**Exercises (Chapters 8 – 9) – Solutions**

* 1. To estimate the regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

ee c gdp

Click OK. Table 1 shows the estimation results. These results indicate the followings: First, the intercept term is estimated to be equal to -0.12. Thus, for a country with zero per capita GDP the per capita expenditure in education is -0.12. Of course, this number is meaningless, so we cannot interpret this intercept estimate. Second, the coefficient of the GDP variable is estimated to be equal to 0.07. If the per capita GDP increases (decreases) by $1, the per capita expenditure in education will increase (decrease) by $0.07. This coefficient is statistically significant at the 1% level, indicating a statistically significant positive relation between domestic product and education expenditures. Finally, the coefficient of the regression is 86%, indicating that 86% of the variation in education expenditures is explained by the model, while the remaining 14% remains unexplained.

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| **Table 1: OLS estimates regressing EE on GDP** | | | | |
| Dependent Variable: EE | | |  |  |
| Method: Least Squares | | |  |  |
| Sample: 1 34 | |  |  |  |
| Included observations: 34 | | |  |  |
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|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.124573 | 0.048523 | -2.567308 | 0.0151 |
| GDP | 0.073173 | 0.005179 | 14.12755 | 0.0000 |
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|  |  |  |  |  |
| R-squared | 0.861823 | Mean dependent var | | 0.476735 |
| Adjusted R-squared | 0.857505 | S.D. dependent var | | 0.359903 |
| S.E. of regression | 0.135858 | Akaike info criterion | | -1.097393 |
| Sum squared resid | 0.590635 | Schwarz criterion | | -1.007608 |
| Log likelihood | 20.65569 | Hannan-Quinn criter. | | -1.066774 |
| F-statistic | 199.5875 | Durbin-Watson stat | | 1.774258 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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* 1. Figure 1 plots the least squares residuals with respect to per capita GDP. The plot indicates that the variation of the residuals is related to the county per capita GDP. Therefore, the uncertainty of the error term is larger for richer countries. This finding is evidence of heteroskedasticity. Table 2 reports the results of the White test for heteroskedasticity. To conduct this test, click on View -> Residual Diagnostics -> Heteroskedasticity Tests, and choose White. We observe that the p-values of all three test statistics are lower than all conventional significance level. We conclude that the null hypothesis of homoskedasticity is rejected, leading us to accept the alternative hypothesis that the error term exhibits heteroskedasticity.



**Figure 1: Scatter plot between residuals and GDP**

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| **Table 2: White test for heteroskedasticity** | | | | |
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|  |  |  |  |  |
| F-statistic | 6.423119 | Prob. F(2,31) | | 0.0046 |
| Obs\*R-squared | 9.961449 | Prob. Chi-Square(2) | | 0.0069 |
| Scaled explained SS | 11.90754 | Prob. Chi-Square(2) | | 0.0026 |
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* 1. Table 3 shows the results of the regression model estimated with White standard errors. To estimate this regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

ee c gdp

Then choose Options and in the Coefficient covariance field choose as Covariance method Huber-White. As expected, the only difference between the results of Table 1 and 3 concerns the estimated standard errors. In particular, the standard error of the slope coefficient estimate has increased without affecting the statistical significance of the slope parameter. Therefore, we conclude that considering the heteroskedasticity in the error term decreases the precision of the OLS estimation.

Table 4 shows the results of estimating the regression model using generalized least squares assuming that . In so doing, we go to Quick-> Estimate Equation, and in the Equation specification field we write:

ee c gdp

Then choose Options and in the Weights field choose as Type Variance and write in Weight series field gdp. Set Scaling to Average.

The parameters estimates have changed but they are very close to those reported previously. Moreover, the slope coefficient remains statistically significant, indicating the existence of a strong positive relation between per capita GDP and education expenditures even when the variance of the error term is related to per capita GDP. In addition, the coefficient is larger compared to the of the OLS estimation indicating that the transformed model fits better into the data.

Standard errors are less than both errors calculated using ordinary least squares (Table 1) or White standard errors (Table 3). Given the assumption is true, we expect the GLS standard errors to be narrower than White standard errors, reflecting that GLS is more precise than OLS when heteroskedasticity is present. A direct comparison of the GLS standard errors with that obtained using the conventional least squares standard errors is not meaningful, however, because the least squares standard errors are biased in the presence of heteroskedasticity.

