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Investigating Aggregation Bias in the Case of the Interest Rate Pass-through

This analysis examines aggregation bias in the case of the interest rate pass-through in the Republic of Macedonia. By using bank-level data, the authors investigate whether there are heterogeneities and asymmetries in the size and speed of the adjustment of lending rates to changes in the cost of the funds rate. The findings in general suggest the presence of aggregation bias in the literature, implying that the empirical studies based on aggregated data may provide biased results.

The objective of this study is to examine aggregation bias in the case of the interest rate pass-through in the Republic of Macedonia, a small open transition economy with fixed exchange rates. To this end, bank-level data are used to examine differences in the speed and size of the long- and short-run adjustments of banks' lending rates to changes in the "cost of funds" rate. Additionally, we explore asymmetries in the adjustment of lending rates when the reference rate increases or decreases.

The rationale for examining the aforementioned issues using bank-level data is to investigate whether the results reported in the previous empirical literature based on aggregated data are prone to aggregation bias. For example, the empirical studies that investigate the interest rate pass-through in the Macedonian banking sector imply that it is incomplete in the short run but complete in the long run.[1] However, as these studies are conducted using aggregated data – like many other studies for Central and Southeastern Europe (CSEE) – we argue that they may suffer from aggregation bias (discussed below).

* The views and opinions expressed in this paper are those of the authors and do not necessarily represent the views of the National Bank of the Republic of Macedonia.

1 Z. Jovanovski, A. Krstevska, A. Mitreska, S. Bojceva-Terzijan: Monetary transmission through the interest rates in the Republic of Macedonia, National Bank of the Republic of Macedonia Working Paper, No. 13, 2005; I. Velickovski: Potential costs of Euro adoption for transition countries: a case study for Macedonia, Frankfurt 2010; G. Petrevski, J. Bogoev: Interest rate pass-through in South East Europe: an empirical analysis, in: Economic Systems, http://DX.DOI.ORG/10.1016/j.ecosys.2012.03.001, 2012.

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Consequently, those findings may provide misleading information for policymakers in designing policy strategies, which ultimately could result in sub-optimal policy decisions.

The analysis thoroughly explores banks' heterogeneities in the size and speed of setting their lending rates conditional on changes in the reference rate and provides useful information for policymakers to better design monetary policy measures and instruments. In this way, our findings may help policymakers to increase the effectiveness of the interest rate channel by targeting those banks that impede the transmission process and/or by taking other regulatory measures that may increase the effectiveness of the interest rate pass-through.

Theoretical Background and Assessment of Empirical Studies

We follow the mark-up pricing model by Rousseas[2] and Ho and Saunders[3] of how banks set their retail rates. This is a mark-up pricing model designed for an imperfectly competitive banking sector, since it is argued that banks exhibit some degree of market power. This may especially apply for the CSEE, because their financial systems are still underdeveloped, bank-dominated and highly concentrated.[4]

The starting argument of the mark-up pricing theory is that banks in the loan market are price setters and are modelled to set their retail interest rates as a mark-up

2 S. Rousseas: A mark-up theory of bank loan rates, in: Journal of Post Keynesian Economics, Vol. 8, Issue 1, 1985, pp. 135-144.

3 T.S.Y. Ho, A. Saunders: The determinants of bank interest margins: theory and empirical evidence, in: Journal of Financial Intermediation and Quantitative Analysis, Vol. 16, No. 4, 1981, pp. 581-600.

4 G. Petrevski, J. Bogoev, op. cit.

margin over their prime costs (variable costs), expressed as follows:

$$i = k\,(u) \tag{1}$$

where i is the interest rate on loans, u represents the unit prime or variable costs and k is the mark-up margin over the prime or variable costs.

According to Rousseas[5] and Ho and Saunders,[6] the prime or variable costs are determined by the variations in the costs of funding their lending activities known as cost of funds. These costs represent the interest rates on banks' borrowings in the money market that is assumed to be exogenously determined.

