**Sensitivity of the Ramsey’s RESET Test on the Degree of Nonlinearity of the Functional Form**

**Christos Christodoulou-Volos[[1]](#footnote-1) and Dikaios Tserkezos[[2]](#footnote-2)**

**Abstract**

The present paper aims to demonstrate that the Ramsey’s Regression Specification Error Term Test (RESET) is very sensitive to the degree of nonlinearity between the variables of the under-specification functional form. This widely used test, for testing the functional specification of a model, is based on the notion that if nonlinear combinations of the explanatory variables have any power in explaining the predictor, the model is mis-specified and the data generating mechanism might be approximated by a nonlinear functional form. Using Monte Carlo techniques, we find that the power of the Ramsey’s RESET test is highly influenced and related with the degree of nonlinearity between the dependent and the independent variables of the under-specification functional form.

**JEL Classification Numbers:** C32, C52

**Keywords:** Ramsey RESET test; Regression specification; Monte Carlo Simulation

1. Introduction

The Ramsey’s (1969) Regression Specification Error Term Test (RESET) test is designed to test the functional specification between economic magnitudes and, in general, is a very useful tool of empirical analysis.[[3]](#footnote-3) Specifically, it tests whether nonlinear combinations of the fitted values help explain the independent variable. It is based on the notion that if nonlinear combinations of the dependent variables have any power in explaining the predictor, the model is misspecified and the data generating mechanism might be approximated by a nonlinear functional form.

The purpose of this paper is to demonstrate the effects of the nonlinearity degree of the under-specification form on the Ramsey’s RESET test. Using Monte Carlo techniques,[[4]](#footnote-4) assuming different characteristics of the independent variable(es) of the under-specification form, and different number of available observations, we prove that the RESET test is very sensitive to the degree of nonlinearity of the under-specification form. Irrespectively of the characteristics of the independent variable(es) in small number of available observations, the effects of the degree of nonlinearity on the power of the RESET test are very serious. This problem is getting less serious as the number of the available observations increases.

According to our results, it is possible that the functional form between economic magnitudes to be a nonlinear one and using the RESET test to accept linearity when we have small number of available observations and the nonlinearity degree between the variables of the under-specification form, is weak.

The rest of the paper is organized as follows. Section 2 presents the RESET specification test. Section 3 presents the simulation results. Section 4 discusses the results and section 5 offers some concluding remarks.

1. **The Regression Specification Error Term Test (RESET)**

The RESET is a general misspecification test, which is constructed to detect both omitted variables and inappropriate functional form. It is based on the Lagrange Multiplier principle and is usually performed utilizing the critical values of the *F*-distribution. Most reseachers have studied the properties of the RESET tests in single equation situations (e.g., Ramsey and Gilbert (1972); Thursby and Schmidt (1977); Thursby (1989)), while others have investigated the small sample properties of various generalization of the test in systems of equations (e.g. Shukur and Edgerton (2002); Shukur and Mantalos (2004)). In addition, Wooldridge (1995) states that RESET has no power of detecting omitted variables whenever they have expectations that are linear in the included independent variables in the model. Further, if the functional form is properly specified, RESET has no power for detecting heteroscedasticity.

In the following, we investigate the power of the RESET test utilizing data at different systematic sampling levels. Consider the standard linear regression model,

 (1)

where  (dependent variable) is a  vector, is a  matrix of repressors,  ( constant) and and assume that the data on **y** and Xare stationary time-series. The RESET tests the (null) hypothesis that above model is specified correctly. Select a *T*x*M* matrix Zof “test variables,” to employ Ordinary Least Squares (OLS) to the equation:

 (2)

where Z is an  matrix and α is an hx1 vector with h-1 the number of additional variables.

