4 ANNEXES*

* Les opinions et résultats décrits dans les études présentées dans cette partie sont ceux des auteurs. Ils ne doivent pas être considérés comme étant ceux de la BCL ou de l'Eurosystème.

1. L'IMPACT DE LA RÉGULATION DE LA LIQUIDITÉ BANCAIRE SUR L'OFFRE DE CRÉDIT AUX MÉNAGES ET AUX ENTREPRISES NON FINANCIÈRES AU LUXEMBOURG

David Kremer[86]

RÉSUMÉ

Cette étude propose une évaluation de l'impact de la régulation de la liquidité bancaire, à savoir du « Liquidity Coverage Ratio (LCR) », sur l'offre de crédit aux sociétés non-financières et aux ménages luxembourgeois. Après une revue des tendances générales au cours dernières années, l'analyse empirique exploite des données d'un panel d'établissements de crédit pour l'estimation d'un modèle dynamique par la méthode des moments généralisée.

Les résultats obtenus suggèrent que le niveau du ratio de liquidité (LCR) a un impact légèrement négatif sur le taux de croissance des crédits octroyés. L'étude révèle que les établissements bancaires luxembourgeois disposant d'un ratio de liquidité plus élevé ont octroyé moins de crédits aux ménages et aux entreprises non financières luxembourgeois. Toutefois, l'effet estimé demeure relativement limité.

1 INTRODUCTION

Suite à l'émergence de la crise financière de 2007-2008 et de l'importance de ses répercussions sur les économies des pays occidentaux, les risques liés aux crises de liquidité furent au centre de l'attention des régulateurs et des autorités de supervision. Ainsi, le Comité de Bâle a pris l'initiative d'introduire, en 2010, de nouvelles exigences prudentielles en matière de liquidité à court et à moyen terme. Il s'agit de la mise en place de deux ratios, l'un à court terme (*LCR, Liquidity Coverage Ratio*) destiné à couvrir les besoins immédiats, en l'occurrence 30 jours, en période de stress ; tandis que le second (*NSFR, Net Stable Funding Ratio*) couvre les besoins structurels de long terme.

Le LCR a pour objectif de renforcer le profil de liquidité à court terme des banques en veillant à ce que celles-ci disposent de suffisamment d'encours d'actifs liquides de haute qualité (*HQLA, High Quality Liquid Assets*) pour faire face aux besoins de liquidité jusqu'à 30 jours calendaires[87] en période de stress ou d'assèchement de liquidité sur les marchés financiers. Ce ratio de couverture est composé de deux éléments, les HQLA au numérateur et le total des sorties nettes de trésorerie sur les prochains 30 jours au dénominateur. Il s'écrit :

$$\text{LCR} = \frac{\text{HQLA}}{\text{Total des sorties nettes de trésorerie sur les 30 jours suivants}}$$

Les besoins de liquidités sont calculés en multipliant les divers types d'encours à payer et d'engagements hors bilan par les taux anticipés de sortie de flux en période de stress. Les flux sortants doivent être compensés par les entrées de liquidités prévues sur la même période pour calculer les sorties nettes de liquidités. Toutefois et afin de prémunir les établissements de crédit de s'appuyer principalement

86 Département Economie et Recherche. Cette analyse fut réalisée pendant une période de stage au sein du Département Stabilité Financière et Surveillance Macroprudentielle.

87 L'objectif du NSFR est de renforcer le profil de liquidité des banques à moyen et long terme, plus précisément à l'horizon d'un an.

sur les flux entrants pour respecter le niveau du LCR, l'usage du montant de ces flux est plafonné à 75 % du total des flux sortants[88]. Les HQLA comprennent notamment le cash, les réserves auprès de la Banque centrale et les titres de créance émis (ou garantis) par les autorités publiques.

Le LCR est devenu une norme contraignante dès le début du mois octobre 2015 avec un ratio de couverture minimal fixé à 60 %. Ce seuil est amené à progresser graduellement durant la période de grâce pour atteindre le niveau de 100 % en janvier 2018. Ainsi, la norme exigée dès la fin de la période transitoire consiste à tenir un niveau d'actifs de HQLA au moins équivalent au total des sorties nettes de trésorerie estimées sur 30 jours à venir.

L'introduction de la régulation de liquidité a suscité beaucoup de débats sur l'impact potentiel de ces nouvelles normes sur l'activité bancaire et sur les flux de crédit à l'économie. Le groupe des parties intéressées (EBA Banking Stakeholder Group) au secteur bancaire mis en place par l'Autorité Bancaire Européenne[89] a alerté fin 2011 sur les implications potentielles du LCR. L'analyse conduite par ce groupe évalue que le déficit en matière d'actifs liquides (HQLA) des banques opérant dans l'Union Européenne s'élevait à plus d'un billion d'euros. De plus, celles-ci devraient orienter les fonds générés vers des actifs plus liquides au détriment des prêts à l'économie et à d'autres actifs moins liquides pour se conformer avec les nouvelles contraintes légales induites par le LCR. En d'autres terme le Groupe conclut que le LCR a un effet d'éviction sur l'investissement productif en mobilisant plus d'un billion d'euros à des actifs liquides.

Or, les études empiriques les plus récentes ont révélé que l'impact de la mise en place des nouveaux standards de liquidité sur les flux de crédit à l'économie serait très limité. Banerjee et Mio (2018) examinaient ex-post la réaction des banques au Royaume-Uni au resserrement des normes de liquidité. Les résultats obtenus suggèrent que ce resserrement a constitué en effet une contrainte additionnelle sur la composition des actifs et des passifs intrabancaires, sans pour autant avoir affecté les flux de crédit à la sphère réelle de l'économie. Bonner, C. (2012) exploite des données spécifiques aux Pays-Bas et en estime que les banques disposant de ratios de liquidités proches du niveau exigé par la régulation n'avaient pas répercuté le coût additionnel sur les taux d'intérêt des crédits accordés aux entreprises. Il conclut notamment que « (…) bien qu'il s'agisse de l'une des critiques les plus courantes, il semble peu probable que la conception actuelle du LCR ait un effet négatif majeur sur les crédits au secteur privé. ». Enfin, en s'appuyant sur les données d'un panel de banques, un récent rapport de l'Autorité bancaire européenne (ABE, 2019) aboutit à la conclusion « d'absence de preuve évidente d'un quelconque impact du règlement de la liquidité sur les crédits à l'économie réelle ».

88 Contrairement aux standards de liquidité de court terme établis par le Comité de Bâle, la régulation adoptée par l'Union européenne en matière de LCR incorpore quelques exemptions partielles ou totales à ce plafond sous réserve d'approbation de l'autorité compétente.

89 Ce groupe fut institué par l'article 37 de la Régulation EU 1093/2010 du 24 novembre 2010 relative à la mise en place de l'Autorité bancaire européenne.

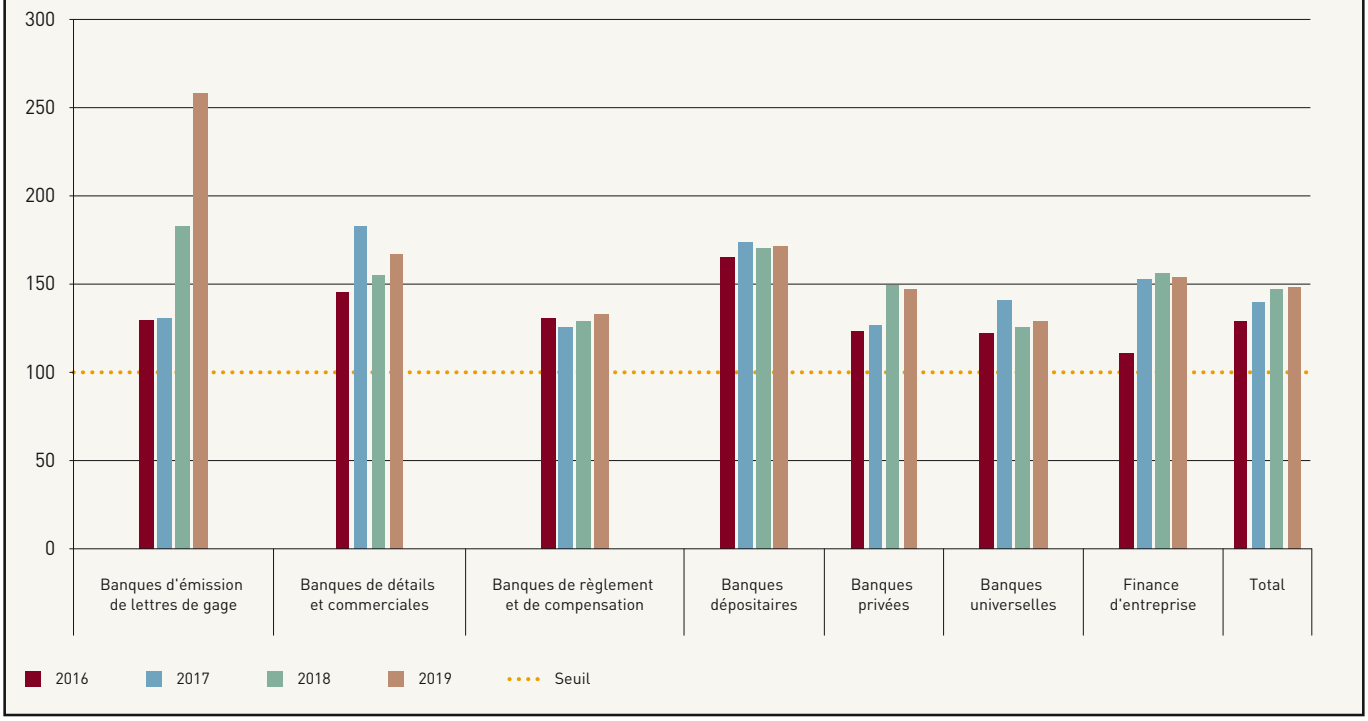
2 MODÈLES D'AFFAIRES ET POSITIONS DE LA LIQUIDITÉ DES ÉTABLISEMENTS DE CRÉDIT LUXEMBOURGEOIS

Sur la période couverte par cette analyse, les banques luxembourgeoises ont affiché des ratios moyens de liquidité supérieurs au seuil de 100 %. Ainsi, la moyenne annuelle pondérée pour l'ensemble des établissements de crédit a fluctué entre 126 % et 148 % avec une tendance ascendante. Toutefois, l'analyse granulaire, illustrée par le graphique 1, révèle des hétérogénéités importantes des niveaux du LCR, qui s'expliquent par la diversité des modèles d'affaires.

Les facteurs sous-jacents aux disparités des situations des banques en matière de liquidité peuvent être attribués à trois éléments :

- Les besoins en HQLA peuvent varier en fonction de la spécialisation dans des domaines d'activités bancaires spécifiques. Le graphique 2 illustre la position de chaque banque selon ses encours d'actifs liquide (HQLA) et ses sorties nettes des flux de trésorerie exprimés en pourcentage de son actif bilantaire. Il ressort de cette représentation que les banques privées affichaient des besoins de liquidité 3 à 4 fois plus élevés qu'une banque dont le modèle d'affaire est orienté vers la banque de détails.
- La taille des établissements bancaires. En effet, il ressort de l'analyse des données individuelles que les petites banques affichaient des ratios de liquidité beaucoup plus volatiles que les grands établissements. Selon (Bonner et al. 2015), cet excès de volatilité s'explique par l'instabilité de la trésorerie des

Graphique 1
Niveau du LCR selon le modèle d'affaire des établissements de crédit luxembourgeois : 2016-2019
(Moyenne pondérée)

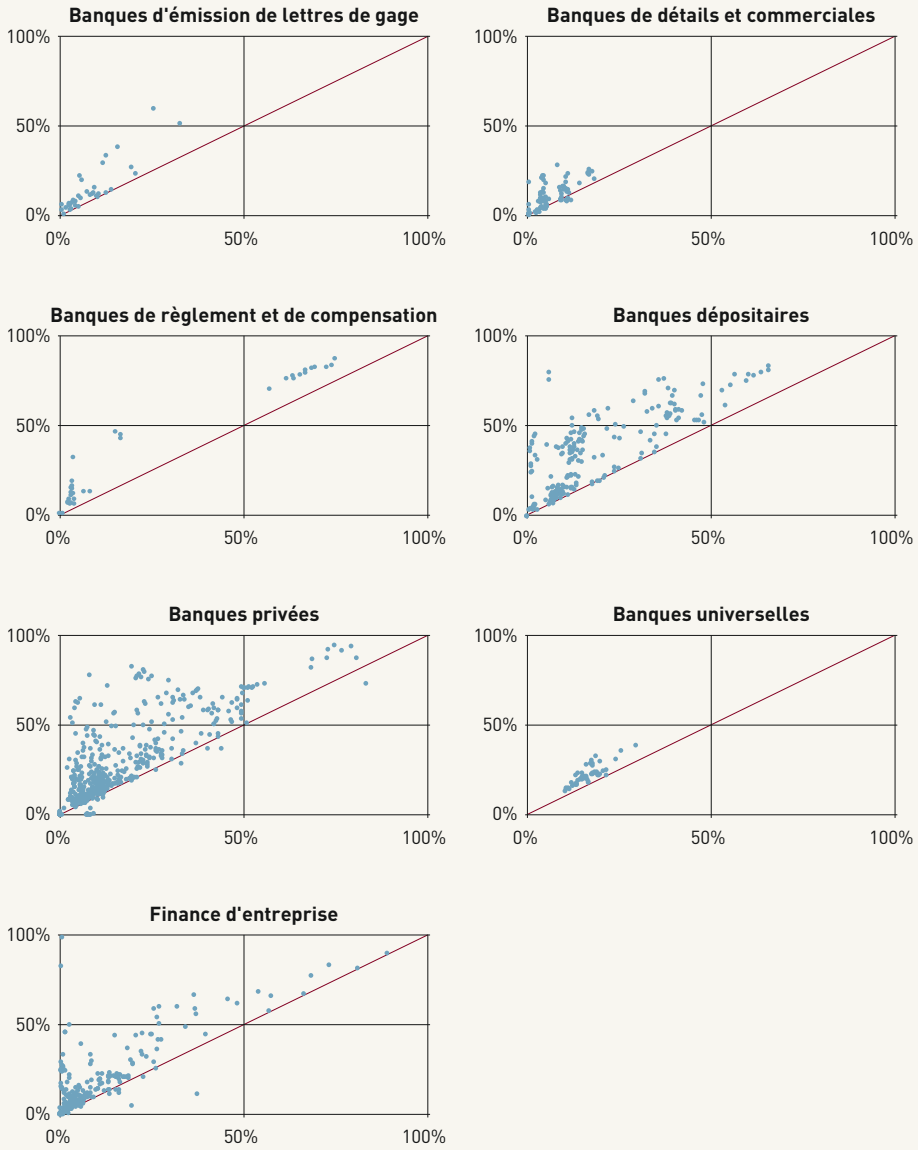


Sources : CSSF, calculs BCL

petites banques par rapport à celle enregistrée par les banques de grandes taille. Il semblerait que le levier des flux compensatoires joue un rôle prépondérant pour la stabilité de la trésorerie de ces dernières, tandis que pour les petites structures, le rôle de ces flux est moins important dans la mesure où une simple transaction est susceptible affecter le niveau de leur ratio de liquidité de court terme. Ceci pourrait amener les petites banques à viser un niveau du LCR plus élevé pour garder une certaine marge de sécurité. À titre indicatif, les établissements de crédit dont le modèle d'affaire est orienté vers la banque *de détails et commerciales* comprennent plus de 25 % de banques de petite taille dont l'actif bilantaire est inférieur à 500 millions d'euros en 2018 ; tandis que la cohorte des banques orientées vers un modèle d'affaire dit universel est composée exclusivement de structures avec des sommes de bilans supérieures à 10 milliards d'euros.

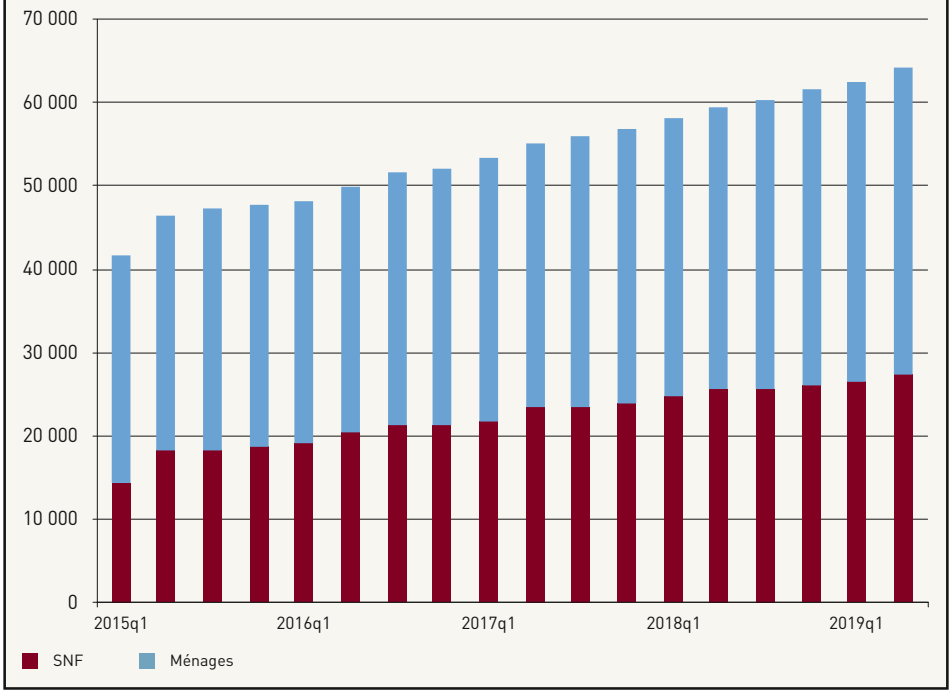
- Finalement, l'appréciation et la stratégie de gestion des risques de liquidité varient d'un établissement à un autre et dépend de facteurs propres aux dirigeants.

Graphique 2
HQLA et sorties nettes (par rapport au total d'actifs)



Sources : CSSF, calculs BCL

Graphique 3
Évolution des encours envers les SNF et ménages luxembourgeois
Encours (EUR Millions)



Sources : CSSF, calculs BCL

3 ANALYSE EMPIRIQUE : DONNÉES ET ESTIMATION ÉCONOMÈTRIQUE

3.1 ANALYSE DESCRIPTIVE ET TENDANCES STATISTIQUES

Tout d'abord, il y a lieu de souligner que les montants des encours de crédit envers les sociétés non financières et les ménages luxembourgeois illustrés par le graphique 3 affichaient une tendance ascendante tout au long de la période couverte par cette analyse avec un taux de croissance moyen trimestriel de 2,5 %. A priori, l'implémentation du LCR en tant que nouvelle norme contraignante depuis 2015 ne semble pas avoir impacté l'évolution agrégée des crédits à l'économie réelle au Luxembourg.

Cette étude se base sur un sous-échantillon de 34 établissements de crédits, observés trimestriellement sur la période 2016T3 – 2019T2 et couvrant près de 95 % des encours de crédit accordés aux SNF et aux ménages luxembourgeois. Le tableau 1 ci-dessous affiche un récapitulatif des principales variables et leurs moments statistiques.

Tableau 1 :
Caractéristiques statistiques des variables de l'échantillon

VARIABLES	(1) N	(2) MOYENNE	(3) MIN	(4) MAX	(5) SD	(6) P5	(7) P25	(8) P50	(9) P75	(10) P95
LCR	403	1.704	0.457	7.031	0.931	1.008	1.227	1.414	1.773	3.625
Encours (en million d'€)	403	1,635	0	18,832	3,596	11.71	29.95	103.3	816.0	8,355
Tx. de croissance du PIB désaisonnalisé	403	0.0527	0.0257	0.0801	0.0158	0.0257	0.0407	0.0562	0.0680	0.0801
D/L	400	1.472	0	19.40	1.732	0	0.424	1.061	1.932	4.186
Nombre de banques	34	34	34	34	34	34	34	34	34	34

Sources des données : Statec, FINREP, COREP

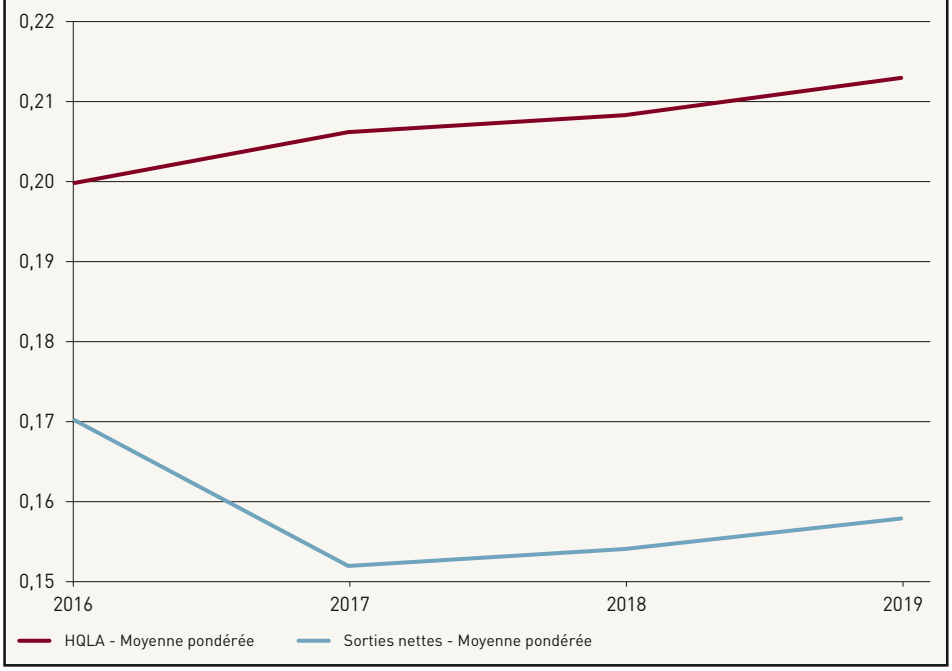
L'approche adoptée dans cette étude s'appuie en partie sur celle adoptée dans le récent rapport précité de l'autorité bancaire européenne (ABE, 2019) sur les flux de crédit aux économies européennes en transposant l'analyse au secteur bancaire luxembourgeois.