Based on the mark-up pricing model for applied research, de Bondt[7] has redefined the retail rate setting shown Equation (1) as follows:

$$i = \beta_1 + \beta_2 u \tag{2}$$

where i is banks' retail interest rate (the loan interest rate), β_1 is the mark-up margin, u is the cost of funds rate and β_2 represents the demand elasticity of deposits or loans, which is the size of the pass-through coefficient. According to this equation, variations in retail rates are again determined by the variations in the cost of funds rate, but the extent to which those variations are transmitted to the banks' retail rates depends upon the size of the β_2 coefficient. A value of β_2 less than one implies an incomplete pass-through from the cost of funds rate to banks' retail rates. A β_2 coefficient equal to unity refers to complete pass-through, and a value greater than one indicates an overshooting.

Regarding the empirical literature exploring the interest-rate pass-through at the micro level, most studies focus on advanced economies, while research on the rest of the CSEE is still scarce. A short survey of the most influential articles in this area is presented below.

Studies by Weth[8] and Mueller-Spahn[9] examine the interest rate pass-through for the German banking system. The results presented in Weth[10] suggest the homogeneous and almost complete long-run adjustment of lending rates to changes in the cost of funds rate, whereas the size of short-run adjustment is estimated as heterogeneous among various banks. Regarding the speed of adjustment, the results reveal that it is quite sluggish and differs among banks, ranging from -0.1 to -0.3. Different findings are presented in Mueller-Spahn,[11] where results indicate not only a significant heterogeneous short-run adjustment but also a heterogeneous long-run adjustment of lending rates to changes in the cost of funds rate.

Concerning the Italian banking system, the analyses by Cottarelli et al.[12] and Gambacorta[13] indicate a significant heterogeneous and sluggish short-run adjustment of lending rates to changes in the cost of funds rate. The size of the short-run pass-through multipliers in Gambacorta[14] are estimated between 0.3 and 0.6, whereas the pass-through multipliers among various banks in Cottarelli et al.[15] are not reported in the paper. In contrast, the long-run adjustment of lending rates is estimated as complete and homogeneous among banks in both studies, a finding consistent with what Weth[16] found in Germany.

The results by de Graeve[17] indicate heterogeneous sizes of long- and short-run adjustments of lending rates among Belgian banks, which is in line with the analysis by Mueller-Spahn[18] for Germany. The heterogeneity is more pronounced in the short run than the long run. In a similar manner, the study by Lago-González and Salas-Fumás[19] indicates heterogeneous and quite rigid long- and short-run adjustments among Spanish banks. For the case of the Polish banking system, the research conducted by Chmielewski[20] also implies a different speed and size of long- and short-run adjustments of lending rates to changes in the cost of funds rate, which is in line with

5 S. Rousseas, op. cit.

6 T.S.Y. Ho, A. Saunders, op. cit.

7 G. de Bondt: Interest rate pass-through: empirical results for the Euro Area, in: German Economic Review, Vol. 6, No. 1, 2005, pp. 37-78.

8 M.A. Weth: The pass-through from market interest rates to bank lending rates in Germany, Deutsche Bundesbank Discussion paper, No. 11/02, 2002.

9 S. Mueller-Spahn: The pass-through from market interest rates to retail bank rates in Germany, Centre for Finance and Credit Markets Working Paper, No. 08/05, 2008.

10 M.A. Weth, op. cit.

11 S. Mueller-Spahn, op. cit.

12 C. Cottarelli, G. Ferri, A. Generale: Bank lending rates and financial structure in Italy: a case study, International Monetary Fund Working Paper, No. 95/38, 1995.

13 L. Gambacorta: How do banks set interest rates?, in: European Economic Review, Vol. 52, No. 5, 2008, pp. 792- 819.

14 Ibid.

15 C. Cottarelli, et al., op. cit.

16 M.A. Weth, op. cit.

17 F. de Graeve, O. de Jonghe, R.V. Vennet: The determinants of pass-through of market conditions to bank retail interest rates in Belgium, National Bank of Belgium Working Papers – Research Series, No. 47, 2004.

