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An Analysis for the OECD Industrial Countries**

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Does Inflation Targeting Reduce Inflation?

An Analysis for the OECD Industrial Countries^{*}

Thomas Y. Wu^{**}

Abstract

Despite of its popularity, empirical studies have failed to find evidence of the causal effect of a country's adoption of the Inflation Targeting regime on that country's inflation rate decline. This paper applies the multi-period differences-in-differences estimation to the quarterly CPI inflation rates from the first quarter of 1985 until the third quarter of 2002 to the 22 OECD industrial countries and finds two basic sets of results. The first set of evidences is that countries that have officially adopted Inflation Targeting experience a decrease in their average inflation rates that is not only due to a reversion to mean process. The second set of results is that (1) there seems to be no evidence that Inflation Targeting countries experienced a significant increase in the level of their real interest rates after they adopted the new regime and that (2) even after controlling for the level of real interest rates there is still a causal effect from the adoption of Inflation Targeting to the reduction in inflation rates. In other words, the empirical evidence rejects the idea that the better performance in the inflation rates of the Inflation Targeting countries is only due to a more "aggressive" monetary policy.

Keywords: Inflation targeting, Monetary policy, Empirical evaluation

JEL Classification: E42, E52, E58

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1. Introduction

After the introduction in New Zealand in 1990, many others developed and emerging countries also adopted Inflation Targeting as their monetary policy regime [see Carare and Stone (2003) for a survey]. Despite of its popularity, most empirical studies have failed to find evidence of the causal effect of a country's adoption of the Inflation Targeting regime on that country's inflation rate. Taking an event-study approach, Neumann and von Hagen (2002) "cannot confirm the superiority of IT over other monetary policy strategies geared at price stability". Using a two-period differences-in-differences analysis for 20 OECD countries, Ball and Sheridan (2003) "find strong evidence of generic regression to mean. Just as short people on average have children who are taller than they are; countries with unusually high and unstable inflation tend to see these problems diminish, regardless of whether they adopt inflation targeting." They conclude that once these initial effects are controlled "the apparent benefits of [inflation] targeting disappear."

The problem with Neumann and von Hagen (2002)'s methodology is that the sample selected is small and arbitrary. There are only 6 Inflation Targeting countries (Australia, Canada, Chile, New Zealand, Sweden and the United Kingdom) and only 3 non Inflation Targeting countries (Germany, Switzerland, and the United States) from which 2 of them are "accused" to behave in practice as an Inflation Targeting country: Germany [see Bernanke and Mihov (1998)] and the United State [see Mankiw (2001)]. The potential sample selection bias is large. The sample used in Ball and Sheridan (2003) is more representative (20 OECD countries). Since they are regressing the change in the mean of the inflation rate in two different periods in Inflation Targeting dummies, they are running a regression with only 20 observations. The potential problem associated with the small sample is the lack of power to reject a false null hypothesis¹. Furthermore, the before and after sample averages constructed to calculate the change in inflation rates cover different periods across countries (since each of them adopted the regime in different period in time) which leaves for the non Inflation Targeting countries an arbitrarily choice of the "break" date, which could potentially affect the results.

¹ The null hypothesis on question is that the coefficient of the Inflation Targeting dummy is equal to zero, which means that Inflation Targeting does not matter.

The main objective of this paper is to provide further empirical evidence of whether or not the official adoption of the Inflation Targeting monetary policy regime by a country is effective to reduce both the unconditional inflation rate and the inflation rate conditional on the monetary policy instrument utilization in that country. We are also interested to test if this effect persists after initial conditions in inflation rates are controlled. This paper avoids the potential problems of previous works using the multi-period differences-in-differences estimation to the quarterly CPI inflation rates from the first quarter of 1985 until the third quarter of 2002 to all the 22 OECD countries. The multi-period differences-in-differences is a more suitable framework when the different individuals in the sample started the “treatment” in different periods². As we will see in the dataset description, the range of dates when countries in our sample adopted the Inflation Targeting regime varies from March 1990 (New Zealand) to January 2000 (Switzerland).

The first set of evidence found is that, after controlling for country specific effects and time effects, countries that have officially adopted Inflation Targeting experience a decrease in their average inflation rates after the adoption of the new regime and no evidence that this estimated effect is only due to a reversion to mean process in the inflation rate. The second set of results is found reapplying the analysis conditioning the expected inflation rate to the real interest rate. The real interest rate is the channel through which the short run nominal interest rate determined by the Monetary Authority affects the inflation rate (by affecting credit, consumption, investment and the usual components of the aggregate demand). One could suggest that the performance “gain” in the inflation rates of the adoption of the Inflation Targeting regime is only due to a more “aggressive” monetary policy. But we fail to find empirical evidence that Inflation Targeting countries experience a significant increase in their real interest rates level after adopting the new regime. Furthermore, we also find strong empirical evidence of a decrease in the level of inflation rates even after the controlling for the real interest rate level.