L'évolution des composantes du LCR (graphique 4) pour les banques de l'échantillon permet d'identifier deux tendances distinctes. Tout d'abord, le niveau moyen annuel des HQLA par rapport au total d'actifs a augmenté au cours des trois dernières années. Il convient de souligner que cette progression s'explique en partie par les réserves excédentaires des établissements bancaires auprès de la Banque centrale. Par ailleurs, les établissements de crédit semblent avoir poursuivi une stratégie qui vise à réduire graduellement les sorties de flux pour améliorer leur position de liquidité. Bien que cette tendance soit inversée dès 2017, le niveau des flux nets enregistrés en 2019 demeure inférieur à celui de 2016.

Afin d'analyser l'impact du LCR sur les flux de crédits bancaires accordés à l'économie réelle, il serait utile de comparer, dans un premier temps, le niveau du LCR des établissements ayant abaissé leurs encours de crédit vis-à-vis des ménages et entreprises non financières aux banques ayant augmenté leur encours. Le graphique 5 affiche l'évolution temporelle des ratios LCR pour les deux catégories de banques. Il semblerait difficile d'extraire une relation visuelle claire entre le niveau du LCR et les crédits attribués aux agents économiques au Luxembourg.

Il est, toutefois, envisageable que les banques aient besoin d'une période pour ajuster leurs activités au nouvel environnement induit par la mise en place du LCR. Afin de tenir compte de cet aspect, le graphique 6 affiche conjointement le niveau du LCR en début de période et la variation annuelle des

Graphique 4
Évolution des composantes du LCR (par rapport au total d'actifs)
(% - Total d'actifs)

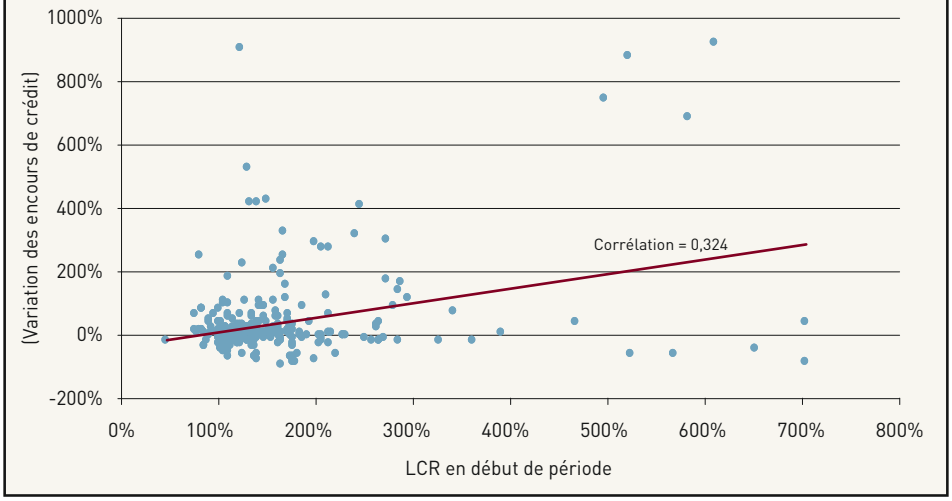


Sources : CSSF, calculs BCL

Graphique 5
LCR moyen des banques ayant réduit vs augmenté les crédits aux SNF et ménages
(Moyenne pondérée du LCR)

Sources : CSSF, calculs BCL

Graphique 6
Variation des encours vs. LCR



Sources : CSSF, calculs BCL

encours de crédit à la fin de ladite période. Il ressort de cet exercice une corrélation positive entre les deux variables suggérant qu'un niveau du LCR élevé favorise l'octroi de nouveaux crédits. Toutefois, cette simple corrélation ignore les effets induits par l'environnement financier et économique et par la structure des données de notre échantillon.

3.2 ANALYSE ÉCONOMÉTRIQUE SUR DES DONNÉES EN PANEL

Afin de vérifier si les banques ayant des LCR plus élevés vont accorder davantage de crédits à l'économie réelle au Luxembourg, la spécification linéaire suivante est estimée selon deux méthodes économétriques de panel : effets fixes et les moments généralisés (GMM) :

$$\Delta_{t-1}^{t} L_i = \beta_o + \beta_1 \Delta_{t-2}^{t-1} L_i + \beta_2 LCR_{i,t-1} + \beta_3 \Delta PIB_{t-1}^{t} + \beta_4 \left(\frac{D}{L}\right)_{t-1} + \delta_i + \varepsilon_{i.t} \quad (1)$$

où $\Delta_{t-1}^{t} L_i$ désigne le taux de croissance annuel au trimestre t des encours envers les SNF et les ménages luxembourgeois. Afin de tenir compte de la persistence, la variable retardée $(\Delta_{t-2}^{t-1} L_i)$ est introduite dans l'estimation en tant que variable explicative (IMF, 2012). La varaible $LCR_{i,t-1}$ correspond au LCR de la banque i en début de période. L'estimation inclut des effets fixes spécifiques aux banques individuelles δ_i et des variables de contrôle de l'environnement macroéconomique et bilantaires. Il s'agit du taux de croissance du PIB désaisonnalisé et de la structure du bilan d'une banque approximée par le ratio des dépôts des SNF et ménages sur les crédits accordés à ces derniers $\left(\frac{D}{L}\right)_{t-1}$.

Dans un premier temps, un estimateur à effets fixes est utilisé et les résultats sont reportés dans la colonne (1) du tableau 2. Toutefois, afin de prendre en compte le biais d'endogénéité induit par l'introduction de la variable retardée, la méthode des moments généralisée (GMM) est appliquée dans une seconde étape. Plus précisément, la colonne (2) correspond aux résultats issus de l'estimation d'un système GMM en deux étapes « *Two-Step system GMM* » conformément à l'approche proposée par Arellano et Bond (1991). La variable expliquée retardée et le ratio des dépôts sur les crédits sont considérés comme étant non complètement exogènes.

Les résultats affichés dans le tableau 2 montrent que la corrélation positive affichée dans le graphique 6 disparait. En effet, le paramètre d'intérêt affiche un signe négatif ce qui est synonyme d'une relation négative entre le LCR et les nouveaux crédits octroyés aux ménages et aux entreprises. Toutefois, la valeur de ce coefficient demeure contenue. Ainsi, les résultats des estimations semblent indiquer que l'effet du LCR sur le taux de croissance des encours de crédit serait limité[90]. D'ailleurs, ce paramètre

90 Comme présenté dans le tableau récapitulatif, le LCR est exprimé en unités et une augmentation du ratio d'une unité correspondrait par exemple à un niveau de couverture qui a augmenté de 100 %.

est statistiquement non-significatif selon l'estimation issue de la méthode à effets fixes. Les paramètres gagnent en précision et deviennent statistiquement significatifs suivant la méthode GMM. Ainsi, l'augmentation du LCR d'un point de pourcentage pour une banque implique, toute chose égale par ailleurs, une baisse de l'octroi de nouveaux crédits de près de -0.14 %.

Les paramètres des variables de contrôle présentent des signes conforment aux attentes. Le coefficient du PIB est positif et statistiquement significatif selon les spécifications. Ainsi, la progression du PIB contribue positivement à la croissance des crédits. Le paramètre du ratio D/L est également positif signifiant que le taux de couverture des crédits par les dépôts serait un facteur déterminant pour la croissance des flux des crédits à l'économie.

Tableau 2 :

Résultats des estimations

	(1) EFFETS FIXES	(2) TWO-STEP SYSTEM GMM
VARIABLES	TAUX DE CROISSANCE ANNUEL DES CRÉDITS DÉSAISONNALISÉS	TAUX DE CROISSANCE ANNUEL DES CRÉDITS DÉSAISONNALISÉS
$\Delta L - 1$	0.338***	0.614***
	(0.0671)	(0.0751)
LCR en début de période	**-0.141**	**-0.138***
	(0.104)	**(0.0721)**
Taux de croissance du PIB désaisonnalisé	5.463**	6.069**
	(2.474)	(2.728)
D/L	0.297***	0.410***
	(0.0411)	(0.103)
Constante	-0.284	-0.606**
	(0.237)	(0.253)
Observations	260	260
R^2	0.406	
Nombre de banques	34	34
F-stat.	59.09	198.5
Valeur p Hansen stat.		0.711

*Écarts-types entre parenthèses. *** p<0.01, ** p<0.05, * p<0.1*

4 CONCLUSION

Cette étude avait pour objectif de quantifier l'impact de la mise en place du LCR par la régulation européenne sur l'offre de crédits par un échantillon de banques représentatif aux SNF et aux ménages luxembourgeois à l'aide d'un modèle économétrique estimé sur des données de panel dynamique. Les résultats obtenus révèlent une relation négatif entre le niveau du LCR et les flux de crédit à l'économie. Toutefois, cet effet demeure marginal. Il est dominé par les effets positifs issus des variables de contôle, qui sont la performance de l'économie nationale (croissance du PIB) et le ratio de couverture des crédits par les dépôts collectés auprès des ménages et des entreprises non financière. Dans ce contexte, il est utile de rappeler que les craintes soulevées par le Groupe des parties intéressées (EBA Banking Stakeholder Group) ne se sont pas matérialisées.

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2. MONITORING RISKS IN THE LUXEMBOURG NON-BANK FINANCIAL SECTOR

Max Gehrend and Fabienne Weber[91]

ABSTRACT

Luxembourg constitutes the main domicile for non-bank financial institutions in Europe.[92] This component of the Luxembourg financial sector has expanded rapidly since the global financial crisis, with total assets growing from €4.2tr in 2008 to €14.5tr in 2019. The non-bank financial sector is exposed to risks at the global level, including the risks associated with the COVID-19 pandemic. Signs of increased financial risk-taking have been emerging in recent years, raising the potential for negative cross-sectoral spillovers. To assist in the identification of the potential financial stability risks linked to non-banks, this special feature proposes a monitoring framework for investment funds and insurance corporations[93].

Uncertainty in global financial markets has increased dramatically since the outbreak of COVID-19, thereby exposing investment funds to potential large-scale investor outflows. In March 2020, Luxembourg investment funds reported net outflows of -2.7% of their aggregate net asset value, which were the largest outflows since October 2008. Low volatility net asset value money market funds (-14.5%), high-yield corporate bond funds (-8.5%) and emerging market bond funds (-7.1%) experienced the most important outflows.

In parallel, to these developments, the investment fund sector engaged in search-for-yield behaviour before the outbreak of COVID-19. Amid globally decreasing yields, investment funds have increased their exposure to interest rate risk, credit risk, and to foreign currency assets. Despite the increased risks, the sector's liquid asset holdings in February 2020 far exceeded the investor outflows that were observed in March. However, reduced liquidity buffers in certain segments such as high-yield bond funds, the uncertainty regarding the impact of COVID-19 on financial markets and the real economy, and expectations that interest rates will remain low going forward, underscore the need for continued risk monitoring efforts.

Unlike investment funds, Luxembourg insurance corporations did not engage in increased risk-taking prior to the outbreak of COVID-19. Their exposure to interest rate risk, credit risk and foreign exchange rate risk has not changed materially over the past five years. One explanation might be that life insurers in Luxembourg display a high share of unit-linked business, which means that they mostly do not offer policyholders guaranteed returns. Therefore, they might be less inclined to engage in a search-for-yield behaviour than life insurers with a significant share of non-unit-linked business.

91 Financial Stability and Macroprudential Surveillance Department, Banque centrale du Luxembourg.
92 The non-bank financial sector includes insurance corporations, pension funds, investment funds and other financial institutions.
93 In this special feature, insurance corporations include life insurers, non-life insurers and reinsurers.

Nonetheless, similar to investment funds, insurance corporations have been impacted by the consequences of the COVID-19 outbreak. Recent asset price declines are expected to negatively impact insurers' solvency ratios, the low interest rate environment and the potential decline in investment income due to COVID-19 are likely to weigh on their profitability, and a potential reduction in cash inflows and an increase in outflows could lead to an increase in liquidity risk.

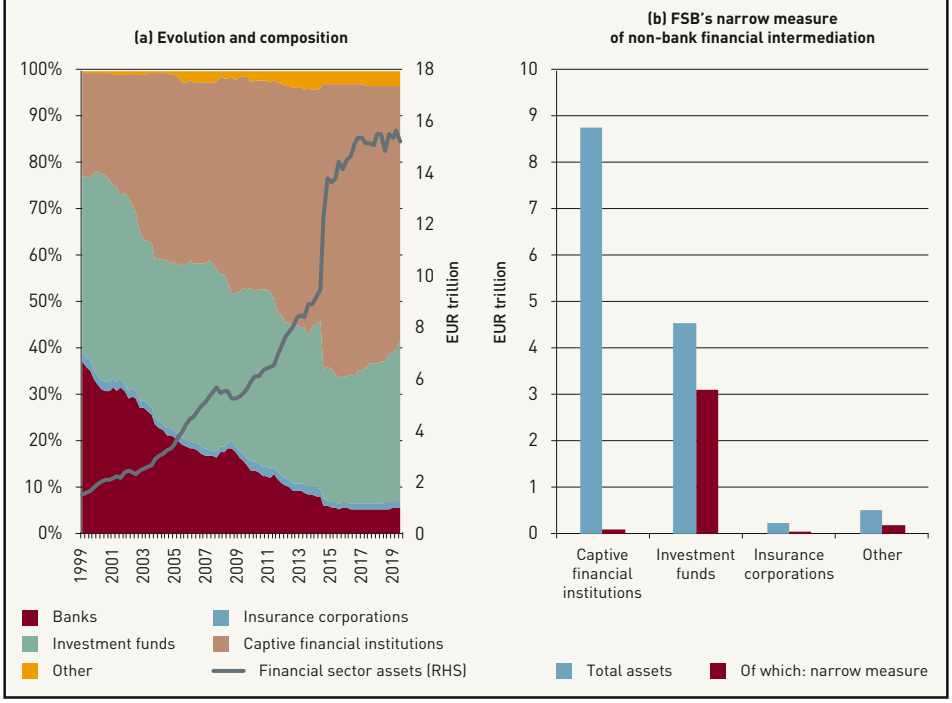
Regarding the potential for cross-sectoral spillovers between banks, insurance corporations and investment funds, two possible contagion channels were investigated, namely common securities holdings and holdings of investment fund shares/units. Insurance corporations appear more susceptible to contagion from the investment fund sector than banks via these two channels.

1. INTRODUCTION

The Luxembourg financial sector is characterised by the presence of a large number of non-bank financial institutions. Over the last two decades, the aggregate Luxembourg financial sector has grown to €15.3 trillion in total assets while the share of the banking sector has decreased from 37% to 5% (figure 1(a)). In terms of total assets, investment funds and captive financial institutions represent the largest share of the Luxembourg financial sector. At the European level, Luxembourg is the main hub for hosting non-bank financial institutions, followed by the UK, the Netherlands and Ireland (ESRB, 2019a).

In the persistent low interest rate environment, the expansion of the non-bank financial sector has been accompanied by signs of increased risk-taking at the European level (ECB, 2019b; ESRB, 2019a). In addition, non-bank financial institutions tend to be important investors in financial markets, with the latter having been severely affected by the financial volatility resulting from the COVID-19 pandemic. The heightened risk environment warrants ongoing monitoring efforts of the financial system beyond the banking sector.

Figure 1
Overview of the Luxembourg financial sector



Sources: BCL, FSB. Periods: March 1999-December 2019 (left panel), December 2018 (right panel). Notes: Investment funds include money market funds (MMFs) and non-MMF investment funds. "Other" consists mainly of the European Financial Stability Facility (EFSF) and securitisation vehicles, and further includes pension funds, financial auxiliaries and other financial intermediaries. Financial sector assets refers to total assets of all financial sector entities in Luxembourg. In the left panel, the jump in 2014Q4 is due to an improvement in the data coverage for captive financial institutions. In the right panel, the "narrow measure" refers to the FSB's narrow measure of non-bank financial intermediation and comprises entities involved in credit intermediation that may pose bank-like financial stability risks (FSB, 2020).

The FSB's narrow measure of non-bank financial intermediation, which includes entities involved in credit intermediation that may pose bank-like financial stability risks[94] (FSB, 2020), constitutes a starting point to determine for which entities monitoring efforts should be prioritised (figure 1(b)). The vast majority of entities falling under the FSB's narrow measure in Luxembourg consists of different types of investment funds (e.g. bond funds, mixed funds). Most of the captive financial institutions domiciled in Luxembourg are not part of the narrow measure as they mainly engage in intra-group financial transactions between entities of non-financial corporations, thereby not posing financial stability risks.[95]

For this reason, monitoring the Luxembourg non-bank financial sector focuses on the investment fund sector. In addition, as insurance corporations[96] provide important services to the non-financial and financial private sector, they are included in the monitoring exercise.

In the following assessment, both the investment fund sector and the insurance sector are assessed individually, and then their degree of interconnectedness is examined.

2. INVESTMENT FUNDS

Overview and recent developments

The investment fund sector in Luxembourg experienced important investor outflows following the outbreak of COVID-19. In February 2020, the sector continued to experience net inflows (+0.3% relative to the net asset value). However, with the spread of the virus in March and the implementation of the containment measures, the economic consequences started to become apparent. Investment funds recorded aggregate net outflows of -2.7% in March, amounting to the worst month since October 2008.[97]

The recorded outflows differed across types of funds, reflecting the riskiness and liquidity of the asset classes in which the funds invest, as well as the structure of the funds. The most impacted funds were low volatility net asset value (LVNAV) money market funds (MMFs) (-14.5% net outflows relative to the net asset value) (table 1). LVNAV MMFs invest mostly in short-term private sector debt securities and offer a constant share price to investors under certain conditions.[98] Outflows from LVNAV MMFs in March 2020 might have partly reflected increased need for liquidity by investors. Other factors that could have played a role were a flight-to-safety behaviour by investors towards public debt constant net asset value (CNAV) MMFs, which reported very high net inflows (+54.8%) in March, and the possible concern that LVNAV MMFs might be unable to continue offering a constant share price under the extremely stressed market conditions. In April, outflows from LVNAV MMFs reversed partly, following decisive central bank actions that lead to an easing of tensions in money markets.

94 Bank-like financial stability risks comprise credit intermediation activities that involve liquidity and maturity transformation, leverage and/or imperfect credit risk transfer (FSB, 2020).
95 Details can be found in Duclos, C., & Morhs, R. (2017). Analysis of the shadow banking content of captive financial companies in Luxembourg. Working document of the Comité du Risque Systémique.
96 In this special feature, insurance corporations include life insurers, non-life insurers and reinsurers.
97 In October 2008, the Luxembourg investment fund sector reported net outflows of -3.8% of its aggregate net asset value.
98 LVNAV MMFs may offer a constant net asset value (NAV) per unit/share if the constant NAV calculated in accordance with the amortised cost method does not deviate by more than 20 basis points from the NAV per unit/share calculated in accordance with the mark-to-market/mark-to-model method. For details, please see Regulation (EU) 2017/1131 of the European Parliament and of the Council of 14 June 2017 on money market funds.

Other types of funds that experienced strong outflows were high-yield corporate bond funds (-8.5%), emerging market bond funds (-7.1%) and investment grade corporate bond funds (-5.4%) (table 1). Outflows from these funds likely reflected rising credit risk due to the impact of the COVID-19 containment measures on the real economy, as well as potential liquidity concerns, especially for high-yield bond markets. Outflows from hedge funds (-4.5%) probably reflected an overall increase in risk aversion of investors, which can affect hedge funds due to their higher risk investment strategies.

Table 1:

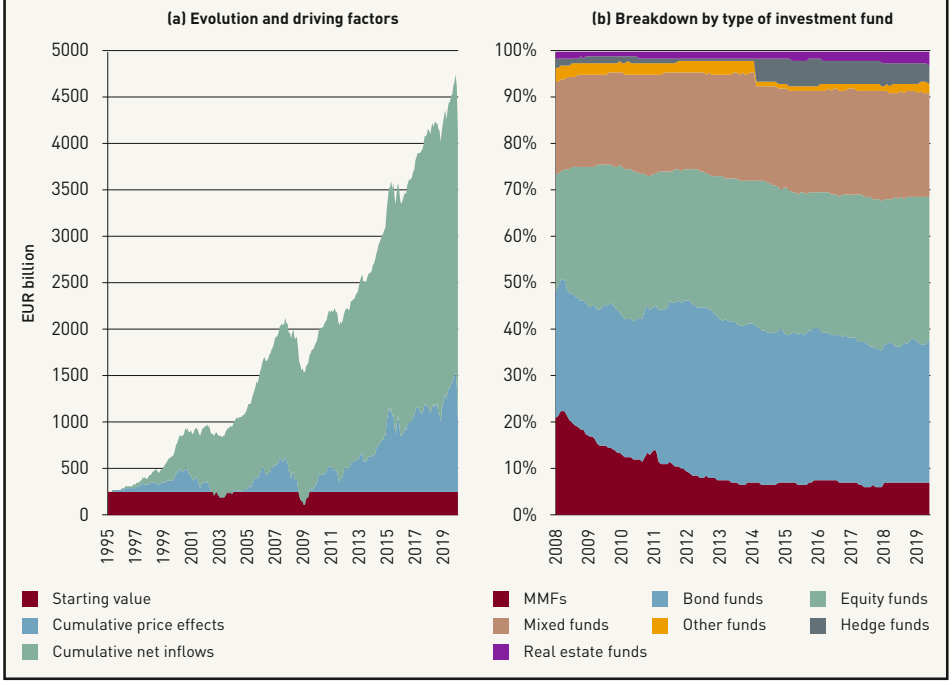
Net flows by type of investment fund

TYPE OF INVESTMENT FUND	NET FLOWS/NET ASSET VALUE (IN %)	
	FEBRUARY 2020	MARCH 2020
Equity funds	0,4%	-2,5%
Bond funds	1,1%	-4,7%
of which: government bond funds	0,9%	-1,1%
of which: investment grade corporate bond funds	1,0%	-5,4%
of which: high-yield corporate bond funds	0,3%	-8,5%
of which: emerging market bond funds	0,1%	-7,1%
Mixed funds	0,2%	-2,6%
Real estate funds	0,3%	0,3%
Hedge funds	-0,3%	-4,5%
Money market funds (MMFs)	-1,6%	4,3%
of which: public debt constant net asset value (CNAV) MMFs	0,8%	54,8%
of which: low volatility net asset value (LVNAV) MMFs	-4,6%	-14,5%
of which: short-term variable net asset value (VNAV) MMFs	2,9%	9,5%
of which: standard variable net asset value (VNAV) MMFs	1,5%	13,8%

Sources: CSSF, BCL calculations.

