Behavioural Modelling for ALM Focus on Non Maturity Deposits

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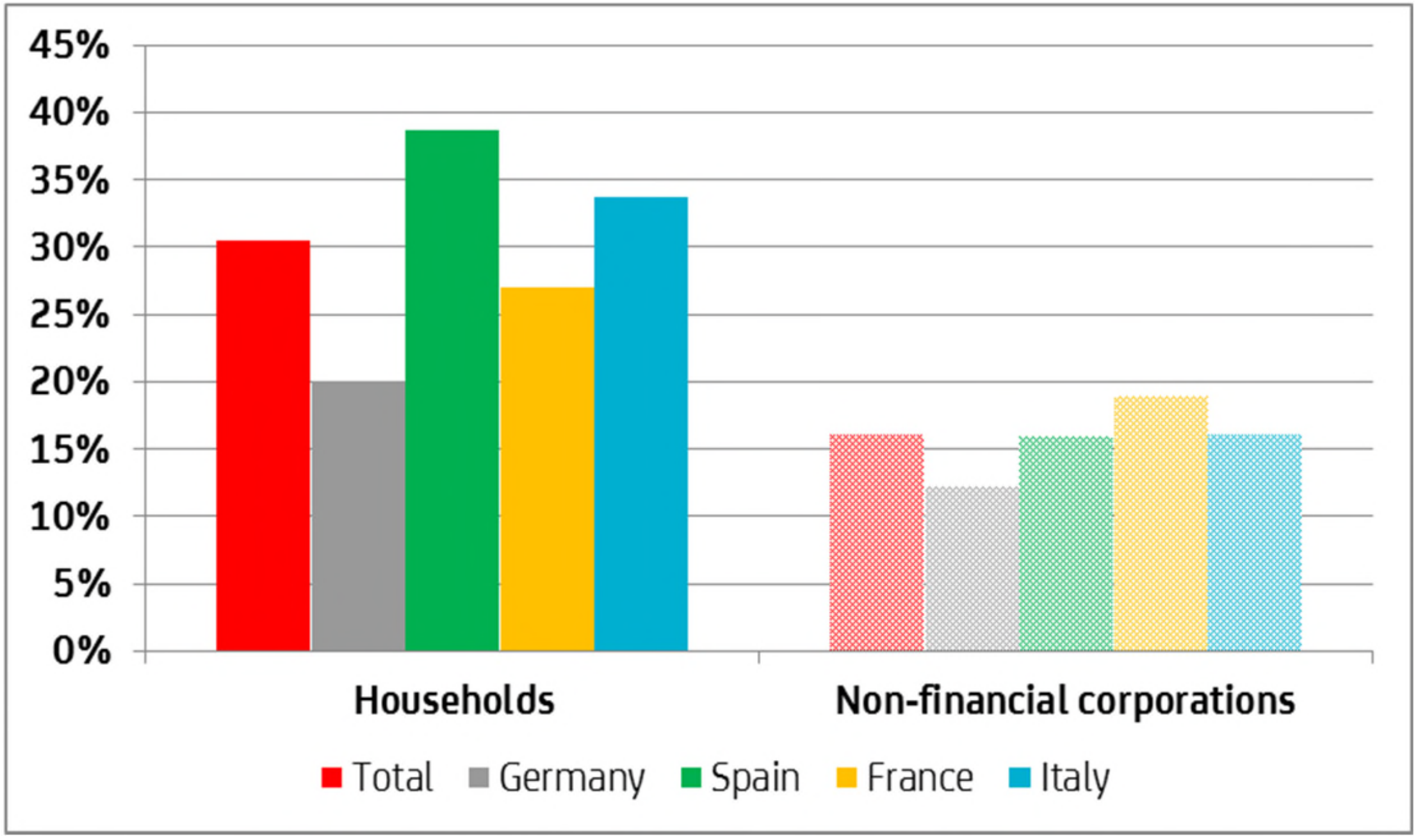
Agenda

- Historical Trends
- ALM Behavioural Modelling for Non Maturity Deposits
  - A. Time Series Model
  - B. Replicating Portfolio Models
  - C. Monetary Economics Models
- Final Remarks

Deposit from Households & Non Financial Corporation 45% c.a. of Total Liabilities (EUR 9,881bn)



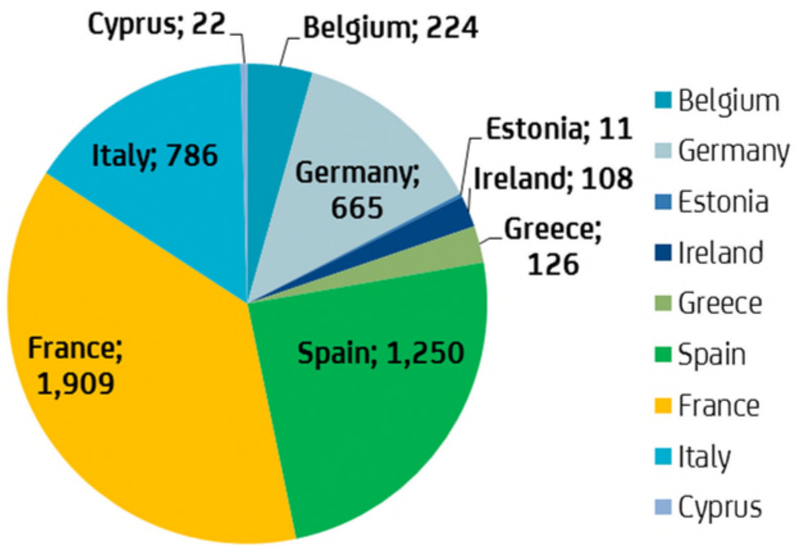
- **Deposits are the main funding source** for EU significant bank
- **Households represents 30% of funding needs** (from 20% in Germany to 38% in Spain)
- **NFC represents 15% of funding needs** (from 12% in Germany to 18% in France)

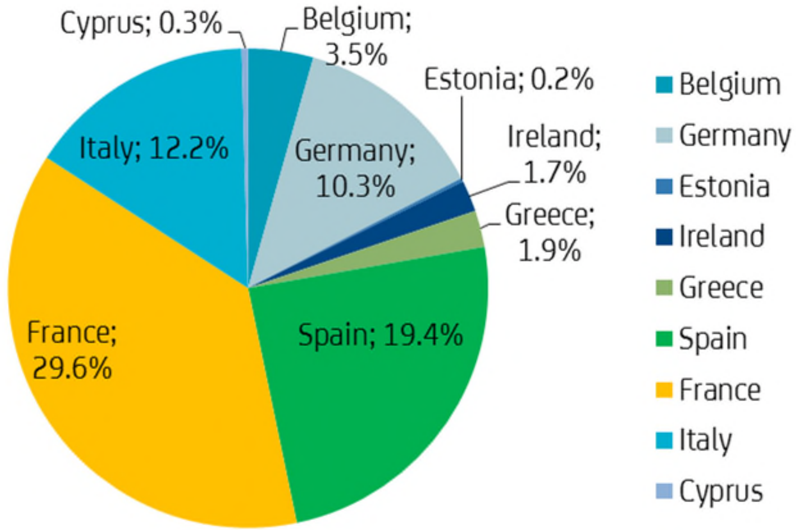
Source: ECB Supervisory banking statistics for banks designated as significant institutions
Reference Date: 2Q2020

