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Interest Rate Risk Model in Banking Book

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Abstract

The aim of this project is to create an interest rate model for *Banco CTT's* Banking Book capable to meet the upcoming regulatory requirements as well as internal demands driven by recent portfolio expansion and expectations of future interest rate normalization after a long period marked by a negative interest rate environment. Upon the results obtained, it is clear that Bank's exposure to interest rate risk is stable and within the limits defined by regulatory authorities. However, veracity of the model should be continuously assessed, and structural balance sheet adjustments should be performed so that interest rate exposure is aligned with its overall low risk appetite.

Key Words

IRRBB – Interest Rate Risk in Banking Book

EVE – Economic Value of Equity

NII – Net Interest Income

SOT – Supervisory Outlier Test

Table of Contents

Abstract	2
Introduction	4
Interest Rate Risk in Banking Book	4
<i>Banco CTT</i> Overview	5
□ Business Model.....	5
□ Risk Approach	6
Purpose of Directed Research Internship	6
Methodology	7
□ Overview of interest rate-sensitive items	7
□ Economic Value Approach.....	10
□ Earnings Approach	16
□ Model Dynamics.....	18
□ Main Results	21
□ Sensitivity Analysis	25
□ Model Drawbacks.....	25
Conclusion.....	26
Regulatory thresholds	26
Hedging Considerations	28
Annexes	29
References	37

Introduction

Interest Rate Risk in Banking Book

Banking Institutions are affected by changes that may occur in the level and/or shape of market interest rate curves. Those effects may materialize into a loss of value bank's assets and/or a rise in price of its liabilities, and consequently, deteriorate the overall value of its equity. At the same time, it could also decrease bank's overall profitability due to variations in income from interest earning assets and/or changes in costs incurred from banks' funding liabilities. The combination of these two effects is broadly defined as interest rate risk. For the purpose of the project, it is only covered interest rate risk arising from banking book activities, IRRBB, since *Banco CTT* does not pursue any trading activity. There are three different sources of interest rate risk from banking book activities:

- Gap risk, which arises from changes in the timing of cash flows that may result in tenor mismatches. The extent of gap risk depends on whether the shocks in interest rate curve are parallel, where the magnitude of the shock is the same along the curve; or non-parallel, where different shock types are applied along the yield curve.
- Basis risk represents the difference in impact of interest rate shocks in the value of financial instruments that have similar tenors but are priced using different interest rate indices with non-perfect correlation between them.
- Option risk can arise from option derivative positions or from optional elements embedded in bank's assets, liabilities and off-balance sheet items, where the bank or the customer are able to alter the level and timing of their cash flows. Option risk comes both from automatic option risk and/or behavioral option risk. The automatic option risk may arise from the presence of caps and puts embedded in financial instruments and its exercise is dependent upon its financial viability for the option holder. Whereas behavioral risk can be materialized into prepayment of loans and/or earlier redemption

of deposits, and its exercise is not entirely dependent on the financial viability as other dimensions can have some weighing, therefore, an assumption that all customers are rational may not adjust.

In the course of its activities, credit institutions might be exposed to these three sources of interest rate risk altogether. In order to be fully aware of its interest rate risk exposure, there should be developed tools and instruments that can accurately capture the exposure of equity capital to interest rate variations, also known as equity risk, but also to changes on total interest received and paid, or earnings risk.

Banco CTT Overview

- **Business Model**

Banco CTT was founded in 24th of August 2015, following the transformation process of *CTT Serviços, SA*. *Banco CTT* is a recently launched retail bank that operates in-borders positioning itself into the Portuguese market with a *cost advantage* strategy. Within this strategy, *Banco CTT* targets the *mass market*. The Bank has managed to comply with its targeting mission by capturing the huge customer network of its unique shareholder, *CTT*, and relying on its brand awareness. Therefore, the Bank has been able to grow at very quick pace in the Portuguese market. The *cost advantage* strategy is supported by the use of the already existent *CTT*'s infrastructures, which include both personnel and physical retail branches, counting with 208 of the latter at the end of 2017. These low costs result in low prices charged to its customers, the absence of maintenance fees associated with current accounts or the competitive mortgage spreads are some of the examples. Given the Bank's age and complexity, its balance sheet is still composed by a small range of simple products. However, it keeps growing day by day, through customer acquisition and/or via portfolio expansion. In fact, on 24th July 2018 *Banco CTT* announced the acquisition of 321 *Crédito*, the forth Portuguese major player in the car

loan business with 10,3% market share and with 251€ million of credit conceded at the end of December 2017. After in the beginning of 2018 having acquired *Payshop*, which is a company that facilitates day-to-day transactions working as an intermediary.

- **Risk Approach**

According to *Banco CTT's Risk Appetite Statement*, it seeks to develop a strategy built upon solid capital ratios and focus on simple and low-risk products, such as mortgage loans, and maintaining a fair simple balance sheet. This way, *Banco CTT* aims to be safeguarded under adverse extreme scenarios of credit risk and/or liquidity constraints. However, on what concerns interest rate risk, Bank does not possess a tool that can measure its exposure to a variety of stress scenarios. To carefully assess the interest rate risk exposure, it is important that Bank develops a comprehensive Asset Liability Management tool that fully captures all sources of IRRBB. Governing Body has responsibility for understanding, in a timely manner, the nature and level of the bank's IRRBB exposure (*BSBC368*, page 4). In other words, a better comprehension of all dimensions of interest rate risk, implies better efficiency of the corrective actions undertaken to hedge it. Plus, management should improve risk management framework by settling internal limits to interest rate risk exposure that are aligned with its overall low risk appetite.

Purpose of Directed Research Internship

Interest rate risk in banking book is subject to the Basel Committee's guidance set out in the *2004 Principles for the management and supervision of interest rate risk* (*BSBC368*, page 1). In April 2016, the Basel Committee on Banking Supervision updated the standards concerning IRRBB treatment, presenting new proposals on how international banks should align their approach towards interest rate risk. The main objective of this collection of proposals lies on strengthening IRRBB identification, measurement, monitoring and control as well as its supervision (*BSBC368*, page 1). So, in order to be compliant with Basel Committee proposals,

credit institutions should develop robust and agile models that can be responsive to stress scenarios that may occur in the market, always adapted to their nature and complexity. In the course of the updated guidelines, the Supervisory Outlier Test was created. Its main goal is to promote comparison fairness by standardizing interest rate risk measurement among Credit Institutions such that Regulatory Authorities can take more informed conclusions on banks' interest rate risk exposure. The BSBC will be implemented within the EU in two phases: first, through the update of the EBA guidelines, and second, through the ongoing revision of the Capital Requirements Directives (CRD) and Capital Requirements Regulation (CRR) (EBA/GL/2018/02, page 3). This topic is especially relevant at a time when interest rates may normalize after the long and remaining period marked by a negative interest rate environment.

As result of the new regulatory guidance, the expected changes in interest rate environment and the Bank's growth, *Banco CTT* needs to finetune its approach by creating an integrated tool that can incorporate forthcoming Regulatory Requirements and, at the same time be agile and complex enough so that could be tested against possible stress scenarios defying bank's own assumptions regarding IRRBB modelling.

Methodology

- Overview of interest rate-sensitive items

Before stepping into the model and for better understanding of the same, it is important to briefly introduce each of the interest rate sensitive items that compose *Banco CTT* 's banking book. Therefore, its Asset side is composed by:

Floating rate mortgages, with a maturity ranging from 10 to 40 years, and with a basis spread starting on 1,1%, that could go up according to borrowers' account characteristics and financial viability. These mortgages are indexed to 12-month Euribor and they might be subject to prepayment risk. In case of prepayment, *Banco CTT* tries to mitigate costs by charging a

prepayment penalty fee corresponding to 0,5% of the principal remaining, which is the maximum allowed under the Portuguese law.