Over the longer term, the Luxembourg investment fund sector has increased in size by a factor of approximately seventeen between January 1995 and March 2020. This expansion occurred against the background of sustained net investor inflows, accounting for 80% of the sector's growth since 1995. Favourable price effects from financial market developments have accounted for the remaining 20%. Since the end of 2008, the price effects have become relatively more important for the growth of the sector's net asset value, although positive net investor inflows remain the main driver of growth (figure 2(a)). In March 2020, the net asset value contracted by -11.1%, mainly due to negative price effects (-8.4%). Figure 2(a) displays the Luxembourg investment fund sector's net asset value in 1995 (€242bn) (red area), the cumulative increase in the net asset value since 1995 due to price effects (blue area), and the cumulative increase in the net asset value since 1995 due to net inflows by investors (green area).

Figure 2
Net asset value of Luxembourg investment funds

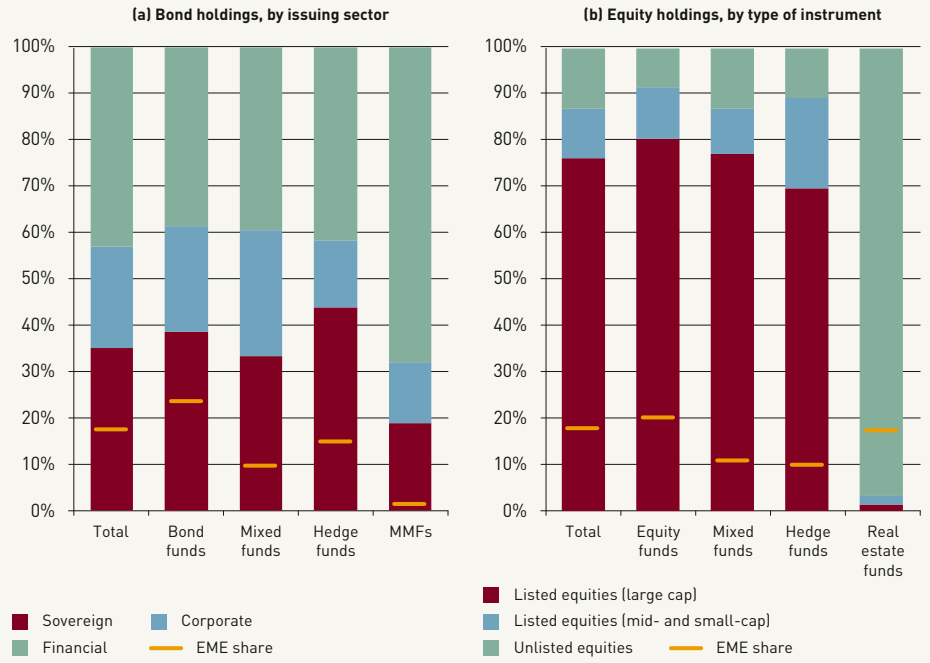


Sources: BCL, CSSF. Periods: January 1995-March 2020 (left panel), December 2008-February 2020 (right panel). Notes: The net asset value equals the aggregate value of the shares/units issued by investment funds. In the left panel, the starting value equals the net asset value of the sector in January 1995 (€242bn). Cumulative price effects equal the sum of the monthly fluctuations in the net asset value due to market movements. Cumulative net inflows equal the sum of monthly fluctuations in the net asset value due to the difference between investor purchases and redemptions of fund shares/units. In the right panel, the shares are affected by reclassifications of fund types over time, most notably in December 2014, where a significant part of mixed and "other" funds were reclassified into the hedge fund category.

The composition of the Luxembourg investment fund sector has changed over time. Figure 2(b) displays the evolution of the shares of the different types of investment funds in the aggregate net asset value. The relative decline of money market funds (MMFs) since end-2008 is particularly noticeable.[99] While some segments have declined, the share of equity funds in the net asset value of the Luxembourg investment fund sector increased from 25% in 2008 to 31% in February 2020, amid a decade of strong equity market performance, particularly in the US.

99 In absolute terms, the growth of the MMF sector has also remained subdued following the global financial crisis. The cumulative growth since end-2008 was 7% for MMFs, compared to triple digit cumulative growth rates for all other fund types.

Figure 3
Composition of bond and equity holdings of investment funds



Sources: BCL, FTSE, Bloomberg. Period: February 2020. Notes: In both panels, the emerging market economy (EME) share is calculated based on the FTSE market classification and the portfolio shares do not take into account exposures through investment fund shares/units. In the left panel, bonds to total assets vary between 88% for bond funds and 41% for hedge funds. Sovereign bonds include securities issued by the public sector. Corporate (Financial) bonds include securities issued by non-financial (financial) corporations. In the right panel, equities to total assets vary between 90% for equity funds and 24% for hedge funds. Listed equities that are part of major stock indices are classified as large capitalisation ("large-cap") stocks. Listed equities included in mid-cap or small-cap indices, as well as listed equities that are not part of a stock index, are considered as "mid- and small cap" stocks. Unlisted equities are not listed on a stock exchange.

Portfolio composition

The aggregate portfolio of Luxembourg investment funds is mainly composed of bond holdings (46%, €2.6 trillion), equities (31%, €1.7 trillion), and investment fund shares/units (11%, €0.6 trillion).[100] These portfolio shares have remained relatively stable since 2008.

The debt securities held by investment funds in Luxembourg consist mainly of bonds issued by financial corporations and the public sector (figure 3(a)). MMFs are particularly exposed to financial corporations as they mostly invest in debt securities issued by banks. The share of emerging market debt securities is highest for the most specialised fixed income investors, namely bond funds, and remains more limited for other fund types with important debt security portfolios.

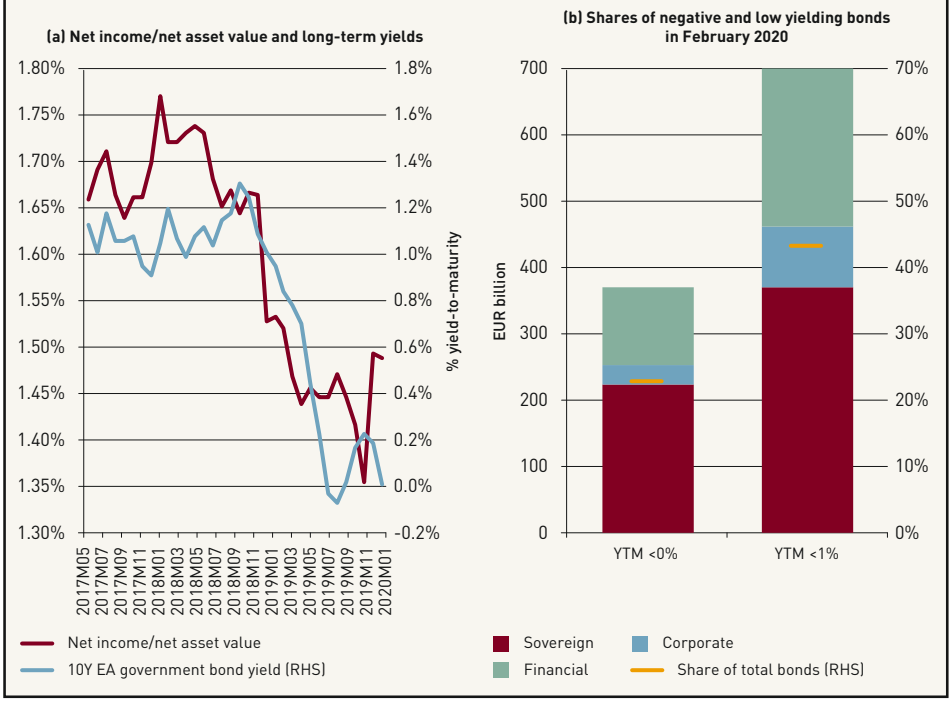
In terms of equity holdings, the vast majority of these securities consist of listed equities issued by companies with a large market capitalisation[101] (figure 3(b)). Such "large-cap" stocks are usually the most liquid and the least volatile type of equity investments. The equity portfolio of real estate funds is an exception, as it consists mainly of unlisted shares of companies holding real estate assets. As for debt securities, the share of emerging market equity holdings is highest for the most specialised fund type, in this case equity funds.

100 Hereafter, the focus lies on debt and equity securities. Holdings of investment fund shares are not directly analysed as (i) they inflate the presented numbers in the case where funds hold shares/units of other Luxembourg funds due to double counting and (ii) the data is unavailable to the BCL in the case of holdings of shares/units of foreign funds.
101 Listed equities that are part of major stock indices are classified as large capitalisation ("large-cap") stocks.

The environment of prolonged low interest rates significantly impacted the investment fund sector's aggregate portfolio. On one hand, by supporting valuations in asset markets[102], decreasing yields played a prominent role in supporting the long-term expansion of the investment fund sector in Luxembourg. On the other hand, since the end of 2018, the ratio of investment funds' net income to their net asset value[103] has declined amid a sharp decrease in yields (figure 4(a)).

In parallel, the share of bonds with a negative yield-to-maturity (YTM) in Luxembourg investment funds' bond portfolios equalled 23% in February 2020, up three percentage points since the end of 2019. The share of bonds with a YTM below one percent amounted to 43% in February 2020, representing also a 3 percentage point increase since end-2019 (figure 4(b)). Although falling yields increase the price of funds' current bond holdings, thereby generating positive valuation effects, persistently low yields should negatively impact the interest income received by funds as maturing bonds have to be replaced with new bonds paying lower coupon rates.

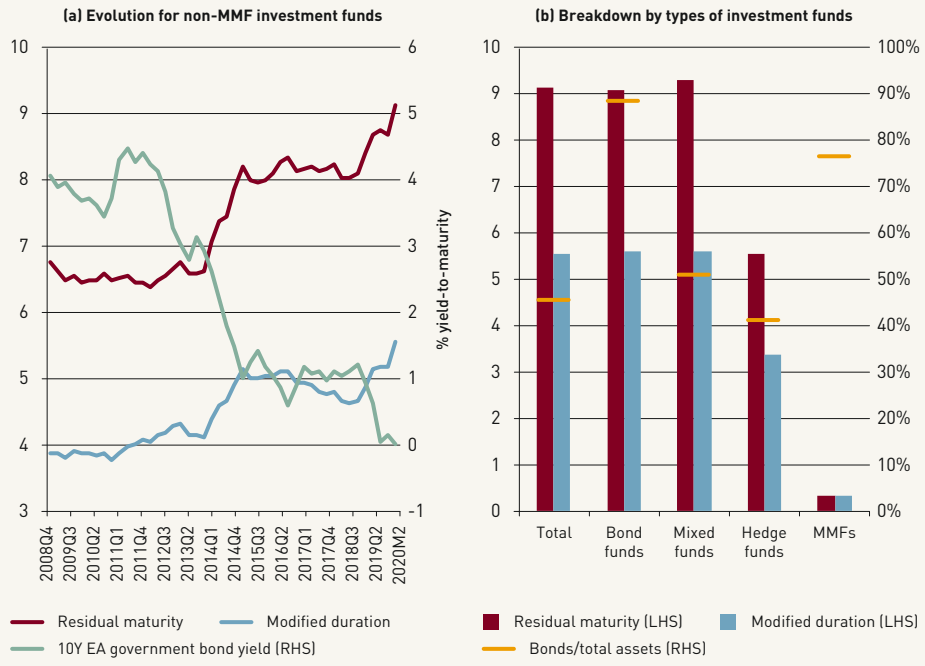
Figure 4
The impact of low interest rates on investment fund portfolios



Sources: BCL, CSSF, ECB. Periods: May 2017-February 2020 (left panel), February 2020 (right panel). Notes: In the left panel, net income is calculated over a rolling 12-month period and equals the sum of dividend, interest and other income minus the sum of charges, fees and other expenses. Net assets are averaged over 12 months. The net asset value of investment funds equals the market value of their issued shares/units. 10-year euro area government bond yield data are a monthly composite measure compiled by the ECB. In the right panel, YTM stand for yield-to-maturity. The right bar includes all bonds with a YTM below 1% and therefore also includes negative yielding bonds from the left bar. Sovereign bonds include securities issued by the public sector. Corporate (Financial) bonds include securities issued by non-financial (financial) corporations.

102 Decreasing yields play a supporting factor for asset prices as they increase the present value of future coupon payments from existing bonds and of dividend payments from shares.
103 This ratio displays the net income that is attributable to fund investors in relation to the price of a fund's shares/units.

Figure 5
Maturity transformation and interest rate risk in investment funds



Source: BCL. Periods: December 2008-February 2020 (left panel), February 2020 (right panel). Notes: Weighted average residual maturity and weighted average modified duration of debt securities held by Luxembourg investment funds. The residual maturity is an indicator for maturity transformation and the modified duration an indicator for interest rate risk. The figures in the left panel and the "Total" in the right panel exclude MMFs. The calculation considers all debt securities and caps the maturity at 100 years (for example for perpetual bonds). In both panels, the y-axis unit for the residual maturity is in years and the y-axis unit for the modified duration is the percentage change in bond prices following a one percentage point parallel shift of the yield curve. Exposures through investments in fund shares/units are not considered. In the left panel, 10-year euro area government bond yield data are a quarterly composite measure compiled by the ECB. In the right panel, differences with the table in section 2.1.1 of this Review arise because of differing time periods and securities samples.

Risk-taking

Against the background of globally decreasing yields, investment funds in Luxembourg have shifted their portfolios towards riskier assets. More specifically, they rebalanced their portfolios towards debt securities with longer maturities to increase the term premium earned on their bond holdings. The weighted average residual maturity of funds' bond holdings increased from 6.5 to 9.1 years since 2009 and has displayed a consistent negative relationship with euro area government bond yields since 2013 (figure 5(a)). Interestingly, Luxembourg investment funds continued to increase the residual maturity of their bond portfolios from 8.7 years in December 2019 to 9.1 years in February 2020, amid the spread of COVID-19.

As investment funds are mainly funded through short-term liabilities in the form of redeemable fund shares/units, this increase in residual maturity has translated into a more pronounced engagement in maturity transformation, thereby potentially increasing the risk of investor runs.[104] In parallel, the exposure towards interest rate risk, measured by the modified duration, has also increased. Similar developments are observable at the European level (ECB, 2019a; ESRB, 2019a; Deutsche Bundesbank, 2017).

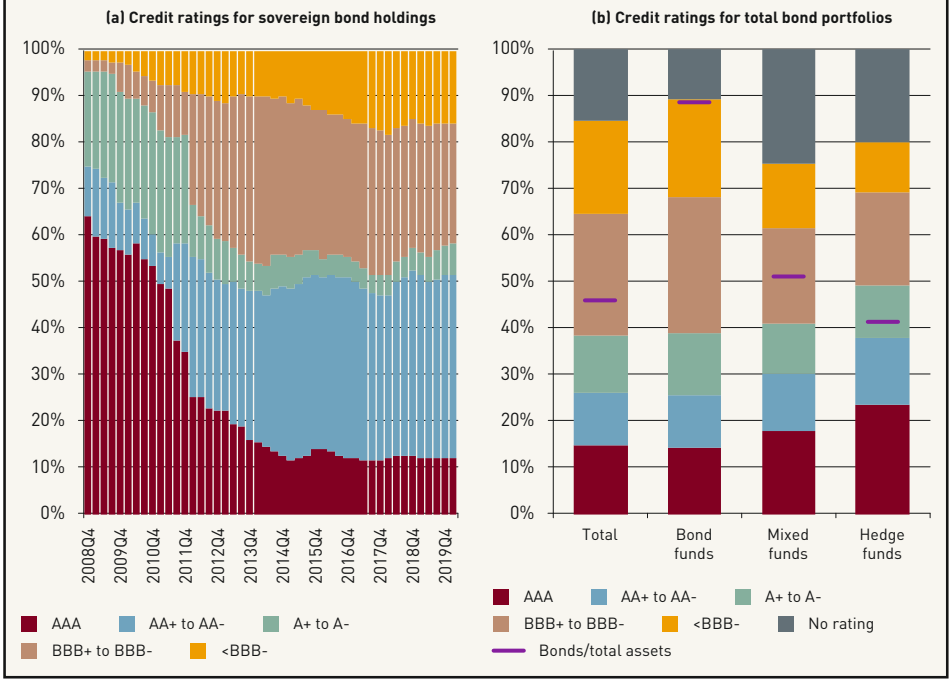
Concerning specific fund types, the residual maturity and modified duration are equally elevated for bond and mixed funds, while they are notably lower for hedge funds (figure 5(b)). As expected, the average residual maturity and average modified duration of MMFs' debt securities portfolios are very low, in line with regulatory requirements.

The overall increase in the residual maturity and the modified duration at the beginning of 2020 was observable for bond funds, mixed funds and hedge funds simultaneously. The increase in residual maturity was most pronounced for hedge funds (+0.6 years), while the increase in modified duration was strongest for mixed funds (+0.4).

104 According to the FSB (2013): "[...] in extreme circumstances, some collective investment vehicles that are involved in credit intermediation with maturity/liquidity transformation and/or leverage can be susceptible to runs."

In parallel, the overall credit quality of bond holdings has tended to deteriorate over time. This was partly due to credit rating downgrades, but also due to deliberate portfolio shifts towards lower rated securities. For example, the credit quality of sovereign bond holdings, which should typically exhibit the lowest level of credit risk in funds' portfolios, has deteriorated noticeably since 2008 (figure 6(a)).[105] At the same time, the share of sovereign bonds to total bond holdings has remained roughly stable at around one third.

Figure 6
Credit risk in investment funds



Sources: BCL, ECB Centralised Securities Database (CSDB), S&P. Periods: December 2008-February 2020 (left panel), February 2020 (right panel). Notes: The left panel includes only sovereign bonds and the right panel all bonds, including private sector bonds. In the right panel, the total excludes MMFs. Exposures through investments in fund shares/units are not considered.

Turning to the aggregate bond portfolio of Luxembourg investment funds, including private sector bonds, around 20% of the securities are high-yield bonds rated below BBB- (figure 6(b)).[106] It is worth noting that hedge funds appear to hold bonds with the lowest level of credit risk, mirroring the aforementioned lower interest rate risk of their bond portfolio. However, the riskiness of hedge funds' strategies is not adequately assessed by considering only their securities portfolios. Their derivatives positions as well as the accompanying leverage embedded in these positions also needs to be taken into account.

Between end-2019 and February 2020, amid the spread of COVID-19, the credit quality of investment funds' aggregate bond portfolio decreased slightly. The share of bonds rated A- or higher decreased by 1.2 percentage points, while the share of bonds rated BBB+ to BBB- increased by 1.3 percentage points.[107] The increase in the share of BBB+ to BBB- rated bonds was most pronounced for hedge funds (+2.8 percentage points). Bonds rated BBB+ to BBB- are particularly vulnerable to potential credit rating downgrades due to the negative financial effects of COVID-19 as they might lose their investment grade status.

The shift towards more risky assets in funds' portfolios has translated into a higher degree of liquidity transformation. Securities with lower credit ratings and/or longer maturities tend to display a lower level of market liquidity (Chen et al., 2007; EBA, 2013). In combination with the fact that most investment

105 The ratio of sovereign bond holdings rated BBB+ or lower increased from 4% in December 2008 to 42% in February 2020. Rating downgrades accounted for 75% of this increase and deliberate portfolio shifts towards lower rated securities for 25%.
106 The ratings distribution of Luxembourg investment funds' bond holdings is roughly in line with the distribution for the euro area investment funds reported by the ECB (2019b).
107 The shares of high-yield bonds (<BBB-) and of securities without a credit rating remained stable between end-2019 and February 2020.

fund shares can be redeemed at a high frequency, usually daily, the shift towards less liquid assets might therefore create a liquidity mismatch between the asset and the liability sides of investment funds' balance sheet.[108]

The liquidity transformation activity of investment funds is relevant from a financial stability perspective as it can lead to a first-mover advantage for investors, thereby increasing the probability of runs on investment funds (FSB, 2013). The risk of a run can mainly arise due to (i) higher asset liquidation costs and (ii) the danger of mispricing assets due to infrequent pricing information (Doyle et al., 2016). Elevated asset liquidation costs create a potential first-mover advantage for investors as adjustments costs, including potential price declines induced by the asset sales, are usually only reflected in the fund's net asset value (NAV) after redeeming investors have been repaid. Hence, the investors remaining in the fund bear the liquidation costs.[109] Similarly, most investment funds need to value their assets on a daily basis as they offer daily redemptions to investors. However, the assets held by funds might be traded at a lower frequency, thereby increasing the risk of a mispricing of assets by fund managers.[110] This difference between the value of a fund's assets and the pricing of the shares can also create a first-mover advantage, namely when the shares are overpriced (Doyle et al., 2016).

Empirical evidence extensively documents the negative relationship between holdings of liquid assets and the susceptibility to investor runs. For instance, Chen et al. (2010) provide evidence for equity funds, Goldstein et al. (2017) for corporate bond funds, and Schaub and Schmit (2013) as well as Agarwal et al. (2019) for hedge funds.

In practise, the share of liquid assets in funds' portfolios has tended to decrease over the last decade (figure 7(a)). The decline in liquid asset holdings was mainly driven by a gradual reduction in the share of demand deposits in funds' portfolios. The liquidity measure employed in figure 7(a) categorises exposures based on broad asset classes that are assumed to be either liquid or illiquid.[111]

For a more granular assessment, the most detailed framework for assessing individual securities' liquidity has been developed by the BCBS (2013) and Commission Delegated Regulation (EU) 2015/61 in the context of banks' liquidity coverage ratio. It defines the eligibility as "high-quality liquid assets" (HQLA) based on criteria such as the credit rating and the maturity of an asset and subject to certain haircuts. As this framework was designed for banks, which usually promise to repay pre-fixed amounts (e.g. deposits), it might be overly strict for investment funds, which are mainly equity financed and do not promise to repay a certain amount to investors. Nonetheless, as it is the only framework available, and since it has been widely used for investment funds[112], it is also employed in this context. Figure 7 (b) shows the ratio of HQLA to liquid liabilities of investment funds, a measure of investment funds' engagement in liquidity transformation.