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| **Table 3: OLS estimates with White standard errors regressing EE on GDP** | | | | |
| Dependent Variable: EE | | |  |  |
| Method: Least Squares | | |  |  |
| Sample: 1 34 | |  |  |  |
| Included observations: 34 | | |  |  |
| White heteroskedasticity-consistent standard errors & covariance | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.124573 | 0.040414 | -3.082420 | 0.0042 |
| GDP | 0.073173 | 0.006212 | 11.78005 | 0.0000 |
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|  |  |  |  |  |
| R-squared | 0.861823 | Mean dependent var | | 0.476735 |
| Adjusted R-squared | 0.857505 | S.D. dependent var | | 0.359903 |
| S.E. of regression | 0.135858 | Akaike info criterion | | -1.097393 |
| Sum squared resid | 0.590635 | Schwarz criterion | | -1.007608 |
| Log likelihood | 20.65569 | Hannan-Quinn criter. | | -1.066774 |
| F-statistic | 199.5875 | Durbin-Watson stat | | 1.774258 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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| **Table 4: GLS estimates regressing EE on GDP** | | | | |
| Dependent Variable: EE | | |  |  |
| Method: Least Squares | | |  |  |
| Sample: 1 34 | |  |  |  |
| Included observations: 34 | | |  |  |
| Weighting series: GDP | | |  |  |
| Weight type: Variance (average scaling) | | | |  |
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| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.092921 | 0.028904 | -3.214853 | 0.0030 |
| GDP | 0.069321 | 0.004412 | 15.71307 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
|  | Weighted Statistics | |  |  |
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| R-squared | 0.885264 | Mean dependent var | | 0.345461 |
| Adjusted R-squared | 0.881678 | S.D. dependent var | | 0.197886 |
| S.E. of regression | 0.101734 | Akaike info criterion | | -1.675889 |
| Sum squared resid | 0.331193 | Schwarz criterion | | -1.586103 |
| Log likelihood | 30.49012 | Hannan-Quinn criter. | | -1.645270 |
| F-statistic | 246.9005 | Durbin-Watson stat | | 1.842122 |
| Prob(F-statistic) | 0.000000 | Weighted mean dep. | | 0.269168 |
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* 1. To estimate the regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

inf c wgwth

Click OK. Table 1 shows the estimation results. These results indicate the followings: First, the intercept term is estimated to be equal to -0.02. Thus, if the percentage change in wages is zero, the level of inflation will be equal to -0.02 percentage points. The intercept term is however insignificant. Second, the coefficient of the WGWTH variable is estimated to be equal to 1.025. If the percentage change in wages increases (decreases) by 1 percentage point, inflation rate will increase (decrease) by 1.025 percentage points. This coefficient is statistically significant at the 1% level, indicating a statistically significant positive relation between changes in wages and inflation. The coefficient of the regression is 43%, indicating that 43% of the variation in inflation is explained by the model, while the remaining 57% remains unexplained. Finally, the Durbin-Watson test statistic is 1.10, indicating the presence of positive autocorrelation in the least square residuals.

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| **Table 1: OLS estimates regressing INF on WGWTH** | | | | |
| Dependent Variable: INF | | |  |  |
| Method: Least Squares | | |  |  |
| Sample: 1 160 | | |  |  |
| Included observations: 160 | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.021452 | 0.114208 | -0.187835 | 0.8512 |
| WGWTH | 1.025420 | 0.094246 | 10.88021 | 0.0000 |
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|  |  |  |  |  |
| R-squared | 0.428321 | Mean dependent var | | 1.098563 |
| Adjusted R-squared | 0.424703 | S.D. dependent var | | 0.824906 |
| S.E. of regression | 0.625678 | Akaike info criterion | | 1.912458 |
| Sum squared resid | 61.85265 | Schwarz criterion | | 1.950898 |
| Log likelihood | -150.9967 | Hannan-Quinn criter. | | 1.928067 |
| F-statistic | 118.3790 | Durbin-Watson stat | | 1.104274 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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* 1. We formulate the null and alternative hypothesis as follows: . The t-statistic of this test is:

The critical values of the test are and . We observe that , so the null hypothesis cannot be rejected. Therefore, we conclude that a one-to-one relationship between changes in wage and inflation is not incompatible with the data.

* 1. Table 2 shows the result of the LM test for autocorrelation. To conduct this test, click on View -> Residual Diagnostics -> Serial Correlation LM Test. The p-values of both test statistics reported are lower than any conventional significance level, indicating that the null hypothesis of no autocorrelation up to 2 lags in the error term is rejected. Therefore, we conclude that autocorrelation is present in the error term of the regression model.

