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Research Article

Central Bank Losses and the Shareholder Values of Commercial Credit Institutions

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Abstract

Quantitative Easing (QE) created huge excess reserves of Eurozone credit institutions. When Quantitative Tightening (QT) set in, these reserves had to be remunerated by the European Central Bank (ECB) at the deposit facility rate. Hence, credit institutions presently benefit from large interest incomes on their reserve holdings, reflected by increasing share prices. I study the case of Deutsche Bank Aktiengesellschaft (AG) using a structural vector autoregression (SVAR) framework to identify the root causes of the recent rise in Deutsche Bank share prices. In order to identify the effects of QT on stock prices, each empirical model is estimated on two different samples: One sample which ends in June 2022 when QE was discontinued and a second sample spanning the same time period plus the rather short QT-period July 2022 to September 2023. The stark difference in results suggests that autonomous monetary policy decisions which raised the deposit facility rate since June 2022 have significantly increased the price of Deutsche Bank stocks. Since the interest payments to commercial credit institutions are not offset by revenues from ECB assets purchased during QE, this implies that private wealth of shareholders increased at the expense of central bank profits that would normally contribute to public budgets.

Keywords

Quantitative Easing, Central Bank Losses, Deposit Facility, Structural Vector Autoregression

1. Introduction

The surge in inflation after the COVID-19 pandemic forced major central banks to discontinue quantitative easing (QE) and to switch to quantitative tightening (QT). Due to an abundance of bank reserves, increasing the money market interest rate required remuneration of excess reserves. Since the deposit facility rate (at which excess reserves are remunerated) essentially functions as a floor to the overnight interbank rate, increases in the deposit facility rate cause higher interbank rates. As refinancing credits to non-banks becomes more expensive, money market rates also increase.

While this is the policy effect desired by central banks, the unwelcome consequence of a rapid transition from QE to QT are large central bank losses, cf. Levin et al. [8]. During QE, central banks have expanded their balance sheets, acquiring fixed interest securities on the asset side. On the liability side, this is matched by greatly increased reserve positions of commercial credit institutions, remunerated with flexible interest rates. The maturity mismatch caused by this fixed-for-floating-rate swap necessarily creates a large interest rate exposure (Belhocine et al. [2]). With the yield from QE-securities being close to zero, remuneration of the corresponding reserve holdings creates uncovered costs for central

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banks.

For instance, excess reserves in the Eurosystem were approximately 4 trillion Euro in 2023. At the current (December 2023) 4% level of the ECB's deposit facility rate, this translates to approx. 160 billion Euro interest expenditure for the Eurosystem. Since asset yields after QE are close to zero (even negative for some assets), central banks within the European System of Central Banks (ESCB) face the dilemma of either recording substantial losses for 2023 and subsequent years or resorting to balance sheet operations. These operations may involve activating hidden reserves or trimming down published reserves to avert the necessity of reporting losses arising from monetary policy. As Wellink and Marsh [11] point out, this may not be without political risk, though.

Much of the literature has focused on the size and economic importance of current and expected central bank losses. This has been done in either a flow perspective (essentially interest earnings minus interest expenditures, or in a stock perspective (unrealized loss positions), both with reference to central banks' securities portfolios for monetary policy purposes. See, e. g. Gros and Shamsfakhr [6], Anderson et al. [1], de Grauwe and Ji [5], Belhocine et al. [2].

While from a present-value perspective the stock and the flow approach should come to similar conclusions, actual loss estimates can be very different. For instance, Anderson et al. [1] compute much smaller losses for the Federal Reserve System under a flow perspective (cumulated losses of about $ 120 billion US-$) than under a stock perspective (unrealized losses of $ 670 billion US-$ at end-2022 in their baseline scenario). For the Eurosystem, flow estimates yield losses of 670 billion Euro (and possibly more) in Gros and Shamsfakhr [6], while stock estimates by Belhocine et al. [2] result in a peak of unrealized losses of more than one trillion Euro in 2023.

In any case, the magnitudes involved are substantial. Frequently, authors emphasize that these losses are ultimately shouldered by the taxpayer – constituting a negative seigniorage income. This, in turn, leads to diminished or zero disbursements to the government budget and may necessitate the recapitalization of the central bank to avert negative central bank capital.

Apart from this, however, there is a flip side of the cost to taxpayers pointed out by e. g. de Grauwe and Ji [5]: The negative net interest income of central banks on their QE portfolio translates into a positive interest income on excess reserves for commercial credit institutions that had sold securities to the central bank during QE.

In a market economy, interest payments to banks as creditors have a number of justifications. They can be seen as letting the creditor participate in the marginal product of capital an investor may realize with borrowed funds. Moreover, they contain a liquidity premium paid to the creditor in compensation for exchanging a liquid asset against a less liquid one. And, of course, they contain a risk premium that rewards the creditor for bearing illiquidity or insolvency risk of the debtor.

None of these justifications for paying interest applies to reserve holdings at a central bank, though. Nowhere do central bank reserves cause any marginal product of capital. Moreover, reserves are completely liquid, so there is no liquidity risk. And, obviously, there is no credit risk either: A central bank cannot go bankrupt. What, then, is the economic justification for a public institution to "print" substantial amounts of money and channel them as interest payments to private credit institutions?

The answer to this question may be contentious and I will not try to give it in this paper. Rather, I will focus on the wealth effect the interest payments on excess reserves have. Private banks are owned by private agents. Interest payments on excess reserves are unearned incomes that cause windfall profits for private banks and windfall capital gains for private agents who own the banks' equity.

Central bank monetary policy always and necessarily entails distributional effects. Yet, since a central bank has no mandate to subsidize (or tax) certain groups of agents, it is imperative that it studies the size and nature of non-neutralities caused by its monetary policy decisions. In the Eurozone, no such study seems to have emerged from the ECSB's research departments. This is even more surprising since a ruling by the German Federal Constitutional Court (FCC) explicitly charges the ECB with assessing side effects of its policy and ensuring that they do not violate the principle of proportionality enshrined in the Article 5 of the Treaty on the Europan Union, cf. FCC [7].

This study aims to close this gap. I address the problem of (unwarranted?) increases in the wealth of private agents by studying the stock price of a particular credit institution, the Deutsche Bank AG. Since stock prices change for many different reasons, the challenge consists in analyzing if the price of a Deutsche Bank share has in a statistically significant way increased due (in a causal sense) to higher remuneration of excess reserves by the European Central Bank. To this end, I utilize structural vector autoregressions (SVARs) to decompose changes in stock prices into different components, one of which will be an autonomous monetary policy decision to change the ECB's deposit facility rate.

The remainder of this paper is organized as follows: Section 2 presents some (stylized) facts about commercial banks' liquidity needs, excess reserves at the ECB and bank profits attributable to increase remuneration of these reserves. Section 3 describes the data and outlines the methodology used in structural vector autoregression (SVAR) analysis. Section 4 studies SVAR models aimed at identifying the causal effect of increased excess reserve remuneration on the share price of Deutsche Bank AG. Section 5 concludes.

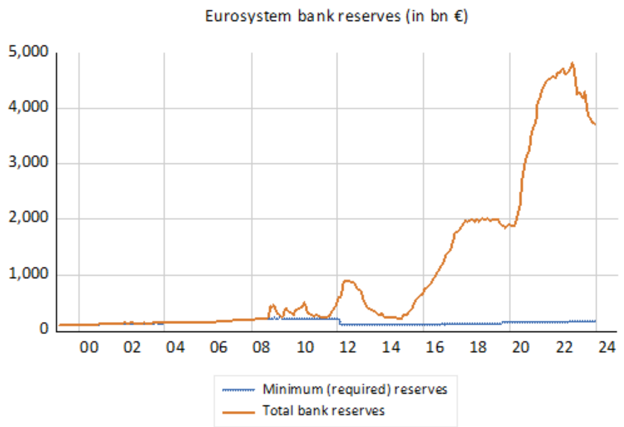
2. Some Facts

Banks need sufficient liquidity. The most liquid asset is central bank money, i. e. cash or reserves at the central bank.

Typically, cash is needed for certain payments in regular day-to-day business. Reserves are also used for many regular payments, mostly for transactions between banks. But, as the name indicates, reserves are also held as a liquidity buffer for times of crisis. Banks want to make sure that they can honour all their payment obligations smoothly even in situations of severe economic stress.

Currently, the ECB requires commercial banks to have minimum reserves of 1% of essentially all non-bank deposits and securities with maturity of up to two years. The minimum reserve coefficient used to be 2% prior to January 18, 2012. Up to October 2008, i. e. prior to and even in the first months of the financial crisis, actual reserves (on current account and in the deposit facility) hardly surpassed the minimum reserve requirement. This suggests that up to the fiancial crisis commercial banks viewed the minimum reserves as sufficiently great to satisfy their liquidity needs – or had other, less costly means of liquidity buffer management.