108 Liquidity and maturity mismatches are typical features of a bank's balance sheet, where short-term liquid deposits fund long-term illiquid loans. Mismatches at the investment fund level are usually less pronounced, for instance because funds do not promise to repay a pre-fixed amount. Nonetheless, these mismatches at the fund level might also have a destabilising effect under stressed market conditions.

109 Anti-dilution measures, such as swing pricing, alleviate the risk of liquidation costs being passed on to remaining investors. For example, swing pricing adjusts a fund's net asset value to effectively pass on transaction costs stemming from in- and outflows of the fund to the investors associated with the activity and is widely available to asset managers. However, Lewrick and Schanz (2017) show that swing pricing might not have the expected stabilising effect during adverse market conditions.

110 The EBA (2013) finds that on average, EU corporate bonds only trade in one out of five trading days. For the US, Edwards et al. (2007) report that corporate bonds do not trade on around half of the trading days. In addition, Cici et al. (2012) find that corporate bond mutual funds that underperform tend to price their holdings above the Bloomberg mid-spread.

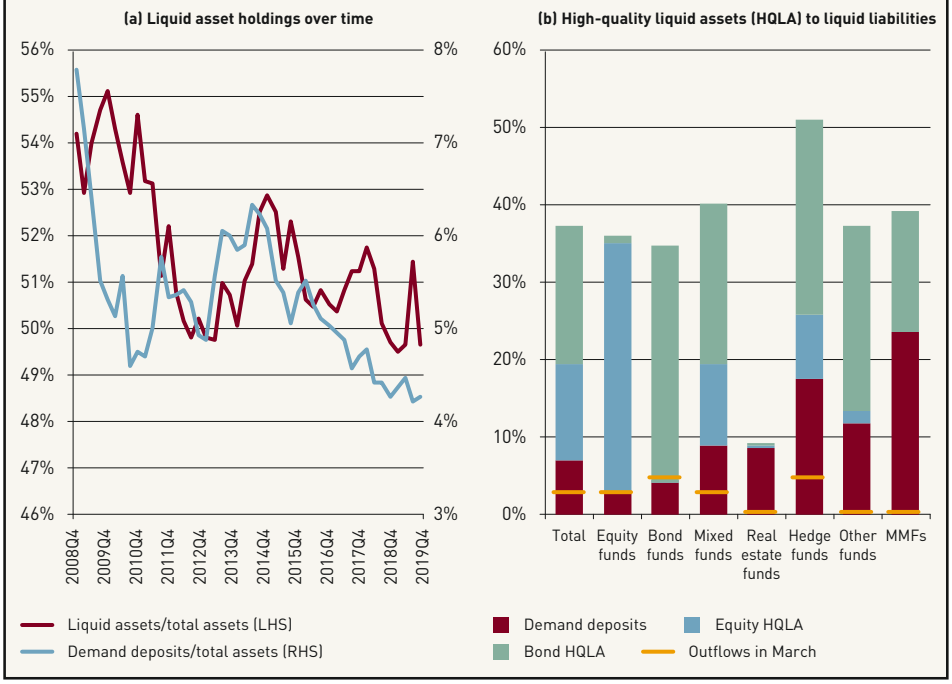
111 The ECB (2018), the ESRB (2019a), Doyle et al. (2016) and van der Veer et al. (2017) have adopted similar approaches to assess the liquidity of investment funds' portfolios.

112 Examples include the ESMA's 2019 Stress simulation for investment funds (ESMA, 2019), the 2017 IMF FSAP for Luxembourg (Bouveret, 2017), and the ECB (2019b).

As of February 2020, Luxembourg investment funds' aggregate HQLA holdings covered 37% of their liquid liabilities, which corresponds to 14 times the net outflows experienced by the sector following the COVID-19 shock in March (figure 7(b)). Thus, on aggregate, the sector appeared well placed to meet subsequent investor outflows.

In general, real estate funds display the most pronounced engagement in liquidity transformation as their HQLA holdings cover only 9% of their liquid liabilities. In line with the lower riskiness of their debt security portfolios, hedge funds report the highest amount of HQLA relative to their liquid liabilities (51%). These findings are generally in line with what is observed by the ESMA (2020) and the ESRB (2019a) at the EU level.[113]

Figure 7
Liquidity transformation and liquidity risk in investment funds

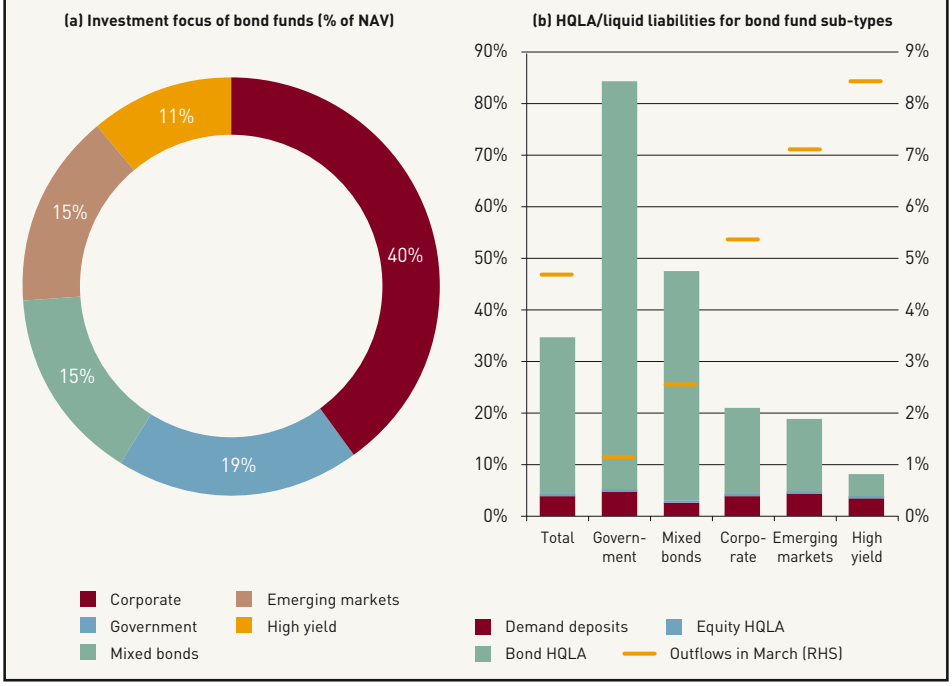


Sources: BCL, ECB Centralised Securities Database (CSDB). Period: December 2008-February 2020 (left panel), February 2020 for HQLA, March 2020 for net outflows (right panel). Notes: In the left panel, the ratios have been calculated for non-MMF investment funds. Liquid assets include demand deposits, MMF shares, investment grade sovereign bonds, other bonds with an original maturity below one year and listed equities. In the right panel, assets have been classified according to Commission Delegated Regulation (EU) 2015/61, which defines HQLA eligible assets for banks in the context of the Basel III liquidity coverage ratio. Haircuts from the Regulation (e.g. 50% for equity HQLA) have already been applied. Funds-of-funds are excluded. Liquid liabilities include shares/units issued by open-ended funds and debt liabilities with less than one year original maturity. Net outflows in March 2020 are shown as positive numbers. Real estate funds and MMFs are assigned zero net outflows as they experienced net inflows in March.

Interestingly, equity funds and MMFs, two types of funds generally perceived to invest in liquid instruments[114], display ratios of HQLA to liquid liabilities that are not significantly above the average for the total investment fund sector. For equity funds, this is because the HQLA approach applies much more severe haircuts to shares than to bonds. Meanwhile, MMF holdings include a large share of securities issued by financial institutions, which are mostly not eligible under the HQLA framework. In line with their exclusion from the HQLA perimeter, some of the securities issued by private sector entities and held especially by low volatility net asset value (LVNAV) MMFs displayed a lower level of market liquidity during March 2020, as the effects of the spread of COVID-19 on financial markets intensified.

113 The high level of demand deposits that is held by hedge funds can likely be explained by the fact that these funds maintain large liquidity buffers to meet potential margin calls on their derivatives positions (ESMA, 2020).
114 For instance, equity funds and MMFs display the lowest level of liquidity transformation on the ESRB's corresponding risk metric (ESRB, 2019a).

Figure 8
Special focus on liquidity risk in bond funds



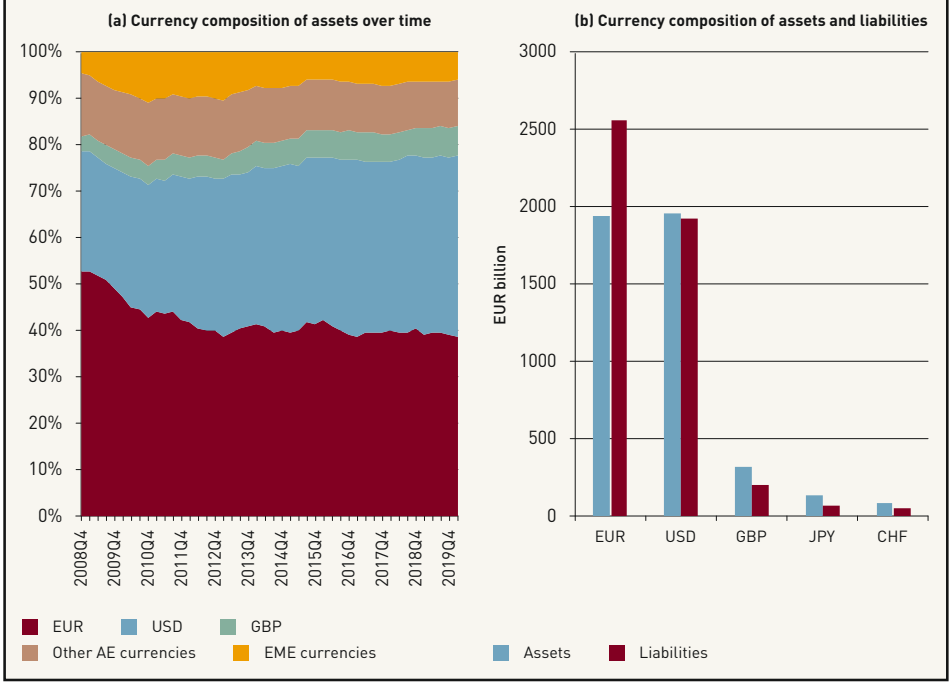
Source: BCL, ECB Centralised Securities Database (CSDB). Period: February 2020. Notes: In the left panel, "Corporate", "Government" and "Mixed bonds" include funds focusing on bonds issued by entities in advanced economies and with an investment grade rating. "Mixed bonds" includes funds investing in a mix of government and private sector bonds. In the right panel, assets have been classified according to Commission Delegated Regulation (EU) 2015/61, which defines HQLA eligible assets for banks in the context of the Basel III liquidity coverage ratio. Haircuts from the Regulation have already been applied. Funds-of-funds are excluded. Liquid liabilities include shares/units issued by open-ended funds and debt liabilities with less than one year original maturity. Net outflows in March 2020 are shown as positive numbers.

The liquidity position does not only vary between fund types, but also within fund types. This is especially true for bonds funds, where investment strategies vary from well-rated government bond to high-yield corporate bonds (figure 8(a)). High-yield bond funds appear particularly vulnerable as their HQLA holdings only covered 8.1% of their liquid liabilities in February 2020, which is slightly less than the outflows they experienced in March (-8.5%) (figure 8(b)).

For bond funds, there appears to be a negative relationship between the amount of HQLA held in February 2020 and subsequent investor outflows experienced in March due to the COVID-19 shock (figure 8(b)). This is in line with previous findings in the aforementioned literature (e.g. Goldstein et al., 2017) that funds that invest in less liquid assets are more vulnerable to investor runs due to the presence of a first-mover advantage.

Over the last decade, Luxembourg investment funds have also increased their exposure to currencies other than the euro (figure 9(a)). The share of total assets denominated in euros decreased from 53% in 2008 to 39% in February 2020, while the US dollar share rose from 26% to 39%. Since the outbreak of COVID-19, the share of USD-denominated assets continued to increase slightly, partly due to less pronounced asset price declines in the US than in Europe.

Figure 9
Currency risk and international diversification of investment funds



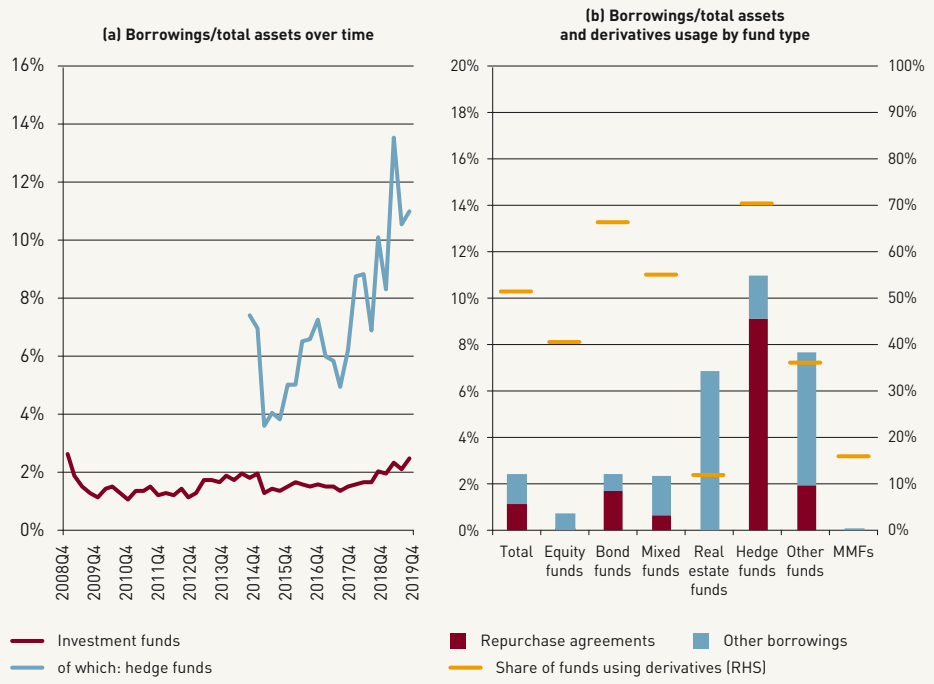
Sources: BCL, CSSF, FTSE. Periods: December 2008-February 2020 (left panel), February 2020 (right panel). Notes: AE = advanced economies, EME = emerging market economies. Currencies are assigned to AEs and EMEs according to the FTSE market classification of the underlying countries/regions. Shares are calculated for the total investment fund sector, including MMFs, and cover all types of assets, except for non-financial assets and derivatives (for which a currency breakdown is unavailable). In the right panel, liabilities include issued shares/units and exclude derivatives.

For equity and bond funds, and especially MMFs, USD-denominated assets surpass their holdings of EUR-denominated assets. As a consequence, a large share of Luxembourg MMFs' holdings of debt securities are not eligible for the ECB's Pandemic Emergency Purchase Programme (PEPP), despite the recent decision to broaden the scope of the ECB's Corporate Sector Purchase Programme (CSPP) to non-financial commercial paper.[115] Nonetheless, Luxembourg MMFs invested in EUR-denominated assets probably benefitted from the expansion of the CSPP to non-financial commercial paper, while MMFs invested in USD-denominated assets likely benefitted indirectly from improved liquidity conditions resulting from the Federal Reserve's Money Market Mutual Fund Liquidity Facility.

Although funds shifted their portfolios towards foreign currency denominated assets, their liabilities, which consist mostly of the shares/units they issued, remain largely denominated in euros (51%) (figure 9(b)). This shift towards foreign currency assets might expose investors in these funds to exchange rate risk. At the same time, it is an indication of the international diversification that Luxembourg funds provide to investors. They tend to have a more global investment focus and to display a lower home bias compared to peers in other larger European countries (ECB, 2020; FSB, 2020).

115 For details, please see the ECB Governing Council decisions from 18 March 2020.

Figure 10
Leverage in investment funds



Source: BCL. Periods: December 2008-February 2020 (left panel), February 2020 (right panel). Notes: Borrowings include overnight borrowings, borrowings with an agreed maturity, borrowings redeemable at notice, and repurchase agreements. In the left panel, investment funds include hedge funds. Separate leverage data for hedge funds is only shown starting in 2014Q4 as an important reclassification of funds during that quarter makes previous figures incomparable. In the right panel, the share of funds using derivatives is calculated as the number of funds that report at least one derivative position on the asset or liability side.

Balance sheet leverage employed by investment funds in Luxembourg remains very limited, even for hedge funds (figure 10(a)). For the entire sector, total borrowing amounts to 2% of the aggregate balance sheet and is well below UCITS leverage limits.[116] This is mainly because the sector is dominated by UCITS funds (81% in terms of NAV), with even hedge funds being primarily registered under the UCITS framework (68% in terms of NAV).[117] Hedge funds primarily use repurchase agreements, often with less than one year maturity, to build up financial leverage, whereas real estate funds mainly rely on more standard long-term loans (figure 10(b)).

Although balance sheet leverage remains very limited, even for the most active fund types, synthetic leverage that relies on derivatives might be more pronounced, especially for hedge funds as they are the most active derivatives users (figure 10(b)). The IOSCO (2020) reports a synthetic leverage figure, calculated as the absolute sum of all derivatives positions divided by the NAV, of 5.46 for a sample of hedge funds domiciled in Luxembourg.[118] However, the net synthetic leverage reported by the IOSCO (2020) for the same sample of Luxembourg hedge funds equals 0.15, thereby suggesting a lower level of synthetic leverage.[119] Similar to liquidity and maturity transformation, leverage can make investment funds more vulnerable to runs, as demonstrated by van der Veer et al. (2017).

116 Under the UCITS Directive, borrowings are limited to 10% of a fund's net asset value (NAV) and should be on a temporary basis.
117 For comparison, at the euro area level, 44% of hedge funds are UCITS funds in terms of NAV (ESMA, 2020)
118 The sample used by the IOSCO (2020) includes hedge funds domiciled in Luxembourg with a NAV of €135bn as of September 2018, compared to an aggregate NAV of €216bn from the hedge fund statistics of the BCL for the same period.
119 According to the IOSCO (2020): "Net Synthetic Leverage excludes IRS and FX positions. The calculation offsets positions in the same derivatives asset class before summing the absolute value of remaining positions. The final summation is divided by NAV."

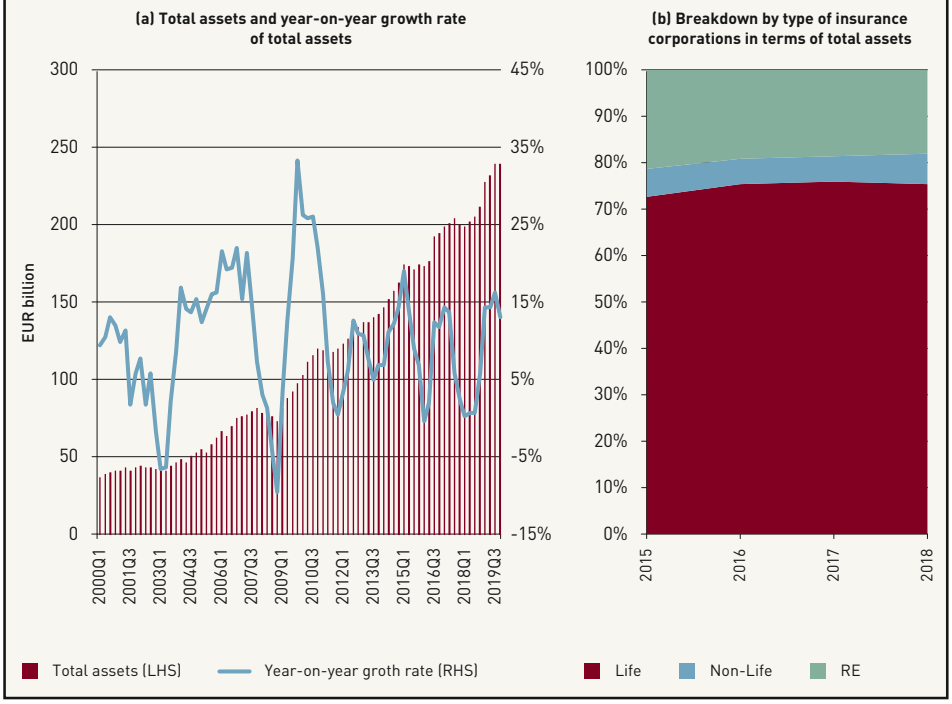
3. INSURANCE CORPORATIONS

Overview

Luxembourg is one of the countries with the highest number of insurance corporations[120] in the euro area (ECB, 2020). The sector has expanded rapidly over the last two decades as the aggregate balance sheet of Luxembourg insurance corporations increased by a factor of more than six (figure 11(a)). In terms of total assets, insurance corporations account for a stable share of 1.6% of the total Luxembourg financial sector (figure 1(a)).

While total assets expanded, the number of insurance corporations somewhat decreased over the past five years. More specifically, the number of reinsurance and life insurance corporations decreased, but the number of non-life insurance corporations increased, mostly due to Brexit.