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| **Table 2: Breusch-Godfrey Serial Correlation LM Test** | | | | |
|  |  |  |  |  |
| F-statistic | 20.69910 | Prob. F(2,156) | | 0.0000 |
| Obs\*R-squared | 33.55508 | Prob. Chi-Square(2) | | 0.0000 |
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* 1. To estimate the model adding one lag of the dependent variable in the right-hand-side go to Quick -> Estimate Equation. In the Equation specification field, write:

inf c wgwth inf(-1)

Click OK. Then perform the LM test for autocorrelation. Repeat this procedure by adding sequentially lag 2 and 3 of INF as independent variables. Table 3 reports the LM test statistics and the associated p-values for all models estimated. The results of the table indicates that we need to add the first 3 lags of inflation as independent variables to capture the documented autocorrelation of the error term. In that case, the p-value of the LM test is 56% and the null of no autocorrelation cannot be rejected.

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| **Table 3: Serial correlation LM test results** | | |
| Lags included | LM test statistic | p-value |
| INF(-1) | 6.43 | 0.04 |
| INF(-1), INF(-2) | 8.13 | 0.01 |
| INF(-1), INF(-2), INF(-3) | 1.14 | 0.56 |

* 1. Table 4 shows the OLS estimates of the regression model:

We formulate the null and alternative hypothesis as follows: . The t-statistic of this test is:

The critical values of the test are and . We observe that , so the null hypothesis is rejected. Therefore, we conclude that there is not a one-to-one relationship between changes in wage and inflation. Note here that this conclusion is the opposite to the one reached in (b). Therefore, ignoring the presence of autocorrelation may produce misleading results in the hypothesis tests.

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| **Table 4: OLS estimates regressing INF on WGWTH and lags of INF** | | | | |
| Dependent Variable: INF | | |  |  |
| Method: Least Squares | | |  |  |
| Sample (adjusted): 4 160 | | | |  |
| Included observations: 157 after adjustments | | | | |
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|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -0.052190 | 0.093608 | -0.557538 | 0.5780 |
| WGWTH | 0.388551 | 0.108994 | 3.564877 | 0.0005 |
| INF(-1) | 0.479596 | 0.077174 | 6.214497 | 0.0000 |
| INF(-2) | -0.066215 | 0.087368 | -0.757885 | 0.4497 |
| INF(-3) | 0.243851 | 0.076183 | 3.200851 | 0.0017 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.631173 | Mean dependent var | | 1.094777 |
| Adjusted R-squared | 0.621467 | S.D. dependent var | | 0.831953 |
| S.E. of regression | 0.511859 | Akaike info criterion | | 1.529794 |
| Sum squared resid | 39.82395 | Schwarz criterion | | 1.627127 |
| Log likelihood | -115.0888 | Hannan-Quinn criter. | | 1.569324 |
| F-statistic | 65.02944 | Durbin-Watson stat | | 1.928578 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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* 1. To estimate the regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

d(homes) c d(rates(-1))

Click OK. Table 1 shows the estimation results. These results indicate the followings: First, the intercept term is estimated to be equal to -1.90. Thus, if the monthly change in the mortgage rate the previous month is zero, the monthly change in the number of new houses purchased will be -1.90. The intercept term is however insignificant. Second, the coefficient of the lagged monthly change in the mortgage rate is estimated to be equal to -53.74. If the lagged monthly change in the mortgage rate increases (decreases) by 1 percentage point, the monthly change in the number of new houses purchased will decrease (increase) by 53.74. In other words, if the mortgage rate increases by 1 percentage point more during the previous month compared to one month before, there would be a drop in the number of new houses purchased by 53.74 compared to the previous month. This coefficient is statistically significant at the 1% level, indicating a statistically significant negative relation between changes in mortgage rates and new houses purchased. The coefficient of the regression is 4%, indicating that 4% of the variation in the number of new houses purchased monthly change is explained by the model, while the remaining 96% remains unexplained. Finally, the Durbin-Watson test statistic is 2.64, indicating the presence of negative autocorrelation in the least square residuals.