Households Deposits as of Q2 2020
EUR 6,455bn

Overall amount of Households deposits for significant institutions: EUR 6,455bn

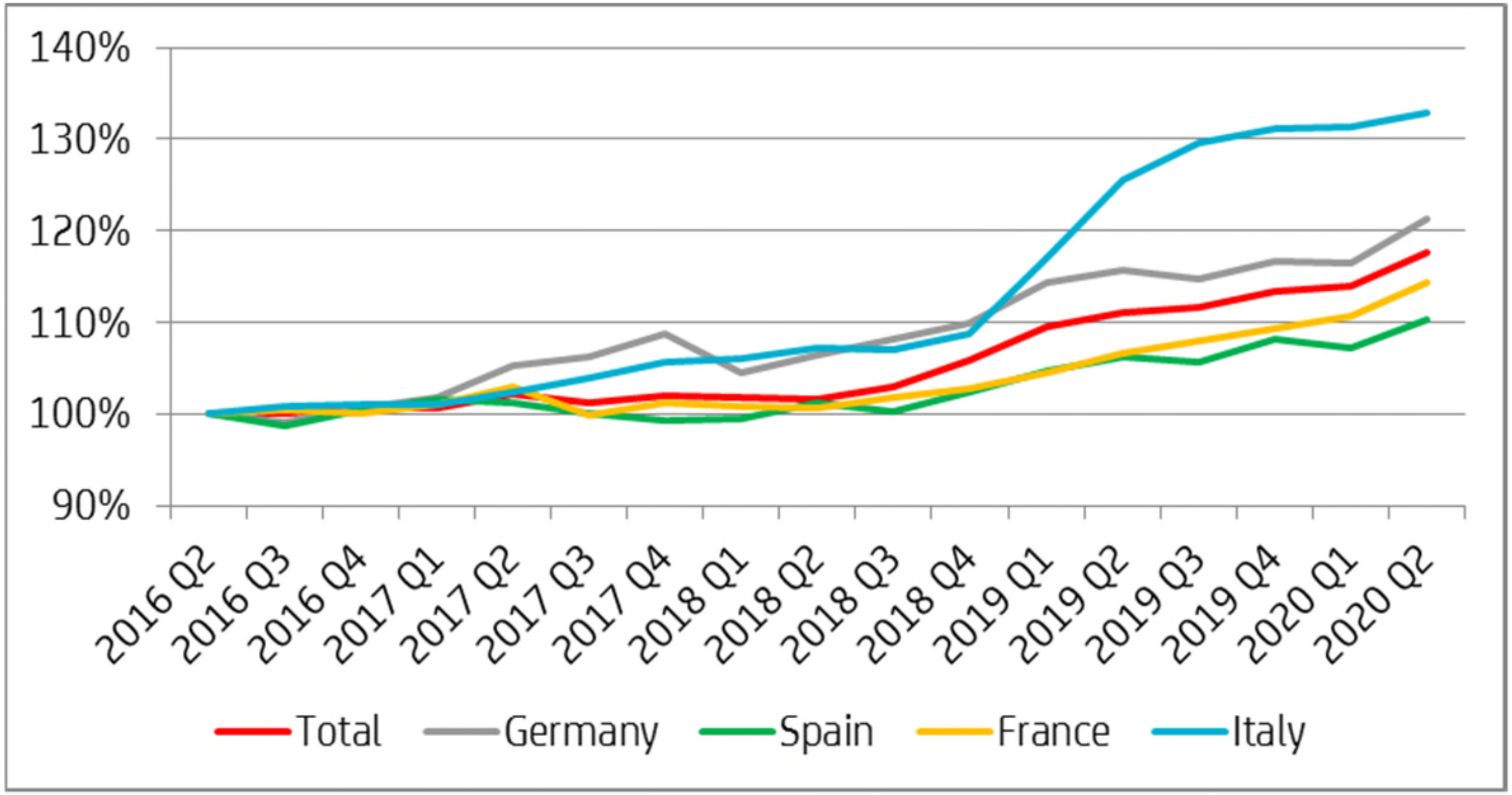
- France: 1,909bn (29.6%)
- Spain: 1,250bn (19.4%)
- Italy: 786bn (12.2%)
- Germany: 665bn (10.3%)





Source: ECB Supervisory banking statistics for banks designated as significant institutions
Reference Date: 2Q2020

Historical Trend for Households Deposits +18% c.a. from Q2 2016



Source: ECB Supervisory banking statistics for banks designated as significant institutions

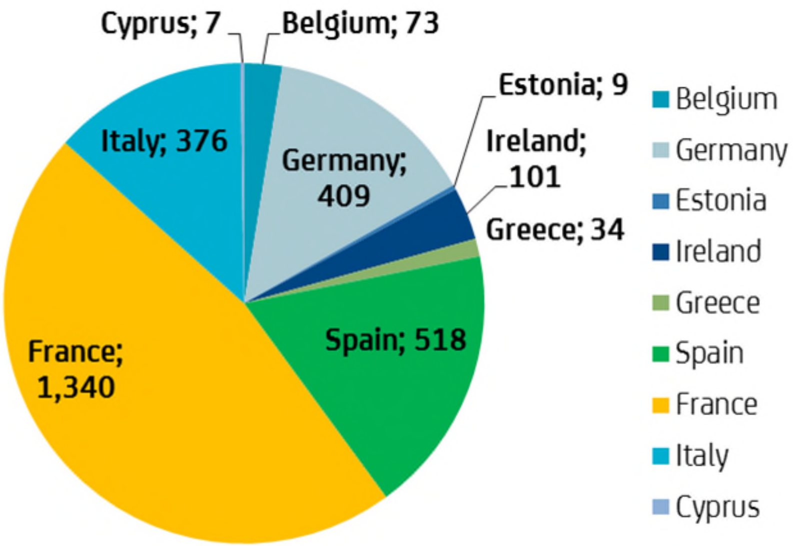
On average the volume of **Households deposits** increased by **+18%** from Q2 2016

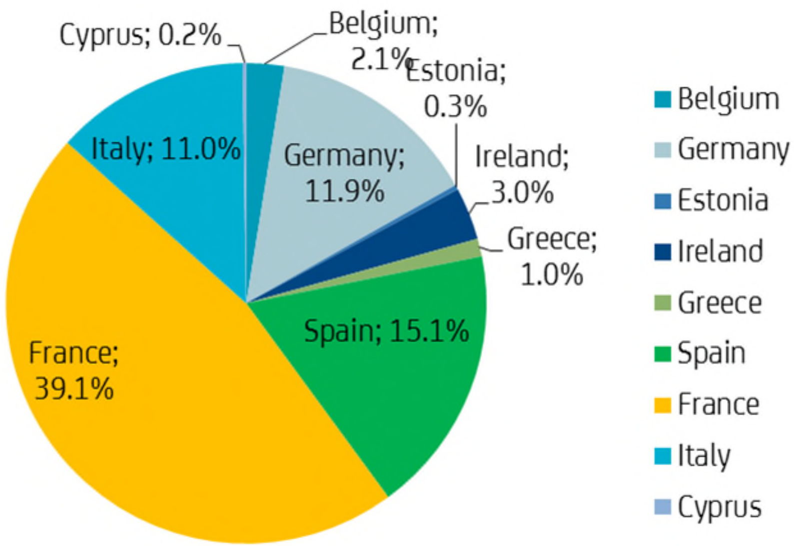
- Italy: +33%
- Germany: +21%
- France: +14%
- Spain: +10%

Non Financial Corporations Deposits as of Q2 2020
EUR 3,425bn

Overall amount of Non Financial Corporations deposits for significant institutions: EUR 3,425bn

