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# The impact of non-traditional activities on banks' efficiency in a low interest rates environment

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## Abstract

**Purpose** – This paper assesses the potential growth of non-traditional production in commercial banks in the Eurozone during the 2015–2019 period characterized by excessively low interest rates. In this environment, it is common for commercial banks to seek opportunities to diversify their sources of income and explore alternatives to traditional banking production, like the expansion of off-balance sheet items.

**Design/methodology/approach** – Using Data Envelopment Analysis, this study evaluates the production plans of 63 European commercial banks under European banking supervision. Our working data refer to the years 2015–2019. High levels of inefficiency in any of the banking outputs indicate potential for growth through efficiency reduction by banks.

**Findings** – Our results indicate that non-traditional banking activities experience substantial growth from 2017 onward, accompanied by a significant reduction in inefficiency, signalling that banks have adapted to the low interest rate environment. Our main findings identify variations in efficiency management across different countries, with some banks struggling in managing non-traditional outputs. These findings highlight the importance of effective management in non-traditional activities although the transition to a higher interest rate environment may have shifted the focus back to traditional banking products.

**Originality/value** – Literature that includes off-balance sheet assets as outputs in the geographical framework of the European Union is still scarce. This work aims to increase and research within this field. Also this research provides insights for bank managers to optimize both traditional and non-traditional activities, improve efficiency and better navigate shifting market conditions.

**Keywords** Off-balance sheet items, European banking, Efficiency, Data envelopment analysis, Directional distance functions

**Paper type** Research paper

## 1. Introduction

Financial institutions simultaneously produce a variety of heterogeneous products-services (outputs) from some equally heterogeneous resources (inputs). There is consensus on the intermediary functions banks need to perform on the inputs. However, this is not the case for the outputs. Banking undergoes continuous innovation, and the creation of new products and services —such as the securitization of mortgages or derivatives — makes operational activities of commercial banks increasingly complex, and the range of products and services they offer increasingly distant from traditional products (Zang and Malikov, 2022).

Regarding the European markets, the 2015–2022 period was characterised by the strength of the Euro and interest rates close to zero. During periods of low interest rates, the profitability of commercial banks can result in low intermediary's margins in the traditional banking business, such as lower net interest margins, increased loan demand, lower investment profitability or potential increase in credit risk. In this environment, it is common for commercial banks to seek opportunities to diversify their sources of income and explore alternatives to traditional banking production. One such alternative is the expansion of off-balance sheet items.

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This paper will introduce off-balance sheet assets (OBS) and banking commissions as banking outputs. It will also analyse the changes in the production plans through the reduction of their specific output inefficiencies of the selected financial institutions during the 2015–2019 period. We have selected only the 2015–2019 period because the data for years 2020, 2021 and 2022 might have been deeply affected by the economic policies as well as the economic restrictions during the fight against the Covid-19 pandemic. Specifically, this paper analyses the technical efficiency of 63 commercial banks that operated in the Eurozone during the 2015–2019 period. To measure their efficiency, a non-parametric frontier method is used. Concretely, this paper employs Data Envelopment Analysis (DEA) as it does not require any kind of functional connection between the variables and has a multi-product design nature that fits well with the banking business model. The DEA model, which allows for multiple criteria, is thus suitable for measuring the efficiency of the group of institutions selected for this paper.

This environment should be suitable to focus on non-traditional assets. Over the mentioned period, the total volume of assets of the analysed financial institutions increased by 1%, while OBS items increased by 35%. They have thus gone from representing 18.61% of the balance in 2015 to represent 24.84% at the end of 2019. In short, OBS items have increased their weight in the banking sector and should therefore be included in efficiency studies to get more precise measurements. Furthermore, all analysed financial institutions have followed the same strategy, because while the importance of OBS items over assets has increased, so has the level of homogeneity of the data during the mentioned period.

## 2. Literature review

### *2.1 Banking efficiency in the European Union*

Several studies have analysed banking efficiency in the geographical context of the European Union using non-parametric methods, in particular DEA (e.g. Altunbas *et al.*, 2007a, b; Chortareas *et al.*, 2012, 2013; Garcia Gil, 2017; Grmanová and Ivanová, 2018; Jemric and Vujcic, 2002; Licerán-Gutiérrez *et al.*, 2025). Banks are considered to be all the more efficient the more they fit to the set that defines which are best practices through an optimization process. At this point, these studies and the main questions that have been raised are briefly outlined.

The first important point deals with the way to define efficiency, and different approaches emerge based on what is meant by efficiency. Some authors look for a set that measures banks' technical efficiency. Such is the case of Lozano-Vivas *et al.* (2002), who studies the differences in the technical efficiency of 612 commercial banks in 10 European countries. In the second part of their research environmental factors are included concluding that each country's specific environmental factors also have a big impact on the behaviour of each country's banking industry.

Following this approach, Casu and Molyneux (2003) analyse the improvement and possible convergence in technical efficiency of a group of banks in five countries of the EU-15 in the 1993–1997 period. An improvement in the technical efficiency levels of the banks under analysis is observed during this period. However, similar to Lozano-Vivas *et al.* (2002), they also conclude that the specific conditions of each country have an impact on their operating banks efficiency levels.

