The Application of Interest Rate Risk Regulation on the Czech and Slovak Banking Sectors[1]

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Abstract

This paper examines the regulation of Interest Rate Risk Management of the Banking Book in the Czech and Slovak banking sectors. We provide modeling of bank balance sheets in terms of regulatory requirements. The contribution of our paper is two-fold. First, we identify the key business drivers of Interest Rate Risk of the Banking Book of the Czech and Slovak banking sectors. Second, when comparing the interest rate risk of the banking book of both banking sectors, we find that major banks in both sectors report a higher interest rate risk from their client liabilities than from client assets. This fact implies that the banks are exposed to the risks inherent in rising interest rates. We find that the interest rate risk exposure of the Czech and Slovak banks is relatively high, and therefore, the potential contagion risk for large foreign owners with subsidiaries in both countries is not negligible.

Keywords: *bank, economic value, embedded option, interest rate risk, market value, regulation*

JEL Classification: G21, G10

Introduction

In many countries, central banks have provided expansive monetary policy and have set basic interest rates to zero, or even negative values, in the last few years. This new situation will continue to affect the market risk management and profitability of banks, which has drawn the significant research interest of academic researchers (Alessandri and Nelson 2015; Claessens et al. 2017), as

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well as international organizations and stability regulators (Altavilla, Boucinha and Peydro, 2017; Bikker and Vervliet, 2017; BCBS, 2016;[2] Borio, Gambacorta and Hofmann, 2017; EBA, 2018[3]). While Alessandri and Nelson (2015) and Borio, Gambacorta and Hofmann (2017) show the adverse impact of monetary policy on easing banks' net interest margins, Claessens, Coleman and Donnelly (2017) highlight the exponentially negative effects of expansive monetary policy on bank profitability in a low-interest rate environment.

In our paper, we focus on interest rate risk management in the Czech and Slovak banking sectors and quantify its impact on bank profitability. Literature defines interest rate risk as the risk of a change in a value of an instrument stemming from changes in interest rates and client behavior (Mejstřík, Pečená and Teplý, 2015). Regulation separates interest rate risk into the four following risks, as defined by Bohn and Elkenbrach-Huizig (2014), EBA (2018) and BCBS (2016). It are i) repricing risk – a risk that assets and liabilities reprice at different times; ii) yield curve risk – a risk of unfavorable movements of market interest rates; iii) basis risk, arising from the usage of different reference rates for products with similar repricing features; and finally (iv) optionality risk, which is a risk stemming from embedded options hidden in client asset and liability banking book products. Such products include i) nonmaturity deposits without defined liquidity and interest rate cash flows; ii) assets subject to prepayment risk and, in the case of revolving loans, to roll-over options; iii) term deposits subject to roll-over options and early termination options; and iv) embedded characteristics such as an implicit zero-floor household demand deposits or flooring of corporate variable rate loans. To analyze interest rate risk, we investigate the structure of a composite of 3 major Czech and Slovak bank balance sheets. We analyse balance sheet to the detail of a product. To the best of our knowledge, we are the first to do so, especially in the product-level detail. We have opted for December 2016 and December 2017 as the months in which we will calculate interest rate risk, given that annual reports are also bases for our investigation.

Interest Rate Risk Management in the Banking Book (thereby denoted as "IRRBB") has become a pivotal point for regulators in recent years due to i) failures in its management during the 2007 – 2009 crisis and ii) the lack of preparedness for the extended low- and negative-interest environment that followed. The main regulations introduced are the following: i) the European Banking Authority's (EBA) update of the IRRBB guidelines from 2015 (EBA 2015); ii) the Basel Committee on Banking Supervision's (BCBS) update of

[2] The Basel Comittee on Banking Supervision thereby denoted as BCBS.

[3] The European Banking Authority thereby denoted as EBA.

IRRBB guidelines from 2016 (BCBS, 2016); and iii) the EBA's (2018) update of EBA (2015) guidelines that harmonized EBA requirements with BCBS (2016), which are binding for banks since 30 June 2019.

IRRBB belongs under Pillar II of the Basel II regulatory framework (within the Internal Capital Adequacy Assessment Process "ICAAP"), in contrast to the Interest Rate Risk in the Trading Book, which belongs under Pillar I. Under Pillar II, banks are supposed to measure, monitor, evaluate and manage interest rate risk within the defined regulatory exposure limits. Both guidelines set up principles of sound interest rate risk management by defining rules for banks' external and internal models, as well as for their supervision.

There are several recent studies dedicated to this topic in the European context. First, with the EBA stress test, EU banks should benefit from increasing market rates (EBA, 2017). Second, Cerrone et al. (2017) found that Italian banks are exposed positively, as well as negatively, to increasing interest rates, and they actively use different hedging strategies simultaneously to manage their interest rate risk. Third, Memmel, Seyman and Teichert (2016) and Chaudron (2016) did not find evidence that a low interest rate environment resulted in significant exposure to interest rate risk in the German and Dutch banking sectors.

The remaining manuscript is structured as follows. In Section 1, we provide the theoretical background. In Section 2, we investigate the composite structure of the TOP 3 Czech and Slovak bank balance sheets, mainly in relation to optionality risk, and we undertake an empirical analysis of the interest rate risk. The last section concludes the paper and states final remarks.

1. Theoretical Background

Both EBA (2018) and BCBS (2016) guidelines set principles of sound interest rate risk management and supervision of Banking Book assets and liabilities subject to risks arising from changes in client behavior, market environment and interest rates. Formally, BCBS (2016) defines IRRBB as: "*the current or prospective risk to the bank's capital and earnings arising from adverse movements in interest rates that affect the bank's banking book positions*".

Management of IRRBB in both guidelines comprises two major areas: i) a management of earnings risk and ii) a management of economic value (EV) risk[4]. In this paper, we primarily focus on the latter, which is a long-term view on the interest rate sensitivity of assets and liabilities recorded in the Banking

[4] Or management of economic value of equity risk, which compares the amount of economic value risk to banks' outstanding capital.

Book. This approach can unlock structural discrepancies in the Banking Book, especially those arising from maturity and reprising mismatch or embedded options dependent on interest rates, and provide bank risk managers with insight on how to manage such exposures in the future.

The management of economic value of risk consists of four major areas that correspond to 4 Sections in our article: i) the calculation of economic value of a bank's balance sheet for every relevant interest rate scenario (1.1.); ii) the definition of interest rate scenarios (1.2.); iii) the treatment of embedded options (1.3.); and iv) the impact of changes in a bank's balance sheet value under different scenarios on the bank's own funds (2).

