Banks in an environment of higher interest rates

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Abstract

The core financial intermediation function of banks, providing loans and taking deposits, is closely related to the level of interest rates. We construct a simplified balance sheet of a representative bank and assess how increases in interest rates may affect its profitability (through changes in net interest income, the fair value of financial assets, and credit losses) as well as the market value of its assets and liabilities (i.e., market value of equity). Using a sample of 103 EU banks from the 2022 EBA Transparency Exercise, we find that, mainly on account of higher net interest income, higher interest rates increase bank profits, with an inverted-U shaped curve over time. There is however a non-negligible share of banks reporting losses, mainly because of their high share of loans at fixed-rates or of debt securities at fair value. Looking at the market value of equity, it declines for most of the banks in our sample, confirming the negative relation between interest rates and banks' assets and liabilities.

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1. Introduction

The core financial intermediation function of banks, providing loans and taking deposits from shareholders, is closely related to the level of interest rates. The main source of profits for banks is the difference between the interest they charge to the loans they grant and the interest they pay to deposits. Interest rates also affect the market value of bank assets and liabilities, which, in turn, reflect the opportunity costs of having loans and deposits in the balance sheet. The intensity of changes in the market value of bank assets and liabilities is a function of their maturity, which tends to be higher in assets than in liabilities. Contrary to profits, changes in the market value of bank assets and liabilities are not immediately observable and may remain unrealised.

Interest rate risk is thus of paramount importance for the risk management of banks, which try to hedge or minimise this risk in their balance sheet. One way to achieve this is through the alignment of maturities of assets and liabilities, as documented by, among others, Flannery (1981). More recently, Drechsler et al. (2021) show that banks hedge their interest rate risk through the maturity transformation between loans and deposits (benefitting from the so-called "deposit franchise"). Derivatives can also contribute to the management of interest rate risk. Gorton and Rosen (1995) looked at the hedging of interest rate risk through derivatives, finding that banks seemed to hedge most of the risk. Most recent contributions find a less significant degree of hedging through derivative markets (Jiang et al., 2023; McPhail et al., 2023).

The key role played by interest rates in the financial intermediation function performed by banks is reflected in the separate treatment of interest rate risk in the regulatory framework (Basel Committee on Banking Supervision, 2016). The two main channels through which interest rates affect banks (profits, and market value of assets and liabilities) are at the core of the regulatory framework of interest rate risk. Since the banking turmoil in March 2023 there have been intense discussions on amendments to the way interest rate risk is currently regulated (Basel Committee on Banking Supervision, 2023; International Monetary Fund, 2023). After all, inappropriate management of interest rate risk, among other factors, led to the collapse of Silicon Valley Bank in March 2023 (Board of Governors of the Federal Reserve System, 2023).

Since early 2022, monetary policy in the main world economies (US, euro area) have changed stance, starting a process of tightening. As a result, official interest rates are increasing, and, as expected, so have done bank profits. In turn, bank profits are used to remunerate shareholders (or owners), so higher distributions can make banks more attractive for investors. Besides, the undistributed part of profits (i.e., retained earnings) are a component of the own funds of the bank, contributing to increase the resilience of the bank. From this point of view, thus, profits contribute to increase resilience.[1]

Findings in the academic literature on the impact of high interest rates point to an increase in bank profits derived from higher interest rates, operating though the net interest income (Samuelson, 1945; Hancock, 1985; Corvoisier and Gropp, 2002; Alessandri and Nelson, 2015; Borio et al., 2017). Symmetrically, the recent period of low interest rates led to a decrease in the net interest margin of banks, negatively impacting their profitability. However, there are some nuances to this assessment. Pérez Montes and Ferrer (2018) highlight the importance of considering also volumes of loans and

[1] On the wider relation between bank profits and financial stability, there is still no consensus among the academic community (see, for example, the discussion in Xu et al., 2019).

deposits, finding a mixed result for Spanish banks. Bikkers and Vervliet (2017) find that low interest rates comprise interest margins, but profitability levels in a sample of US banks were constant on account of lower impairments. Similar findings are in Altavilla et al. (2018). English et al. (2018) find that increases in interest rates initially result in higher net interest margins and higher returns on assets, but after a few quarters, these positive effects dissipate and even reverse, leading to a decline in bank profitability after about one year. An important component of the expected increase in profits from higher interest rates is the remuneration of deposits. Saunders and Schumacher (2000) find that restrictions in the remuneration of deposits have a strong impact on net interest margins. More recently, Ulate (2021) and Altavilla et al. (2022) discuss lower bank profits when interest rates on deposits are negative, with a potential impact on monetary policy transmission mechanisms.

This paper contributes to the academic literature by offering a comprehensive analysis of the impact of high interest rates on banks. It complements the most recent publications focused on the period of low interest rates (Alessandri and Nelson, 2015; Borio et al., 2017; Bikkers and Vervliet, 2017; Altavilla et al., 2018; Ulate, 2021; Altavilla et al., 2022), and re-visits some of the findings in the earlier academic literature discussing, in general, the relation between interest rates and bank profits (Samuelson, 1945; Hancock, 1985; Saunders and Schumacher, 2000; Corvoisier and Gropp, 2002). We also touch upon interest rate risk in the balance sheet of banks, indirectly relating our paper (in particular, the empirical analysis) to the literature on this topic (Flannery, 1981; Gomez et al., 2016; Drechsler et al., 2021).

Considering the impact of higher interest rates on bank profits, we focus on three channels: net interest income (i.e., the difference between the interest earned on loans and the interest paid to deposits), changes in the fair value of financial assets, and increases in credit losses. On the changes in the fair value of financial assets, we also consider latent losses in the portfolios of debt securities, which triggered the fall of Silicon Valley Bank in March 2023. Based on our analytical work, we undertake an empirical analysis, using data from a sample of 103 EU banks reporting to the 2022 EBA Transparency Exercise, of the most recent episode of monetary policy tightening in Europe. We want to assess which of the three dominates when interest rates increase and under which circumstances banks can incur into losses. In addition to profits, the paper also covers a second way through which interest rates can impact banks: changes in the market value of bank assets and liabilities, which we denominate market value of equity. This complements the direct impact on profitability, leading us to cover the two metrics used in the banking regulatory framework.

There are some methodological issues about our paper that are worth mentioning at this point. First, we construct a simplified balance sheet with relatively few items, which are then assumed to behave linearly and in similar terms in the cross-section of banks. In reality, the dynamics of the banking sector are more complex, with many different instruments and non-linearities, that are not taken into account in our model (for example, the collateral attached to some loans or the access to central bank facilities). In this sense, our analysis can be seen as a stylised representation of a complex issue. Second, the yield curve used to compute the discounted value of assets and liabilities should ideally be that of the country of the bank. For simplicity reasons, we have used the yield curve of the US Treasury bonds, typically taken as the global safe asset. In principle, the yield curve of European government bonds should somehow resemble that of the US, but there could be differences across EU countries that we do not cover in our analysis. And third, there are important research questions that affect our analysis but that clearly go beyond the scope of the paper. The determinants for changes in bond and equity prices or the variables that anticipate increases in non-performing loans are two key examples of this. In these two particular and relevant cases, we focus solely on the impact of interest rates, but other variables could offset that impact.

Turning to the main results, the total impact of higher interest rates on the profits of banks remains uncertain. As expected, we document an increase in the net interest income due to higher interest rates. Two variables determine the size of this increase: (i) the share of variable-rate loans, and (ii) the difference in the pass-through of higher interest rates to loans and to deposits. The former implies that in countries where fixed-rate loans dominate, the increase in profits derived from higher interest rates may be limited, while, at the same time, the subsequent increase in credit losses would be contained as the debt servicing burden of borrowers remains unchanged. Our empirical analysis reports positive cumulated profits for 79 banks and negative for 24 banks from the third quarter of 2022 to the third quarter of 2023. We also find that changes in the fair value of assets are not playing a substantial role when there are increases in interest rates, except for unrealised losses from financial assets held to maturity, which can be large in some outlier banks if they need to be realised. Regarding credit losses, they tend to increase with higher interest rates as a result of higher payments by borrowers. Here, a key parameter is the speed through which higher payments by borrowers can generate non-performing loans. In our empirical analysis, we assume that it takes at least one year, leading to the recognition of limited modest credit losses.[2] Overall, though, the increase in net interest income tends to dominate the other two channels. Moving to the market value of equity, higher interest rates lead to declines in it under a normal business model (i.e., when the duration of assets is higher than the duration of liabilities). Our empirical analysis finds that the market value of equity declines for all banks in our sample, except for 6, which report an increase. Finally, there are 24 banks simultaneously showing declines in profits and in the market value of equity, suggesting that they would thus be strongly and negatively affected by increases in interest rates. These banks tend to show large shares either of fixed-rate loans over total assets or of debt securities at fair value. Indicators of asset quality (i.e., rate of non-performing loans, and the share of stage 2 loans) do not seem to determine that a bank can report losses in an environment with higher interest rates.

The paper is organised as follows. A schematic representation of the balance sheet and the profit and loss account is presented in Section 2. Section 3 discusses in detail the impact of higher interest rates on bank profitability, through three channels: net interest income, changes in the fair value of assets and liabilities, and credit losses, while Section 4 considers changes in the market value of equity. Section 5 goes through the empirical exercise in detail, and Section 6 concludes. Five annexes complement the discussion in the main text.

2. A simplified representation of a bank

Let's start with a representative bank that mainly grants loans (some of which are performing and some others non-performing) or buys securities. The latter can be equities or debt securities. Debt securities can be classified as held-for-trading, available-for-sale or held-to-maturity while equities are classified always as held-for-trading. The bank also keeps some amount of liquid assets (i.e., cash), to be able to respond to deposit outflows. Liabilities comprise equity, wholesale funding and deposits, some of which are insured by deposit guarantee schemes. The gross carrying amount of loans is adjusted by loan loss provisions, which are formally classified within equity, together with the

[2] This could also be linked to the ongoing debate on the low credit losses recognised by EU banks after the COVID-19 pandemic (see, among others, Enria, 2023).

regulatory capital requirements, calculated as a fixed proportion of the assets. Schematically, the balance sheet of our bank would then be:

Table 1. Schematised view of the balance sheet

Assets	Liabilities
Loans (L) =	Equity (E) =
Performing loans (PL) +	Capital (C) +
Non-performing loans (NPL)	Loan Loss Provisions (LLP)
Equities (EQ)	Wholesale funding (WF)
Debt securities (DS) =	Deposits (D) =
Debt securities held-for-trading (DST) +	Insured deposits (ID) +
Available-for-sale debt securities (DSA) +	Uninsured deposits (UD)
Debt securities held-to-maturity (DSM)	Other liabilities (OL)
Liquid assets (LA)	
Other assets (OA)	

The profit and loss account of the bank considers income and expenses from the activities of the bank (interest earned on performing loans, interest from debt securities, interest paid to deposits, operational costs, and credit losses recognised in the period), as well as changes in the valuation of financial instruments held-for-trading. We are assuming that non-performing loans and liquid assets do not accrue interest income. Credit losses refer to loan loss provisions, including those generated by non-performing loans.

The profit function of the bank at time t is:

$$PR_t = [i_t L_t (1 - npl_t)] + i'_t DS_t - i''_t D_t - i'''_t WF_t + \Delta FV_t - OC_t - CL_t \quad (1)$$

where i_t, i'_t, i''_t and i'''_t are the average interest rates of loans, debt securities, deposits and wholesale funding respectively, npl_t is the rate of non-performing loans calculated as non-performing loans divided by total loans, OC_t are other charges, CL_t are credit losses, and ΔFV_t represents changes in the fair values of equities and debt securities.

In principle, there are seven ways through which the level of interest rates can impact the profits earned by banks on their assets and liabilities: (i) interest income from loans at variable rates, (ii) interest income from new loans granted, in place of those maturing, (iii) interest expense of overnight deposits, (iv) interest expense of new term deposits, (v) interest expense of new wholesale funding (i.e., debt securities issued), (vi) additional credit losses due to a deteriorated debt servicing capacity of borrowers, and (vii) revaluations of financial assets at fair value. They relate to the stylised profit and loss account presented by Equation (1) and are further developed in the next section.

3. Interest rates and bank profitability

This section describes three channels through which interest rates can impact bank profitability: (i) changes in the interest rates of loans and deposits, (ii) changes in the fair value of financial assets and liabilities, and (iii) credit losses, as interest rates affect the debt servicing capacity of borrowers.

3.1. Net interest income and income gap

The level of interest rates in an economy has an immediate impact on the profit and loss account of banks via their interest income and expenses. To assess this impact, it is useful to use the concept of "income gap". Gomez et al. (2016), following Mishkin and Easkin (2009), define the income gap as the difference between assets automatically repricing due to a change in interest rates and the liabilities automatically repricing due to a change in interest rates. On the asset side of the balance sheet, we can consider that the income gap includes variable-rate loans and the new loans granted by the bank. On the liabilities side, it includes overnight deposits, plus the flow of new term deposits and of new wholesale funding.

To compute the income gap of our stylised bank, we first compute its net interest income. Within the interest income from loans, we must distinguish those at variable rates from those at fixed rates, and consider that new loans that are granted at a different interest rate than those previously recognised in the balance sheet of the bank. On that basis, we can decompose the total amount of loans in the balance sheet of a bank into fixed-rate loans, variable-rate loans, new loans and non-performing loans, the latter not generating interest income.

As a result, the interest income of a bank would be equal to:

$$InterestIncome = i_t L_t(1-npl_t) = \left(1-\frac{1}{m_t}\right)\left[\alpha L_t\left[\hat{\imath}_t\left(1-\widehat{npl_t}\right)\right]+(1-\alpha)L_t\left[\overline{\imath_t}\left(1-\overline{npl_t}\right)\right]\right]+\frac{1}{m_t}\left[i_t L_t(1+c_t)\right] \quad (2)$$

where m_t is the average maturity of loans, α is the share of loans with variable-rate interest, $\hat{\imath}_t$ is the average interest rate of variable-rate loans, $\widehat{npl_t}$ is the rate of non-performing loans with fixed-rate, $\overline{\imath_t}$ is the average interest rate of fixed rate loans, $\overline{npl_t}$ is the rate of non-performing loans with variable rate, and c_t is overall credit growth.

Interest expenses from bank deposits can be broken down as those derived from overnight deposits and those from term deposits. We assume that term deposits have a fixed maturity and cannot be modified or cancelled. Therefore, we express interest expenses from deposits as:

$$InterestExpense\ (deposits) = i''_t D_t = (1+od_t){i^{od}}_t OD_t + \left(1-\frac{1}{md_t}\right)({i^{td}}_t TD_t) + \frac{1}{md_t}\left[{i^{td}}_t TD_t(1+td_t)\right] \quad (3)$$

where od_t is the growth rate of overnight deposits, ${i^{od}}_t$ is the interest rate paid to overnight deposits, OD_t is the amount of overnight deposits, md_t is the average maturity of term deposits, i^{td} is the interest paid to term deposits, TD_t are term deposits, and td_t is the growth rate of term deposits.