Andries (2011) studies the impact that joining the EU had on the banking efficiency of commercial banks in seven central and eastern European countries from 2004 to 2008. He concludes that increased competition and the adoption of European regulations resulted in an efficiency increase in the analysed banks. In this line, Tsionas *et al.* (2015) analyse the technical and assignative efficiency of a group of EU commercial banks in 2005–2012, thus analysing a pre- and post- 2008 financial crisis period. They reach the conclusion that efficiency decreased in most of the analysed entities during the financial crisis of 2007–2008.

A second type of approach consists of analysing efficiency from a cost and profit point of view. Maudós *et al.* (2002) and Maudós and Pastor (2003) follow this approach when studying

different groups of EU countries. The first one analysed banks cost and profit efficiency in 10 countries in 1993–1996 finding high levels of efficiency in costs and lower levels in profits, while the second one analysed the cost and profit efficiency of the Spanish banking sector in the 1985–96 period and shows the existence of average levels of cost efficiency much higher than the levels of profit efficiency. Similarly, Kasman and Yildirim (2006) analyse the cost–benefit efficiency of commercial banks in eight countries in 1995–2002 that had recently joined the European Union finding significant levels of cost and profit inefficiency.

Following this line, Koutsomanoli-Filippaki *et al*. (2013) investigate a group of banks based in the last 10 countries to join the EU in order to analyse cost-efficiency in the 2004–2009 period. The results show low efficiency rates, although according to the authors there is a certain degree of convergence on cost-efficiency rates in the banks under study during that period. Their empirical analysis also shows that structural reforms on the labour and business markets, increased credit regulation and a better capitalization make banks more cost efficient.

Some studies outside the European Union have used DEA to measure the efficiency of financial institutions. For example, Le *et al*. (2020) use data from 44 commercial banks in Vietnam to estimate the efficiency of banks using DEA. Non-performing loans are used as an undesirable output to capture credit risk. The results show that small banks are more efficient than large banks at the mean level and across the entire distributions of inefficiency of the two groups. Also outside Europe, Li *et al*. (2020) analyse the efficiency of banks in China depending on their shareholder ownership and location. They estimate the efficiency of banks using the bootstrap-DEA method. These authors claim that, in comparison with the bootstrap-DEA model, the traditional DEA method overestimates China's banking efficiency, and this is an especially serious problem for those banks with a high efficiency score. Like Le *et al*. (2020) these authors also introduce NPLs as an undesirable output.

### *2.2 Banking efficiency assessment*

The second point to consider when designing these models is to decide the inputs and outputs to be used. Defining inputs and outputs has been a topic of great interest in the study of banking efficiency. García Gil (2017) makes an exhaustive review of the literature on this topic. According to her, the inputs most traditionally used in banking literature are deposits, staff expenses and fixed assets. Other relevant inputs are the number of employees and interest expenses (Avkiran, 1999; Hassan and Bashir, 2003; Casu and Girardone, 2004; Sturm and Williams, 2004; Chortareas *et al*., 2013; Ayadi *et al*., 2016a, b).

On the other hand, the variables most widely used as outputs in banking literature are loans, profitable assets, commissions or non-interest income and interests (García Gil, 2017). However, some authors such as Rogers (1998) and Clark and Siems (1997, 2002) highlight the importance of including in the output vector off-balance sheet assets (OBS) like credit securitisation, letters of credit, sales, provision of services and derivatives, among other products. These products are not part of banks' balances, and yet they generate a different income to that of interest, and need resources that are included in banks' input matrices to be managed. But, models that tried to identify an efficiency set had consistently failed to include these assets (OBS) underestimating the output vector created in the process of financial intermediation, as banks use part of their resources (inputs) to generate these assets. Since Roger's work in 1998 some authors such as Altunbas *et al*. (2000) have introduced these assets in the output vector when designing their DEA models to estimate banks' efficiency sets. Despite this, as there is no consensus on the definition of the output vector, off-balance sheet assets still fail to be included in many models.

Authors including these assets in their analysis have obtained results that are not very conclusive about the impact of OBS in the estimation of the efficiency set. For example, Clark and Siems (2002) include OBS in their output vector in a study conducted for US-based banks from 1992 till 1997. They also examine the composition of these off-balance sheet activities

and conclude that they help to explain interbank differences in efficiency estimations. Thus, banks with bigger volumes of credit lines, guarantees or loan commitments show more efficiency. They also assert that banks with more derivatives activity show lower efficiency levels, although their findings to support this claim were less robust.