Figure 11
Overview of the Luxembourg insurance sector



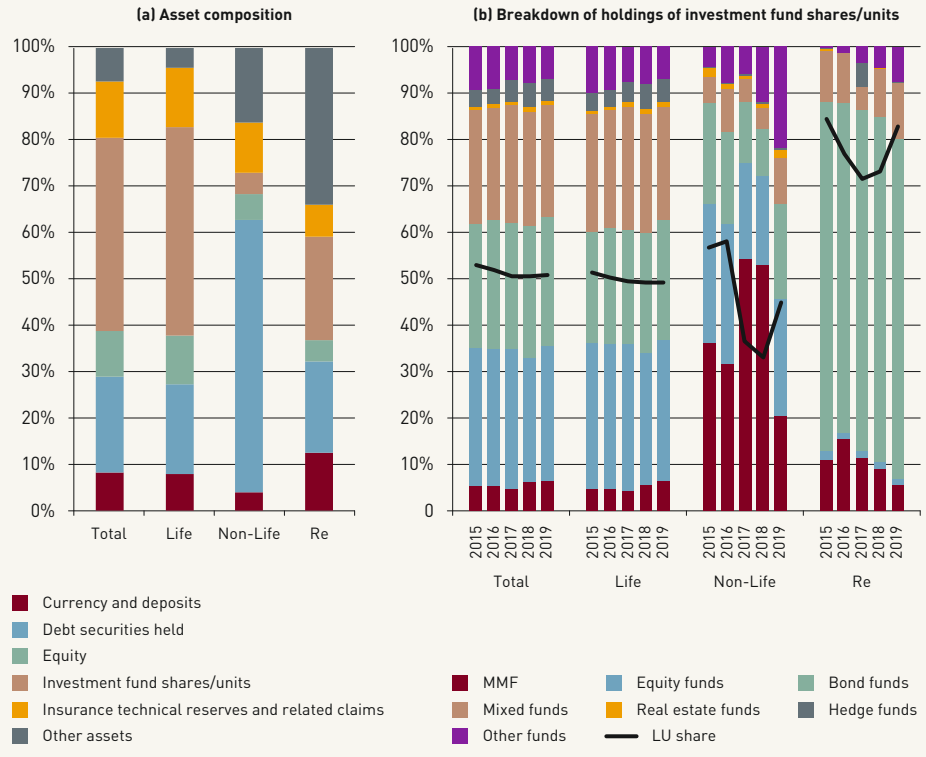
Sources: BCL, CAA. Periods: March 2000 – December 2019 (left panel), December 2015 – December 2018 (right panel). Notes: The Luxembourg insurance sector includes life, non-life and reinsurance corporations. In the right panel, "Life" refers to life insurance corporations, "Non-Life" to non-life insurance corporations and "Re" to reinsurance corporations.

Currently, in terms of the number of insurance corporations in Luxembourg, 71% are reinsurance corporations, 16% are non-life insurance corporations and 13% are life insurance corporations.[121] However, in terms of total assets, life insurance corporations largely dominate the sector (figure 11(b)).

In the life insurance sub-sector, one can further distinguish between unit-linked[122] and non-unit-linked[123] business. The total share of unit-linked business in life gross written premiums (GWP) has slightly declined from 65.5% in 2018Q4 to 60.6% in 2019Q4.[124] Overall, the majority of life insurance contracts in Luxembourg are unit-linked. However, it is noteworthy that while non-resident clients mainly hold unit-linked policies, resident clients are mainly non-unit-linked policyholders.

120 In this special feature, insurance corporations include life insurers, non-life insurers and reinsurers. Pension funds that fall under the regulation of the Commissariat aux Assurances (CAA) are not included in our analysis.
121 Information was obtained from the Commissariat aux Assurances (CAA) website (accessed 27/04/2020).
122 In a unit-linked life insurance contract, the policyholder's future claims depend on the performance of a pool of assets in which the policyholder's funds are invested. In this type of contract, the investment risk is borne by the policyholder. Any gain or loss from fluctuations in the fair values of the investment pool is channeled from the insurer to the policyholder (appropriate change in the technical reserves).
123 In a non-unit-linked life insurance contract, the policyholder's future claims do not depend on the performance of any defined pool of assets. In this type of contract, the investment risk is borne by the insurer. The insurer guarantees in this case a return to the policyholder. The policyholder's claims against the insurer do not change due to asset valuation changes; the insurer's own funds are instead affected.
124 Data on gross written premiums is available via quarterly published information notes by the Commissariat aux Assurances (CAA).

Figure 12
Asset allocation and composition of investment fund shares



Source: BCL. Periods: December 2019 (left panel), December 2015 – December 2019 (right panel). Notes: In the left panel, Other assets include loans, non-financial assets, financial derivatives, and other assets. In the right panel, "LU share" refers to the share of the portfolio of investment fund shares/units issued by funds domiciled in Luxembourg.

Portfolio Composition[125]

The aggregate balance sheet of Luxembourg insurance corporations is dominated by securities. Investment fund shares/units account for 42%, bonds for 21% and equities for 10% (figure 12(a)). The aggregate portfolio resembles the portfolio allocation of life insurance corporations, given the dominance of this subsector in terms of total assets. For both non-life and reinsurers, the asset portfolio allocation significantly differs. Bonds constitute the most important investment instrument for non-life insurers (59%), while reinsurers invest 22% in investment fund shares/units, 20% in bonds and 4% in equities.

Life insurance corporations hold 45% of their assets in investment fund shares/units, of which the majority is held for unit-linked contracts. Most of these fund shares/units are held in equity funds (30%), bond funds (26%) and mixed funds (24%). These shares have remained stable over the past five years (figure 12(b)). Around half of life insurers' investment fund shares/units are issued by Luxembourg investment funds. For non-life insurers, which allocate only 4% of their assets in investment fund shares/units, the composition has been very volatile over the past 5 years (figure 12(b)). Finally, reinsurers invest primarily in bond funds and more than 70% are Luxembourg investment funds.

Debt securities held by insurance corporations in Luxembourg consist mainly of bonds issued by financial corporations (figure 13(a)), which account for an even larger share than that observed in investment funds' bond portfolios. Meanwhile, the share of sovereign bonds is lower, as is the share of bonds issued by counterparties from emerging markets.

Between end-2019 and February 2020, the composition of debt securities held by life insurers and non-life insurers in Luxembourg remained unchanged, whereas for reinsurers, which hold 20% of their total assets in debt securities, the share of bonds issued by non-financial corporations significantly decreased by 3.9 percentage points.

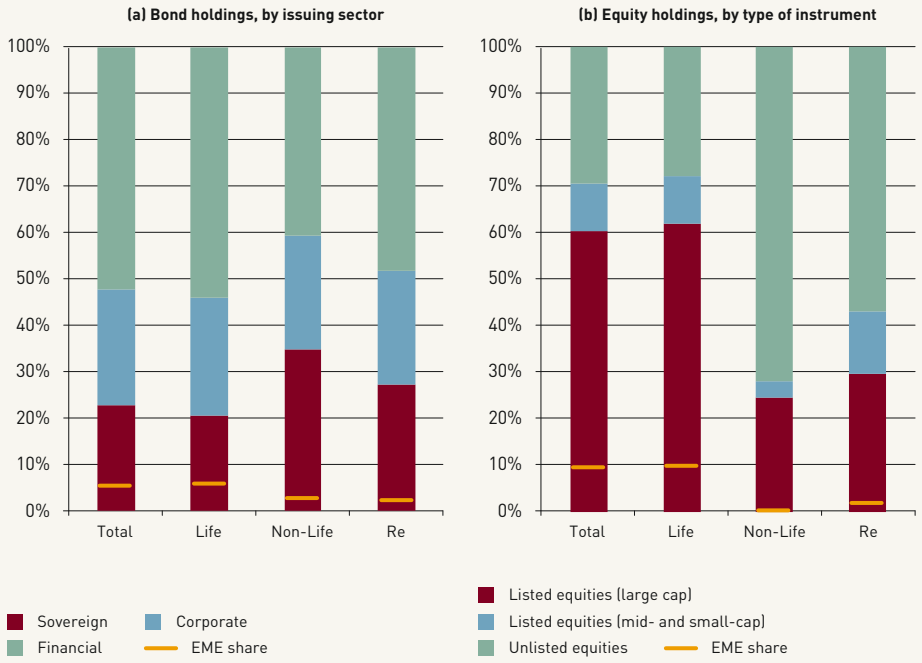
125 Exemption thresholds apply for the statistical data collection for insurance corporations by the BCL, such that around 75% of the insurance sector's total assets are covered. The data coverage for the different sub-sectors, life, non-life and re-insurance corresponds to 90%, 40% and 40% of the assets in each respective sub-sector. For further details on the BCL statistical data collection for insurance corporations, please refer to the circular BCL/2015/239.

Insurance corporations' equity portfolio consists mostly of listed equities issued by companies with a large market capitalisation[126] (figure 13(b)). However, compared to investment funds, a much larger part of the equity portfolio consists of unlisted shares, which tend to be less liquid. This is especially true for non-life insurers and reinsurers (figure 13(b)), although both types of insurance corporations hold less than 6% of their total assets in equities.[127] At the same time, the share of emerging market securities in the equity portfolios of Luxembourg insurers is lower than for investment funds.

In February 2020, 34% of the aggregate insurance sector's bond holdings had a negative yield to maturity (YTM), which is higher than the share in investment funds' portfolios (23%). However, the share of bonds with a YTM below one percent amounted to 67%, well above the 43% observed for funds (figure 14). The holdings of negative-yielding bonds have significantly increased since the end of 2019, where they amounted to 25% of insurance corporations' bond portfolio. The aforementioned bonds consist not only of highly rated government bonds, but also of debt securities issued by financial corporations, mostly banks.

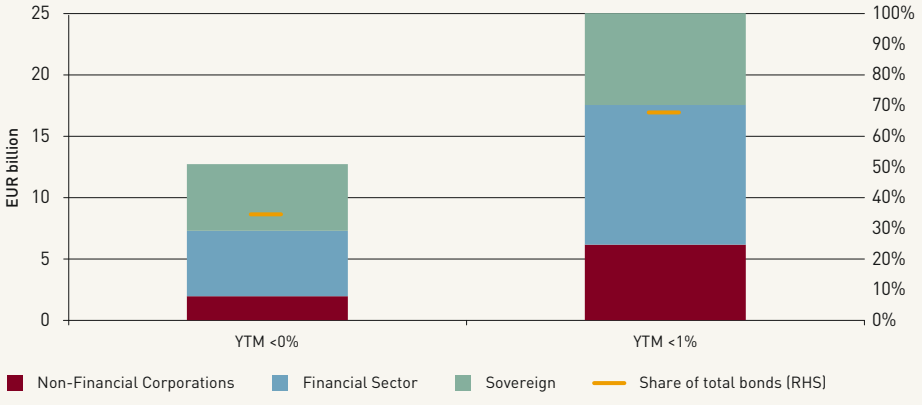
As for investment funds, bonds traded at negative rates can potentially

Figure 13
Composition of bond and equity holdings of insurance corporations



Sources: BCL, FTSE. Period: February 2020 (left and right panel). Notes: In both panels, the emerging market economy (EME) share is calculated based on the FTSE market classification and the portfolio shares do not take into account exposures through investment fund shares/units. In the left panel, sovereign bonds include securities issued by the public sector. Corporate (Financial) bonds include securities issued by non-financial (financial) corporations. In the right panel, listed equities that are part of major stock indices are classified as large capitalisation ("large-cap") stocks. Listed equities included in mid-cap or small-cap indices, as well as listed equities that are not part of a stock index, are considered as "mid- and small cap" stocks. Unlisted equities are not listed on a stock exchange.

Figure 14
Shares of negative and low yielding bonds in February 2020



Source: BCL. Period: February 2020. Notes: YTM stand for yield-to-maturity. The left bar includes all bonds with a YTM below 0% and the right bar includes all bonds with a YTM below 1% and therefore also includes negative yielding bonds from the left bar. The bars give information on which economic sector issued those bonds. Sovereign bonds include securities issued by the public sector.

126 Listed equities that are part of major stock indices are classified as large capitalisation ("large-cap") stocks.
127 At the EU level, a slight shift towards unlisted equity could be observed (EIOPA, 2020). However, a similar asset reallocation cannot be observed for the Luxembourg insurance sector.

decrease investment income of insurance corporations in the medium term and incentivise increased risk-taking.

The sustained low interest rate environment puts particular pressure on non-unit-linked life insurance business, as it becomes increasingly difficult to generate investment returns in excess of guaranteed returns promised to policyholders in the past. According to estimates by EIOPA, the median spread of investment return over guaranteed interest rate for life insurers is equal to -0.1% (-0.9% the 25th and 0.9% the 75th percentile) in Luxembourg.[128] Non-unit-linked life insurance contracts make up 27% of life insurers' technical provisions, with significant differences between resident and non-resident policyholders.[129] The share of non-unit-linked technical provisions equals 58% for residents and 25% for non-residents.

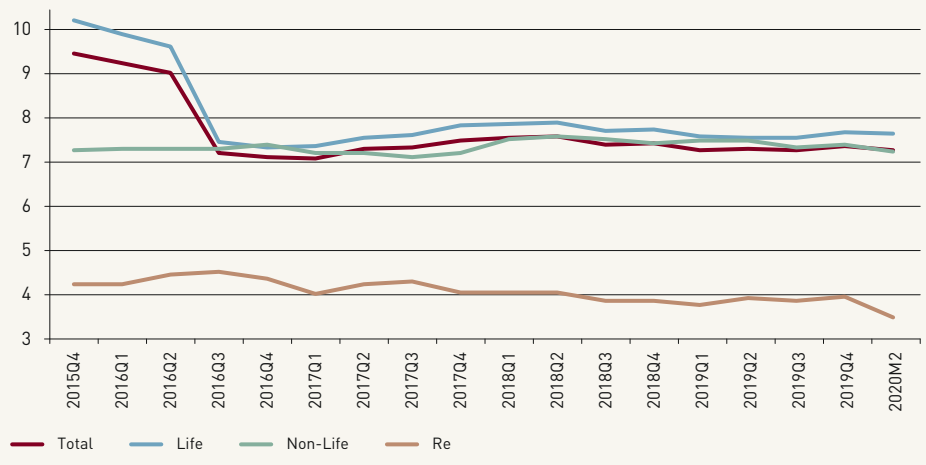
Risk taking

Similar to investment funds, insurance corporations might engage in increased risk-taking to increase profits in a low interest rate environment.

After a sharp decline in 2016, the residual maturity of debt securities held by insurers stabilised between 7 and 8 years thereafter (figure 15). This is somewhat below the euro area average for insurance corporations (ECB, 2019a).

Hence, over the past years, insurance corporations did not shift their bond portfolio towards securities with longer maturities. However, in general, an increase in the residual maturity would be less of a concern for insurers as the maturity of their liabilities often exceeds the maturity of their assets, thereby generating a negative duration gap (ECB, 2017). Therefore, an increase in the residual maturity may reduce duration risk on insurers' balance sheets.

Figure 15
Residual maturity for insurance corporations' bond holdings



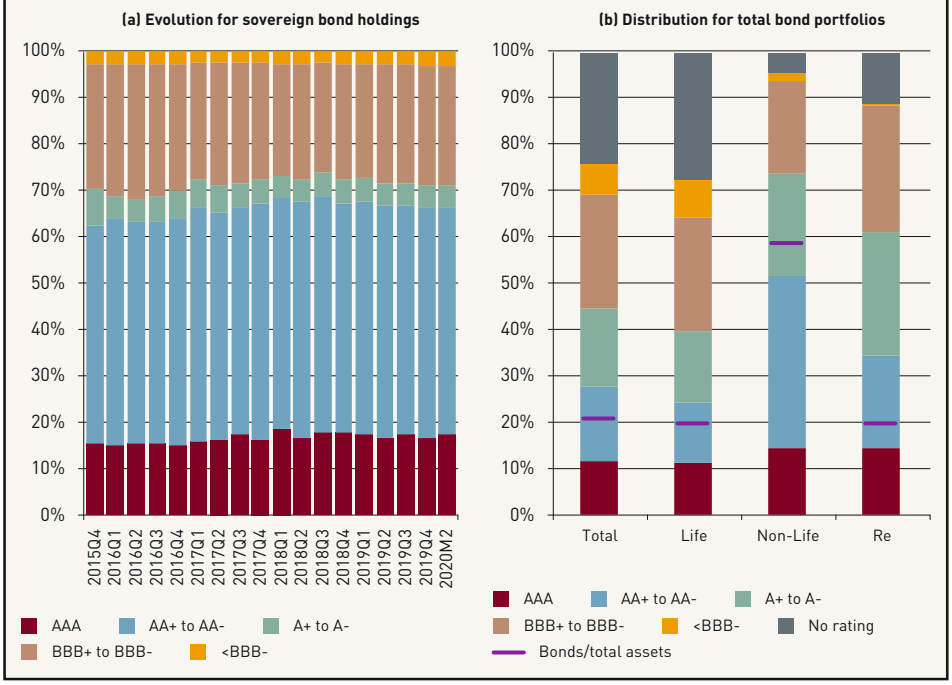
Source: BCL. Periods: December 2015 - February 2020. Notes: Weighted average residual maturity of debt securities held by Luxembourg insurance corporations. The calculation considers all debt securities and caps the maturity at 100 years (for example for perpetual bonds). The y-axis unit for the residual maturity is in years. Exposures to debt securities through investments in fund shares/units are not considered.

128 See EIOPA (2019). The estimates are based on Solvency II reporting.
129 Resident policyholders account for 7% of life insurance technical provisions.

Between end-2019 and February 2020, on aggregate, insurance corporations in Luxembourg only slightly decreased the residual maturity of their bond portfolios. A more significant decrease in residual maturity from 4 years to 3.5 years was observed for reinsurance corporations.

Turning to credit risk, the share of high-yield bonds in Luxembourg insurance corporations' aggregate debt security portfolio is relatively low. The same can be observed at the euro area level (ECB, 2019a). Credit ratings of insurance corporations' sovereign bond holdings have remained stable and include only a negligible amount of securities rated below BBB- (figure 16(a)). Looking at the credit ratings of the entire bond portfolio, life insurance corporations hold the highest share of high-yield bonds (close to 8%) and of unrated securities (27%) (figure 16(b)). For non-life insurance corporations, more than 90% of their bond holdings have an investment grade rating.

Figure 16
Credit risk in insurance corporations



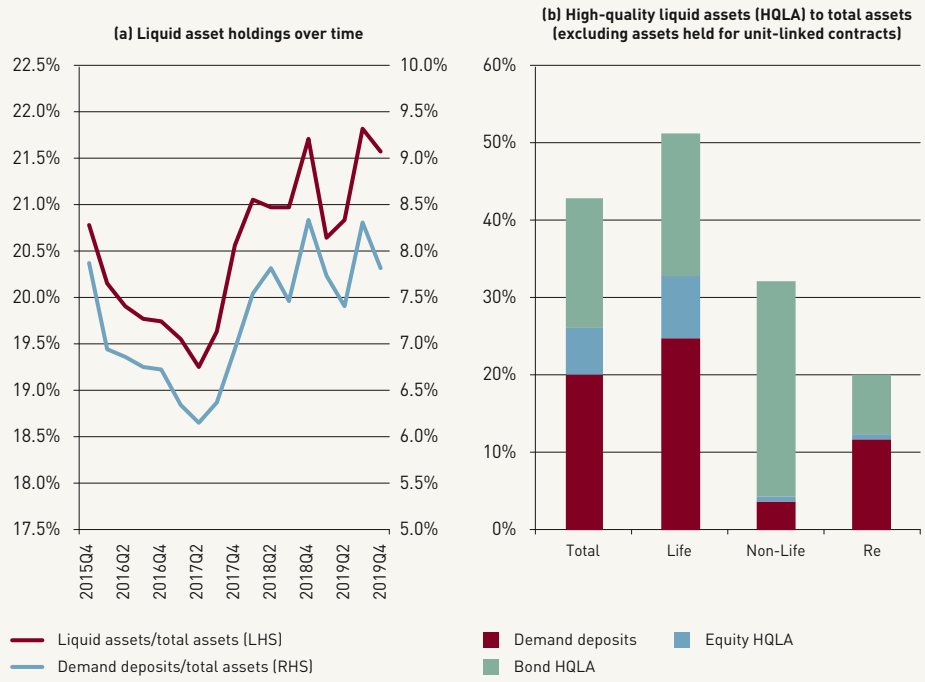
Sources: BCL, ECB Centralised Securities Database (CSDB), S&P. Periods: December 2015 – February 2020 (left panel), February 2020 and December 2019 for bonds/total assets (right panel). Notes: The left panel includes only sovereign bonds and the right panel all bonds, including private sector bonds. Exposures through investments in fund shares/units are not considered.

Luxembourg insurance corporations' holdings of liquid assets improved over the past five years (figure 17(a)), accounting for 21.6% of insurers' aggregate portfolio as of the end of 2019. Demand deposits are the biggest component of liquid assets in insurers' portfolios and account for approximately 8% of their total assets. The rising share of liquid asset holdings suggests that insurance corporations did not increase their exposure to liquidity risk.

Liquidity risk for insurance corporations can for instance arise in the context of a sharp increase in interest rates that triggers a potential rise in the lapse rate[130] (EIOPA, 2019; Feodoria and Foerstemann, 2015). Indeed, with a potential sudden reversal of risk premia and rising yields, life insurance policyholders could have an incentive to terminate their insurance policies (i.e. to redeem their funds) and look for more attractive alternative investments that promise higher returns. In view of the financial shock resulting from the COVID-19 pandemic, the sharp deterioration of the macroeconomic outlook could also trigger capital outflows and lower cash inflows, thereby affect insurers' liquidity positions. Life insurance policyholders generally have the option to terminate their life insurance policy and to receive a cash surrender value, which corresponds to a potentially large pay-out, forcing insurers to liquidate securities. Thus, a

130 The lapse rate (policy surrender) corresponds to the number of life insurance policyholders who voluntarily discontinue their life insurance policies prior to maturity or death.

Figure 17
Liquidity risk in insurance corporations



*Sources: BCL, ECB Centralised Securities Database (CSDB). Periods: December 2015-December 2019 (left panel), December 2019 (right panel). Notes: Liquid assets include demand deposits, MMF shares, investment grade sovereign bonds, other bonds with an original maturity below one year and listed equities. In the right panel, assets have been classified according to Commission Delegated Regulation (EU) 2015/61, which defines HQLA eligible assets for banks in the context of the Basel III liquidity coverage ratio. Applicable haircuts from the Regulation (e.g. 50% for equity HQLA) have already been applied. Funds-of-funds are excluded. The HQLA ratio shows the proportion of HQLA on total assets (excluding assets held for unit-linked). This definition is in line with EIOPA (2019), (sum of liquid asset(category)*weight) / (total assets - assets held for unit linked contracts), where the different weights reflect the liquidity profile of the different assets.*

significant increase in the lapse rate can directly impact life insurers' liquidity needs and can even expose life insurers to run-like situations (i.e. mass lapses) (ESRB, 2018).[131] In this context, contractual and fiscal implications for policyholders can play a mitigating effect for liquidity risk as they render policy terminations less attractive (ESRB, 2020).

