Temporal Aggregation and the Ramsey's (RESET) Test for Functional Form : results from Empirical and Monte Carlo experiment.

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Abstract.

This short paper demonstrates that the use of temporally aggregated data may affect the power and the size of the well known the Ramsey's (1969) RESET test. This test is widely used for testing the functional specification of a model. Using Empirical data and Monte Carlo techniques we found that temporal aggregation could affect seriously the power and the size of the test.

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I. Introduction.

It is common practice for developments concerning most economic magnitudes to be analyzed on the highest level of temporal disaggregation. Very often, however, the available data correspond to high levels of time aggregation, which frequently lead to erroneous results with respect to the diachronic dependencies in various economic variables and the powers of some tests. In fact, it is not uncommon to arrive at different results[1] even when using the same magnitudes with different temporal aggregation. Similar effects should also be expected in the case of the application of some time domain tests used widely to test for the functional specification between economic variables.

The temporal aggregation effects on the power of Ramsey's (1969) RESET[2] test have been studied not in extend in a paper of Clive W. J. Granger and Tae-Hwy Lee (1999)[3]. These authors concluded that aggregation is inclined to simplify nonlinearity. Given the above, it is the aim of this paper to study the effects of time aggregation on the power and the size of the Ramsey's (1969) RESET test. More specifically, we report the results of an extended Monte Carlo experiment which examines the effects of using data at different level of time aggregation on the power of the Ramsey's (1969) RESET test. An empirical application of the temporal aggregation effects on testing the functional form using the Ramsey's (1969) RESET at different temporal aggregation levels, is presented with the well example of capital expenditures and appropriations.

According to our results the level of temporal aggregation of a time series involved in the specification , the number of the total available observations and the characteristics of the independent variable(s) are important for the reliability of the Ramsey's (1969) RESET test to test the functional specification form. It goes without saying that a prerequisite for this to be averted is the use of the respective data on the highest possible level of time disaggregation.

An empirical application to present the effects of temporal aggregation on testing the functional form using well known example capital expenditures (y_t) and appropriations (x_t) is presented at section 4.

[1] The effects of time aggregation in univariate and multivariate time series work are explored by Tiao (1972), Brewer (1973), Shiller, R.J. and Perron, P. (1985), Oguchi and Furuchi (1990), Tserkezos (1992), (1998), (Drost and Nijman (1993), Pierce R and Snell A. (1995), Rossana and Seater (1995), C.W.J. Granger and P.L. Siklos,(1995), Gunningham S and Vilasuso (1995), Ng, S., 1995, Lahiri, K. and Mamingi, N., 1995. Choi, I. and Chung, B.S., (1995), Jesus Otero and Jeremy Smith., (2000) and Cook S. (2001) to mention only a few.

[2] RESET: Regression Specification Error Test, Ramsey (1969).

[3] This paper used three types of aggregation, namely: cross-sectional aggregation, temporal aggregation and systematic sampling.

The short paper is organised as follows. Section 2 presents the RESET specification test and some essential notation for temporal aggregation. Section 3 presents the simulation model and the results. Section 4 presents the empirical application and finally section5 offers some concluding remarks.

2. *The Ramsey's(1969) RESET*[4] *Specification test.*

The RESET test proposed by Ramsey (1969) is a general misspecification test, which is designed to detect both omitted variables and inappropriate functional form. The RESET test is based on the Lagrange Multiplier principle and usually performed using the critical values of the *F*-distribution. While most authors (e.g., Ramsey and Gilbert (1972); Thursby and Schmidt (1977)) have studied the properties[5] of the RESET tests in single equation situations. In what follows we examine the power and the size of the test using data at different time aggregation.

Consider the standard linear regression model:

$$y = X\beta + u \qquad (1)$$

and assume that the data on y and X are stationary time-series. The RESET tests the hypothesis that this (null) model is specified correctly. Choose a *T*xh matrix Z of "test variables," to apply simple Ordinary Least Squares (OLS) to the equation:

$$y = X\beta + Za + \varepsilon \qquad (2)$$

and test the hypothesis $H_o : \alpha = 0$ using a standard *F* test:

$$F = \frac{(R^2{}_2 - R^2{}_1)/h}{(1 - R^2{}_2)/(T-(k+1+h)} \sim F[h,(T-(k+1+h))] \qquad (3)$$

R_1^2 *obtained from (1) and* R_2^2 *is obtained from (2).*

If the computed F value is significant, say, at the 5 percent level, one can reject the linearity implied by (1).