Starting in 2008, however, commercial banks' reserve holdings have increasingly exceeded the minimum requirements, cf. Figure 1, left panel. This may have been caused by a desire to have larger liquidity buffers in times of crisis (the financial crisis was almost immediately followed by the Eurozone sovereign debt crisis). It may also have been an undesired consequence of unconventional monetary policies introduced by the ECB in an attempt to boost investment by providing ample liquidity to commercial banks. For instance, in response to the financial crisis the ECB moved to a policy of unlimited liquidity provision through fixed rate tenders with full allotment, accepted lower-quality assets as collateral in refinancing operations, introduced several waves of long-term refinancing operations (LTROs) and started the first asset purchase programmes (e. g. for covered bonds and asset-backed securities)[1]. All these measures increased reserve holdings greatly and there was no way how the banking system as a whole could have reduced them.



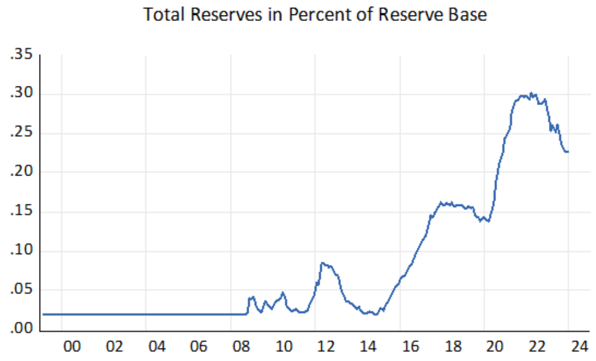


Figure 1. *Eurosystem bank reserves (in bn €).*

However, it is remarkable that even in the period between 2008 and March 2015 actual reserves were usually below 5% of the reserve base, cf. Figure 1, right panel. The one exception is due to two LTROs in November 2011 and February 2012, dubbed the "Big Bertha" by ECB president Mario Draghi. These operations created unprecedentedly high levels of reserves. The fact that banks reduced their reserve holdings subsequently (i. a. by repaying a substantial share of the LTROs as early as 2013) indicates that banks deemed such high reserve holdings excessive. By 2014, reserves were back at roughly 2% of the reserve base, twice as much as required, but substantially lower than in the two previous years.

On balance, it seems fair to say that commercial banks may voluntarily hold higher reserves than required, but that 2% seems to be just fine in normal times and that even in times of crisis, banks do not see any need to hold more than at most 5% of the reserve base (i. e. deposits and securities with maturity or period of notice of not more than two years). These estimates seem to be very cautious, as 2% translates to saying that current reserves are about 12 times higher than necessary. Observe that former Bundesbank president Jens Weidmann and Commerzbank chief economist Jörg Krämer seem to think that just 1% is enough, since they state that current excess reserves are 23 times higher than necessary, cf. Weidmann and Krämer [10].

Using this finding, I will henceforth call reserves "redundant" when they exceed 5% of the reserve base. Thus, redundant reserves are reserves which a bank most likely would not need as a liquidity buffer even in adverse scenarios. This is not to say that there cannot be crises (e. g. bank runs) which require much higher quantities of central bank money. It merely states that banks seem to be confident that 5% reserve holdings are enough as immediate shock absorber and would let bank managers sufficient time to increase liquidity by refinancing operations, asset sell-offs or emergency measures negotiated with the central bank.

If all banks held the same proportion of their short term liabilities (i. e. their reserve base) as reserves, then the average 2023 redundant reserve position for all Eurozone credit institutions would be € 3237 billion. The 2023 interest income on redundant reserves, taking into account the changes in the

1 By contrast, the ECB's Securities Market Programme (SMP) and Outright Monetary Transactions (OMT) programme did not create additional liquidity due to weekly sterilization.

deposit facility rate (increase from 2% in January 2023 to 4% in December 2023), would then equal € 108 billion for all Eurozone banks. This is a substantial amount of money that increases the shareholder value of the credit institutions. At the same time, it is a substantial cost to national central banks in the Eurosystem and reduces the shareholder value of the central banks, i. e. it comes at the expense of the general public, represented by the Eurozone governments as the shareholders. Unfortunately, it is hard to explain what the economic justification for such a transfer of wealth from the state to the banking sector would be: Redundant bank reserves at a central bank do not finance productive investment or generate a marginal product, they bear no risk, involve no loss of liquidity and do not provide a financial stability function in the sense of a precautionary liquidity buffer.

Two more remarks on this: First, I have introduced the unconventional concept of redundant reserves (i. e. in excess of any reasonable liquidity buffer) to emphasize the fact that banks, the recipient of large payments from their central bank, do not, by holding such large reserves, provide any service that could justify the payments. Little is changed if we study the conventional condept of excess reserves instead, i. e. reserves exceeding the 1% minimum reserve requirements. In this case, obviously, the interest income of commercial credit institutions is somewhat higher and in 2023 amounts to € 130 billion, cf. Table A1 in the appendix.

Second, it is sometimes argued that the positive interest income under QT is a compensation for negative interest income under QE. (Recall Eurozone central bank interest rates were negative during QE). This argument is misleading. Adding interest incomes of Eurozone commercial banks over 2015.03 – 2023.12 gives a positive interest income of €80 billion on excess reserves (or € 71 billion on redundant reserves). Hence, the negative interest incomes have already been greatly overcompensated. But after 2023, each additional year will generate additional positive income in excess of € 100 billion as long as reserve holdings and interest rates stay at or fall only mildly below current levels.

Bank excess reserves will stay high for many years to come, albeit on a declining path. The International Monetary Fund (IMF), cf. Belhocine [2], assumed the remaining weighted average maturity (WAM) of the ECB's asset portfolio to be 7.1 years in June 2023. Very roughly one might take this as saying that half of the assets will mature within seven years, with the other half staying on the ECB's balance sheet for even longer and reinvestment in fresh bonds still taking place in the ECB's Pandemic Emergency Purchase Programme (PEPP) at least until the end of 2024. If bank reserves develop proportional to ECB assets, they would still account for roughly € 1600 billion by 2030. Since it seems highly unlikely that the deposit facility rate returns to values close to zero soon, commercial banks will have substantial interest income on excess reserves for years to come. The expectation of such income streams should be visible in share prices already today.

For instance, let us look at a single prominent Eurozone bank, Deutsche Bank AG. According to published balance sheets, cash and central bank balances were € 74 billion at the end of 2014, shortly before QE began. It is unclear how much of this was cash and how much was reserves. In any case, on December 31, 2022, the same position was at € 179 billion. This is an increase of € 105 billion and it is not likely that much of it is due to increased cash positions. If we assume that in 2014 Deutsche Bank will have made sure it had sufficient reserves to safeguard its liquidity, it follows that approximately € 100 billion have been built up as redundant reserves between 2014 and 2022.

The average deposit facility rate in 2023 was 3.4%. Applying this rate to € 100 billion yields interest income on redundant reserves equal to € 3.4 billion (bn). Compare this to published before-tax profits of Deutsche Bank: In the five fiscal years 2018-2022 profits were € 1.3 bn, € 2.6 bn, € 1.0 bn, € 3.4 bn and €5.6 bn, respectively. This is to say that the interest income from redundant reserves in 2023 is of the same order of magnitude as the annual profit Deutsche Bank earns on all its financial services. In fact, it is substantially larger than the average before-tax profit over these five years (€ 2.8 bn) and second only to the 2022 profit (which already includes about € 200 millon of such interest income).

For yet another back-of-the-envelope calculation, assume that redundant reserves of Deutsche Bank decrease linearly from € 100 billion in 2022 to zero over fifteen years. Assume the deposit facility rate is 3% throughout this period and discount future interest incomes to their 2023 present value with the same rate. It then turns out that Deutsche Bank shareholders should expect over these fifteen years a total payment of interest on redundant reserves equal to € 21 billion in 2023 present value terms.

Obviously, the expectation of high interest income may have built up much earlier than the start of QT actually occurred. Redundant reserves were accumulated ever since QE began and rational agents may since then have anticipated increased future profits due to reserve remuneration once interest rates returned to normal. But for a long time it was completely unclear when interest rates would rise again and for how long, in the meantime, Deutsche Bank would have to endure zero or even negative interest rates on central bank reserves. In June 2022, however, the decision of the ECB board to raise interest rates for the first time since 2011 (!) against the background of rapidly rising inflation was crucial information for markets to revalue the share of Deutsche Bank. And, in fact, market data convey a 32% appreciation within a short time: The share price increased from € 8,05 on July 1, 2022 to € 10.59 on December 30, 2022.

In the following sections I will use SVAR models to analyse if the appreciation of the share price of Deutsche Bank was indeed caused by the decision of the ECB board to rapidly increase the remuneration of reserves held in the deposit facility or if it must be traced back to other events.

