

Executive Summary

The purpose of this report is to determine if we can apply *Time Series Regression using trend and seasonal variables* to forecast Edison's quarterly revenues for 2000, and *compare this result to those belong to previously used forecasting methods* (Naive I, Moving Average, Simple Exponential Smoothing, and Holt's Linear Exponential Smoothing, and Winter's Seasonal Linear Exponential Smoothing).

In previous report, we know that the data has a strong seasonality pattern of four periods, and has a linear trend pattern as well. To develop a time series regression, we add a *trend variable*, to account for the trend, and *four dummy variables* to account for four periods of seasonality. We do not use constant in this case, because it has been incorporated into one of the dummy variables. Then we run multiple regression analysis using these trend and dummy variables as independent variables, and revenue as dependent variable.

Appendix 1 shows the regression output and its analysis of variance. The *coefficients are significantly different from zero*, as their coefficients have high t values ($t_{0.05, 60} = 2.00$) and low p values. The *regression is also significant* with high adjusted-R square (91.0%), large F ratio (150), and small P value. But the Durbin-Watson (DW) statistic (1.14) is smaller than lower bound (1.408), a sign of a *serial correlation*. The residual pattern in Appendix 2 (top graph) seems to suggest a serial correlation as well (string of positive residuals followed by string of negative residuals). Although the residuals appear to be distributed with constant variability, thus have *no heteroscedasticity* problem. Appendix 4 (top graph) indicates that the forecast data does *fit well* with the actual data. Overall the time series regression is *significant with a positive serial correlation*.

We can fix the serial correlation problem by autoregressing the model with first order difference (Autocorrelation Regression). Appendix 3 shows the autocorrelation regression output and its analysis of variance. Again the *coefficients are significant*, as their coefficients have high t values and low p values. The *regression is also significant* with high adjusted-R square (93.0%), large F ratio (193), and small P value. Difference is that the DW statistic (2.33) is now higher than upper bound (1.767), thus we solve the serial correlation problem. Residuals in Appendix 2 (bottom graph) appear to be more randomly distributed about zero with constant variability, thus we have *no serial correlation and heteroscedasticity problems*. Appendix 4 (bottom graph) indicates that the forecast data also *fit well* with the actual data. In comparison, *the autocorrelation regression is significant but less biased than the previous time series regression*. Because the serial correlation leads us to believe that the previous regression is better than it really is. Only that the autocorrelation regression will not allow us to compare its Mean Square Error (MSE) with those of other methods because the value of dependent variable has been changed.

If we compare the result of the time series regression with those of previously used methods in terms of MSE (see Appendix 5), time series regression has the *second least MSE* after Winter's Seasonal Linear Exponential Smoothing. Unfortunately we cannot use MSE of the autocorrelation regression for comparison for reason I mention above. But we can look at its autocorrelation plot (see bottom plot in Appendix 6) to compare its error terms. The p-value is lower than 0.05 that we reject the random hypothesis. The plots have pattern and they are outside the control limit, another indication that the *residuals are not random*. Similar results can be said for the time series regression (see top plot in Appendix 6). Therefore the *Winter's Seasonal Linear Exponential Smoothing has better error terms than either the time series regression's and the autocorrelation regression's*. (see Appendix 5 for error terms comparison table).

Appendix 1: Multiple Regression Analysis

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FILE: EDISON, NO. OF VARIABLES: 6, NO. OF CASES: 60 (MISS. CASES: 0)
 LABEL: Quarterly Revenues for Consolidated Edison (\$ million), 1985-1999

MULTIPLE REGRESSION

**MODEL: Qtr_Revenue = 9.73661Trend + 1292.11Dm1 + 1044.3Dm2 + 1436.77Dm3
 + 1124.43Dm4**

	COEF.	SD. ER.	t(55)	P-VALUE	PT. R SQ.
Trend	9.73661	0.534082	18.2306	5.60804E-25	0.858011
Dm1	1292.11	24.0969	53.6212	3.58016E-49	0.98123
Dm2	1044.3	24.4436	42.7229	7.16246E-44	0.970749
Dm3	1436.77	24.797	57.9412	5.42980E-51	0.983881
Dm4	1124.43	25.1567	44.697	6.39437E-45	0.973208