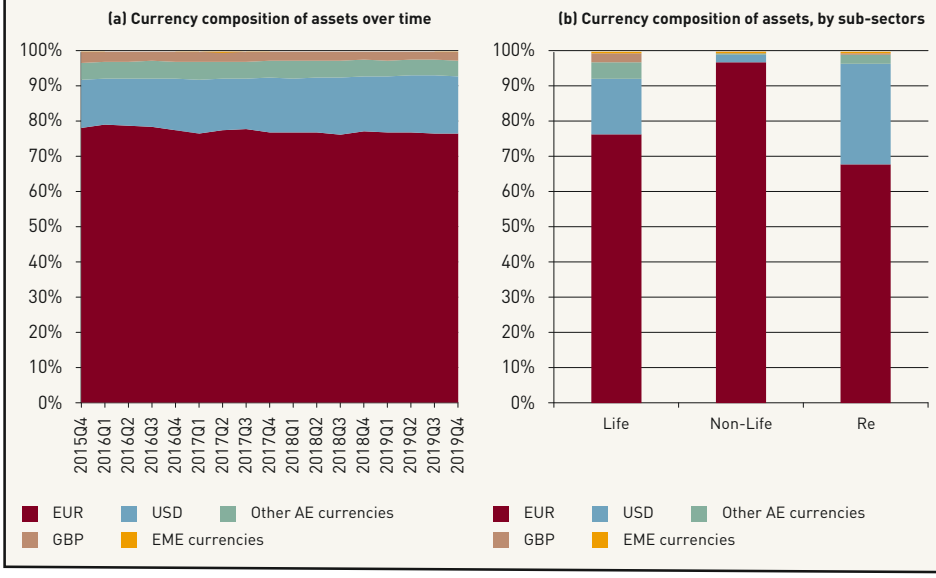
As a measure for liquidity risk, figure 17(b) provides the ratio of high-quality liquid assets (HQLA) to total assets (excluding assets held for unit-linked contracts)[132]. The same approach to assess liquidity risk is used by the ESRB (2019b) and by the EIOPA (2019). In December 2019, 52% of non-unit linked assets held by life insurers consisted of HQLA, which could significantly mitigate liquidity risk.[133] The corresponding ratio is lower for non-life and for reinsurance corporations. However, they might also be less exposed to this type of risk.

Between December 2019 and February 2020, the share of HQLA in total securities held by insurers remained unchanged, suggesting that their liquidity position remained stable at the onset of the market turmoil that intensified in March. 35% of insurers' listed equity holdings consisted of HQLA and 32% of insurers' bond holdings.

131 In a hypothetical scenario, where interest rates rise, policyholders have an incentive to terminate their insurance policies and to look for more attractive alternative investments (due to a slow interest rate pass-through).
132 We use unit-linked technical provisions as a proxy to measure the amount of assets held for unit-linked contracts. Assets held for unit-linked contracts are excluded from the denominator, as they do not expose insurance corporations to liquidity risk.
133 To put this into perspective, Kubitza et al. (2019) estimate that for Germany an interest rate rise of 4.5 percentage points over two years would require the liquidation of 12% of life insurers' assets due to policy terminations.

Similar to insurance corporations at the euro area level (ECB, 2019b), Luxembourg insurers hold the majority of their assets in euro denominated assets. As depicted in figure 18(a), more than 75% of the aggregate asset holdings are EUR-denominated. Over the past 5 years, the share of securities denominated in US-dollars has slightly increased from 14% to 17% of the aggregate asset holdings. Compared to the investment fund sector, the degree of international portfolio diversification, as measured by the share of non-euro denominated assets, appears lower, thereby making insurance corporations potentially more vulnerable to local shocks. However, life-insurance corporations, in particular, may indirectly increase their exposure to foreign currencies via investment fund shares/units.

Figure 18
Currency composition



Sources: BCL, FTSE. Periods: December 2015 - December 2019 (left panel), December 2019 (right panel). Notes: AE = advanced economies, EME = emerging market economies. Currencies are assigned to AEs and EMEs according to the FTSE market classification of the underlying countries/regions. The left panel covers all types of assets, except for non-financial assets, financial derivatives and other assets (for which a currency breakdown is unavailable).

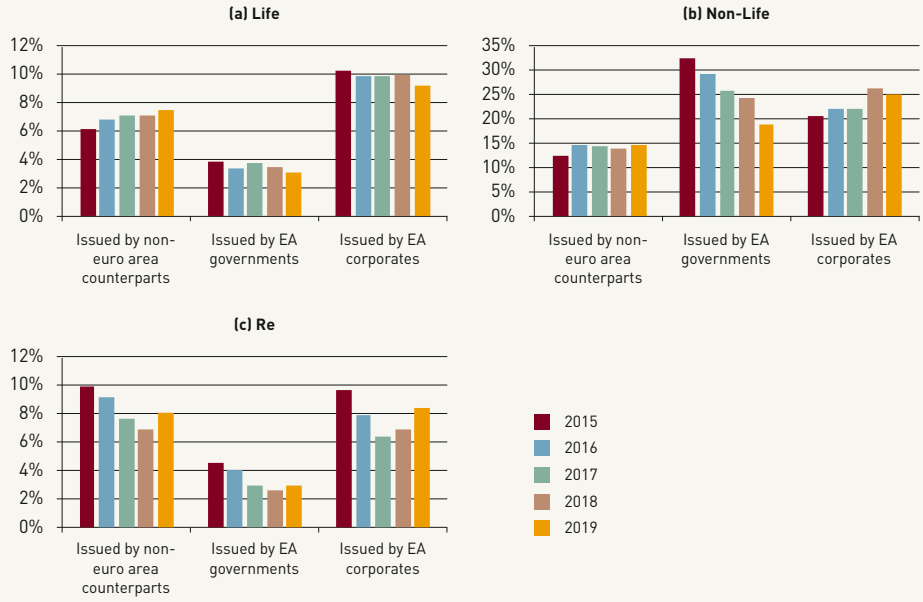
Although there are no clear signs of increased risk-taking by insurance corporations in Luxembourg in recent years, a certain degree of portfolio rebalancing in their bond holdings is noticeable.

Life insurers have started to shift their bond portfolios towards securities issued by counterparties outside the euro area, potentially in search of higher yields (figure 19(a)).

At the same time, non-life insurers, which are heavily invested in fixed income assets (59% of their total assets), have shifted from euro area sovereign to corporate bonds.

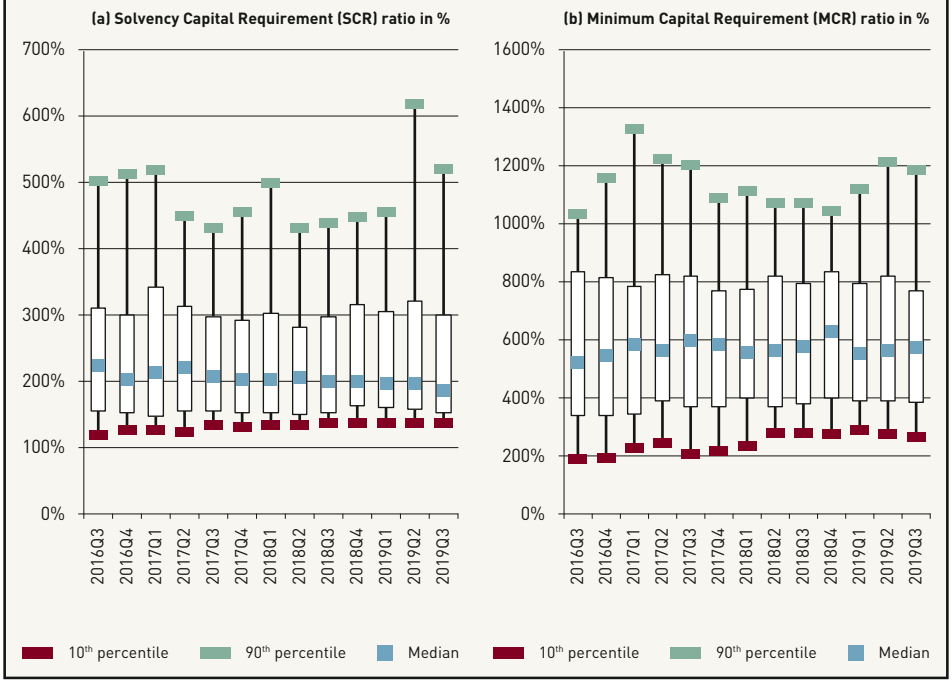
Reinsurance corporations decreased their overall bond holdings from 24% of total assets in 2015 to 20% in 2019, which explains the decrease in all three bond categories in figure 19(c).

Figure 19
Breakdown of bond holdings by counterparty



Source: BCL. Periods: December 2015 - December 2019 (all panels). Notes: The breakdown of bond holdings is in % of total assets. "EA" refers to euro area. Bonds issued by EA governments include securities issued by the public sector. Bonds issued by EA corporates include securities issued by non-financial and financial corporations.

Figure 20
Own funds (Solvency II)



Source: EIOPA (Solvency II template S.23.01). Periods: March 2016 - September 2019 (both panels). Notes: The SCR (MCR) ratio is the total eligible own funds to meet SCR (MCR) divided by the SCR (MCR). Reported are the median, the interquartile range and the 10th and 90th percentile.

Apart from the decrease in euro area government bond holdings displayed in figures 19(a)-(c), it is worth noting that the majority of these holdings were issued by higher-rated euro area governments.[134] For instance, only 12.5% of non-life insurers' euro area government bond holdings were issued by lower-rated euro area governments.

Going forward, the announced fiscal policy measures to counteract the effects of COVID-19 might lead to public debt sustainability concerns, thereby potentially triggering stress in sovereign debt markets, especially for lower-rated euro area government bonds.

Under the Solvency II regime, insurance corporations are required to comply with the Solvency Capital Requirement (SCR) and the Minimum Capital Requirement (MCR). Both requirements depend on the risk to which insurance corporations are exposed.[135]

Insurance corporations' solvency position slightly deteriorated over the past quarters (figure 20). The median SCR ratio decreased from 198% in 2018Q3 to 187% in 2019Q3, while the MCR ratio decreased from 583% to 577%. Although there is considerable variation amongst insurance corporations, the distribution of SCR ratios and MCR ratios is still well above 100%, indicating that insurance corporations in Luxembourg hold enough eligible funds to absorb significant losses. Looking forward, the sustained low interest rate environment is expected to put further pressure on insurance corporations' capital position (EIOPA, 2019). Similarly, the adverse financial impact associated with the COVID-19 pandemic could adversely affect insurance corporations' solvency ratios, as they are required to value their assets using the mark-to-market method.

134 Higher-rated euro area government bonds had a credit rating of at least AA- in 2019Q4. Euro-area government bonds with a rating below AA- are considered as being lower-rated.

135 The SCR (standard formula) corresponds to the 99.5% Value at Risk (VAR) of own funds over a one-year period. Hence, an insurer holding own funds exactly equal to its SCR is expected to cover any unexpected losses over a one-year period with a probability of 99.5%. The Regulation 15/03 of the Commissariat aux Assurances (CAA) gives further details on eligible own funds to meet the SCR, eligible own funds to meet the MCR and on both capital requirements, the Solvency Capital Requirement (SCR) and the Minimum Capital Requirement (MCR).

4 INTERCONNECTEDNESS

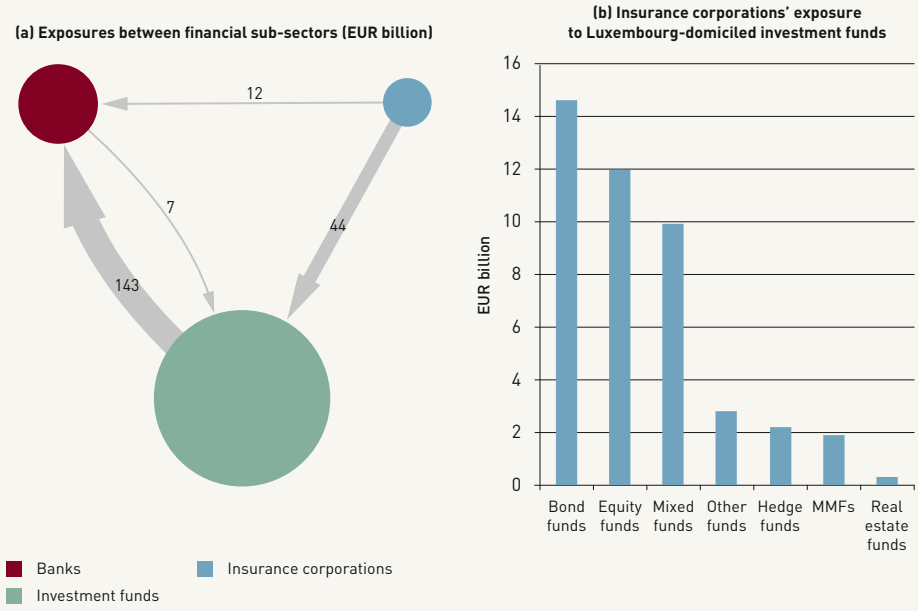
The ESRB (2019a) identifies "interconnectedness and the risk of contagion across sectors and within the non-bank financial system (...)" as one of the major risks associated with the non-bank financial sector. Similarly, according to Portes (2018), "the essence of systemic risk is interconnectedness" as the collapse of individual entities or a market can lead to a breakdown of the financial system through interlinkages. In the context of Luxembourg, the importance of the investment fund sector from a financial stability perspective arises not only because of its size, but importantly also due to its linkages with banks and insurance corporations.

Direct balance sheet links

In the Luxembourg financial system, the most important direct balance sheet link between sectors originates from investment funds domiciled in Luxembourg that hold around half of their deposits at Luxembourg banks (figure 21(a)). A more detailed analysis on these linkages is provided in subsection 1.8.5. of this *Revue de stabilité financière*. Another important link arises because Luxembourg insurance corporations hold around half of their portfolio of investment fund shares/units or €44bn in securities issued by Luxembourg funds. They are mostly invested in Luxembourg bond, equity and mixed funds (figure 21(b)).

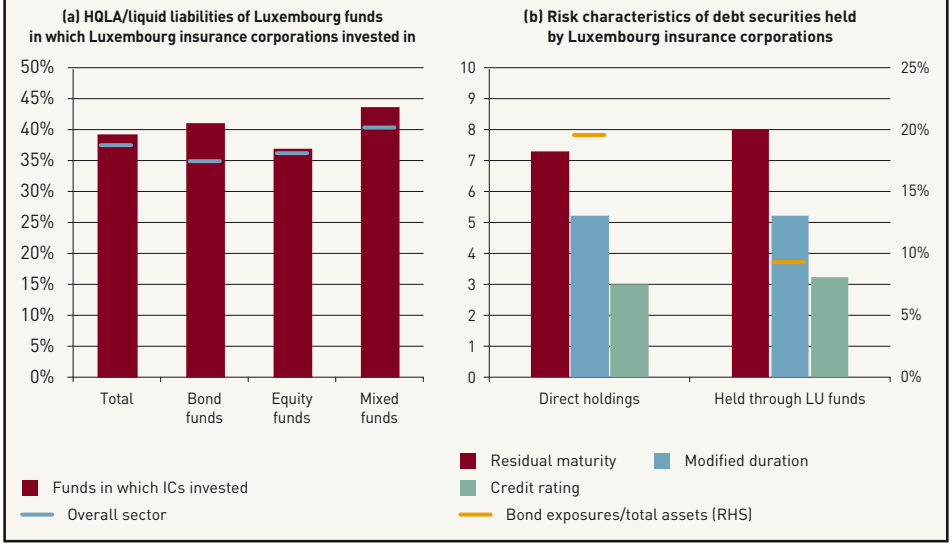
On aggregate, insurance corporations in Luxembourg are exposed to investment funds that display a level of liquidity risk that is slightly lower than the sector-wide average. More

Figure 21
Balance sheet exposures between Luxembourg entities



Source: BCL. Period: February 2020. Notes: In the left panel, an arrow going from A to B indicates that A has an exposure on the asset side of its balance sheet towards B. The arrows are labelled with the relevant amounts in EUR billions. Exposures below €1bn are not displayed. The exposures from insurance corporations to banks (€12bn) and from banks to investment funds (€7bn) are based on December 2019 data.

Figure 22
Characteristics of insurance corporations' investments in funds



Sources: BCL, ECB Centralised Securities Database (CSDB). Period: February 2020. Notes: In the left panel, the ratio of high-quality liquid assets (HQLA) to liquid liabilities of the investment funds in which Luxembourg insurance corporations invested in is weighted by the invested amounts. In the right panel, "direct holdings" refers bonds directly reported in insurance corporations' balance sheets. "Held through LU funds" refers to bonds held indirectly through shares/units of Luxembourg investment. The y-axis unit for the residual maturity is in years. The y-axis unit for the modified duration is the percentage change in bond prices following a one percentage point parallel shift of the yield curve. The y-axis unit for credit ratings is as follows: 1 (AAA), 2 (AA+ to AA-), 3 (A+ to A-), 4 (BBB+ to BBB-), 5 (BB+ to BB-), 6 (B+ to B-), and 7 (CCC+ and below).

specifically, as of February 2020, the weighted average HQLA to liquid liabilities ratio equalled 39% for funds in which insurance corporations invested in, compared to 37% for the whole investment fund sector (figure 22(a)). In addition, the ratio of HQLA to liquid liabilities for funds in which insurance corporations invested in remained unchanged between December 2019 and February 2020, amid the spread of COVID-19. This suggests that insurance corporations do not particularly rely on investment funds to gain indirect exposure to more illiquid asset classes, but that they invest in a set of funds that are rather representative for the overall composition of the Luxembourg investment fund sector.

In addition, insurance corporations' exposure to fixed income markets gained indirectly through investment funds displays broadly similar risk characteristics to the exposure gained through direct bond holdings (figure 22(b)). The residual maturity of the bonds held indirectly through fund shares/units is somewhat higher than the maturity of the bonds held directly, the modified duration is almost identical, and credit ratings are slightly lower.

Common securities holdings

In addition to direct interconnectedness, financial institutions can also be indirectly linked through, for example, common or closely correlated exposures towards a specific sector, instrument or asset. In the following paragraphs, the fact that two entities hold a security with the same ISIN will be considered as a common security holding or a portfolio overlap.

Due to the size of the Luxembourg investment fund sector, overlaps with the securities portfolios of the domestic banking and insurance sectors may be important. Indeed, 42% (49%) of the securities held by Luxembourg banks (insurance corporations) are also held by the investment fund sector (table 2).[136] Interestingly, these figures are higher than the ones observed at the euro area level (FSB, 2019). Meanwhile, from the perspective of the investment fund sector, the overlap of securities holdings with other sectors is much more limited, equalling 1% with banks and 2% with insurance corporations. The overlap is lower from the perspective of the investment fund sector due to the large difference in size.

Table 2:

Common securities holdings

		OVERLAP TO ... % WITH SECURITIES HELD BY ...		
THE SECURITIES HELD BY ...		BANKS	INSURANCE CORPORATIONS	INVESTMENT FUNDS
	Banks	100%	6%	42%
	Insurance corporations	5%	100%	49%
	Investment funds	1%	2%	100%

Source: BCL. Period: February 2020. Notes: The overlaps displayed in the above table are calculated between portfolios of Luxembourg entities only. The 42% in the last column of the row "Banks" indicate that 42% of the amount of securities held by Luxembourg banks can also be found in portfolios of Luxembourg investment funds (i.e. they invested in securities with the same ISIN). Details on the formula for calculating the overlap are provided in the FSB (2019), which takes into account the amounts of a security held by the two considered sectors. Investment funds exclude MMFs.

136 It is worth noting that common securities holdings between banks or insurance corporations on one hand, and other parts of the financial system on the other hand (e.g. MMFs, securitisation vehicles or captive financial institutions) are negligible. The most important of these overlaps is between banks and MMFs and amounts to only 5% of banks' securities holdings.

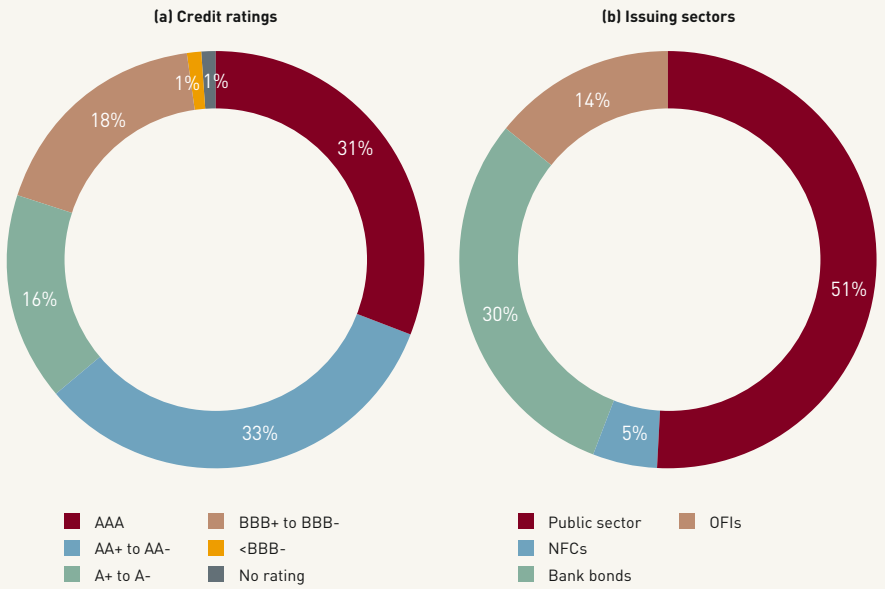
Common securities holdings can have two implications. First, a high degree of portfolio overlap between two sectors means that these sectors are exposed to the same shocks and that the value of their portfolios is correlated. Second, if one sector sells the commonly held securities in large quantities, market prices could be negatively impacted and cause negative spillovers to other sectors. It is possible that the sale of securities by funds, for example to cover redemptions under adverse market conditions, puts downward pressure on price.

