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Highlights

- his paper considers the impact of the Brexit referendum on the bank efficiency
- Results suggest that the uncertainty created by the 2016 referendum has negatively influenced the banking sector
- The loss of efficiency is estimated in 5.6% for UK banks and 3.7% for Ireland banks
- Evidence of decreasing returns to scale has been obtained

THE IMPACT OF BREXIT ON BANK EFFICIENCY: EVIDENCE FROM UK AND IRELAND

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ABSTRACT

The withdrawal of the United Kingdom (UK) from the European Union (EU) opens an unprecedented scenario for the UK and EU economy. One of the sensitive points concerns the banking sector. This paper considers the impact of the Brexit referendum on the bank efficiency. Using stochastic frontier analysis (SFA) methods, an input-oriented distance function was estimated for 56 British and Ireland leading banks over the 2007 to 2016 period. Results suggest that the uncertainty created by the 2016 referendum has negatively influenced the banking sector. The loss of efficiency is estimated in 5.6% for UK banks and 3.7% for Ireland banks.

KEYWORDS: *Brexit*, bank efficiency, SFA, UK, Ireland.

1. INTRODUCTION AND BACKGROUND

Over a quarter of a century, intense efforts have been made to build the European Union Single Financial Market (SFM). As a result, the EU-28 has become the largest financial area in the world by total assets (43 billion Euros) ahead of China and the United States of America (European Central Bank, 2017).

As an integral part of the European Union since 1973, both, the United Kingdom and the Republic of Ireland actively participated in the bank harmonization process which took form on the First Banking directive (1977) and the Second Banking directive (1989). The further development of the SFM was strongly influenced by the British policy-makers (Posner and Véron, 2010), the City of London (Howarth and Quaglia, 2017), and the UK financial industry (Mügge, 2010, Bell and Hindmoor, 2017).

Influenced by the global trends, both, the UK and Irish banks have gone through two main movements in capital regulations:

Prior to 2008, and over a long period, there was a significant winding down in capital levels in a major risk shift from the banks to the state (Haldane and Alessandri, 2009). This capital wind-down was facilitated by the Basel accords (Bell and Hindmoor, 2017, Fujii et al., 2018). During that time, the Irish economy experienced a period of rapid economic growth. The *Celtic Tiger* economic boom (1994–2007), based in low corporate taxes, low interest rates, and soft bank supervision, led to an expansion of credit and a real estate bubble that burst in 2007.

From 2008, as a result of the global financial crisis, capital levels were increased, through the Basel III implementation. Subsequently, the Bank of England tightened the capital requirements, turning the English financial system into one of the world's toughest standards on capital adequacy. In the Irish case this period was very difficult. Irish banks, overexposed to the Irish real estate market, suffered severe difficulties in September 2008 (Donovan and Murphy, 2013, or Clarke and Hardiman, 2012). In November 2010, The Republic of Ireland was forced to enter to an EU- IMF financial support programme which was accompanied by tough regulatory measures.

As a consequence of the above, the UK and Ireland banking industries have undergone intense regulatory changes, consolidation through mergers and acquisitions (M&As), important technological changes, and significant competitive increases.