² Chapter 11 in Stock and Watson (2002) describes the general set up of the multi-period differences-in-differences estimator (see Appendix 11.2). For more technical details on panel regression and fixed effects estimators, see Chapter 5 in Hayashi (2000).

Table 1: Selected OECD Countries Characteristics (1 = yes, 0 = no)

OECD countries	Inflation Targeting:	
	Yes or no?	When?
Australia	1	Sep-94
Austria	0	-
Belgium	0	-
Canada	1	Feb-91
Denmark	0	-
Finland	1	Feb-93 to Dec-98
France	0	-
Germany	0	-
Greece	0	-
Ireland	0	-
Italy	0	-
Japan	0	-
Luxembourg	0	-
Netherlands	0	-
New Zealand	1	Mar-90
Norway	0	-
Portugal	0	-
Spain	1	Nov-94 to Dec-98
Sweden	1	Jan-93
Switzerland	1	Jan-00
United Kingdom	1	Oct-92
United States	0	-
Total	8	-

The rest of the paper is organized as follows: Section 2 briefly describes the dataset and the estimation strategy of the multi-period differences-in-differences. Section 3 estimates the effect of the Inflation Targeting regime on the expected inflation rates not conditioned in any other macroeconomic variable. Section 4 recalculates the effects of the Inflation Targeting regime on the expected inflation rates conditioned on lagged values of the real interest rates. Section 5 concludes.

2. Methodology and Data Description

Since the interest in this paper is on the causal effect of the adoption of Inflation Targeting on the inflation rate of a country, the differences-in-differences estimator is the natural approach. The sample includes quarterly CPI inflation rates and interest rates for the 22 OECD industrial countries from the first quarter of 1985 until the third quarter of 2002 (71 periods). This data was collected in the IMF IFS database. For these

22 countries, the control group consists of the 12 countries that have never officially adopted Inflation Targeting regime during our sample period. For the 8 countries in the treatment group, the official date of adoption of the Inflation Targeting regime varies from March 1990 (New Zealand) to January 2000 (Switzerland)³.

The differences-in-differences estimator compares the average change in the inflation rate for the countries in the treatment group over the course of the experiment (the official adoption of the Inflation Targeting regime) relative to the average change in the inflation rate in the control group over the same time. When there are more than two periods, the differences-in-differences estimator in the multi-period can be calculated in a panel regression with combined time and country specific fixed effects:

$$(1) \quad \pi_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 C_i + \beta_3 T_t + \varepsilon_{it}$$

where $i = 1, \dots, 22$ denotes the country in alphabetical order, $t = 1, \dots, 71$ denotes the periods from 1985.1 to 2002.3, π_{it} is the CPI inflation rate for country i in period t , $\text{Treatment}_{it} = 1$ if the i^{th} country official monetary policy regime was Inflation Targeting in period t and $= 0$ otherwise, C_i is a set of controls for omitted variables that vary across countries but are constant through time, and T_t is a set of controls for omitted variables that vary through time but are constant across countries. In equation (1), β_1 is the differences-in-differences coefficient. If the official adoption of the Inflation Targeting regime by a country effectively reduces that country's inflation rate, we should expect a negative and significant coefficient.

As mentioned in the Introduction, this is not the only test in which we are interested. We are also interested to test whether or not the estimated effect measured by β_1 is just capturing an exogenous tendency of inflation to revert to common mean. This would be the case if the countries that adopted Inflation Targeting were countries with high inflation rates that would fall independently of the adoption or not of the Inflation Targeting regime. This hypothesis will be tested with the inclusion of the first lag of the inflation rate as one of the regressors:

³ Also note that two of these countries, Finland and Spain, abandoned the Inflation Targeting regime prior to the launch of the European Currency Union in January 1, 1999.

$$(2) \quad \pi_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \pi_{i,t-1} + \beta_3 C_i + \beta_4 T_t + \varepsilon_{it}$$