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| **Table 1: OLS estimates regressing change in HOMES on lagged change in RATES** | | | | |
| Dependent Variable: D(HOMES) | | | |  |
| Method: Least Squares | | |  |  |
| Sample (adjusted): 1992M03 2010M03 | | | |  |
| Included observations: 217 after adjustments | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -1.902610 | 3.509061 | -0.542199 | 0.5882 |
| D(RATES(-1)) | -53.74024 | 16.99667 | -3.161809 | 0.0018 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.044432 | Mean dependent var | | -1.050691 |
| Adjusted R-squared | 0.039987 | S.D. dependent var | | 52.60151 |
| S.E. of regression | 51.53908 | Akaike info criterion | | 10.73173 |
| Sum squared resid | 571099.5 | Schwarz criterion | | 10.76288 |
| Log likelihood | -1162.393 | Hannan-Quinn criter. | | 10.74432 |
| F-statistic | 9.997038 | Durbin-Watson stat | | 2.641435 |
| Prob(F-statistic) | 0.001794 |  |  |  |
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* 1. The estimated regression predicts that the monthly change in the number new houses purchased will be equal to:

Therefore, we predict that if the mortgage rate decline in the last month by 0.5 percentage points, there would be an additional number of 24.74 houses purchased during the following month.

* 1. Table 2 reports the LM test results for autocorrelation. Figure 1 shows the correlogram of the residuals. The results of the table and the figure indicate the presence of autocorrelation in the error term. In particular, the results of Table 2 show that the null hypothesis of no autocorrelation in the error term is rejected at all conventional significance level. Figure 1 further reveals that this due to the significant negative first order autocorrelation of -33%. This finding is consistent with the Durbin-Watson test statistic reported previously.

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| **Table 2: Breusch-Godfrey Serial Correlation LM Test** | | | | |
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|  |  |  |  |  |
| F-statistic | 14.95457 | Prob. F(2,213) | | 0.0000 |
| Obs\*R-squared | 26.71897 | Prob. Chi-Square(2) | | 0.0000 |
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Εικόνα που περιέχει πίνακας

Περιγραφή που δημιουργήθηκε αυτόματα

**Figure 1: Least square residuals correlogram**

* 1. The findings in (c) imply that the estimates of the regression model reported in Table 1 are not reliable. In the presence of autocorrelation, the conventional OLS standard errors are not correct providing misleading conclusions about the precision of the estimates. Furthermore, if the reported autocorrelation in the error term captures a dynamic relation between the model’s variables which is not described by the systematic part of the model, then the OLS estimator is also biased and inconsistent due to the omitted variable bias.

Therefore, we re-estimate the model including the first lag of the dependent variable as a new independent variable of the model. To estimate the regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

d(homes) c d(rates(-1)) d(homes(-1))

The results are shown in Table 3. Compared to the results of Table 1 we observe a stronger negative relation between monthly changes in mortgage rate and monthly changes in the number of new houses purchased. In fact, if the lagged monthly change in the mortgage rate increases (decreases) by 1 percentage point, the monthly change in the number of new houses purchased will decrease (increase) by 61.60. Moreover, the coefficient estimate of the lagged monthly change in the number of new houses purchased, equal to -0.31, is very close to the documented negative autocorrelation of the residuals reported in Figure 1. This provides evidence that the previously reported negative autocorrelation in the residuals is due to the negative autocorrelation of the dependent variable. This is also reflected in the Durbin-Watson test statistic which is now closer to 2. Finally, note here that the new model fits better into the data given that the adjusted has increased from 4% to 13%.

To formally check if the new model has solved the problems encountered in the initial one, i.e., the autocorrelation in the error term, we conduct the LM test for autocorrelation. The results, shown in Table 4, indicate that the null hypothesis of no autocorrelation cannot be rejected at the 10% level. Therefore, the error term of the new model does not exhibit serial correlation. This is now explicitly modeled in the systematic part of it.

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| **Table 3: OLS estimates regressing change in HOMES on lagged change in RATES and HOMES** | | | | |
| Dependent Variable: D(HOMES) | | |  |  |
| Method: Least Squares | | |  |  |
| Sample (adjusted): 1992M03 2010M03 | | | |  |
| Included observations: 217 after adjustments | | | |  |
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|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -2.531071 | 3.341451 | -0.757477 | 0.4496 |
| D(RATES(-1)) | -61.60728 | 16.25396 | -3.790294 | 0.0002 |
| D(HOMES(-1)) | -0.310550 | 0.064105 | -4.844379 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.138867 | Mean dependent var | | -1.050691 |
| Adjusted R-squared | 0.130819 | S.D. dependent var | | 52.60151 |
| S.E. of regression | 49.04033 | Akaike info criterion | | 10.63689 |
| Sum squared resid | 514660.1 | Schwarz criterion | | 10.68362 |
| Log likelihood | -1151.103 | Hannan-Quinn criter. | | 10.65577 |
| F-statistic | 17.25488 | Durbin-Watson stat | | 2.078481 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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| **Table 4: Breusch-Godfrey Serial Correlation LM Test** | | | |  |
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| F-statistic | 2.211516 | Prob. F(2,212) | | 0.1121 |
| Obs\*R-squared | 4.434823 | Prob. Chi-Square(2) | | 0.1089 |
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* 1. To perform the Chow breakpoint test, click on View -> Stability Diagnostics -> Chow Breakpoint Test. In the new window field write 2007M07. Table 5 presents the test results. These findings suggest the existence of a break in the parameters of the model. In other words, the model’s parameters cannot be considered constant throughout the sample period examined.

