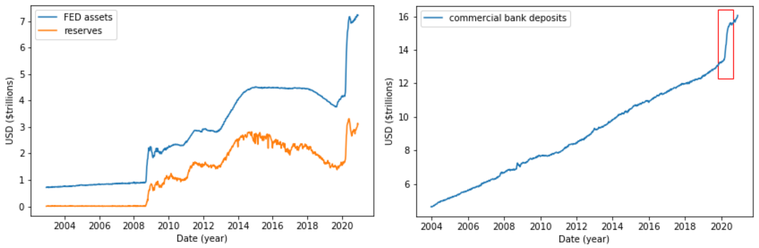
Where Does the Stimulus Go? Deep Generative Model for Commercial Banking Deposits

Jenny Ni Zhan

Introduction

- FED uses quantitative easing (QE) as response to economic slowdowns, such as 2008 and recently Covid-19 crisis
- $2.2 Trillion Cares Act led to unprecedented growth in commercial banking deposits



- Deposits can be classified by holder: **Retail** (held by individuals), and **Wholesale** (held by large corporations)
- How was deposit growth distributed across retail, wholesale?
- Missing direct data for retail, wholesale deposits
- Will infer using FDIC dataset on banks and generative model

Impacts

- Economic Policy – QE and macroeconomic effect on deposits held by individuals vs. large corporation
- Bank Risk Management – Retail and Wholesale deposits largely different in terms of interest rate risk, liquidity risk

Dataset

- FDIC Statistics of Depository Institutions, quarterly financial reporting information of FDIC institutions since 1993
- Number of institutions decreased from 10,100 in 2000 to 5,300 in 2019

Table 1: Bank features and statistics for 5113 FDIC 2019-Q4 banks.

	Domestic deposits		Deposits per office		Total accounts		% small amount	% small accounts	% retail loans
	$B	Log	$B	Log	$\times 10^5$	Log			
Mean	2.6	12.4	0.27	10.9	1.1	9.1	65	98	41
StdDev	-	1.5	-	0.9	-	1.4	15	3	22
Min	0.006	8.7	0.002	7.7	0.003	5.5	0.1	46	0
Max	1400	21.1	123	18.6	980	18.4	100	100	100

- Deposits and accounts approximately log-normal with fat tails on the right
- Small amounts/accounts refers to less than FDIC limit, and higher values indicate bank likely has more retail deposits

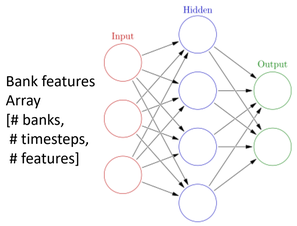
Objective

- Build deep generative model as data-driven method to infer retail, wholesale deposits
- Quantify impact of QE and macroeconomic factors on retail, wholesale deposits

Methods

Deep Generative Model (DGM)

- Model deposits in each bank as sum of account balances
- Assumption: Retail and wholesale account balances arise from separate distributions (use log-normal distribution)
- For each bank b at timepoint t, we learn five parameters:



$p_{b,t}$	Fraction of retail accounts
$\mu_{b,t,\text{ret}}$	Mean of retail distribution
$\sigma_{b,t,\text{ret}}$	Standard deviation of retail distribution
$\mu_{b,t,\text{ws}}$	Mean of wholesale distribution
$\sigma_{b,t,\text{ws}}$	Standard deviation of wholesale distribution

- By minimizing loss $\mathcal{L}_{\text{samples}} = \frac{1}{n_t \cdot n_b} \sum_t^{n_t} \sum_b^{n_b} \sum_{\mathcal{I}} (\mathbf{x}_{b,t,i} - \mathbf{v}_{b,t,i})^2$
- Where $\mathcal{I}$ denotes set of metrics total deposits, deposits in small accounts, fraction of small accounts, and
  - $\mathbf{x}_{b,t,i}$ Actual data
  - $\mathbf{v}_{b,t,i}$ Estimated from samples s of account balances