Banco CTT also holds an Investment Portfolio constituted by both corporate and sovereign bonds, which can be fixed or floating. The Treasury Department is responsible for building up the portfolio according to the underlying principles defined by the Government Body. These bonds are plain vanilla and do not have any automatic interest rates embedded (i.e. Calls and/or Puts). See annex 1.

It also holds investments placed on Interbank lending market. Interbank lending market is where banks borrow and lend money to one another. As hence, *Banco CTT* lends money to other credit Institutions, both Portuguese and overseas, where this agreement works exactly as a regular fixed-rate loan, with yearly installments composed by principal plus interest. See annex 2.

A small part of the Asset side is placed in Factoring. A Factoring contract represents a financial transaction in which a business sells its accounts receivable (i.e., invoices) to a third party (called a factor), in this case *Banco CTT*, at a discount. A business will sometimes factor its receivable assets to meet its present and immediate cash needs. In other words, *Banco CTT* will pay for the business account receivable at a discount factor and will be reimbursed by total value of the account receivable. The discount factor is assumed to be dependent upon interest rate level.

Banco CTT's current deposits that have salary debited directly can have access to an overdraft. Overdraft allows customer to cover unexpected expenses that may arise at the time when one does not have enough money to cover it. In other words, one can use non-owned money, up to a maximum limit of 100% of his salary or 4000€. Overdrafts should be contractually repaid within one month after its use. The current annual interest rate on Bank overdrafts is 12,75%.

Given the current low interest rate levels, profitable investment opportunities are scarce. Therefore, a significant part of its money is placed in other credit Institutions in form of current deposits and they are indexed to Euribor rate. Euribor is the average rate at which Banks in the Eurozone lend to one another.

For better understanding of its Asset side composition, see annex 3.

Concerning Liability Side:

Retail current deposits are deposits that are non-remunerated, for any given interest rate scenario. These deposits do not have a contractual maturity and for that reason, their behavioral should be modelled.

Saving accounts are another type of deposit without defined maturity. What differentiates them from current accounts is that there is remuneration associated with saving accounts. Currently, this product offers two types of remuneration: 1,15% annual interest rate, paid quarterly, for clients that have domiciled salary in *Banco CTT* and 0,15% for the others. These rates are assumed to adjust quarterly given changes in risk-free rate

The other source of funding is via term deposits, which have a contractual maturity defined ranging up to one year and offering remuneration of 0,15% annual interest rate. Despite having contractual maturity, there is no penalty for an earlier deposit redemption, which turns these deposits subject to mobilization at any time and making them vulnerable to behavioral risk.

See annex 4 for better understanding of the liability side composition.

A significant part of off-balance sheet items are fixed rate loan commitments in other credit institutions that will be most certainly exercised in few days, therefore, they are also subject to interest rate risk and considered for modelling. Regarding other off-balance sheet items, namely, the non-used credit lines of overdrafts, they are not being considered for due to data

constraints, plus, their amount can be neglected because it has little to no impact in any of the results.

- **Economic Value Approach**

The Asset-Liability management tool should be able to strike a compromise between net interest income sensitivity and economic value sensitivity, that cannot be simultaneously cancelled out (*EBA FAQ*, page 3). In that sense, it becomes a two-approach model, where the combination of these two features is important to provide a fully interest rate risk assessment, as they are useful for different type of analysis and complement each other. Economic value outcome is highly influenced by the treatment of bank's own equity liability capital (*BSBC 368*, page 41). In accounting terms, equity is net value of assets less liabilities, so it represents an asset for which there are no funding liabilities. Under this approach, equity is excluded from calculation since no rate or term is applied to it. This is the Economic Value of Equity approach, or EVE. The Economic Value approach, or EV, assumes that equity only finances assets that earn an endowment returns for the bank, and those who do not are not a relevant EV risk for the bank (*BSBC*, page 41). This is the *earnings-adjusted*, where equity is included on the calculation and treated as having the same term characteristics as the portfolio of assets that hedges the earnings on. Both economic value measurements consider the net present value of repricing cash flows of instruments. In this model, it is used the EVE approach.

- **Cash-Flow Allocation**

The model enables *Banco CTT* to estimate all repricing cash flows arising from interest rate-sensitive assets, liabilities and off-balance sheet items during their lifetime, for the ones that have defined maturity. Cash-flows distribution is placed among 19-time buckets, as stated in the Supervisory Outlier Test in *BSBC* guidelines (Annex 5) according to the repricing gap of each instrument. Repricing gap defines the period between a reference date and the next date

of interest rate resettlement. Splitting cash-flows among a large number of buckets permits a higher degree of granularity and, hence, a more rigorous *repricing gap* analysis when performing different shock scenarios (i.e. non-parallel interest rate shocks) and possible tenor mismatches. For floating rate instruments, such as floating rate bonds and floating rate mortgages, it is assumed to reprice fully at the next refixing date, hence all principal amount is aggregated in the tenor that corresponds to that date and from that moment onwards only interest is considered. Concerning the overdrafts, given that its contractual maturity is up to one month, it is assumed that all its cash-flows correspond to the bucket “Overnight-1 month”. For the current deposits placed in other credit institutions, the Bank treats them as “Overnight” since those amounts are constantly changing in order to meet Bank’s financial needs.

- Balance Sheet Treatment

As stated in BSBC standards, for the purpose of Economic Value measurement the aggregation of cash-flows should follow a *run-off* view, where the estimation of cash-flows occurs during the remaining life of the interest rate-sensitive items and no-reinvestment is assumed afterwards.

- Treatment of non-maturity deposits

For the purpose of interest risk measurement, it is fundamental to model the behavior of the NMDs, as they represent an important part of *Banco CTT*’s funding liabilities. BSBC guidelines state that should be observed the volume changes over the past 10 years of the NMDs in order to retrieve solid conclusions on their behavior. The early age of the Bank results in lack of historical representative data of its NMDs behavior. In this sense, a recent study was performed by an external consultancy company at *Banco CTT*’s request on both current and saving deposits, which combines the Bank’s historical data and business expert judgement. Given the outcome of the study, it was possible to retrieve useful information regarding the behavior of

these non-maturity deposits. As stated in BSBC guidelines, banks should be able to identify the core and non-core parts of each type of non-maturity deposits, where the core balance is defined as the part that is very unlikely to reprice even under significant interest rate changes and will be the amount subject to modelling. The non-core is likely to reprice in the future, therefore is allocated to the “Overnight” time bucket as recommended in BSBC guidelines. Banks should also be able to define which deposits are considered transactional or non-transactional. A transactional deposit does not care about remuneration, while a non-transactional account takes that in consideration. Therefore, current deposits are considered transactional as they do not offer remuneration and savings are considered non-transactional as they are interest-bearing accounts. The core balances achieved from the study were the following: 85% for current accounts and 82% for savings. Consequently, non-core parts were 15% and 18% respectively. Concerning annual attrition rate, the rate at which deposits decay each year, is 1,5% and 4,1% for current deposits and for savings, respectively. This rate is only applied to the core part. However, this result exceeds maturity caps for NMDs, recommended by regulatory authorities as it can be seen in annex 6.