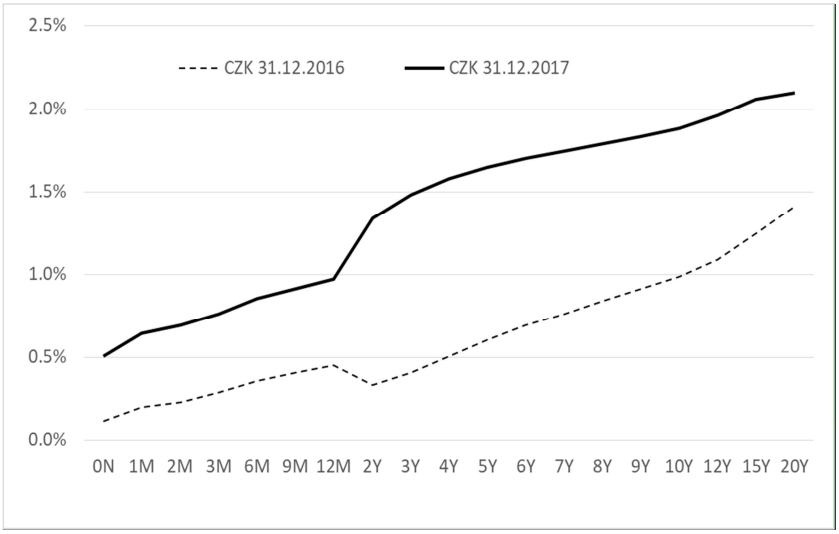
1.1. Economic and Market Value of Equity Risk

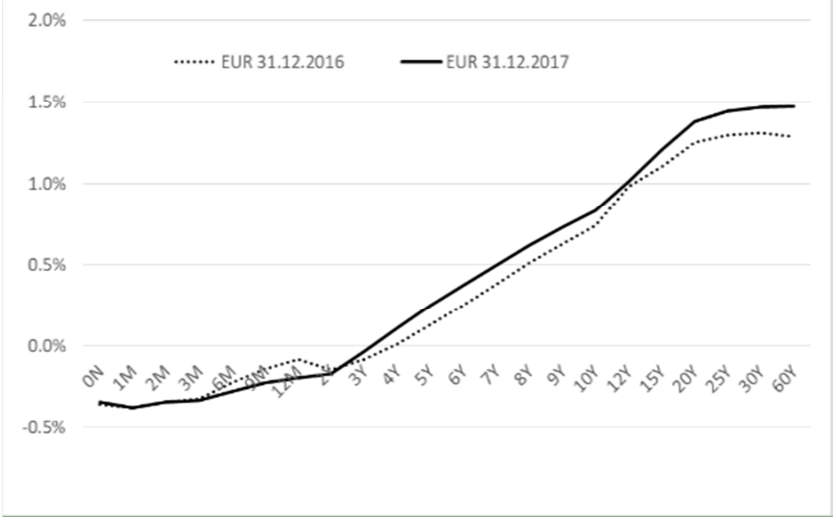
Banks calculate economic value of bank's balance sheet for specific dates using the end of the period yield curve values (base scenario) and volumes booked in the balance sheet at that time. In our analysis, we use the spot and par Czech-currency and EUR-currency yield curves as of 31 December 2016 and December 2017 consisting of money market rates on the short end and swap rates on the long-end, as shown in

We use those yield curves to calculate a zero-coupon rate curves, from which we subsequently receive discount factors and forward rates, as described by Choudhry et al. (2001) or Choudhry (2008) (Figure 1).

F i g u r e 1

Spot and Par CZK and EUR Yield Curve as of 31 December 2016 and 31 December 2017





Source: Author.

The management of interest rate risk assesses changes in value of an instrument, in our case, a bank's balance sheet, under different interest rate scenarios. To measure interest rate risk, we use the economic value of equity (EVOE) measure defined by both the EBA (2018) and BCBS (2016), as well as the market value of equity measure (MVOE).

$$\text{EVOE}_s = \sum_{i=1,t=1}^{N,T} CF_{ai,t} \times DF_{RF,t} + \sum_{i=1,t=1}^{N,T} -CF_{li,t} \times DF_{RF,t} \quad (1)$$

EVOE_s is the economic value of equity for a given interest rate scenario *s*. $CF_{ai,t}$ are future nominal and interest cash flows from a bank's assets *ai* where $i = 1, \ldots N$. $CF_{li,t}$ are future cash flows of nominal and interest cash flows from bank's liabilities *li* where $i = 1, \ldots N$ (liabilities receive a negative sign in the calculation, as those are owed by the bank to the client). Finally, $DF_{RF,t}$ is a risk-free discount factor calculated from a zero-coupon rate r_t, as requested by the EBA (2018):

$$DF_{RF,t} = \frac{1}{\left(1 + r_t\right)^t} \quad (2)$$

This discount factor simplifies for maturities under one year as $\frac{1}{1 + r_t * t}$.

MVOE includes spread *m* into the discount factor (EBA, 2018), which is added to the zero-coupon rate r_t. Spread is a proxy for other risks, such as credit risk, product costs, etc.

$$\mathrm{MVOE}_s = \sum_{i=1,t=1}^{N,T} CF_{ai,t} \times \frac{1}{\left(1 + r_t + m\right)^t} + \sum_{i=1,t=1}^{N,T} -CF_{li,t} \times \frac{1}{\left(1 + r_t + m\right)^t} \qquad (3)$$

Both guidelines consider EVOE to be a basic measure. BCBS (2016) allows for commercial margins (spreads) in discount factors, but only if those are also included in discounted cash flows. EBA (2018) provides that banks may use specific margins if also used in their internal models, as well. EVOE usage as basic measure comes from the fact that spread used in MVOE remains very bank-specific (it comprises charges for credit risk, product costs, etc.). This makes risk outcomes difficult to compare among banks. Despite these shortcomings, we will investigate the MVOE measure in this paper, as it is a measure of interest rate risk closer to reality given that client asset products are not risk-free.

1.2. Interest Rate Scenarios

Interest rate scenarios definition is similar in both the EBA (2018) and BCBS (2016) guidelines through a definition of shocks to the base scenario spot and par yield curve. EBA (2018) proposed two sets of shocks – two parallel regulatory shocks and 6 additional scenarios. The two parallel regulatory shocks to the current spot yield curve are a parallel shock of a base scenario by 2% up and a parallel shock of a base scenario by 2% down. Banks are supposed to floor negative shocks by linearly increasing the minimum interest rate floor, which starts at –1% for the shortest maturity and linearly increases by 0.05% each year for up to 20 years, to 0%. We derive discount factors and forward rates from shocked curves same as from base scenario. For each scenario, the economic value of the equity (EVOE) of assets and liabilities calculates as defined in equation (1). Changes in EVOE in the shock scenario against EVOE in the base scenario are compared relatively with capital to receive an EVOE risk. The adverse impact on the capital should not lead to a loss higher than 20% of a bank's capital tier 1 + tier 2. We proceed likewise in case of MVOE. Additional 6 scenarios aim to access other shocks than parallel impacts (steepening or flattening of the yield curve, for example). Risk coming out of the worst of the 6 scenarios should not exceed 15% of tier 1 capital. Our analysis focuses on the two parallel regulatory shocks as 6 scenarios are only a warning limit.