The hypothesis  is tested using a standard *F* test of the following form,

 (3)

Ramsey’s choice of test variables is

**  (4)

where:  and  is the OLS fitted value from the null model.[[5]](#footnote-5)

There are some theoretical and empirical investigations on the statistical power of the RESET test in particular, and variable addition tests in general. Thursby and Schmith (1977) examine the power using fixed alternative hypothesis, whereas Pagan (1984) study the asymptotic power of variable addition tests under a sequence of local alternatives. Shukur, G., and D. L. Edgerton (1997) extends the application if the RESET test to simultaneous equations models. Lung and Lu (2000, 2002) study how effective are the RESET tests for auto correlated residual and for omitted variables and Hatzinikolaou, D. and Stavrakoudis A., (2005) propose a new variant of RESET test for Distributed Lag Models. S. Sapra (2018) develops a RESET test for the truncated regression model as an extension of the RESET for the linear regression model.

1. **The Monte Carlo Experiments**

Our strategy in the conducted Monte Carlo experiments focuses on the following three dimensions:

1. The degree of the nonlinearity of the functional form. In our experiments this degree of nonlinearity, is approximated by the parameter λ of the following nonlinear specification (Box, G.E.P. (1954) and Box, G.E.P., Cox, and D.R., (1964)).

**,** where  (5)

1. Four specifications of the explanatory variable are used,

***,*** where and  (6)

The first three specifications, based on (6) with the parameter τ, give three autoregressive characteristics stationary time series. The final specification of the independent variable is an exponential time trend defined as

**,where, and ** (7)

1. The number of the available observations vary from 20 to 400.

Specification (6) is the true hypothesis, and the null hypothesis is as follows

 (8)

**Table 1. Rejection Frequencies at different number of observations and different values of the λ Box-Cox parameter and characteristics of the independent variable**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. of Obs | 20 | 40 | 60 | 80 | 100 | 120 | 180 | 250 | 300 | 400 |
| Parameter λ | ***Stationarity*** | | | | | | | | | |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.2 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.3 | 98,01193 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.4 | 79,5207 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.5 | 43,91218 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.6 | 21,62162 | 91,50579 | 98,0695 | 99,6139 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.7 | 9,922179 | 59,53307 | 74,90272 | 83,85214 | 94,74708 | 97,85992 | 99,02724 | 100 | 100 | 100 |
| 0.8 | 4,571429 | 17,52381 | 24,19048 | 30,09524 | 44,95238 | 58,09524 | 68,19048 | 80 | 80,57143 | 84,95238 |
| 0.9 | 1,079914 | 5,183585 | 4,535637 | 4,967603 | 7,12743 | 7,991361 | 10,36717 | 14,47084 | 15,55076 | 16,1987 |
| Parameter  λ | ***Stationarity*** | | | | | | | | | |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.2 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.3 | 98,41549 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.4 | 83,69352 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.5 | 53,41615 | 99,79296 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.6 | 22,98387 | 84,27419 | 97,58065 | 98,3871 | 99,59677 | 99,59677 | 100 | 100 | 100 | 100 |
| 0.7 | 12,57367 | 42,23969 | 71,51277 | 75,83497 | 85,85462 | 87,22986 | 98,42829 | 98,82122 | 99,21415 | 100 |
| 0.8 | 4,255319 | 13,61702 | 31,2766 | 34,89362 | 37,87234 | 40 | 58,29787 | 63,82979 | 70,21277 | 76,38298 |
| 0.99 | 4,608295 | 4,83871 | 7,373272 | 7,834101 | 8,986175 | 8,525346 | 11,52074 | 11,05991 | 11,52074 | 14,74654 |
| Parameter  λ | ***Stationarity*** | | | | | | | | | |
| 0.0 | 63,82979 | 99,3617 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.1 | 19,72318 | 65,91696 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.2 | 10,33797 | 26,83897 | 98,40954 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.3 | 5,91716 | 14,20118 | 83,23471 | 95,66075 | 98,42209 | 99,80276 | 100 | 100 | 100 | 100 |
| 0.4 | 3,501946 | 7,392996 | 51,16732 | 73,92996 | 80,93385 | 93,57977 | 99,22179 | 99,41634 | 100 | 100 |
| 0.5 | 4,496788 | 6,638116 | 21,84154 | 42,82655 | 52,89079 | 71,73448 | 82,22698 | 88,00857 | 100 | 100 |
| 0.6 | 5,212355 | 3,861004 | 11,58301 | 19,30502 | 24,32432 | 38,80309 | 50,3861 | 57,52896 | 100 | 100 |
| 0.7 | 3,018109 | 3,219316 | 4,426559 | 7,645875 | 10,26157 | 15,09054 | 21,12676 | 25,55332 | 96,98189 | 99,79879 |
| 0.8 | 2,434077 | 1,825558 | 3,245436 | 2,839757 | 4,462475 | 7,302231 | 8,11359 | 7,707911 | 64,09736 | 76,26775 |
| 0.99 | 1,986755 | 2,207506 | 1,324503 | 2,207506 | 3,090508 | 3,532009 | 3,090508 | 3,090508 | 10,81678 | 12,80353 |
| Parameter  λ | ***Exponential Trend*** | | | | | | | | | |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.1 | 99,78632 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.2 | 89,94197 | 99,41973 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.3 | 57,11297 | 85,56485 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.4 | 30,81633 | 53,26531 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.5 | 10,9405 | 22,84069 | 98,84837 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.6 | 9,394572 | 11,48225 | 80,16701 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.7 | 5,018587 | 6,319703 | 39,4052 | 88,47584 | 96,28253 | 96,09665 | 99,44238 | 99,81413 | 100 | 100 |
| 0.8 | 2,524272 | 2,912621 | 11,84466 | 42,91262 | 54,56311 | 57,86408 | 71,65049 | 77,47573 | 83,30097 | 90,87379 |
| 0.99 | 3,319502 | 2,282158 | 3,941909 | 6,846473 | 7,46888 | 8,921162 | 11,82573 | 12,6556 | 18,87967 | 24,89627 |

