_SQ	-0.000000	0.000000	-6.55	0.000
PPISP	0.03059	0.00682	4.49	0.000
Q1	-0.0164	0.0256	-0.64	0.524
Q2	-0.0276	0.0256	-1.08	0.285
Q3	-0.0100	0.0258	-0.39	0.701
TIME	0.00784	0.00440	1.78	0.079
TIME_SQ	-0.000088	0.000044	-2.02	0.048

Model Summary

S	R-sq	R-sq(adj)
0.0777063	98.74%	98.59%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	31.3177	3.91471	648.32	0.000
Error	66	0.3985	0.00604		
Total	74	31.7162			

H_o: $\beta_{ADV1000\_SQ} = 0$; There is NO curvilinear relationship between quarterly advertising expense and quarterly Adobe Inc sales revenue
H_A: $\beta_{ADV1000\_SQ} \neq 0$; There IS a curvilinear relationship between quarterly advertising expense and quarterly Adobe Inc sales revenue
$T_c = -6.55$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.000 < \alpha = 0.10$
Reject H_o; There is enough statistical evidence to show a curvilinear relationship exists between quarterly advertising expense and quarterly Adobe Inc sales revenue

H_o: $\beta_{PPISP} = 0$; There is NO linear relationship between quarterly Producer Price Index for Software Publishers and quarterly Adobe Inc sales revenue
H_A: $\beta_{PPISP} \neq 0$; There IS a linear relationship between quarterly Producer Price Index for Software Publishers and quarterly Adobe Inc sales revenue
$T_c = 4.49$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.00 < \alpha = 0.10$

Reject H_o; There is enough statistical evidence to show a linear relationship exists between quarterly Producer Price Index for Software Publishers and quarterly Adobe Inc sales revenue

H_o: $\beta_{TIME\_SQ} = 0$; There is NO curvilinear relationship between time and quarterly Adobe Inc sales revenue
H_A: $\beta_{TIME\_SQ} \neq 0$; There IS a curvilinear relationship between time and quarterly Adobe Inc sales revenue
$T_c = -2.02$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.048 < \alpha = 0.10$
Reject H_o; There is enough statistical evidence to show a curvilinear relationship exists between time and quarterly Adobe Inc sales revenue

H_o: $\beta_{Q1} = 0$; Adobe Inc quarterly sales revenue in Q1 is the SAME as in Q4
H_A: $\beta_{Q1} \neq 0$; Adobe Inc quarterly sales revenue in Q1 is DIFFERENT than in Q4
$T_c = -0.64$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.524 > \alpha = 0.10$
Do not Reject H_o; There is not enough statistical evidence to show Adobe Inc quarterly sales revenue in Q1 is DIFFERENT than in Q4.

H_o: $\beta_{Q2} = 0$; Adobe Inc quarterly sales revenue in Q2 is the SAME as in Q4
H_A: $\beta_{Q2} \neq 0$; Adobe Inc quarterly sales revenue in Q2 is DIFFERENT than in Q4
$T_c = -1.08$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.285 > \alpha = 0.10$
Do not Reject H_o; There is not enough statistical evidence to show Adobe Inc quarterly sales revenue in Q2 is DIFFERENT than in Q4.

H_o: $\beta_{Q3} = 0$; Adobe Inc quarterly sales revenue in Q3 is the SAME as in Q4
H_A: $\beta_{Q3} \neq 0$; Adobe Inc quarterly sales revenue in Q3 is DIFFERENT than in Q4
$T_c = -0.39$
$\pm T_{0.05,66} = \pm 1.645$; $[Degree\ of\ Freedom = (n - k - 1) = (75 - 8 - 1) = 66]$
$p = 0.701 > \alpha = 0.10$
Do not Reject H_o; There is not enough statistical evidence to show Adobe Inc quarterly sales revenue in Q3 is DIFFERENT than in Q4.

Appendix 11: Interpretation of Each Slope/Coefficient in Final Regression Model

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.5341620007442991	0.652	14.62	0.000
ADV1000	0.0000035854642429	0.000000	9.21	0.000
ADV1000_SQ	-0.0000000000010694	0.000000	-6.55	0.000
PPISP	0.0305903876192662	0.00682	4.49	0.000
Q1	-0.0164102034742126	0.0256	-0.64	0.524
Q2	-0.0276315439635518	0.0256	-1.08	0.285
Q3	-0.0099512958027718	0.0258	-0.39	0.701
TIME	0.0078383278419091	0.00440	1.78	0.079
TIME_SQ	-0.0000884909488352	0.000044	-2.02	0.048

$$\boldsymbol{slope\ of\ curve} = b_{ADV1000} + \left(2 \times b_{ADV1000\_SQ} \times ADV1000\right)$$
$$= 0.0000035854642429 + (2 \times -0.0000000000010694 \times 609754)$$
$$= 0.0000035854631789$$

At a level of **quarterly advertising expenses for Adobe Inc** of $609,754,000 (the mean value), if the quarterly advertising expense for Adobe Inc increases by $1,000, Adobe Inc quarterly sales revenue will increase by 0.0003585%, on average, all else equal.

$$\boldsymbol{max} = \frac{-b_{ADV1000}}{2 \times b_{ADV1000\_SQ}} = \frac{-(0.0000035854642429)}{(2 \times -0.0000000000010694)} = 1676390.6129$$

Adobe Inc quarterly sales revenue is maximized at a quarterly advertising expense of $1,676,390,613.