A similar approach can be applied to wholesale funding, which related expenses should be equal to:

$$InterestExpense\ (wholesale) = i'''_t WF_t = \left(1 - \frac{1}{mw_t}\right)(i'''_t WF_t) + \frac{1}{mw_t}[i'''_t WF_t(1 + w_t)] \qquad (4)$$

where mw_t is the average maturity of wholesale funding and w_t is the growth rate of wholesale funding.

We can now compute the net interest income (NII) as the sum of Equation (2), Equation (3) and Equation (4):

$$NII_t = \left(1 - \frac{1}{m_t}\right)\left[\alpha L_t\left[\hat{\imath}_t\left(1 - \widehat{npl_t}\right)\right] + (1-\alpha)L_t\left[\bar{\imath}_t\left(1 - \overline{npl_t}\right)\right]\right] + \frac{1}{m_t}[i_t L_t(1 + c_t)] + i'_t DS_t - (1 + od_t)i^{od}{}_t OD_t - \left(1 - \frac{1}{md_t}\right)(i^{td}{}_t TD_t) - \frac{1}{md_t}[i^{td}{}_t TD_t(1 + td_t)] - \left(1 - \frac{1}{mw_t}\right)(i'''_t WF_t) - \frac{1}{mw_t}[i'''_t WF_t(1 + w_t)] \qquad (5)$$

Equation (5) includes a term $(i'_t DS_t)$ to account for the interest income from debt securities owned by the bank.

There are five different interest rates applied to loans, deposits and wholesale funding in Equation (5). We can express those related to variable-rate loans, overnight deposits, new loans, new term deposits and new wholesale funding as the result of the multiplication of the official interest rates and a pass-through coefficient (φ). The interest rate of fixed-rate loans and of existing wholesale funding would not be directly linked to the prevailing official interest rates; they are excluded from the income gap.

As a result, we obtain:

$$NII_t = r_t\left[\left(1 - \frac{1}{m_t}\right)\alpha L_t\left[\varphi_1\left(1 - \overline{npl_t}\right)\right] + \frac{1}{m_t}[\varphi_2 L_t(1 + c_t)] - (1 + od_t)\varphi_3 OD_t - \frac{1}{md_t}[\varphi_4 TD_t(1 + td_t)] - \frac{1}{mw_t}[\varphi_5 WF_t(1 + w_t)]\right] + \left(1 - \frac{1}{m_t}\right)(1-\alpha)L_t\left[\bar{\imath}_t\left(1 - \overline{npl_t}\right)\right] + i'_t DS_t - \left(1 - \frac{1}{md_t}\right)(i^{td}{}_t TD_t) - \left(1 - \frac{1}{mw_t}\right)(i'''_t WF_t) \qquad (6)$$

Taking a derivative of Equation (6) with respect to interest rates, we obtain the drivers of the change in profits related to the income gap (IG_t), that is to say, the items in net interest income that are directly related to the prevailing level of interest rates in the economy:

$$\frac{\delta NII_t}{\delta r_t} = IG_t = \left(1 - \frac{1}{m_t}\right)\alpha L_t\left[\varphi_1\left(1 - \widehat{npl_t}\right)\right] + \frac{1}{m_t}[\varphi_2 L_t(1 + c_t)] - (1 + od_t)\varphi_3 OD_t - \frac{1}{md_t}[\varphi_4 TD_t(1 + td_t)] - \frac{1}{mw_t}[\varphi_5 WF_t(1 + w_t)] \qquad (7)$$

Accordingly, the impact of the level of interest rates at time t on the profitability of banks depends on the structure of the balance sheet (the share of loans, deposits and wholesale funding) and on the pass-through coefficients ($\varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5$). Under the assumption of perfect movement of loans, deposits and wholesale funding across banks as a result, for example, of intense competition, the pass-through coefficients should be equal ($\varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5$). We can further assume that the maturity of term deposits and wholesale funding is shorter than the maturity of variable-rate loans. That is just a reflection of the maturity transformation carried out by banks in their deposit-taking and lending activity. However, in practice, there may be some stickiness in deposits, which tend to have a lower pass-through coefficient than loans. The difference between the pass-through of loans and of deposits reflects the deposit franchise of banks, which allows banks to pay deposit rates that are low and less sensitive to market interest rates (Drechsler et al., 2021).

If there is a change in the level of interest rates in the economy, the difference in net interest income would be determined by the change in the income gap:

$$IG_t - IG_{t-1} = \Delta IG_t = r_t\left[\left(1-\frac{1}{m_t}\right)\alpha L_t[\varphi_1(1-\overline{npl_t})] + \frac{1}{m_t}[\varphi_2 L_t(1+c_t)] - (1+od_t)\varphi_3 OD_t - \frac{1}{md_t}[\varphi_4 TD_t(1+td_t)] - \frac{1}{mw_t}[\varphi_5 WF_t(1+w_t)]\right] - r_{t-1}\left[\left(1-\frac{1}{m_t}\right)\alpha L_{t-1}[\varphi_1(1-\overline{npl_{t-1}})] + \frac{1}{m_t}[\varphi_2 L_{t-1}(1+c_{t-1})] - (1+od_{t-1})\varphi_3 OD_{t-1} - \frac{1}{md_t}[\varphi_4 TD_{t-1}(1+td_{t-1})] - \frac{1}{mw_{t-1}}[\varphi_5 WF_t(1+w_{t-1})]\right] \quad (8)$$

Assuming that the interest rate in the previous period is a share of the interest rate in the current period ($r_{t-1} = \omega r_t$), then Equation (8) becomes:

$$\Delta IG_t = r_t\left[\left(1-\frac{1}{m_t}\right)\alpha L_t[\varphi_1(1-\overline{npl_t})] + \frac{1}{m_t}[\varphi_2 L_t(1+c_t)] - (1+od_t)\varphi_3 OD_t - \frac{1}{md_t}[\varphi_4 TD_t(1+td_t)] - \frac{1}{mw_t}[\varphi_5 WF_t(1+w_t)]\right] - \omega r_t\left[\left(1-\frac{1}{m_t}\right)\alpha L_{t-1}[\varphi_1(1-\overline{npl_{t-1}})] + \frac{1}{m_t}[\varphi_2 L_{t-1}(1+c_{t-1})] - (1+od_{t-1})\varphi_3 OD_{t-1} - \frac{1}{md_t}[\varphi_4 TD_{t-1}(1+td_{t-1})] - \frac{1}{mw_{t-1}}[\varphi_5 WF_t(1+w_{t-1})]\right] \quad (9)$$

Operating further and under a constant share of variable-rate loans, we obtain:

$$\Delta IG_t = r_t\left[\varphi_1\left(1-\frac{1}{m_t}\right)\alpha\left(L_t(1-\overline{npl_t}) - \omega L_{t-1}(1-\overline{npl_{t-1}})\right) + \varphi_2\frac{1}{m_t}[L_t(1+c_t) - \omega L_{t-1}(1+c_{t-1})] - \varphi_3\left((1+od_t)OD_t + \omega(1+od_{t-1})OD_{t-1}\right) - \varphi_4\frac{1}{md_t}[TD_t(1+td_t) - \omega TD_{t-1}(1+td_{t-1})] - \varphi_5\frac{1}{mw_t}[WF_t(1+w_t) - \omega WF_t(1+w_{t-1})]\right] \quad (10)$$

Equation (10) implicitly assumes that pass-through coefficients remain constant between the two periods.

Finally, if we take a derivative, we get:

$$\frac{\delta\Delta IG_t}{\delta r_t} = \varphi_1\left(1-\frac{1}{m_t}\right)\alpha\left(L_t(1-\overline{npl_t}) - \omega L_{t-1}(1-\overline{npl_{t-1}})\right) + \varphi_2\frac{1}{m_t}[L_t(1+c_t) - \omega L_{t-1}(1+c_{t-1})] - \varphi_3\left((1+od_t)OD_t + \omega(1+od_{t-1})OD_{t-1}\right) - \varphi_4\frac{1}{md_t}[TD_t(1+td_t) - \omega TD_{t-1}(1+td_{t-1})] - \varphi_5\frac{1}{mw_t}[WF_t(1+w_t) - \omega WF_t(1+w_{t-1})] \quad (11)$$

Equation (11) shows the drivers of the change in net interest income from a change in interest rates. It is similar to the earnings-based approach used by the Basel Committee on Banking Supervision for the measurement of interest rate risk in the banking book.

3.2. Changes in the fair value of assets

In addition to the interest rates associated with loans and deposits, interest rates can impact the profitability of banks through changes in the market value of the assets measured at fair value in their balance sheet.

In general, higher interest rates should lead to decreases in the discounted value of loans and debt securities, two of the main assets in the balance sheet of banks. That discounted value can be expressed as:

$$DV_{i,t} = \sum_{t=1}^{T} \frac{CF_{i,t}}{(1+r_t)^T} + \frac{PR_{i,t}}{(1+r_t)^T} \tag{12}$$

where $DV_{i,t}$ is the discounted value of instrument i at time t, $CF_{i,t}$ are associated cash flows in period t (coupons in the case of debt securities and loan repayments), T is the maturity of the loan or debt security in years, and $PR_{i,t}$ is the amount of the principal of the financial instrument.

Discounted values are not directly observable for the items in the balance sheet of banks, where assets are measured at amortised cost (namely, most loans) or at fair value. However, in the case of assets at fair value, the decrease in the discounted value of assets should, theoretically, be reflected in market prices, directly impacting the profit and loss account. For assets at amortised cost, impairment tests could consider, among other issues, the lower discounted value.

Looking at the balance sheet in Table 1, changes in fair value (ΔFV_t) would be equal to:

$$\Delta FV_t = (EQ_t PEQ_t) - (EQ_{t-1} PEQ_{t-1}) + (DST_t PDS_t) - (DST_{t-1} PDS_{t-1}) + [\theta_t \sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}] \tag{13}$$

where ΔFV_t is the change in the fair value of financial instruments (equities and debt securities) at fair value, EQ_t is the amount of equities at time t (assuming all of them are measured at fair value), PEQ_t is the price of equities, DST_t is the amount of debt securities at fair value at time t, PDS_t is the price of debt securities, θ_t is a variable taking a value 1 is there is a reclassification of financial instruments from available-for-sale or held-to-maturity to fair value, which would trigger the recognition of accumulated fair value gains in the profit or loss account, and $\Delta FV_t^{DSA+DSM}$ are the accumulated fair value gains and losses on debt securities available-for-sale and held-to-maturity.

For the available-for-sale debt securities and debt securities held-to-maturity, changes in prices would only be recognised in the profit and loss account in specific circumstances. The parameter θ_t takes the value 0 when the bank has enough liquid assets or assets valued at fair value to respond to deposit outflows. If that is not be the case, the bank would need to sell the debt securities at cost, meaning that first they would need to be reclassified to fair value, realising a large loss. In those rare circumstances, θ_t would take the value 1 and the solvency of the bank could be put into question, as the accumulated fair value losses could be rather large. Our baseline assumption is for a value of θ_t equal to zero.

We decompose further the prices of equities and debt securities, as being a function of a intersect, a vector of variables (Y_t) and the level of interest rates, with the corresponding time-invariant coefficients (b and c for equities, and b′ and c′ for debt securities). Then, Equation (13) becomes:

$$\Delta FV_t = \left(EQ_t(a + bY_t - cr_t)\right) - \left(EQ_{t-1}(a + bY_{t-1} - cr_{t-1})\right) + \left(DST_t(a' + b'Y_t - c'r_t)\right) - \left(DST_{t-1}(a' + b'Y_{t-1} - c'r_{t-1})\right) + [\theta_t \sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}] \quad (14)$$

Operating further, we obtain:

$$\Delta FV_t = \Theta - r_t(cEQ_t + c'DST_t) + r_{t-1}(cEQ_{t-1} + c'DST_{t-1}) + [\theta_t \sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}] \quad (15)$$

where $\Theta = a(EQ_t - EQ_{t-1}) + b(EQ_t Y_t - EQ_{t-1}Y_{t-1}) + a'(DST_t - DST_{t-1}) + b'(DST_t Y_t - DST_{t-1}Y_{t-1})$.

Banks tend to measure at fair value those items in their balance sheet that are used for trading purposes. As such, in an environment of increasing interest rates, which would reduce the fair value of equities and debt securities, banks would be able to quickly react and shift to other asset classes. Therefore, Equation (15) should not always have a negative sign.

Recalling our assumption that the interest rate in the previous period is a share of the interest rate in the current period ($r_{t-1} = \omega r_t$) and taking derivatives on Equation (15), we obtain:

$$\frac{\delta \Delta FV_t}{\delta r_t} = -(cEQ_t + c'DST_t) + \omega(cEQ_{t-1} + c'DST_{t-1}) \quad (16)$$

Depending on the level of change of interest rates between the two periods and the changes in the amounts of equities and debt securities in the balance sheet, the result of Equation (17) would be positive or negative, always under the assumption that there is no need to sell debt securities at amortised cost or available-for-sale.

3.3. Credit losses and impairment

Our bank applies IFRS 9, so credit losses in a period would be the sum of those associated with loans in stages 1, 2 and 3, given by:

$$CL_t = \left(\Delta L_t^1 \sigma_1 \frac{S1}{L_t}\right) + \left(\Delta L_t^2 \sigma_2 \frac{S2}{L_t}\right) + \left(\Delta L_t^3 \frac{(1 - S1 - S2)}{L_t}(\sigma_3 - \pi\sigma_2)\right) \quad (17)$$

where σ_1 is the desired provision for loans in stage 1, $\frac{S1}{L_t}$ is the share of loans in stage 1, σ_2 is the desired provision for loans in stage 2, $\frac{S2}{L_t}$ is the share of loans in stage 2, π is the share of credit losses from non-performing loans already recognised in stage 2, and σ_3 is the associated loss from non-performing loans (similar to the concept of loss given default). ΔL_t^1, ΔL_t^2 and ΔL_t^3 represent the net flow of loans into stage 1, 2 and 3, respectively ($\Delta L_t^1 + \Delta L_t^2 + \Delta L_t^3 = 0$).

We can further express the net flows of loans allocated to stages 2 and 3 as:

$$\Delta L_t^2 = L_t\left(d + eX_t + f\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right) \tag{18}$$

$$\Delta L_t^3 = L_t\left(g + hX_t + m\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right) \tag{19}$$

where d, e, f, g, h and m are time-invariant parameters, X_t is a vector of other variables, $DB_{i,t}$ is the total debt of the borrower, $\Delta k_{i,t}$ is the change in the implied interest rate of the debt of the borrower, $RDGI_{i,t}$ is the gross disposable income of the borrower associated with loan i, in real terms adjusted for inflation, $\Delta C_{i,t}$ is the change in consumption of the borrower associated with the loan i, and $OI_{i,t}$ are other sources of income, such as the sale of assets, of the borrower associated with the loan i. We compare the increase in interest payments associated to their debt with the income of the borrower, taking into account also potential adjustments to consumption and other sources of income. In line with Rinaldi and Sanchis-Arellano (2006) and Ghosh (2015), we consider real gross disposable income an important variable in the recognition of a loan as non-performing or as stage 2.