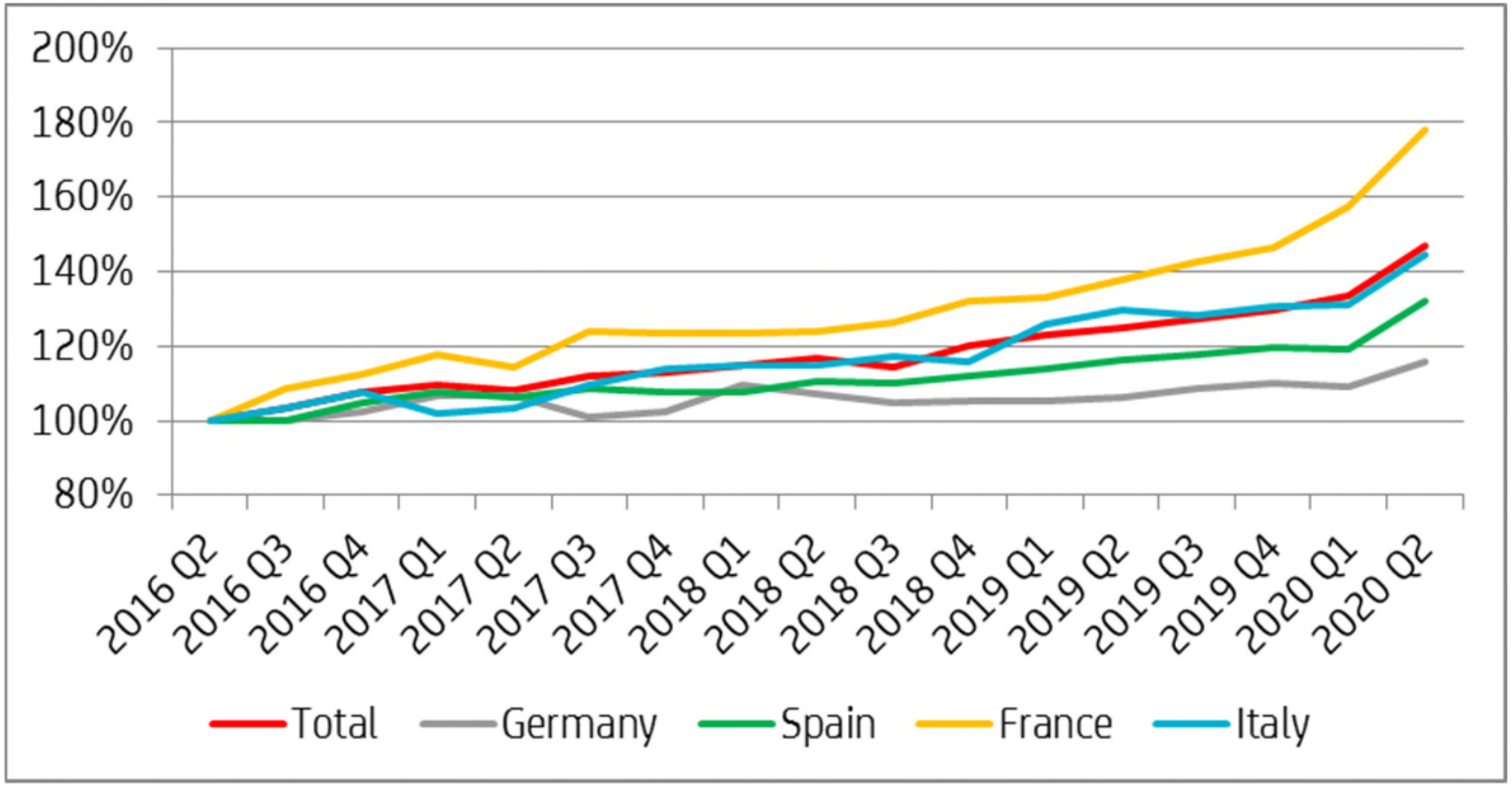
- France: 1,340 (39.1%)
- Spain: 518bn (15.1%)
- Germany: 409bn (11.9%)
- Italy: 376bn (11.0%)





 Source: ECB Supervisory banking statistics for banks designated as significant institutions
Reference Date: 2Q2020

Historical Trend for Non Financial Corporation Deposits
+47% c.a. from Q2 2016



Source: ECB Supervisory banking statistics for banks designated as significant institutions

On average the volume of **NFC deposits** increased by **+47%** from Q2 2016

- France: +78%
- Italy: +45%
- Spain: +32%
- Germany: +16%

ALM Behavioural Modelling on Deposits
Key-Factors

Bank's Strategy
- Bank's Commercial Strategy
- Maturity Transformation Strategy (trade-off between volume stability and opportunity cost)
- Liquidity Strategy (optimal mix between sight deposits, saving deposits, term deposits)
- Market share
- Credit Rating

Macro Variables
- Interest rate environment (high, medium, low, negative)
- Alternative investments opportunities (Term deposits, Government bonds, Mutual funds)
- Macroeconomic environment (GDP growth, inflation rate, currency appreciation/depreciation)

Micro Variables
- Type of client (retail, small business, mid corporate, large corporate)
- Client's income / revenues
- Client's wealth
- Client's age
- Client's financial knowledge / sophistication

Historical data are sometimes not representative of future dynamic
Different modelling approaches are used in the market
"One-size-fits-all" approach is not workable

ALM Behavioural Modelling on Deposits
Main Modelling Approaches

Main goals

- **Liquidity Risk**: estimating the portion of NMDs that can be used as a stable funding source
- **Interest Rate Risk**: reducing net interest income volatility in a multiyear horizon

Times Series Model (A)

Times series analysis techniques are used to independently **estimate stable and core amount** of current accounts

Replicating Portfolio Models (B)

It aims to **convert NMDs into a portfolio of plain vanilla instruments** (money market depo, bonds) which are traded in highly liquid market and exhibit analogous features of NMDs in term of volume and repricing

Option Adjusted Spread Models

Option pricing theory is applied to estimate the **net present value of client's embedded option**

The model considers:

- interest rate term structure
- customers' rate evolution
- volume evolution

Monetary Economics Models (C)

It aims to estimate NMDs volume evolution considering **customers' preference in allocating their financial wealth** among different instruments

A Time Series Model

- The **Times Series Model** determines **stable** and **core** using **times series analysis techniques**
- The model is usually developed using a **two-fold approach:**
  - **First** step: identifying **stable** part
  - **Second** step: determining historical **Pass-Trough Rate**
  - **Core volume** is the proportion of **stable** NMDs that do **not to reprice** due to a market rate change

Core Volume = **Stable** * **(1 - Pass-Trough Rate)**

In Time Series Model, volume stability and repricing dynamic are separately estimated

The correlation between deposit balance and customer/market rate dynamics is not analyzed

A Time Series Model
Stable Estimation 1/2

Stable Estimation

The commonly used approaches are: survival analysis or parametric model

- **"Survival analysis"** is usually performed using monthly data volumes and measures the run-off profile over a set of time horizons from 1 months to 5/10 years using **multi-cohort approach by volume or heads**. This approach may consider:
  - **live accounts at each date vs an the initial stock value** at the start of the analysis *(new accounts are excluded)*
  - **cohort evolution from opening date of new accounts opened in the last 5/10 years** *(accounts opened before the analysis period are excluded)*

- **"Parametric approach"** considers **historical trend and volatility to determine run-off** at a given confidence level. Using log linear time series regression model, the stable volume in each period follows the following equation:

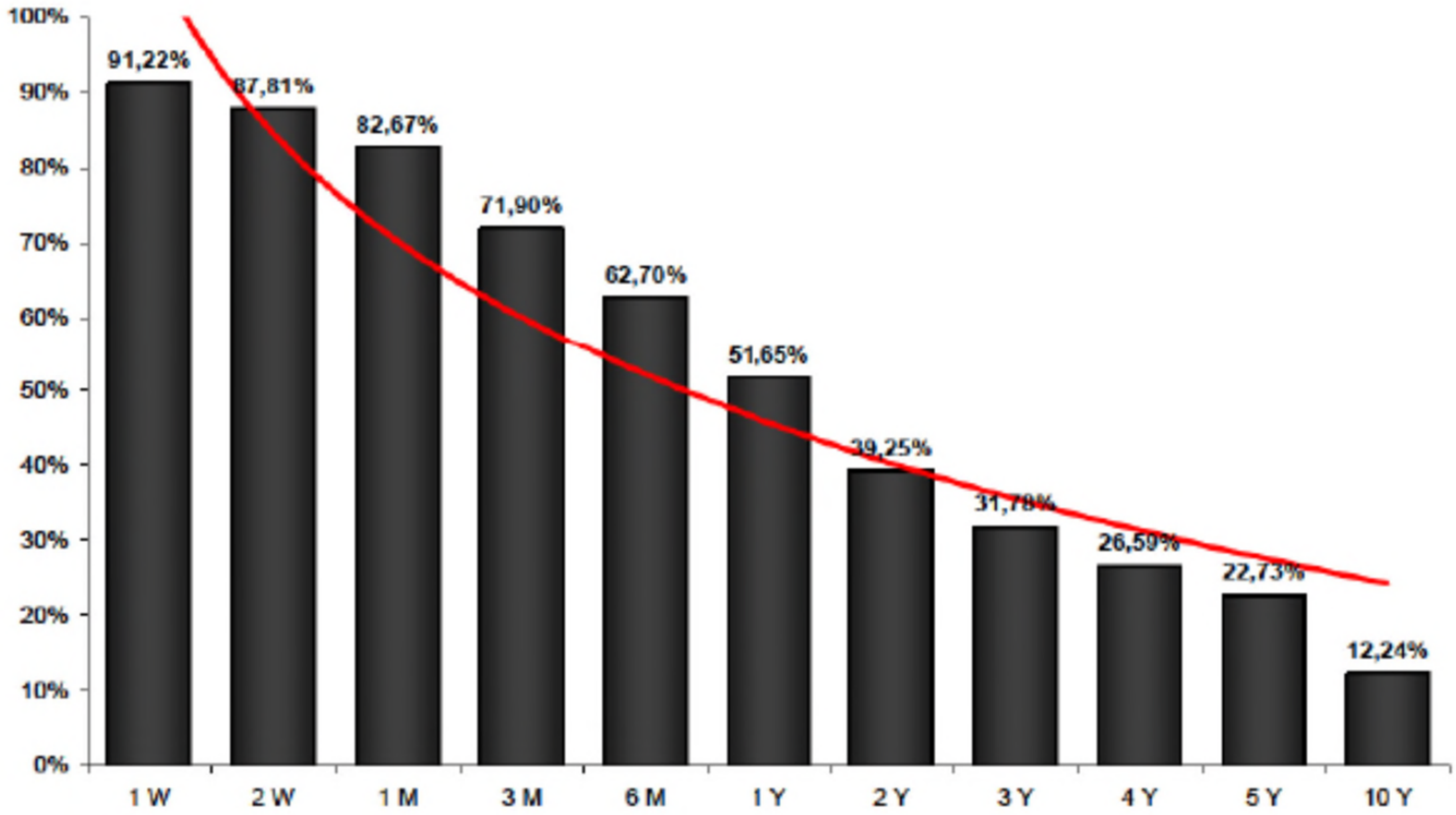
$$V(T) = V(t)\, e^{(\mu - \frac{1}{2}\sigma^2)(T-t) + \sigma\, \varepsilon \sqrt{T-t}}$$

μ = trend component;
σ = volatility;
ε = confidence level from N(0,1)

The Parametric approach can be applied on the overall volume or per capita volume in case of significant increase in the number of clients

Time Series Model

Stable Estimation



A **Time Series Model**

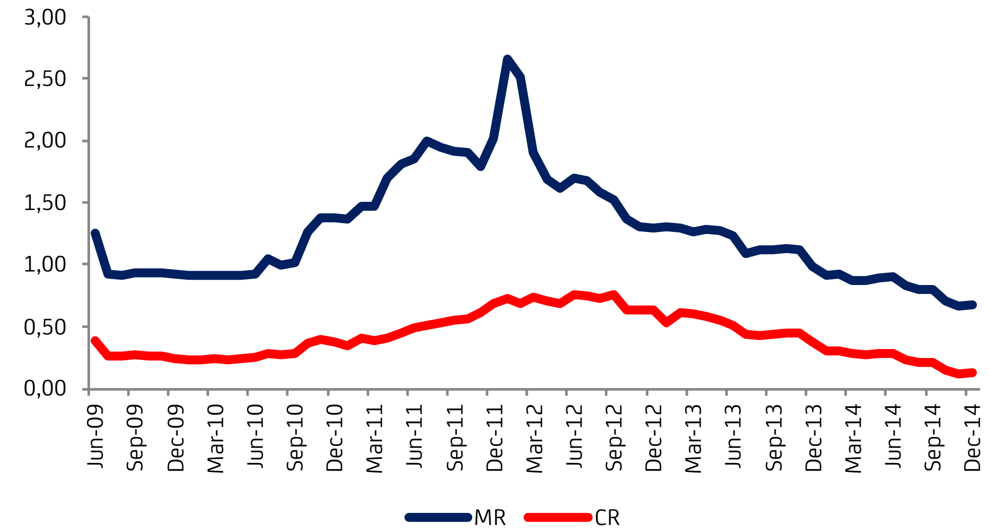
Pass-Through Rate Estimation

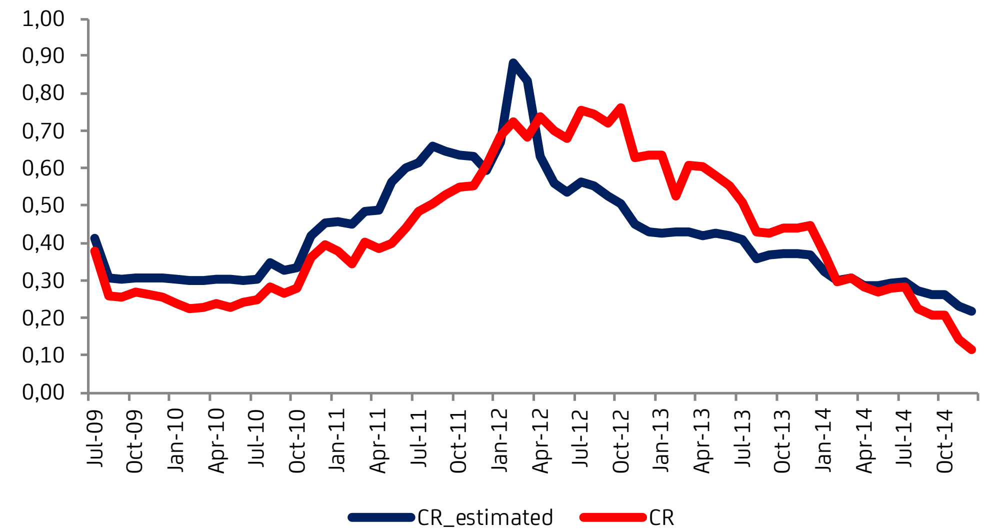
Pass-Through Rate Estimation – Method 1

"Linear Regression Model "

$$Customer\ \ Rate_{(t)} = \alpha + \beta * Market\ Rate_{(t)} + \varepsilon$$

- $Customer\ Rate_{(t)}$: average deposit rate
- α : constant markup applied by the bank
- β: is the proportion of a market rate pass-trough to customers
- $Market\ Rate_{(t)}$: market rate (e.g. Eonia / Euribor / Internal FTP)