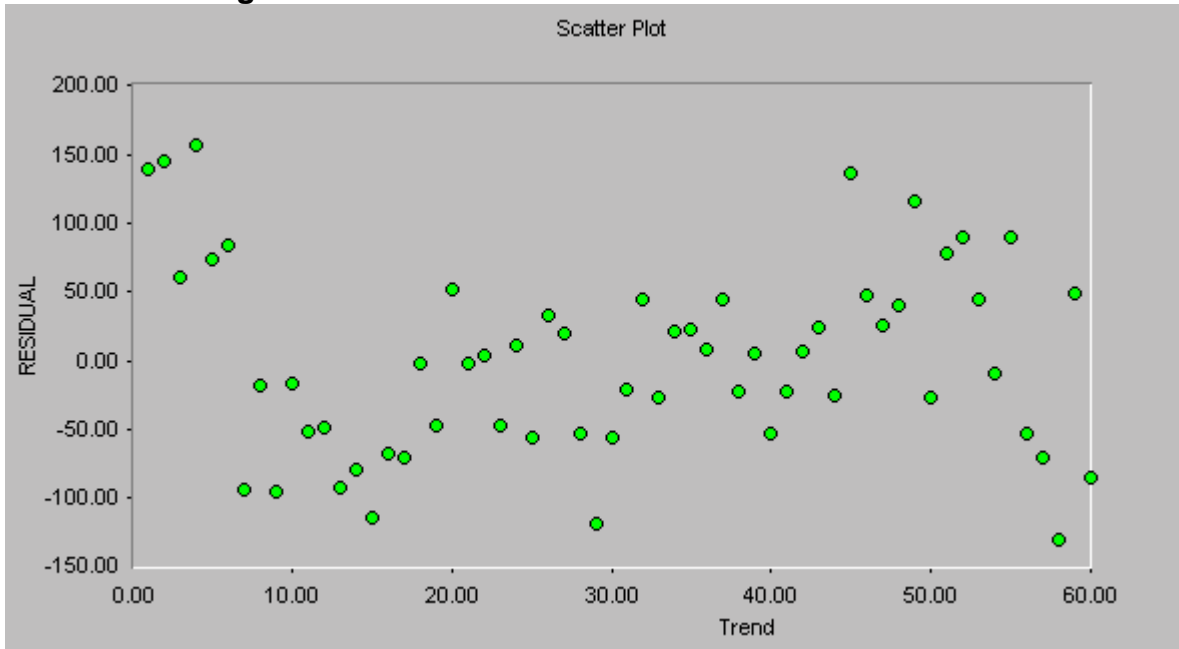
R SQ. = 0.916145, ADJ. R SQ. = **0.910046**, D. W. = **1.14246**
 SD. ER. EST. = 71.4952, F(4/55) = **150.223** (P-VALUE = 6.53563E-29)

ANALYSIS OF VARIANCE TABLE

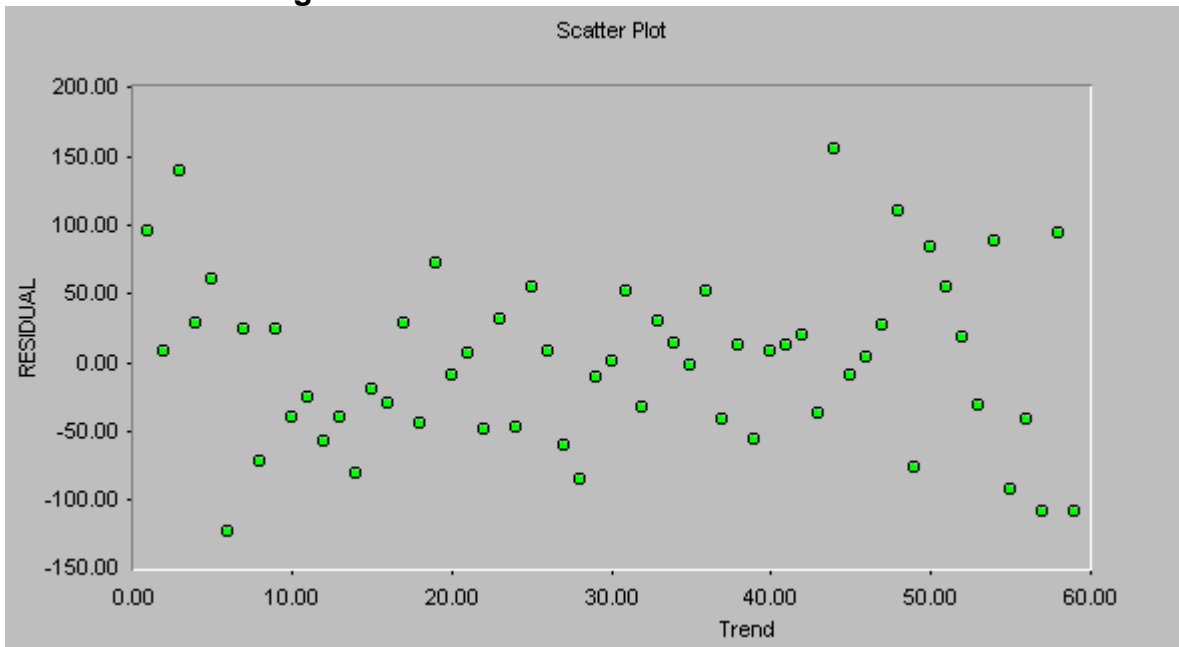
	SUM OF SQ'S	D.F.	MEAN SQ.	F(4/55)	P-VALUE
MODEL	3.07149E6	4	767874	150.223	6.53563E-29
ERROR	2.81136E5	55	5111.56		
TOTAL	3.35263E6	59			