Apart from the predefined regulatory shocks, banks should also define internal scenarios and limits relevant for their market and business based on past behavior or extreme events. For example, in the Czech Republic, we can now derive such shock from the behavior of the Czech National Bank (CNB)'s setting of a 2-week repo rate. The CNB increased the repo rate several times

from the August 2017 value 0.05% to the February 2020 value of 2%, with each increase having a magnitude of 0.25%.[5] Due to this, we will apply the +25 bps sector specific shock in our analysis of the Czech Republic (and we apply this shock for Slovakia as well, as in our opinion, the European Central Bank would start increase rates by 0.25% in the future).

1.3. Managing Optionality Risk

Optionality risk results in cash flows of nominal and interest deviating from the original contract. The reason is that the client exercises his/her option. The management of optionality risk aims to estimate those cash flows. On the asset side, the guidelines mainly require banks to properly monitor and model the interest rate risk arising from the embedded option of early loan termination. On the liability side, the focus is on non-maturity deposits and the early termination of term deposits.

The early termination (prepayment) of a loan has a potentially significant impact on interest rate risk. The weighted average life is shorter than planned in the contract and consequently, interest rate risk is affected. For example, the early termination of a fixed bullet loan for 5 years at the age of 3 years implies exposure to the interest rate risk 2 years earlier than defined by the contract. This can have a substantial adverse impact on the bank's profitability in a decreasing interest rate environment.

Since prepayment modeling can have a significant impact on a bank's interest rate risk, both guidelines require proper modeling of this option, and BCBS (2016) sets minimal rules on the dynamics of baseline prepayment ratios that banks determine from historical data. We will use the same shock parameters in our analysis – prepayments are increasing by 20% in +2% shock and decreasing by 20% in –2% shock, 0.25% shock adjustment is by +/– 2.5% only.

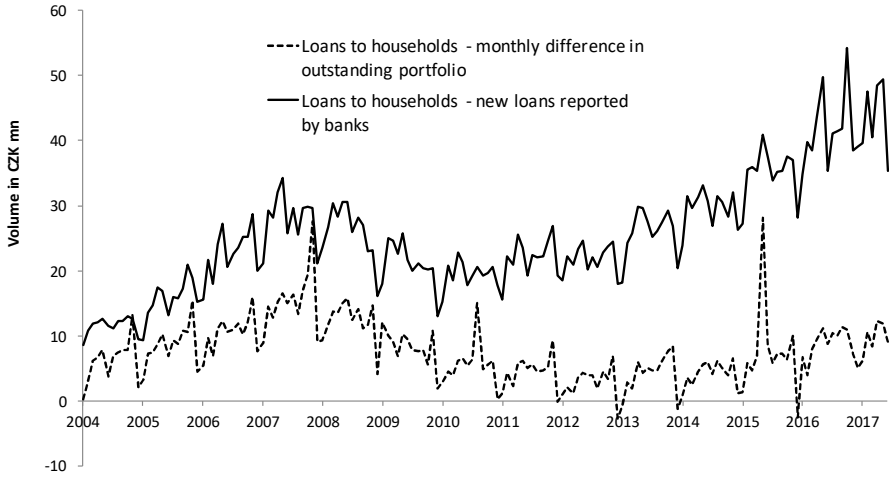
The analysis of the Czech and Slovak banking sectors' outstanding loans provides evidence that prepayment risk is substantial. Figure shows monthly differences in outstanding business and new business of household loans in the Czech Republic. Evidently, new business seems to be much bigger than the change in outstanding business. We can derive prepayment for household loans from these data assuming that 0.5% (based on simple annuity) of total portfolio matures monthly. From such an approximation, we find that prepayment ratio is 1 – 1.5% monthly, which is in line with the data from one Czech bank we have access to. Consumer loans have even higher prepayment rates. We observe that, in the case of Česká spořitelna, CZK 33.5 billion of new volumes of consumer

[5] Except the first hike in August 2017.

unsecured lending were generated during 2016, while the outstanding portfolio reached CZK 64.5 billion. This is an annual increase of only CZK 0.8 billion (Česká spořitelna, 2017). The average maturity of consumer loans in the Czech Republic oscillates approximately 7 years. It means that 20% should mature on a yearly basis. As portfolio practically did not increase within a year, if we subtract estimate for natural amortization from new business equal to CZK 33.5 billion, we get an estimate of prepayments of about 20 billion, i.e. 30% on a yearly basis. This is in line with same comparison of new and outstanding volumes for consumer loans in the whole sector same approach as we used for housing loans above as well as with the data from one Czech bank. The dynamics of prepayments in 2017 are similar. For Slovakia, the situation is alike. Slovakian banks reported EUR 8.1 billion of new loans (mortgage loans and consumer loans), while outstanding volumes increased only by EUR 3.4bn in 2017 (NBS, 2018). We approximate prepayment from the new business from NBS (2018) data same as we did for the Czech Republic. We find that 10% – 12% of mortgages and 20% – 30% of consumer loans prepaid in Slovakia in 2017. This corresponds to the data from one Slovak bank we have access to.

F i g u r e 2

New versus Outstanding Loans to Households 2004 – 2017



Source: Author based on data provided by CNB (2019) in ARAD time series database.

Second, we will discuss IRRBB of nonmaturity deposits (denoted as "NMDs"). The loan-to-deposit ratio in the Czech banking sector amounts to 73%, and NMDs amounted to 77% of total deposits as of 31 December 2016.[6]

[6] Based on the CNB's ARAD time series database. Year 2017 Figures are very similar.

This indicates a huge structural overhang of client deposits over client assets. Given that, assets and liabilities must be equal; this means that banks have to place this liquidity from deposits somewhere else. Practically, there are two options – placing excess liquidity to the CNB or long-term investments into bonds. From this perspective, in volume terms, NMDs must be a major source of interest rate risk for Czech banks. For Slovakia, the loan to deposit ratio is higher, approximately 105% (NBS, 2018). NMDs are bank liability products with two main purposes – transactions and savings. As their name suggests, there is no contractual cash flow calendar for interest and nominal cash flows. Legally, the contractual maturity and repricing period is 1-day. Their realized maturity and repricing period is much longer, however, implying a need to estimate it by the model. BCBS (2016), in its standardized framework, requires the separation of NMDs into the three bundles.