18 S. Mueller-Spahn, op. cit.

19 R. Lago-González, V. Salas-Fumás: Market power and bank interest rate adjustments, Bank of Spain Working Paper, No. 0539, 2005.

20 T. Chmielewski: Interest rate pass-through in the Polish banking sector and bank-specific financial disturbances, Munich Personal RePEc Archive Paper, No. 5133, 2004, http://mpra.ub.uni-muenchen.de/5133/ (last accessed 23/03/2011).

the aforementioned findings for the German and Belgian banking systems. A more recent study conducted for the Czech banking system by Horváth and Podpiera[21] reveals a homogeneous long-run reaction function of the banks in adjusting their lending rates but a heterogeneous short-run reaction function.

In general, the findings of the empirical analyses that use bank-level data differ considerably among each other, which may be due to the sample considered, the estimation method employed or the time span used. A general possible drawback of the majority of the assessed studies may be related to the estimation method used. For example, these studies may provide inefficient estimates because they do not control for the cross-sectional correlation among the units that is expected in the case of the banking sector, because banks' activities may be related. Accordingly, we tackle this issue by controlling for the cross-sectional correlation among the units for which we use the Seemingly Unrelated Regression (SUR) model that has been specifically developed for that purpose (see below). Thus, from the methodological point of view, employing this model is a major value added of this research.

The Essence of Aggregation Bias Hypothesis and the Econometric Method Used

The basic assumption of the aggregation bias hypothesis is that the individual units from which the aggregated data is composed may be individuals with heterogeneous behaviour.[22] Consequently, by estimating the economic relations with aggregated data, the individual behaviour is suppressed, i.e. it may be hidden in the disturbances of the model based on aggregated data.[23] This may result in biased estimates. A simple method of testing the aggregation bias hypothesis according to Zellner[24] is to test the condition (H_0):

$$H_0: \beta_1 = \beta_2 = \beta_3 = \ldots\ldots = \beta_i \quad (3)$$

Condition (H_0) indicates that the slope parameters β must be equal for each individual unit. This indicates homogeneous behaviour among the units of which the aggregated data is composed. If the opposite holds, then the units have heterogeneous behaviour. For the case of the banking sector, banks' differences in adjusting their lending rates may arise from their different market strategies, funding sources and financial characteristics. In that respect, the ultimate objective of this paper is to examine whether there are any differences and asymmetries in the speed and size of long- and short-run adjustments of lending rates among banks.

In order to test whether condition (H_0) holds, we need bank-level estimates of the size and speed of adjustment. By assessing the stationarity of the interest series and the existence of a cointegration relationship, we employ a pooled model based on Engle-Granger[25] methodology that disentangles the long- and short-run relationships among the variables. More precisely, we firstly tested the order of integration of the interest series by applying various panel unit root tests (Im-Pesaran-Shin,[26] Fisher[27] and Hadri[28] tests) by subtracting the cross-sectional means from the series in order to control for the cross-sectional correlation among the units that provides some efficiency gains.[29] Secondly, we tested for the existence of a cointegration relationship among the interest rate series by performing panel cointegration tests (Pedroni[30] and Kao[31]). Nine out of eleven of Pedroni's test statistics pointed to rejection of the null hypothesis of no cointegration at the 1% level, and the other two pointed to rejection of the null hypothesis at the 10% level. Consistent findings are obtained from the Kao cointegration method, implying that the interest rate series are cointegrated.

The empirical model specification for the long-run pass-through based on Equation 2 is as follows:

$$i_{jt} = \beta_{0j} + \beta_{lj}\, u_t + \varepsilon_{jt}\,;\ t = 1,\ldots,T \text{ and } j = 1,\ldots,N \quad (4)$$

where j and t are bank and time subscripts respectively; i_{jt} is the banks' lending rate of loans denominated in domes-

21 R. Horváth, A.M. Podpiera: Heterogeneity in bank pricing policies: the Czech evidence, in: Economic Systems, Vol. 36, No. 1, 2012, pp. 87-108.