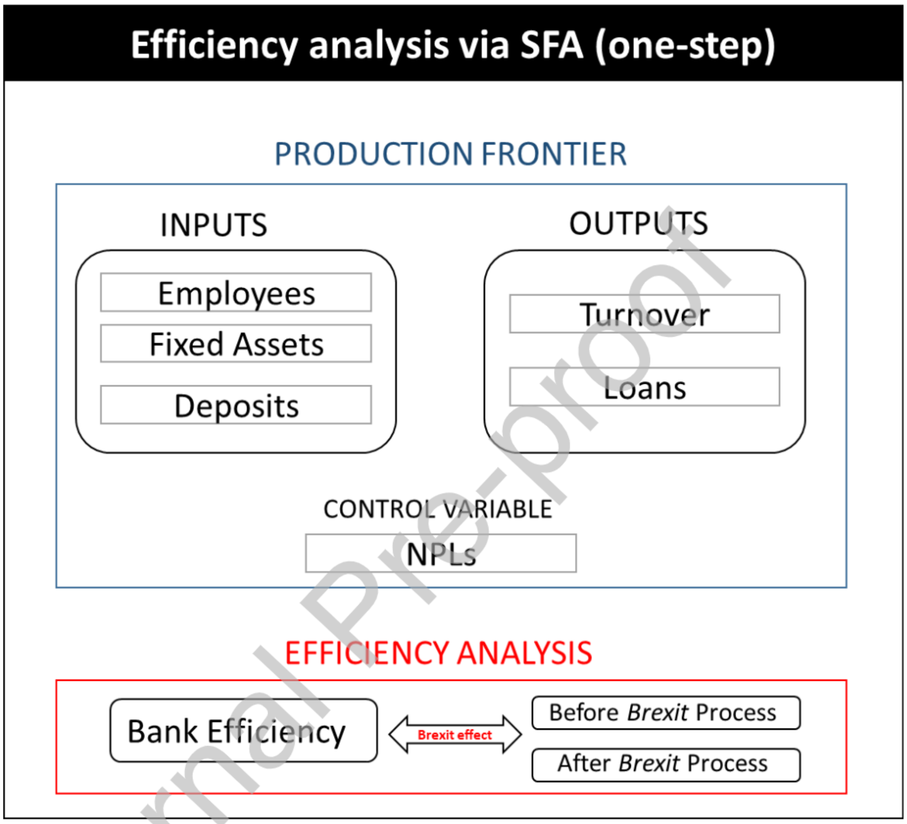
At present, UK leads the EU-28 ranking in banking assets (21% of total EU-28), capitalization (21%), credit (18%) and employment generated (14%). The UK is home of the world's second-largest Financial Centre (Global Financial Centres Index, 2018). The importance of the British financial sector is, however, closely related to the development of the SFM, and to the introduction of the single currency in the EU (Kirby et al., 2017). Thus, foreign banks, which use the UK license as European passport to provide services all over the EU, dominate in London's investment banking business.

On 23 June 2016, voters in the UK decided in a referendum to leave the European Union. The process called *Brexit* is scheduled to end on 31 October 2019 with the definitive withdrawal of the United Kingdom from the European Union. That unprecedented situation has created new uncertainties that are already affecting the British and EU economy (Tata, 2018, Shahzad et al, 2019). In this respect, the European Commission has recognised the unique position of Ireland when it comes to *Brexit* (EU commission, 2017).

There is a sizeable literature on bank efficiency. According to with the surveys carried out by Berger and Humphrey (1997), Berger (2007) and Fethi and Pasiouras (2010), the main topics of interest in the efficiency literature were size, integration, supervision, regulation, competitiveness, convergence, and company mergers. However, despite the high relationship between the financial industry and the economic uncertainty, to the best of author's knowledge, there have not been studies that assess the effect of disintegration processes on bank efficiency.

This paper aims to evaluate whether the withdrawal of the United Kingdom from the European Union (shaped by the 2016 referendum) is affecting the efficiency of the UK and Ireland banking sector. To this end, a stochastic frontier analysis (SFA) with difference in difference approach is used. Figure 1 shows the research framework of this study. The research design involves the join estimation of the function which explains inefficiency and the production technology. One of the advantages of one-step estimation is that avoids the problem of inconsistency of a two-stage estimation process (Wang and Schmidt, 2002).

Figure 1: Research Framework



The rest of the paper is structured as follows: The second section presents the methodology and the empirical specification of the model to be estimated. The third section describes the data and presents descriptive statistics. The corresponding results are presented in the fourth section, and the final section offers the conclusions of the research.