- Prepayment Risk

Mortgage loans have behavioral options embedded, therefore they are subject to option risk. Option risk is materialized by the fact that clients may opt to pay loans before the contractual maturity, which would result in interest earning losses. Sources of prepayment risk are extremely heterogeneous and might be affected by a wide range of factors, such as geo-demographical, financial, social and others. Given the fact that mortgage loan is a very recent product for *Banco CTT*, it lacks representative data concerning prepayment risk. In this model, are used two possible prepayment approaches: CPR, as in constant prepayment rate, and PSA, as in prepayment speed approach. The latter approach was a measure developed by the Bond Market Association that studies the prepayment of mortgage loans. The model is used to derive

prepayment speed of new production loans and it assumes a growing rate of prepayment in each month up to a moment where it stagnates. A 100% PSA loan would have a prepayment rate of 0,2% in the first month and growing 0,2% in the subsequent months until the thirtieth month, where it stagnates at 6% prepayment rate for contract lifetime. Multiples are calculated from this prepayment rate. For instance, a 150% prepayment model will have a 0,3% prepayment rate in first month, growing a 0,3% annually per month and will end up at a constant rate of 9% after the thirtieth month (Annex 7). Regarding the first approach, the baseline constant prepayment rate defined is 2,71%, and results from a seven-year historical average of mortgage prepayment rates, full and/or partial, in the Portuguese market (Annex 8).

- Automatic Interest Rate Options

Currently, *Banco CTT* does not have exposures to automatic interest rate options as their products are all plain vanilla.

- Term Deposit Redemption Ratio

There are several dimensions in which an impact in the depositor redemption behavior may range from account variables such as deposit size, depositor characteristics or contractual interest rates to macroeconomic variables such as, inflation, GDP or stock indices (*BSBC368*, page 11). The annual base deposit redemption ratio is assumed to be 4,1%, which is equal to the attrition rate of saving accounts, as seen before. This assumption is based on the fact that these are two competing products as they offer remuneration, and therefore, their clients are assumed to behave in similar way. Treatment of the deposit redemption ratio is the same as the one suggested by Supervisory Outlier Test, as it can be seen in annex 9. The rationale behind the application of different scalar multipliers for different shocks is the following: for a positive interest rate shock, redemption of term deposits will increase, and vice-versa. This is intuitive

as after a positive interest rate shock, depositors could benefit for entering in a new term deposit that would remunerate at a higher interest rate.

- Interest Rate Floor

While in low-interest rate environment, should be taken in consideration negative interest rate shocks and asymmetrical effects of negative interest rates on their assets and liabilities (*BSBC368*, page 9). Therefore, it is considered a floor of -100 basis points for immediate maturities and increasing 5 basis point per year, eventually reaching a 0% floor for maturities of 20 years and more (*EBA/GL/2018/02*, page 41). This means that, given further negative shocks in yield curve that go beyond the floor, no asset or liability will change its economic value. In other words, in a negative-interest rate environment, the marginal effect of a negative shock exceeding interest rate floor on the economic value of an instrument is zero.

- Model Master Curve

The risk-free interest rate used to discount all the cash flows arising from the different instruments is the 12-month *Euribor/Swap zero curve* (Annex 10). The data is extracted from *Bloomberg* for each reference month. Then, extrapolation of the implied swap curve is done using the Bootstrap procedure. This procedure consists in extracting spot interest rates that are not directly observed in the market using linear interpolation. The discounting is made using spot rate time bucket midpoints. This curve is the best fit for the Bank since all its positions are pegged to one unique currency, the Euro, which makes them indexed to Euribor. Plus, because swap curve is a better proxy to risk-free rate than Treasury bonds, which are artificially too low that results in a price premium that investors are willing to pay for Treasury bonds. The reason stands for the fact that Treasury rates bear a liquidity *convenience yield* stemming from two essential functions they perform. Treasuries are often the preferred instruments to hedge interest rate-sensitive products, in particular, corporate bonds and swaps. In addition, Treasury bonds

give access to the cheapest source of funds (*Grinblatt, 1995*). Annex 11 shows how the price spread behaves throughout time given liquidity shocks.

- *Beta-adjusted Duration*

As aforementioned, basis risk reflects differences in correlation between different indexes that culminates in an interest rate sensitivity differential. In other words, price of assets and liabilities might be affected differently. In this sense, a *beta-adjusted* duration might capture price sensitivity better than the regular modified duration. This approach defines a parameter, β , that reflects how price of an instrument will react given a shock in the yield curve. Therefore, *beta-adjusted* duration of an instrument would be the result of the multiplication of its modified duration by its beta. Currently, on *Banco CTT*'s asset side, both money and Interbank loans placed in other credit Institutions move linearly with Euribor rate, therefore, its β is 1. Concerning portfolio of bonds is composed by stable low default-risk bonds with Rating of Investment Grade (above BBB- or Baa), hence, it is assumed those bonds move linearly with risk-free rate. However, these market conditions might change, and parameters should be regularly subject to revision. For mortgage loans, given the fact that are indexed to 12- month Euribor, they will move according to this rate each year and, therefore, its β is 1. On the liability side, term deposit rate does not behave linearly with the Euribor rate as it can be seen in annex 12, where the sensitivity to interest rate shocks is dependent upon the Euribor rate level, being less sensible in low interest rate environments and higher in high-interest rate environments. Therefore, after discussions with *Banco CTT*'s Marketing, Risk and Treasury departments, it was possible to define a variable *beta-adjusted* duration for term deposits that adjusts itself to the level of the yield curve at a given point in time, as it is shown in annex 13. Concerning the savings, they are assumed to behave according the risk-free rate, with a beta of one. For current accounts is assumed to have β of 0, as it was decided by Government Body that its rate would remain null for any given interest rate scenario.

- Balance Sheet Basis

According to BSBC standards, for IRRBB reporting should be made on a consolidated basis. Therefore, *Payshop* is also being included in the model.

- Earnings Approach

Earnings-based measures focus on future profitability and how future value of earnings would affect the cost of equity that may affect profit and loss accounts (*BSBC*, page 7). The cash-flows are not discounted under this approach.

- Cash-Flow Allocation

For earnings measurement purposes, only interest cash-flows are being considered. The exclusion of the principal is justified by the fact that under any interest rate scenario principal amount would remain unaffected, and only interest earnings/costs would suffer variations. As the opposite from what happened under the Economic Value approach, for floating rate bonds changes in interest earnings for future reset dates are being considered and added up to the spread amount. Net interest income measurement aims to estimate short/medium-term interest earnings variations resulting from potential shifts in interest rates that usually range from 1 up to 3 years. However, BSBC standards states that banks should use a rolling 12-month period. For *Banco CTT*'s case this 1-year term is considered very relevant to capture possible changes in earnings since an important slice of its assets, composed by floating rate mortgages and some floating rate bonds, will reprice within one year and, on the liability side, term deposits have maximum maturity up to one year.

- Balance Sheet Treatment

The model assumes a constant balance sheet, where all instruments maturing within 1-year interval will have like-for like reinvestment. This reinvestment will be made at the new implied forward rates, given the market rates taking effect at that time.

- Treatment of non-maturity deposits

Under Earnings approach, saving accounts are assumed to keep constant throughout the 1-year term as cash-outflows are automatically adjusted with cash-inflows and its amount will remain unchanged. As for current deposits, given the fact they are non-interest-bearing liabilities they are not relevant for earnings considerations.

- Prepayment Risk

The same principle as used in the Economic Value approach.

- Automatic Interest Rate Option

Currently, *Banco CTT* does not have exposures to automatic interest rate options as their products are all plain vanilla.

- Term Deposit Redemption Risk

The same principle as used in the Economic Value approach.

- Interest Rate Floor

On asset side instruments, a zero floor is contractually defined for bonds, loans and factoring items. The only item that does not have an interest rate floor is the cash placed in other credit institutions, and as consequence, its below zero given the current negative interest rate environment. On the liability side, a zero-interest rate floor is defined for savings and term deposits. As current deposits are non-interest liabilities, an interest rate floor is not applicable.

- Model Master Curve

Under this approach, the 12-month Euro-Swaps curve is used to retrieve the implied forward rates for floating rate items after reset dates.