It is important to note that there may be a time lag between the variables in the right-hand side of Equation (18) and Equation (19), and those in the left-hand side. This should reflect that there is a time lapse between the start of the financial stress of the borrower and the recognition of the loan as non-performing or its transfer to stage 2. Ari et al. (2019) identify an average period of 2.4 years before the start of a banking crisis and the peak of the rate of non-performing loans. Furthermore, according to the definition of a non-performing loan (Basel Committee on Banking Supervision, 2017), it needs to have a period of non-payment of 90 days. For the time being, we do not include this time lag in our analysis below, but we will return to this issue later in the empirical analysis.

The net flow of loans into stage 1 would then be:

$$\Delta L_t^1 = L_t(1+c_t) - \Delta L_t^2 - \Delta L_t^3 = L_t(1+c_t) - L_t\left(d + eX_t + f\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right) - L_t\left(g + hX_t + m\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right) \tag{20}$$

Operating further, we obtain:

$$\Delta L_t^1 = L_t\left[(1+c_t) - d - eX_t - f\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} - g - hX_t - m\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right] = \Delta L_t^1 = L_t\left[(1+c_t) - d - eX_t - g - hX_t - (f+m)\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right] \tag{21}$$

Based on Equation (18), Equation (19) and Equation (21), total credit losses at time t then would be equal to:

$$CL_t = \left(L_t(1+c_t) - d - eX_t - g - hX_t - (f+m)\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\sigma_1\frac{S1}{L_t}\right) + L_t\left(eX_t + f\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\sigma_2\frac{S2}{L_t}\right) + L_t\left(\left(g + hX_t + m\frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\right)(\sigma_3 - \pi\sigma_2)\frac{1-S1-S2}{L_t}\right) \tag{22}$$

Grouping terms, we obtain:

$$CL_t = L_t \left[\left((1+c_t) - d - eX_t - \ g - hX_t - (f+m) \frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \sigma_1 \frac{S1}{L_t} \right) + \left(eX_t + f \frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \sigma_2 \frac{S2}{L_t} \right) + \left(\left(g + hX_t + m \frac{DB_{i,t}\Delta k_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) (\sigma_3 - \pi\sigma_2) \frac{1-S1-S2}{L_t} \right) \right] \quad (23)$$

From this channel, an increase in the level of interest rates would increase the interest paid by the borrowers of bank loans, increasing their probability of default and, if above certain threshold, leading to the recognition of loans as stage 2 or non-performing. That would lead to higher credit losses in the profit and loss account of the bank.

Focusing now on interest rates, we assume that the change in the interest rate of the borrower is related to the official interest rate as follows:

$$\Delta k_{i,t} = \gamma(r_t - r_{t-1}) = \gamma(r_t - \omega r_t) = \gamma r_t (1-\omega) \quad (24)$$

Combining Equation (24) and Equation (23), and taking derivative on the latter, we obtain:

$$\frac{\delta CL_t}{\delta r_t} = L_t \left(\left(-(f+m) \frac{\left(DB_{i,t}\,\gamma(1-\omega)\right)}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) \sigma_1 \frac{S1}{L_t} \right) + \left(\left(f \frac{\left(DB_{i,t}\,\gamma(1-\omega)\right)}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) \sigma_2 \frac{S2}{L_t} \right) + \left(\left(m \frac{\left(DB_{i,t}\,\gamma(1-\omega)\right)}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) (\sigma_3 - \pi\sigma_2) \frac{(1-S1-S2)}{L_t} \right) = L_t \gamma (1-\omega) \left(\left(\left(-(f+m) \frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) \sigma_1 \frac{S1}{L_t} \right) + \left(\left(f \frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) \sigma_2 \frac{S2}{L_t} \right) + \left(\left(m \frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \right) (\sigma_3 - \pi\sigma_2) \frac{(1-S1-S2)}{L_t} \right) \right) \quad (25)$$

Operating further, we get:

$$\frac{\delta CL_t}{\delta r_t} = L_t \gamma (1-\omega) \frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}} \left(\left(-(f+m)\sigma_1 \frac{S1}{L_t} \right) + \left(f\sigma_2 \frac{S2}{L_t} \right) + \left(m(\sigma_3 - \pi\sigma_2) \frac{(1-S1-S2)}{L_t} \right) \right) \quad (26)$$

It is interesting to note the opposing effect from credit losses in stages 2 and 3 (negative, implying an impairment) and that of credit losses from stage 1 (positive, implying a reversal of an impairment) in Equation (26). This originates from the construction of the expected credit loss model in IFRS 9, where loans are allocated to stages 1, 2 or 3, as well as for the way we have approached the computation of credit losses by our representative bank.

3.4. Overall impact

In overall terms, the impact of higher interest rates on the profitability of banks ($\frac{\delta PR_t}{\delta r_t}$) would be equal to the sum of Equation (7), Equation (16) and Equation (26):

$$\frac{\delta PR_t}{\delta r_t} = \left(1 - \frac{1}{m_t}\right)\alpha L_t\left[\varphi_1\left(1 - \widehat{npl_t}\right)\right] + \frac{1}{m_t}\left[\varphi_2 L_t(1 + c_t)\right] - (1 + od_t)\varphi_3 OD_t - \frac{1}{md_t}\left[\varphi_4 TD_t(1 + td_t)\right] - \frac{1}{mw_t}\left[\varphi_5 WF_t(1 + w_t)\right] - (cEQ_t + c'DST_t) + \omega(cEQ_{t-1} + c'DST_{t-1}) - \left[L_t\gamma(1-\omega)\frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\left(\left(-(f + m)\sigma_1\frac{S1}{L_t}\right) + \left(f\sigma_2\frac{S2}{L_t}\right) + \left(m(\sigma_3 - \pi\sigma_2)\frac{(1-S1-S2)}{L_t}\right)\right)\right] \quad (27)$$

An important component of the change in bank profitability when there is an increase of interest rates is the starting point; the previous level of interest rates is present in Equation (28), through the parameter ω. There are also two variables from the previous period (equities and debt securities) and those related to credit losses (such as real gross disposable income) should also be understood of enter with some time gap in the overall assessment.

Equation (27) above shows that an increase of interest rates on the profitability of banks would have a positive impact on the interest income from variable-rate loans and from the flow of new loans, and a negative impact associated with overnight and term deposits, wholesale funding, the portfolio of equity and debt securities at fair value, and credit losses. The total impact will be positive if:

$$\left(1 - \frac{1}{m_t}\right)\alpha L_t\left[\varphi_1\left(1 - \widehat{npl_t}\right)\right] + \frac{1}{m_t}\left[\varphi_2 L_t(1 + c_t)\right] + \omega(cEQ_{t-1} + c'DST_{t-1}) > (1 + od_t)\varphi_3 OD_t + \frac{1}{md_t}\left[\varphi_4 TD_t(1 + td_t)\right] + \frac{1}{mw_t}\left[\varphi_5 WF_t(1 + w_t)\right] + \left[L_t\gamma(1-\omega)\frac{DB_{i,t}}{RGDI_{i,t}+\Delta C_{i,t}+OI_{i,t}}\left(\left(-(f + m)\sigma_1\frac{S1}{L_t}\right) + \left(f\sigma_2\frac{S2}{L_t}\right) + \left(m(\sigma_3 - \pi\sigma_2)\frac{(1-S1-S2)}{L_t}\right)\right)\right] + (cEQ_t + c'DST_t) \quad (28)$$

Equation (28) is unresolved in the sense that it does not offer a unique answer to the question of whether higher interest rates lead in all cases to an increase or to a decrease in bank profits. Before turning to the empirical analysis, based on data from the EU banking system, we look at how interest rates impact the market value of assets and liabilities in the balance sheet of banks.

4. Market value of bank's equity

Changes in interest rates also affect the market value of bank's assets, liabilities and equity, going beyond the impact on the profit and loss account. We define the market value of equity as the difference between the market value of assets and the market value of liabilities. Following Freixas and Rochet (2008), who consider first a bank with only loans in the asset side of its balance sheet and a mix of deposits and equity in the liabilities side of the balance sheet, the market value of equity can be approximated to:

$$V_t = A_t B(t, t + t_A) - LI_t B(t, t + t_L) \quad (29)$$

where V_t is the market value of equity, A_t is the value of assets at acquisition cost, $B(t, t + t_A)$ is the price at t of a risk-free bond with maturity $t + t_A$ $(t + t_L)$, LI_t is the value of liabilities, t_A is the maturity of assets and t_L is the maturity of liabilities.

Operating further with Equation (29), we can compute the market value of the equity of a bank as:

$$V_t = A_t e^{-t_A r_A} - LI_t e^{-t_{LI} r_{LI}} \quad (30)$$

where r_A (r_{LI}) is the yield of a risk-free bond with maturity t_A (t_{LI}), being the latter the duration of assets and liabilities of the bank.

Assuming longer duration of assets than of liabilities and a non-inverted yield curve, higher (lower) interest rates decrease (increase) the market value of equity of banks. When the duration gap between assets and liabilities is negative, the opposite relationship with interest rates holds. Insurance corporations, for example, tend to have higher duration in their liabilities,[3] so their market value of equity would increase with increases in interest rates. In other words, as banks tend to have longer durations in their assets, an increase of interest rates should decrease the market value of their equity. This is the second variable explored in the regulatory treatment of interest rate risk in the banking book, denominated economic value of equity (see Basel Committee on Banking Supervision, 2016).

5. *Empirical analysis*

Once we have formalised the impact of higher interest rates on bank profits and on the market value of equity, we now empirically assess it using a sample of EU banks reporting to the 2022 EBA Transparency Exercise. After a short introduction to the data used for the parametrisation, we present first insights from our analytical framework. Afterwards, we apply it to the current tightening cycle in the euro area and look into further detail in the characteristics of those banks reporting a loss.

5.1. Data

This section focuses on the latest hiking cycle in the euro area, which started in July 2022 and continued until September 2023. It comprises the last two quarters of 2022 (Q3 and Q4) and the first three quarters of 2023 (Q1, Q2 and Q3). For each one of them, we compute first the relative change in interest rates from the interest rates of the ECB marginal lending facility, to avoid issues with negative levels of interest rates (Table 2).

Table 2. Computation of relative changes in interest rates of the ECB lending marginal facility

	Interest rate at the end of the quarter	Previous interest rate	Relative change in interest rates (ω)
Q3-2022	1.50%	0.25%	0.17
Q4-2022	2.75%	1.50%	0.54
Q1-2023	3.75%	2.75%	0.73
Q2-2023	4.25%	3.75%	0.88
Q3-2023	4.75%	4.25%	0.89

Sources: European Central Bank (link) and author's calculations. Notes: the relative change in interest rates is calculated as the previous interest rate divided by the interest rate at the end of the quarter.

The data required to compute the formulae in Section 3 and in Section 4 are not minor and, in some cases, go beyond the information disclosed in the 2022 EBA Transparency Exercise. Therefore, for the ease of calculations, we set the value of some parameters and variables, which remain constant over the whole sample of banks (Table 3). In particular, we fix the maturity of loans, term deposits and

[3] See, for example, indicator 5.6 of the ESRB Risk Dashboard (https://www.esrb.europa.eu/pub/rd/html/index.en.html).

wholesale funding to 7 years, 2 years and 2 years, respectively. Regarding the values of the provisions for loans in stages 1, 2 and 3, we use the EU average, as computed in the EBA Risk Dashboard. For credit growth, we use the average quarterly growth rate of total credit to non-MFIs excluding government, between June 2022 (i.e., since the increase in official policy rates in the euro area) and June 2023. In the case of deposit growth (overnight and term), we look at the behaviour of euro area deposits since June 2022. With this starting point, we avoid the long period of low interest rates after the global financial crisis and the accumulation of deposits during the COVID-19 pandemic.

Table 3. Assumptions for parameters and variables

	Value	Source
$\boldsymbol{\sigma_1}$	0.002	Coverage ratio of loans in stage 1, EBA Risk Dashboard, Q3-2022
$\boldsymbol{\sigma_2}$	0.038	Coverage ratio of loans in stage 2, EBA Risk Dashboard, Q3-2022
$\boldsymbol{\sigma_3}$	0.458	Coverage ratio of loans in stage 3, EBA Risk Dashboard, Q3-2022
$\boldsymbol{m_2}$	7 years	Maturity of loans
$\boldsymbol{md_2}$	2 years	Maturity of term deposits
$\boldsymbol{mw_2}$	2 years	Maturity of wholesale funding
$\boldsymbol{c_1}$	0.0069	Average quarterly growth rate of total credit to non-MFIs excluding government, euro area, between Q2-2022 and Q2-2023
$\boldsymbol{od_2}$	-0.0087	Average quarterly growth rate of overnight deposits of non-MFIs excluding government, euro area, between June 2022 and February 2023, ECB
$\boldsymbol{td_2}$	0.0506	Average quarterly growth rate of deposits with agreed maturity of non-MFIs excluding government, euro area, between June 2022 and February 2023, ECB
$\boldsymbol{w_t}$	0.025	Average quarterly growth rate of debt securities issued by credit institutions, euro area, between Q2-2022 and Q2-2023, ECB

We use bank-specific variables of the balance sheet of the 114 banks in the 2022 Transparency Exercise of the EBA (excluding the aggregate "other"), with reference date June 2022. Taking data as of June 2022 places us immediately before the start of the cycle of monetary policy tightening in the euro area, offering a valuable opportunity to gauge the impact of changes in the level of interest rates on banks. Eight banks from Iceland, Liechtenstein and Norway, which took part of the 2022 EBA Transparency Exercise, are excluded as we cannot obtain the necessary data points for them (mainly related to those in Table 3 above).

Three more banks are excluded due to their business model, which does not allow us to build their complete balance sheet. The final number of banks is thus set to 103. On these bases, we are able to build the balance sheet shown in Table 4 for each of the 103 banks. Table A1 in Annex 2 explains how the variables in Table 1 are mapped to those disclosed in the 2022 EBA Transparency Exercise.

Table 4. Schematised view of the balance sheet

Assets	Liabilities
Loans (L) =	Tier 1 capital
Performing loans (PL) +	Wholesale funding (WF)
Non-performing loans (NPL)	Deposits (D)
Equities (EQ)	Overnight deposits (households and corporates)
Debt securities (DS) =	Term deposits (households and corporates)
Debt securities held-for-trading (DST) +	Government deposits
Available-for-sale debt securities (DSA) +	Interbank deposits
Debt securities held-to-maturity (DSM)	Deposits of other financial institutions
Liquid assets (LA)	Central bank deposits
Other assets	Other liabilities

There are two main differences with the balance sheet in Table 1. First, loan loss provisions are not presented in equity, but they are deducted from the gross carrying amount of the related financial assets. In other words, the asset side of Table 1 shows gross carrying amount while the balance sheet with data from the 2022 EBA Transparency Exercise shows carrying amounts. Second, there is no information about insured and uninsured deposits in the 2022 EBA Transparency Exercise, so this breakdown is not shown in Table 4. Instead, we show a breakdown of deposits by counterparty.