2. THE EMPIRICAL FRAMEWORK

2.1. Econometric Specification

The banks' production set is defined through the intermediation approach of Berger and Humphrey (1997). For the measurement of efficiency we employ the parametric Stochastic Frontier Analysis (SFA) approach. Despite data envelopment analysis (DEA) is the most used technique for evaluating bank performance (Fethi and Pasiouras, 2010), its implementation may conduct to some limitations and problems. While the SFA approach allows the estimation of the efficiency and the determining factors ((Brexit in this study) in the same estimate (one step), in the DEA approach, this effect must be measured in a separate step. Furthermore, SFA allows the inefficiency effect to be separated from the statistical noise, permits statistical inference in the significance of the variables included in the model and, allows random unobserved heterogeneity among the different firms.

For the estimation of the technological frontier we use input-oriented distance function. The use of the distance function (Shephard, 1953) is especially important in the bank context since the financial sector is highly regulated (Coelli et al., 2005). The choice of an input-oriented distance function can be easily justified by the conditions under which banks develop their activities. Bank managers are usually under pressure to minimize inputs (for example, number of employees or investment in fixed assets) while outputs (loans, income, etc) depends more on market conditions.

The unit of analysis in this study is a bank. Mathematically, the production technology of a bank that uses the output set, $L(y)$, which represents the input set, $y \in R_{+}^{M}$, which can be produced using the input vector, $x \in R_{+}^{K}$, that is to say:

$$L(y) = \{x \in R_{+}^{K}: x\ can\ produce\ y\} \tag{1}$$

An input-oriented distance function could be defined as:

$$D_I(x, y) = max_{\delta}\{\delta : (x/\delta) \epsilon L(y)\} \tag{2}$$

Where y is the output vector, x represents the vector of factors and $L(y)$ the input set, which defines the groups of all inputs, x, which can be used to obtain the output vector, y. A value $D_I(x, y)$ equal to one reveals that production is carried out efficiently, while a value of $D_I(x, y)$ greater than one will suggests the existence of inefficiencies.

Unlike other industries, banks are characterised by their heterogeneity. This makes necessary the treatment of unobservable heterogeneity. Greene (2005) proposes the true random effects model (hereafter TRE) based on the extension of the panel data version of the Aigner et al. (1977) model. The formulation of the input distance function defined in equations (1) and (2) can be specified following the TRE as:

$D_I(x,y) = f(x,y,\delta)e^{\lambda+v}$

(3)

where δ is a vector of unknown coefficients to be estimated. The term λ represents the bank-specific characteristics that are not captured by the other variables included, and the term ν is the random perturbation term, assumed to be $iidN(0,\sigma_v^2)$, that captures the statistical noise.

Using the Translog[1] functional form for the production technology, with M outputs and K inputs in the year *t*, the following relation exists:

$$\text{Ln}D_{Iit} = \alpha_i + \sum_{r=1}^{M} \beta_r \text{ln}y_{rit} + \frac{1}{2}\sum_{r=1}^{M}\sum_{s=1}^{M} \beta_{rs} \text{ln}y_{rit}\text{ln}y_{sit} + \sum_{j=1}^{K} \gamma_j \text{ln}x_{jit} + \frac{1}{2}\sum_{j=1}^{K}\sum_{h=1}^{K} \gamma_{jh} \text{ln}x_{jit}\text{ln}x_{hit} + \frac{1}{2}\sum_{r=1}^{M}\sum_{j=1}^{K} \rho_{rj} \text{ln}y_{rit}\text{ln}x_{jit} + \Omega NPLs + \lambda_i + v_{it}$$

$$\alpha_i = \alpha + w_i,\ w_i \sim N(0,\sigma_W^2)$$

$$i = 1,\dots,N \quad y \quad t = 1,\dots,T$$

(4)

where D_I is the input-oriented distance function, y is the output vector *r*, x is the input vector *j, i* is related to the bank and t is related to the time period. $NPLR$ is a *blocking variable* related to the bank' risk and/or asset quality, β_r, β_{rs}, γ_j, γ_{jh}, ρ_{rj}, Ω are parameters to be estimated. Finally, in line with the work of Aigner et al. (1977), it can be assumed that v_{it} it is a symmetric error term, independent and identically distributed (iid), with a zero mean that represents a random variable that cannot be controlled by the bank manager. The TRE model includes a term for time-invariant unmeasured unobserved heterogeneity (α_i) and a random component in a random-effects framework (w_i)