If we estimate a coefficient associated with the first lag of the inflation rate, β_2 , between 0 and 1, this will indicate that the inflation rate follows a stationary autoregressive process, which tends to revert to the mean. Intuitively, this new specification is just saying that the inflation rate presents a certain degree of persistence or inertia. In the presence of persistence or inertia, countries with higher initial inflation rates will experience a higher decrease in their inflation rates. This can be seen if we subtract $\pi_{i,t-1}$ from both sides of equation (2):

$$(3) \quad \Delta\pi_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + (\beta_2 - 1)\pi_{i,t-1} + \beta_3 C_i + \beta_4 T_t + \varepsilon_{it}$$

If β_2 lie between 0 and 1, then $(\beta_2 - 1)$ will lie between -1 and 0: the higher is the inflation rate in one quarter the higher will be the decrease in the inflation rate in the next quarter. If it were the case that Inflation Targeting countries experienced a higher decrease in inflation rates only because they were the countries with high inflation in the beginning of our sample period (the second half of the 80's), then we would expect a significant β_2 and an non significant β_1 .⁴

Finally we reapply the analysis conditioning the expected inflation to the real interest rate. The real interest rate is the channel through which the short run nominal interest rate determined by the Monetary Authority affects consumption, credit, investment and all the usual components of the aggregate demand, affecting the inflation rate. So suppose we find empirical evidence that the inflation rate is actually lower if the country is currently under an Inflation Targeting regime. Then one could ask the following interesting question: is the better performance in the inflation rates of the Inflation Targeting countries only due to a more "aggressive" monetary policy? More specifically, we are interested to know if the only reason why Inflation Targeting countries have lower inflation rates is because they set really high real interest rates. If

⁴ This is the result obtained by Ball and Sheridan (2003): a significant β_2 and an insignificant β_1 . Note that if our sample had only 2 periods, equation (3) would be almost identical with Ball and Sheridan (2003)'s regression: a cross-section, as the dependent variable would be just the change in inflation rates between the 2 periods, the Treatment variable would collapse to an indicator variable of whether or not the country had adopted Inflation Targeting, the lag of the inflation rate would just be the inflation rate of the initial period (the first period) and the difference in the coefficients associated with the time-effects would become the new constant.

this is the case, then one could suggest that the adoption of the regime itself doesn't matter much, but only how high you set the real interest rates.

This hypothesis will be tested with two different procedures. The first procedure estimates an equation with the same specification as equation (2) but with the real interest rate as the dependent variable:

$$(4) \quad r_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_3 C_i + \beta_4 T_t + \varepsilon_{it}$$

where r_{it} is the real interest rate for country i in period t . If we estimate a positive and significant β_1 this will mean that countries experienced a significant increase in the real interest rate after adopting the Inflation Targeting regime. The second procedure is to include in equation (2) the real interest rate as a regressor:

$$(5) \quad \pi_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \pi_{i,t-1} + \beta_3 r_{i,t-2} + \beta_4 C_i + \beta_5 T_t + \varepsilon_{it}$$

In equation (5) we assumed that the effect of the real interest rate happens with a lag of 2 periods. Equation (5) can be thought of a reduced form solution of the substitution of an IS Curve into a Phillips Curve. The idea is that the real interest rate takes at least 1 quarter to affect the output gap (via an IS Curve) and the change in the output gap takes at least another quarter to affect the inflation rate (via the sacrifice ratio in the Phillips Curve). We also allowed the effect of a change in the real interest rate on the CPI inflation rate to vary across countries. This coefficient is given by the product of a country's sacrifice ratio with the elasticity of the output gap with respect to the real interest rate. Since these two coefficients are country specific such as the degree of price staggering or the quality of credit markets, it is natural to allow the coefficient of β_3 to vary across countries.

Once again, we should expect the differences-in-differences estimator β_1 to be negative and significant even if the β_3 are negative and significant. This will mean that the expected inflation conditional on the real interest rate is lower if the country is currently under a Inflation Targeting regime.

3. The Unconditional Expected Level of the Inflation Rate

In this section we are interested in two main hypothesis: (1) countries that officially adopted the Inflation Targeting regime experienced a reduction in their inflation rates after adopting the new regime and (2) this effect is not only due to a reversion to the mean process. Table 2 presents the results of the estimation of equation (1), including a set of controls for time and country effects. The set of country specific controls includes country fixed effects and the set of time controls includes time effects and a linear time trend called “Time” to capture some deterministic trend in inflation rates⁵.