First, deposits are separated into retail and wholesale.[7] Second, retail deposits are separated into transactional deposits (used for transactions) and savings deposits (used for savings, no transactions allowed). Third, stable and non-stable deposits are defined. Stable deposits are likely to remain in a bank under any condition. Non-stable deposits receive 1-day liquidity profile. Fourth, regulation separates stable deposits into core and noncore. Core deposits are unlikely to be repriced, even under significant changes in market interest rates. This is the case of current accounts in the Czech Republic and Slovakia, as banks usually pay 0.01% on this type of deposit regardless of underlying market rates. The bigger the bank, the bigger the core proportion, as many transactions take place between clients of the same bank. In our view, stable transactional deposits in the Czech and Slovak banking sectors should be allocated to core deposits. This translates into a large share of stable funding with a high interest rate risk (Džmuráňová and Teplý, 2015; Hejdová, Džmuráňová and Teplý, 2017 and Džmuráňová and Teplý, 2016b). On the other hand, for savings deposits, clients expect a higher rate of return. As we showed in Džmuráňová and Teplý (2016a), a savings deposit pricing in the Czech Republic partially depends on the market interest rates, and clients are interest rate sensitive. In our analysis, we assume that the deposit rate on savings accounts maintains a stable spread to market rates: deposit rate is as a sum of stable spread plus difference in yield curve against the base scenario. Bank reaction to changes in market rates is asymmetric in case of deposit rates. We assume a lag of 12 months in case of rising rates as a bank is reluctant to increase its interest expense. For decreasing rates, we assume immediate impact. The same assumptions we apply also for non-household current accounts.

[7] Deposits from entrepreneurs are treated as retail.

BCBS (2016) also defines limits on the amount of NMDs allocated to those four groups. Table 1 displays that the maximum allowed average NMDs' maturity under BCBS (2016) is 4.5 years, which is slightly shorter than what European banks report recently (EBA, 2017).

T a b l e 1

BCBS (2016) Limits on Core of NMDs under the Standardized Framework

	Maximum allowed proportion of core	Maximum allowed maturity of core (in years)	Maximum allowed average maturity of NMDs (in years)
Retail transactional	90%	10	4.5
Retail savings	70%	9	3.15
Wholesale	50%	8	2

Source: Author based on BCBS (2016).

Notably, a low-rate environment is especially risky for banks in terms of NMDs, as many non-transactional volumes may end up on transactional deposits because other reinvestment opportunities are scarce. Banks must carefully analyze the maturity and repricing characteristics of the core in a low-rate environment. EBA (2017) points out that banks heavily depend on models calibrated in low-rate environments, as longer data history is often not available. This implies large model risk, and Danielsson et al., (2016) conclude that the model risk itself requires a statistical model.

Last but not least, we will briefly outline the interest rate risk management of term deposits, overdrafts, credit cards and asset roll-overs. First, for term deposits, we define two main embedded options – early termination and roll-over options. At rollover, a client receives the new price of a product. Hence-forth, it is an interest rate risk-neutral embedded option. The same principle applies to the asset rollover. For early termination of term deposits, banks use similar risk management techniques as for term loans subject to prepayment risk due to it being similar embedded option. In the Czech Republic (after excluding building savings), we observe that only 10% of household and corporate deposits were formed by term deposits as of 1 July 2017. In Slovakia, volumes on term deposits are larger.

However, because most term deposits have a maturity under 12 months (NBS, 2018), we will not model the early termination option as it cannot affect the interest rate risk significantly.

To household overdrafts and credit cards, we will give similar liquidity and interest rate characteristics as we did to the core of retail transactional accounts. We opted for this because credit cards or overdrafts are, in fact, a mirror of transactional accounts on the banks' asset side.

2. Interest Rate Risk of the Czech and Slovak Banking Sectors

We analyze three major Czech banks in detail – Česká spořitelna, Česko slovenská obchodní banka (CSOB) and Komerční banka – whose total market shares form approximately 70% of total sector assets as of the end of 2016. Due to the strong tendency of bank product commoditization in the Czech Republic (Džmuráňová and Teplý, 2016b), all three banks offer very similar products – mortgage loans, consumer loans, credit cards, overdrafts, current accounts, savings accounts and term deposits. All of these products are subject to optionality risk.

For Slovakia, we closely analyze Slovenská spořitelna (2017; 2018), Všeobecná úvěrová banka (VUB, 2017; 2018) and Tatra banka (2017; 2018). The Slovakian banking sector shows similar commoditization of bank products on the asset side as the Czech banking sector, but the liability side differs. Slovakian banks report more term deposits and fewer savings accounts than the Czech banks. Additionally, Slovakian banks gather funds through mortgage bonds, which is not common practice in the Czech Republic due to significant over liquidity in the sector.

T a b l e 2

Interest Rate Risk Relevant Balance Sheet Items of the Czech and Slovak Analyzed Banks as of 31. 12. 2016 (Balance Sheet is not balanced, as other items, such as intangible assets, are not the subject of analysis)

CZ in CZK bn, SK in EUR bn	Česká spořitelna	CSOB	Komerční banka	Slovenská spořitelna	VUB	Tatra
Assets in analysis	**906**	**937**	**760**	**14.7**	**12.8**	**11.0**
Unsecured loans retail	65	24	23	1.6	1.6	2.0
Secured loans retail	210	257	208	6.1	4.3	2.9
Corporate + Micro loans	236	231	309	2.9	4.1	3.6
Investments + CB placements*	396	425	221	4.1	2.8	2.5
Liabilities in analysis	**767**	**734**	**759**	**13.9**	**12.7**	**10.7**
Current accounts	423	442	496	5.8	5.9	7.7
Savings accounts	138	214	161	2.4	0.2	0.2
Term deposits	5	8	30	2.8	3.3	1.1
Mortgage bonds	0	0	0	1.6	1.7	0.7
Tier + Tier 2	102	70	72	1.3	1.5	1.0

Source: Author based on annual bank reports. Big difference in assets and liabilities in case of CSOB stems from the fact that CSOB has large volumes in the emitted deposit bills to financial institutions that are not included in analysis. On the asset side, those are than booked in deposits to CB. These liabilities are booked under cash and cash-equivalent, hence their repricing risk is very low, basically none. Their exclusion has no impact on our analysis. *High asset volumes in case of Česká spořitelna and CSOB are primarily driven by CB placements.

Apart from client assets and liabilities, Czech and Slovak banks pose a large portion of assets into investments and Central bank placements (i.e., banks' receivables on the Central bank). Due to this, these assets have a significant inherent influence on IRRBB. We face the problem that neither bank reports the

average maturity of their investment portfolio. From the available data, we identified that government bonds form the major part of banks' investments. Table 2 and Table 3 summarize all balance sheet data.