3. Data and Methodology

In the following, I will focus on the share price of Deutsche Bank AG, denoted *db*. The share price reflects profits and (discounted) profit expectations. To evaluate the influence of the ECB's deposit facility rate (*i_df*) on *db*, it is straightforward to assume that bank profits stem from three distinct sources: financial services provided to private companies, interest earned on central bank reserves, and all other forms of bank income. The current and expected profitability of financial services to private firms, in turn, is likely to be correlated with the business prospects of private companies: The greater the profitability of business activities, the higher is the price a bank can charge for financing these activities. Hence, the share price of Deutsche Bank should depend positively on firm values of other companies.

Deutsche Bank operates internationally with a focus on Europe. I use the Morgan Stanley Capital International (MSCI) stock market index *msci_EU* as a proxy for the firm values of EU companies. The first full year for which this index is available is 2005. A basic time series plot comparing *db* and *msci_EU* shows some synchronicity in short-term trends, but notably divergent behavior over the entire observation period from January 2005 to September 2023, as depicted in Figure A1 in the appendix. It is evident that additional factors contribute significantly to (current and expected) bank profits. I will, in particular, explore monetary policy and private equity as two additional drivers of the share price of Deutsche Bank AG.

My point of departure will be a three-variable system consisting of the ECB's deposit facility rate *i_df*, *msci_EU* and *db*. Hence, three types of shocks will drive the share price of Deutsche Bank AG, namely shocks to the ECB's deposit facility rate ε_{DF}, shocks to economic activity in the EU, ε_{EU}, and shocks ε_{DB3} that capture – in this three-dimensional setup – all other shocks relevant for *db* and will therefore considered to be idiosyncratic to *db*. In later analysis, I will also use the worldwide stock market index *msci* as an alternative to *msci_EU*. I will also make use of an index of the total return on private equity (*pe*), since private equity is a major business field of Deutsche Bank.

Share prices often are characterized by the presence of unit roots. Hence, before estimating an SVAR, let us check the unit root and cointegration properties using the standard Augmented Dickey-Fuller (ADF) and Johansen tests. Caution is warranted, though, with respect to the sample size, since the rapid transition from QE to QT that took place in 2022 and 2023 may well be seen as a structural break in a possible cointegrating relationship between bank share prices and the deposit facility rate. The key reason for this may be the unprecedented volume of interest income on central bank reserves that developed after June 2022. Its effect on stock prices is the object of this research. I will therefore conduct the analysis as follows: I first confine my attention to the time period up to and including June 2022, i. e. to the time before QT set in. In a second step I will compare how results change when the sample is extended to also cover the rather short QT-period July 2022 to September 2023. September 2023 is chosen because the deposit facility rate reached its maximum value of 4% by decision of the ECB board on September 20, 2023. Hence, the period of rapid interest rate increases came to an end in September 2023. It is one of the major goals of this paper to assess how much information for share price revaluation this rather brief period of QT conveyed to capital markets.

In the empirical analysis, both in testing and estimation, appropriate lag lengths are determined by Akaike's information criterion (AIC)[2]. Unit root tests for all time series allow for a nonzero drift under the null hypothesis. Results in Table 1 indicate that the unit root hypothesis cannot be rejected for any of the three series at the conventional 5% level of significance. On the other hand, further results (suppressed here) show that the first differences of all variables are very clearly stationary. Hence, I will treat all time series as integrated of order 1.

Table 1. *Unit Root Tests.*

	ADF-statistic	P-value	Lags (AIC)
db	-3.20	0.088	1
i_df	-2.76	0.213	7
msci_EU	-2.25	0.459	1
msci	-3.08	0.118	4
pe	-2.13	0.524	6

Null hypothesis: Unit root process with drift. One-sided finite sample p-values. Sample: 2005.01-2022.06.

Johansen tests for cointegration do not convey clear evidence on the cointegration properties of the variables. For instance, the three-dimensional system consisting of *db*, *i_df* and *msci_EU* produces p-values very close to 5% for the null of no cointegration and the null of at most one cointegrating vector. While, formally, at a 5%-level of significance the conclusion would be acceptance of one cointegrating vector, p-values just a little different would have suggested no cointegration or even two cointegrating vectors. The same is true when *pe* as a fourth variable is added to the system. If, on the other hand, *msci_EU* is replaced by the world index *msci* in either system, then no evidence of cointegration surfaces.

2 The conclusions do not change when Schwarz' Bayesian information criterion BIC is used.

Table 2. *Johansen Trace Tests for Cointegration.*

System	Null hypothesis	Trace-stat.	Crit. Value	P-value
db, i_df, msci_EU	No coint. vector	29.96	29.80	0.048
	1 coint. vector	14.87	15.49	0.062
	2 coint. vectors	0.06	3.84	0.802
db, i_df, msci_EU, pe	No coint. vector	48.49	47.86	0.044
	1 coint. vector	29.38	29.80	0.056
	2 coint. vectors	11.82	15.49	0.166
	3 coint. vectors	0.85	3.81	0.357
db, i_df, msci	No coint. vector	22.01	29.80	0.298
	1 coint. vector	9.47	15.49	0.323
	2 coint. vectors	0.00	3.84	0.983
db, i_df, msci, pe	No coint. vector	35.01	47.86	0.448
	1 coint. vector	20.51	29.80	0.389
	2 coint. vectors	7.71	15.49	0.496
	3 coint. vectors	0.56	3.81	0.456

Deterministics: Constant and restricted trend. Four lags in levels for all systems.

It is therefore not clear whether a structural vector autoregression or a structural vector error correction model (VECM) is the better framework of analysis and, if a VECM were chosen, how many cointegrating vectors (one or two) should be specified. In such a case, it is clearly preferable to choose an unrestricted vector autoregression (VAR) in levels, since this would allow consistent (though not necessarily efficient) estimation regardless of whether there is cointegration and what the dimension of the space of cointegrating vectors. Consistent estimation of a VECM, on the other hand, requires knowledge of the cointegrating rank, cf. e.g. Lütkepohl [9], and would yield inconsistent estimates if this rank is misspecified.

Estimating a VAR in levels yields estimates of a reduced form simultaneous system. The residuals of the reduced form have no structural interpretation. But they can be thought of linear combinations of "structural residuals". For instance, suppose that the simultaneous relationships between k endogenous variables collected in a vector $y_t \in \mathbb{R}^k$, are described by a dynamic linear model

$$A_0 y_t = c + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t \qquad (1)$$

where $\varepsilon_t \in \mathbb{R}^k$ are k structural shocks with diagonal covariance matrix and A_0 is a $k \times k$ nonsingular matrix. Since the diagonal of A_0 is unrestricted, we can assume without loss of generality that the covariance matrix of ε_t is the identity matrix I. Premultiplication of (1) by $B := A_0^{-1}$ yields the reduced form

$$y_t = Bc + \sum_{i=1}^{p} BA_i y_{t-i} + B\varepsilon_t =: b + \sum_{i=1}^{p} B_i y_{t-i} + u_t , \qquad (2)$$

i.e. $u_t := B\varepsilon_t$ with covariance matrix $\Omega_u := BB'$. Estimating (2) by ordinary least squares yields an estimate $\hat{\Omega}_u$ of this covariance matrix. From this, the elements of B can be estimated if at least $k(k-1)/2$ identifying assumptions are imposed on B.

Let us initially consider the three-dimensional system *i_df*, *msci_EU*, *db*. Assume this system is driven by three structural shocks which we think of as an autonomous monetary policy shock from central bank decision makers $\varepsilon_{CB,t}$, an aggregate macroeconomic shock hitting the European Union, $\varepsilon_{EU,t}$, and a shock idiosyncratic to the share price of Deutsche Bank, $\varepsilon_{DB,t}$. To identify these structural shocks, we need three identifying assumptions.

Note that the elements of B describe the immediate impact a structural shock has on a particular variable. For instance, set $y_t := (i\_df_t,\ msci\_EU_t,\ db_t)'$ and $\varepsilon_t := (\varepsilon_{CB,t},\ \varepsilon_{EU,t},\ \varepsilon_{DB,t})'$. Then the first row of B describes the instantaneous effect the three structural shocks have on the deposit facility rate.

It seems reasonable to assume that *i_df* reacts on impact merely to decisions by the central bank, i. e. $b_{11} \neq 0$. Shocks hitting the EU macroeconomy, however, will typically not cause an immediate change in the deposit facility rate. Rather, the board of the central bank will let some time pass to assess the effect of the shock and weigh its policy options. It may well react to a macroeconomic shock with a certain lag and decide to adjust the deposit facility rate in response to, say, last period’s shock, but it is very improbable that the central bank will do this almost in synchronicity with the shock. Hence, $b_{12} = 0$ is a plausible assumption to identify the monetary policy shock.

Precisely the same argument can be made for the share price of Deutsche Bank. In fact, a central bank will usually not react at all if a company is hit by an idiosyncratic shock. This does not say that central banks do not, for instance in particular moments of crisis, act expeditiously when a major credit institution is about to fail. But such decisions will typically not take the form of changes in the deposit facility rate, but rather involve some kind of emergency credit line for the troubled bank. Still, the only assumption I impose here is the absence of an instantaneous change in the deposit facility rate, i. e. $b_{13} = 0$. I do allow that the deposit facility rate responds to lagged idiosyncratic shocks of bank shares.