Ramsey's (1969) choice for test variables is:

$$Z = [\hat{y}_t^2 \ \hat{y}_t^3 \ \hat{y}_t^4 \ \ldots\ldots\ldots \hat{y}_t^h] \qquad (4)$$

where:

$$\hat{y}_t = x_\tau{}' \hat{\beta} \qquad (5)$$

and $\hat{\beta}$ is the simple OLS estimated parameter(s) from the null model (1).

The importance of time aggregation and systematic sampling centers on weather the power of the RESET test is preserved when y_t and x_t are time aggregated.

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[4] RESET: Regression Specification Error Test.

[5] Ramsey's (1969) regression specification error test (RESET) and its variants are known to have high power against certain alternatives, e.g., incorrect functional form, but low against others, e.g., omitted variables or omitted lags; see, e.g., Thursby (1989, Tables 5, 7, 11-13).

C is a time aggregation[6] matrix of the form :

$$C = \begin{bmatrix} 11...11000...........00000000000000 \\ 00000011....11000......0000000000 \\ 0000000000011....1100....000000 \\ .... \\ 0000...............0000000000111...11 \end{bmatrix} \qquad (6)$$

Temporal aggregates , in contrast , are formed by averaging basic observations over nonoverlapping intervals. Let $y_T{}^A$ represent the temporally aggregated data:

$$y_T{}^A = Cy_t \qquad (7)$$

where $y_T{}^A$ is the temporal aggregated data and m is the time aggregation level.

[6]*For more about these Time - Aggregation relations using matrix approach, see: Gilbert C., 1977., pp. 223-225. A similar aggregation formulation is* $\tilde{\tilde{y}}_T = \frac{1}{m}(\sum_{j=o}^{m-1} L^j)r_t$ *where L is the backshift operator on t.*

3. The Monte Carlo experiments and the results.

Our simulation experiment is based on the following nonlinear specification:

$$y_t = a\exp(bx_t) + u_t \qquad (9)$$

$$u_t \approx NID(0,.25) \qquad (10)$$

$$x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \qquad (11)$$

$$w_t \approx NID(.25) \qquad (12)$$

$$\tau = 0.1,\ 0.5,\ 0.95 \qquad (13).$$

Using the equations (9)-(13) to obtain simulated observations of the dependent variable y_t *,we applied the Ramsey's RESET test estimating the linear model:*

$$y_t = a + \beta x_t + u_t \qquad (14)$$

and using the RESET test , testing the following hypotheses:

$$\mathrm{H}_o : u_t \sim NID(0, \sigma^2{}_u) \qquad (15)$$

$$\mathrm{H}_1 : u_t \sim NID(\mu, \sigma^2{}_u) \ \ with \ \ \mu \neq 0 \qquad (16)$$

The sampling intervals examined are 1 to 20 observations of the basic time series. Different number of observations for the basic series were used starting from 400 observations[7] until to 1300.We tried several values of the variance of the simulated independent variable but we did not find any difference in the results we present in Table 1.

Under the null hypothesis, 5,000 replications of the basic time series (9)-(13) are generated and time aggregated for each sampling interval. Four specifications of the independent variable were used[8]. The first three specifications based on (11) with the parameter τ as specified in (13) give us three different in their autoregressive characteristics stationary time series.

[7] We hat to start from the 400 observations because this number of observations at the highest level of temporal aggregation gives only 20 observations, which we believe is the a limit of data to apply the RESET test.

[8] The final specification of the independent variable is an exponential time trend defined as:

$$x_t = \exp(0.004TR_t) + w_t \qquad w_t \approx NID(.25) \qquad TR_t = 1,2,\ldots\ldots,T\,.$$

Simple RESET tests were performed to test if the appropriate functional specification between the two variables is a linear one. Analytical results[9] are summarized in Table 1 for 20 different time aggregation levels $j = 1,2,...,20$, three different properties of the independent variable and different number of available observations ($t = 400,500,.....1300$).