22 H. Theil: Specification errors and the estimation of economic relationships, in: Review of International Statistical Institute, Vol. 25, No. 1, 1957, pp. 41-51; A. Zellner: An efficient method of estimating seemingly unrelated regression equations and tests of aggregation bias, in: Journal of the American Statistical Association, Vol. 57, No. 298, 1962, pp. 500-509.

23 A. Zellner, op. cit.

24 Ibid.

25 R.F. Engle, C.W.J. Granger: Co-integration and error correction: representation, estimation, and testing, in: Econometrica, Vol. 55, No. 2, 1987, pp. 251-276.

26 K. Im, M. Pesaran, Y. Shin: Testing for unit roots in heterogeneous panels, in: Journal of Econometrics, Vol. 115, No. 1, 2003, pp. 53-74.

27 R. Fisher: Statistical Methods for Research Workers, 4th Edition, Edinburgh, 1932.

28 K. Hadri: Testing for stationarity in heterogeneous panel data, in: Econometrics Journal, Vol. 3, No. 2, 2000, pp. 148-161.

29 A. Levin, C. Lin, C. Chu: Unit root tests in panel data: asymptotic and finite-sample properties, in: Journal of Econometrics, Vol. 108, No. 1, 2002, pp. 1-24.

30 P. Pedroni: Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis, in: Econometric Theory, Vol. 20, No. 3, 2004, pp. 597-625.

31 C. Kao: Spurious regression and residual-based tests for cointegration in panel data, Journal of Econometrics, Vol. 90, No. 1, 1999, pp. 1-44.

tic currency; β_{0j} is the bank-specific intercept term; u_t is the cost of funds rate, i.e. the Macedonian money market rate (MBKS); β_{1j} is the size of the pass-through coefficient; and ε_{jt} are white noise residuals.

We estimate the short-run relationship and the speed of adjustment of interest rate series using an error correction model (ECM):

$$\Delta i_{jt} = \gamma_{0j} + \gamma_{1j}\,\Delta u_t + \gamma_{2j}(i_{jt} - \beta_{0j} - \beta_{1j} u_t) + v_{jt} \qquad (5)$$

where Δ denotes the first difference operator; γ_{0j} is the constant of the short-run relationship model; γ_{1j} is the size of the short-run multiplier; γ_{2j} is the speed of adjustment, the error correction term (ECT); and v_{jt} are white noise residuals. In order to test for any asymmetries in the size and speed of adjustment of lending rates in Equation 5 when the cost of funds rate increases or decreases, we follow Égert et al.[32] and set the following specification:

$$\Delta i_{jt} = I(\Delta u_t < 0) * [\gamma_{3j} + \gamma_{4j}\Delta u_t + \gamma_{5j}(i_{jt} - \beta_{0j} - \beta_{1j} u_t) + v_{jt}] + [1 - I(\Delta u_t < 0)] * [\gamma_{6j} + \gamma_{7j}\Delta u_t + \gamma_{8j}(i_{jt} - \beta_{0j} - \beta_{1j} u_t) + v_{jt}] + v_{jt} \qquad (6)$$

where $I(\cdot)$ is an indicator function that takes value 1 if the argument is true and 0 otherwise. In order to test whether the impact multiplier and the ECT are statistically different (asymmetric) when the money market rate increases or decreases, we use the F-test for the following restrictions:

$$\gamma_{3j} = \gamma_{6j};\ \gamma_{4j} = \gamma_{7j};\ \gamma_{5j} = \gamma_{8j} \text{ for all } j \qquad (7)$$

Following Rapach and Wohar[33] and Sørensen and Werner,[34] we employ a pooled two-step estimation method. In estimating the long-run pass-through coefficients (Equation 4), where the regressor is identical across the cross-sectional units, we apply ordinary least squares. In estimating Equation 5, i.e. the speed and the size of short-run adjustment, where the bank-specific equations have non-identical regressors and, thus, a cross-sectional correlation among the units might exist, we employ Zellner's[35] seemingly unrelated regression (SUR) model estimated by feasible generalised least squares. This estimator provides efficiency gains by using the information of the variance-covariance matrix of the error terms (this assumption will be tested by performing the Breusch-Pagan[36] test for the contemporaneous correlation of error terms). Employing the SUR model for estimating the ECM with pooled data is called a seemingly unrelated regression error correction model (SURECM).