Lozano-Vivas and Pasiouras (2010) analyse the relevance of these non-traditional activities in the estimation of the efficiency levels of 752 commercial banks in 87 worldwide countries in the 1999–2006 period aiming to compare the impact of these activities in regions with different levels of economic development. The authors estimate cost and profit efficiency using a conventional specification that treats loans and other earning assets as the sole outputs, complemented by two alternative models that incorporate non-traditional banking activities—one including OBS items and the other incorporating non-interest income as an additional output. Their results show that cost-efficiency increased in the studied banks regardless of whether OBS and non-financial income were used or not in addition to traditional outputs. Furthermore, OBS did not alter the impact that environmental factors had on efficiency levels.

Authors such as Lozano-Vivas and Pasiouras (2014) or Pasiouras (2008), have taken these assets into account and found that certain countries' regulations to limit banking activities and increased supervision improve banks' efficiency in costs and benefits. Other authors (e.g. Jagtiani *et al*., 1995) have not found robust connections between OBS and efficiency levels. This is an important point in relation to the present study as the hypothesis we are trying to test is based on how commercial banks would increase the production of OBS using the available productive resources in situations where traditional production may not be as profitable due to reductions in levels of non-traditional production inefficiency. In this regard, very high levels of inefficiency in the initial period of analysis can help us understand the potential growth of these banking outputs, considering the market conditions in which banks operate.

There are some more studies that focus on developed countries (Tortosa-Ausina, 2003; Rime and Stiroh, 2003). However, literature that includes OBS as outputs in the geographical framework of the European Union is still scarce. This work aims to increase and research within this field.

Glick and Plaut (1990) found that while financial disintermediation happens, off-balance sheet (OBS) banking is considered one of the main forms of non-traditional banking activities. These OBS banking services provide liquidity to bank customers and remain a substitute for on-balance sheet liquidity. The implications of this relationship for the determination of interest rates and monetary policy are also discussed. In particular, it is argued that monetary policy should pay more attention to off-balance-sheet liquidity when choosing targets and operational procedures.

To the best of our knowledge, this is the first time that the consequences and changes in production plans of commercial banks in the European banking market are being analysed when, as a result of a very low interest rate environment, bank loans reduce their profitability levels. One possible way to optimally use productive resources and seek alternatives to this decline in profitability is precisely by exploring other options, such as increasing the production of non-traditional activities that were already being carried out but, in some cases, less efficiently than the rest of the traditional production.

## 3. Data and methodology

Our empirical analysis is based on data from Moody's Analytics BankFocus, a database that contains information on approximately 46,300 banks worldwide. This database offers accounting and financial data that are reliable for cross-country comparisons.

The criteria for determining whether banks are considered significant - and therefore under the ECB's direct supervision - are set out in the Single Supervisory Mechanism (SSM) Regulation and the SSM Framework Regulation (ECB/2014/17). To qualify as significant, banks must fulfil at least one of the following four criteria: the total value of its assets exceeds €30bn; it represents an economic importance for the specific country or for the EU economy

as a whole; the total value of its assets exceeds €5bn and the ratio of its cross-border assets/liabilities in more than one other participating Member State to its total assets/liabilities is above 20%; it has requested or received funding from the European Stability Mechanism or the European Financial Stability Facility. Furthermore, a supervised bank can also be considered significant if it is one of the three most significant banks established in a particular country.

In the process of selecting our sample of Eurozone banks, we have taken the following steps. In the first place, we extracted all information available in the Orbis BankFocus database on commercial banks operating in the euro area and we only selected banks whose assets exceeded €30bn. Orbis BankFocus dataset contains information on 71 Eurozone commercial banks with their total assets value above this amount. We then eliminated the observations –banks– that lacked information about any of the variables used to characterize the banking production function. The third step was to detect and eliminate duplicate observations (Orbis BankFocus database returns some duplicate observations for a few banks).

Hence, our working data refer to the years 2015, 2016, 2017, 2018 and 2019 and contain information about 63 significant commercial banks under European banking supervision belonging to these euro area countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Please see Figure 1 for the distribution of those 63 banks across the countries. The working data file can be found as supplementary material.

In order to characterise the banking production function, we have followed the intermediation approach (Sealey and Lindley, 1977), according to which, banks use production factors and gain resources such as deposits or capital – inputs – to invest in financial products such as credits, loans or securities – desirable outputs. See Table 1 for the