[9] Analytical results for testing the effects of temporal aggregation to the size of the test using exactly the same procedure as in the case of the power of the test are not presented hear but are available by request fro the author at dtsek@tellas.gr

Table 1. Rejection Frequencies at different: Number of observations, Temporal Aggregation level and characteristics of the independent variable.

Number Of Observations	400	500	600	700	800	900	1000	1100	1200	1300
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .1$									
1	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
5	71,18	88,82	97,36	99,9	100,0	100,0	100,0	100,0	100,0	100,0
10	51,62	57,38	52,98	60,26	69,7	77,5	73,78	73,38	79,66	74,7
15	14,28	40,52	42,88	44,9	18,88	23,14	22,78	40,84		31,1
20	10,1	36,86	37,08	34,52	35,28	31,58	36,6	40,84	49,82	48,62
20	10,1	36,86	37,08	34,52	35,28	31,58	36,6	25,88	32,86	31.12
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .5$									
1	100,00	100,0	100,0	100,0	100,09	100,09	100,04	100,00	100,00	100,00
5	30,99	74,03	86,44	96,27	98,04	99,20	99,60	99,82	99,91	100,00
10	7,56	30,86	39,53	67,81	67,14	75,77	79,68	83,06	83,82	93,20
15	9,56	14,05	20,05	27,79	35,66	38,28	35,75	58,20	56,60	63,23
20	1,78	2,36	5,16	6,76	10,94	11,78	13,29	11,56	15,30	26,19
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .9$									
1	100	100	100	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100
10	99,98	100	100	100	100	100	100	100	100	100
15	86,44	99,74	99,94	99,98	99,98	100	100	100	100	100
20	61,1	84,76	93,92	96,72	97,98	98,94	100	100	100	100

Source: Data entries are probabilities of type II error where the null is the existence of Linearity which is false by construction. The RESET test was replicated 5000 times for the specification (9)-(13) . The size of the test is a=0.025. Data entries are given by n/5000 where n is the number of times the null is rejected.

The following conclusions regarding the effects of time aggregation on the power of the RESET test can be drawn from an analysis of the data in Table 1.

The probability to accept the false hypothesis (i.e linearity between the dependent and the independent variable) using the RESET test increases as time aggregation invreases.

In the highest level of temporal aggregation the probability of accepting the 'true ' hypothesis i.e accepting non linearity, is in all the cases very low and its magnitude is closely related to the characteristics of the independent variable and the number of the available observations at the highest level of temporal disaggregation.

As the value of the autoregressive parameter τ lies between .1 and .5 the probability of rejecting linearity (i.e accept the true hypothesis) is on the average[10] *30% , approaching an average of the 5% at the highest level of temporal aggregation.*
With the parameter τ around .9 (high autoregressive characteristics) the probability of accepting the true hypothesis is on the average........ 10% . In the case the independent variable exhibits a trending behavior as the one described by equation (14) the probability of accepting the true hypothesis is on the average........... 10% for temporal aggregation.

As the number of the available observations at the highest level of time disaggregation increases the probability of accepting linearity (i.e rejecting the true hypothesis) is minimized after 400 observations especially in the cases of *autoregressive and trending characteristics of the independent variable***.**

In the short time aggregation levels the picture is quite similar : at an aggregation level of 10 the probability of rejecting the true hypothesis is on the average (100-40)% for temporal aggregation and (100-10)% for systematic sampling with τ is around .1 and .6.The analogous percentages for the case the parameter τ is around .9 is on the average (100-40)% for temporal aggregation and (100-10)% for systematic sampling

[10] The average corresponds to different characteristics of the dependent variable and number of available total observations at the highest level of temporal disaggregation.

4. An Illustrative Example.

In order to present with an empirical application , the effect of temporal aggregation on testing the functional form we used the well known example capital expenditures (y_t) and appropriations (x_t). These data are on quarterly basis, covers the period 1953-1974 and are obtained from the National Industrial Conference Board. In order to test nonlinearity we applied the Ramsey's (1969) RESET test using the available data on quarterly and on yearly basis.