However, to assess whether common securities holdings can be a channel for contagion, it is necessary to assess more than the degree of the portfolio overlap. The potential for contagion also depends on the market liquidity of the securities underlying the portfolio overlap.[137] For example, two entities can hold exactly the same securities portfolio, thereby having a perfect overlap. However, if the overlapping securities are highly liquid, it appears unlikely that the sale of the portfolio by one entity would significantly impact the other entity.

The portfolio overlap between banks and investment funds amounts to €47bn and arises mainly through common bond holdings, as opposed for example to common equity holdings. These bonds are generally of high quality as 98% are investment grade securities and around half were issued by the public sector

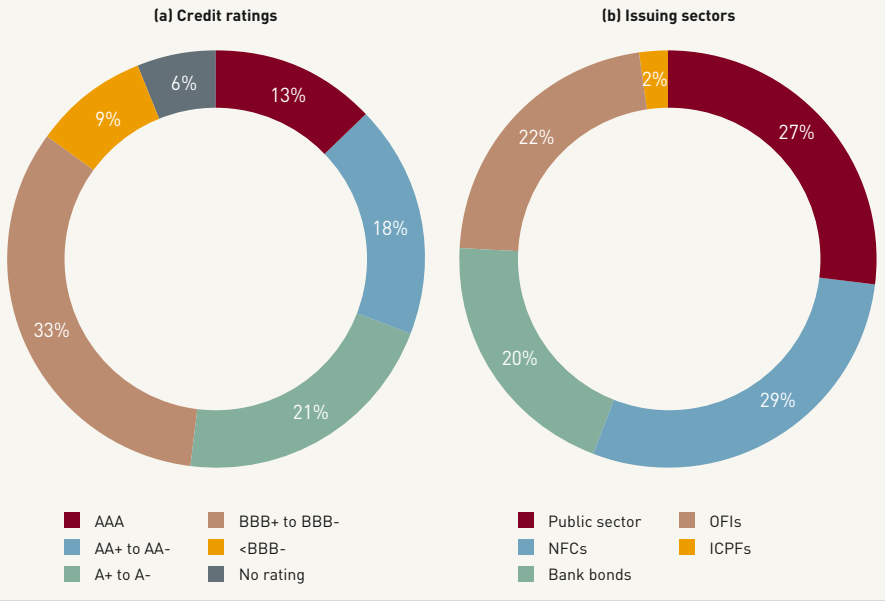
137 In the same vein, to assess the transmission of fire-sale losses between portfolios, Cont and Schaanning (2017) calculate a liquidity-weighted overlap.

Figure 23
Characteristics of the common bond holdings between banks and non-MMF investment funds



Sources : BCL, ECB Centralised Securities Database (CSDB). Period: February 2020. Notes: NFCs = non-financial corporations, ICPFs = insurance corporations and pension funds, OFIs = other financial institutions.

Figure 24
Characteristics of the common bond holdings between insurance corporations and non-MMF investment funds



Sources : BCL, ECB Centralised Securities Database (CSDB). Period: February 2020. Notes: NFCs = non-financial corporations, ICPFs = insurance corporations and pension funds, OFIs = other financial institutions.

(figure 23). Hence, the potential for contagion should be limited as these securities mostly trade in deep and liquid markets.

The portfolio overlap between insurance corporations and investment funds amounts to €71bn and arises through a more diverse set of securities (45% bonds, 35% fund shares/units, and 20% listed shares). The common bond holdings are also of lower credit quality than those between banks and funds and were to a large extent not issued by the public sector (figure 24). Although 85% are investment grade securities, 33% are rated BBB+ to BBB- and might be particularly vulnerable to rating downgrades into the high-yield domain and subsequent sell-offs in the current market environment driven by the adverse macro-financial impact of COVID-19.

At the same time, the equity holdings underlying the overlap between insurance corporations and investment funds consist to 87% of shares from large-cap companies in advanced economies, thereby suggesting a high level of market liquidity and a more limited potential for contagion.[138] However, compared to banks, insurance corporations appear more vulnerable to contagion from investment funds via common securities holdings, even though it should be kept in mind that most common bond holdings have an investment grade credit rating.

5. CONCLUSION

In an effort to compensate for decreasing yields on more standard debt securities, such as euro area government bonds, Luxembourg investment funds have increased their exposure towards interest rate risk, credit risk and to assets denominated in currencies other than the euro. At the same time, their holdings of high-quality liquid assets (HQLA) remain significant and could act as a potential safeguard against the large-scale investor runs under very adverse market conditions. Indeed, the outflows reported by the sector in March 2020, due to the adverse COVID-19 related shock, were significantly lower than the sector's HQLA holdings. However, certain types of funds such as high-yield bond funds appear significantly more vulnerable to investor runs than the broader sector.

In the insurance sector, no significant shift in risk appetite was observed. This might be because the investment strategy of insurance corporations is generally liability-driven (ESRB, 2020). Luxembourg life insurers, which represent the vast majority of the insurance sector in terms of total assets, have a high share of unit-linked business. Therefore, they have not guaranteed a return on those investments to policyholders, potentially reducing their incentives to engage in more risk-taking.[139] However, although life insurers might not be directly impacted in case of low unit-linked investment returns, they could be exposed to reputational risk in case those returns are below the policyholders' expectations.

Nonetheless, the adverse financial market effects resulting from the COVID-19 pandemic are expected to negatively affect insurers in Luxembourg through at least three channels: (i) the solvency ratios might decrease due to the recent reduction in asset valuations, (ii) adverse market conditions have the potential to significantly reduce investment income and profitability, and (iii) the macroeconomic environment may have a significant impact on insurers' cash inflows and outflows, potentially exposing them to higher liquidity risk.

138 While this limits the potential for contagion spreading from the Luxembourg investment fund sector to Luxembourg insurance corporations, both sectors remain still vulnerable to a general decline in these assets emanating for example from the consequences of the spread of COVID-19.

139 Unit-linked investments on life insurers' balance sheet do not reflect their own risk appetite, but the policyholders' risk appetite. The life insurance company only holds the unit-linked investments on their balance sheet without holding the investment risk.

Finally, the potential for negative spillovers between investment funds, insurance corporations and banks varies. On one hand, the potential for contagion through common securities holdings appears low from investment funds to banks, given the high quality of the debt securities responsible for this overlap. On the other hand, insurance corporations could be more susceptible to negative spillovers from investment funds, due to (i) their important direct holdings of investment fund shares/units and (ii) the lower quality of the debt securities underlying their common securities holdings.[140]

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3. ESTIMATES OF BANK EFFICIENCY IN LUXEMBOURG: A DETAILED ASSESSMENT OF THE DRIVERS ACROSS BUSINESS MODELS

Boubacar Diallo[141]

1. INTRODUCTION

Since the Global Financial Crisis (GFC) 10 years ago, there have been significant changes in the global banking system with implications for bank efficiency. The reasons underlying these changes include the significant losses incurred by European and U.S. banks, the persistent low interest rate environment and newly introduced regulatory elements such as macroprudential policy as well as Basel III. Basel III was implemented in order to make banks more resilient to financial and economic downturns, and macroprudential measures were introduced to help mitigate systemic risk but combined, the increase in regulatory measures may have had an impact on bank efficiency.

In this research, we investigate the efficiency of banks in Luxembourg according to their country of origin as well as their different business models. In the second step, this work investigates the underlying drivers of bank efficiency scores. Luxembourg is an interesting candidate for assessing bank efficiency for numerous reasons. First, Luxembourg is a worldwide financial center and hosts more than 129 banks originating from 27 different countries.[142] Indeed, more than 95 percent of banks operating in Luxembourg come from abroad having parent institutions in Germany, France, Switzerland, Italy and other non-European countries such as China, the U.S. and U.K., to name a few. The banking and financial sector contributed around 25 percent of the country's gross domestic product (GDP) in the third quarter of 2019.[143] In addition, the country is the second largest investment fund center in the world after the U.S. Finally, it is the most important private banking center and the leading center for reinsurance companies in Europe, and the IMF considers Luxembourg as one of the 25 most interconnected economies based on criteria such as the size of the financial sector and connections with financial sectors in other countries.[144] Hence, understanding bank efficiency in terms of different segments such as country of origin as well as business model may have important implications as far as financial stability is concerned in this context of the persistently low interest rate environment. Importantly, studying bank efficiency in a financial centre allows us to reduce potential biases related to the common use of self-reported country data in the sense that it decreases issues related to omitted variables. To the best of our knowledge, this study is the first to investigate bank efficiency in terms of segments and business models in general, and for a financial center, in particular.

One of the challenges in this paper is to measure bank efficiency, which cannot be directly observed. To tackle this issue, we use the nonparametric approach called Data Envelopment Analysis (DEA) to calculate bank efficiency scores. This helps us differentiate our study from the existing literature in the sense that previous research articles mainly used private credit, liquid liabilities or bank assets as measures of financial efficiency and development. However, many researchers including Hasan et al. (2009), Rousseau and Watchel (2011), Diallo (2018) among others have challenged the use of these measures and argued that they only measure the quantity of available funds within the financial sector rather than their quality. The use of the DEA approach also allows us to focus on microeconomic

141 Financial Stability and Macroprudential Surveillance Department, Banque centrale du Luxembourg
142 Revue de Stabilité Financière 2019, Banque Centrale du Luxembourg (BCL).
143 Statistics Luxembourg: https://statistiques.public.lu/fr/economie-finances/index.html
144 The IMF criteria do not reflect a country's broader economic or political importance, and may be periodically re-evaluated as financial sectors develop and their size and connections change over time.

measures of bank efficiency following the intermediation or value added approaches according to input and output variables.

This research uses two avenues for the implementation of the DEA, namely the intermediation and value added approaches. Under the intermediation approach banks play the role of intermediaries as they collect deposits to provide loans. With this approach, we use fixed assets, labor measured by the number of employees, administrative expenses and total deposits as inputs and total loans and non-interest income as outputs. The use of non-interest income as an output is motivated by the fact that the Luxembourg banking sector relies more on fees and commissions as a source of income after the financial crisis. The value added approach assumes that bank liabilities and assets are outputs. Specifically, the categories of both liabilities and assets that have a net contribution in terms of value added according to the external operating costs are considered as outputs. This approach considers a bank as an institution creating income from the difference between earnings from the sale of products and the costs of inputs used in producing these products. For this approach we use fixed assets, labor measured by the number of employees, administrative and interest expenses as inputs and total deposits and loans and non-interest income as outputs following Berger et al. (1987), Berger and Humphrey (1997) and Fethi and Pasiouras (2010). However, using deposits as an output has been challenged by Guarda et al. (2013) who found that deposits are inputs using the directional technology distance function. In this study, we also present the results of efficiency scores using the value added approach. The use of these two approaches in calculating efficiency scores is a novelty and fills a gap in the literature in banking since previous studies mainly followed one approach, namely the intermediation approach.

All data on inputs and outputs come from the Central Bank of Luxembourg (BCL). As this research focuses on bank efficiency in Luxembourg and, most importantly across segments and business models, we use seven geographical segments, namely Luxembourgish, German, French, Swiss, Italian, Chinese and other segments. In terms of business models, we follow the classification of the BCL and the Commission de Surveillance du Secteur Financier (CSSF) in collaboration with the International Monetary Fund (IMF). This classification scheme was used to divide banks into 7 business model segments such as universal, retail and commercial, private, custodian and investment funds, corporate finance and covered bonds banks. In addition, we employ the classification of the Single Supervisory Mechanism (SSM) to classify banks into 3 categories including significant and less significant banking institutions and others. Because the DEA approach assumes certain specifications for returns to scale, this paper uses constant returns to scale (CRS) since this estimator allows for a greater discriminatory power in measuring all banks to the same and optimal level of scale (Curi et al. (2013) and Zelenyuk and Zelenyuk (2015)). The variables in nominal values are converted to real terms using the GDP deflator of Luxembourg with the base year 2010. Our final sample covers 214 banks over the period of 2000-2018, with a total of 2049 bank-year observations available for estimations.

Our results show that the banking sector in Luxembourg has an average efficiency score lying between 0.79 and 0.83 using the intermediation and value added approaches, respectively. This suggests that banks operating in Luxembourg could increase their output by 21 and 17 percent while holding the quantity of inputs constant on average using the intermediation and value added approaches, respectively. We also find that the difference in subsidiary and branch efficiency scores is statistically significant at the 1 percent level using both the intermediation and value added approaches. However, in terms of segments, Luxembourgish banks are found to be the most efficient followed by the German segment. Under the different business models, we find that corporate and retail and commercial banks are the most efficient using both the intermediation and value added approaches. Significant banking institutions have an average score of 0.78, while less significant banking institutions exhibit a score of 0.79 on average. Despite these scores for bank efficiency, it is worth mentioning that average bank

efficiency has been decreasing since the GFC but still remains at acceptable level with an average value of 0.8. We also find a statistically significant difference in the means of efficiency scores before and after the global financial crisis at 1 percent level using both the intermediation and value added approaches.

Next, we investigate the micro drivers of bank efficiency in Luxembourg. Our results indicate that there is a positive and significant relationship between bank income diversification and efficiency both measured by the intermediation and value added approaches. We also show that bank concentration measured by the Herfindahl-Hirschmann index (HHI) is positively and significantly related to bank efficiency, rejecting the quiet life hypothesis (QLH). According to bank size, this research establishes the existence of a non-linear relationship between bank size and efficiency, namely an inverted U-shaped relation. In addition, this research finds that equity ratio has a negative and significant effect on bank efficiency, thus validating the agency costs theory. These findings remain robust to potential endogeneity issues such as reverse causality and omitted variables using an instrumental variable (IV) Tobit model. Furthermore, the use of the IV approach confirms the positive effect of bank income diversification on efficiency.

Finally, this research adds several advances to the existing literature. First, it determines efficiency scores for banks operating in a financial centre using both the intermediation and value added approaches. Second, it discusses those scores in terms of business models and segments. Third, it empirically investigates the micro drivers of bank efficiency across business models by tackling the endogeneity issues often present in such empirical exercises. The remainder of this special feature is as follows; section 2 outlines the model and data and section 3 presents the results. Finally, Section 4 discusses and summarizes the findings.

2. MODELS AND DATA

Despite the role played by the banking sector in Luxembourg there have been only a few parametric studies on the efficiency of the banking sector. This research adds to the existing literature by using the nonparametric DEA approach. The DEA is a linear programming based approach that links inputs and outputs of Decision Making Units (DMU) (Charnes et al. (1978) and Charnes et al. (1995)). This approach describes how inputs are used in order to produce outputs across banks. The DEA facilitates the estimation of efficiency scores associated with each bank during a certain period in the first stage. The resulting efficiency scores are analyzed across segments i.e. according to banks countries of origin, branch versus subsidiary; types of banking activities or business models, and implications for financial stability using the Single Supervisory Mechanism (SSM) classification. In the following section, we present the mathematical formalization of the DEA approach following Diallo (2018). We use the output-oriented technique following the literature in bank efficiency. The output-oriented technique solves a linear programming problem to maximize the output of a given bank without adjusting the amount of inputs.[145]

The DEA Model Let n be the sample size of banks. k and o, be inputs and outputs, respectively of bank i. Let $x_i = (x_{i1}, x_{i2}, ..., x_{kj})$ be the vector of inputs of bank i. Let $y_i = (y_{i1}, y_{i2}, ..., y_{oj})$ also be the vector of outputs of bank i. For simplicity, let us assume that the matrix of inputs $k \times n$, and outputs $o \times n$ are respectively given by: $X = (x_1, x_2, ..., x_n)$ and $Y = (y_1, y_2, ..., y_n)$. The linear programming DEA problem of bank i, where (i = 1...n) is:

$$1/Ef\, f_i = \max(\beta_i \geq 1/xi, yi, X, Y) = \max(\beta_i \geq 1 | \beta_i y_i \leq Y a_i, Xa_i \leq x_i, a_i \geq 0, I'a_i = 1) \quad (1)$$

where a_i are non-negative vector of parameters.

145 The output and input-oriented techniques give the same results under constant returns to scale (CRS).

This maximization problem is posed such that a virtual output $Y\,a_i$ is constructed for each bank i according to the weights of outputs of all other banks and then this virtual output is expanded as much as possible under the inputs' constraints of that bank $Xai \geq xi$. This virtual output is then compared to the actual output yi. In terms of efficiency, if the output obtained with the maximization problem, namely $Y\,ai$ is higher than the actual output y_i of bank i, then the bank is inefficient, otherwise the bank is located at the efficient frontier.

It is very important to choose the right specification for returns to scale. In their seminal paper, Charnes et al. (1978) first proposed a DEA linear programming technique using the input-oriented method combined with constant returns to scale (CRS). Notwithstanding, in 1984, Banker et al. (1984) introduced a model using variable returns to scale (VRS). Since then there has been significant debate among academics regarding the use of CRS and VRS in banking. Particularly, McAllister and McManus (1993), Wheelock and Wilson (2001), Hughes et al. (2001), Feng and Seritilis (2010), and Wheelock and Wilson (2012) all found that banks operate under increasing returns to scale for the U.S. banking sector. For example, according to Tim Coelli (2008) the use of the CRS should only be considered when all decision DMUs (i.e. banks in our case) are operating at an optimal scale. In this research, we use CRS since it allows for more discriminatory power across all banks in terms of the level of scale.

Econometric Model

To estimate the determinants of bank efficiency, we use the panel random-effects Tobit model, which imposes an upper limit of 1 on the efficiency scores obtained during the first stage. In doing so, the following econometric model is estimated:

$$\text{Efficiency}_{it} = X_{it}\beta + v_i + \theta_j + \rho_t + E_{it} \qquad (2)$$

where i and t denote bank and year, respectively. X_{it} are the determinants of bank efficiency, consisting of capital and equity ratios, diversification, size and concentration. We also add bank, country of origin and year fixed-effects captured by v_i, θ_j and ρ_t, respectively. Eit is the error term.

Data

We use annual bank data obtained from the Central Bank of Luxembourg (BCL) for the period 2000-2018. Under the intermediation approach we use fixed assets consisting of the sum of property, equipment and investment property, labor measured by the number of employees, administrative expenses and total deposits defined as the sum of interbank and customer deposits as inputs and total loans consisting of interbank and customer loans and non-interest income such as net fees and commissions, foreign exchange and dividend income and other income as outputs. For the value added approach, we use fixed assets, labor, administrative and interest expenses as inputs and total deposits and loans and non-interest income as outputs. The variables in nominal values are converted to real terms using the GDP deflator of Luxembourg with the base year 2010. The final sample is an unbalanced panel and covers 2049 bank-year observations. Below we present some descriptive statistics of the input and output variables.

3. RESULTS

3.1 EFFICIENCY SCORES

The results obtained from the intermediation approach are displayed in Table 1. For our sample of 2049 bank-year observations, including branches and subsidiaries with all types of business models, the average bank efficiency in Luxembourg between 2000-2018 amounted to 0.79, with a standard deviation of 0.059. This suggests that banks in Luxembourg operating under this approach could increase their level of output by 21 percent on average while holding the quantity of inputs constant. In addition, the results suggest that the mean bank efficiency was equal to 0.78 and 0.82 for banks with subsidiaries and branches, respectively. Using segments, specifically classification according to a bank's country of origin, we find that Luxembourgish banks are the most efficient followed by German and Chinese banks. The least efficient banks are found to be French and Swiss banks. However, the efficiency scores of Chinese banks should be interpreted with caution since Chinese banks are predominantly corporate banking institutions. Using the business models classification, we find that corporate, custodian and retail and commercial banks are the most efficient with a score of 0.83 and 0.81 on average, respectively. In terms of financial stability based on SI versus LSI classification, significant and less significant banking institutions have efficiency scores of 0.78 and 0.79 on average, respectively.

Table 1:

Bank Efficiency Scores–Intermediation Approach

VARIABLES	OBS	MEAN	STD. DEV.	MIN.	MAX.
Average bank efficiency (Luxembourg)	2,049	0.788	0.059	0.570	1
Banks with subsidiaries	1,818	0.785	0.053	0.570	1
Banks with branches	231	0.818	0.088	0.601	1
Luxembourgish segment	88	0.835	0.080	0.719	1
German segment	214	0.804	0.068	0.601	1
French segment	175	0.779	0.040	0.723	0.997
Swiss segment	159	0.783	0.049	0.570	1
Italian segment	94	0.799	0.052	0.672	1
Chinese segment	77	0.801	0.079	0.618	1
Other segment	1,242	0.783	0.055	0.584	1
Universal banks	74	0.762	0.014	0.731	0.800
Retail and commercial banks	116	0.811	0.074	0.645	1
Custodian banks and IF activities	314	0.781	0.054	0.602	1
Private banks	663	0.780	0.044	0.570	1
Corporate finance banks	222	0.828	0.083	0.607	1
Covered bonds banks	23	0.805	0.060	0.690	1
Other	637	0.786	0.057	0.584	1
Significant banking institutions	518	0.784	0.044	0.653	1
Less significant banking institutions	585	0.790	0.061	0.570	1
Other	946	0.790	0.064	0.584	1

Source: BCL

Table 2 displays the descriptive statistics of efficiency scores using the value added approach. The average level of bank efficiency in Luxembourg over the period of 2000-2018 was estimated at 0.83 with a standard deviation of 0.062. This suggests that under this approach banks could increase their output by 17 percent while holding the quantity of inputs constant on average. In terms of subsidiary versus branch banks, we find that the averages efficiency scores are equal to 0.82 and 0.87, respectively. The interpretation of findings obtained for segments, business models and financial stability are similar to those obtained via the intermediation approach. Figure 1 shows the evolution of bank efficiency scores using both the intermediation and value added approaches over the period 2000-2018 for the Luxembourg banking sector.