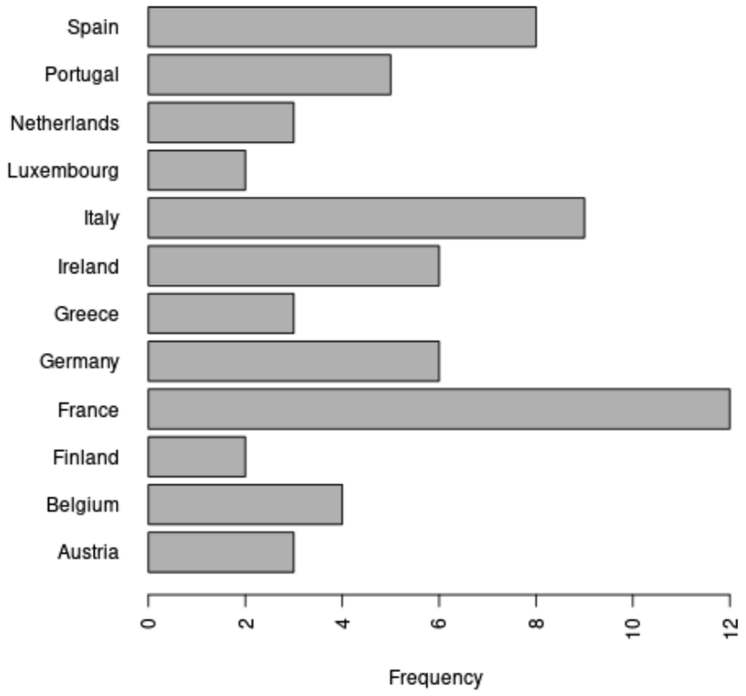


**Figure 1.** Distribution of the significant banks across countries. Source: Authors own work

description of the input, output (desirable, undesirable and optional), source and concept variables.

Therefore, and in line with previous papers (e.g. Jiménez-Hernández *et al*., 2019), the inputs included in our characterisation of the technology are staff expenses as a proxy for labour, non-earning assets as a proxy for physical capital and equity and customer deposits as financial inputs. The desirable outputs are gross loans, financial assets and fee and commission income. Similarly to Le *et al.* (2020), and Li *et al*. (2020), we also consider Non-performing Loans (NPLs) as an undesirable output that unavoidably accompanies the production of desirable outputs. As a further development to the production function used in the dissertation by Jimenez-Hernandez (2021), we also consider, as an additional output, the most commonly used measure of the non-traditional activity of banks, the so-called OBS (Lozano-Vivas and Pasiouras, 2010). Descriptive measures of all the considered variables can be found in Table 2.

This study applies Directional Distance Functions (DDFs) to carry out a specific analysis of the efficiency with which different production plan decisions in this sector are managed under a low-interest rate environment. This approach has been previously employed in the banking sector (e.g. Jiménez-Hernández *et al*., 2019; Park and Weber, 2006; Sáez-Fernández *et al*., 2021) to account for risk as an undesirable output of banking, highlighting its relevance in evaluating efficiency while considering both desirable and undesirable outputs.

Let us assume that we observe a sample of b = 1, …, B banks using a set of N inputs $x \in R_{+}^{N}$ to obtain a vector of M desirable outputs represented by $y \in R_{+}^{M}$. Transforming inputs into desirable outputs necessarily generates a certain level of Non-performing loans NPLs, which is represented by a set of H variables $r \in R_{+}^{H}$; moreover, NPLs is considered as an undesirable output similarly to Le *et al.* (2020), and Li *et al*. (2020).

The technology that models the transformation of inputs into desirable and undesirable outputs (NPLs) is represented by:

$$T = [(x, y, r) \vee x \text{canproduce}(y, r)] \tag{1}$$

Additionally, we assume that the technology satisfies the Shephard (1970) axioms. Furthermore, null-jointness and weak disposability of the undesirable output are also assumed (Färe *et al*., 1989, 2005). On the other hand, weak disposability of the undesirable output allows the modelling of the idea that increasing any desirable output is not costless, but rather involves an increase of the undesirable output (Kuosmanen and Matin, 2011). This assumption is particularly relevant in the banking industry, where reducing NPLs requires the consumption of productive inputs that could otherwise be allocated to generating desirable outputs.

**Table 1.** Description of the input, output (desirable, undesirable and optional), source and concept variables

| Variable | Technology | Code |
|---|---|---|
| *Input variables* | | |
| Staff expenses | Proxy for labour | Staff |
| Non-earning assets | Proxy for physical capital | NEA |
| Equity | Financial inputs | Equity |
| Customer deposits | Financial inputs | Deposits |
| *Output variables* | | |
| Gross loans | Desirable outputs | Loans |
| Financial assets | Desirable outputs | |
| Fee and commission income | Desirable outputs | FC income |
| Off-balance sheet items | Desirable outputs | OBS |
| Non-performing Loans | Undesirable output | NPLs |

**Source(s):** Authors' own work

**Table 2.** Descriptive statistics

| | Mean | SD | CV | Min | Q1 | Median | Q3 | Max | n |
|---|---|---|---|---|---|---|---|---|---|
| Staff | 2.0803 | 3.2418 | 1.5584 | 0.1120 | 0.3790 | 0.7269 | 1.9715 | 17.5530 | 308 |
| NEA | 34.7123 | 58.9176 | 1.6973 | 0.6090 | 4.1681 | 10.9265 | 36.8721 | 308.4530 | 308 |
| Equity | 17.0798 | 22.6068 | 1.3236 | 0.8652 | 4.1488 | 8.4128 | 17.9735 | 111.8450 | 308 |
| Deposits | 128.5706 | 165.7779 | 1.2894 | 3.8510 | 32.2047 | 56.6595 | 151.6055 | 834.6670 | 308 |
| Loans | 143.3307 | 179.7136 | 1.2538 | 7.4943 | 37.9365 | 67.3125 | 150.1937 | 959.6650 | 308 |
| Financial Assets | 53.6108 | 84.2435 | 1.5714 | 0.0091 | 8.9297 | 18.2878 | 48.5522 | 489.9850 | 308 |
| FC Income | 2.1004 | 3.0654 | 1.4594 | 0.0100 | 0.3861 | 0.7573 | 2.3169 | 13.3350 | 308 |
| OBS | 62.1236 | 91.5922 | 1.4744 | 0.1580 | 6.5915 | 21.1765 | 75.8333 | 479.8090 | 308 |
| NPLs | 8.4184 | 12.5596 | 1.4919 | 0.0348 | 1.1519 | 3.4190 | 9.1610 | 82.8594 | 308 |