- Pass-Through rate

Under earnings approach, this is the rate at which the different instruments will pass on the interest rate shocks that might occur. In practice, this is the same as the *beta-adjusted* duration for Economic Value measurement. So, all interest rate-sensitive items will have a pass-through rate of 100% except for the term deposits, where its pass-through rate is dependent upon interest rate level (recall annex 13) and for current accounts, where its pass-through rate is always zero.

- Balance sheet Basis

As in the Economic Value approach, earnings exposure is reported on a consolidated basis.

- Model Dynamics

In BSBC standards is stated that banks should have measurement systems able to assess both economic value and earnings variations for a range of interest rate shocks and stress scenarios. This tool allows to assess and meet these guidelines concerning the soundness and reasonability of the assumptions used for the modelling purposes by having an agile structure that can be responsive to the application of different scenarios. It is important that these scenarios can be sufficiently wide-ranging to capture the different sources of interest rate risk: parallel and non-parallel gap risk, basis risk and option risk. This framework should provide an ongoing assessment, with minimum monthly frequency, of interest rate risk. In order to guarantee the integrity of the model, base assumptions of the model should be reviewed regularly. The data sources that feed into the input of the model come from the Internal core system of the Bank, but also from data given by the Accounting Department. Internal controls assessing the integrity of the data were added to guarantee that updating process flows correctly as it can be seen in annex 14.

- Base scenario

Under this scenario, baseline assumptions are considered, and any subsequent shock/stress tests performed will be compared to this one. It assumes no shocks along the yield curve, therefore, risk-free curve is built upon forward rates estimated at a given reference date. For mortgage loans, it assumes a yearly prepayment rate of 2,71% as seen before. The baseline term deposit redemption rate is the same as defined above, 4,1%, and assumes no maturity caps on non-maturity deposits treatment. Pass-through rate and *beta-adjusted* duration used are the same as mentioned before.

- Interest rate Shock Scenarios

For these scenarios, the model includes all the six prescribed shocks defined under the Supervisory Outlier test (see Annex 15). The package of interest rate shocks is composed by constant parallel shocks, positive and negative; positive and negative short rate shocks, where the magnitude of the shock is higher among short-term and lower on the long-term buckets, and two rotational shocks. Rotational shocks are able to change the slope of the yield curve, the flattener shock shifts yield curve slope close to zero and the steepener shock moves it towards one. Calculation of interest rate shocks are further detailed in annex 16. Plus, it was added a base scenario which is composed by the implied forward rates of euro swaps index, where it assumes absence of further future shocks in the yield curve. On top of that, it can be easily added interest rate shock scenarios to the model that *Banco CTT* might consider relevant for the analysis. Concerning the shock magnitude, it can be easily altered as well. Given the diversity and magnitude of shocks applied, parallel and non-parallel gap risk can be fully assessed.

- Stress Scenarios

The following scenarios are aligned with bank's nature and complexity, aiming to measure the sensitivity of the output to changes in the main underlying assumptions that can affect both equity capital and earnings, which are the following:

- Changes on the Mortgage prepayment type of can be applied, where one can choose between PSA prepayment speed and Constant Prepayment rate approaches. It is also possible to change the rate of prepayment whether by adjusting the prepayment speed factor desirable and the constant prepayment rate, under PSA and CPR approaches, respectively. These scenarios target behavioral risk.
- Concerning the treatment of non-maturity deposits, core and non-core parts of both savings and current accounts might need to be reviewed and adjusted. Plus, annual attrition rate for both non-maturity deposits can suffer alterations as well. Again, behavioral risk is being captured.
- Changes on the baseline term deposit redemption ratio can be also applied.
- On what concerns the price sensitivity to interest rate risk, *beta-adjusted* duration should be reviewed and adjusted if it is appropriate to do so. The same goes to remuneration sensitivity, where pass-through rates can be modified. Both changes in these scenarios address basis risk, as possible differences in correlation between different indexes may arise and adjustment of current parameters might be needed.
- Changes on type of reporting can also be performed, which can be done under consolidated or individual basis. Individual measurement allows to exclude *Payshop* from the overall interest rate risk assessment and, henceforth, targeting solely *Banco CTT*'s exposure.

For better understanding of these features, please see annex 17.

- Supervisory Outlier Test

This stress scenario should be integrated in the overall internal IRRBB management system. Under this approach, magnitude for each different type of shocks for each currency is defined in the guidelines, as it can be seen in annex 18. Reporting is conducted on a consolidated basis. Given that time bucketing used in this test is the same as requested by the Supervisory Outlier Test, no adjustment is required. Given current attrition rates applied to savings and current deposits, the average maturity of NMDs surpasses maturity caps under BSBC guidelines as seen in annex 6. Therefore, maturity caps are being considered for this test by automatically adjusting attrition rates and core parts for each of the NMDs in order to be compliant with the guidelines (Annex 19).

- **Main Results**

Under the new Regulatory guidelines, *Banco CTT* is considered a Category 3 Institution given its size, nature and complexity, in a scale from 1 to 4, where Category 1 corresponds to the most sophisticated institutions. Given its level of complexity, in the Economic Value approach the following metrics should be computed: duration, partial duration and changes in Economic Value of Equity. Duration is computed for each item on banking book and only captures parallel changes in interest rate curve. Duration is calculated as the product of the sum of the cash-flows by the discount factors per bucket and by the midpoints correspondent to each time bucket, which then is divided by the overall economic value of the instrument (See annex 20). While partial duration estimates the duration of all different items in the same time bucket, measuring both parallel and non-parallel changes in interest rate curve. Partial dollar duration, DV01, assesses how much the economic value changes given a change of one percentage point in the interest rate level (See annex 21).

- For the baseline scenario, the following results were obtained:

	Price/Economic Value	Portfolio Duration
Assets		
Cash available in other OCIs	97 726 748,01 €	0,0
Interbank Loans	94 665 322,31 €	0,6
Bonds	463 823 793,70 €	5,6
Mortgage loans	182 153 444,88 €	2,2
Overdrafts	711 551,07 €	0,0
Factoring	16 935 563,52 €	0,2
Off-Balance	578 679,35 €	1,4
TOTAL	856 595 102,85 €	3,6
Liabilities		
Term Deposits	- 75 264 782,05 €	1,1
Savings	- 99 098 360,94 €	7,6
Current Deposits	- 447 209 748,60 €	15,0
TOTAL	- 621 572 891,59 €	12,1
EQUITY	235 022 211,25 €	

Table 1 – Banking Book Composition and duration under baseline scenario

Given these results, it is possible to infer that duration of liabilities is much higher than duration of assets. The main reason stands for the fact that non-maturity deposits have very high duration given the fact that their attrition rates are very low. Being 4,1% for savings and 1,5% for current deposits.

Table 2 – Partial Duration and Dollar duration per bucket

Time bucket	Partial DV01	Partial Duration
Overnight	- 460,04 €	0,00
O/N-1 M	9 261,87 €	0,04
1M-3M	97 029,08 €	0,17
3M-6M	177 064,99 €	0,38
6M-9M	98 048,36 €	0,63
9M-1Y	532 884,21 €	0,88
1Y-1.5Y	- 442 443,03 €	1,25
1.5Y-2Y	- 122 196,13 €	1,75
2Y-3Y	362 266,54 €	2,50
3Y-4Y	- 368 090,88 €	3,50
4Y-5Y	- 361 135,55 €	4,50
5Y-6Y	2 367 183,38 €	5,50
6Y-7Y	- 1 851 511,51 €	6,50
7Y-8Y	3 079 476,56 €	7,50
8Y-9Y	350 625,47 €	8,50
9Y-10Y	- 3 373 697,65 €	9,50
10Y-15Y	- 4 115 633,06 €	12,50
15Y-20Y	641 462,02 €	17,50
>20Y	1 004 216,76 €	25,00

The most sensitive bucket to a change in interest rate level is the “10-15Y” time bucket, where a 1 percentage point increase in interest rate, will lead to an estimated loss of economic

value of 4 115 633 €. Hence, *Banco CTT* is particularly sensitive to long-term rate movements of the yield curve.