Appendix 2: Scatter Plot of Residual

Time Series Regression



Autocorrelation Regression



Appendix 3: Autocorrelation Regression Analysis

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FILE: Edison_residual, NO. OF VARIABLES: 6, NO. OF CASES(MISS. CASES: 0)
 LABEL: Quarterly Revenues for Consolidated Edison (\$ million), 1985-1999

AUTOCORRELATION

AUTOCORRELATION COEF. (r) = **0.391565**

MODEL: **Qtr_Revenue-rL1 = 10.0427Trend-rL1 + 1269.75Dm1-rL1 + 1029.84Dm2-rL1
 + 1425.21Dm3-rL1 + 1113.83Dm4-rL1**

	COEF.	SD. ER.	t(54)	P-VALUE	PT. R SQ.
Trend-rL1	10.0427	0.797308	12.5957	1.05266E-17	0.746064
Dm1-rL1	1269.75	31.5702	40.2201	6.17013E-42	0.967697
Dm2-rL1	1029.84	30.8269	33.4073	9.47823E-38	0.953848
Dm3-rL1	1425.21	30.9912	45.9876	5.43720E-45	0.975102
Dm4-rL1	1113.83	31.4601	35.4044	4.71556E-39	0.958699

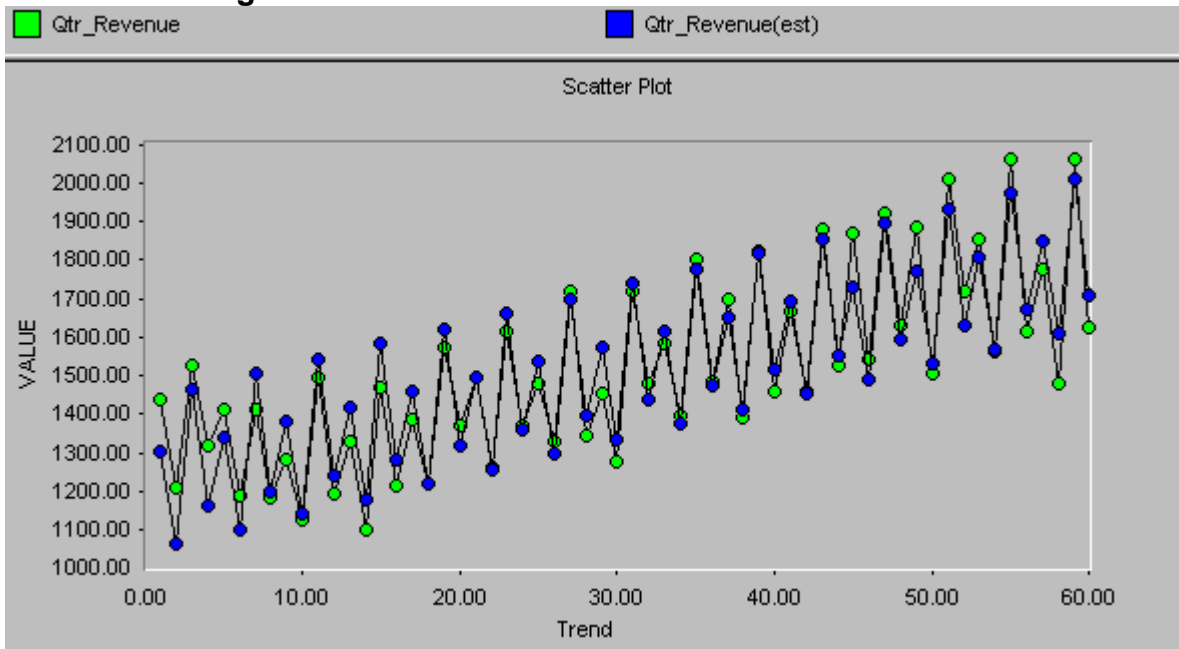
R SQ. = 0.93477, ADJ. R SQ. = **0.929938**, D. W. = **2.33113**
 SD. ER. EST. = 63.3993, F(4/54) = **193.461** (P-VALUE = 2.56428E-31)