**Source(s):** Authors' own work

Let us now define the directional distance function (Färe and Grosskopf, 2000) as:

$$\overrightarrow{D}\left[x, y, r;\ g = \left(-g_x, g_y, -g_r\right)\right] = \mathrm{Sup}\left[\phi \,|\left(x - \phi g_x, y + \phi g_y, r - \phi g_r\right) \in T\right], \qquad (2)$$

with $g = (-g_x, g_y, -g_r)$ being the so-called direction vector. This directional distance function generalises Shephard's input and output distance functions (Shephard, 1970), and provides a complete representation of the technology seeking the maximum achievable expansion of desirable outputs in the $g_y$ direction, and the largest feasible contraction of both inputs and NPLs in the $-g_x$ and $-g_r$ directions, respectively.

An important characteristic of DDFs is that they allow the modelling of different scenarios in performance studies. In our case, we are interested in comparing the performance of the European banking industry in the management of traditional and non-traditional activities under a low interest rates scenario. In this sense, the DDF can be employed to compute output-specific scores of technical efficiency. In order to do so, let us suppose that we are interested in measuring the maximum feasible increase of output $y_i$ while maintaining the remaining outputs $y_{-i}$, the input and the undesirable output vectors at their observed levels. The direction vector that represents these preferences is:

$$g = [0, (y_i, 0), 0] \qquad (3)$$

Hence, the DDF is defined as follows:

$$\overrightarrow{D}[x, y, r;\ g = (0, (y_i, 0), 0)] = \mathrm{Sup}\left[\phi \,|\, (x, (1 + \phi)y, r) \in T\right] \qquad (4)$$

From this viewpoint, efficiency calculations will be performed as many times as the number of outputs included in the production function (once for each output) in order to measure the level of achieved efficiency on a case-by-case basis. For example, a computed score for the DDF from expression (4)—parameter $\phi$ —for a given bank of, let us say, 0.15 would mean that by efficiently performing this bank could proportionally increase its desirable output by 15% without increasing NPLs, input usage and remaining outputs $y_{-i}$. In terms of the expression $(1+ \phi)$, the potential or efficient level of the desirable output would be 1.15 times their observed level.

The DDFs involved in our efficiency assessment are computed with Data Envelopment Analysis (DEA) (Charnes *et al.*, 1978). This technique allows a surface to be built over a set of observed data on productive units—banks in our study—representing the best observed

practices. Then, all productive units in the sample are projected onto the technological frontier, returning an indicator of performance (see details in Cooper *et al*., 2007).

Projecting bank b′ in our sample onto the technology frontier and in a direction that increases the specific desirable output, while maintaining the same level of inputs, NPLs and remaining outputs $y_{-i}$, entails solving the following optimization program:

$$\overrightarrow{DDF}[x, y, r;\ g = (0, (y_i, 0), 0)] = Max_{z^b, \mu^b, \phi_{b'}} \phi_{b'} \tag{5}$$

subject to.

$$(1)\ (1 + \phi_{b'}) y_{mb'} \leq \sum_{b=1}^{B} z_b y_{mb} \qquad m = 1, \ldots, M$$

$$(2)\ r_{hb'} = \sum_{b=1}^{B} z_b r_{hb} \qquad h = 1, \ldots, H$$

$$(3)\ x_{nb'} \geq \sum_{b=1}^{B} (z_b + \mu_b) x_{nb} \qquad n = 1, \ldots, N$$

$$(4)\ \sum_{b=1}^{B} (z_b + \mu_b) = 1$$

$$(5)\ z_b, \mu_b \geq 0 \qquad b = 1, \ldots, B$$

In program (5) variable returns to scale (VRS), are imposed through constraint (4) (Banker *et al*., 1984). VRS is a type of frontier scale used in DEA that helps to estimate efficiencies whether an increase or decrease in input or outputs does not result in a proportional change in the outputs or inputs respectively (Banker *et al*., 2011). Nonetheless, as noted by Zago and Dongili (2011, p. 542), the standard DEA-based specification grounded on VRS avoids the technology from satisfying weak disposability of both desirable and undesirable outputs (NPLs). In order to overcome this weakness, we have applied the Kuosmanen (2005) approach (see also Kuosmanen and Podinovsky, 2009), which allows performance assessment with VRS and weak disposability. Accordingly, $\mu_b$ denotes the so-called *scale effect*, and $z_b$ stands for the *efficient effect* (further technical details can be found in Kuosmanen, 2005, p. 1079–80).