The distance function of inputs (4) is transformed into an econometric model that can be estimated by maximum simulated likelihood techniques. The imposition of homogeneity by reducing the K-1 inputs by the K-h input leads to:

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[1] The likelihood ratio (LR) test has been used to identify whether the Cobb–Douglas functional form, or the translog specification, was the most adequate.

$$\ln D_{Iit} - \ln x_{Kit} = \lambda_i + g[(\ln x_{kit} - \ln x_{Kit}), y_{rit},] + v_{it} \quad (5)$$

where $g[.]$ represents the translog functional form. To estimate the input distance function, this expression is reorganized as:

$$-\ln x_{Kit} = \lambda_i + g[(\ln x_{kit} - \ln x_{Kit}), y_{rit}] + v_{it} - u_{it} \quad (6)$$

where $u_{it} = lnD_{Iit}$. The parameter u_{it} follows a non-negative truncated normal distribution ($u_{it} \sim iidN^{+}(\mu, \sigma_u^2)$). It is assumed that the specific fixed effect of the bank λ_i enters the mean of the inefficiency term (Belotti et al., 2012), μ_{it}, which is defined as a function of the Brexit referendum:

$$-\mu_{it} = (\lambda_i + \delta_0) + \delta_1 Brexit + \omega_{it} \quad (7)$$

In (9) the perturbation parameter ω_{it} it represents a random variable ($\omega_{it} \sim N(0, \sigma_\omega^2)$, but not necessarily identically distributed. The conditional expectation of u_{it} is used to obtain the predicted value of the inefficiency of the banks (Jondrow et al., 1982):

2.2. Output and Input variables

The banking sector is a type of multi-product business. The most used input variables are fixed assets and personnel expenses (Maudos and Pastor, 2003; Pasiouras, 2008). In terms of output variables, loans and other profitable assets (Casu and Molyneux, 2003, Casu et al., 2004, Casu and Girardone, 2006, among others) are the most used variables in the existing literature. Accordingly, our set includes: *fixed assets*, *number of employees* and *deposits*. The set of inputs includes turnover and loans. Similar variables were also used in other studies such as Chortareas et al., (2012).

This paper includes the *Non-performing Loans* (NPLs) as control variable. The inclusion of the *NPLs* variable is justified on two arguments: first to track observable heterogeneity (specific characteristics of the bank that we would like to control for) and, second, to isolate the effects that other factors, other than the *Brexit* process, can have on efficiency. The importance of taking NPLs into account when estimating banking technology has yet been addressed in recent literature (Berger and Mester, 1997, Altunbas et al., 2000, Jiang et al., 2013, Assaf et al., 2013, Fujii et al., 2014, Malikov et al., 2016).

3. DATA ANALYSIS

The sample used in the empirical analysis includes data from 56 leading banks[2] from the United Kingdom and the Republic of Ireland over the 2007 to 2016 period. The sample covers the most majority of UK and Ireland banks, as depicted in Appendix A1. The data source is the *BankScope* database, which has been expanded using the corporate website of each entity and the website *Companies house* (2018).

Table 1 shows the descriptive statistics of the variables used in the regression analysis. All data were deflated to 2007 prices.

Table 1. Summary statistics

	Variables	Definition and units
Outputs	Turnover	Total income (interest, commissions and other financial and operating income), € millions
	Loans	Total amount of loans and advances to customers, , € millions
Inputs	Number of employees	Total number of employees
	Fixed Assets	Property and equipment, , € millions
	Deposits	Deposits and customer accounts, , € millions
Control Variable	NPLs	Total amount of Non-Performing Loans, € millions

	Variables	Minimum	Maximum	Mean	Standard deviation
Outputs	Turnover	0.22	85,459.25	7,366.31	16,038.66
	Loans	0.22	1,127,570.00	86,871.24	182,522.60
Inputs	Number of employees	17.00	331,458.00	22,558.20	53,504.70
	Fixed Assets	0.01	20,889.44	1,053.84	2,642.75
	Deposits	5.19	1,039,535.00	84,266.52	183,328.30
Control Variable	NPLs	0.01	55,154.47	2,803.51	6,879.31