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| **Table 5: Chow Breakpoint Test: 2007M07** | | | | |
| Null Hypothesis: No breaks at specified breakpoints | | | | |
| Varying regressors: All equation variables | | | |  |
| Equation Sample: 1992M03 2010M03 | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 3.490530 |  | Prob. F(3,211) | 0.0166 |
| Log likelihood ratio | 10.51065 |  | Prob. Chi-Square(3) | 0.0147 |
| Wald Statistic | 10.47159 |  | Prob. Chi-Square(3) | 0.0150 |
|  |  |  |  |  |
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* 1. Given our answer to the previous question, we re-estimate the model including the dummy variable datedum which takes the value of 1 if the observation is after July 2007 and 0 otherwise. Let denote this variable as . Then, we estimate the following regression model:

To estimate this regression model, go to Quick -> Estimate Equation. In the Equation specification field, write:

d(homes) c datedum d(rates(-1)) d(rates(-1))\*datedum d(homes(-1))

The estimation results are reported in Table 6. These results indicate the followings: First, the intercept term is estimated to be equal to 0.17 and statistically insignificant. Second, the dummy intercept term is equal to -15.72 and statistically significant at the 10% level. Therefore, all else being equal, the monthly change in the number of new houses purchased is 15.73 lower after July 2007 than before this date. Third, before July 2007 the increase (decrease) of the lagged monthly change in the mortgage rate by 1 percentage point, is related to a decrease (increase) of the monthly change in the number of new houses purchased by 82.34. This parameter is strongly statistically significant indicating a significant negative relation between these two variables before July 2007. Fourth, the slope coefficient of the dummy interaction term is positive, equal to 99.42, and statistically significant at the 5% level. This finding indicates that the outbreak of the financial crisis is related to a significant change in the relation between changes in mortgage rate and changes in the number of new houses purchased. Fifth, the slope coefficient of the lagged dependent variable captures the well-established negative autocorrelation of it. Finally, the adjusted of the new model is higher compared to the adjusted of the model estimated in (d), indicating that the inclusion of the dummy variable improves the model’s goodness-of-fit.

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| **Table 6: OLS estimates regressing change in HOMES on lagged change in RATES, HOMES and a financial crisis dummy** | | | | |
| Dependent Variable: D(HOMES) | | |  |  |
| Method: Least Squares | | |  |  |
| Sample (adjusted): 1992M03 2010M03 | | | |  |
| Included observations: 217 after adjustments | | | |  |
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| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
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|  |  |  |  |  |
| C | 0.177844 | 3.542261 | 0.050206 | 0.9600 |
| DATEDUM | -15.72169 | 9.467239 | -1.660642 | 0.0983 |
| D(RATES(-1)) | -82.34269 | 17.68924 | -4.654959 | 0.0000 |
| D(RATES(-1))\*DATEDUM | 99.42448 | 41.97641 | 2.368580 | 0.0188 |
| D(HOMES(-1)) | -0.338869 | 0.063549 | -5.332422 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.178451 | Mean dependent var | | -1.050691 |
| Adjusted R-squared | 0.162950 | S.D. dependent var | | 52.60151 |
| S.E. of regression | 48.12535 | Akaike info criterion | | 10.60827 |
| Sum squared resid | 491002.4 | Schwarz criterion | | 10.68614 |
| Log likelihood | -1145.997 | Hannan-Quinn criter. | | 10.63973 |
| F-statistic | 11.51228 | Durbin-Watson stat | | 2.116448 |
| Prob(F-statistic) | 0.000000 |  |  |  |
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* 1. To assess the significance of the effect of the change in mortgage rates on the creation of new houses only during the period of economic crisis we formulate the following test hypothesis: . The t-statistic of this test is 0.45. The critical values of the test with a 5% significance level are and . We observe that , so the null hypothesis is not rejected. We reach a similar conclusion using the test p-value, equal to 65%. Therefore, we conclude that after July 2007 the change in mortgage rates do not impact the change in the number of new houses purchased.