Data

We use monthly data for the period January 2002 – December 2010. All data series used in this paper are taken from the National Bank of the Republic of Macedonia (NBRM), which are not publicly available. We have 108 observations per bank for a sample of 14 banks that have operated continually during the analysed period (a total of 1512 observations). These banks had a loan market share of around 92% during the entire period of analysis. The reason for using a balanced panel is that a SURECM estimation requires a balanced data structure.

We use the interest rate series on banks' outstanding loans for each bank separately. We use an interest rate series denominated in domestic currency. The interest rate series includes both corporate and household sectors. Another limitation of the interest rate series is that it includes all types of loans, regardless of their purpose, because data disaggregated by loan purpose are not available. Regarding the cost of funds rate, we use the weighted average MBKS, which comprises all transactions with different maturities at the money market rate that are also denominated in domestic currency. The money market transactions have a maximum maturity of three months, but more than 90% of the transactions have a maturity of up to one month. The summary statistics of the interest rate series are presented in Table 1.

Results

The long-run pass-through estimates based on Equation 4 are presented in Table 2. All bank-specific regressions and the model as a whole are statistically significant at the 1% level. The independent variable (the MBKS rate) is individually and jointly statistically significant in all bank-specific regressions at the 1% level. The sign of the long-run pass-through multipliers is positive as expected, but the magnitude of the coefficients differs among banks, ranging from 0.5 to 1.2. In order to investigate whether the long-run pass-through multipliers statistically differ and whether the condition (H_0) can be statistically justified, we performed an F-test for joint equality of the coefficients.

32 B. Égert, J. Crespo-Cuaresma, T. Reininger: Interest rate pass-through in Central and Eastern Europe: reborn from ashes merely to pass away?, in: Journal of Policy Modeling, Vol. 29, No. 2, 2007, pp. 209-225.

33 D.E. Rapach, M.E. Wohar: Testing the monetary model of exchange rate determination: a closer look at panels, in: Journal of International Money and Finance, Vol. 23, No. 6, 2004, pp. 867-895.

34 K. Sørensen, T. Werner: Bank interest rate pass-through in the Euro Area: a cross country comparison, European Central Bank Working Paper, No. 580, 2006.

35 A. Zellner, op. cit.

36 T. Breusch, A. Pagan: The Lagrange multiplier test and its applications to model specification in econometrics, in: Review of Economic Studies, Vol. 47, No. 1, 1980, pp. 239-253.

Table 1
Summary Statistics of the Interest Rate Series Used

	Observations	Minimum	Maximum	Mean	Median	Std. Dev.	Sum	Sum Sq. Dev.
MBKS	108	0.025	0.152	0.067	0.065	0.030	7.278	0.093
Lendrate_bank1	108	0.088	0.208	0.132	0.129	0.036	14.261	0.138
Lendrate_bank2	108	0.082	0.170	0.107	0.096	0.028	11.543	0.083
Lendrate_bank3	108	0.118	0.199	0.153	0.135	0.031	16.576	0.104
Lendrate_bank5	108	0.090	0.175	0.119	0.103	0.028	12.871	0.084
Lendrate_bank6	108	0.095	0.160	0.122	0.118	0.023	13.161	0.056
Lendrate_bank7	108	0.091	0.205	0.125	0.119	0.023	13.514	0.057
Lendrate_bank8	108	0.104	0.300	0.168	0.159	0.062	18.167	0.412
Lendrate_bank9	108	0.105	0.265	0.150	0.125	0.056	16.155	0.334
Lendrate_bank10	108	0.085	0.185	0.111	0.099	0.029	12.035	0.092
Lendrate_bank11	108	0.068	0.165	0.106	0.089	0.034	11.443	0.121
Lendrate_bank12	108	0.092	0.175	0.115	0.106	0.022	12.460	0.053
Lendrate_bank13	108	0.091	0.210	0.133	0.117	0.041	14.336	0.182
Lendrate_bank16	108	0.100	0.165	0.128	0.125	0.020	13.784	0.041
Lendrate_bank27	108	0.102	0.224	0.139	0.124	0.036	14.990	0.136

Source: Authors' calculations based on NBRM data.

