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IDENTIFICATION OF EU BANK BUSINESS MODELS

A NOVEL APPROACH TO CLASSIFYING BANKS IN THE EU REGULATORY FRAMEWORK

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ABSTRACT

This paper proposes a standardised classification of business models of the European Union (EU) banks. Our work is based on a rich and unique dataset collected for the first time for the full population of EU banks at individual level. The proposed approach to classification combines both a qualitative and a quantitative component, which is a new approach compared with relevant literature in business model identification and classification. The qualitative component is based on an expert knowledge of the supervisory authority, which is confirmed or challenged by quantitative indicators. Our findings are that banks' classification through this mixed approach allows better and more granular identification of banks' business models than the clustering methodology, which is more commonly used in the literature. The business model categorisation can provide the supervisory and regulatory authorities with a benchmark for classifying institutions for a more structured and consistent approach to regulatory impact assessment, analysing trends and risks, proportionality, and supervision, ensuring the continuity and comparability of results over time.

KEYWORDS

Business models, business model analysis, EU banks, clustering, regulation, impact assessment, proportionality, peer review.

Abbreviations

BMA	business model analysis
CCP	central counterparty
COREP	common reporting
CRR	Capital Requirements Regulation
CSD	central securities depository
CSDR	Central Securities Depositories Regulation
EBA	European Banking Authority
EU	European Union
FINREP	financial reporting
IFRS	International Financial Reporting Standards
IP	immovable property
LCR	liquidity coverage ratio
LR	leverage ratio
GAAP	generally accepted accounting principles
NSFR	net stable funding ratio
PTF	pass-through financing
SREP	Supervisory Review and Evaluation Process
TA	total assets

1. Introduction

Following the financial crisis of 2008, there has been a wave of regulatory reforms aiming to address the weaknesses in the financial system as well as banks' business models (Liikanen, 2012). As a response to the new regulatory context, banks adapted their business strategies and balance sheet structures to comply with the new rules while focusing on recovering profitability (Ayadi et al., 2011).

In this context, the identification of business models emerges as an important task for regulators and supervisors for three reasons. First, the crisis showed the need to understand at a macro level the various business models, as they determine the types of risks the institutions are exposed to and possible threats to financial stability. Second, with the introduction of new capital and liquidity rules, business models are a tool to assess how different groups of banks might be affected by forthcoming regulation and how they might adapt to incorporate these new rules into their business strategies. Finally, for supervisory purposes, it is important to maintain a micro view at the institution level to assess its performance and riskiness in relation to its peers.

In this paper, we propose a business model classification that can be used for all of the above purposes. Moreover, we propose that this business model classification be used as a baseline classification of banks to tailor the regulation to the specific features of each business model group, i.e. to calibrate regulation in a proportionate manner.

A business model classification is useful if it is standardised and readily available whenever a regulatory impact assessment is required. Despite the requirement for EU supervisors to assess the business models of the supervised banks, there are no common business model definitions and categories across the EU for regulatory purposes. Business model analysis (BMA) within the current supervisory review and evaluation of banks, commonly known as Pillar 2 capital add-ons, is a detailed analysis of the viability and sustainability of banks' business models.[1] However, because of its focus on the identification of each bank's business and strategic risks and the assessment of the institution's business model viability, the BMA does not provide a classification of banks by business model that is readily available and easily usable for analysis of trends and risks at macro level and regulatory impact assessment.

The academic literature also attempted to classify banks by business model. The studies in the area of business model classification focus on quantitative approaches, based on clustering methodologies applied to the financial accounts of banks. This approach is rigorous because it reflects the balance sheet structure of the banks. However, missing any qualitative assessment, it allows only three to five very broad categories of universal, retail and wholesale banks to be distinguished, without further granularity with respect to specialised business models such as mortgage banks or public development banks. Moreover, the existing studies use data at consolidated level, which means that data for many individual institutions within the same banking group, which probably follow different business models, is aggregated and disregarded. The application of such a classification for policy purposes is limited by lack of granularity and identification of specialised business models.

[1] In the current European framework, business model analysis (BMA) is one of the key elements of the Supervisory Review and Evaluation Process (SREP) Guidelines (EBA, 2014). This is a set of guidelines regarding the application of common supervisory procedures and methodologies by all the supervisory authorities in the EU, commonly known as Pillar 2 capital add-ons. According to the SREP Guidelines, the key outcome of the business model analysis is the identification of business and strategic risks and the assessment of the institution's business model viability and sustainability.