T a b l e 3

Interest Rate Risk Relevant Balance Sheet Items of the Czech and Slovak Analyzed Banks as of 31. 12. 2017 (Balance Sheet is not balanced, as other items, such as intangible assets, are not the subject of analysis)

CZ in CZK bn, SK in EUR bn	**Česká spořitelna**	**CSOB**	**Komerční banka**	**Slovenská spořitelna**	**VUB**	**Tatra**
Assets in analysis	**992**	**1173**	**897**	**16.2**	**13.5**	**11.4**
Unsecured loans retail	66	28	38	1.7	1.6	1.4
Secured loans retail	233	282	219	7.0	5.2	3.5
Corporate + Micro loans	222	237	301	3.4	4.2	3.9
Investments + CB placements*	471	626	341	4.1	2.5	2.6
Liabilities in analysis	**825**	**802**	**828**	**14.8**	**13.7**	**11.8**
Current accounts	562	507	557	6.6	6.4	8.8
Savings accounts	155	215	164	2.8	0.2	0.2
Term deposits	5	12	28	2.6	3.2	1.0
Mortgage bonds	0	0	0	1.5	2.3	0.8
Tier + Tier 2	104	69	79	1.3	1.6	1.0

Source: Author based on annual bank reports. Big difference in assets and liabilities in case of CSOB stems from the fact that CSOB has large volumes in the emitted deposit bills to financial institutions that are not included in analysis. On the asset side, those are than booked in deposits to CB. These liabilities are booked under cash and cash-equivalent, hence their repricing risk is very low, basically none. Their exclusion has no impact on our analysis. *High asset volumes in case of Česká spořitelna and CSOB are primarily driven by CB placements.

Table 4 defines the contractual and optionality characteristics of client assets and liabilities in our analysis. This serves as an input from which to derive nominal and interest cash flows for the calculation of EVOE and MVOE as defined in equations 1, 2 and 3. We apply same characteristics for all banks due to commoditization tendency in both banking sectors. We discuss specific reasoning how cash flows are derived for products with contractually undefined maturity and pricing behaviour or prepayment option in Section 1.3. Client prices for products that reprice before maturity (variable loans, corporate loans, savings accounts) are equal to a sum of an underlying interest rate defined by the interest rate scenario and margin. We work with the legal floor of 0% client rate on NMDs and 0% floor on underlying reference rate in case of variable rate-linked products. BCBS (2016) defines buckets into which all balance sheet positions are slotted. Entrop et al. (2009) show that cash flow slotting can significantly bias results compared to using more relaxed assumptions that would be closer to the actual product behavior. Additionally, EBA (2018) does not require such cash flow slotting. Due to this, we do not apply cash flow slotting, as we consider it an unnecessary simplification. All cash flows in our analysis happen on a monthly basis.

T a b l e 4

Behavioral and Contractual Characteristics of Client assets and Liabilities

Product	Assumption	Slovakia	Czechia
Household consumer loans	Maturity	7 years	7 years
	Length of fixation period	7 years	7 years
	Type of redemption	annuity	annuity
	Interest rate	10.7%/9.8%	12.2%/10.8%
	Prepayment ratio (monthly)	3%	3%
	Spread	10.8%/10.7%	11.7%/11.4%
Household mortgage loans	Maturity	20 years	20 years
	Length of fixation period	5 years	1 month – 7.5 years*
	Type of redemption	annuity	annuity
	Interest rate	2.5%/2.3%	2.88%/2.6%
	Prepayment ratio (monthly)	1%	1%
	Spread	2.42%/1.97%	1.8-2.4%/2-2.2%
Household overdrafts	Maturity	10 years	10 years
	Length of fixation period	10 years	10 years
	Type of redemption	linear	linear
	Interest rate	15.5%/15.5%	13.6%/12.5%
	Spread	13%/13.1%	14.16%/14%
Household credit cards	Maturity	10 years	10 years
	Length of fixation period	10 years	10 years
	Type of redemption	Linear	Linear
	Interest rate	15.5%/15.5%	21%/19.4%
	Spread	13%/13.1%	20.8%/20.8%
Corporate + micro loans	Maturity	5 years	5 years
	Length of fixation period	1 month	1 month
	Type of redemption	Annuity	Annuity
	Interest rate	2.6%/2.4%	2.54%/2.74%
	Prepayment ratio (monthly)	1%	2%
	Spread	3.2%/3.1%	1.8%/1.75%
Households current accounts	Maturity core/non-core	10 years/1 day	10 years/1 day
	Length of fixation period	fixed to maturity	fixed to maturity
	Type of redemption	linear	linear
	Interest rate	0.01%	0.01%
	Volume core	90%	90%
Households savings accounts	Maturity core/non-core	9 years/1 day	9 years/ 1 day
	Length of fixation period	12 months	12 months
	Type of redemption	Linear	Linear
	Interest rate	0.2%/0.1%	0.2%
	Volume core	70%	70%
Households term deposits	Maturity	1 year	1 year
	Length of fixation period	1 year	1 year
	Type of redemption	Bullet	Bullet
	Interest rate	0.58%	1%/0.6%
	Volume sensitivity	0%	0%
Corporate current accounts	Maturity core/non-core	8 years/1 day	8 years/ 1 day
	Length of fixation period	12 months	12 months
	Type of redemption	linear	linear
	Interest rate	0.01%	0.01%
	Volume core	50%	50%
Investments and Central bank placements*****	Maturity	10 years	10 years
	Length of fixation period	10 year	10 year
	Type of redemption	linear	linear
	Interest rate	3.34%/3%	2.9%/2.6%
Mortgage bonds	Maturity	7 years	
	Length of fixation period	7 year	
	Type of redemption	linear	
	Interest rate	2.16%/1.7%	

Notes: * 60% 5-year fixation, 20% 1-month fixation and 20% 7.5-year fixation, based on the Czech National Bank data. ** Banks should manage investments based on the liquidity and the interest rate characteristics of liability that used as a source of money for investments. These are stable cores of NMDs. Due to this; we model investments in our analysis as 10-year bullet deals in the linear replicating portfolio. Concerning yields, we use government bonds' residual maturity basket yields to derive average portfolio yield. *** For the Central bank placement, we assume that it is a bullet of 14 days and receives repo rate. This implies negligible (for simplicity 0 in our analysis) interest rate risk.

Source: Author. Two numbers x/y are for year-end 2016 respectively 2017.

To derive the characteristics summarized in Table 4, we used the following key sources: i) the Central Bank's data, Internet and Regulation sources are from freely available information (client rates, prepayments approximations); ii) knowledge and expert opinion provided by two banks in the Czech Republic and Slovakia; iii) webpages of analyzed banks (source of information for maturities and client rates); iv) regulatory guidelines of BCBS (2016) and EBA (2018) – the baseline setup for separation of NMDs into cash flow buckets and the response of prepayment ratios to different interest rate scenarios and v) a paper by Džmuráňová and Teplý (2016b), in which the authors derived the liquidity profile of term deposits and NMDs in the Czech Republic, and where we also discussed the prepayment option of a client and its impact on a banks' profit.