Regression (1) presents the results for the regression of the CPI inflation rate on the “Treatment” variables without any further control for individual characteristics, country fixed effects or time effects. The estimated coefficient of -0.40 for the “Treatment” variable is significant at the 1% significance level, which means that the quarterly inflation rate fell in average by 0.40% in the Inflation Targeting countries after they have adopted the new regime. This causal effect is significant even after controlling for the fact that inflation rate has presented an exogenous downward trend estimated by the coefficient associated with the “Time” variable. The estimated coefficient of -0.02 is significant at the 1% significant level and implies that inflation rates tended to decrease 0.02% per quarter. The coefficients associated with the country fixed effects and the time effects are not displayed for sake of clearness (there are 22 + 71 estimated coefficients), but the F-statistics testing the exclusion of each group are presented in the table. The null hypothesis that each group of dummy variables is zero can be easily rejected. The R^2 of 45% can be considered satisfactory since the dependent variable is being explained only by a set of dummies and not any other economic variable.

⁵ Technically, the inclusion of a linear time trend in the regression is redundant since we already included time effects: all other coefficients, standard errors and descriptive statistics such as R^2 will remain the same. But the explicit inclusion of the linear time trend can make it easier to see if there was any deterministic downward or upward trend in the inflation rate through our sample period.

Table 2: Estimation Output**Dependent Variable: CPI Inflation Rate (quarterly % rate)**

Frequency: quarterly

Sample Period: 1985.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.40** (0.085)	-0.35** (0.081)
Time trend	-0.03** (0.005)	-0.02** (0.003)
Initial condition		0.10** (0.037)
F-statistics Testing Exclusion of Group of Variables		
Country effects = 0	20.37 (<0.001)	12.16 (<0.001)
Time effects = 0	5.27 (<0.001)	5.20 (<0.001)
R ²	0.45	0.45

These regressions are estimated using panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002. White's robust standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

Regression (2) adds to regression (1) the first lag of the inflation rate as one of the regressors in order to control for the initial condition. The coefficient associated with the lagged inflation rate, called “Initial condition”, is significant at the 1% significant level. The estimated coefficient of 0.10 lies between 0 and 1 and therefore indicates that the inflation rate follows a stochastic process that reverts to mean process. The inclusion of the new variable also decreases the magnitude of the negative coefficient of the “Treatment”: the new difference-in-differences estimator goes from -0.40 to -0.35, however, it remains significant at the 1% significance level. There is also practically no change in the R² with the inclusion of the new variable. Also note that the null hypothesis that each group of dummy variables that control for country fixed effects and time effects is zero can still be easily rejected. Given these results, one can conclude that the decrease in inflation rates experienced by Inflation Targeting countries effect was not only due to a reversion to mean process.

4. The Expected Level of Inflation Rate Conditional on the Real Interest Rate

The previous section presented strong empirical evidence that the countries that officially adopted the Inflation Targeting regime experienced a decrease in their inflation rates. It also presented empirical evidence that this effect was not only due to a reversion to mean process.

Given these results, there is one last interesting question to be asked: is the better performance in the inflation rates of the Inflation Targeting countries due to a more "aggressive" monetary policy? More specifically, we are interested to know if the only reason why Inflation Targeting countries have lower inflation rates is because they set really high real interest rates. If this is the case, then one could suggest that the regime itself doesn't matter much, but only how high you set the real interest rates.

This question is addressed in two ways. Table 3 shows the results of the first procedure. We estimate the same set of regressions estimated for the level of the inflation rate (with country fixed effects and time effects) but using the real interest rate as the dependent variable. The difference from regression (1) to regression (2) is that in the latter there is a control for the initial condition introducing the first lag of the real interest rate as one of the regressors. In both specifications, the coefficient for the treatment variable was insignificant. Given this result, it is hard to believe in the hypothesis that Inflation Targeting countries experienced a significant increase in the level of their real interest rates after they adopted the new regime.

Table 3: Estimation Output**Dependent Variable: Real Interest Rate (annualized quarterly % rate)**

Frequency: quarterly

Sample Period: 1986.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.25 (0.332)	-0.15 (0.331)
Time trend	-0.02 (0.016)	-0.01 (0.011)
Initial condition		0.04 (0.045)
F-statistics Testing Exclusion of Group of Variables		
Country effects = 0	13.76 (<0.001)	7.98 (<0.001)
Time effects = 0	4.58 (<0.001)	4.46 (<0.001)
R²	0.34	0.34

These regressions are estimated using panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002. White's robust standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

The second set of evidence is presented in Table 4. The equations estimated in the table have the same specification of the equations presented in Table 3 with the inclusion of the second lag of real interest rate as one of the regressors explaining the inflation rate. That is, we regress the inflation rate on our Treatment variable, the first lag of the inflation rate, the second lag of the real interest rate, a time trend, country fixed effects and time effects.