The third and last identifying assumption I impose is $b_{23} = 0$. It says that an idiosyncratic shock to the share price of Deutsche Bank does not have an instantaneous effect on the index of European share prices *msci_EU*. By definition, this assumption is technically incorrect, when the share of Deutsche Bank is part of the *msci_EU* index. But since the *msci_EU* index contains more than 400 constituent companies the weight of Deutsche Bank, if nonzero, will be negligibly small.

4. SVAR Results

Using the identification scheme just discussed we can compute the impulse response functions (IRF) of the endogenous variables with respect to the identified structural shocks. Figure 2 shows these IRFs for the sample 2005.1-2022.6, Figure 3 does so for the expanded sample 2005.1-2023.9.

Impulse responses are shown over a 120 months, i. e. ten years. As one would expect, a positive monetary policy shock (column 1 of Figure 2) drives up the deposit facility rate (first row of Figure 2). This effect is significant throughout the first year after the monetary policy decision. But according to the SVAR IRFs, the deposit facility rate is not only adjusted in response to autonomous (exogemous) central bank decisions, but also reponds to macroeconomic developments and to idiosyncratic shocks which hit a major credit institution like Deutsche Bank: Positive macroeconomic shocks (in column 2 of Figure 2) increase the deposit facility rate – not on impact, but significantly so with lags of up to two years. Similarly, shocks idiosyncratic to Deutsche Bank also significantly affect the deposit rate (albeit at just about half the size that macro shocks have) and such responses by a major central bank policy variable are observed even for slightly longer than two years. The economics of this is probably best understood by reversing signs: If Deutsche Bank (or any other major credit institution) is negatively affected by idiosyncratic shocks, then the central bank may try to accommodate economic conditions by lowering interest rates sooner or later.

Turning to the second row of Figure 2 we see that stock prices (in the second row) generally react negatively to a monetary policy decision that raises interest rates. This effect sets in gradually and becomes statistically significant after approximately 18 months, prevailing at least up to 36 months after the central bank decision before reverting back to zero. Of course, this effect is very similar to well-documented reponses of aggregate activity to monetary policy shocks, see e. g. Bagliano and Favero [3] or Beaudry and Lucke [4].

Macroeconomic shocks have the expected effect on stock prices, clearly significant over the first two years or so. Idiosyncratic bank shocks, however, are basically insignificant and in any case numerically very small. This is, of course, the natural implication of the small weight Deutsche Bank has in *msci_EU*.

Finally, the third row of Figure 2 shows the responses of Deutsche Bank share to the three structural shocks. Except for a brief instantaneous effect, the deposit rate oes not have any significant effect on *db* so long as the sample ends prior to the most recent interest hike episode. But Deutsche Bank shares benefit from positive macro shocks and from idiosyncratic shocks, both of which are significant for at least the first year (and much longer for idiosyncratic shocks). Quantitatively, the two shocks have roughly the same effect on the price of Deutsche Bank shares.

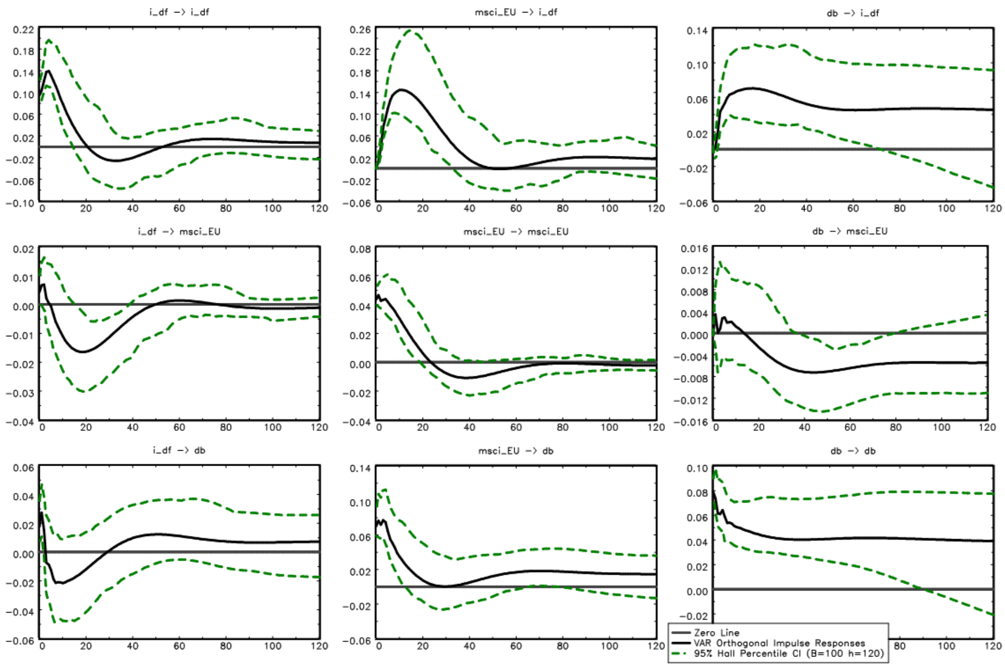


Figure 2*. SVAR Impulse Responses, k=3, Sample 2005.1-2022.6.*

It seems fair to say that the IRFs just discussed are very much in line with common economic wisdom, i. e. with the priors most economists would presumably have for the IRFs of such an SVAR. Turning to the IRFs obtained by estimating the same SVAR on the extended sample 2005.1-2023.9 (cf. Figure 3), we see that all IRFs except the lower left are qualitatively unchanged. The significant segments of the IRFs are generally somewhat more extended along the time axis, but otherwise these eight IRFs are very similar to those obtained with the shorter sample.

But there is a dramatic change in the response of the share price of Deutsche Bank to monetary policy shocks which increase the deposit rate. Now, with observations from 2022/2023 added, the share price of Deutsche Bank increases greatly and significantly over the medium to long-run horizon of four to ten years. Clearly, this suggests that the remuneration of excess reserves at the deposit facility rate raises the wealth of Deutsche Bank owners significantly and lastingly.

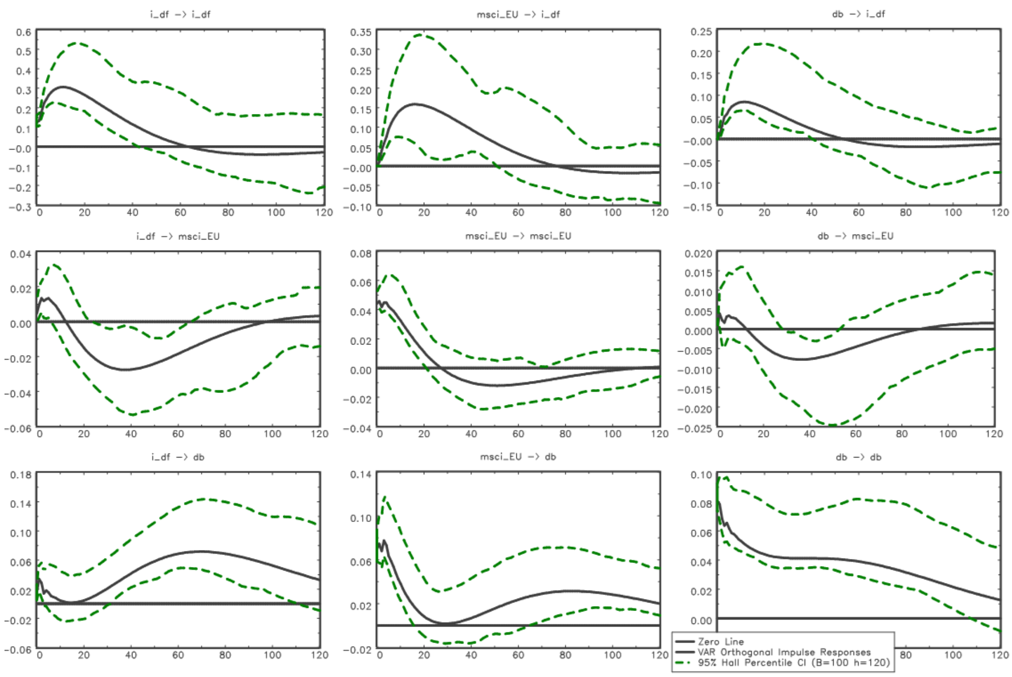


Figure 3*. SVAR Impulse Responses, k=3, Sample 2005.1-2023.9.*

This conclusion is reinforced by the the foreward error variance decompositions (FEVDs) of the SVARs. Figure 3a and 3b display the shares of the forward error variances of the three variables attributable to the three structural shocks over the same horizon of ten years. The share of the monetary policy shock is shown in red, the share of the macro shock in green and the share of the idiosyncratic bank shock in blue.