The F-test results indicate that the null hypothesis of their joint equality can be rejected at the 1% level, which implies that in the long run banks adjust their lending rates to changes in the cost of funds rate differently.

The short-run pass-through estimates based on Equation 5 and the detection of an asymmetric adjustment of the impact multiplier and the ECT based on Equations 6 and 7 are presented in Table 2. The results suggest that all bank-specific regressions and the model as a whole are statistically significant at the 1% level. The results of the Breusch-Pagan test reject the null hypothesis of zero contemporaneous covariance dependence between the errors from each equation at the 1% level, implying that there is some efficiency gain from employing the SURECM method.

By performing the F-test to detect the asymmetry in the size and speed of adjustment (Equation 7), we found that at the 1% level for all banks there is an asymmetric size of short-run adjustment when the "cost of funds" rate increases/decreases. Nonetheless, the F-test results reveal that the impact multiplier is jointly statistically insignificant when the money market rate increases, whereas it is jointly statistically significant at the 1% level when the money market rate decreases. This indicates the heterogeneous and asymmetric short-run adjustment of lending rates. Therefore, condition (H_0) does not hold. When analysed at the level of individual banks (where the impact multiplier is individually statistically significant), it has a positive sign and ranges between 0.2 and 0.6. This reveals that when the money market rate decreases by 100 basis points, banks reduce their lending rates from 20 to 60 basis points. Assessing the speed of adjustment, the ECT term is individually and jointly statistically significant for all banks at the 1% level. Its magnitude statistically differs across the banks, ranging between -0.1 and -0.2, implying heterogeneity in the speed of adjustment, indicating again that condition (H_0) cannot be justified. Regarding the speed of adjustment, the F-test results reveal that it is asymmetric only for five banks in the sample, indicating that the speed of adjustment of these banks varies depending on whether the cost of funds rate increases or decreases.

Comparison of the Results Based on Aggregate Data

The results of the empirical studies based on aggregated data for the case of Macedonia[37] suggest that the size of the long-run multiplier is equal to 1, the impact multiplier is low (estimated around 0.05) and the speed of adjustment is sluggish (around -0.1). Additionally, Velickovski[38] did not find any asymmetries in the size and speed of the adjustment of lending rates for the aggregate data set.

In this study we find both heterogeneity and asymmetries in the size and speed of the short-run adjustment of lend-

37 I. Velickovski, op. cit.; G. Petrevski, J. Bogoev, op. cit.
38 I. Velickovski, op. cit.

Table 2

Estimates of the Short-run Pass-through Multipliers and the Speed of Adjustment from the Cost of Funds Rate to Banks' Lending Rates

Panel A: banks with symmetric speed of adjustment (symmetric ECT)

	Constant	Asymmetric impact multiplier of change in the money market rate (dMBKS)		Symmetric error correction term (ECT)	Adjusted R-squared	F-test for the overall significance of each bank-specific equation (p-value)
		When dMBKS > 0	When dMBKS < 0			
Bank2	-0.000769*	-0.063	-0.118	-0.0866***	0.138	0.000
	(0.000414)	(0.106)	(0.0893)	(0.0223)		
Bank5	-0.000	-0.074	0.179	-0.117***	0.075	0.006
	(0.000526)	(0.135)	(0.114)	(0.0353)		
Bank6	-0.000729*	0.057	-0.077	-0.0970***	0.117	0.000
	(0.000427)	(0.109)	(0.092)	(0.0237)		
Bank7	-0.001	-0.215*	0.052	-0.141***	0.131	0.000
	(0.000482)	(0.124)	(0.104)	(0.0337)		
Bank8	-0.001	0.109	0.367*	-0.108***	0.065	0.000
	(0.000941)	(0.242)	(0.203)	(0.0286)		
Bank11	-0.000884*	0.067	0.045	-0.0705***	0.002	0.002
	(0.000491)	(0.126)	(0.106)	(0.0184)		
Bank12	-0.000950**	-0.024	-0.096	-0.203***	0.172	0.000
	(0.000456)	(0.117)	(0.0984)	(0.0324)		
Bank16	-0.000	0.018	0.156*	-0.0745***	0.125	0.009
	(0.000412)	(0.106)	(0.0893)	(0.0276)		
Bank27	-0.00127**	0.047	-0.057	-0.168***	0.219	0.000
	(0.000521)	(0.134)	(0.112)	(0.0249)		