Finally, the 2022 EBA Transparency Exercise does not disclose information about the share of loans at fixed or variable interest rates. To get this information, we use the share of new variable rate loans in total new loans to households and non-financial corporations, from the ECB.[4] We take the data from the country of domicile of each bank and, if not available, the euro area average.

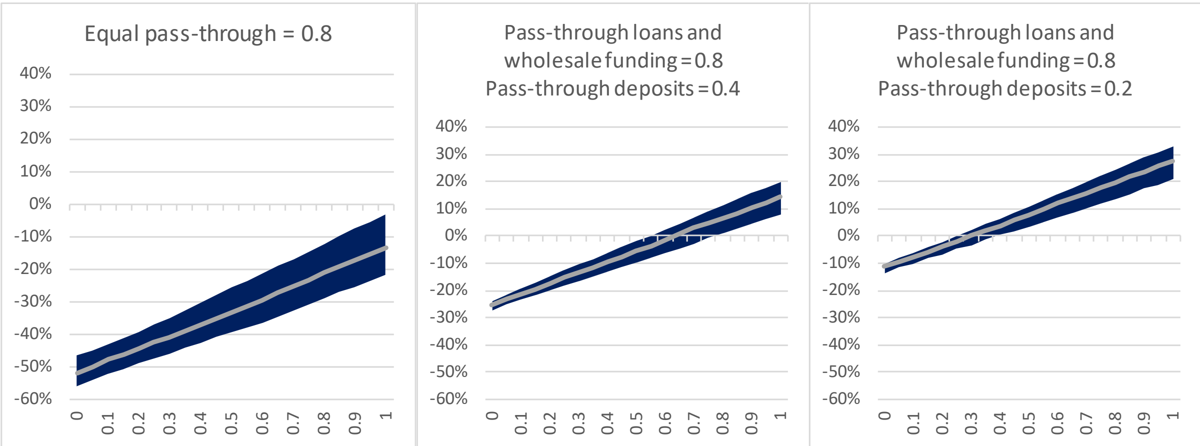
5.2. Insights from our analytical framework

Before moving to the assessment of the current monetary policy tightening cycle in the euro area, we present three important insights to better understand the impact of higher interest rates on the profitability of banks.

First, regarding net interest income and the income gap, the two key variables to determine the impact are the share of variable-rate loans, and the pass-through of higher interest rates to the interest rate of loans and deposits. Figure 1, following Equation (11), shows the interquartile range (in blue) and the median (as a grey line) of the income gap (as a share of total assets) under different shares of variable-rate loans (x-axis) and three assumptions for the pass-through of higher interest rates into loans, wholesale funding and deposits.

[4] See ECB Data Portal.

Figure 1. Income gap, as a share of total assets, under different assumptions on the share of variable-rate loans and the pass-through rates of loans and deposits



Sources: 2022 EBA Transparency Exercise and author's calculations. Notes: the x-axis shows different values of the share of variable-rate loans over total loans (from 0 to 1) and the y-axis shows the related change in income gap as a share of total assets. Each panel makes a different assumption about the pass-through of official interest rates to the interest rate of loans, wholesale funding and deposits.

The left-hand side panel shows the results for an equal pass-through for loans and deposits, at 0.8, a hypothetical situation where both sides of the balance sheet of banks adjust simultaneously. Not surprisingly, in these circumstances, no bank in our sample reports a positive income gap, regardless of the share of loans at variable-rates. This seems to support the argument in the academic literature highlighting the importance of the deposit franchise, which allows banks to make profits from their financial intermediation activities (see Drechsler et al., 2021). Without the deposit franchise (in other words, when the pass-through of deposits is not lower than the pass-through of loans), banks are not able to generate profits from their core financial intermediation function. The middle panel in Figure 1 assumes a lower pass-through for deposits, at 0.4, leading to a higher share of banks showing a positive income gap as a result of it. This assumption can be seen as the expected one in view of past tightening cycles (see Grodzicki et al., 2023). The right-hand side panel shows a situation with a very low pass-through for deposits, at 0.2, which could be seen more in line with the reported data in the earlier phase of the current tightening cycle (see Messer and Niepmann, 2023). In this latter case, the positive income gap is large and widespread across most of the banks in our sample.

5.3. Bank profits in the current tightening cycle in the euro area

Starting with the change in the net interest income from changes in the level of interest rates, according to Equation (11), we use data from the ECB Interest Rate Statistics to compute the actual pass-through of interest rates to loans, overnight deposits and term deposits, at country level. For simplification purposes, we keep the assumption that wholesale funding has the same pass-through as loans. Each pass-through is then allocated to a bank based on its country of domicile. We also take the share of variable-rate loans for the country of domicile of the bank. We further assume that government and central bank deposits are remunerated as term deposits and the rest of liabilities as overnight deposits. As already stated, the maturity of term deposits and wholesale funding is set to 2 years. Regarding the pace of re-pricing of variable-rate loans, we consider that they are not immediately repriced. Usually, variable-rate loans are repriced once a year, so we can assume that in the first quarter of higher interest rates, 25% of the variable-rate loans are repriced. This amount increases every quarter until reaching 100%, as shown in Table 5.

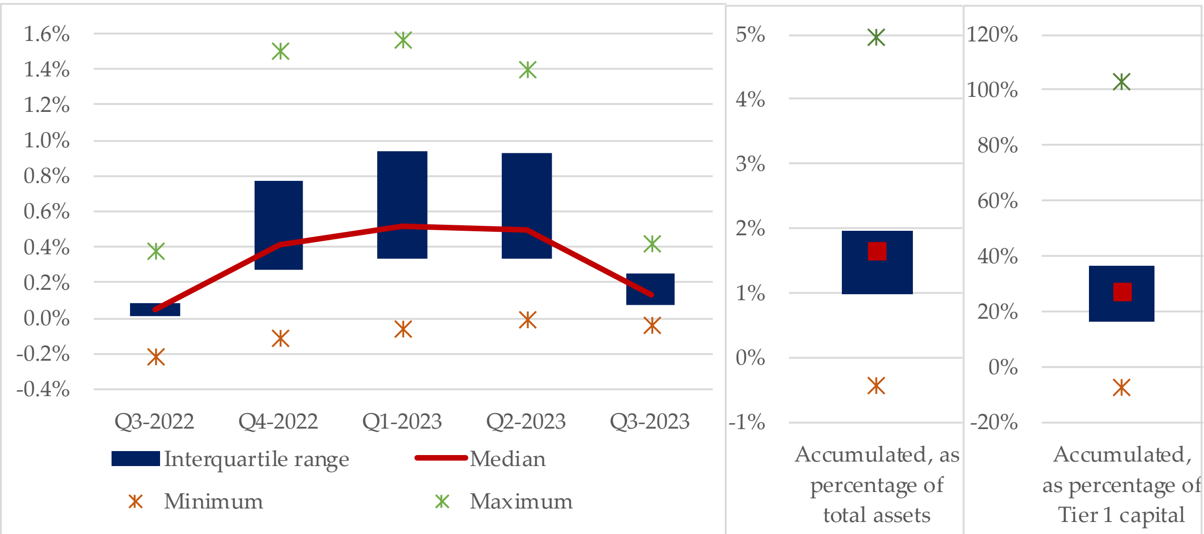
Table 5. Computation of relative changes in interest rates of the ECB lending marginal facility

	Percentage of repriced loans, current quarter	**Percentage of repriced loans, previous quarter**
Q3-2022	25%	0%
Q4-2022	50%	25%
Q1-2023	75%	50%
Q2-2023	100%	75%
Q3-2023	100%	100%

Sources: own elaboration.

Figure 2 shows the change in net interest income, as a share of total assets, over the five quarters under consideration. While the net interest income of most banks benefits substantially from the environment of higher interest rates, few banks see their net interest income slightly decreasing. Looking at the dynamics over time, there is an increasing trend in the first quarters, with a peak in Q1-2023 and a subsequent decline. In accumulated terms over the five quarters, banks increase their profits by between 1% and 2% of their total assets, which is a substantial increase. As a percentage of Tier 1 capital, the change in net interest income represents almost 30% for the median bank, with the first quartile close to 20%.

Figure 2. Change in net interest income as a share of total assets in the current monetary policy tightening cycle in the euro area

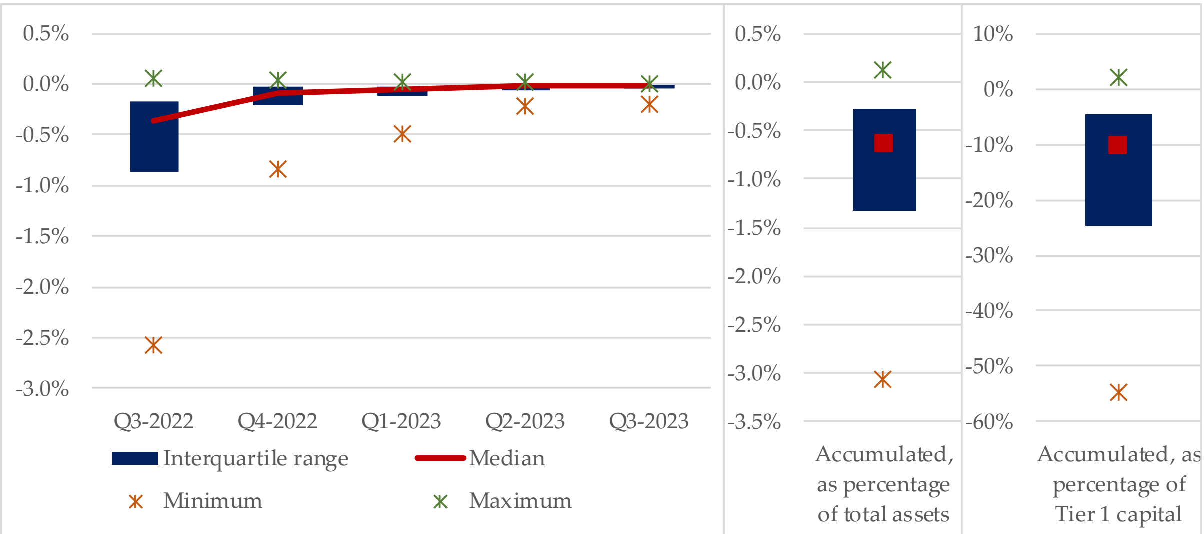


Sources: 2022 EBA Transparency Exercise, European Central Bank and author's calculations. Notes: the y-axis shows the change of the net interest income as a share of total assets (or of Tier 1 capital in the right-hand side panel). The blue boxes represent the interquartile range and the red lines (or squares) the median. A green and orange star represent the maximum and the minimum, respectively.

To consider the changes in the fair value of financial assets and liabilities, we make a couple of additional assumptions. First, we take the average duration of debt securities in the balance sheet of European banks, as reported in the confidential EBA quantitative impact study on interest rate risk in the banking book. The average duration is 4 years, implying that an increase of one percentage point of interest rates would decrease the value of bonds by 4%. That would be our c′ in Equation (16). For equity prices, the correlation with interest rates seems to be negative, according to the academic literature (see Weis et al., 2017, and references in section 2.2). Bernanke and Kuttner (2005) find that an unanticipated 25-basis-point cut in the Federal funds rate target is associated with an 1% increase in stock indexes, with unanticipated monetary policy decisions accounting for most of the changes in stock returns. Similar results are documented in English et al. (2018). Consequently, we define the sensitivity of stock prices to interest rates to be -4 for the first period of our analysis, implicitly assuming that the change in monetary policy stance was at that time unanticipated by market participants. Later on, this sensitivity is set to zero, also on account of increasing stock prices since the last months of 2022 (for example, the S&P500 increased by almost 20% between Q4-2022 and Q3-2023).

Moving to fair value losses, Figure 3 shows the distribution of changes in fair value, according to Equation (16). We implicitly assume that only interest rates change, not the other variables that could affect the market values of debt securities and equities, and that banks do not adjust their assets to the new environment of higher interest rates. Annex 3 presents three hypothetical scenarios considering changes in the holdings of debt securities and equities by banks. Finally, we also assume, for the time being, that there are not unrealised losses from debt securities at amortised cost.

Figure 3. Change in the fair value of debt securities and equities as a share of total assets in the current monetary policy tightening cycle in the euro area

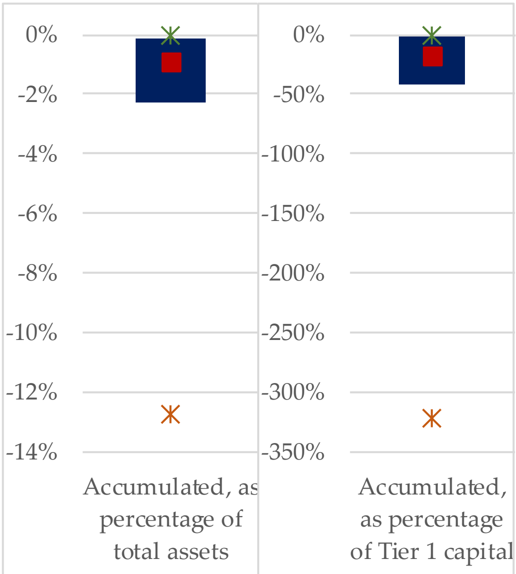


Sources: 2022 EBA Transparency Exercise, European Central Bank and author's calculations. Notes: the y-axis shows the related fair value gains or losses as a share of total assets (or of Tier 1 capital in the right-hand side panel. The blue boxes represent the interquartile range and the red lines (or squares) the median. A green and orange star represent the maximum and the minimum, respectively.

The largest losses are recognised in the initial quarter, which shows higher relative changes in interest rates. Subsequent quarters show smaller losses. In aggregate terms, these losses are limited as a share of total assets for most banks in the sample, although for some outliers they can represent more than 1% of total assets and more than 15% of Tier 1 capital.

Now we consider a situation where debt securities at amortised cost need to be sold. We assume that banks keep the amount of debt securities at cost constant, accumulating unrealised losses as interest rates increase, and are forced to sell them in Q3-2023. In these circumstances, the unrealised losses that they would need to recognise could be a substantial part of their total assets and Tier 1 capital for a subset of banks in our sample (Figure 4). However, it is worth recalling that the sale of debt securities at amortised cost should be a last resort for banks struggling with liquidity (i.e., an event with very low probability). After all, the bank could always post the debt securities at cost at the central bank and obtain liquidity against them, without the need to sell them and recognise large losses.

Figure 4. Unrealised losses in debt securities at amortised cost, as a share of total assets in the current monetary policy tightening cycle in the euro area



Sources: 2022 EBA Transparency Exercise, European Central Bank and author's calculations. Notes: the y-axis shows the unrealised losses from debt securities at amortised cost as a share of total assets (left-hand side panel) or of Tier 1 capital (right-hand side panel) if banks are forced to sell them at the end of Q3-2023. The blue boxes represent the interquartile range and the red squares the median. A green and orange star represent the maximum and the minimum, respectively.