Of great interest is the third row of the FEVDs where the forward error variance of the Deutsche Bank share is decomposed. For the sample ending in 2022.6 (Figure 4), the autonomous monetary policy shock plays next to no role over all horizons. Rather, the variance of *db* is mostly explained by the idiosyncratic shock whose long-run share exceeds 70%. In the short run, the macro shock and the idiosyncratic shock are approximately of equal importance.

For the extended sample ending in 2023.9, autonomous monetary policy decisions play a greatly increased role in the FEVD of *db*. As the third panel in Figure 5 shows, about 50% of the long-run variance of *db* is traced back to the monetary policy shock. This is very much in line with the previous assessment that Deutsche Bank will continue to benefit from high remuneration of excess reserves for the next ten years or so and that the amount of interest income earned on excess reserves is roughly the same size as all other profits from Deutsche Bank operations.

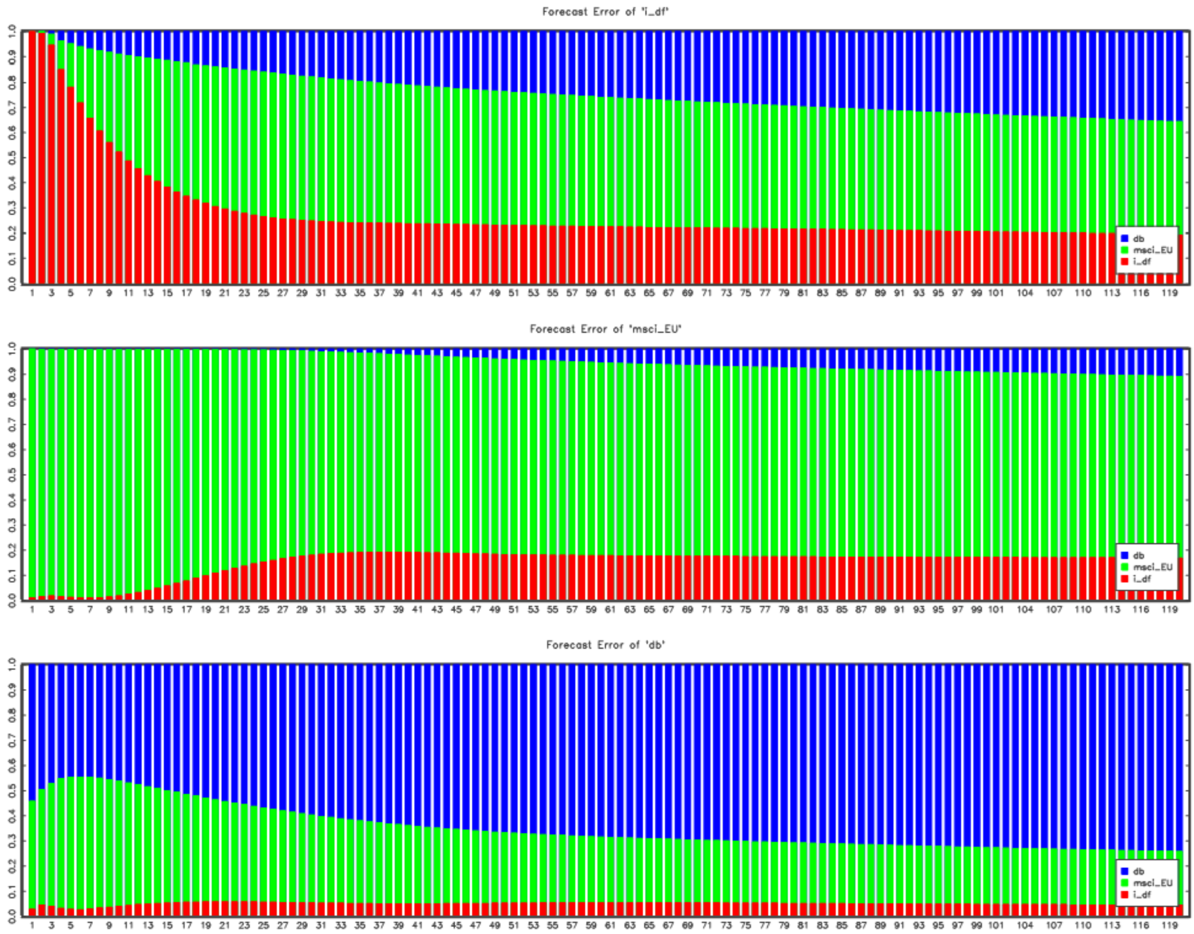


Figure 4. *FEVDs, Sample 2005.1-2022.6.*

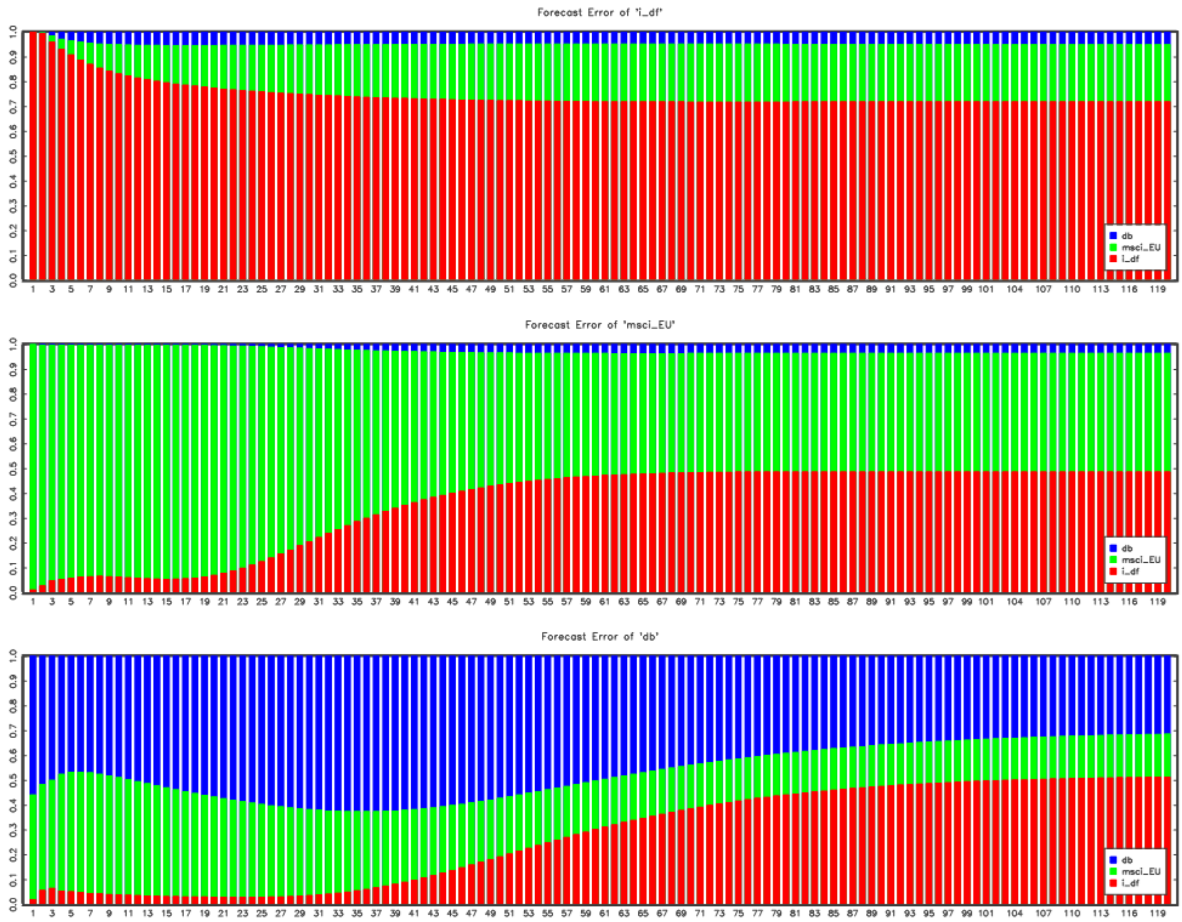


Figure 5. *FEVDs, k=3, Sample 2005.1-2023.9.*

In marked contrast to the comparative analysis of IRFs, not only one, but all three FEVDs differ substantially for the two sample sizes. For instance, the variance of the deposit facility rate is mostly driven by the autonomous monetary shock and the macroeconomic shock. This is a very plausible result, but it is intresting to see that the relative importance of the former is greatly increased at the cost of the latter when the sample size is increased to include 2022.7-2023.9. Of course, this just reflects the general difficulty to assess by how much monetary policy decisions of a central bank are exogenous (autonomous) or endogenous (macro shock). The great reduction in the importance of the macro shock we observe when the sample is expanded suggests that recent interest hikes by the ECB are seen by the model as autonomous decisions rather than decisions motivated by concerns about how real activity (represented by a broad index of EU share prices) develops in the Eurozone.