**Source**: Data entries are probabilities of rejecting the null hypothesis. The RESET test is replicated 5000 times for the specification (6) and (7). The size of the test is α=0.025. Data entries are given by m (λ, num) / n (λ, num), where m is the number of times the null is rejected at different λ and n is the number of variable observation (num) and n(λ, num) is the total number of iterations for different λ and number of variable observation (num)

Under the null hypothesis, 5,000 replications for each of the four specifications (6) with ****** and (7) of the basic time series (5) are generated for different values of the parameter λ in the interval (0.0,0.99). For each experiment we apply the RESET test for 20 to 400 available observations with an increasing step of 20 observations.[[6]](#footnote-6) Our results are presented in Table 1.

1. **Results and Discussions**

Based on the results and an analysis of Table 1, nmerous

conclusions about the effects of the degree of nonlinearity of the under-specification form the power of the RESET test can be drawn. Irrespective of the characteristics of the independent variable(s), the effects of the degree of nonlinearity of the under-specification form on the power of the RESET test is very serious especially at small number of available observations.[[7]](#footnote-7) At a number of 20 available observations and as the degree of nonlinearity is decreasing, the power of the RESET test is getting smaller. When the value of λ approaches unity with 20 available observations the percentages of rejection the null hypothesis is 1.07%, 4.6%, 1.45%, and 3.31% for the four assumptions of the characteristics of the independent variable respectively. However, as the number of the available observations is increasing the problem is not so serious. Although, in a magnitude of 400 observations, the negative effects of the degree of nonlinearity of the under-specification form on the power of the RESET test might be observed.

1. Conclusions

This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex. The results of this paper show the importance of degree of nonlinearity of the under-specification form, on the power of the RESET test. Using Monte Carlo techniques, we found that the degree of nonlinearity of the under-specification form, effects seriously the power of the RESET test.