----- ANALYSIS OF VARIANCE TABLE -----

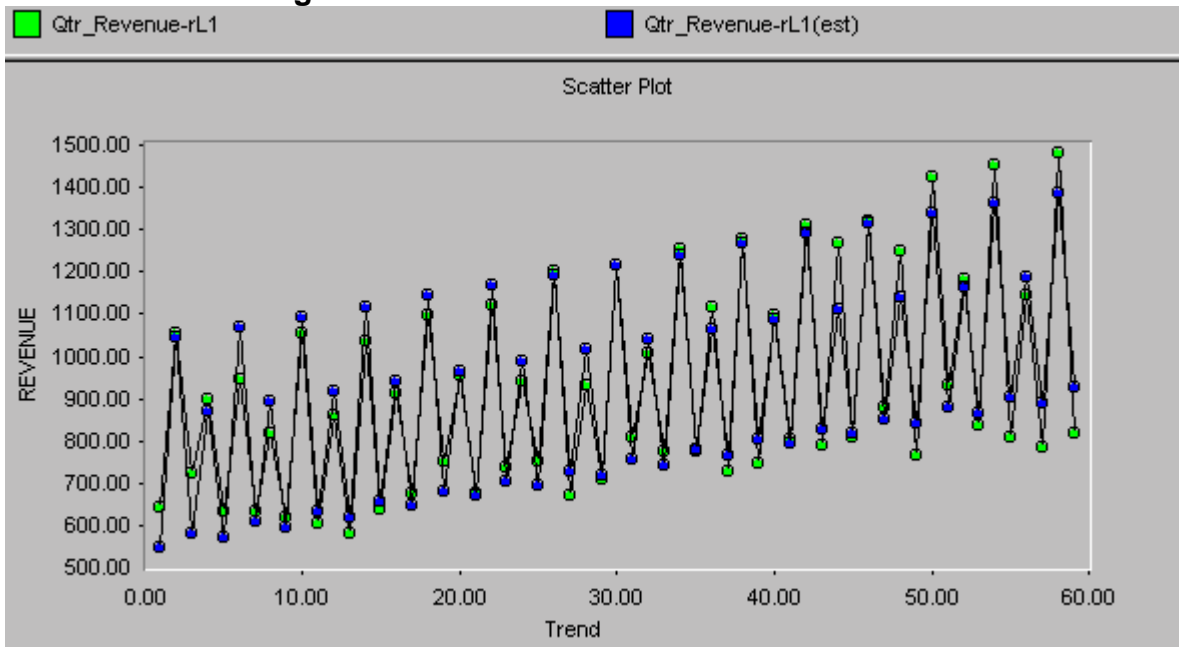
	SUM OF SQ'S	D.F.	MEAN SQ.	F(4/54)	P-VALUE
MODEL	3.11044E6	4	777611	193.461	2.56428E-31
ERROR	2.17051E5	54	4019.47		
TOTAL	3.32749E6	58			