Also, the variance of real activity is to a much larger extent attributed to the autonomous monetary policy shock in the extended sample than in the sample ending 2022.6 where the macroeconomic shock dominates the long-run variance. In the extended sample, the macro shock and autonomous monetary policy decisions each explain about 50% of the long run forecast variance of stock prices in Europe, with virtually no importance of shocks idiosyncratic to Deutsche Bank.

To robustify these results, let us consider an expanded system with four variables. Banks not only provide financial services to established and rather large companies, whose economic success and prospects are reflected by share prices. A second important pillar of banking is directed at private equity, i. e. diverse forms of venture capital including startups. A substantial share of the business activities of Deutsche Bank is known to focus on private equity, so it is interesting to see if the strong impact of excess reserve muneration survives in a four dimensional VAR which not only relates the share price of Deutsche Bank to real economic activity as measured by *msci_EU*, but also to the development of private equity.

The development of private equity is easily tracked by appropriate stock market indices, e. g. the index "total return on private equity", *pe* introduced earlier. As documented in Table 2, the four dimensional system *i_df*, *msci_EU*, *pe* and *db* rejects the hypothesis of no cointegration. There is at least one cointegrating vector, possibly even two. Therefore, we can again estimate a VAR in levels. The AIC recommends five lags in levels.

In an SVAR setting, we will now need to identify four structural shocks. I retain the concepts of the previous three structural shocks and posit the existence of a fourth orthogonal shock called the market shock. The market shock should be thought of as representing changes in market structures through new products, business ideas, companies or even new markets. Or, to put it differently: The macro shock is a shock that hits a macroeconomy assumed to be structurally constant. The market shock is a shock which changes this structure and therefore represents i. a. the creative destruction inherent in competitive markets.

Identification of these four structural shocks is again obtained by zero restrictions on the *B*-matrix. As before, the deposit rate is assumed to respond only to the autonomous monetary policy shock on impact. *msci_EU* may instantaneously react to this shock and to the macro shock. A market shock would not immediately change the stock prices of corporations in the *msci_EU* (although it may so as early as after a lag of one month). But the monetary policy shock, the macro shock and the market shock are allowed to have an impact effect on private equity. The last shock is again the idiosyncratic shock to the share price of Deutsche Bank and is assumed to affect only this share price without a lag.

These assumptions, effectively identifying *B* as the Cholesky decomposition of the covariance matrix $\Omega_u := BB'$, are sufficient to just-identify the four structural shocks. Estimating the reduced form VAR first for the shorter sample ending in 2022.6, we obtain IRFs as displayed in Figure 6. It turns out that the identified monetary, macro and idiosyncratic shocks are very similar to the same shocks in the three-dimensional system, cf. the scatter plots in Figure 8. The new market shock is, therefore, almost orthogonal to these earlier structural shock estimates and represents, therefore, a type of shock unaccounted for in the three-dimensional system.

Thus, it is not surprising that the IRFs of *i_df*, *msci_EU* and *db* with respect to monetary, macro and idiosyncratic shock are very similar to those obtained earlier. In particular, the response of Deutsche Bank's share price to the monetary policy shock is clearly either negative or zero. But this again changes dramatically when the slightly longer sample is used to estimate the SVAR: Suddenly, the shock driving the deposit rate has a strong and long-lasting positive effect on the share price of Deutsche Bank.

Turning to FEVDs, the same phenomenon is observed, cf. Figure 9: If the shorter sample is used, the variance of *db* is predominantly driven by the idiosyncratic shock. The macro shock plays a role in the short run and gradually gives way to the market shock in the long run. The shock driving the deposit facility rate seems to be rather unimportant for the forecast variance of Deutsche Bank's share price.