Source: Own elaboration

3.1. Efficiency determinants: The Brexit effect

Our analysis considers whether the Brexit process (initiated by the referendum held on June 23, 2016) has impacted the UK and Ireland bank efficiency. To analyze the impact of the *Brexit* we used a dummy variable (as z-variable). Thus, the *Brexit* variable takes

[2] The sample includes 42 banks from England, 6 from Scotland, 2 from Northern Ireland, 1 from Wales and 5 banks from the Republic of Ireland

value 1 in the year 2016 when the bank belongs to England, Scotland, Wales, and Northern Ireland and value 0 otherwise.

The impending withdrawal of the United Kingdom (UK) from the European Union (EU) has brought political and financial instability. Aggarwal, R., & Goodell (2009) show a strong association of political stability with a predilection for markets. Thus, national preferences for market financing increase with political stability.

In accordance with *Brexit withdrawal agreement* (2018), the future financial-services relationship between Britain and the European Union should be based on recognizing each other's regulations, a process known as equivalence, resulting in more restrictions on bank activities. In this regard, Beck et al. (2006) demonstrate that restrictions on bank activities have a negative influence on bank performance and stability.

On the basis of the arguments made above, we expect that the political and regulatory instability triggered by the 2016 Brexit referendum should impact negatively on bank efficiency.

4. EMPIRICAL EVIDENCE

The results of the estimation of the production frontier function and the determinants of inefficiency (coefficient values and significance) are shown in Table 2. Displayed on the right, in brackets, are the standard errors. The first-order coefficients of Table 2 may be interpreted as elasticity's evaluated on the data average since their respective geometric mean has divided each of the variables. All the first-order coefficients are statistically significant and have the expected sign. The parameters of the input variables are positive and, thus, indicate that distance from the frontier decrease when input diminishes. This implies that the estimated distance function complies with all the theoretical properties expected.

Table 2: SFA estimation (period 2007-2016)

Variable	Parameter	Coeffic.	Estd. Error
$\ln(y_1)$	β_1	-0.360	(0.024)***
$\ln(y_2)$	β_2	-0.391	(0.022)***
$\ln(x_1)$	γ_1	0.591	(0.026)***
$\ln(x_2)$	γ_2	0.320	(0.022)***
$\ln(y_1)\ln(y_1)$	β_{11}	0.015	(0.013)
$\ln(y_2)\ln(y_2)$	β_{22}	-0.057	(0.007)***
$\ln(x_1)\ln(x_1)$	γ_{11}	0.206	(0.027)***
$\ln(x_2)\ln(x_2)$	γ_{22}	0.103	(0.012)***
$\ln(y_1)\ln(y_2)$	β_{12}	0.018	(0.010)*

$\ln(y_1)\ln(x_1)$	$\rho_{1\,1}$	0.070	(0.021)***
$\ln(y_1)\ln(x_2)$	$\rho_{1\,2}$	-0.047	(0.015)***
$\ln(y_2)\ln(x_1)$	$\rho_{1\,2}$	0.003	(0.015)
$\ln(y_2)\ln(x_2)$	$\rho_{2\,2}$	-0.013	(0.011)
$\ln(x_1)\ln(x_2)$	$\rho_{2\,2}$	-0.130	(0.017)***
ln(NPLs)	Ω	-0.038	(0.013)***
Constant	α_0	-3.353	(0.038)***
Brexit	δ_1	12.605	(6.082)**
Constant	δ_0	-28.507	(10.96)***
Sigma²	$\sigma^2=\sigma_V^2+\sigma_\upsilon^2$	1.343	(0.368)***
Gamma	$\gamma=\sigma_u^2/(\sigma_V^2+\sigma_u^2)$	0.929	
Number of observations		532	
Number of banks		56	
Log-likelihood funtion		-37.137	

Notes:

Significance codes: 0.01 '***', 0.05 '**', 0.10 '*'.