Table 4: Estimation Output**Dependent Variable: CPI Inflation Rate (quarterly % rate)**

Frequency: quarterly

Sample Period: 1986.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.34** (0.082)	-0.28** (0.087)
Time trend	-0.01** (0.004)	-0.01* (0.004)
Initial condition	0.12** (0.038)	0.18** (0.048)
Real interest rate	-0.06** (0.009)	
Real interest rate effect?	group	individual
F-statistics Testing Exclusion of Group of Variables		
Real interest rate = 0		5.89 (<0.001)
Country effects = 0	13.86 (<0.001)	7.88 (<0.001)
Time effects = 0	5.23 (0.009)	4.91 (<0.001)
R ²	0.48	0.53

These regressions are estimated using panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002. White's robust standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

The first column of results in Table 4 restricts the effects of real interest rate on the inflation rate to be the same for the whole group of countries [$\beta_{3i} = \beta_3$ for all i]. This coefficient is negative and significant at 1%: a 1% increase in the annualized real interest rate reduces inflation two quarters ahead in 0.06%. The differences-in-differences coefficient remains negative and significant at 1%: the estimated coefficient of -0.34 is practically the same as the coefficient estimated in Table 2. The coefficient associated with the lagged inflation rate also remains practically unchanged: the estimated value was 0.12, statistically significant at 1%. The deterministic time trend coefficient remains negative and significant at 1%, but its magnitude is reduced from -0.02 to -0.01. The R² of 48% is marginally higher than the one in the regression without

the real interest rate as a regressor. Finally, the null hypothesis that each group of dummy variables that control for country fixed effects and time effects is zero can be rejected at the 1% significance level.

In the second column of results in Table 4 we allow the effects of real interest rate on the inflation rate to be individual, varying across countries [$\beta_{3i} \neq \beta_{3j}$ for $i \neq j$]. Although the table does not present any of such 22 coefficients estimated, the null hypothesis that this group of coefficients is zero can be easily rejected. The inclusion of the real interest rate marginally reduces the magnitude of differences-in-differences coefficient: it goes from -0.34 to -0.28, a less than one standard deviation change. Nevertheless, the differences-in-differences coefficient remains significant at 1%. The deterministic time trend coefficient remains practically the same but has its standard deviation increased: the -0.01 coefficient is no longer significant at 1% but remains significant at 10%. The coefficient associated with the first lag of the inflation rate remains significant at 1% but presents a more than one standard deviation increase, indicating a higher measure of persistence or inertia: 0.18. The R^2 increases to 53% and the null hypothesis that each group of dummy variables that control for country fixed effects and time effects is zero can be easily rejected.

In summary, this section has provided two sets of empirical evidence. First, it failed to find evidence that Inflation Targeting countries experienced a significant increase in the level of their real interest rates after they adopted the new regime. Second, it showed that even after we control for the level of real interest rates (that have a negative and significant effect) there is still a causal effect from the adoption of Inflation Targeting to the reduction in inflation rates. These evidences allow us to reject the idea that the better performance in the inflation rates of the Inflation Targeting countries is only due to a more "aggressive" monetary policy (that is, setting really high real interest rates).

5. Conclusion

After the introduction in New Zealand in 1990, many other developed and emerging countries also adopted Inflation Targeting as their monetary policy regime. Despite of

its popularity, empirical studies have failed to find evidence of the causal effect of a country's adoption of the Inflation Targeting regime on that country's inflation rate.

This paper applies the multi-period differences-in-differences estimation to the quarterly CPI inflation rates from the first quarter of 1986 until the third quarter of 2002 to all the 22 OECD industrial countries. The first set of evidence finds that even countries that have officially adopted Inflation Targeting experienced a decrease in their average inflation rates after the adoption of the new regime and also that this estimated effect persists even after we control for the initial inflation rate. In other words, the better performance of Inflation Targeting countries is not only due to a reversion to mean process in the inflation rate.