Using the available data on quarterly basis and the Ramsey's (1969) RESET we obtained:

$$F_{test} = \frac{((R^2_2\text{-}R^2_1)/h)}{((1\text{-}R^2_1)/(T\text{-}(k+1+h))} = \frac{((0.90431\text{-} 0.88351)/2)}{((1\text{-} 0.90431)/(88\text{-}(1+1+2))} = 8.97627$$

Using the available data on an annual basis[11] the analogous estimates of the test is the following:

$$F_{test} = \frac{((R^2_2\text{-}R^2_1)/h)}{((1\text{-}R^2_1)/(T\text{-}(k+1+h))} = \frac{((0.31516\text{-}0.16124)/2)}{((1\text{-}0.31516)/(22\text{-}4))} = 1.73545$$

According to the above results using the Ramsey's (1969) RESET test at quarterly basis we reject the linearity and using yearly data we accept linearity between capital expenditures and appropriations at 2.5%,5% and 10% significance levels respectively.

[11] The annual data were obtained using the relation $y_T^{\ A} = Cy_t$ with a time aggregation martix:

$$C = \begin{bmatrix} 1111000............00000000000000 \\ 00001111000......0000000000000 \\ 00000000111100....00000000000 \\ .... \\ 0000...............000000000001111 \end{bmatrix}$$

5. Conclusions.

The results of this paper show the importance of temporal aggregation in applied time series analysis. Using Monte Carlo techniques we found that temporal aggregation could lead to wrong conclusions about the functional form between economic magnitudes using the Ramsey's (1969) RESET test.

On the basis of our Monte Carlo results, we may conclude that as the span of time aggregation widens, the time series properties are distorted, leading to wrong conclusions about the functional form between economic magnitudes. Using the RESET test is very possible to accept the linearity between economic variables using data temporally aggregated although their 'true' relation at highest level of temporal disaggregation is not a linear one[12].
Crucial role also plays the role of the characteristics of the independent variable and the number of total available observations at the highest level of temporal disaggregation.

After a number of observations, more than 400, the number of cases to accept the wrong hypothesis decreases rapidly especially in the case were the autoreggressive parameter τ is near .9 and the case of trending independent variable.

In general the effects of temporal aggregation in the power of the RESET test are serious and related strongly with the characteristics of the dependent variable and the number of available observations at the highest level of temporal disaggregation.

Lastly, the conclusions of this paper are in line with the more general findings of similar studies [13]on the negative effects of temporal aggregation on the effectiveness of the statistical criteria for controlling the interdependencies between economic magnitudes.

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where y_T^A is the temporal aggregated data , m is the time aggregation level and

[12] Granger and Tae-Hwy (1999) describe this as 'the ....neglected nonlinearity'.
[13] Granger and Tae-Hwy (1999). These authors concluded that time aggregation is inclined to simplify nonlinearity.

References.

Brewer K.R.W., 1973., 'Some consequences of temporal aggregation and systematic sampling for ARMA and ARMAX models', *Journal of Econometrics*, 1, pp.133-154

Choi, I. and Chung, B.S., 1995. 'Sampling frequency and the power of tests for a unit root: a simulation study'. Economics Letters 49, pp. 131-136.

Cook Steven., 'Temporal aggregation and time deformation'., 2001. Applied Economics Letters, ,8,,pp.363-365.

Drost F.C. and Nijman T.E., 1993 'Temporal aggregation of GARCH processes' *Econometrica*, 61, pp.909-927

Hatzinikolaou, Dimitris and Stavrakoudis Athanassios, 2005., "A New Variant of RESET for Distributed Lag Models." *Economics Bulletin,* Vol. 3, No. 56 pp. 1-4.

Hooker, M.A., 1993. 'Testing for cointegration: power versus frequency of observation'. Economics Letters 41, pp. 359-362.

Gilbert, C.L, 1977, "Estimation of regression equations using mixed annual and quarterly Data '. Journal of Econometrics. pp. 221-239

Granger C.W.J. and. Siklos, P.L .,1995. 'Systematic sampling, temporal aggregation, seasonal adjustment, and cointegration: Theory and evidence', *Journal of Econometrics*, 66, pp.357-369

Granger, C.W.J. (1987), "Implications of aggregation with common factors," Econometric Theory, 3, 208-222.