According to Sueyoshi and Goto (2012) and Wang *et al*. (2019), considering only weak and strong disposability in efficiency evaluation presents several limitations, as these concepts fail to distinguish between natural disposability—where firms passively reduce inputs to decrease undesirable outputs—and managerial disposability, which involves strategic investments in technology or management to simultaneously enhance desirable outputs while mitigating undesirable ones. This omission may lead to an underestimation of the efficiency of firms that implement technological innovations or environmental management strategies, as the model does not account for the positive impact of such proactive measures. Moreover, the rigid separation between weak and strong disposability limits the model's ability to reflect firms' operational realities, where compliance with regulations often involves a mix of both disposability approaches, potentially introducing biases in efficiency assessment and reducing the accuracy of cross-firm comparisons. Given that this study examines the potential growth of non-traditional production in Eurozone commercial banks during a period of excessively low interest rates—where banks actively seek to diversify income sources through alternatives such as off-balance sheet items—it is essential to incorporate undesirable outputs into the production technology. The primary objective of doing so is not to analyse how production combinations shift with fluctuations in desirable outputs but to prevent a significant underestimation of efficiency distributions, ensuring a more accurate assessment of banks' performance in an evolving financial landscape.

Let us now consider that we are interested in measuring banks' performance in the presence of NPLs as the maximum proportional attainable increase in all the desirable outputs while maintaining the same level of NPLs and input usage, i.e. the desirable output-oriented

approach (e.g. Ataullah *et al*., 2004 or Ataullah and Le, 2006). In this scenario, the DDF of expression (4) becomes:

$$\overrightarrow{D}[\mathrm{x},\mathrm{y},\mathrm{r};\ \mathrm{g}=(0,\mathrm{y},0)]=\mathrm{Sup}\,[\phi\mid(\mathrm{x},(1+\phi)\mathrm{y},\mathrm{r})\in\mathrm{T}] \tag{6}$$

where $g=(0,y,0)$ is the direction vector that represents our preferences on how to measure banks' performance. Hence, projecting bank b′ in our sample onto the technology frontier and in a direction that increases all the desirable outputs, while maintaining the same level of inputs and NPLs, entails solving the following optimization program:

$$\overrightarrow{DDF}[x,y,r;\ g=(0,y,0)]=Max_{z^b,\mu^b,\phi_{b'}}\phi_{b'} \tag{7}$$

subject to.

(1) $(1+\phi_{b'})y_{mb'}\leq\sum_{b=1}^{B}z_b y_{mb}$ $\quad$ m = 1, . . . , M

(2) $r_{hb'}=\sum_{b=1}^{B}z_b r_{hb}$ $\quad$ h = 1, . . . , H

(3) $x_{nb'}\geq\sum_{b=1}^{B}(z_b+\mu_b)x_{nb}$ $\quad$ n = 1, . . . , N

(4) $\sum_{b=1}^{B}(z_b+\mu_b)=1$

(5) $z_b,\mu_b\geq 0$ $\quad$ b = 1, . . . , B

All calculations were carried out using R, version 4.2.2 (R Core Team, 2025), and the DJL package (Lim, 2021), which implements Luenberger's shortage (benefit) function to evaluate efficiency. Specifically, the function dm.sf() was employed to measure the extent to which the production of desirable outputs can be increased without altering the use of inputs and bad outputs.

## 4. Results and discussion

The main objective of this research lies in comparing whether the potential increase in each of the outputs via the reduction of inefficiency levels shows clearly different results. The results for the technical efficiency of Eurozone banks in the sample have been obtained from programs (5) and (7).

Program (5) allows to measure, on a case-by-case basis, the efficiency level achieved on an output. In this sense, Table 3 shows, in average, high levels of inefficiency when we obtain OBS output oriented results in contrast with the traditional production in the sector (Gross loans, Financial assets and Fee and commission income), that in many cases, show how banks are already operating on the efficient frontier for these traditional activities. A bank operating

**Table 3.** Output case-by-case basis level of efficiency

| Year | Gross loans | Financial assets | OBS items | FC income | Total outputs |
|---|---|---|---|---|---|
| 2015 | 0.065 | 0.155 | 0.214 | 0.169 | 0.038 |
| 2016 | 0.092 | 0.259 | 0.705 | 0.181 | 0.055 |
| 2017 | 0.093 | 0.288 | 0.857 | 0.218 | 0.057 |
| 2018 | 0.068 | 0.221 | 0.594 | 0.226 | 0.043 |
| 2019 | 0.086 | 0.266 | 0.540 | 0.275 | 0.055 |

**Source(s):** Authors' own work

in the efficient frontier indicates that it is not possible to continue increasing the production of these outputs without having to increase the use of inputs, the level of NPLs or reduce the production of another output.