Source: Own elaboration

It is observed that the highest input-elasticity corresponds to labour (0.59). Thus, an increase of 1% in the bank number of workers lead to an output increase of 0.59%. Regarding outputs, loans is the variable with the highest output-elasticity in the model (0.39), which indicates that loans are the major economic source in the bank sector. The cross product of the input variables is negative, indicating that number of employees and deposits are substitute factors. The sum of the first-order input coefficients is less than 1 (0.93) in absolute value, suggesting the presence of decreasing returns to scale, as suggested by Miller (1996) for the larger US banks, or Jiang et al. (2009) for the Chinese banking sector.

It is not surprising to find that the effect of non-performing loans, *NPL*, is significantly negative. The coefficient indicates that an increase in NPL by 1%, with the other factors held constant, leads to an output decrease by 0.038% on average.

The parameter γ lies between zero and one and indicates the importance of the inefficiency. As the estimate of γ is 0.93 it is possible to conclude that 93% of the deviation is due to inefficiency and 5% to the random component

Since we found that inefficiency is significantly present in the sample, there is room to investigate its determinants, specifically the *Brexit* impact on Banking efficiency. Inefficiency in equation (9) is measured regarding the distance from the frontier; an adverse impact indicates an increase in efficiency (i.e., catching up toward the frontier).

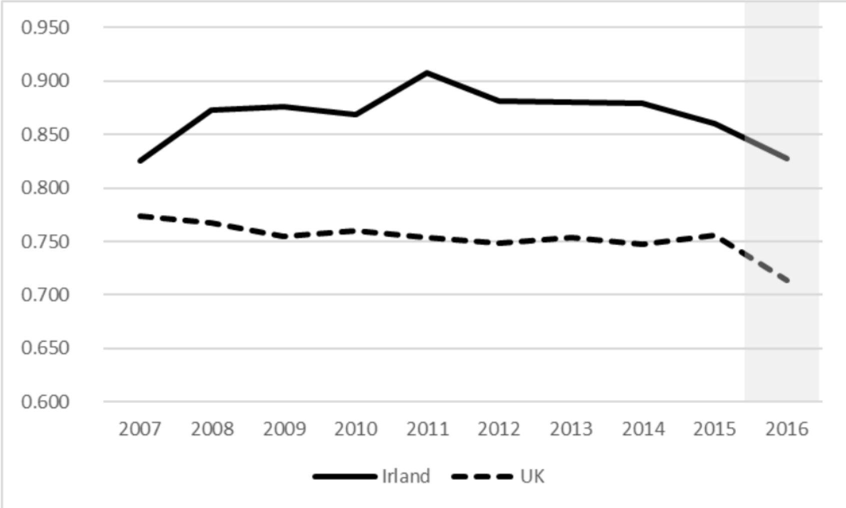
The *Brexit* variable has a positive coefficient and is statistically significant, indicating negative effects on technical efficiency. In accordance with the results obtained, the political and financial instability provoked by the outcome of the *Brexit* referendum has had a detrimental impact on the bank efficiency of the UK. These findings are in line with those obtained by Aggarwal, R., & Goodell (2009), who show a strong association of political stability with bank stability. In this sense, the position of London as a global financial centre could generate a contagion effect. As stated by Degl'Innocenti et al. (2017), the increase of power of global financial centres amplify the instability of the banking system worldwide.

Another possible reason is associated with the future restrictions on bank activities. In accordance with the *Brexit withdrawal agreement (2018),* the UK will lose passporting rights for EU financial services. As demonstrated by Beck et al. (2006), restrictions on bank activities have a negative influence on bank performance.

The average efficiency index for the entire sample is relatively high (76%). Comparing the banking sector in the UK and Ireland over the period considered (2007-2016), there is greater efficiency of Irish banks in all years. Likewise, there is a greater impact of *Brexit* on the British banking system (Figure 2).