Concerning Earnings approach, changes in net interest income and net interest margin should be assessed. Net interest income represents the difference between interest earnings and interest liabilities. Net interest margin is the net interest income divided by the interest earning assets and, it can be seen as the Bank's return on equity.

The following results were obtained:

Table 3 – NIM and NII under baseline scenario

	NII(1-year)
Assets	
Cash available in other OCIs	- 734,81 €
Interbank loans	25 066,50 €
Bonds	7 188 243,69 €
Mortgage loans	1 888 843,60 €
Overdrafts	98 467,71 €
Factoring	207 667,94 €
Off-Balance	2 724,84 €
TOTAL	9 410 279,46 €
Liabilities	
Term Deposits	- 92 514,67 €
Savings	- 1 976 955,83 €
Current Deposits	- €
TOTAL	- 2 069 470,50 €

NII	NIM
7 340 808,96 €	0,86%

Current Bank's net interest income is positive, meaning that current return on assets is higher than current cost of funding liabilities. However, net interest margin is very low, 0,86 %, given the current low interest rate environment where high return opportunities are scarce. Therefore, *Banco CTT* should monitor more closely changes on EVE than on NII, since the latter is currently a small source of interest rate risk exposure and, consequently, less important to IRRBB analysis.

- For the Supervisory Outlier Test scenario, the following results were obtained:

	Price/Economic Value	Portfolio Duration
Assets		
Cash available in other OCIs	97 726 748,01 €	0,0
Interbank Loans	94 665 322,31 €	0,6
Bonds	463 823 793,70 €	5,6
Mortgage loans	182 153 444,88 €	2,2
Overdrafts	711 551,07 €	0,0
Factoring	16 935 563,52 €	0,2
Off-Balance	578 679,35 €	1,4
TOTAL	856 595 102,85 €	3,6
Liabilities		
Term Deposits	- 75 264 782,05 €	1,1
Savings	- 101 226 737,18 €	4,5
Current Deposits	- 541 125 575,86 €	5,0
TOTAL	- 717 617 095,10 €	4,5
EQUITY	138 978 007,75 €	

Table 4 – Banking Book Composition and duration under SOT scenario

Under this scenario, duration of liabilities is still higher than duration of assets but has sharply decreased. The reason stands for the fact that maturity caps, defined in annex 6, were applied. Solving the attrition rates in order to achieve the given application of the caps, the values of 5,36% and 7,25% were obtained for savings and current deposits, respectively. Additionally, core part of saving accounts is restricted to 70%. However, the economic value of equity has been reduced under this approach. Again, this is due to an increase of economic value of both savings and current deposits given the new attrition rates. Under earnings approach, the results were the following:

Table 5 – NIM and NII under SOT scenario

	NII(1-year)
Assets	
Cash available in other OCIs	- 734,81 €
Interbank loans	25 066,50 €
Bonds	7 188 243,69 €
Mortgage loans	1 888 843,60 €
Overdrafts	98 467,71 €
Factoring	207 667,94 €
Off-Balance	2 724,84 €
TOTAL	9 410 279,46 €
Liabilities	
Term Deposits	- 92 514,67 €
Savings	- 1 976 955,83 €
Current Deposits	- €
TOTAL	- 2 069 470,50 €

Δ NII	Δ NIM
- €	0,00%

Under earnings approach, there were no changes compared to the baseline scenario. The reason is straightforward, as earnings approach assume a *constant-balance sheet* view, where cash inflows automatically replace cash outflows. Therefore, changes in the maturity of NMDs will have no impact.

- **Sensitivity Analysis**

As previously stated, stress tests should be computed in order to assess the viability of current IRRBB assumptions. Therefore, this section focuses in measuring the responsivity of the Economic Value of Equity to changes in the baseline modelling assumptions as it can be seen in the Annex 22. By analyzing the graph, only changes on the constant prepayment rate of mortgage loans will have a considerable effect on the overall value of equity. However, concerning other changes in the baseline assumptions the marginal effect is very low, which means the model is robust. Therefore, if in the revision process adjustments are deemed necessary, one would not expect a significant impact on the overall conclusions. Plus, if scope of the analysis was shifted towards an individual approach, value of equity would be sensitive to the exclusion of *Payshop*. This is because *Payshop* has around 10 000 000 € invested in interest rate-sensitive assets. On Earnings approach, sensitivity analysis was not performed. Again, the reason stands for the fact that a constant balance sheet is assumed, and behavioral changes do not come into play.

- **Model Drawbacks**

The model has the following limitations:

- For aggregation purposes, it assumes the midpoints for each time bucket when computing duration measures, which might not correspond exactly to the reality. This

is especially relevant for the “> 20Y” time bucket, in which is assumed a midpoint of 25 years, and might be short for longer products (e.g. mortgage loans, NMDs).

- Assumes that Bank adjusts the deposit rate and savings rate instantaneously with changes in the risk-free curve, which, may take months.
- Interest is assumed to be continuously compounded for some products, and discrete compounded for others.
- Due to lack of data, the model assumes that term deposits’ customers behave similar to savings’ customers, which in reality may not occur.
- For the 12 month- Euro swap curve computation, *Bloomberg* data goes only up to 30 years. The remaining curve was built using the excel function “Forecast”.

Conclusion

Regulatory thresholds

Updated guidelines include two thresholds that limit the exposure of economic value of equity to possible interest rate changes. The first thresholds stem from the CRD and assumes that institutions calculate the impact of parallel changes in interest rates of +/-200 basis points on their own funds. If the decline is greater than 20% of institution’s own funds, the institution should inform competent authorities immediately. After the application of the parallel shocks, changes in economic value were the following:

Table 6 – Changes to Economic Value of Equity after application of parallel shocks

Economic Value	Δ Economic Value	Shock
141 573 628,07 €	2 595 620,32 €	parallel +200 bp
133 460 524,40 €	- 5 517 483,35 €	parallel -200 bp

Own Funds	73 390 063,58 €
20% Own Funds	- 14 678 012,72 €

Under a positive interest rate shock, Bank is able to increase its value of equity. In this scenario, both value of assets and liabilities decrease. However, the decrease is higher on the liability side and, consequently, there is an equity gain. On a negative interest rate shock scenario, both

liabilities and assets increase in value, however, this increase is more noticed on the liability side. These conclusions are intuitive as liabilities have higher duration and, hence, their price is more sensitive to interest rate parallel movements. As it is possible to conclude, *Banco CTT*'s balance sheet is relatively stable given changes in interest rates and under a negative shock of 200 basis points, the regulatory threshold is not exceeded.

Second threshold originates from the BCBS Standards. The institutions are expected to calculate the impact of six predefined shock scenarios on their own funds. If the overall decline in economic value is greater than 15% of Tier 1, the institution should inform the competent authority. Under this test, positive changes have a 50% weight, while negative changes have 100% weight. The 15% threshold is introduced not as a hard threshold but rather as a trigger for an enhanced supervisory dialogue. Currently, Bank also does not exceed the second regulatory threshold as it can be seen below:

Table 7 – Changes to Economic Value of Equity under Supervisory Outlier Test

Economic Value	Δ Economic Value	Shock
141 571 950,16 €	2 594 806,14 €	parallel +200 bp
133 460 635,16 €	- 5 516 508,86 €	parallel -200 bp
136 334 883,20 €	- 2 642 260,82 €	Short+250 bp
138 236 264,98 €	- 740 879,04 €	Short -250 bp
140 455 801,64 €	1 478 657,62 €	Steepener
136 582 812,81 €	- 2 394 331,22 €	Flattenner
Σ EVE	- 9 257 248,06 €	
15% CET 1	- 11 008 509,54 €	

There are no regulatory limits on earnings measures. However, given that earning measures have a very low impact on interest rate exposures, *Banco CTT* should also not also consider for now the creation of internal limits addressing earnings as small changes in interest rates will have a very high impact on NII and NIM since they are currently very low.