Next, we consider additional credit losses as a result of higher interest rates, based on Equation (26). We obtain the coverage of stage 1, 2 and 3 loans from the EBA Risk Dashboard (Table 2) and are able to compute the share of loans in each stage for each individual bank from the 2022 EBA Transparency Exercise. Ghosh (2015) finds a coefficient of approximately 1.4 for the impact of real personal income on non-performing loans. We take this value in our computation for both the share of loans moving to stage 2 and to stage 3 (being the latter equivalent to non-performing loans). We also assume that 75% of the loans moving to stage 3 were previously recognised in stage 2.[5]

Then, we estimate the coefficient γ in Equation (26), which represents the extent to which the interest rate of the borrower is a fraction of the official interest rate. We use this coefficient to signal the difference between fixed- and variable-rate loans. With fixed-rate loans ($\gamma = 0$), borrowers do not have any change in the interest rate of their loan and are, somehow, isolated from changes in official interest rates. With variable-rate loans, the pass through of official interest rates to loan rates is faster. In this calibration, we take γ as the share of variable-rate loans in the country of the bank. In practical terms, as we assume that loans have a maturity of seven years, we take the average share of new variable-rate loans, as computed by the ECB, over the last seven years.

To compute the ratio between debt and real gross disposable income, we use data from the quarterly sectoral accounts of households and non-financial corporations, as reported by Eurostat. We use loans

[5] The recent entry into force of IFRS 9, in 2018, does not allow yet for having solid evidence on this regard.

and debt securities in the liabilities side of these sectors to account for their debt, and gross savings, which is computed after consumption, to account for gross disposable income. Data is available from 2013 for most EU countries: Belgium, Czechia, Denmark, Germany, Ireland, Spain, France, Italy, Hungary, Netherlands, Austria, Poland, Portugal, Slovenia, Finland and Sweden. For the other countries, we use the EU average. Annex 4 shows how the results could change depending on the level of the ratio of debt to real gross disposable income.

An important decision here refers to the temporal recognition of credit losses. For practical reasons, we separately look at credit losses from the transfer of exposures to stage 2 and from new non-performing loans. In both cases, instead of an immediate recognition, we assume that it takes certain amount of time for them to arise.

Starting with non-performing loans, Ari et al. (2019) find an average period of 2.4 years between the start of a banking crisis and the point at which the NPL rate reaches its maximum. While Ari et al. (2019) limit their sample to banking crises and the EU banking sector was certainly not in a crisis in 2022 and 2023, we decide to partially follow their findings and assume that it takes one year to witness increases in non-performing loans. In this way, for example, non-performing loans linked to the change in interest rates in Q3-2022 are recognised in Q2-2023.

For credit losses related to the transfer of exposures to stage 2, we start with the relative change in interest rates, as in Table 2, and with the percentage of repriced loans in the current quarters, as in Table 5. Instead of an immediate transfer to stage 2, we assume that it takes one quarter to do that. For example, the change in interest rates in Q3-2022 should not trigger a transfer into stage 2 of the loan in the same quarter, but in the next one. Table 6 shows how this approach is applied.

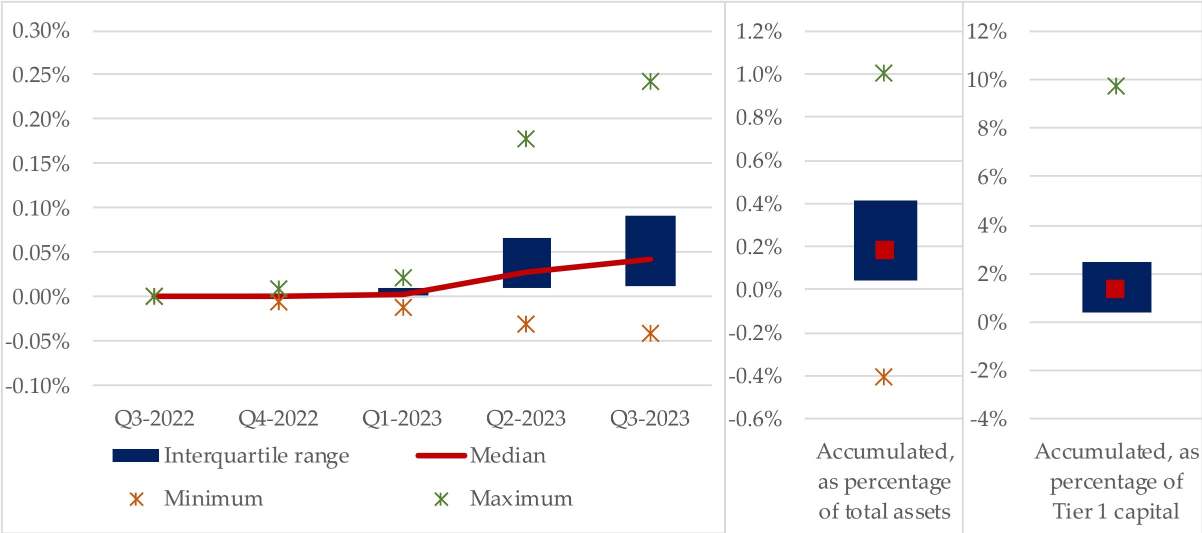
Table 6. Computation of credit losses derived from the transfer of exposures to stage 2

	Percentage of repriced loans, current quarter	**Relative change in interest rates**	**Computation of credit losses**
Q3-2022	25%	0.17	0%
Q4-2022	50%	0.54	25%*0.17
Q1-2023	75%	0.73	(25%*0.17) + (25%*0.54)
Q2-2023	100%	0.88	(25%*0.17) + (25%*0.54) + (25%*0.73)
Q3-2023	100%	0.89	(25%*0.17) + (25%*0.54) + (25%*0.73) + (25%*0.89)

Sources: own elaboration.

Leaving aside the first period, where there is no impact due to our way to compute them, Figure 5 shows a marked increase of credit losses for most banks only from Q2-2023, the first quarter when non-performing loans arise. Until then, credit losses from transfers of exposures to stage 2 are almost zero and, when non-performing loans start to be recognised, pick up until a median value of circa 0.05% of total assets in Q3-2023. The overall impact remains limited, below 0.4% of total assets for 75% of banks in our sample.

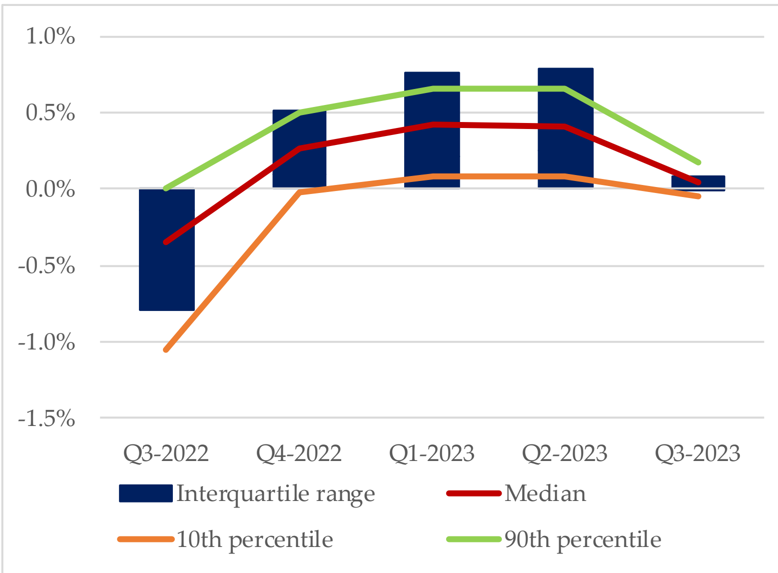
Figure 5. Credit losses as a share of total assets in the current monetary policy tightening cycle in the euro area



Sources: 2022 EBA Transparency Exercise, European Central Bank and author's calculations. Notes: the y-axis shows the related credit losses as a share of total assets (or of Tier 1 capital in the right-hand side panel). The blue boxes represent the interquartile range and the red lines (or squares) the median. A green and orange star represent the maximum and the minimum, respectively.

Finally, we consolidate the results of Figure 2, Figure 3 and Figure 5 to get the overall impact of higher interest rates on profits (Figure 6). We observe an inverted U shape of the median, as most banks have lower profits in the first period (due to losses from debt securities and equities at fair value) and in the last period (as a result of higher credit losses). From this perspective, losses immediately realise for financial assets at fair value and are differed in the case of borrowers.

Figure 6. Estimated total impact of higher interest rates on profits as a share of total assets in the current monetary policy tightening cycle in the euro area



Sources: 2022 EBA Transparency Exercise, European Central Bank and author's calculations. Notes: the y-axis shows the sum of (i) the change in net interest income, (ii) fair value gains and losses and (iii) credit losses as a share of total assets. The blue boxes represent the interquartile range and the red lines (or squares) the median. A green and orange lines represent the 90th and the 10th percentiles, respectively.

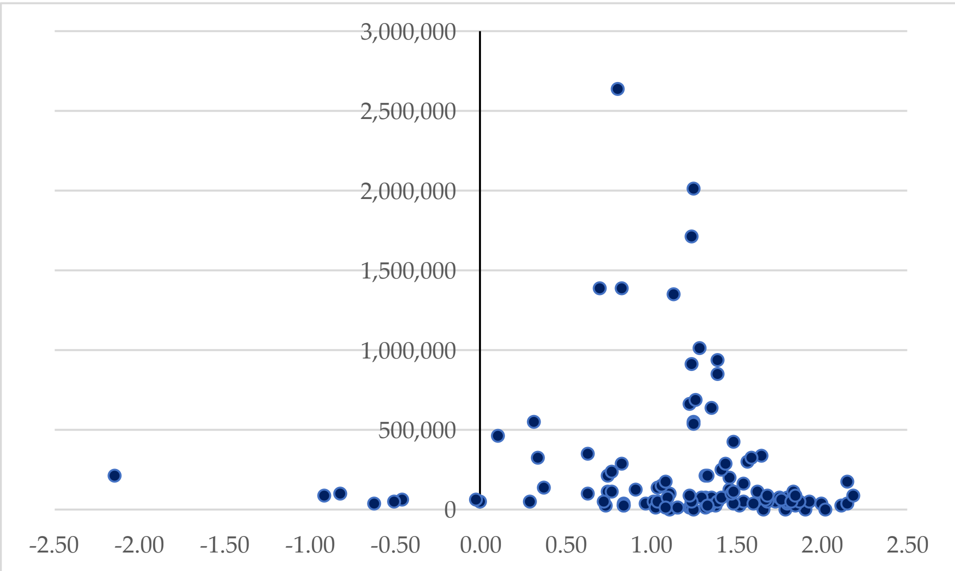
Around 10% of the banks are consistently showing losses from the increase in interest rates through the five quarters under consideration. Overall, however, increases in the level of interest rates are beneficial for the profitability of banks. In a comparison with the data reported by banks in the 2023 EBA Transparency Exercise, our results are comparable in absolute terms, with net interest income clearly dominating over the other two channels. Annex 5 provides further details on this comparison.

5.4. Market value of equity in the current tightening cycle in the euro area

The positive impact of higher interest rates on bank profitability co-exists with an expected negative impact on the market value of equity. Using confidential data from the EBA quantitative impact study on interest rate risk in the banking book, it is possible to compute the average duration of the balance sheet items in Table 4. From there, we obtain the duration gap of EU banks in June 2022 (defined as the average duration of assets minus the average duration of liabilities, excluding equity). In further detail, we assume that the duration of equities (in the asset side) equals that of other assets and the duration of liquid assets is equal to the duration of interbank exposures.

Figure 7 below show the duration gap in the x-axis, with the total assets in y-axis, of banks in the 2022 EBA Transparency Exercise. In general, EU banks tend to have a positive duration gap, with only few small banks showing a negative duration gap. Largest banks tend to have lower duration gaps, albeit always on the positive side.

Figure 7. Estimated duration gap of EU banks, Q2-2022

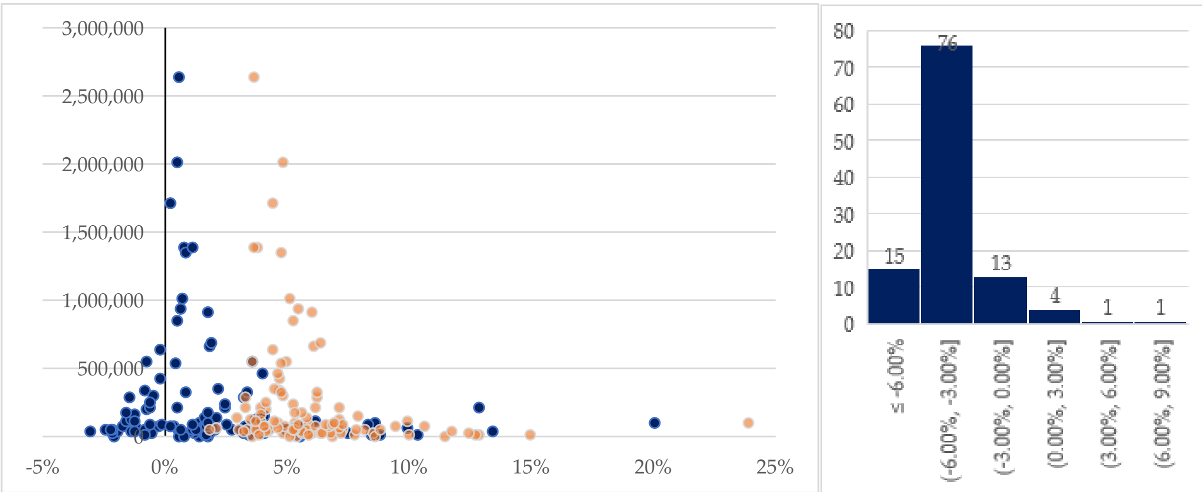


Sources: 2022 EBA Transparency Exercise, EBA report on IRRBB and author's calculations. Notes: the x-axis shows the duration gap of banks participating in the 2022 EBA Transparency Exercise, based on the durations reported in the EBA report on IRRBB and the y-axis shows the amount of total assets in Q2-2022. Each dot represents a bank.

In principle, a positive duration gap implies that the impact of increases in interest rates on the market value of equity is negative (although in an environment of an inverted yield curve, it would be possible to find the opposite, as the higher duration of assets would be associated with lower interest rates). To confirm this hypothesis, we compute the present value of the assets and liabilities of banks reporting to the 2022 EBA Transparency Exercise, according to Equation (30). We use the yield curve of US Treasuries as of 19 January 2024 and linearly extrapolate the reported yields to be able to get the yields associated with the duration of assets and liabilities.[6]

Next, we compute the market value of equity for each bank, which we compare to the equivalent results using the yield curve of US Treasuries during the low interest rate environment (in this case, as of 19 January 2021). Figure 8 below shows the total assets in the y-axis and the market value of equity, computed as above, in the x-axis (each blue dot is a bank). A relevant number of EU banks show a negative market value of their equity, including some of the largest banks. There are even more banks where the market value of equity computed with interest rates as of 19 January 2024 is below the market value of equity computed under a low interest rate environment (shown in orange in Figure 8 and on the right-hand side panel). Actually, only 6 banks out of a sample of 103 have now a market value of equity higher than the market value of equity with interest rates as of 2021. From this perspective, higher in interest rates are not beneficial to EU banks.