Program (7) allows to measure banks' performance in the presence of NPLs as the maximum proportional attainable increase in all the desirable outputs (traditional and non-traditional activities) while maintaining the same level of NPLs and input usage. The last column of Table 3 reflects the enormous differences between the individual analyses for each output when we compare it with the analysis that includes the set of outputs included in the sample.

We have conducted calculations for each year in order to analyse whether, in a low-interest rate environment like the one that occurred in the Eurozone during the examined period of 2015–2019, these types of production planning strategies were affected. We also examined whether there are indications that managers modify their production strategies by reducing their levels of inefficiency, giving more relevance to these non-traditional activities in the total produced output. In this sense, we can see in Figure 2 how traditional production shows an increase in the average inefficiency levels when compared to the rest of the production. The non-traditional production, although initially also increases its levels of inefficiency, as of 2017 it clearly reduces the average levels of inefficiency, being the only output that reduces its levels of relative inefficiency.

As mentioned earlier, our hypothesis focuses on analysing whether, in times when traditional production becomes less profitable for commercial banks due to a very low interest rate environment, as it is the case we are analysing, non-traditional production can be a good option through the reduction of their inefficiency levels. By showing that non-traditional production clearly exhibits higher levels of inefficiency than the rest of the production, we could initially think that it is possible to increase its production without increasing the consumption of inputs, without increasing the production of undesired outputs and without reducing the production of other outputs. This hypothesis would not justify the stability observed in Table 4 in the evolution of total loan production, but we need to consider the role played by the demand side in this output when interest rates are very low. Even if banks are not allocating more productive resources to attract loans, the mere fact of being in a low interest rate environment promotes consumers demand for this type of product. However, what we understand to be more relevant is the fact that bank's managers should explore and increase alternative production options that may be more profitable.

Figure 3 shows the evolution in the production of traditional outputs and non-traditional output. Although at first it might be thought that the mere fact of increasing production levels is a sign of efficiency improvement, this may not be the case. It is possible that this new production, replacing more traditional production, is not accompanied by efficient management of the inputs that were previously used for traditional production, in addition to the effect that this substitution in production decisions may have on the generated level of non-performing loans. However, in this case, as well as significantly increasing their levels of non-traditional output production, we can observe how they also clearly and significantly

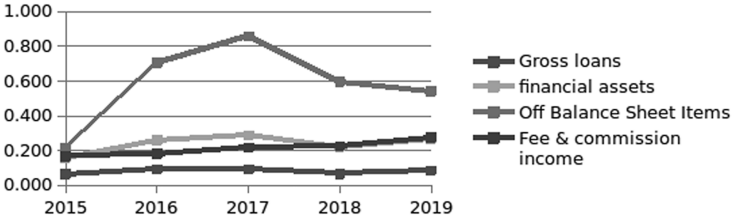


**Figure 2.** Output case-by-case basis efficiency level. Source: Authors own work

**Table 4.** Output total production (Billions Euros)

| Year | Gross loans | Financial assets | OBS items | FC income |
|---|---|---|---|---|
| 2015 | 8,620 | 3,441 | 3,240 | 124 |
| 2016 | 8,491 | 3,427 | 3,655 | 123 |
| 2017 | 8,832 | 3,295 | 3,568 | 134 |
| 2018 | 8,916 | 3,082 | 4,270 | 131 |
| 2019 | 9,286 | 3,266 | 4,401 | 135 |

**Source(s):** Authors' own work

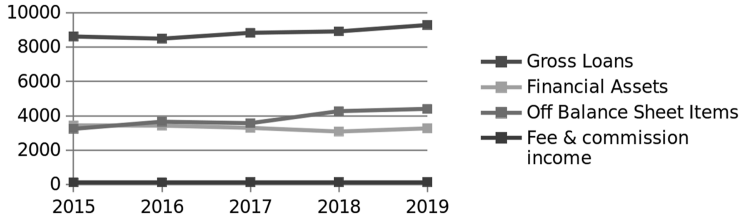


**Figure 3.** Outputs total production. Source: Authors own work

reduce the levels of inefficiency associated with this non-traditional output. This finding could support our hypothesis that commercial banks in the Eurozone found an alternative production option during a period when traditional production may be affected by low profitability environments caused by low interest rates.

Within the sample, we might also find great differences between countries in these banks' management. To this end, if we observe the efficiency results obtained for the set of countries and observations (each bank contributes one observation per year) included in the final sample, in general, almost all countries present much higher levels of inefficiency in the efficient management of non-traditional output versus traditional production. There are also great differences between the Eurozone member countries in terms of their efficient output-oriented management. Table 5 shows that although there are significant differences in terms of the average levels of inefficiency among the countries, the differences between traditional