Table 5 shows the results for the interest rate risk in terms of adverse capital impact. We show impact with and without investments and mortgage bonds to be able to fully separate interest rate risk inherent to the business model of client asset and liabilities.

Table 6 shows value changes of client assets versus value changes of client liabilities as of 31 December 2017 (this is a proxy for maturity mismatch or repricing gap).

Table 7 shows how individual client products contribute to a bank's client asset and liabilities interest rate risk in terms of economic value across all shock scenarios. The result shows product drivers of interest rate risk.

T a b l e 5

Interest Rate Risk – Capital Impact with/without Investment Portfolio and Mortgage Bonds (in %)

	31 December 2016			**31 December 2017**		
	Impact on capital EVOE	*Impact on capital MVOE*	*Shock with the highest negative capital impact*	*Impact on capital EVOE*	*Impact on capital MVOE*	*Shock with the highest negative capital impact*
Česká spořitelna	–6/–20	–5/–19	–2	–16/–32	–15/–31	–2
CSOB	–11/–27	–10/–26	–2	–25/–43	–24/–41	–2
Komerční banka	–15/–24	–13/–23	–2	–28/36	–26/–35	–2
TOP 3 Czech Republic	–10/–23	–9/–22	–2	–22/–36	–21/–36	–2
Slovenská spořitelna	–8/–16	–7/–15	–2	–12/–21	–11/–20	–2
VUB	–2/–3	–1/–3	–2	–7/–5	–7/–4	–2
Tatra banka	–7/–12	–7/–12	–2	–15/–19	–15/–19	–2
TOP 3 Slovakia	–5/–10	–5/–9	–2	–11/–14	–10/–13	–2

Source: Author's own calculations. The first number is with investments; the second one is without investments. We show thereby only negative impact into capital which is for all banks present for –2% yield curve shock scenario. For positive scenarios, all banks report positive impact on capital.

T a b l e 6

Economic Value (effective duration) **Mismatch between Client Assets and Client Liabilities as of 31. 12. 2017 and Gain/Loss to Capital**

Changes to base scenario economic value, TOP 3 Slovakia, in EUR mn			
Scenario	2%	–2%	0.25%
Client assets	–585	562	–80
Client liabilities	1 799	–1 104	237
Relative mismatch A/L*	–32%	–51%	–34%
Total value change	1 215	–542	157
Changes to base scenario economic value, TOP 3 Czech Republic, in CZK bn			
Scenario	2%	–2%	0.25%
Client assets	–21	46	–3
Client liabilities	121	–138	16
Relative mismatch A/L*	–17%	–34%	–17%
Total value change	100	–91.5	13.3

Source: Author's own calculations. The lower the percent, the higher the mismatch.

T a b l e 7

Interest Rate Risk – Bank Products (in %)

	Slovakia		**Czechia**	
Client assets	*2016*	*2017*	*2016*	*2017*
Unsecured loans retail	31	27	11	12
Secured loans retail	51	55	63	68
Corporate + Micro loans	18	18	26	20
Client liabilities				
Current accounts	86	87	75	76
Savings accounts	10	11	25	24
Term deposits	4	3	0	0

Source: Author's own calculations. The table shows relative importance of the product on an economic value change of client assets or client liabilities across all analyzed scenarios. It shows which products have the biggest impact.

First, banks are exposed to the interest rate risk of liabilities, which stems from the fact that assets reprice faster than liabilities, as well as banks having fewer client assets than client liabilities (Table 6). Slovakian banks' exposure is to a lesser extent, mainly stemming from a lower amount of savings accounts and higher amount of term deposits that reprice more quickly than savings accounts. Due to this exposure to liabilities, for all banks, the adverse and relevant regulatory impact on capital comes from decreasing interest rates, as shown in Table 5. The positive impact on capital in the case of increasing rates (+2% scenario) is substantial, and is on average +25% of capital for Slovakia and the Czech Republic. In terms of client assets and liabilities only, it amounted, for example, to CZK 100 billion for TOP3 Czech banks as of 31. 12. 2017 (Table 6). This stems by the fact that we assume there will not be higher outflows from retail current accounts in case of positive shocks. This assumption results from the usage of regulatory caps as described in Table 1, which are already restrictive enough. However, on both markets, there is evident

tendency of decrease of term deposits and increase of demand deposits (based on central banks data). If we would add additional higher outflow to household current accounts from 10% to 25% in the Czech Republic and 15% in Slovakia in case of 2% shock, we would see that benefit of banks from higher interest rates would decrease by 20% in both countries. Our results are in line with the findings of EBA (2017), as the Czech and Slovakian banks will benefit from increasing market rates, as will around one third of other European banks.

Second, two analyzed Czech banks (CSOB, 2017; 2018 and Komerční banka, 2017; 2018) are not within both regulatory limits set by the EBA (2018) and BCBS (2016) on EVOE, as the maximum detrimental impact into capital goes above –20% in 2017. We also see that the risk almost doubled between 2016 and 2017. The reason for this yearly increase is an application of a floor on a yield curve and its shocked scenarios, as defined by EBA (2018), as well as of a legal floor of 0% on interest rates to ensure that commercial margins would not decrease (banks are not expected to decrease client rates below a value of credit risk, for example). The further yield curve goes away from the floor; the possible loss stemming from decreasing interest rates gets bigger. The floor application is also the reason why Slovakian banks are well within the limit given that EUR interest rates are significantly lower than CZK interest rates.

Third, prepayment options affects the interest rate risk exposure largely. The presence of prepayments largely decreases the time to re-pricing of fixed assets. For consumer loans, we found an average duration of approximately 1 year, which is significantly lower than the average maturity of a portfolio of 3.5 years. We compared our prepayment ratios with the EBA (2017), and ours are slightly higher. This we attribute to the fact that the Czech and Slovak economic sectors have larger proportions of long-term fixed mortgage loans than other European countries. The EBA (2017) points out that impact of EVOEs is significantly dependent on the presence of prepayment options, which our analysis confirms. Moreover, the interest rate risk impact of prepayments indicates that assets reprice faster in the case of decreasing market rates as prepayments increase, which also explains why the relative mismatch between economic value changes has a bigger magnitude in negative shocks. This result confirms the findings by Teplý and Bečvaříková (2016), who showed a significant impact of prepayments on banks' interest margins. To provide the complete picture, we approximated the impact on capital without a prepayment option, as well. The negative impact on capital would decrease by 25% on average, but banks would also gain less benefit from increasing interest rates.