Panel B: banks with asymmetric speed of adjustment (asymmetric ECT)

	Asymmetric constant		Asymmetric impact multiplier		Asymmetric ECT		Adjusted R-squared	F-test for the overall significance of each bank-specific equation (p-value)
	When dMBKS > 0	When dMBKS < 0	When dMBKS > 0	When dMBKS < 0	ECT when dMBKS > 0	ECT when dMBKS < 0		
Bank1	-0.001	-0.001	-0.002	0.421***	-0.041	-0.0733***	0.277	0.000
	(0.000525)	(0.000483)	(0.0997)	(0.0861)	(0.0261)	(0.025)		
Bank3	0.000	-0.001	-0.029	-0.057	-0.076	-0.230***	0.140	0.000
	(0.00116)	(0.00109)	(0.229)	(0.195)	(0.0511)	(0.0514)		
Bank9	-0.001	-0.002	0.067	0.644***	-0.157***	-0.009	0.249	0.000
	(0.00151)	(0.0014)	(0.267)	(0.231)	(0.031)	(0.0297)		
Bank10	-0.000	-0.000	-0.383***	0.157*	-0.046	-0.160***	0.293	0.000
	(0.000562)	(0.00052)	(0.0986)	(0.0882)	(0.0331)	(0.0367)		
Bank13	-0.001	-0.001	0.026	0.263**	-0.115***	-0.013	0.195	0.000
	(0.000828)	(0.000765)	(0.148)	(0.129)	(0.0223)	(0.0229)		

Panel A: F-test for the joint significance of the ECT variable in all bank-specific equations: F (9, 1418) = 13.81; p= 0.000; F-test for parameter equality of the ECT among each bank: F (8, 1418) = 4.03; p = 0.000.

Panel B: F-test for the joint significance of the ECT when ECT > 0 in all bank-specific equations: F (5, 1418) = 8.45; p = 0.000; F-test for the joint significance of the ECT when ECT < 0 in all bank-specific equations: F (5, 1418) = 9.56; p = 0.000; F-test for the joint equality between ECT when ECT > 0 and ECT < 0 in all bank-specific equations: F (9, 1418) = 3.33; p = 0.000; Tests for all banks in the sample: jointly for those with symmetric and asymmetric ECT; Adjusted R-squared of the whole model: 0.14; F-test for the overall significance of the whole model (p-value): 0.000; F-test for the joint significance of the dMBKS variable when dMBKS > 0 in all bank-specific equations: F (1, 1418) = 0.00; p = 0.982; F-test for the joint significance of the dMBKS variable when dMBKS < 0 in all bank-specific equations: F (1, 1418) = 23.87; p = 0.000; F-test for the joint equality between dMBKS variable when dMBKS > 0 and dMBKS < 0 in all bank-specific equations: F (1, 1418) = 10.07; p = 0.002; Breusch-Pagan test for the contemporaneous covariance independence between the error terms in the whole system: chi2 (91) = 393.802; p-value = 0.000.

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% level respectively.

Source: Authors' calculations based on NBRM data.