If the **Producer Price Index for Software Publishers** increases by 1 point, Adobe Inc quarterly sales revenue will increase by 3.059%, on average, all else equal.

$$\boldsymbol{slope\ of\ curve} = b_{TIME} + \left(2 \times b_{TIME\_SQ} \times TIME\right)$$
$$= 0.00784 + (2 \times -0.000088 \times 75) = 0.00536$$

At quarter 75, If **time** increases by 1 quarter, Adobe Inc quarterly sales revenue will increase by 0.536%, on average, all else equal.

$$\boldsymbol{max} = \frac{-b_{TIME}}{2 \times b_{TIME\_SQ}} = \frac{-(0.00784)}{(2 \times -0.000088)} = 44.5454$$

Adobe Inc quarterly sales revenue is maximized at quarter 45 of the series.

Q1 (p=0.524): There is not enough statistical evidence to show that Adobe Inc quarterly sales revenue in Q1 is different than in Q4.

Q2 (p=0.285): There is not enough statistical evidence to show that Adobe Inc quarterly sales revenue in Q2 is different than in Q4.

Q3 (p=0.701): There is not enough statistical evidence to show that Adobe Inc quarterly sales revenue in Q3 is different than in Q4.

Appendix 12: Hypothesis Test of Regression Validity

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.534	0.652	14.62	0.000
ADV1000	0.000004	0.000000	9.21	0.000
ADV1000_SQ	-0.000000	0.000000	-6.55	0.000
PPISP	0.03059	0.00682	4.49	0.000
Q1	-0.0164	0.0256	-0.64	0.524
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Q3	-0.0100	0.0258	-0.39	0.701
TIME	0.00784	0.00440	1.78	0.079
TIME_SQ	-0.000088	0.000044	-2.02	0.048

Model Summary

S	R-sq	R-sq(adj)
0.0777063	98.74%	98.59%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	31.3177	3.91471	648.32	0.000
Error	66	0.3985	0.00604		
Total	74	31.7162			

H_o: $\beta_1 = \beta_2 = \beta_3 = \cdots = \beta_7 = \beta_8 = 0$; None of the independent variables are related to Adobe Inc quarterly sales revenue and therefore this is not a valid regression.
H_A: At least one $\beta_i \neq 0$; At least one of the independent variables is related to Adobe Inc quarterly sales revenue and therefore this is a valid regression.
F_C =648.32
$F_{\alpha,k,n-k-1} = F_{0.10,8,66} \approx F_{0.10,8,70} = 1.760$
$p = 0.000 < \alpha = 0.10$
Reject H_o; There is enough statistical evidence to show that at least one of the independent variables is related to Adobe Inc quarterly sales revenue and therefore this is a valid regression.

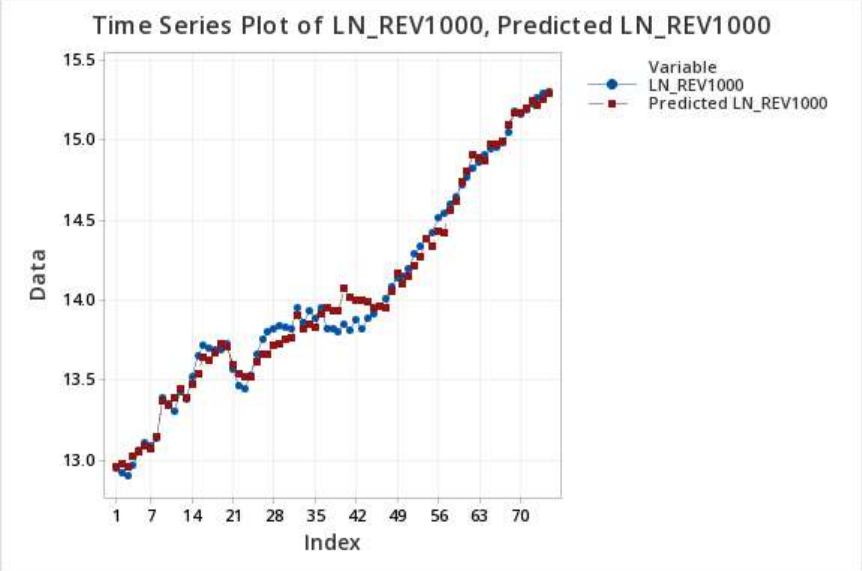
Appendix 13: Graph of Actual Dependent Variable vs. Predicted Dependent Variable

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	9.534	0.652	14.62	0.000
ADV1000	0.000004	0.000000	9.21	0.000
ADV1000_SQ	-0.000000	0.000000	-6.55	0.000
PPISP	0.03059	0.00682	4.49	0.000
Q1	-0.0164	0.0256	-0.64	0.524
Q2	-0.0276	0.0256	-1.08	0.285
Q3	-0.0100	0.0258	-0.39	0.701
TIME	0.00784	0.00440	1.78	0.079
TIME_SQ	-0.000088	0.000044	-2.02	0.048

Model Summary

S	R-sq	R-sq(adj)
0.0777063	98.74%	98.59%



Here, we can see the final model has an adj-R2 of 98.59% which means that 98.59% of the variation in Adobe Inc quarterly sales revenue is explained by the variation in all of the predictors in the final regression model. Thus, this model can be used to make solid predictions as indicated by the graph above which show the actual values of Adobe Inc revenue in comparison to the values of Adobe Inc revenue predicted from the regression model. Like, it can be seen the regression model provides a good prediction for most quarters in the sample.