A Time Series Model

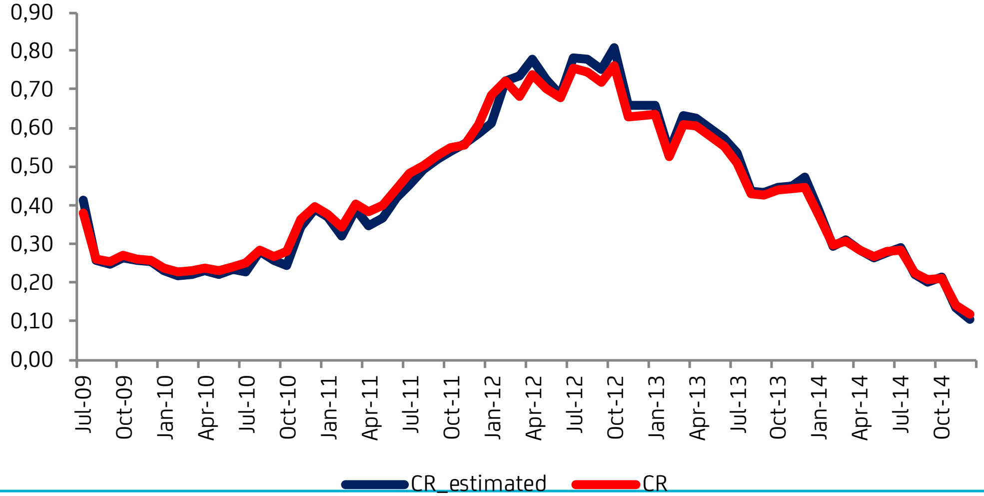
Pass-Through Rate Estimation 2/2

Pass-Through Rate Estimation – Method 2

"Error Correction Model" is based on two distinct relationships:

- **long term equilibrium:** $Customer\ \ Rate_{(t)} = \alpha + \beta * Market\ Rate_{(t)} + \varepsilon_{(t)}$
- **short term dynamic:** it measures the shift in market rates that are not instantaneously reflected on Customer Rate

$$\Delta CustomerRate_{(t)} = \gamma \Delta MarketRate_{(t)} + \theta(CustomerRate_{(t-1)} - \beta MarketRate_{(t-1)}) + \mu_{(t)}$$



- $\boldsymbol{Customer\ Rate_{(t)}}$: average deposit rate
- $\boldsymbol{\alpha}$: constant markup applied by the bank
- $\boldsymbol{\beta}$: long term pass-through coefficient of market rate
- $\boldsymbol{Market\ Rate_{(t)}}$: market rate (e.g. Eonia / Euribor)
- $\boldsymbol{\gamma}$: short-term pass-through coefficient
- $\boldsymbol{\theta}$: error-correction adjustment speed when the customer rate is not equal to long term equilibrium. *In some models a different adjustment speed is considered (θ^+ or θ^-) when residual of the long- term equilibrium is positive or negative*
- $(\boldsymbol{CR_{t-1} - \beta MR_{t-1} - k})$: *residual of the long- term equilibrium*

B Portfolio Replication

- The **replicating portfolio** model determines the **composition of an investment portfolio that best mimics the cash flow and repricing profile of NMDs**
- In a **static replication** strategy the portfolio is a **buy and hold** where maturing tranches are always renewed
  In a **dynamic replication** strategy the portfolio requires a **periodic adjustment** that depends on changes in market
- The NMDs Replicating Portfolio is usually split in three components:
  - **"Core" not sensitive to interest rate** *(constant or amortizing to zero over a medium-long term period)*
  - **"Stable Sensitive" to interest rate** *(constant or amortizing to zero over a medium-long term period)*
  - **"Volatile"** *(withdrawn over a short term period)*

  *One of the **critical point** of this approach stands in the **estimation of the amortisation schedule***
- A replicating portfolio **composition**
  - **fixed rate bonds** to match the inelastic part of the deposit that is not reactive to changes of market rates
  - **floating rate bonds** to match the elastic part of the deposits rates.

  If NMDs show significant Vega risk, the **replicating portfolio may also include caps and floors**

B Portfolio Replication 2/2

- **Portfolio's weights** are computed by solving an **optimisation problem** that is set using different rules:
  - **minimizing the tracking error** between the cash flows of the portfolio (coupon payments) and those of the NMDS (given by client rate and volume changes)
  - **maximize the risk-adjusted margin**, measured by Sharpe Ratio (average margin divided by its volatility)
  - **minimize the expected downside deviation** of not meeting a specific margin

- The replicating portfolio model consists of **the following building blocks**:
  - **Investments rules** (e.g. available instruments, constrains on portfolio's compositions and short positions)
  - **Market Rate Evolution** (e.g. historical sample, market forwards, stochastic simulation)
  - **Deposit Rate Evolution** (e.g. historical sample , historical correlation with market rate)
  - **Deposit Volume Evolution** (e.g. historical sample, straight line up to 10Y/15Y, stochastic simulation)

- **Portfolio's composition** and **related economics** are **sensitive** to the **sample used** to calibrate the model

- One of the simplest approaches is **Static replicating portfolio** using **historical sample** for calibration
  In some cases the actual yield of replicating portfolio could be materially lower or more volatile than the expected one

- In more **advanced modelling**, **weights** are **frequently adjusted** and derived from thousands of **stochastic scenarios** of future Market Rates, Deposit Rate and Volume dynamic

C Monetary Economics Models

Customers deposit their money in a bank's current accounts for different purposes

- **"Transactional purpose":** deposited amount depends on the amount of the **planned revenues and expenses in a given period of time.** The amount allocated on the deposit increases as a consequence of an increase in expenses and is ultimately influenced by salary/wealth for a retail customer and by revenues for a corporate client

- **"Precautionary purpose":** deposit depends on the **unexpected gap between planned revenues and expenses** in a given period of time

- **"Speculative purpose":** deposit is held as **"reserve of wealth"** and it is determined considering the yield of alternative investments and related **opportunity cost**

Monetary Economics Models
Financial Wealth Allocation Model

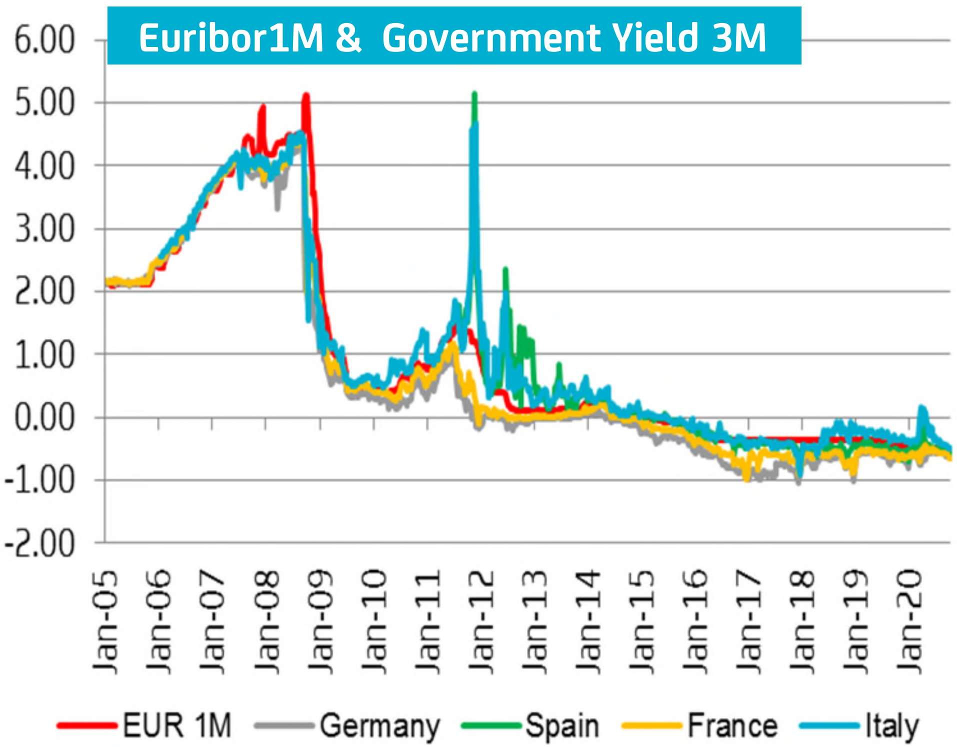
- **The NMDs models described so far** are calibrated on **aggregated time series** and **don't consider customers' preference in allocating their financial wealth** among different financial instruments depending on economic scenario (**financial wealth allocation process)**
- This approach applies the economic theory of **demand of money** in order to estimate the amount allocated on NMDs for **transactional**, **precautionary** and **speculative** purposes