These effects are related closely with the characteristics of the independent variable and the number of the available total observations. Independently of the autoregressive, stationary and trending characteristics of the independent time series, as the value of parameter λ increases the power of the RESET test is getting very small and for very small samples as 20 observations, very disappointing. As the total number of observations increase then the problem is not that serious but, in some cases, (especially when τ=.90, λ>.8) exists increasing the likelihood to accept the null hypothesis. According to our results the power of the RESET test is very sensitive to the degree of nonlinearity of the under-specification form. Lastly, the conclusions of this paper are in line with the more general findings of similar studies, sch as Lung and Lu (2000, 2002).

References

1. Box, G. E. P. 1954. “Some theorems on quadratic forms applied in the study of analysis of variance problems.” *Annals of Statistics*, 25: 290-302.
2. Box, G.E.P., and Cox, D.R. 1964. “An analysis of transformations.” Journal of the Royal Statistical Society: Series B 26: 211–243.
3. Hatzinikolaou, D. and Stavrakoudis A. 2005. “A New Variant of RESET for Distributed Lag Models.” *Economics Bulletin,* Vol. 3, No. 56: 1-4.
4. Leung, S.F., and S. Yu. 200). “The sensitivity of the RESET tests to disturbance autocorrelation in regression residuals. *Empirical Economics* 26: 721-726.
5. Leung, S.F., and S. Yu. 2000. “How Effective are the RESET tests for Omitted Variables.” *Communication Statistics* 29-4: 897-902.
6. Pagan, A.R., and A.D. Hall (1983). “Diagnostic tests as residual analysis,” *Econometric Reviews* 2: 159-218.
7. Porter, R.D., and A.K. Kashyap. 1984. “Autocorrelation and the sensitivity of RESET” *Economics Letters* 14: 229-233.
8. 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.
9. Sapra, S. 2005. “A regression error specification test (RESET) for generalized linear models.” *Economics Bulletin,* Vol. 3, No. 1: 1-6.
10. Sapra, S. 2018. “A regression error specification test (RESET) for the truncated regression model”, *International Journal of Accounting and Economics Studies* 6(2): 53
11. 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.
12. Shukur, G., and Mantalos, P. (2004), “Size and Power of the RESET Test as Applied to Systems of Equations: A Bootstrap Approach,” Journal of Modern Applied Statistical Methods, Vol. 3, No. 2, 370-385.
13. Thursby, J.G. 1989. “A comparison of several specification error tests for a general alternative.” *International Economic Review* 30: 217-230.
14. 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.

1. Department of Economics and Business, Neapolis University Pafos, Cyprus; e-mail: c.volos@nup.ac.cy [↑](#footnote-ref-1)
2. Department of Economics and Business, Neapolis University Pafos, Cyprus; e-mail: d.tserkezos@nup.ac.cy

   Article Info: *Received: xx xx, 2022. Revised: xx xx, 2022. Published online: xx xx, 2022* [↑](#footnote-ref-2)
3. Additional prove is the existence of this test in all the well-known statistical and econometric software. [↑](#footnote-ref-3)
4. Studies revealing power comparisons among RESET test are analytically intractable (Leung and Yu.,2001., p. 884.) [↑](#footnote-ref-4)
5. The steps involved in applying the RESET are as follows: **Step1**. From the chosen model, e.g., (1), obtain the estimated ; **Step2**. Rerun (1) introducing  in some form as additional regressor(s); **Step3**. Let the obtained from (1) beand that obtained from (2) be . Then we can use the F test (3) to test if the increase in  from using (2) is statistically significant.; **Step4**. If the computed F value is significant, say, at the 5 percent level, one can accept the hypothesis that the model (1) is mis-specified. [↑](#footnote-ref-5)
6. In the experiments (eq. 2), the variable z is approximated as (Ramsey and Gilbert): ** [↑](#footnote-ref-6)
7. Different levels of the autoregressive order of the stationary independent variable and time trend. [↑](#footnote-ref-7)