Figure 8. Estimated market value of equity of EU banks, Q2-2022

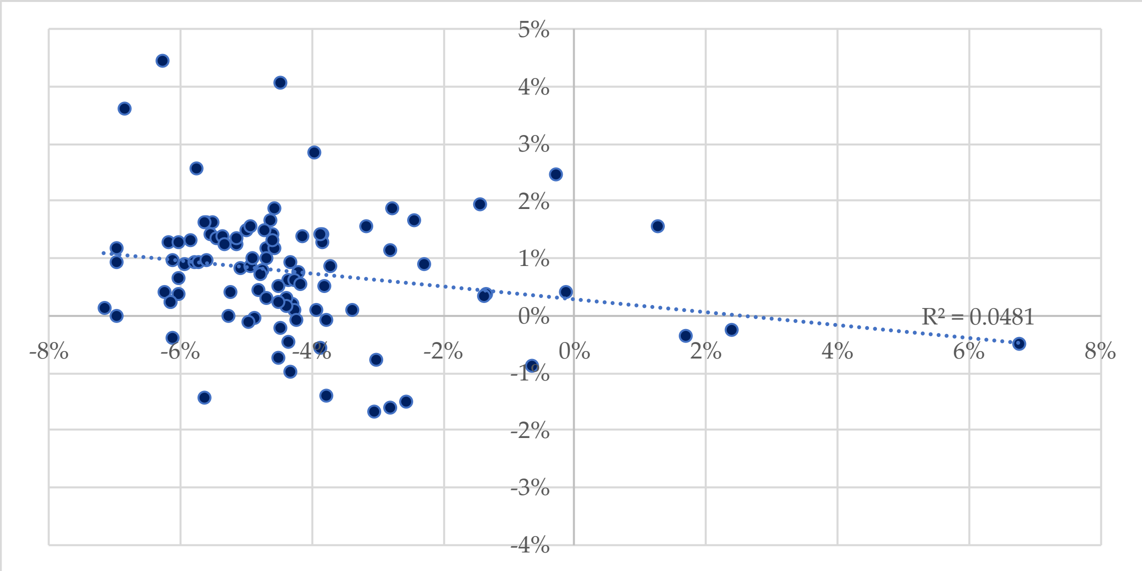


Sources: 2022 EBA Transparency Exercise, EBA report on IRRBB, Haver Analytics and author's calculations. Notes: in the left-hand side panel, the x-axis shows the market value of equity as a share of total assets (blue and orange dots) of banks participating in the 2022 EBA Transparency Exercise, based on the durations reported in the EBA report on IRRBB and the yield curve of US Treasures as of 19 January 2024 and of 19 January 2021, respectively. The y-axis shows the amount of total assets in Q2-2022. The right-hand side panel shows the histogram of the difference between the market value of equity as a share of total assets, computed according to the yield curve of US Treasuries on 19 January 2024 and 19 January 2021.

In the next step, Figure 9 shows together the change in profits (calculated as the sum of the change in net interest income, fair value gains and losses, and credit losses) as reported in Figure 6 (y-axis) with the difference between the market value of equity using the yield curve of US Treasuries as of 19 January 2024 and 2021 (x-axis).

[6] For example, if a bank has a duration of the assets of 2.2 years, we linearly extrapolate the yields of 1Y and 2Y US Treasuries.

Figure 9. Changes in the estimated market value of equity of EU banks and changes in profits

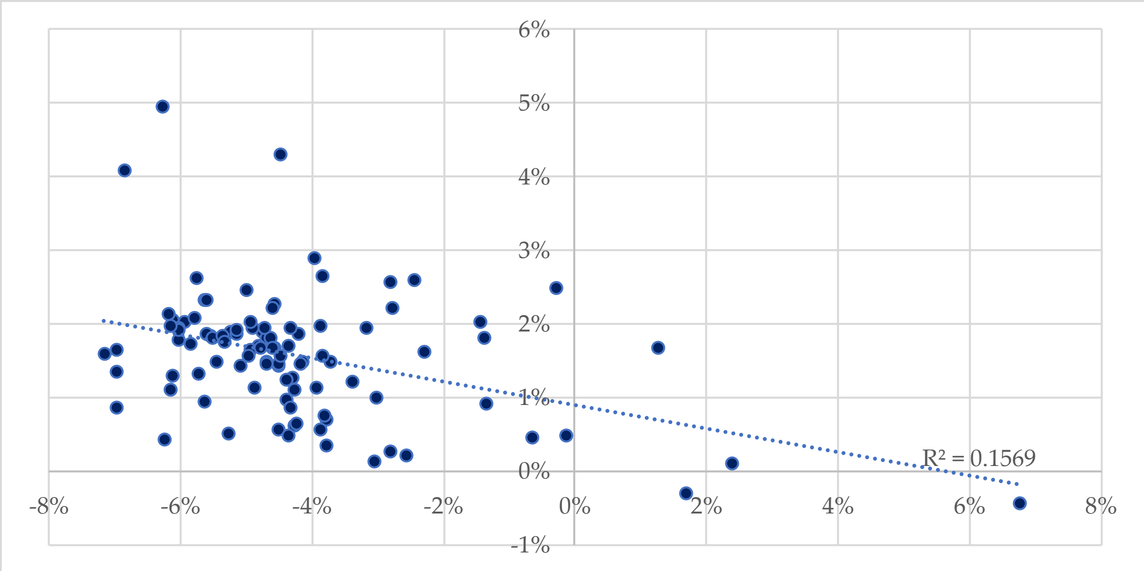


Sources: 2022 EBA Transparency Exercise, ECB, EBA report on IRRBB, Haver Analytics and author's calculations. Notes: the x-axis shows the difference between the market value of equity when using interest rates of the US Treasuries as of 19 January 2024 and 19 January 2021, as a share of total assets, while the y-axis shows the impact of higher interest rates on profits.

Figure 9 can be divided in four quadrants. The top-right quadrant shows banks with higher profits and higher market value of equity, which would then be positively impacted by higher interest rates. Only one bank goes into this quadrant. Approximately 75% of the banks are on the top-right quadrant, showing higher profits and lower market value of equity. This would be in line with expectations on the impact of high interest rates on banks, given their financial intermediation function and showing thus an inconclusive final picture. The bottom-left panel shows the opposite (i.e., banks with less profits and higher market value of equity). The three banks in this quadrant probably have a particular business model to explain that behaviour. Finally, the most worrying is the bottom-right panel, which shows 24 banks with less profits and lower market value of equity as a result of higher interest rates. We return to these 24 banks in Section 5.5.

One could argue that banks with negative results on one variable (for example, market value of equity) would show positive results in the other (for example, profits). To eliminate the potential noise created by changes in the fair value of assets and by credit losses, Figure 10 considers only net interest income in the y-axis. In this case, EU banks concentrate on the top-left quadrant, with just four exceptions. That suggests the existence of a trade-off (albeit imperfect) between changes in the market value of equity and changes in net interest income.

Figure 10. Estimated market value of equity of EU banks and changes in income gap



Sources: 2022 EBA Transparency Exercise, ECB, EBA report on IRRBB, Haver Analytics and author's calculations. Notes: the x-axis shows the share of variable-rate loans in the country of domicile of each bank, while the y-axis shows the impact of higher interest rates on the income gap. Each dot represents a bank.

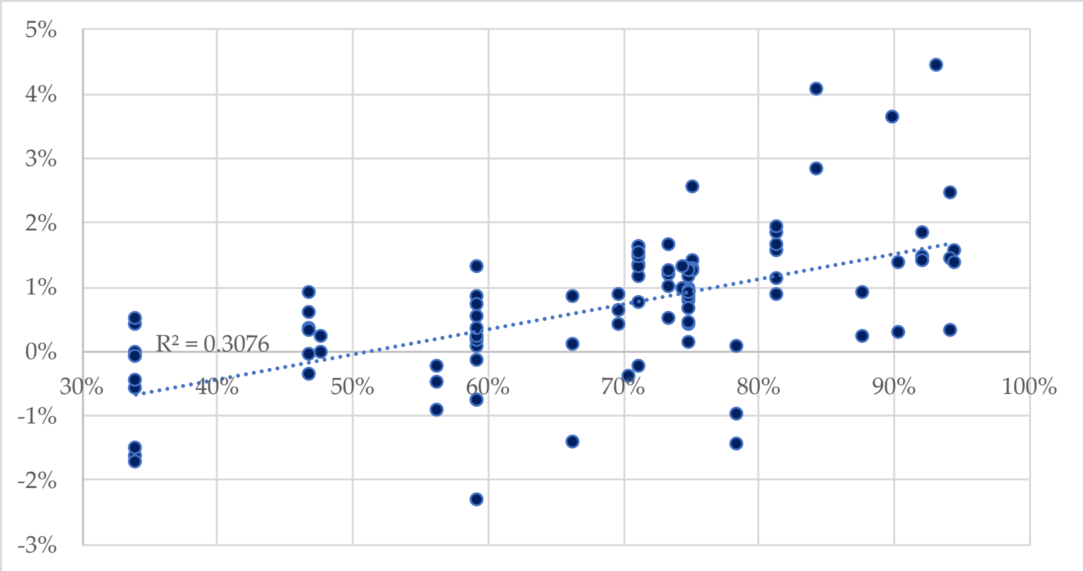
To sum up, our empirical analysis finds that EU banks (i) tend to have benefitted substantially from higher interest rates in terms of profitability, and (ii) have seen a decline in the market value of their equity. Besides, around one fourth of the banks in our sample of 103 banks show an overall negative impact of high interest rates on both profitability and the market value of equity. The next section offers further details of them.

5.5. Main characteristics of banks reporting a loss with higher interest rates

In Figure 9, we have reported 24 banks with less profits and a lower market value of equity as a result of higher interest rates. In this section we want to analyse these banks more closely in order to understand their main characteristics, which could later be used as early-warning signals when monetary policy changes stance.

First, lower profits with higher interest rates can stem from the share of loans at fixed interest rates. Figure 11 depicts a positive relation between the change in profits and the share of variable-rate loans, but with substantial heterogeneity across banks in the same country, suggesting that factors other than the share of variable-rate loans drive bank profitability.

Figure 11. Changes in profits of EU banks and share of variable-rate loans

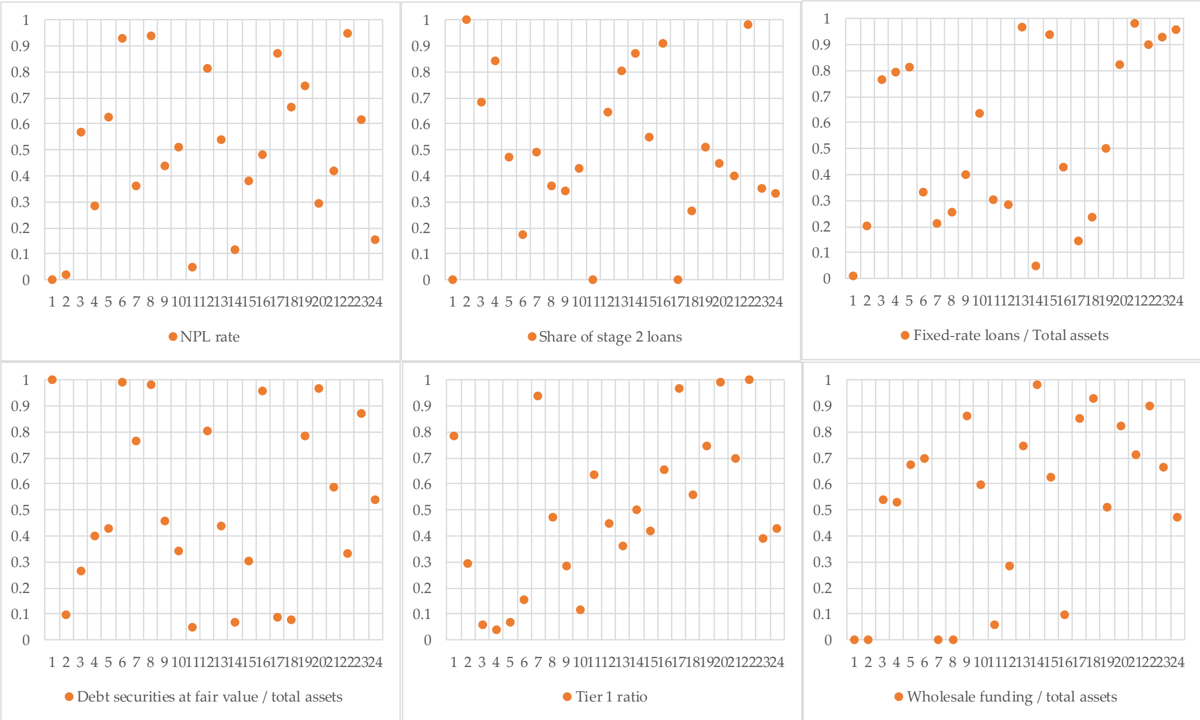


Sources: 2022 EBA Transparency Exercise, ECB and author's calculations. Notes: the x-axis shows the share of variable-rate loans in the country of domicile of each bank participating in the 2022 EBA Transparency Exercise, while the y-axis shows the impact of higher interest rates on profits. Each dot represents a bank.

There is a need to go further from here, considering other variables that could explain why some banks are not profitability in an environment with higher interest rates.

Consequently, we now look at the structure of the balance sheet of the 103 banks in our sample and define the following ratios: (i) rate of non-performing loans; (ii) share of Stage 2 loans; (iii) fixed-rate loans divided by total assets; (iv) debt securities at fair value divided by total assets; (v) Tier 1 capital divided by total assets, and (vi) wholesale funding divided by total assets. In the context of our empirical analysis, higher values of the ratios (i), (ii), (iii), (iv) and (vi) should lead to lower profits (due to higher credit losses, lower net interest income or higher fair value losses), while the relation of ratio (v) is uncertain. Then we calculate these ratios for the 103 banks in our sample and compute the percentile value for each one of them. Figure 12 shows the quantile values of these six ratios for the 24 banks reporting a loss, displayed in the x-axis.

Figure 12. Percentile of the six ratios to explain the structure of banks' balance sheet



Sources: 2022 EBA Transparency Exercise, ECB and author's calculations. Notes: the x-axis represent a bank showing a loss from higher interest rates according to our empirical analysis. The y-axis shows the quantile over the whole sample of 103 banks where the value for each bank is.

We can observe how several banks with losses in our empirical analysis tend to have a relatively high share of fixed-rate loans over total assets. These are loans not immediately repricing after a change in interest rates, establishing a link with the results presented in Section 5.3. Indicators on asset quality (NPL rate and share of stage 2 loans) are rather dispersed and do not seem to play a strong role in pushing banks to recognise losses when interest rates increase. Several of the banks reporting losses seem to have a particular business model, as evidenced by the high share of debt securities at fair value and the low and high values reported for wholesale funding. Finally, it is worth noting that among the 10 banks reporting the highest losses (values 1 to 10 in the x-axis of Figure 12), five are below the 20 percentile in the distribution of Tier 1 capital to total assets, pointing to a dangerous combination of low profitability and weak capitalisation.