Figure 2 shows a comparison between the Ireland and the United Kingdom efficiency scores over the 2007 to 2016 period. A decrease in average efficiency for both British and Irish banks in 2016 is observed. The banking sector of Ireland, as a bordering country, is also affected by Brexit process. The loss of efficiency, after the 2016 referendum, is estimated in 5.6% for the UK banking sector and 3.7% for the Ireland banks.

Figure 2. Efficiency in the banking sector of the Republic of Ireland and UK (2007-2016).



Source: Own elaboration

5. CONCLUSIONS AND POLICY IMPLICATIONS

This paper analyses the impact of the Brexit process on the banking efficiency of United Kingdom and Ireland. To this end, using stochastic frontier analysis (SFA) methods, we estimate an input-oriented distance function for 56 banks over the 2007 to 2016 period.

Results suggest that the uncertainty created by the 2016 referendum had negatively influenced the efficiency levels of the British and Ireland banking industry. The loss of efficiency, after the 2016 referendum, is estimated in 5.6% for the UK banking sector and 3.7% for the Ireland banks. The estimated average efficiency is 76%. It is also observed that labour is the input variable with the most influence on outputs (0.59%), while loans is the output with the highest elasticity in the model (0.39%). In addition, evidence of decreasing returns to scale has been obtained.

To the knowledge of the authors, this is the first work that estimates the effect of a disintegrating process on bank efficiency. Previously, integrating processes had been studied, obtaining evidence of positive effects on efficiency (Delis, M. D., & Papanikolaou, N. I. (2009), Brissimis et al., 2010, Fiordelisi et al., 2011, Gallizo et al., 2015).

Political and financial instability are highly interrelated. Our empirical results describe the efficiency of the sector in UK and Ireland and are relevant to policymaker, bank managers, shareholders and Bank customers. The strength of financial systems is strongly linked to political stability. Our results provided evidence that a negotiated withdrawal agreement is the best option to reduce the negative impact of the Brexit on the bank industry.

There are limitations to this research. We focused only on the UK and Ireland case and results may not be generalizable. Although we found a direct relationship between the *Brexit* process and bank efficiency, future research might focus on the future evolution of this relationship as well as on the effect of Brexit on the EU bank industry.

Appendix A1

List of banks considered in this research (See Table A1)

Table A1. Sample of 56 UK and Ireland banks

HSBC Holdings PLC
Lloyds Banking Group PLC
Barclays PLC
Barclays Bank PLC
Lloyds Bank PLC
HSBC Bank PLC
Standard Chartered PLC
The Royal Bank of Scotland Group Public Limited Company
Bank of Scotland PLC
Santander UK PLC
Credit Suisse International
Schroders PLC
TSB Bank PLC
Investec Bank PLC
Citibank International Limited
Clydesdale Bank PLC
Virgin Money PLC
The Co-Operative Bank P.L.C.
Bank of Ireland (UK) PLC
Close Brothers Group PLC
RBC Europe Limited
Hewlett-Packard International Bank Public Limited Company
Sumitomo Mitsui Banking Corporation Europe Limited
Aldermore Bank PLC
Aldermore Group PLC
Sainsbury's Bank PLC
AIB Group (UK) P.L.C.
Onesavings Bank PLC
Shawbrook Group PLC
VTB Capital PLC
Mizuho International PLC
Icbc Standard Bank PLC
Itau BBA International PLC
Metro Bank PLC
Northern Bank Limited
Scotiabank Europe PLC
HSBC Private Bank (UK) Limited
C. Hoare & CO.
Secure Trust Bank Public Limited Company

Schroder & CO. Limited
Lloyds Bank Private Banking Limited
Scottish Widows Bank PLC
EFG Private Bank Limited
Morgan Stanley Bank International Limited
Julian Hodge Bank Limited
Europe Arab Bank PLC
Brown Shipley & CO. Limited
Arbuthnot Banking Group PLC
National Bank of Kuwait (International) PLC
Al Rayan Bank PLC
R. Raphael & Sons PLC
Kleinwort Benson Bank Limited
Ulster Bank of Ireland UK PLC
Bank of Ireland
AIB Group
Permanent tsb

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