Table 3
Estimates of Long-run Pass-through Multipliers from the Cost of Funds Rate to Banks' Lending Rates

Bank:	Variable: Constant	MBKS	Adjusted R-squared	F-test for the overall significance of each bank-specific equation (p-value)
Bank1	0.0599***	1.071***	0.777	0.000
	(0.00406)	(0.0552)		
Bank2	0.0544***	0.779***	0.678	0.000
	(0.0038)	(0.0517)		
Bank3	0.0954***	0.861***	0.664	0.000
	(0.00434)	(0.059)		
Bank5	0.0633***	0.828***	0.764	0.000
	(0.00325)	(0.0443)		
Bank6	0.0767***	0.670***	0.744	0.000
	(0.00278)	(0.0379)		
Bank7	0.0826***	0.632***	0.653	0.000
	(0.00326)	(0.0443)		
Bank8	0.0433***	1.154***	0.778	0.000
	(0.007)	(0.0952)		
Bank9	0.0393***	1.637***	0.748	0.000
	(0.00673)	(0.0915)		
Bank10	0.0539***	0.854***	0.742	0.000
	(0.00356)	(0.0485)		
Bank11	0.0457***	0.894***	0.617	0.000
	(0.00498)	(0.0677)		
Bank12	0.0720***	0.643***	0.721	0.000
	(0.00283)	(0.0385)		
Bank13	0.0523***	1.194***	0.733	0.000
	(0.0051)	(0.0694)		
Bank16	0.0933***	0.510***	0.588	0.000
	(0.00302)	(0.0411)		
Bank27	0.0668***	1.069***	0.781	0.000
	(0.00401)	(0.0545)		

Adjusted R-squared of the whole model: 0.79; F-test for the overall significance of the whole model p-value: 0.000;
F-test for the joint significance of the MBKS variable in all bank-specific equations: F (14, 1448) = 73.34; p = 0.000;
F-test for parameter equality of the MBKS variable among each bank: F (13, 1484) = 66.31; p = 0.000;
F-test of whether the parameters in front of the MBKS variable statistically differ from 1 for each bank: F (14, 1484) = 204.47; p = 0.000.

Notes: *** denotes statistical significance at the 1% level.

Source: Authors' calculations based on NBRM data.

ing rates among banks as well as heterogeneity in the size of long-run adjustment. Moreover, using an F-test we tested the null hypothesis that the long-run pass-through multipliers are statistically equal to 1 for all banks in the sample, which was rejected at the 1% level (see Table 3). All of these findings suggest that the previous estimates of the speed and the size of long- and short-run pass-throughs conducted using aggregate data may suffer from aggregation bias.

Conclusions

The aim of this paper was to examine aggregation bias in the case of the interest rate pass-through. The results presented in this paper in general support the aggregation bias hypothesis in the existing literature. More precisely, this research provides statistical evidence that banks in Macedonia react differently in setting their lending rates when the cost of funds rate changes in both the long and short run. Moreover, the results show asymmetric short-run adjustments for all banks and asymmetric speeds of adjustment for some banks in the sample, conditional on the direction of the change of the cost of funds rate. Further evidence in support of the aggregation bias hypothesis is provided by a comparison of the bank-level estimates with the ones from previous empirical studies based on aggregated data, implying that the bank-level estimates substantially differ from those based on bank-level data.

All empirical findings presented in this paper suggest that banks are agents with heterogeneous behaviour, and consequently, the results of the previous studies based on aggregated data may be biased due to the suppression of banks' individual lending rate-setting behaviour. Thus, in order for the interest rate pass-through to become more effective, the central bank should target those banks that have sluggish short- and/or long-run pass-through multipliers. This could be done by introducing various regulatory requirements. An interesting direction for future research would be to investigate how past regulatory requirements have affected the transmission mechanism, whether those regulatory requirements have caused any distortion in the banking sector and which banks have been most severely affected. For example, the incomplete and different reactions of banks in adjusting their lending rates to changes in the reference rate may be a consequence of their balance sheet adjustments due to regulatory frameworks previously imposed by the central bank. An additional question for further research is how banks' financial characteristics affect their lending rate-setting behaviour, which is beyond the scope of this paper.