To confirm the importance of the share of fixed-rate loans on the profitability of banks with higher interest rates, we run an econometric analysis to understand the bank characteristics that may explain the different level of bank profits computed in Section 5.3 for the banks participating in the 2022 EBA Transparency Exercise.

We consider here all 103 banks, regardless of whether they report losses or profits in our empirical analysis. The starting point is the following regression equation:

$$Profits_i = c + \beta X_i \tag{31}$$

where $Profits_i$ are the profits of bank i computed according to Equation (7), Equation (16) and Equation (26), c is the intersect, and β are the coefficients associated with the vector of independent variables X_i. Purposedly, we consider only bank-specific variables as we are interested in identifying bank-specific factors in the cross-section.

As in Figure 12, we consider as independent variables (i) the rate of non-performing loans; (ii) the share of stage 2 assets over total loans; (iii) the share of fixed-rate loans to total assets; (iv) the share of debt securities at fair value to total assets; (v) the share of Tier 1 capital over total assets; and (vi) the share of wholesale funding over total assets. Except for the share of Tier 1 capital, we could expect a negative sign in the related coefficients of the independent variables. The contribution of capital to bank profitability has been subjected to an agitated debate, without clear results so far. Besides, we introduce only a country dummy, to check whether there is a national component in the profitability of banks.

Table 7 below summarises the results of this econometric analysis. Column (I) shows the results for ordinary least squares. The value of the Durbin-Watson statistics suggests the presence of autocorrelation in the residuals, which is later confirmed when assessing the serial correlation LM-test and the correlogram Q-statistics. Moreover, there is indication of heteroscedasticity in this regression. On these grounds, we discard the use of ordinary least squares. Column (II) considers a quantile regression, dividing the sample of banks into five groups. However, the indicators of measurement of fit are really poor and we decide not to use quantile regressions any further. Column (III) and Column (V) show the results of the regression under robust least squares, addressing outliers in the dependent variable (M-estimation) and outliers in the dependent and independent variables (MM-estimation). Results in these two columns seem to be statistically sound and point to the role of the shares of debt instruments at fair value and of fixed-rate loans. Interestingly, no other variable is statistically significant in Column (III) and Column (V). That includes the country dummy, highlighting the importance of bank-specific variables in the determination of profitability. In Column (IV) and Column (VI) we gradually remove the variables which are not statistically significant and keep those that become statistically significant in the new configuration. This happens only with the rate of non-performing loans in Column (IV), showing the expected negative sign. In both columns, the shares of fixed-rate loans and of debt securities at fair value over total assets continue to be statistically significant with small changes in the associated coefficients.

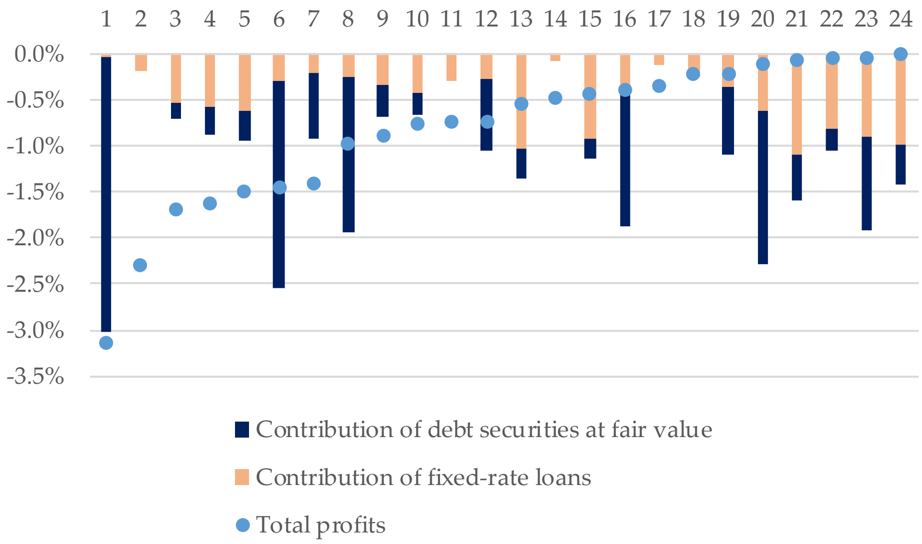
Table 7. Results of the regressions on the profits of banks participating at the 2022 EBA Transparency Exercise

	Dependent variable: profits / total assets					
	(I) Ordinary least squares	(II) Quantile regression (tau = 0.2)	(III) Robust least squares (M)	(IV) Robust least squares (M)	(V) Robust least squares (MM)	(VI) Robust least squares (MM)
Constant	0.0137***	-0.0050	0.0167***	0.0205***	0.0175***	0.0173***
	(0.0041)	(0.0065)	(0.0032)	(0.0018)	(0.0031)	(0.0016)
Debt securities at fair value	-0.1173***	-0.0970***	-0.1116***	-0.1033***	-0.1111***	-0.1073***
	(0.0226)	(0.0305)	(0.0177)	(0.0137)	(0.0171)	(0.0153)
Fixed-rate loans	-0.0229**	-0.0027	-0.0237***	-0.0296***	-0.0252***	-0.0234***
	(0.0095)	(0.0090)	(0.0075)	(0.0060)	(0.0072)	(0.0065)
Rate of non-performing loans	0.0597	0.3273***	-0.0872	-0.1174*	-0.0935	
	(0.1094)	(0.1057)	(0.0858)	(0.0647)	(0.0830)	
Share of stage 2 loans	-0.0329**	-0.0304***	0.0162		0.0139	
	(0.0137)	(0.0105)	(0.0107)		(0.0104)	
Tier 1 ratio	0.0489	-0.0104	-0.0200		-0.0172	
	(0.0402)	(0.0371)	(0.0316)		(0.0305)	
Wholesale funding	-0.0011	0.0001	0.0002		0.0008	
	(0.0056)	(0.0063)	(0.0044)		(0.0043)	
Country dummy	0.0175	0.0600**	0.0122		0.0101	
	(0.0151)	(0.0232)	(0.0118)		(0.0114)	
Number of observations	103	103	103	103	103	103
(Pseudo) R-squared	0.2804	0.1360	0.1849	0.2005	0.1889	0.1777
Adjusted R-squared		0.0724	0.4477	0.5248	0.4741	0.4479
Durbin-Watson	0.5095					
Sum of squared residuals	0.0101		0.0121	0.0118	0.0121	0.0113
F-statistic	5.2875					
Prob (F-statistic)	0.0000					
Quasi LR statistic		16.8247				
Prob (Quasi LR-statistic)		0.0186				
Rn-squared statistic			57.7563	78.4570	61.9889	60.0529
Prob			0.0000	0.0000	0.0000	0.0000

Notes: ***, ** and * denote statistical significance at 0.01, 0.05 and 0.1 levels. For Column (III) to Column (VI), the adjusted R-squared represents the robust Rw-squared, and the sum of squared residuals refer to the non-robust statistics.

Finally, we apply the coefficients in Column (VI) of Table 7, the column with the lowest sum of square residuals among the estimates using robust least squares, to the 24 banks reporting a loss, to graphically depict the main drivers of these losses. As shown by Figure 13, several of these banks have a significant push-down in profits derived from their loans at fixed interest rates or their debt securities at fair value. However, there are also several banks for which our econometric analysis is not able to offer an explanation of the determinant of their losses.

Figure 13. Contribution of debt securities at fair value and fixed-rate loans to losses of selected EU banks



Sources: 2022 EBA Transparency Exercise and author's calculations. Notes: the x-axis represents a bank showing a loss from higher interest rates according to our empirical analysis. The coefficients of the independent variables in Column (VI) of Table 7 are applied to the values of the ratio computed by each bank. The blue dots signal the total profits as estimated in our empirical analysis.

6. Conclusions

After a long period of low interest rates in the aftermath of the global financial crisis, inflation peaked again and central banks raised interest rates. One of the key questions in this macroeconomic environment relates to the impact that higher interest rates can have on banks. Using a simplified balance sheet of a representative bank, we have decomposed this impact into two main channels, also aligned to those identified in the regulatory framework: profits and the market value of equity. Within profits, we have looked at changes in net interest income (being closely linked to the concept of income gap), changes in the fair value of assets, and additional credit losses.

In conceptual terms, banks with higher shares of variable-rate loans would particularly benefit from higher interest rates over the short-term, provided that the pass-through of loans is higher than the pass-through of deposits. Indeed, our analysis shows that equal pass-through of loans and deposits decreases profits, no matter the share of variable-rate loans, supporting the hypothesis of a deposit franchise (Drechsler et al., 2021). Moving to our empirical analysis, higher interest rates result in higher profits for banks on account of higher interest income from loans and despite higher costs of funding, credit losses and potential losses in financial assets at fair value. With few exceptions, the increase in net interest income dominates over losses from financial assets at fair value and credit losses. Therefore, in general, higher interest rates are found to generate higher profits for banks.[7] The inverted-U shaped curve for the additional profits resembles similar findings in the literature in terms

[7] However, if some banks are forced to recognise unrealised losses on their financial assets at amortised cost, they may incur a substantial loss.

of an increase in bank profits in the short-term followed by a decrease afterwards (Borio et al., 2017; English et al., 2018).

Higher interest rates also affect the market value of banks' assets and liabilities. Under a business model where the duration of assets is higher than the duration of liabilities, we expect a decrease in the market value of equity (understood as the difference between the market value of assets minus the market value of liabilities). Our empirical analysis confirms this intuition, with only six banks reporting an increase in their market value of equity.

Our results, even if subject to several important methodological issues (related, among others, to the simplification of the balance sheet of the bank, to the temporal recognition of interest income and credit losses), contribute to the current discussion on the impact of higher interest rates on banks. We are able to identify the variables that may drive this impact, such as the share of variable-rate loans or the relative change of interest rates.

Finally, further work, exploring greater granularity in the data and addressing some of the shortcomings of our methodology, would be necessary to enhance our knowledge about banks' financial intermediation function and how it is impacted by the levels of interest rates (and their changes) in an economy.

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Annex 1. Mathematical considerations

Net interest income

Starting with Equation (5), we exclude fixed-rate loans and existing wholesale funding and group together items related to the level of interest rates in the economy, so we get to Equation (6):

$$NII_t = \left(1-\frac{1}{m_t}\right)\left[\alpha L_t\left[\hat{\imath}_t\left(1-\widehat{npl_t}\right)\right]+(1-\alpha)L_t\left[\overline{\imath_t}\left(1-\overline{npl_t}\right)\right]\right]+\frac{1}{m_t}\left[i_t L_t(1+c_t)\right]+i'_t DS_t$$
$$-(1+od_t)i^{od}{}_t OD_t-\left(1-\frac{1}{md_t}\right)\left(i^{td}{}_t TD_t\right)-\frac{1}{md_t}\left[i^{td}{}_t TD_t(1+td_t)\right]$$
$$-\left(1-\frac{1}{mw_t}\right)\left(i'''{}_t WF_t\right)-\frac{1}{mw_t}\left[i'''{}_t WF_t(1+w_t)\right]$$

$$NII_t = \left[\left(1-\frac{1}{m_t}\right)\left[\alpha L_t\left[\hat{\imath}_t\left(1-\widehat{npl_t}\right)\right]+(1-\alpha)L_t\left[\overline{\imath_t}\left(1-\overline{npl_t}\right)\right]\right]+\frac{1}{m_t}\left[\varphi_2 r_t L_t(1+c_t)\right]\right]+i'_t DS_t$$
$$-(1+od_t)\varphi_3 r_t OD_t-\left(1-\frac{1}{md_t}\right)\left(i^{td}{}_t TD_t\right)-\frac{1}{md_t}\left[\varphi_4 r_t TD_t(1+td_t)\right]$$
$$-\left(1-\frac{1}{mw_t}\right)\left(i'''{}_t WF_t\right)-\frac{1}{mw_t}\left[\varphi_5 r_t WF_t(1+w_t)\right]$$

$$NII_t = \left(1-\frac{1}{m_t}\right)\alpha L_t\left[\varphi_1 r_t\left(1-\overline{npl_t}\right)\right]+\frac{1}{m_t}\left[\varphi_2 r_t L_t(1+c_t)\right]-(1+od_t)\varphi_3 r_t OD_t-\frac{1}{md_t}\left[\varphi_4 r_t TD_t(1+td_t)\right]$$
$$-\frac{1}{mw_t}\left[\varphi_5 r_t WF_t(1+w_t)\right]+\left(1-\frac{1}{m_t}\right)(1-\alpha)L_t\left[\overline{\imath_t}\left(1-\overline{npl_t}\right)\right]+i'_t DS_t$$
$$-\left(1-\frac{1}{md_t}\right)\left(i^{td}{}_t TD_t\right)-\left(1-\frac{1}{mw_t}\right)\left(i'''{}_t WF_t\right)$$

$$NII_t = r_t\left[\left(1-\frac{1}{m_t}\right)\alpha L_t\left[\varphi_1\left(1-\overline{npl_t}\right)\right]+\frac{1}{m_t}\left[\varphi_2 L_t(1+c_t)\right]-(1+od_t)\varphi_3 OD_t-\frac{1}{md_t}\left[\varphi_4 TD_t(1+td_t)\right]\right.$$
$$\left.-\frac{1}{mw_t}\left[\varphi_5 WF_t(1+w_t)\right]\right]+\left(1-\frac{1}{m_t}\right)(1-\alpha)L_t\left[\overline{\imath_t}\left(1-\overline{npl_t}\right)\right]+i'_t DS_t$$
$$-\left(1-\frac{1}{md_t}\right)\left(i^{td}{}_t TD_t\right)-\left(1-\frac{1}{mw_t}\right)\left(i'''{}_t WF_t\right)$$

Changes in the fair value of financial assets

We start with Equation (15) and operate further to obtain Equation (16):

$$\Delta FV_t = \left(EQ_t(a+bY_t-cr_t)\right)-\left(EQ_{t-1}(a+bY_{t-1}-cr_{t-1})\right)+\left(DST_t(a'+b'Y_t-c'r_t)\right)$$
$$-\left(DST_{t-1}(a'+b'Y_{t-1}-c'r_{t-1})\right)+\left[\theta_t\sum_{t=t-x}^{t}\Delta FV_t^{DSA+DSM}\right]$$

$$\Delta FV_t = EQ_t a+EQ_t bY_t-EQ_t cr_t-EQ_{t-1}a-EQ_{t-1}bY_{t-1}+EQ_{t-1}cr_{t-1}+DST_t a'+DST_t b'Y_t-DST_t c'r_t$$
$$-DST_{t-1}a'-DST_{t-1}b'Y_{t-1}+DST_{t-1}c'r_{t-1}+\left[\theta_t\sum_{t=t-x}^{t}\Delta FV_t^{DSA+DSM}\right]$$

$$\Delta FV_t = a(EQ_t - EQ_{t-1}) + b(EQ_tY_t - EQ_{t-1}Y_{t-1}) - c(EQ_tr_t - EQ_{t-1}r_{t-1}) + a'(DST_t - DST_{t-1}) + b'(DST_tY_t - DST_{t-1}Y_{t-1}) - c'(DST_tr_t - DST_{t-1}r_{t-1}) + \left[\theta_t \sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}\right]$$

$$\Delta FV_t = a(EQ_t - EQ_{t-1}) + b(EQ_tY_t - EQ_{t-1}Y_{t-1}) + a'(DST_t - DST_{t-1}) + b'(DST_tY_t - DST_{t-1}Y_{t-1}) - r_t(cEQ_t + c'DST_t) + r_{t-1}(cEQ_{t-1} + c'DST_{t-1}) + \left[\theta_t \sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}\right]$$

$$\Delta FV_t = \Theta - r_t(cEQ_t + c'DST_t) + r_{t-1}(cEQ_{t-1} + c'DST_{t-1}) + [\theta_t \textstyle\sum_{t=t-x}^{t} \Delta FV_t^{DSA+DSM}]$$

where $\Theta = a(EQ_t - EQ_{t-1}) + b(EQ_tY_t - EQ_{t-1}Y_{t-1}) + a'(DST_t - DST_{t-1}) + b'(DST_tY_t - DST_{t-1}Y_{t-1})$.