**Table 5.** Average levels of efficiency per country

| 2015–2019 | Gross loans | Financial assets | OBS items | FC income | Total outputs |
|---|---|---|---|---|---|
| Austria | 0.386 | 1.788 | 4.518 | 1.260 | 0.302 |
| Belgium | 0.273 | 1.437 | 1.669 | 0.784 | 0.188 |
| Finland | 0.082 | 0.206 | 0.160 | 0.202 | 0.047 |
| France | 0.052 | 0.163 | 0.182 | 0.070 | 0.023 |
| Germany | 0.147 | 0.277 | 0.517 | 0.271 | 0.076 |
| Greece | 0.539 | 1.656 | 11.016 | 1.868 | 0.481 |
| Ireland | 0.638 | 2.108 | 10.331 | 2.813 | 0.490 |
| Italy | 0.062 | 0.233 | 0.576 | 0.199 | 0.043 |
| Luxembourg | 0.299 | 0.814 | 2.303 | 2.484 | 0.213 |
| Netherlands | 0.043 | 0.375 | 0.521 | 0.302 | 0.034 |
| Portugal | 0.654 | 2.170 | 1.531 | 2.515 | 0.297 |
| Spain | 0.202 | 0.748 | 1.662 | 0.522 | 0.140 |
| Total | 0.160 | 0.481 | 1.071 | 0.409 | 0.101 |

**Source(s):** Authors' own work

productions compared to non-traditional production are maintained throughout all analysed markets.

## 5. Conclusions

Financial institutions produce a range of products and services from different resources. While there is an agreement on the inputs required for banking functions, the outputs are more subject to innovation and can deviate from traditional products.

The low interest rates period from 2015 to 2022 in the Eurozone was influenced by structural factors, the consequences of the 2008 financial crisis and the management of the COVID-19 pandemic. Recent inflation issues and geopolitical events have led to abrupt changes in interest rates. During periods of low interest rates, commercial banks face profitability challenges and may explore non-traditional assets and off-balance sheet items to diversify income sources.

This paper analysed changes in the production plans of selected financial institutions during the 2015–2019 period. A non-parametric frontier method was employed to measure the potential increase in each of the outputs via the reduction of inefficiency levels of 63 commercial banks operating in the Eurozone during the specified period. The exclusion of data from 2020–2022 accounts for the potential impact of pandemic-related policies and economic restrictions.

Changes in interest rate environments can affect banks' financial margins, but their profits are also influenced by the effective recovery of bad credit and the deposits' remuneration. Some banks use these changes as an opportunity to eliminate commissions for clients. The emphasis on non-traditional activities in production plans can impact banks' overall production. Banks often target riskier segments in search of higher yields during low interest rate periods, despite shrinking margins. In addition to competition from other types of financial entities and financial technology firms, banks face general pressure on margins, prompting them to diversify income sources and reduce dependence on net interest income. The low interest rate environment provides favourable conditions to implement the necessary adjustments to the banks' balance sheets.

Merely observing the evolution of production levels for these traditional outputs is insufficient since growth alone does not guarantee efficiency. However, our study within the euro area reveals a noteworthy trend: non-traditional production average levels experienced substantial growth from 2017 onwards, accompanied by a significant reduction in average inefficiency. This seems to indicate that significant Eurozone commercial banks have restructured their production plans, placing greater emphasis on non-traditional production. Remarkably, despite using the same productive resources and encountering similar levels of non-performing loans, they achieved increased production levels that were previously unattainable due to inefficiency.

In the sample, there are variations in bank management across different countries. Most countries show higher inefficiency levels in managing non-traditional output compared to traditional production.

The period of zero interest rates that has been analysed in this work is meant as a learning experience for financial institutions in relation to OBS. We have verified how in the 2015–2019 period these products have come to have a greater weight in the balance sheets of banks. In addition, according to our results, since 2017 the level of inefficiency in the management of these products has decreased. However, since July 2022, with the aim of curbing inflation, the European Central Bank began escalating interest rates, going from 0% in July 2022 to 3.75% in May 2023. This level is the very same that interest rates had in November 2008, just at the moment when the ECB began the de-escalation to counteract the financial crisis effects.

In this environment of non-zero interest rates, once again, the most traditional banking products offer higher intermediation margins, making it relevant to re-analyse the position that financial institutions will take concerning off-balance sheet assets. However, accurately

assessing this strategic shift requires a robust efficiency evaluation framework. A potential limitation of this study lies in the exclusive consideration of weak and strong disposability in the efficiency assessment. While this approach, as discussed in the methodology section following Sueyoshi and Goto, is deemed sufficient for the objectives of this paper, it does not fully capture the potential impact of managerial disposability or alternative adaptive strategies. Furthermore, Ray (2004, p. 95) points out that DDFs fail to account for non-zero slacks in efficiency measures, which could lead to an incomplete assessment of inefficiencies related to input congestion. Future research could refine the model by incorporating slack-adjusted approaches or exploring a broader range of disposability assumptions to enhance the accuracy of efficiency estimations.

This study provides key insights for commercial banks, emphasizing the importance of efficiency in non-traditional production amid shifting interest rates and growing competition. Bank managers can use these insights to optimize traditional and off-balance-sheet activities, balancing profitability and risk while improving efficiency evaluation frameworks for better strategic decision-making. Greater banking efficiency benefits society through lower service costs, enhanced financial stability and reduced shocks risk.

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**Supplementary material**
The supplementary material for this article can be found online.

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