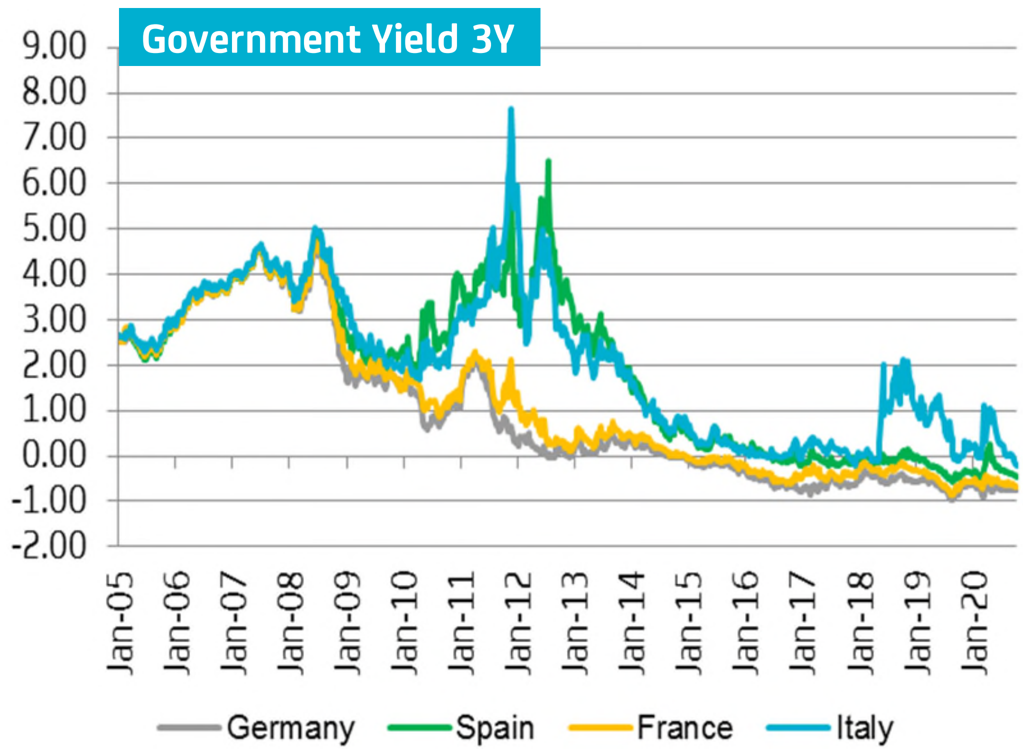
- **The model calculates the fraction of total financial wealth allocated to NMDs** in different market scenario. The amount allocated on NMDs is the result of individual's choice and varies from customers to customers

- The **fraction** is linked to several risk-factors **(RF)** that affect the NMD's volume evolution:
  - financial wealth of each customer
  - customer's idiosyncratic variables (e.g. age, financial knowledge / sophistication, type of client-bank relationship)
  - returns of alternative financial investments (e.g. bond, equity)
  - market volatility (e.g. volatility in equity index)

Monetary Economics Models
Financial Wealth Allocation Model

- After the 2008 financial crisis, there was a general reduction in the yield of short term fixed rate investments
- Starting from 2014 many interest rates were pushed into negative territory due to Quantitative Easing