Annex 2. Variables used from the 2022 EBA Transparency Exercise

Table A1 matches the variables in Table 1 to those in the 2022 EBA Transparency Exercise.

Table A1. Balance sheet variables taken from the 2022 EBA Transparency Exercise

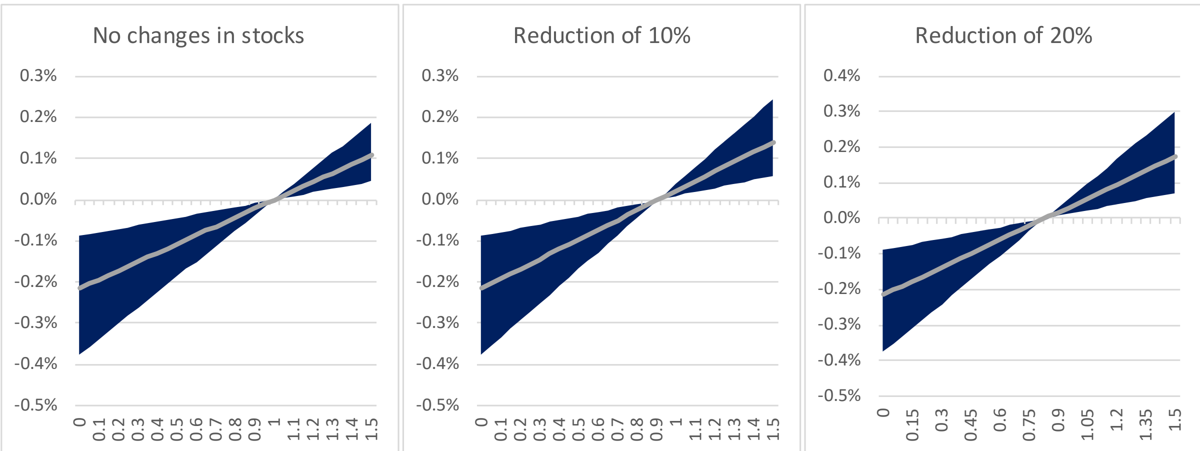
	2022 EBA Transparency Exercise
Total assets	Total assets
Loans	Carrying amount of loans (gross carrying amount minus accumulated impairment)
Performing loans	Difference between loans and non-performing loans
Non-performing loans	Carrying amount of loans (gross carrying amount minus accumulated impairment) classified in Stage 3
Equities	Difference between financial assets held for trading and debt securities held for trading, assuming that equities are not classified as held-to-maturity
Debt securities	Carrying amount of debt securities (gross carrying amount minus accumulated impairment)
Debt securities held-for-trading	Difference between carrying amount of debt securities, debt securities at amortised cost and debt securities through other comprehensive income
Available-for-sale debt securities	Carrying amount of debt securities at fair value through other comprehensive income (gross carrying amount minus accumulated impairment)
Debt securities held-to-maturity	Difference between financial assets at amortised cost and carrying amount of loans. Banks with negative value or with values lower than the carrying amount of debt securities are excluded
Liquid assets	Cash, cash at central banks and demand deposits
Equity	Tier 1 capital
Wholesale funding	Debt securities issued
Deposits	Sum of overnight deposits, term deposits, deposits government, interbank deposits, deposits of other financial institutions and central bank deposits
Overnight deposits	Overnight deposits of households, non-financial corporations and deposits with central bank
Term deposits	Term deposits of households and non-financial corporations
Loans in stage 1	Loans and advances at amortised cost, classified in stage 1
Loans in stage 2	Loans and advances at amortised cost, classified in stage 2
Loans in stage 3	Loans and advances at amortised cost, classified in stage 3

Annex 3. Effects of changes in financial assets due to changes in interest rates

The results shown in our empirical analysis consider that banks do not modify their holdings of financial assets as a result of the change in interest rate. In the following paragraphs, we lift this assumption and consider the behavioural response of banks; in other words, how they react to the decline in value of some of their assets. In this vein, three scenarios are considered: (i) amounts of equities and debt securities remain constant, (ii) there is a reduction of 10% when interest rates increase, and (iii) there is a reduction of 20% when interest rates increase. The first case represents, for instance, the case when the bank is having some constraint on the free disposal of the asset in order to meet regulatory binding requirements or to manage their liquidity position on a daily basis. That would be the case also of banks undertaking market-making activities. In the other two scenarios, banks are able to shift their investments somewhere else.

Figure A1 shows the results in a graphic way. The x-axis represents different values for the relative change in interest rates. A value of 1 implies that interest rates remain unchanged, a value above 1 a decrease in interest rates and a value below 1 an increase in interest rates. Values closest to zero represent the situation when the initial level of interest rates is very low (for example, 0.1%), when a relatively modest increase (for example, from 0.1% to 0.25%) leads to lower values (0.1%/0.25% = 0.4).

Figure A1. Change in the fair value of debt securities and equities, as a share of total assets, under higher interest rates



Sources: 2022 EBA Transparency Exercise and author's calculations. Notes: the x-axis shows different values of the relative changes in interest rates (values below 1 imply an increase in interest rates and above 1 a decrease in interest rates), and the y-axis shows the related fair value gains or losses as a share of total assets. Each panel makes a different assumption about the bank behavioural reaction to the change in interest rates.

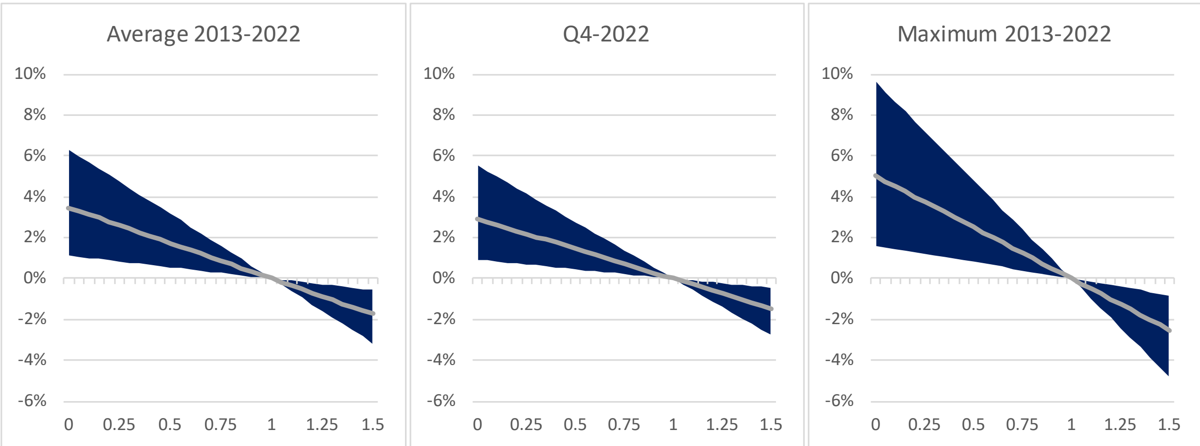
Looking at Figure A1, there are limited differences across the three scenarios, suggesting that our assumption in the empirical analysis should not drive our results. The overall impact in the three cases is low in terms of total assets. So, changes in the valuation of debt securities at fair value (excluding, thus, debt securities at amortised cost) due to higher interest rates should in principle not lead to the recognition of large losses for banks.

Annex 4. Credit losses and the ratio of debt to real gross disposable income

As stated in the empirical analysis, we use data from the quarterly sectoral accounts of households and non-financial corporations, as reported by Eurostat, to compute the ratio between debt and real gross disposable income. We use loans and debt securities in the liabilities side of these sectors to account for their debt, and gross savings, which is computed after consumption, to account for gross disposable income. Data is available from 2013 for most EU countries: Belgium, Czechia, Denmark, Germany, Ireland, Spain, France, Italy, Hungary, Netherlands, Austria, Poland, Portugal, Slovenia, Finland and Sweden. For the other countries, we use the EU average.

Figure A2 shows the credit losses to be recognised under different changes in the level of interest rates, represented in the x-axis, with different values of the ratio of debt to gross disposable income. Values below 1 imply an increase of interest rates and above 1 a decrease. The three panels are computed under different values of the ratio of debt to gross savings of households and non-financial corporations: the average between 2013 and 2022, the value in Q4-2022 and the maximum in the period 2013-2022.

Figure A2. Credit losses, as a share of total assets, under higher interest rates



Sources: 2022 EBA Transparency Exercise and author's calculations. Notes: the x-axis shows different values of the relative changes in interest rates (values below 1 imply an increase in interest rates and above 1 a decrease in interest rates), and the y-axis shows additional credit losses as a share of total assets. Each panel shows a different value of the ratio of debt to gross disposable income.

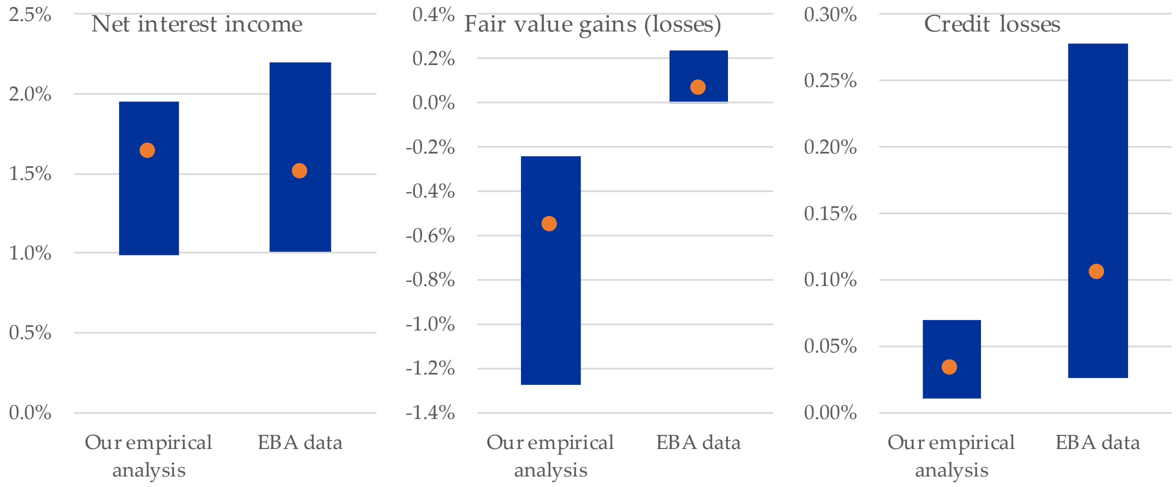
As expected, there is a negative relation between the level of interest rates and credit losses. The impact can be sizable as a share of total assets (up to 5%), particularly when considering a situation with highly indebted economic agents (maximum 2013-2022 in Figure A2).

Annex 5. A comparison with the 2023 EBA Transparency Exercise

We now look at the results of the 2023 EBA Transparency Exercise and check whether the findings in our empirical analysis are consistent with the observed dynamics of European banks between Q3-2022 and Q2-2023. While there are minor differences in the sample of banks in the 2022 and the 2023 EBA Transparency Exercises, they are not significant enough to prevent us from making this comparison.

Starting with the change in net interest income, the left-hand side panel of Figure A3 presents similar accumulated profits from net interest income, only with a higher third quartile by the 2023 EBA Transparency Exercise. From this point of view, our empirical analysis does a good job in computing the total additional net interest income by EU banks as a result of higher interest rates. The assumptions made to allocate the increase in interest income over time (namely, when the interest rate of variable-rate loans is revised to reflect market interest rates) may explain the different profile of the time series over time, as the adjustment is made by banks in a smoother manner in real life.

Figure A3. Changes in net interest income, in the fair value of financial assets and in credit losses, in our empirical analysis and in the 2023 EBA Transparency Exercise



Sources: 2022 and 2023 EBA Transparency Exercises, ECB and author's calculations. Notes: the left-hand side panel shows the accumulated profits from net interest income as a share of total assets between Q3-2022 and Q2-2023 in terms of median (orange dots) and interquartile range (blue bars). The middle panel shows the accumulated gains or losses from financial assets measured at fair value as a share of total assets between Q3-2022 and Q2-2023 in terms of median (orange dots) and interquartile range (blue bars). It does not consider unrealised losses from financial assets at amortised cost. The right-hand side panel shows the accumulated credit losses as a share of total assets between Q3-2022 and Q2-2023 in terms of median (orange dots) and interquartile range (blue bars).

When looking at changes in the fair value of financial assets, EU banks did not incur into losses from their financial instruments at fair value, contrary to the results of our empirical analysis (middle panel in Figure A3). This divergence is driven by the large loss that we compute for the first period (Q3-2022). An initial explanation for this difference may be that banks are carefully managing interest rate risk in their financial assets at fair value (including those held for trading), and thus are able to remain in equilibrium (i.e., with small profits or losses) even under an environment of increasing interest rates. It may also be possible that the 2023 EBA Transparency Exercise includes financial assets other than debt securities and equities in the gains and losses from changes in fair value, although this explanation seems less plausible. A third (maybe more plausible) explanation stems from the adjustments made by EU banks in the last quarters regarding the accounting treatment of government bonds in their balance sheet. As documented by the EBA Risk Dashboard, EU banks first decreased the share of government bonds at fair value and held for trading between Q2-2022 and Q4-2022, and then increased that share in the first half of 2023. That, if also made with other financial assets at fair value, would decrease fair value losses in the first periods in our empirical analysis and then leads to fair value gains from government bonds acquired in the most recent periods. Our empirical analysis does not cover this type of interim reclassifications. Last but not least, we have assumed that the variables other than interest rates in Equation (14) remain constant over time, something which could be unlikely to occur in reality.

When turning to credit losses, our empirical analysis leads to lower credit losses than the ones recognised by EU banks (right-hand side panel of Figure A3). This could be the result of the temporal recognition of non-performing loans, which we have estimated to require four quarters to materialise. The median value for Q2-2023, not shown in the chart, is already above the maximum value computed using data from the 2023 EBA Transparency Exercise and, according to our assumptions, should increase further in subsequent quarters, probably reducing the gap between the two.