Fourth, banks extensively use investments to close value change mismatches generated by the repricing gap between client assets and liabilities. Excluding

the impact of investment portfolios (and Mortgage bonds), the adverse impact on the capital shown would be at least double (Table 5).

Fifth, in terms of the interest rate risk of individual product types, we will comment briefly on mortgage loans and current accounts. Based on balance sheet importance (Table 2 and Table 3) and the product characteristics summarized in Table 4, we would expect that the major interest rate risk of client assets stems from mortgage loans, while the major interest rate risk of client liabilities will be driven by current accounts. Table 7 supports this conclusion. The results also show that the Czech banking sector is more exposed to interest rate risk from savings accounts than the Slovak banking sector, which is relevant as it poses higher uncertainty about the interest rate risk of Czech banks' liabilities, as savings accounts are modeled products and each model is subject to model risk.

Finally, we need to highlight that our analysis of the interest rate risk of banks' balance sheets did not take into the account hedging due to the un-availability of data. We also neglect possible gains from currency compensation as defined in EBA (2018). Banks are allowed to decrease negative impact from the major currency with 50% weight of positive impact (if any) across same shocks from other currencies. As TOP3 analysed Czech and Slovak banks are largely retail-business-based, we consider analysis in terms of major currency only as sufficient. EBA (2017), as well as Cerrone et al. (2017), mention that banks use hedging to manage their interest rate risk exposures. CSOB and Komerční banka would need to have around CZK 40 billion (CSOB) to CZK 70 billion (Komerční banka) of fix receiver interest rate swaps with an average duration of 5 years to ensure an EVOE ratio below –20% as of 31. 12. 2017. These amounts are far below reported volume of derivatives in annual reports. This indicates that neither CSOB nor Komerční banka would in fact be above 20% in their regulatory reporting to the Czech National Bank. From this perspective, our results focus mainly on the client view and products perspective. Our analysis shows that Slovak and Czech banks' exposure to the interest rate risk of client assets and liabilities is substantial and cannot be covered solely by investments into risk-free, long-term government bonds. We claim that the baseline interest rate exposure stems from client asset and liabilities, and the rest (i.e., investments and hedging) are dependent on it. Due to this, our analysis provides a unique view on IRRBB, since we separate client assets' and liabilities' risks. Such an analysis has not been presented in any study on either the domestic level nor on the international level.[8]

[8] Apart from studies dedicated solely to value of NMDs such as Bloechlinger (2010), Kalkbrener and Willing (2004) or Strnad (2009).

Conclusion

This paper discusses the recent updates of the IRRBB by regulators EBA (2018) and BCBS (2016). In accordance with both regulatory guidelines, we calculated the interest rate risk of client assets and liabilities of the Czech and Slovak banking sectors, approximated by financial statements of the TOP 3 large banks. Unlike other researchers, who provided high-level analyses, we provide the granular modeling of bank balance sheets and behavioural options embedded in client products (prepayments, non-maturity deposits). We found that both banking sectors are largely exposed to the interest rate risk of client liabilities because of high shares of non-maturity deposits and the fact that those liabilities have higher sensitivity to changes in interest rates than client assets. Client assets reprice more quickly than client liabilities also due to the prepayment option of a client which exposes the bank to the early termination of positions. Consequently, the Czech and Slovak banking sectors would be able to benefit from increasing market rates.

Both the Czech and Slovak banking sectors report similar exposure to interest rate risk, which might be a potential source of contagion for large foreign owners with assets in both countries, as both sectors would respond similarly to alike interest rate developments.

This paper separates Interest Rate Risk of the Banking Book into different types of client products using aggregated balance sheet data and product behavioral characteristics. We observe the interest rate risk of only the client part of the balance sheet, which gives us a unique view of IRRBB because other studies are usually high level oriented. In this respect, our research is unique and provides new insights at the product level, as well as baseline information about the drivers of interest rate risk in the Czech and Slovak banking sectors.

References

ALESSANDRI, P. – NELSON, B. D. (2015): Simple Banking: Profitability and the Yield Curve. Journal of Money, Credit and Banking, *47*, No. 1, pp. 143 – 175.

ALTAVILLA, C. – BOUCINHA, M. – PEYDRO, J. L. (2017): Monetary Policy and Bank Profitability in a Low Interest Rate Environment. [Working Paper, No. 2105.] Frankfurt: European Central Bank.

BCBS (2016): Interest Rate Risk in the Banking Book. Basel Committee on Banking Supervisions. Available at: <https://www.bis.org/bcbs/publ/d368.pdf>.

BIKKER, J. A. – VERVLIET, T. (2017): Bank Profitability and Risk-Taking Under Low Interest Rates. [Working Paper, No. 560.] Amsterdam: De Nederlandsche Bank.

BLOECHLINGER, A. (2010): Interest-Rate Risk of Non-Maturity Bank Accounts: From the Marketing to the Hedging Strategy. [Working Paper.] Zürich: Zurcher Kantonalbank.

BOHN, A. – ELKENBRACH-HUIZIG, M. (2014): The Handbook of ALM in Banking. Interest Rates, Liquidity and the Balance Sheet. London: Nick Carver. ISBN 978-1-782720-11-9.

BORIO, C. – GAMBACORTA, L. – HOFMANN, B. (2017): The Influence of Monetary Policy on Bank Profitability. International Finance, No. 20, pp. 48 – 63.

CERRONE, R. – COCOZZA, R. – CURCIO, D. – GIANRANCESCO, I. (2017): Does Prudential Regulation Contribute to Effective Measurement and Management of Interest Rate Risk? Evidence from Italian Banks. Journal of Financial Stability, No. 30, pp. 126 – 138.

ČESKÁ SPOŘITELNA (2017): Annual Report 2016. Available at: <https://www.csas.cz/static_internet/cs/Obecne_informace/FSCS/CS/Prilohy/vz_2016.pdf>.

ČESKÁ SPOŘITELNA (2018): Annual Report 2017. Available at: <https://www.csas.cz/static_internet/cs/Obecne_informace/FSCS/FSCS/Prilohy/vz-2017.pdf>.

ČESKOSLOVENSKÁ OBCHODNÍ BANKA (CSOB) (2017): Annual Report 2016. Available at: <https://www.csob.cz/portal/documents/10710/444804/vz-csob-2016.pdf>.

ČESKOSLOVENSKÁ OBCHODNÍ BANKA (CSOB) (2018): Annual Report 2017. Available at: <https://www.csob.cz/portal/documents/10710/444804/vz-csob-2017.pdf>.

CHAUDRON, R. (2016): Bank Profitability and Risk Taking in a Prolonged Environment of Low Interest Rates: A Study of Interest Rate Risk in the Banking Book of Dutch Banks. [Working Paper, No. 526.] Copenhagen: Danish National Bank.