Granger, C.W.J. (1998), "Overview of nonlinear time series specifications in economics," UCSD, mimeo.

Granger, Clive W. J. and Lee, Tae-Hwy .,1999 'The effect of aggregation on nonlinearity', Econometric Reviews,18:3,259 — 269

Gunningham S. and Vilasuso.J, 1995., 'Time aggregation and causality tests: results from a monte carlo experiment'., Applied Economics Letters.,2,403-405.

Otero Jesus and Smith Jeremy.,2000., 'Testing for cointegration: power versus frequency of observation further Monte Carlo results' ., Economics Letters 18, pp. 381-386

Lahiri, K. and Mamingi, N., 1995. 'Testing for cointegration: power versus frequency of observation - another view'. Economics Letters 49, pp. 121-124.

Lee, Tae-Hwy, Halbert White and Clive W.J. Granger (1993), "Testing for neglected nonlinearity in time series models: A comparison of neural network methods and alternative tests," Journal of Econometrics, 56, 269-290.

Leung, S.F., and S. Yu (2001) "The sensitivity of the RESET tests to disturbance autocorrelation in regression residuals" Empirical Economics 26, 721-726.

Oguchi N.and Furuchi T., 1990. 'On temporal aggregation of linear dynamic models', *International Economic Review*, 31, pp.187-193

Pierce R.G. and Snell, A.J. .,1995. 'Temporal aggregation and the power of tests for a unit root', *Journal of Econometrics*, 65, pp.333-345

Ramsey, J. B. (1969): "Test for Specification error in Classical Linear Least Squares Regression Analysis," *Journal of the Royal Statistical Society, Series B*. 31, 350-371.

Rossana R.J. and Seater, J.J. .,1995. 'Temporal aggregation and economic time series', *Journal of Business and Economic Statistics*, 13, pp.441-451

Sapra, Sunil, (2005) 'A regression error specification test (RESET) for generalized linear models".." *Economics Bulletin,* Vol. 3, No. 1 pp. 1-6.

Shukur, G., and D. L. Edgerton (1997): "The Small Sample Properties of the RESET Test As Applied to Systems of Equations," Department of Statistics, Lunds University, Sweden.

Shiller, R.J. and Perron, P., 1985. 'Testing the random walk hypothesis: power versus frequency of observation'. Economics Letters 18, pp. 381-386

Terasvirta, T. (1996), "Power properties of linearity tests for time series," Studies in Nonlinear Dynamics and Econometrics, 1, 3-10.

Terasvirta, T., Chien-Fu Lin, and C.W.J. Granger (1993), "Power of the neural network linearity test," Journal of Time Series Analysis, 14, 209-220. Thursby, J.G. (1989) "A comparison of several specification error tests for a general alternative" International Economic Review 30, 217-230.

Thursby, J. G., and P. Schmidt (1977): "Some Properties of Tests for Specification Error in a Linear Regression Model," *Journal of American Statistical Association*, 72, 635-641.

Tsay, R.S. (1986), "Nonlinearity tests for time series," Biometrika, 73, 461-466.

Tserkezos Dikaios .,1992., ' Forecasting Residential Electricity Consumption in Greece Using Monthly and Quarterly Data'., Energy Economics. Vol. 14 N.3 July 1992 pp.226-232.

Tserkezos D. ,Georgutsos D and Kouretas G,1998.,'Temporal Aggregation in Structure VAR Models.' Applied Stochastic Models and Data Analysis, 14,pp. 19-34.

Tserkezos Dikaios .,, 1998. 'GNP quarterly disaggregation of selected OECD countries using a related time series approach.' Applied Economics Letters..,,5,pp.733-736.

White, H. (1987), "Specification testing in dynamic models," Advances in Econometrics, Fzjlh World Congress, Vol. 1, 1-58, edited by T.F.Bewley, Cambridge University Press.

White, H. (1989), "An additional hidden unit test for neglected nonlinearity in multilayer feedforward networks," Proceedings of the International Joint Conference on Neural Networks, Washington, D.C., San Diego: SOS Printing 11: 451-455.