The second set of results is found reapplying the analysis conditioning the inflation rate to the real interest rate. The real interest rate is the channel through which the short run nominal interest rate determined by the Monetary Authority affects the inflation rate (by affecting credit, consumption, investment and the usual components of the aggregate demand). One could suggest that the performance "gain" in the inflation rates of the adoption of the Inflation Targeting regime is only due to a more "aggressive" monetary policy. Intuitively, this would mean that that the adoption of the regime itself doesn't matter much, but only how high you set the real interest rates. However, the empirical evidence provided in this paper rejects this hypothesis. First, there seems to be no evidence that Inflation Targeting countries experienced a significant increase in the level of their real interest rates after they adopted the new regime. Second, it showed that even after controlling for the level of real interest rates (that have a negative and significant effect) there is still a causal effect from the adoption of Inflation Targeting to the reduction in inflation rates.

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Appendix

All regressions in this paper have been estimated with robust standard errors. The reason for this option is because the residuals are not spherical. In a panel data, a non-spherical error structure means that there is either cross-sectional heteroskedasticity across panels or time series autocorrelation within panels or both.

Table A.1: Estimation Output

Dependent Variable: CPI Inflation Rate (quarterly % rate)

Frequency: quarterly

Sample Period: 1985.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.35** (0.061)	-0.31** (0.056)
Time trend	-0.02** (0.002)	-0.02** (0.002)
Initial condition		0.13** (0.026)
χ^2-statistic Testing Heteroskedasticity		
H ₀ : no Heteroskedasticity	886.14 (<0.001)	885.82 (<0.001)
F-statistic Testing Autocorrelation		
H ₀ : no Autocorrelation	4.33 (0.050)	102.66 (<0.001)

These regressions are estimated using FGLS for panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002, controlling for heteroskedastic error structure and panel specific first-order autocorrelation. Standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics and χ^2 -statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

The output of the tests that detect heteroskedasticity and autocorrelation are presented in this Appendix. For each specification estimated in this paper, two different tests are run. The first test, which tests for heteroskedasticity, is the likelihood ratio test. The second test is the test for serial correlation in the idiosyncratic errors of a linear panel-data model discussed by Wooldridge (2002). Table A.2 refers to the specifications estimated

in Table 2, Table A.2 refers to the specifications of Table 3 and Table A.3 refers to Table 4.

Table A.2: Estimation Output

Dependent Variable: Real Interest Rate (annualized quarterly % rate)

Frequency: quarterly

Sample Period: 1986.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.18 (0.300)	-0.10 (0.291)
Time trend	-0.03** (0.010)	-0.02* (0.010)
Initial condition		0.06* (0.026)
χ^2-statistic Testing Heteroskedasticity		
H ₀ : no Heteroskedasticity	593.17 (<0.001)	616.12 (<0.001)
F-statistic Testing Autocorrelation		
H ₀ : no Autocorrelation	2.03 (0.169)	62.63 (<0.001)

These regressions are estimated using FGLS for panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002, controlling for heteroskedastic error structure and panel specific first-order autocorrelation. Standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics and χ^2 -statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

We can see by these tables that we can easily reject the null hypothesis that the residuals are spherical. In the presence of non-spherical disturbances, there are two solutions: one is to use robust standard errors; the other is to use FGLS. Although robust standard errors tend to be less efficient than FGLS, they are robust to any type of correlation within the observations of each panel/group. FGLS will only be correct (and in these cases also more efficient) if the assumptions about the error structure are correct.

Table A.3: Estimation Output**Dependent Variable: CPI Inflation Rate (quarterly % rate)**

Frequency: quarterly

Sample Period: 1986.1 to 2002.3

Regressor	(1)	(2)
Treatment	-0.33** (0.061)	-0.29** (0.057)
Time trend	-0.01** (0.002)	-0.01** (0.002)
Initial condition	0.09** (0.027)	0.12** (0.026)
Real interest rate	-0.01* (0.006)	
Real interest rate effect?	group	individual
χ^2-statistic Testing Heteroskedasticity		
H ₀ : no Heteroskedasticity	775.31 (<0.001)	755.62 (<0.001)
F-statistic Testing Autocorrelation		
H ₀ : no Autocorrelation	92.528 (<0.001)	266.78 (<0.001)

These regressions are estimated using FGLS for panel data for the 22 OECD countries collected at the IMF IFS database for the first quarter of 1985 until the third quarter of 2002, controlling for heteroskedastic error structure and panel specific first-order autocorrelation. Standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics and χ^2 -statistics. The symbols * and ** denote that the individual coefficient is significant at the 10% and 1% significance level respectively.

In this Appendix we also recalculate the estimated coefficients using FGLS controlling for heteroskedastic error structure and panel specific first-order autocorrelation. As we can see, the results are practically the same as the ones presented in the paper using robust standard errors.

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