Hedging Considerations

Banco CTT can decrease its exposure to interest rate risk whether by increasing the level of capital in order to ensure that possible losses are covered or by reducing its IRRBB exposures using hedging strategies. Increasing its capital is not a viable strategy as Bank would have to incur in negotiations with its unique shareholder, *CTT*, for a new capital injection and this option should be excluded. Regarding hedging strategies, there are two approaches: structural hedging and derivative hedging. Under a derivative hedging strategy, *Banco CTT* could focus on different interest rate swaps contracts, with each one of the contracts has contractual maturity correspondent to each time bucket midpoint. For each time bucket, if duration gap is positive, meaning duration of liabilities higher than duration of assets, Bank should enter in Interest Rate Swap agreement paying float and receiving fixed, where the notional is the dollar duration at that time, such that duration of equity would turn null (See annex 23). If gap is negative, *Banco CTT* should be the float-receiver and fixed-payer. Given its nature and level of complexity, *Banco CTT* should not consider derivative hedging a viable option for now. This comes from the fact that derivative hedging needs to be dynamic in order to be effective and these hedging adjustments come with huge trading costs and managerial difficulty associated. Other approach is via structural hedging, which consists in adjusting duration of its assets and liabilities by changing the overall asset and liability composition in order to transform equity duration into zero. Given that *Banco CTT* has currently excess of liquidity, as it was seen before, by having a considerable amount of cash stagnated in other Credit Institutions. Therefore, Bank is able to adjust its asset side composition, on a regular basis, in order to match duration of liabilities. This structural hedging could be achieved by investing this cash in long-duration assets, such as fixed-rate bonds and turn its equity exposure into zero so it could be immune to changes in interest rate curve.

Annexes

(valores expressos em euros)

	2017	2016
Obrigações e outros títulos de rendimento fixo		
Títulos de dívida pública		
Nacionais	162.425.502	47.956.965
Estrangeiros	75.110.116	31.784.315
Obrigações de outros emissores		
Nacionais	24.013.514	15.142.554
Estrangeiros	-	210.709
Investimentos detidos até à maturidade	261.549.132	95.094.543

Annex 1- Bond Investment portfolio (Source: *Banco CTT Annual Report 2017*, page 77)

(valores expressos em euros)

	2017	2016
Aplicações em instituições de crédito no país	73.720.671	58.718.171
Empréstimos a instituições de crédito no país	19.690.523	-
Aplicações em instituições de crédito no estrangeiro	8.500.614	-
Aplicações em instituições de crédito	101.911.808	58.718.171

Annex 2 – Interbank lending market assets (Source: *Banco CTT Annual Report 2017*, page 78)

(valores expressos em euros)

	À vista	Até 3 meses	De 3 a 12 meses	De 1 a 3 anos	Mais de 3 anos	Indeter- minado	2017 Total
Ativo							
Caixa e disponibilidades em bancos centrais	58.064.476	-	-	-	-	-	58.064.476
Disponibilidades em outras instituições de crédito	176.975.449	-	-	-	-	-	176.975.449
Ativos financeiros disponíveis para venda	-	503.709	2.072.485	2.500.506	674.674	-	5.751.374
Aplicações em instituições de crédito	-	16.716.838	73.363.848	7.473.850	4.357.272	-	101.911.808
Crédito a clientes	299.171	13.414.575	1.357.066	3.680.670	60.641.851	71.708	79.465.041
Investimentos detidos até à maturidade	-	5.328.909	10.392.464	47.282.099	198.545.660	-	261.549.132
Total do Ativo	235.339.096	35.964.031	87.185.863	60.937.125	264.219.457	71.708	683.717.280

Annex 3 – Asset side composition (Source: *Banco CTT Annual Report 2017*, page 94)

(valores expressos em euros)

	2017	2016
Depósitos à ordem	408.639.274	114.041.001
Depósitos a prazo	129.945.220	131.417.483
Depósitos de poupança	80.645.186	8.486.356
Recursos de clientes e outros empréstimos	619.229.680	253.944.840

Annex 4 – Liability Side composition (Source: *Banco CTT Annual Report 2017*, page 84)

Standardized Model	
Years	Bucket
0,00	Overnight
0,01	O/N-1 M
0,08	1M-3M
0,25	3M-6M
0,50	6M-9M
0,75	9M-1Y
1,00	1Y-1.5Y
1,50	1.5Y-2Y
2,00	2Y-3Y
3,00	3Y-4Y
4,00	4Y-5Y
5,00	5Y-6Y
6,00	6Y-7Y
7,00	7Y-8Y
8,00	8Y-9Y
9,00	9Y-10Y
10,00	10Y-15Y
15,00	15Y-20Y
20,00	>20Y

Annex 5 – Model time buckets

Table 2. Caps on core deposits and average maturity by category

	Cap on proportion of core deposits (%)	Cap on average maturity of core deposits (years)
Retail/transactional	90	5
Retail/non-transactional	70	4.5
Wholesale	50	4

Annex 6 – Caps on core deposits and average maturity by category (Source: *BSBC368*, page 26)

100% PSA prepayment speed	
1	0,20%
2	0,40%
3	0,60%
4	0,80%
5	1,00%
6	1,20%
7	1,40%
8	1,60%
9	1,80%
10	2,00%
11	2,20%
12	2,40%
13	2,60%
14	2,80%
15	3,00%
16	3,20%
17	3,40%
18	3,60%
19	3,80%
20	4,00%
21	4,20%
22	4,40%
23	4,60%
24	4,80%
25	5,00%
26	5,20%
27	5,40%
28	5,60%
29	5,80%
30	6,00%
>30	6,00%

Annex 7 – PSA Prepayment Speed Model

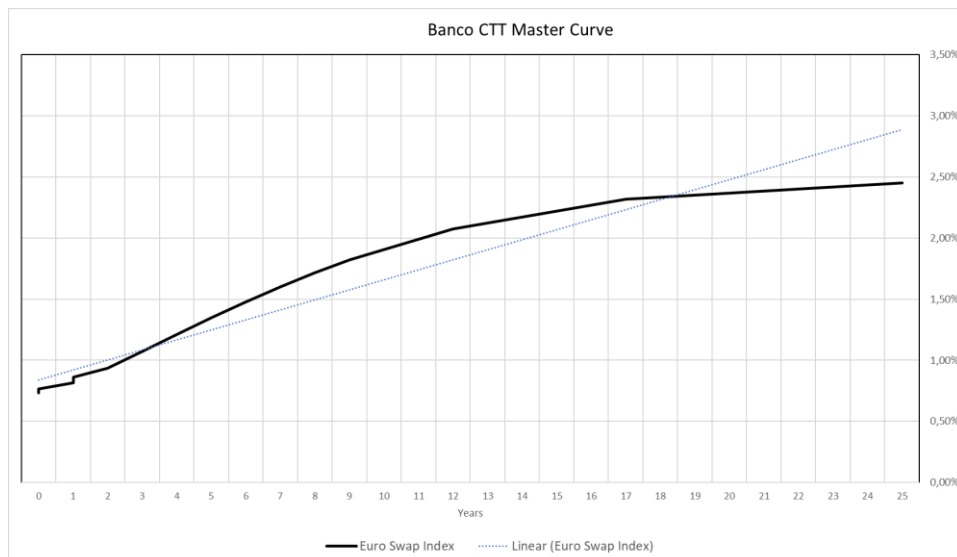
(million €)	Prepayment						
	2011	2012	2013	2014	2015	2016	2017
Full prepayment	2 098,65 €	1 404,00 €	1 197,00 €	1 336,00 €	1 881,00 €	2 876,00 €	3 882,00 €
Partial prepayment	590,96 €	484,00 €	403,00 €	358,00 €	338,00 €	350,00 €	379,00 €
Mortgage loans	100 303,00 €	104 987,00 €	94 406,00 €	93 585,00 €	90 489,00 €	88 363,00 €	87 664,00 €
Prepayment	2,68%	1,80%	1,69%	1,81%	2,45%	3,65%	4,86%