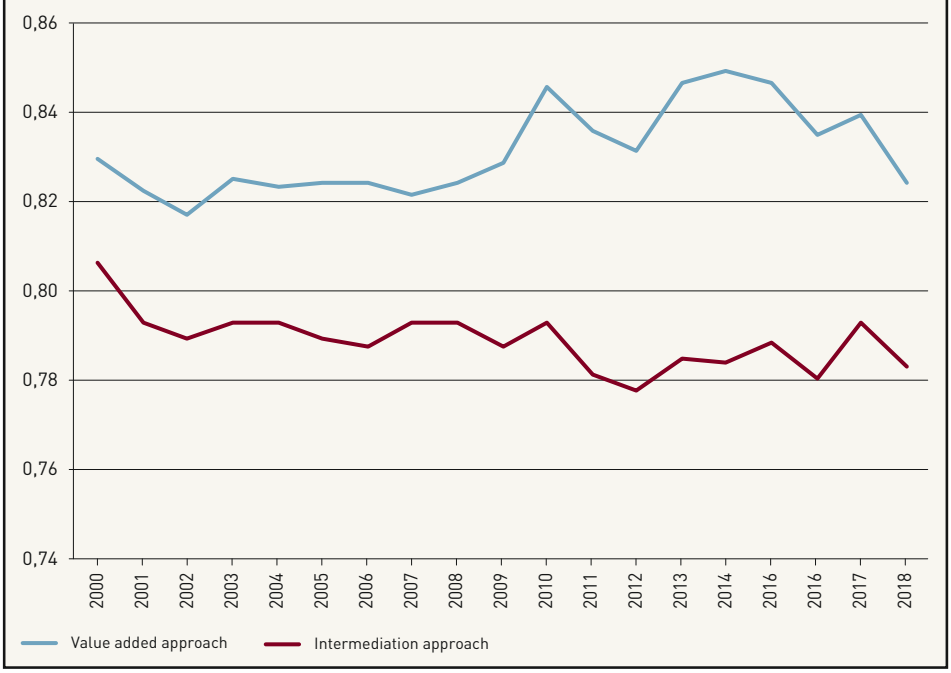
Table 2:

Bank Efficiency Scores–Value Added Approach

VARIABLES	OBS	MEAN	STD. DEV.	MIN.	MAX.
Average bank efficiency (Luxembourg)	2,049	0.831	0.062	0.543	1
Banks with subsidiaries	1,818	0.825	0.056	0.543	1
Banks with branches	231	0.874	0.082	0.696	1
Luxembourgish segment	88	0.866	0.075	0.767	1
German segment	214	0.851	0.067	0.696	1
French segment	175	0.818	0.046	0.752	1
Swiss segment	159	0.823	0.047	0.676	1
Italian segment	94	0.854	0.051	0.696	1
Chinese segment	77	0.842	0.062	0.754	1
Other segment	1,242	0.825	0.062	0.543	1
Universal banks	74	0.795	0.016	0.754	0.832
Retail and commercial banks	116	0.852	0.083	0.668	1
Custodian banks and IF activities	314	0.852	0.058	0.737	1
Private banks	663	0.821	0.049	0.676	1
Corporate finance banks	222	0.853	0.085	0.543	1
Covered bonds banks	23	0.834	0.055	0.719	0.968
Other	637	0.823	0.059	0.591	1
Significant banking institutions	518	0.826	0.048	0.696	1
Less significant banking institutions	585	0.835	0.067	0.543	1
Other	946	0.831	0.065	0.591	1

Source: BCL

Figure 1
Banking Efficiency Scores in Luxembourg



Source: BCL

In order to test the independence of the two samples of efficiency estimates, we perform the mean-comparison test and we find that the efficiency scores of subsidiary and branch banks are statistically different from each other, on average, at the 1 percent level for both the value added and intermediation approaches. This finding is in contradiction with those of Aly et al. (1990) who showed that there is no difference in the distribution of efficiency estimates for branches versus non-branch banks in the United States. This result is, however, in line with Curi et al. (2013) for Luxembourg. In terms of efficiency in both the pre- and post-financial crisis periods (i.e. before and after 2007), we find a statistically significant difference in the means of efficiency scores before (p-value=0.0091) and after (p-value=0.000) the crisis using the intermediation and value added approaches, respectively.

3.2 DRIVERS OF BANK EFFICIENCY

Table 3 presents the descriptive statistics of the variables used to investigate the main drivers of bank efficiency in Luxembourg. Recall that capital and equity ratios are expressed in terms of total assets. Bank diversification is measured by the ratio between non-interest income and total assets. Size is the logarithm of total assets and concentration is the measure of a bank's market power in terms of total assets obtained using the Herfindahl-Hirschmann index (HHI).

Table 3:

Summary statistics–Determinants of Bank Efficiency

VARIABLES	OBS	MEAN	STD. DEV.	MIN.	MAX.
Efficiency (Intermediation)	2,049	0.788	0.059	0.570	1
Efficiency (Value added)	2,049	0.831	0.062	0.543	1
Capital ratio	2,049	0.064	0.187	0	3.078
Equity ratio	1,933	0.091	0.121	-0.523	1.172
Diversification	2,042	0.020	0.041	0.0000119	0.7252
Size	2,042	16.649	1.714	10.410	20.636
$(Size)^2$	2,042	280.148	57.073	108.380	425.868
HHI assets	2,049	0.165	0.301	0	1

Source: BCL

We present results in Table 4 using bank efficiency scores calculated under the intermediation approach as the dependent variable. In column (1) of this Table, we regress the determinants, namely capital and equity ratios, diversification, size and its square and concentration on bank efficiency for all banks in the sample. We find a positive and significant relationship between income diversification and efficiency at the 1 percent level. The coefficients associated with size and its square are positive and negative, respectively. Both estimated coefficients are significantly different from zero at the 1 percent level. This result suggests the existence of a nonlinear relation between bank size and efficiency. Moreover, it suggests that there is an inverted-U shaped relationship between size and efficiency in Luxembourg, reconciling both views on the impact of bank size on efficiency. Using the HHI index as measure of bank concentration, we are also able to reject the quiet life hypothesis (QLH) for banks operating in Luxembourg since its coefficient is positive and significantly different from zero at the 1 percent level. In columns (2)-(5) of Table 4, we look at the determinants of bank efficiency by considering different types of business models in the Luxembourg banking sector. Column (2) estimates the same model for universal banks and shows that bank income diversification is positively and significantly related to efficiency at the 1 percent level and the magnitude of its coefficient increases sharply. However, bank efficiency is negatively and significantly associated with equity ratio. In addition, the inverted U-shaped relationship between size and efficiency is confirmed for this type of banking business model. Column (3) focuses on retail and commercial banks, the coefficient of diversification remains positive but becomes insignificant. Moreover, the QLH is also rejected for this type of banking activity. Column (4), shows the results for private banks and confirms the fact that diversification and concentration remain positive and significant at the 1 level, respectively. For private banking, the nonlinear relationship between size and efficiency remains robust. Interestingly, the coefficient associated with the capital ratio enters positively and significantly different from zero at the 5 percent level, while the equity ratio is found to be negatively and significantly related to bank efficiency at the 5 percent level. Finally, columns (5) and (6) show the results for custodian and investment fund banks, and corporate banks, respectively. For these banks, the coefficient of bank income diversification remains positive and significant at the 1 percent level, supporting the positive association between diversification and efficiency. These findings are suggestive of the strong positive impact of bank income diversification on efficiency across banks and business models in Luxembourg.

Table 4:

Determinants Bank Efficiency–Intermediation Approach

	ALL BANKS	UB	RCB	PB	CIFB	CFB
Capital ratio	0.0075	0.0037	0.0811	0.0194**	0.0037	0.0128
	(0.0073)	(0.0103)	(0.1378)	(0.0087)	(0.0215)	(0.0188)
Equity ratio	-0.0130	-0.1148***	-0.0557	-0.0526**	0.1478***	-0.0351
	(0.0172)	(0.0203)	(0.0920)	(0.0252)	(0.0410)	(0.0486)
Diversification	0.4306***	3.2070***	0.1117	0.7026***	0.2865***	1.4178***
	(0.0409)	(0.1788)	(0.7319)	(0.0917)	(0.0478)	(0.3871)
size	0.0747***	0.3583**	0.3644***	0.1233***	0.0071	0.0521
	(0.0198)	(0.1619)	(0.1290)	(0.0304)	(0.0349)	(0.0690)
$(size)^2$	-0.0016***	-0.0085**	-0.0112***	-0.0030***	0.0001	-0.0008
	(0.0006)	(0.0041)	(0.0043)	(0.0009)	(0.0011)	(0.0020)
HHI assets	0.0165***	0.1124	0.0622***	0.0163*	0.0174	0.0215
	(0.0059)	(0.1241)	(0.0184)	(0.0085)	(0.0111)	(0.0191)
Country of origin fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1391	74	116	644	301	200
Number of groups	114	4	11	43	26	24
Number of right-censored observations	14	0	2	2	3	6
Log likelihood	2633.708	292.859	220.527	1390.872	585.034	305.690
x^2	2231.058	624.389	445.531	968.879	321.934	394.911

*Source: BCL. Note that (***, ** and *) indicate significance at the 1%, 5% and 10% levels, respectively. All regressions contain the constant coefficient. Standard errors are in parenthesis. UB, RCB, PB, CIFB and CFB, respectively stand for Universal, Retail and Commercial, Private, Custodian and Investment Funds and Corporate Finance Banking.*

In Table 5, we use bank efficiency measured by the value added approach as dependent variable. Column (1) considers all banks and shows positive and significant relationships between diversification, concentration and bank efficiency at the 1 percent level. However, the coefficients associated with bank size and its square are not significant. Interestingly, the equity ratio enters negatively and significantly different from zero at the 1 percent level, suggesting that a higher level of equity decreases efficiency. This finding may be related to the agency costs theory developed by Jensen and Meckling (1976). Moreover, this theory argues that equity financing increases the agency costs between equity-holders and managers of banks because of their diverging objectives. The results for universal banks in column (2) indicate positive and significant relationships between banks' capital ratios and diversification at the 5 and 1 percent levels, respectively. Column (3) focuses on retail and commercial banks. The results show that the coefficients associated with size and concentration all enter positively and significantly different from zero at the 1 percent level, respectively. The square of bank size also enters negatively and is significantly different from zero at the 1 percent level. This evidence suggests the presence of an inverted U-shaped relation between size and efficiency for retail and commercial banks. The equity ratio and diversification are found to be negatively and significantly associated with efficiency at the 5 and 1 percent levels, respectively. This negative relationship between income diversification and efficiency may suggest that diversification has a negative impact on the efficiency of retail and commercial banks. Using private banks in column (4), the coefficients for income diversification and concentration remain positive and significant at the 1 percent level, thus rejecting the QLH. The same findings emerge for corporate finance banking in column (6). However, for custodian and investment fund banks, none of the determinants of bank efficiency are found to be significant as shown in column (5).

Table 5:

Determinants Bank Efficiency–Value Added Approach

	ALL BANKS	UB	RCB	PB	CIFB	CFB
Capital ratio	0.0095	0.0286**	0.1771	0.0151	-0.0102	0.0180
	(0.0072)	(0.0133)	(0.1397)	(0.0096)	(0.0178)	(0.0155)
Equity ratio	-0.0454***	-0.0420	-0.1586*	-0.0691**	0.0371	-0.0034
	(0.0167)	(0.0261)	(0.0926)	(0.0277)	(0.0343)	(0.0398)
Diversification	0.1059***	2.4202***	-2.6255***	0.4318***	-0.0260	0.8722***
	(0.0404)	(0.2302)	(0.7417)	(0.1007)	(0.0406)	(0.3196)
Size	0.0008	0.2450	0.3885***	0.0252	-0.0086	0.0868
	(0.0198)	(0.2084)	(0.1298)	(0.0334)	(0.0329)	(0.0562)
$(Size)^2$	0.0003	-0.0057	-0.0127***	-0.0003	0.0001	-0.0019
	(0.0006)	(0.0053)	(0.0043)	(0.0010)	(0.0010)	(0.0016)
HHI assets	0.0216***	-0.0055	0.0726***	0.0334***	-0.0004	0.0481***
	(0.0057)	(0.1598)	(0.0189)	(0.0093)	(0.0091)	(0.0156)
Country of origin fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1391	74	116	644	301	200
Number of groups	114	4	11	43	26	24
Number of right-censored observations	37	0	5	6	13	13
Log likelihood	2615.213	274.176	211.363	1315.159	615.184	329.659
x^2	3106.954	495.128	587.754	1083.646	918.651	671.976

*Source: BCL. Note that (***, ** and *) indicate significance at the 1%, 5% and 10% levels, respectively. All regressions contain the constant coefficient. Standard errors are in parenthesis. UB, RCB, PB, CIFB and CFB, respectively stand for Universal, Retail and Commercial, Private, Custodian and Investment Funds and Corporate Finance Banking.*

3.3 Instrumental variable (IV) estimation and causal relationships

The use of the Tobit IV method allows us to deal with endogeneity problems in terms of reverse causality between our determinants i.e. capital and equity ratios, diversification, size and con- centration, and bank efficiency as well as omitted variables issues. This endogeneity between capital, equity, diversification, size and concentration has been extensively discussed in the literature (Berger and Bonaccorsi di Patti (2006), Altunbas (2007), Laeven and Levine (2007) and Fiordelisi et al. (2011) among others). For example, if bank efficiency affects the choice of capital structure in terms of leverage, then failure to take this reverse causality into account may result in simultaneous equations bias. In addition, as financial institutions choose to diversify or not to diversify, the same bank level characteristics that guide this decision may also impact bank efficiency, which may lead to omitted variables issues. Finally, more efficient banks seem to eventually become better capitalized, tend to increase their market share and hence, become larger financial institutions.

Instruments

Finding good instruments that satisfy both the independence assumption and exclusion restriction for a causal inference can be a challenging task in applied econometrics. In this paper, the instruments we use are the first and second lagged variables of banks capital and equity ratios, diversification, size and its square, and concentration in the spirit of Blundell and Bond (1998, 2000). Recently, Reed (2015) motivated the use of lagged variables as instruments instead of using them as controls if there is no serial correlation. The main idea is that the first and second lagged variables of capital and equity ratios, diversification, size and its square and concentration precede the real variables and the causality goes from the lagged variables to the real ones. This technique allows us to establish a causal relationship between our drivers and bank efficiency.

Table 6 re-estimates the model using the IV approach and intermediation method in selecting inputs and outputs. When all banks are considered in our sample, we find that income diversification has a positive and significant effect on bank efficiency at the 1 percent level, and there is an inverted U-shaped causal relationship between bank size and efficiency. These findings validate the results obtained with the panel Tobit model. However, the use of the IV approach renders the coefficient of concentration insignificant. This suggests that there is no clear evidence in favour of an impact of bank concentration on efficiency also known as the QLH. Moreover, the negative and significant effect of equity ratio on bank efficiency remains altered, thus confirming the agency costs theory. Using universal banks in column (2), the result related to diversification remains unaltered. For retail and commercial banks in column (3), the capital ratio also enters positively and significantly different from zero at the 5 percent level. However, bank income diversification becomes insignificant. Interestingly, the QLH is not rejected for this business model as the coefficient associated with bank concentration enters negatively and significantly different from zero at the 10 percent level. For private and custodian banks in columns (4) and (5), diversification and size seem to play an important role in enhancing bank efficiency.

Table 6:

IV Method–Intermediation Approach

	ALL BANKS	UB	RCB	PB	CIFB	CFB
Capital ratio	-0.0005	-0.0573	0.4761**	0.0183	-0.0446*	0.0257
	(0.0109)	(0.0367)	(0.2090)	(0.0120)	(0.0254)	(0.0468)
Equity ratio	-0.0602*	-0.1067**	-0.0866	-0.0934**	-0.0229	-0.0513
	(0.0322)	(0.0525)	(0.1459)	(0.0369)	(0.0770)	(0.1410)
Diversification	0.3376***	3.0128***	-0.8386	0.6545***	0.0611	1.4006
	(0.0689)	(0.4038)	(0.8002)	(0.2249)	(0.0836)	(1.1463)
Size	0.0898***	0.4157	0.1960	0.1330***	0.0756	-0.0212
	(0.0303)	(0.4258)	(0.1748)	(0.0441)	(0.0467)	(0.1761)
$(Size)^2$	-0.0021**	-0.0099	-0.0057	-0.0032**	-0.0025*	0.0012
	(0.0009)	(0.0108)	(0.0055)	(0.0013)	(0.0014)	(0.0050)
HHI assets	-0.0335	0.1986	-0.4071*	0.0107	-0.1507*	-0.0898
	(0.0417)	(0.3411)	(0.2342)	(0.0469)	(0.0822)	(0.1308)
Country of origin fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1073	62	75	532	237	131
x^2	2399.313	216.425	660.427	1124.67	333.140	295.274

*Source: BCL. Note that (***, ** and *) indicate significance at the 1%, 5% and 10% levels, respectively. All regressions contain the constant coefficient. Standard errors are in parenthesis. UB, RCB, PB, CIFB and CFB, respectively stand for Universal, Retail and Commercial, Private, Custodian and Investment Funds and Corporate Finance Banking. The instruments are the first and second lag of capital and equity ratios, diversification, size and its square, and concentration.*

Finally, Table 7 uses the IV method and value added approach for bank efficiency. The results are quite similar to those obtained previously, namely the positive and significant effect of bank income diversification on efficiency for all banks and business models exception for retail and commercial banks. In addition, the equity ratio has also a negative and significant impact on bank efficiency for retail and commercial, and private banks.

Table 7:

Instrumental Variable Method: Determinants Bank Efficiency–Value Added Approach

	ALL BANKS	UB	RCB	PB	CIFB	CFB
Capital ratio	0.0024	0.0172	0.9003***	0.0137	-0.0324	0.0428
	(0.0110)	(0.0339)	(0.2667)	(0.0134)	(0.0253)	(0.0349)
Equity ratio	-0.0598*	-0.0283	-0.4207**	-0.1094***	0.0254	-0.0802
	(0.0326)	(0.0485)	(0.1843)	(0.0411)	(0.0772)	(0.1054)
Diversification	0.2330***	2.2159***	-3.2534***	0.8645***	0.1938**	1.1531
	(0.0706)	(0.3728)	(1.0075)	(0.2505)	(0.0981)	(0.8699)
Size	-0.0117	0.7009*	0.3532	0.0415	0.0113	-0.1161
	(0.0339)	(0.3932)	(0.2200)	(0.0491)	(0.0639)	(0.1311)
$(Size)^2$	0.0006	-0.0173*	-0.0112	-0.0007	-0.0003	0.0037
	(0.0010)	(0.0100)	(0.0070)	(0.0014)	(0.0019)	(0.0037)
HHI assets	-0.0269	-0.1550	-0.2824	-0.0578	0.0910	0.0364
	(0.0419)	(0.3149)	(0.2949)	(0.0522)	(0.0912)	(0.0973)
Country of origin fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1073	62	75	532	237	131
x^2	3205.958	351.292	642.445	1249.751	709.077	637.530

*Source: BCL. Note that (***, ** and *) indicate significance at the 1%, 5% and 10% levels, respectively. All regressions contain the constant coefficient. Standard errors are in parenthesis. UB, RCB, PB, CIFB and CFB, respectively stand for Universal, Retail and Commercial, Private, Custodian and Investment Funds and Corporate Finance Banking. The instruments are the first and second lag of capital and equity ratios, diversification, size and its square, and concentration.*

4. CONCLUSION

According to our findings using both the intermediation and value added approaches, we show that corporate finance, retail, and commercial banks are the most efficient banks in Luxembourg, followed by custodian and investment funds and private banks. These findings may be explained by the revenue and cost structures of banks' business models. According to the BCL's 2019 Financial Stability Review, interest income represents more than 78 percent of retail and commercial banks revenues. A similar observation is also found for corporate finance banks with 69 percent of their income coming from interest-related income. However, different results emerged for custodian and investment funds and private banks. More precisely, non-interest income such as net fees and commissions represent the largest share of their incomes with 75 and 49 percent for custodian and private banks, respectively. In view of the persistently low interest rate environment, we looked at bank efficiency scores of banks deriving their revenues from interest-related activities, namely retail and commercial, and corporate finance banks before and after the Global Financial Crisis (GFC). Our results did not indicate any statistical differences in relation to efficiency estimates for these banks before and after the GFC using both the intermediation and value added approaches as we found *p-values* of 0.56 and 0.26, respectively. In order to delve into these findings, we assess the drivers and other factors underlying bank efficiency scores in Luxembourg. More precisely, this study conducts an empirical investigation to analyze the

main determinants of bank efficiency across business models. Using the instrumental variable approach for causal inference, we find the following results. For retail and commercial banks, the coefficient associated with the capital ratio in terms of total assets is positive and significant; suggesting that better capitalization enhances efficiency for this particular business model. This finding is in line with the literature in banking, which argues that banks holding more capital are more likely to be well managed and more profitable financial institutions, hence more efficient compared to those with less capital. For private and custodian and investment banks, size has a nonlinear impact on bank efficiency, namely an inverted U-shaped relationship between size and efficiency. Interestingly, we show that diversification has a positive and significant effect on efficiency for all banks across business models exception for retail and commercial banks.

To conclude, this research used the Data Envelopment Analysis (DEA) method to estimate bank efficiency in Luxembourg, which is an international financial center. Using data from 2000-2018, this study finds that the Luxembourg banking sector has an average efficiency score lying between 0.79 and 0.83 using the intermediation and value added approaches, respectively. According to segments, i.e. countries of origin, this work also shows that Luxembourgish banks are the most efficient, while corporate banks are found to be the most efficient in terms of their business models. In addition, the levels of bank efficiency for significant and less significant banking institutions are similar on average. However, bank efficiency scores in Luxembourg have been decreasing since the Global Financial Crisis (GFC). Precisely, we find a statistically significant difference in the means of efficiency scores before and after the crisis at the 1 percent level for both the intermediation and value added approaches.

Looking ahead, the results obtained in this paper may have important policy implications. First, this research has clearly shown the positive effect of bank income diversification on efficiency for banks according their type of activity. This result is in line with the ECB's November 2019 Financial Stability Review , which found that the low profitability of the euro area banking sector can be mainly attributed to the limited degree of revenue diversification since 2012. Second, it found an inverted U-shaped causal relationship between size and efficiency, suggesting there is a nonlinear relationship between bank size and efficiency. Third, the equity ratio has a negative and significant effect on bank efficiency, in line with the agency costs theory developed by Jensen and Meckling (1976). Hence, our results suggest that banks operating in Luxembourg could diversify their activities/revenues in order to increase efficiency. Additionally, financial regulators could monitor banks in terms of size and the equity ratio in order to enhance bank efficiency. Third, there was no clear evidence between bank concentration and efficiency as suggested by the quiet life hypothesis (QLH). The drivers identified in this research provide some insight into how banks in Luxembourg may potentially increase their efficiency.

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