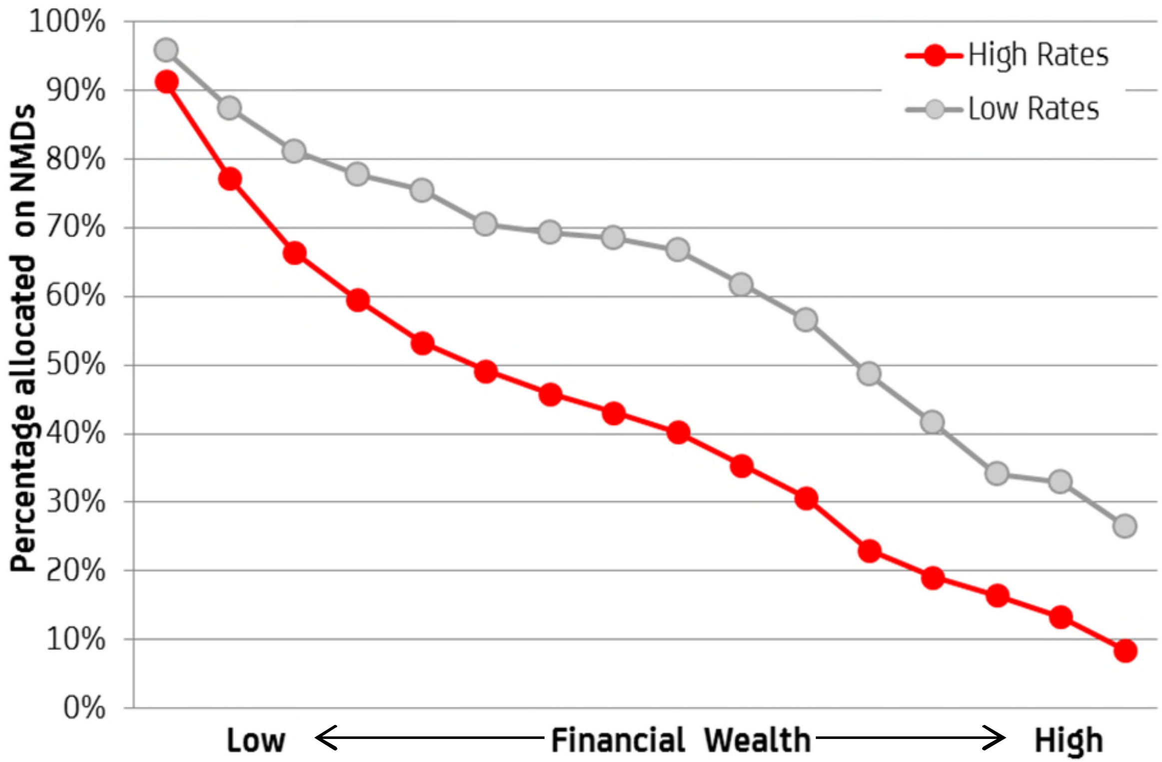




C Monetary Economics Models
Financial Wealth Allocation Model

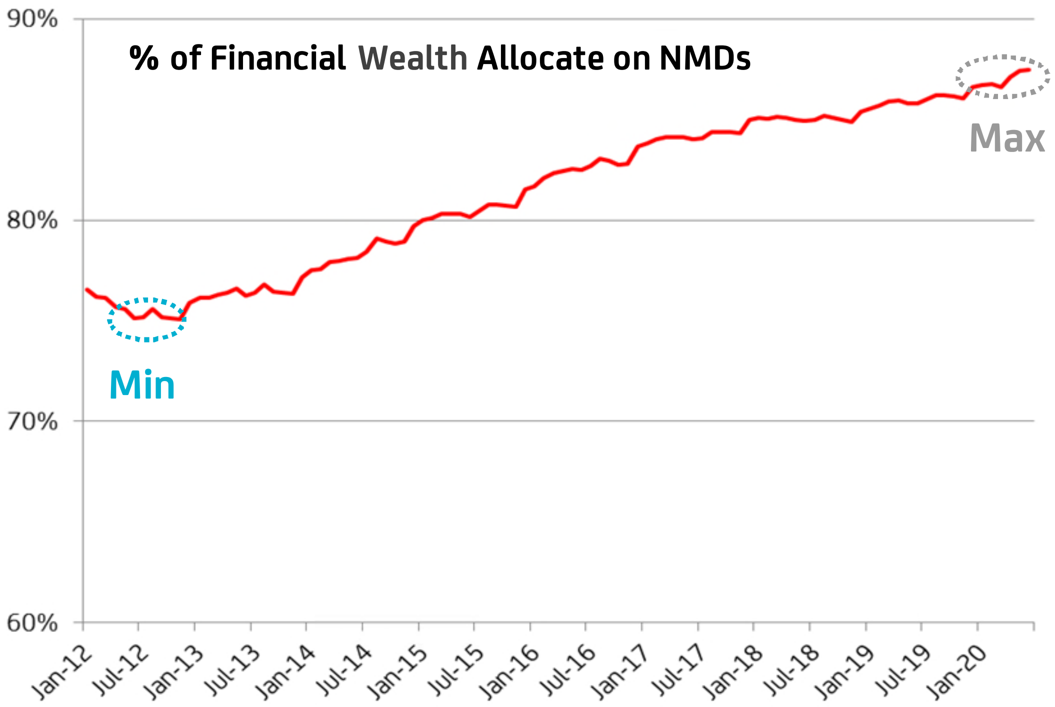
On average the **fraction** of total financial wealth **allocated to NMDs depends on**

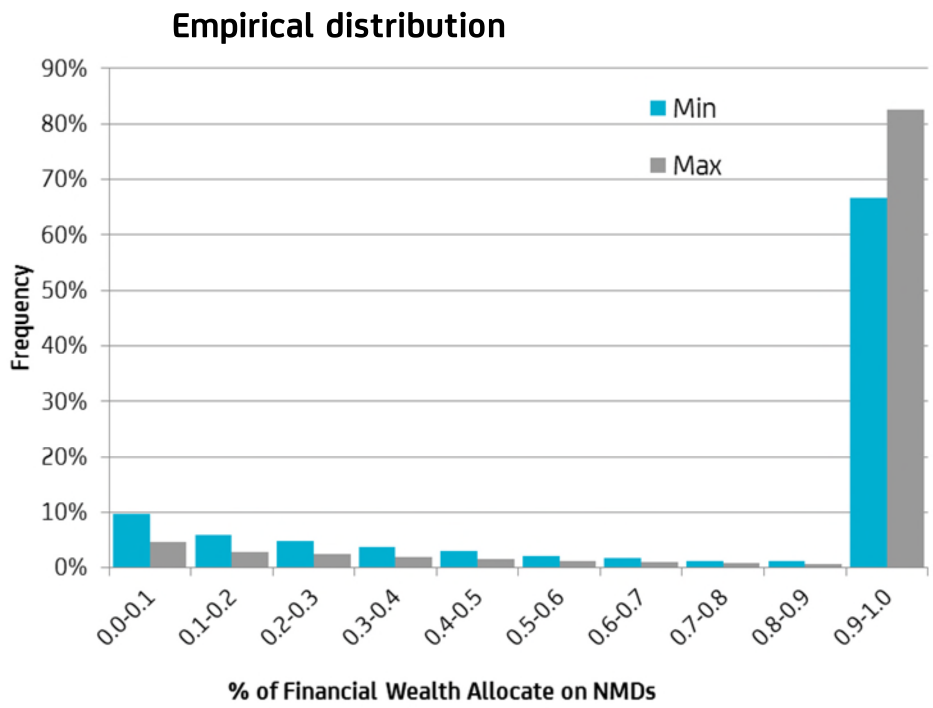
- **Overall Financial Wealth**: the percentage decreases with the increase of customer's financial wealth
- **Difference between Customer Rate and Market Rate**: the percentage increases when the opportunity cost is low or negative (liquidity preference)