Annex 8 – Historical Mortgage Prepayment rate 2011-2017 (Source: *Bank of Portugal*)

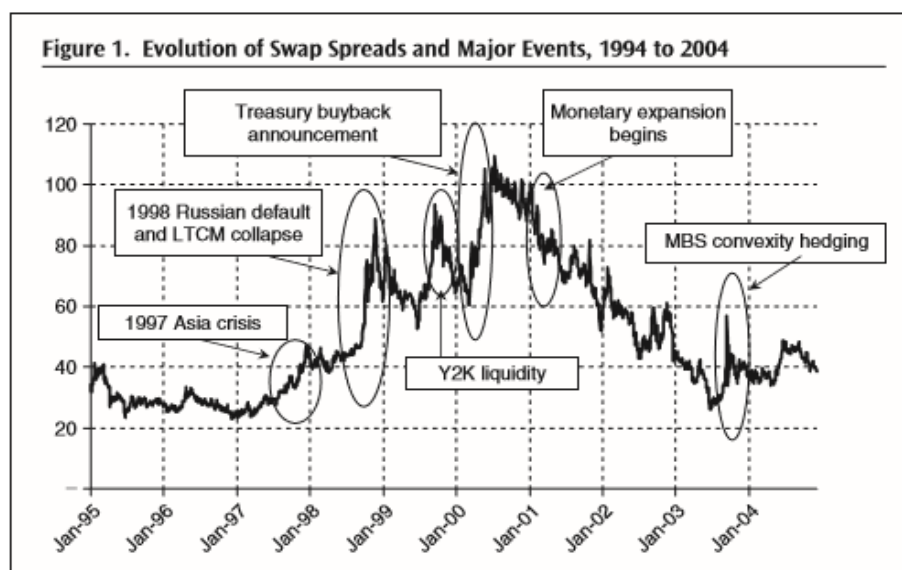
Table 4. Term deposit redemption rate (TDRR) scalars under the shock scenarios

Scenario number (i)	Interest rate shock scenarios	Scalar multipliers u_i
1	Parallel up	1.2
2	Parallel down	0.8
3	Steeper	0.8
4	Flattener	1.2
5	Short rate up	1.2
6	Short rate down	0.8

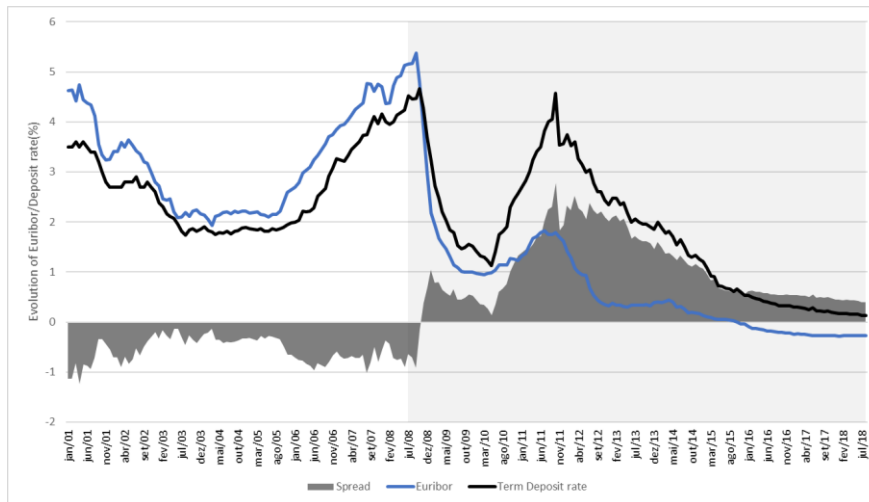
Annex 9 – Term Deposit Redemption Ratio Scalars multipliers per shock (Source: *BSBC368*, page 29)



Annex 10 – 12-month Euro/Swap Curve (Source: *Bloomberg*)



Annex 11 – Evolution of liquidity spread



Regression Statistics	
Multiple R	0,806602
R Square	0,650607
Adjusted R Square	0,648943
Standard Error	0,700453
Observations	212

Annex 12 – Regression of Term Deposit Rate against Euribor-12 months (Source: *Bloomberg*)

Interes rate level	β
< 0%	25%
[0%; 0,5%]	50%
[0,5%;1%]	75%
> 1%	100%

Annex 13 – *Beta-adjusted* duration of term deposits rate according to risk-free interest rate level

Checks		
ASSETS		
Cash available in OCIs	TRUE	FALSE
Application in OCIs	TRUE	
Bonds	TRUE	
Mortgage loans	FALSE	
Overdrafts	TRUE	
Factoring	TRUE	
LIABILITIES		
Term Deposits	TRUE	
Savings	TRUE	
Current Deposits	TRUE	
Off-balance	TRUE	

Annex 14 – Internal controls assessing quality of the model

The six interest rate shock scenarios for measuring EVE under the standard EVE outlier test are:

- (i) parallel shock up;
- (ii) parallel shock down;
- (iii) steepener shock (short rates down and long rates up);
- (iv) flattener shock (short rates up and long rates down);
- (v) short rates shock up; and
- (vi) short rates shock down.

Annex 15 – Prescribed shock under Supervisory Outlier Test (BSBC368, page 49)

- (i) *Parallel shock for currency c*: a constant parallel shock up or down across all time buckets.

$$\Delta R_{parallel,c}(t_k) = \pm \bar{R}_{parallel,c}$$

- (ii) *Short rate shock for currency c*: shock up or down that is greatest at the shortest tenor midpoint. That shock, through the shaping scalar $S_{short}(t_k) = (e^{-\frac{t_k}{x}})$, where $x=4$, diminishes towards zero at the tenor of the longest point in the term structure.^{43, 44}

$$\Delta R_{short,c}(t_k) = \pm \bar{R}_{short,c} \cdot S_{short}(t_k) = \pm \bar{R}_{short,c} \cdot e^{-\frac{t_k}{x}}$$

- (iii) *Long rate shock for currency c (note: this is used only in the rotational shocks)*: Here the shock is greatest at the longest tenor midpoint and is related to the short scaling factor as: $S_{long}(t_k) = 1 - S_{short}(t_k)$.

$$\Delta R_{long,c}(t_k) = \pm \bar{R}_{long,c} \cdot S_{long}(t_k) = \pm \bar{R}_{long,c} \cdot \left(1 - e^{-\frac{t_k}{x}}\right)$$

- (iv) *Rotation shocks for currency c*: involving rotations to the term structure (ie steepeners and flatteners) of the interest rates whereby both the long and short rates are shocked and the shift in interest rates at each tenor midpoint is obtained by applying the following formulas to those shocks:

$$\Delta R_{steepener,c}(t_k) = -0.65 \cdot |\Delta R_{short,c}(t_k)| + 0.9 \cdot |\Delta R_{long,c}(t_k)|$$

$$\Delta R_{flattener,c}(t_k) = +0.8 \cdot |\Delta R_{short,c}(t_k)| - 0.6 \cdot |\Delta R_{long,c}(t_k)|$$