Appendix 4: Scatter Plot of Actual and Forecast Data

Time Series Regression



Autocorrelation Regression



**Appendix 5: Error Terms Comparison Table
(Trend and Seasonal data)**

Forecasting Method	Mean Square Error (MSE)	AutoCorrelation of Error Terms Inside Control Limit?	AutoCorrelation of Error Terms Have no Pattern?	p-value is greater than 0.05?	Actual Error Terms have no Pattern?
Naive I	90,382.20	No	No	No	No
Moving Average (2 periods)	33,119.60	No	No	No	No
Simple Exponential Smoothing (0.2 factor)	34,615.10	No	No	No	No
Holt's Linear Exponential Smoothing (0.1 smoothing factor, 0.1 trend factor)	30,970.10	No	No	No	No
Winter's Seasonal Linear Exponential Smoothing (0.6 smoothing factor, 0.1 trend factor, 4 seasons)	3,583.20	Yes	Yes	Yes	Yes
Time Series Regression (for trend & seasonal)	5,111.56	No	No	No	Yes
Autocorrelation Regression (for trend & seasonal)	N/A	No	No	No	Yes

Appendix 6: Residual Autocorrelation Plot

Time Series Regression

Auto/Partial Correlation Plot OF RESIDUAL

BOX-PIERCE Q(15) = 40.3329, P-VALUE = **0.00040386**

AUTOCORRELATION PLOT

	CORRELATION	STD.ERROR	-1	-.75	-.5	-.25	0	.25	.5	.75	1
Lag -1	0.381591	0.129099	.	.	(	*****	***	.	.	.	.
Lag -2	0.448568	0.146698	.	.	(	*****	***	.	.	.	.
Lag -3	0.192123	0.16801	.	.	(	*****	)	.	.	.	.
Lag -4	0.265879	0.171633	.	.	(	*****	)	.	.	.	.
Lag -5	-0.13205	0.178366	.	.	(	****	)	.	.	.	.
Lag -6	0.0615692	0.179987	.	.	(	**	)	.	.	.	.
Lag -7	-0.0990077	0.180338	.	.	(	***	)	.	.	.	.
Lag -8	-0.0738713	0.181242	.	.	(	**	)	.	.	.	.
Lag -9	-0.22986	0.181743	.	.	(	*****	)	.	.	.	.
Lag -10	-0.0193023	0.186525	.	.	(	*	)	.	.	.	.
Lag -11	-0.249762	0.186559	.	.	(	*****	)	.	.	.	.
Lag -12	-0.149693	0.192051	.	.	(	****	)	.	.	.	.
Lag -13	-0.188597	0.193986	.	.	(	*****	)	.	.	.	.
Lag -14	-0.00361441	0.197018	.	.	(	*	)	.	.	.	.
Lag -15	-0.0878718	0.197019	.	.	(	***	)	.	.	.	.

Autocorrelation Regression

Auto/Partial Correlation Plot OF RESIDUAL

BOX-PIERCE Q(15) = 53.412, P-VALUE = **0.00000329281**

AUTOCORRELATION PLOT

	CORRELATION	STD.ERROR	-1	-.75	-.5	-.25	0	.25	.5	.75	1
Lag -1	-0.214111	0.130189	.	.	(	*****	)	.	.	.	.
Lag -2	0.35018	0.136026	.	.	(	*****	**	.	.	.	.
Lag -3	-0.159396	0.150532	.	.	(	****	)	.	.	.	.
Lag -4	0.344544	0.153366	.	.	(	*****	*)	.	.	.	.
Lag -5	-0.401323	0.165968	.	.	(	*****	)	.	.	.	.
Lag -6	0.259183	0.181673	.	.	(	*****	)	.	.	.	.
Lag -7	-0.165827	0.187835	.	.	(	****	)	.	.	.	.
Lag -8	0.0948765	0.190301	.	.	(	***	)	.	.	.	.
Lag -9	-0.332624	0.191101	.	.	(	*****	)	.	.	.	.
Lag -10	0.214041	0.200674	.	.	(	*****	)	.	.	.	.
Lag -11	-0.262919	0.204507	.	.	(	*****	)	.	.	.	.
Lag -12	0.0168028	0.210158	.	.	(	*	)	.	.	.	.
Lag -13	-0.186879	0.21018	.	.	(	*****	)	.	.	.	.
Lag -14	0.183039	0.212978	.	.	(	*****	)	.	.	.	.
Lag -15	-0.136337	0.215628	.	.	(	****	)	.	.	.	.