In this paper, we use a unique dataset with information on business models from all the individual European Union (EU) credit institutions. We propose a novel approach to the classification of banks that combines a qualitative and a quantitative component, which is a new approach compared with relevant literature in business model identification and classification. The qualitative assessment is provided by the expert judgement of supervisory authorities, as these are closer to the institutions that they supervise and thus have a better understanding of their business. The results of the qualitative assessment are challenged afterwards using quantitative indicators, which represent balance sheet ratios based on common reporting (COREP) and financial reporting (FINREP).

We find that the business model classification is compatible with the classification resulting from a clustering methodology, which is more commonly used in the academic literature. However, in addition, the hybrid approach allows a more granular classification compared to the clustering methodology, taking into account the specificities of the banking sector in each country and other information that is not quantifiable, such as legal structure and ownership. It thus captures both diversified and specialised business models of EU banks. This business model classification can provide a standardised benchmark for classifying institutions and can be used in a broader context, for instance for the identification of trends, risks, supervisory peer review, regulatory impact assessment and proportionality.

The paper is organised in six sections. In the second part, the literature that classifies banks by business model is reviewed and provides context to the methodology used in this paper. The third part describes the methodology, the data and the process of challenging the original data submitted for this analysis. In the fourth part, the final business model classification is presented, together with the overview of the EU banking population and business model categories. The fifth part compares the business model classification with the results of the clustering methodology. Finally, the sixth part provides the conclusion, proposes policy recommendations on how the classification can be used in practice by supervisors and regulators, and suggests venues for further research.

2. Literature review

This section reviews the relevant literature on the definition of business models for banks, the methodologies for identifying categories of business models and the allocation of banks to these categories.

2.1 Identification of business models

There is wide agreement in the supervisory community and in the academic literature that banks follow different business models because of the different choices that they make in terms of assets and liabilities, as well as strategies taken for profitability purposes. Beyond this general understanding of the business model, there is no consensus on the business model definition itself and on which characteristics are most relevant in assigning a bank to a business model.[2] These characteristics may vary from balance sheet and income structure, to strategy and market segment.[3] In a hypothetical scenario where one would take into account all the relevant and available

[2] This lack of consensus on business model definition also persists outside the financial sector (Zott and Amit, 2011).

[3] For example, for credit institutions, one of the most commonly used dimensions is specialisation, which distinguishes betwee n two groups of banks: 'specialised banks', which restrict themselves to a few activities (e.g. consumer credit, mortgage, trade finance, project finance, lending to public entities), and 'universal banks', which combine different banking activities. The market segment dimension can be used to differentiate between 'retail focus banks' such as 'consumer credit', 'savings' and 'cooperative banks', which mostly deal with individuals and small businesses customers, 'wholesale banks', which provide most of their services to large business entities and receive funds predominantly from wholesale clients, and 'private banks', which provide wealth management services to wealthy individuals.

dimensions, the conclusion would inevitably be that each institution (or a small set of institutions) has a unique business model, tailored to its specific needs, market and circumstances. This is in line with the conclusion of Mergaerts and Vennet (2016) that the European banking sector is characterized by a continuum of possible business models, rendering any classification based on balance sheet indicators difficult. In practice, taking into account all possible dimensions for purposes other than a detailed analysis of a single bank for supervisory purposes may be a daunting and resource-consuming task. Hence, a more efficient way of separating banks by business models should be identified.

Several papers in recent years have proposed classifications of banks into discreet business model categories that would be meaningful, intuitive and based on quantitative characteristics of the institutions classified. These papers can be classified based on the methodologies employed as follows:

- Studies that use clustering approaches to classify banks based on a set of characteristics. The clustering methodology uses an algorithm that assigns items (in this case banks) to clusters in such a way as to minimise the distance between the items within one cluster and maximise the distance between the averages/median/centroids of the clusters. The distance is a pre-defined metric of how similar or dissimilar the items are, based on certain variables. The most commonly used distance measure is the within-group sum of squares (i.e. variation). These papers mostly rely on the agglomerative hierarchical clustering method described by Ward (1963) or the partitional clustering method based on that of Vichi and Kiers (2000).[4]

- Studies that use qualitative approaches to classify banks by business model. These studies use a pre-defined business model classification, based on activities, funding and legal structure of the banks. The banks are then allocated to each of these categories based on expert judgement. The only author using such a qualitative approach is the EBA (2014b, 2015, 2016).

Starting with the first group of papers employing the clustering methodology, Ayadi et al. (2011) explore which variables are relevant to define a bank business model, and provide preliminary evidence on the importance of business model analysis in regulation and supervision.[5] Ayadi et al. (2011, 2012) and Ayadi and De Groen (2014)[6] introduce the asset-liability approach and use a hierarchical clustering method based on that of Ward (1963) to identify groups of banks with similar balance sheet characteristics. The authors distinguish between key banking activities (i.e. retail versus market or mixed) and the funding strategies (i.e. retail versus market or mixed). To account for these factors collectively, without over-representing any particular factor, indicators that constitute the defining activity/funding features of a business model in banks from an asset and liability stand point were used to form the clusters.