Annex 16 – Computation of interest rate shocks (BSBC368, page 44)

Prepayment Type	Prepayment Type	Treatment of NMDs	
CPR	PSA	SA	CA
		% Core	
		Attrition rate	
	100%		
2,7%		☐ Caps	
		82,0%	85,0%
		4,10%	1,50%

Shock magnitude	Approach	Base TDRR	Base TDRR
0%	Consolidated	Yes	None
		4,1%	

	Pass Through Rate
Cash available in other OCIs	100%
Applications in OCIs	100%
Bonds	100%
Mortgage loans	100%
Overdrafts	100%
Factoring	100%
Term Deposits	25%
Savings	100%
Current Deposits	-
Off-Balance Sheet	100%

Annex 17 – IRRBB Model Inputs

Table 1. Specified size of interest rate shocks $\bar{R}_{shocktype,c}$

	ARS	AUD	BRL	CAD	CHF	CNY	EUR	GBP	HKD	IDR	INR
Parallel	400	300	400	200	100	250	200	250	200	400	400
Short	500	450	500	300	150	300	250	300	250	500	500
Long	300	200	300	150	100	150	100	150	100	350	300

Annex 18 - Specified size of interest rate shocks per currency (BSBC368, page 44)

% Core Attrition rate	Treatment of NMDs	
	SA	CA
	70,0%	85,0%
☒ Caps	5,36%	7,25%

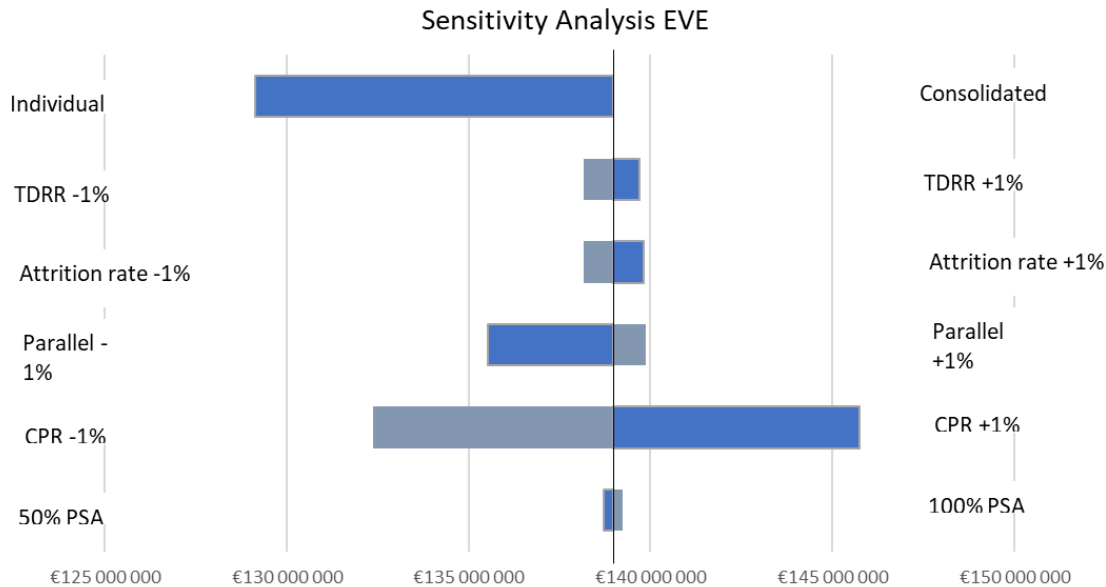
Annex 19 – Treatment of NMDs with maturity caps defined under BSBC368 guidelines (Excel Function: Goal Seek)

Duration		5,592892313
Midpoints	Discount Factors	Bonds Portfolio
0,0028	1,000007509	148 125,00 €
0,044466667	1,000119251	563 869,21 €
0,166666667	1,000446966	8 806 653,65 €
0,375	1,001005674	6 080 483,43 €
0,625	1,001451058	2 288 918,55 €
0,875	1,001531178	9 067 340,30 €
1,25	1,001666387	9 710 078,84 €
1,75	1,001676404	29 712 383,84 €
2,5	1,000001411	56 079 493,48 €
3,5	0,995117144	32 510 502,80 €
4,5	0,987257991	35 908 875,00 €
5,5	0,97681554	88 815 750,00 €
6,5	0,964278139	15 245 375,00 €
7,5	0,949910186	88 033 875,00 €
8,5	0,934114109	49 249 125,00 €
9,5	0,917836453	6 165 375,00 €
12,5	0,865091782	42 452 375,00 €
17,5	0,783772898	- €
25	0,68471677	- €

Annex 20 – Duration of Bonds Portfolio

	2Y-3Y
Assets	
Cash available in OCIs	- €
Application in OCIs	3 027 843,34 €
Bonds	56 079 493,48 €
Mortgage loans	2 789 753,13 €
Overdrafts	- €
Factoring	- €
Liabilities	
Term Deposits	- €
Savings	- 7 315 248,20 €
Current Deposits	- 40 843 857,92 €
Off-Balance Sheet	78 176,91 €
Partial Duration	2,5
DV01	345 404,02 €

Annex 21 – Partial Duration and PVO1 correspondent to “2Y-3Y” time bucket



Annex 22 – Sensitivity Analysis of Economic Value of Equity to changes in underlying assumptions

$$DV01_{equity} = DV01_{asset} - DV01_{asset} + DV01_{swap} = 0$$

Annex 23 – Equity Immunization using Interest Rate Swaps

References

Basel Committee on Banking Supervision. 2016. "Standards: Interest Rate Risk In The Banking Book". Accessed August 15. <https://www.bis.org/bcbs/publ/d368.pdf>.

(Basel Committee on Banking Supervision 2016)

Bank of Portugal. 2018. "Projeto De Instrução". Accessed November 15. https://www.bportugal.pt/sites/default/files/anexos/documentos-relacionados/anteprojeto_de_instrucao_reporte_irrb.pdf.

(Bank of Portugal 2018)

Bank of Portugal. 2018. "Relatório De Acompanhamento Dos Mercados Bancários De Retalho". Accessed December 4. https://www.bportugal.pt/sites/default/files/anexos/pdf-boletim/relatorio_de_acompanhamento_dos_mercados_bancarios_de_retalho_2017.pdf.

(Bank of Portugal 2018)

CTT. 2018. "Aquisição Da 321 Crédito". Accessed October 20. <https://www.ctt.pt/contentAsset/raw-data/2b62523e-841b-4bc9-9c09->

[e6ec9b2ca97c/ficheiro/34634d45-a20e-41ca-a97b-7c9b390a008b/export/321%20Presentation_ENG.pdf](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).

(CTT 2018)

European Banking Authority. 2018. "Final Report - Guidelines on The Management Of Interest Rate Risk Arising From Non-Trading Book Activities". Accessed November 26. <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>.

(European Banking Authority 2018)

Deloitte. 2017. "Taking A Closer Look at BSBC Standards". Accessed September 3. <https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/lu-interest-rate-risk-banking-book-18012018.pdf>.

(Deloitte 2017)

Global Association of Risk Professionals. 2015. "Interest Rate Risk in the Banking Book". In *Asset and Liability Management: Financial Risk and Regulation Series*, edited by Global Association of Risk Professionals, 35–47. GARP.

(Global Association of Risk Professionals 2015, 35)

World Bank. 2005. "What Determines U.S. Swap Spreads?". Accessed November 3. <http://documents.worldbank.org/curated/pt/603931468317080717/pdf/334270rev0pub.pdf>.

(World Bank 2005)

Veronesi, Pietro. 2010. *Fixed income securities: valuation, risk, and risk management*. John Wiley & Sons.

(Pietro Veronesi 2010)