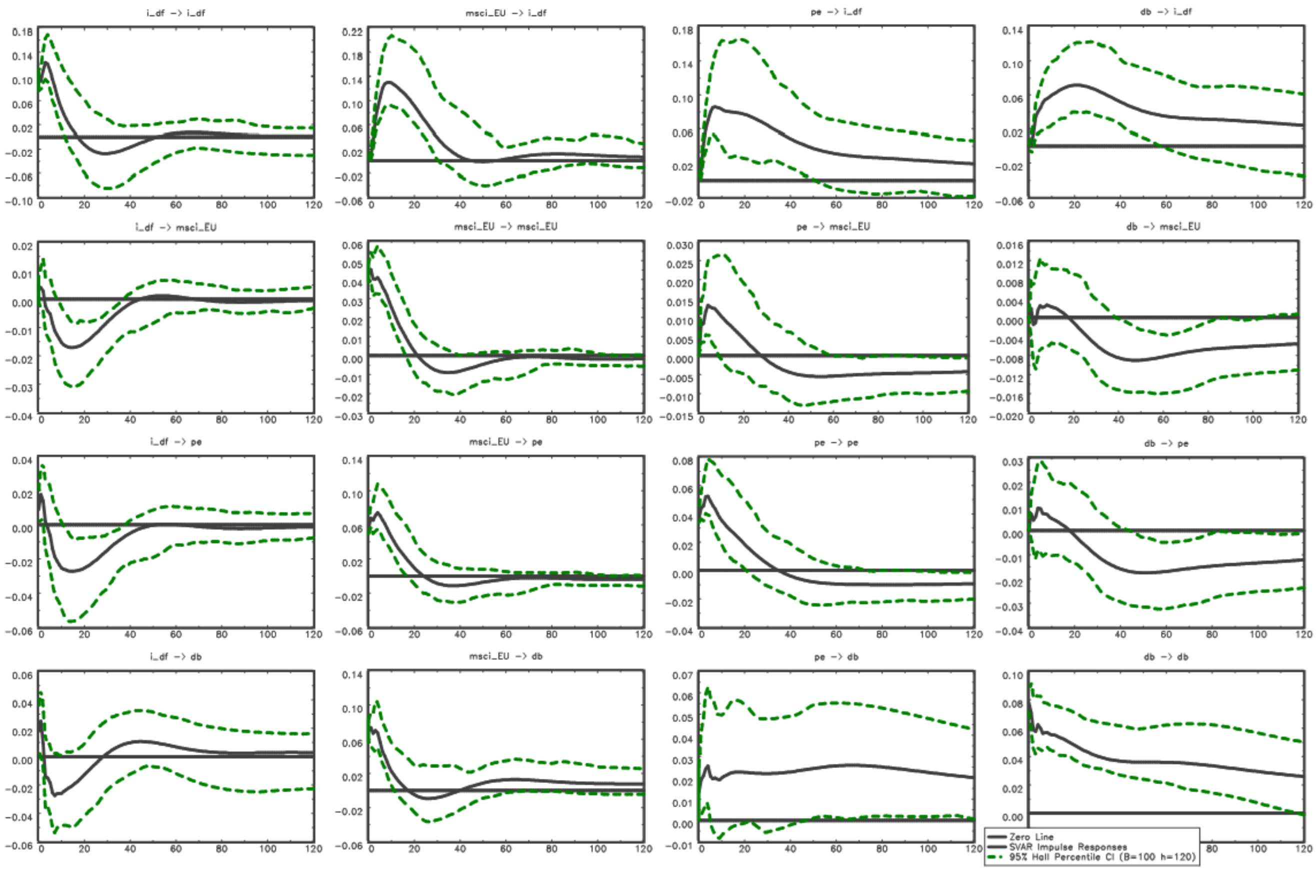


Figure 6. *SVAR Impulse Responses, k=4, Sample 2005.1-2022.6.*

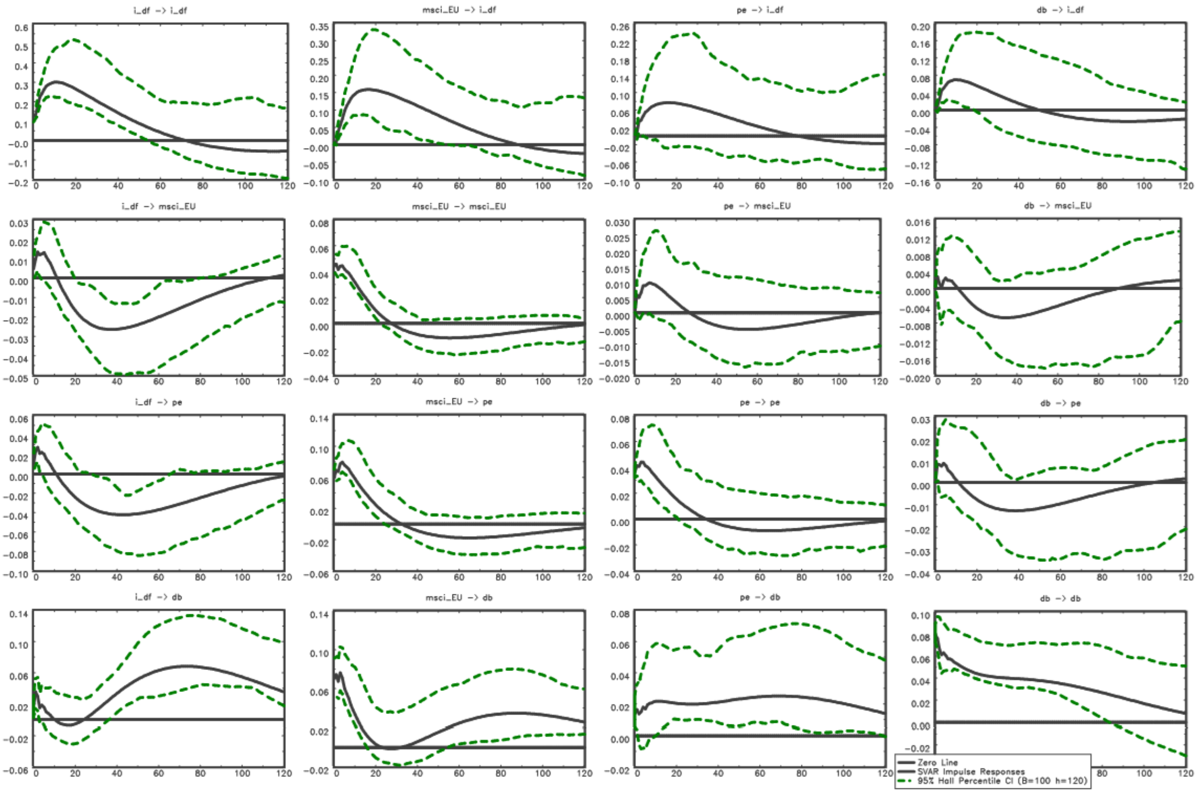


Figure 7. *SVAR Impulse Responses, k=4, Sample 2005.1-2023.9.*

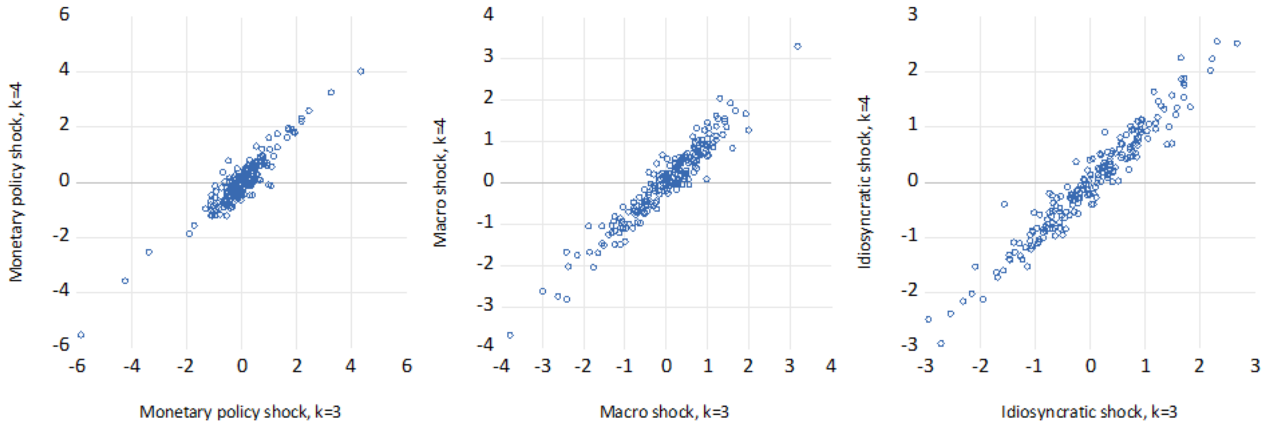


Figure 8. *Correlations of structural residuals, sample 2005.1-2022.6.*

However, with the extended sample, cf. Figure 10, the forecast error variance of *db* over long horizons is mostly attibuted to the monetary policy shock. Idiosyncracies and macro shocks are responsible for much of the variance in the short run, but decrease in importance over time. The market shock as a contributor to forecast error variance sets in very gradually and unfolds somewhat as the time horizon increases. This what one would expect of a shock which affects market structure. Yet, at the long end, the monetary policy shock explains a larger share of the forecast variance than all other shocks combined.