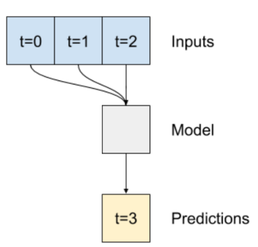
  $s_{b,t,\text{ret}} \sim \text{lognormal}(\mu_{b,t,\text{ret}}, \sigma^2_{b,t,\text{ret}})$ $\quad s_{b,t,\text{ws}} \sim \text{lognormal}(\mu_{b,t,\text{ws}}, \sigma^2_{b,t,\text{ws}})$
- Inference of retail deposits: $\mathbf{r}_{b,t} = \frac{n_{\text{accounts},b,t}}{n_{\text{samples}}} p_{b,t} \sum s_{b,t,\text{ret}}$
- Implementation details in paper

Benchmark

- Using FDIC Branch Office Deposits, deposits in branches less than $500 Million considered retail, else wholesale

Time Series Regression

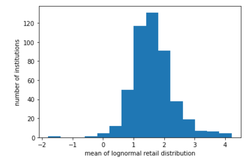
- Predicting wholesale, retail deposits, Use DGM inference as ground truth
- Reserves, loans, retail loans as input
- Linear regression with four backward period lag
- Caveat is association not causation



Results

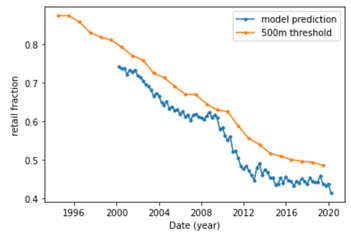
Validate Retail, Wholesale Account Balance Distribution

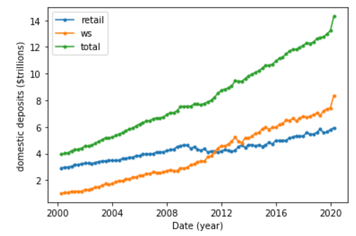
- Most means for retail are between 1 – 2 ($2,718 – $7,389)
- Wholesale distribution means are higher, estimated 4.5 ($54,500) and 3.5 ($33,000) for two wholesale-only banks



Deep Generative Model prediction

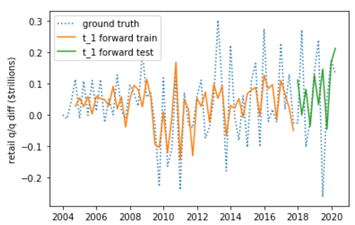
- Below left: Model has similar trend as benchmark with 4x higher frequency prediction
- Below right: Model predicts large jump in wholesale deposits in Q1 2020, appears correct in light of Covid crisis

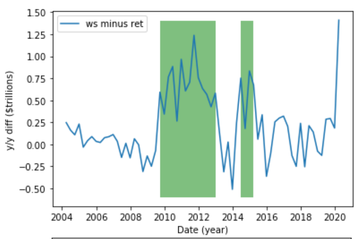




Time Series Model

- Below left: forecast matches well in direction, magnitude





- Right: Green periods with wholesale deposits growing much faster than retail correspond with high reserves and low loan growth

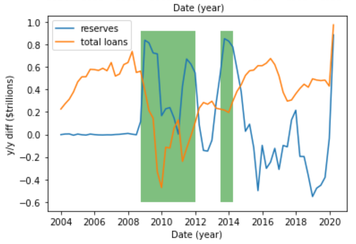


Table 2: Impact of Macroeconomic Inputs on Deposits

	Reserves	Total Loans	Retail Loans
Retail	-6%	53%	-23%
Wholesale	61%	64%	-23%
Total	54%	116%	-45%

Conclusions

- Novel generative model splits deposits by retail, wholesale
- QE increases wholesale, Loans increase wholesale and retail
- Previous QE increased deposits more for large companies than for individuals