C Monetary Economics Models
Financial Wealth Allocation Model

Low Financial Wealth



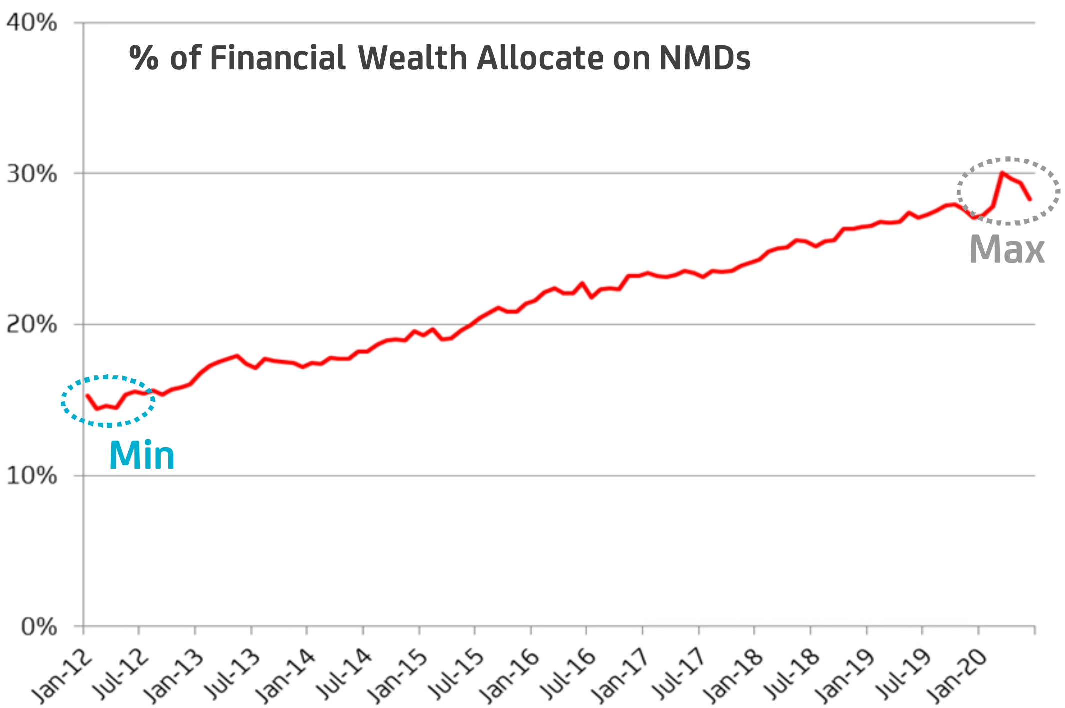


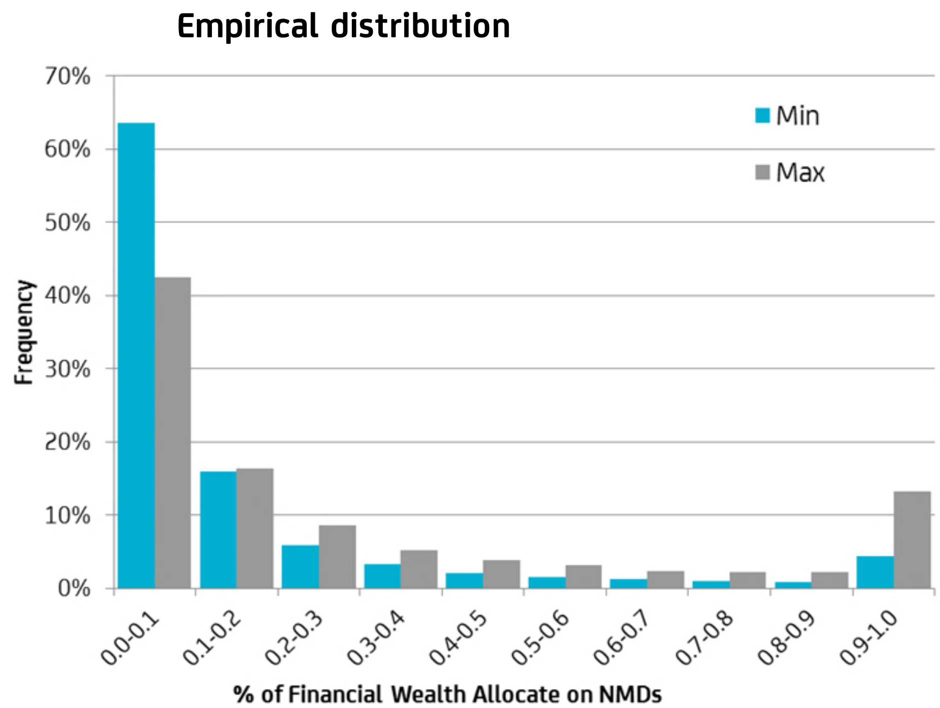
Low or negative yields imply a general increase in the financial wealth allocated on current account (+10 p.p. c.a.)

For customers with low financial wealth the behaviour is almost homogenous: the greatest part of the financial wealth is allocated on NMDs

C Monetary Economics Models
Financial Wealth Allocation Model

High Financial Wealth





Low or negative yield implies a general increase in the financial wealth allocated on current account (+10 p.p. c.a.)

For customers with high financial wealth
the behaviour is quite heterogenous and deeply influenced
by market rates

C Monetary Economics Models
Financial Wealth Allocation Model

Opportunity cost & alternative financial investments

- A **client allocates his financial wealth into NMDs and alternative financial investments** based on his risk appetite. Heterogeneous behavior among customers depending on their utility functions and risk / return profile of alternative investments

- If an **risk adjusted return of alternative investments is higher than the deposit rate**, there exists a **financial incentive** for the client **to allocate the excess liquidity for speculative purposes** leaving on the current account only the liquidity for transactional and precautionary purposes

- The model considers the following financial variables **(risk factors)** to take into account the opportunity cost:

  1. **Bond financial incentive.** It is the difference between the Treasury yield rate *l*(*t*) and the deposit client rate *c(t)*
  2. **Equity financial incentive.** It is equal to monthly return of equity market
  3. **Risk Aversion.** It is calculated using the implied volatility of equity options with different maturities

1. Bond financial incentive

$$r_B(t) = \frac{1}{m_B}\sum_{q=1}^{m_B}(l(t)-c(t))_{t-q+1}$$

2. Equity financial incentive

$$r_E(t) = \frac{1}{m_E}\sum_{q=1}^{m_E}\log\left(\frac{E_t}{E_{t-1}}\right)_{t-q+1}$$

3. Risk Aversion

$$\sigma_E(t) = \frac{1}{m_{\sigma_E}}\sum_{q=1}^{m_{\sigma_E}}\sigma_{t-q+1}$$

C Monetary Economics Models
Financial Wealth Allocation Model

- The **empirical distribution** is characterized by **high concentration of clients allocating the totality of their financial wealth to NMDs** even when the return of alternative investments is positive (strong risk aversion or significant buffer for prudential purposes)

- The **following mixed random variable Λ is used to fit the empirical distribution** characterized by extreme values

$$F_\Lambda(\lambda) = \begin{cases} \Pr(\Lambda = 0) & \lambda = 0 \\ \Pr(\Lambda = 0) + [1 - \Pr(\Lambda = 0) - \Pr(\Lambda = 1)]F_{\mathfrak{B}}(\lambda) & \lambda \in (0,1) \\ 1 & \lambda = 1 \end{cases}$$

where $F_{\mathfrak{B}}(\lambda)$ denotes the cumulative distribution function (**CDF**) of the beta random variable $\mathfrak{B}$ and $\Pr(\Lambda = j)$ is the probability that Λ is equal to j, with j = 0, 1. It represents the so called "**zero-one inflated**".

- The dependencies of the distribution's **parameters** from financial variables (Bond financial incentive, Equity financial incentive, Risk Aversion) are **estimated** by applying a **methodology similar to Generalized linear models** (GLMs) developed by McCullagh and Nelder. The **beta regression model** is used For the **continuous part** of the data. The **logistic regression model** is used for the **discrete part** of the data

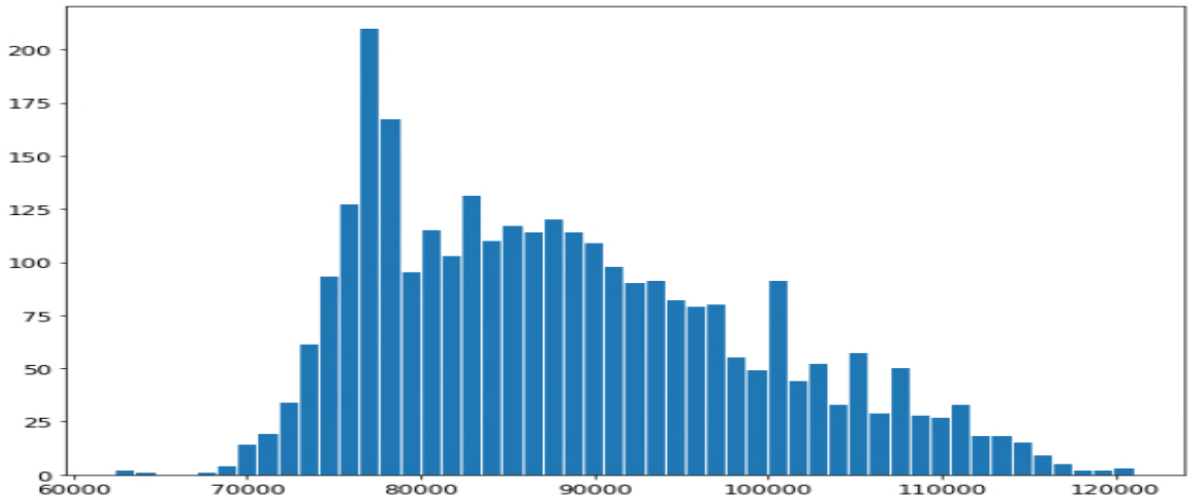
- A detailed explanation of the model in the article **"NMD Modelling: Financial Wealth Allocation Approach"** by Francesco Frascarelli and Vanessa Pagliaccia in "A Guide to Behavioural Modelling"*

* A Guide to Behavioural Modelling by Matteo Formenti and Umberto Crespi – Risk books

Monetary Economics Models
Financial Wealth Allocation Model

Stable Volume Estimation

- The **stable volume is estimated performing a scenario simulation** that consists of the following steps:
  - computation of market scenario (e.g via a MonteCarlo approach) for financial variable
  - calculating the resulting forecasted volumes under scenario
  - taking the i-th percentile of the simulated distribution as stable part to take into account unfavourable market dynamic that may cause a reduction of the outstanding volume



Final Remarks

- There are **several ways of modelling Non Maturity Deposits** depending on the scope of the model
- The **relationship** between deposit balances and deposit rate dynamics **may change from bank to bank and even**, within the same bank, **over time**
- The usage of longer time series (**backward looking approach**) may not reveal relevant information when the future is likely to be very different from the past and **may increase the risk of not detecting changes in market or behavioural structure**
- **Sensitivity and scenario analyses** may help to understand **customer's behaviour in different economic environment**
- **ALM Behavioural Modelling of Non Maturity Deposits remains an art as well as a science**