CHOUDHRY, M. (2008): The Yield Curve, and Spot and Forward Interest Rates. Available at: <http://www.yieldcurve.com/mktresearch/files/choudhry_introtoyieldcurve_jan2008.pdf>.

CHOUDHRY, M. – JOANNAS, D. – PEREIRA, R. – PIENAAR, R. (2001): Capital Markets Instruments: Analysis and Valuation. New Jersey: FT Prentice Hall. ISBN 978-0-230-57603-2.

CLAESSENSC, S. – COLEMAN, N. – DONNELLY, M. (2017): Low-For-Long' Interest Rates and Banks' Interest Margins and Profitability: Cross-Country Evidence. [International Finance Discussion Papers 1197.] Washington, DC: Board of Governors of the Federal Reserve System.

ČESKÁ NÁRODNÍ BANKA (CNB) (2019): Arad Time Series Database. Available at: <http://www.cnb.cz/docs/ARADY/HTML/index.htm>.

DANIELSSON, J. – KAMES, K. R. – VALENZUELA, M. – ZER, I. (2016): Model Risk of Risk Models. Journal of Financial Stability, No. 23, pp. 79 – 91.

DŽMURÁŇOVÁ, H. – TEPLÝ, P. (2015): Duration of Demand Deposits in Theory. In: PROCHAZKA, D. (ed.): Procedia Economics and Finance. [Proceedings]. Procedia Economics and Finance, No. 25, pp. 278 – 284.

DŽMURÁŇOVÁ, H. – TEPLÝ, P. (2016a): Why are Savings Accounts Perceived as Risky Banks Products? Prague Economic Papers, *25*, No. 5, pp. 617 – 633.

DŽMURÁŇOVÁ, H. – TEPLÝ, P. (2016b): Risk Management of Demand Deposits in a Low Interest Rate Environment. [Working Paper, No. 10/2016.] Prague: Institute of Economics Studies, Faculty of Social Sciences, Charles University in Prague.

ENTROP, O. – MEMMEL, C. – WILKENS, M. – ZEISLER, A. (2009): Quantifying the Interest Rate Risk of Banks: Assumptions do Matter. European Financial Management, *15*, No. 5, pp. 1001 – 1018.

EUROPEAN BANKING AUTHORITY (EBA) (2015): Guidelines on the Management of Interest Rate Risk Arising from Non-trading Activities. Available at: <https://eba.europa.eu/documents/10180/1084098/EBA-GL-2015-08+GL+on+the+management+of+interest+rate+risk+.pdf>.

EUROPEAN BANKING AUTHORITY (EBA) (2017): Sensitivity Analysis of IRRBB – Stress test 2017. Available at: <https://www.bankingsupervision.europa.eu/press/pr/date/2017/html/ssm.pr171009.en/ssm.pr171009_slides.en.pdf>.

EUROPEAN BANKING AUTHORITY (EBA) (2018): Guidelines on the Management of Interest Rate Risk Arising from Non-trading Activities. Available at: <https://eba.europa.eu/documents/10180/2282655/Guidelines+on+the+management+of+interest+rate+risk+arising+from+non-trading+activities+%28EBA-GL-2018-02%29.pdf>.

HEJDOVÁ, M. – DŽMURÁŇOVÁ, H. – TEPLÝ, P. (2017): Interest Rate Sensitivity of Non-Maturing Bank Products. In: PROCHÁZKA, D. (ed.): New Trends in Finance and Accounting. [Proceedings.] Springer Proceedings in Business and Economics.

KALKBRENER, M. – WILLING, W. (2004): Risk Management of Non-maturing Liabilities. Journal of Banking and Finance, *28*, No. 7, pp. 1547 – 1568.

KOMERČNÍ BANKA (2017): Annual Report 2016. Available at: <https://www.kb.cz/getmedia/47a07451-d748-4c67-b745-320d10d2b38b/kb-2016-vyrocni-zprava.pdf.aspx>.

KOMERČNÍ BANKA (2018): Annual Report 2017. Available at: <https://www.kb.cz/getmedia/425bf81f-1f24-4a0f-a228-45ecd54befb2/KB_VZ_2017_CZ.pdf.aspx>.

MEJSTŘÍK, M. – PEČENÁ, M. – TEPLÝ, P. (2015): Banking in Theory and Practice. Prague: Karolinum Press. ISBN 9788024628707.

MEMMEL, C. – SEYMAN, A. – TEICHERT, M. (2016): Banks' Interest Rate Risk and Search for Yield: A Theoretical Rationale and Some Empirical Evidence. [Working Paper, No. 22/2016.] Frankfurt: Deutsche Bundesbank.

SLOVENSKÁ SPOŘITELNA (2017): Annual Report 2016. Available at: <https://www.slsp.sk/sk/informacie-o-banke/investori/financne-ukazovatele>.

SLOVENSKÁ SPOŘITELNA (2018): Annual Report 2017. Available at: <https://www.slsp.sk/sk/informacie-o-banke/investori/financne-ukazovatele>.

SLOVENSKÁ NÁRODNÍ BANKA (NBS) (2018): Statistics. Available at: <https://www.nbs.sk/sk/statisticke-udaje/financne-institucie/banky>.

STRNAD, P. (2009): Fair Value and Interest Rate Risk of Demand Deposits. Bratislava: Journal of Economics, *57*, No. 7, pp. 682 – 699.

TATRA BANKA (2017): Annual Report 2016. Available at: <https://www.tatrabanka.sk/files/archiv/financne-ukazovatele/vyrocne-spravy/Vyrocna_sprava_Tatra_banky_20161.pdf>.

TATRA BANKA (2018): Annual Report 2017. Available at: <https://www.tatrabanka.sk/files/archiv/financne-ukazovatele/vyrocne-spravy/TB_Vyrocna_sprava_2017.pdf>.

TEPLÝ, P. – BEČVAŘÍKOVÁ, V. (2016): Consumer Protection and Regulation. [Internal Study.] Prague: Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague.

VŠEOBECNÁ ÚVĚROVÁ BANKA (VUB) (2017): Annual Report 2016. Available at: <https://www.vub.sk/files/ludia/sekundarna-navigacia/financne-ukazovatele/vyrocne-spravy/najnovsie-vyrocne-spravy/v_vub_2016_svk_88.pdf>.

VŠEOBECNÁ ÚVĚROVÁ BANKA (VUB) (2018): Annual Report 2017. Available at: <https://www.vub.sk/files/ludia/sekundarna-navigacia/financne-ukazovatele/vyrocne-spravy/najnovsie-vyrocne-spravy/vub_vyrocna_sprava-2017.pdf>.