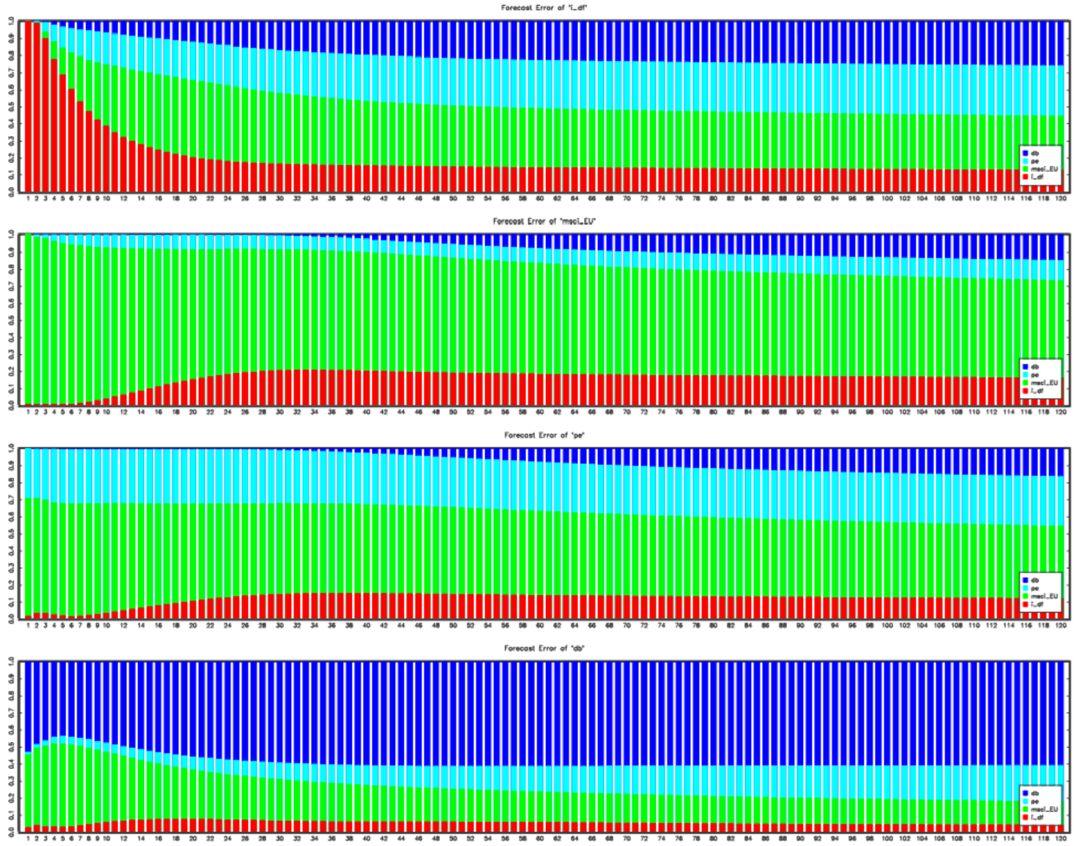


Figure 9. *SVAR FEVDs, k=4, Sample 2005.1-2022.6.*

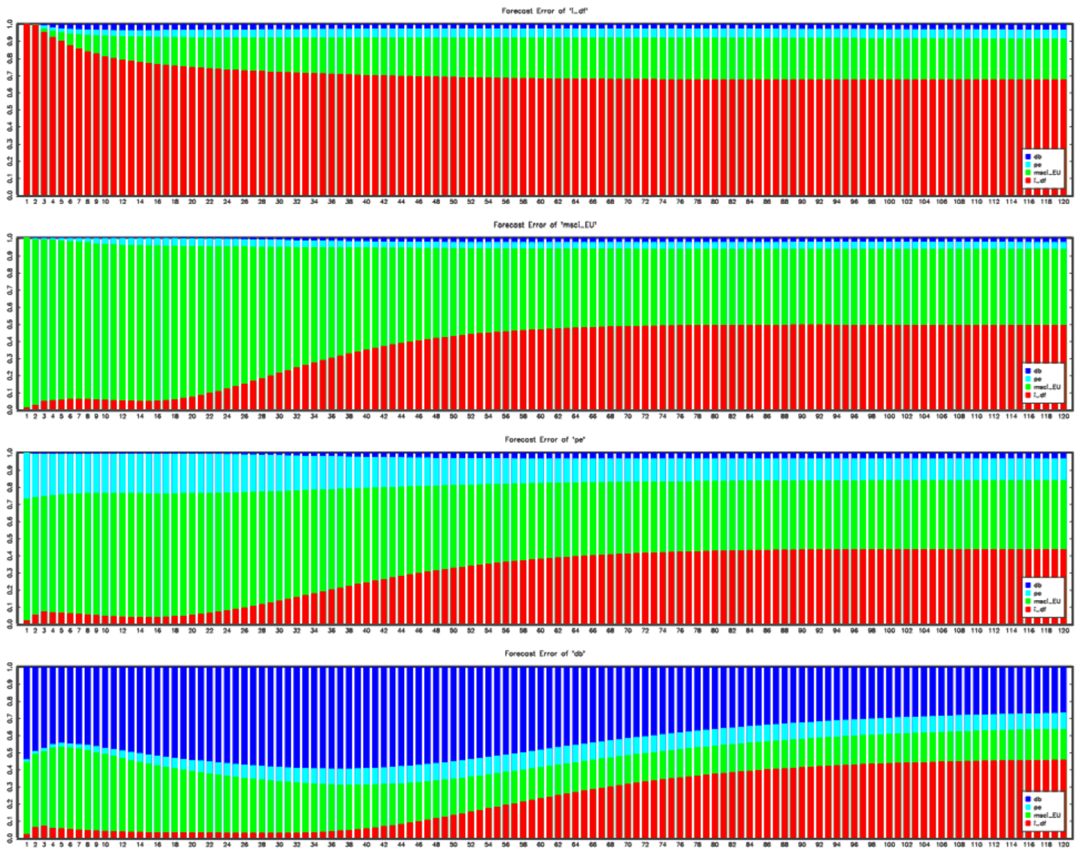


Figure 10. *SVAR FEVDs, k=4, Sample 2005.1-2023.9.*

This is strong evidence that the remuneration of central bank reserves, despite of being no new phenomenon, has only very recently become a major component of bank profits and markets' profit expectations. Much of the recent increase in Deutsche Bank's share price can thus be traced back to interest income paid on excess reserves at the central bank.

Hence, interest payments on excess reserves clearly have substantial wealth effects for private shareholders. While the above analysis demonstrated these wealth effects for a single credit institution, i. e. Deutsche Bank AG, there is little reason to doubt that all Eurozone banks that built up major positions of excess reserves during QE benefit from QT in much the same way. Present and future discounted profits, i. e. share prices of commercial credit institutions are driven up by a monetary policy that incurs substantial losses on national central banks in the ECB system. Put differently: Central bank losses, today and for years to come, finance significant increases in private wealth for shareholders of commercial credit institutions.

5. Conclusions

After the financial crisis, central banks switched from a corridor system for the overnight interbank interest rate to a floor system, where the deposit facility rate administered by the central bank acts as a lower bound. Reserves had been remunerated already much earlier, but this did not matter greatly in a regime of reserve scarcity. Huge excess supplies, however, are constitutive for the new policy regime. Thus, banks benefit from remuneration of excess reserves to a much greater extent than previously.

The sudden surge in inflation after the COVID-19 pandemic forced the ECB and other western central banks to increase interest rates rapidly from negative territory to 4% or even more. To be precise: Once the decision was taken, the rise in interest rates was rapid, but it was delayed by several months during which, apparently, central bankers hesitated and tried to ascertain whether the rise in price level possibly was a merely temporary phenomenon that does not require imminent action.

It is for this reason that I have not included the inflation rate as an additional variable in the SVAR. It would be too simplistic to assume that increases in inflation mechanically induce certain monetary policy decisions. Rather, there is discretion by the ECB board, when and how to act. This discretion is represented by the exogenous (autonomous) monetary policy shock.

A structural change in monetary policy is at odds with the assumption of structural constancy underlying VAR analysis. Ideally, separate VARs should be estimated for the subsamples drawn from different monetary policy regimes. But in the present context, this is hardly possible. For the major policy change is not so much QE but rather QT. QE meant driving interest rates down by different means than in a regime with reserve scarcity, but it did not yet generate large interest incomes for commercial banks. Quite to the contrary: Via negative interest rates, reserves were costly for banks just as demand for reserves was costly in the previous scarcity regime.

It was the advent of QT which changed greatly for commercial banks. But there is no way to derive a reasonable VAR estimate for a subsample as short as June 2022 to September 2023. Hence, I used two different sample lengths, finding that the addition of relatively few observations made during QT has a dramatic effect on the impulse responses and variance decompositions of the Deutsche Bank share price with respect to autonomous monetary policy decisions driving the deposit facility rate: Even though the sample is "contaminated" with lots of data representing QE and the reserve scarcity regime where the deposit facility rate is not expected to and actually does not affect the share price in any significant way, the few observations on QT change the estimate of the IRF completely and indicate a significant and long-lasting positive effect on the price of Deutsche Bank shares.

Obviously, as more data become available, further research may test for structural change and, if structural change is confirmed, estimate VARs for the QE and QT subsample separately. Also, it may be interesting to broaden the analysis to the share prices of other Eurozone banks. If, as one would expect, similar results hold throughout all credit institutions, it may be interesting to study the implications of QE and QT for the EU wealth distribution. After all, regular households are often fixed interest savers while wealthier investors tend to hold a larger share of their wealth in stocks. A significant increase in share prices of credit institutions may therefore mean that the distribution of wealth has become more unequal by QT.

The size of the wealth effects (and the resulting dispersion of the wealth distribution) directly depends on the size and persistence of the losses Eurozone central banks endure from the remuneration of excess reserves and and the maturity mismatch between reserves and their low-interest QE-induced asset portfolio. Monetary policy based on large excess reserves is expected to continue for years to come. The average maturity of sovereign bonds in the portfolio of Eurozone central banks is approximately seven years and net purchases are to be discontinued in December 2024. This implies that central bank losses decrease only gradually over time as long as interest rates stay at levels higher than the ECB's target inflation rate of 2%. Quite possibly, losses may still be at roughly 40%-50% of their current level when half of the stock of bonds has matured in 2031. To what extent such longlasting effects of QE and QT increase the inequality of the wealth distribution and how much of this is a permanent effect must, at the present data availability, be left for further research.

Abbreviations

ADF	Augmented Dickey-Fuller Test
AG	Aktiengesellschaft
AIC	Akaike Information Criterion
bn	Billion
ECB	European Central Bank
ESCB	European System of Central Banks
FEVD	Forward Error Variance Decomposition
IMF	International Monetary Fund
IRF	Impulse Response Function
LTRO	Long-Term Refinancing Operations
MSCI	Morgan Stanley Capital International
PEPP	Pandemic Emergency Purchase Programme
QE	Quantitative Easing
QT	Quantitative Tightening
SVAR	Structural Vector Autoregression
VAR	Vector Autoregression
VECM	Vector Error Correction Model
WAM	Weighted Average Maturity

Author Contributions

Bernd Lucke is the sole author. The author read and approved the final manuscript.

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Conflicts of Interest

The author declares no conflicts of interest.

Appendix

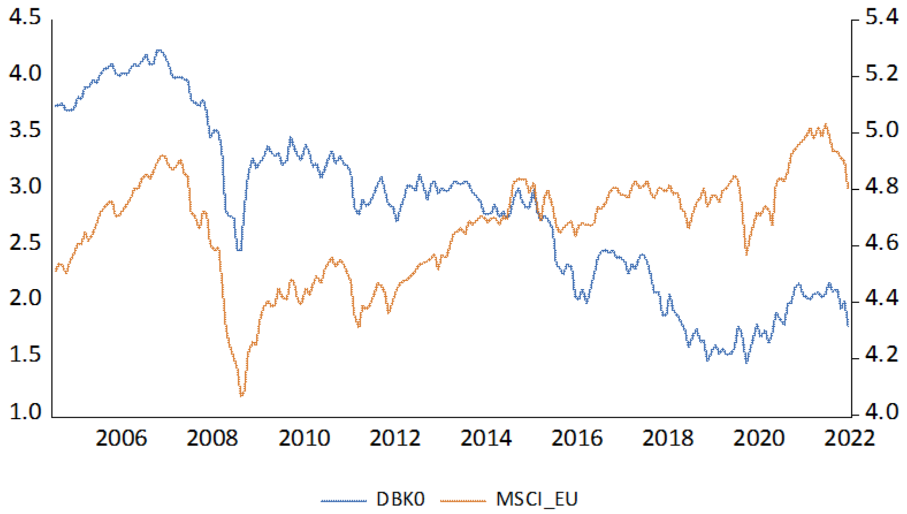

Figure A1. *Time series plot of the share price of Deutsche Bank AG and price of msci_EU.*

Table A1. *Eurosystem reserves and deposit facility rate 2023.*

	Minimum reserves (bn €)	Excess reserves (bn €)	Redundant reserves (bn €)	Deposit facility interest rate
January	167	4324	3655	2.00%
February	168	4079	3407	2.50%
March	165	4129	3471	3.00%
April	165	4071	3410	3.00%
May	166	4013	3350	3.25%
June	165	4143	3484	3.50%
July	165	3930	3270	3.50%

	Minimum reserves (bn €)	Excess reserves (bn €)	Redundant reserves (bn €)	Deposit facility interest rate
August	165	3717	3056	3.75%
September	165	3656	2995	4.00%
October	165	3587	2929	4.00%
November	164	3572	2915	4.00%
December	164	3557	2901	4.00%

Source: ECB

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