In their latest paper (Ayadi et al., 2016), the sample used for the clustering consists of 2 542 EEA banking groups and subsidiaries over the period 2005-2014. This represents 95 % of the total assets in the EEA and Switzerland. The authors are able to distinguish five types of banks based on a hierarchical clustering algorithm: focused retail,

[4] A partitional clustering is a division of a set of data objects into non-overlapping subsets (clusters) such that each data object is in exactly one subset. By contrast, a hierarchical clustering results in a set of nested clusters that are organised as a tree.

[5] Their second publication (Ayadi et al., 2012) provides the evidence on a larger sample and emphasises the importance of monitoring bank business models.

[6] The most recent paper of a series authored by Rym Ayadi and Willem Pieter De Groen is Ayadi et al. (2015). We mainly refer to this last paper, as it has the largest sample and widest database in terms of data.

diversified retail Type I (more trading assets and bank loans), diversified retail Type II (mostly relying on debt liabilities), wholesale and investment.

Roengpitya et al. (2014) use a similar clustering approach on a sample of 222 banks from 34 countries worldwide over the period 2005-2013. The authors identify three separate clusters that are described as 'retail funded', 'wholesale funded' and 'trading'. Roengpitya et al. (2017) apply a similar clustering methodology to a sample of 178 banks over 11 years (2005-2015). This examines the systematic effects that a bank's transition across business models over time may have on the bank's performance. Like Ayadi and colleagues before them, they find that the retail-funded and wholesale-funded commercial banking models are more robust to the choice of inputs than business models focused on trading activities and a universal banking model.

In the papers mentioned above, the analysis is primarily driven by data, but incorporates elements that call for judgement when selecting the variables for clustering the institutions into business model clusters. The variables in all studies mentioned are limited to balance sheet indicators, with ratios that reflect the structure of the assets and the liabilities of the banks. The result depends to a large extent on several methodological choices: distance metric; instruments chosen for clustering; and stopping rule used to determine the optimal number of clusters.

Farne and Vouldis (2017) reduce the judgemental components by taking a more structured approach to selecting indicators. Out of a set of 1 039 variables, the authors use only those that have the highest discriminatory power, reducing the number of indicators to 382.[7] The clustering was conducted on a sample of 365 banks in 19 euro area countries in Q4 2014. The authors applied k-means clustering based on the method of Vichi and Kiers (2001), which is a partitional method, as opposed to hierarchical as in Ayadi et al. (2011, 2012, 2016), Ayadi and De Groen (2014) and Roengpitya et al. (2014, 2017). Following this approach, the authors identified four business models – traditional commercial banks; complex commercial banks; wholesale-funded banks; and securities-holding banks – and, in addition, several outlier banks that did not fit into any of the groups identified (mainly small investment firms and specialised lenders).

A more qualitative approach is used by the EBA (2014b, 2015, 2016), which assesses the impacts of liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) and calibrates the leverage ratio (LR). The analysis in the EBA reports is based on samples of 322 banks (as of December 2013), 279 banks (as of December 2014) and 246 banks (as of June 2015) respectively. In all cases, data is collected at the highest level of consolidation. EBA (2017b) uses a sample of 157 banks to analyse the impact of the LCR requirement on a number of business models (as of December 2016). Unlike in other reports, subsidiaries with an EU parent institution are included in the analysis. The expansion of the sample to subsidiaries aims to take into account the diversity of business models within the overall banking groups.[8] The business model classifications in these reports are based purely on the expert judgement of the national supervisors. These business model categories are defined together with the supervisory authorities, and the banks are assigned to each business model category in this process. The assumption behind such an approach is that supervisors responsible for the bank have all the necessary information, including the relevant qualitative information, to accurately assign each banks to its business model.

[7] The selection of variables was done according to their importance, measured for each variable as the sum of the absolute correlations with respect to all the other variables. Data points that were very narrowly populated were also removed.

[8] It also is in line with the condition that all banks have to comply with the capital and LCR minimum requirement both on a consolidated and individual basis, unless waivers apply.

2.2 Comparing approaches

Quantitative approaches, i.e. those based on clustering methods, allow the differentiation of institutions into very broad categories of universal, retail and wholesale banks, based on rigorous criteria. Further granularity is difficult to achieve based on balance sheet indicators alone. Even in the case of Farne and Vouldis (2017), where the variables were carefully chosen based on their discriminatory power from a wide dataset, the clustering generated four meaningful business models (traditional commercial banks; complex commercial banks; wholesale-funded banks; and securities-holding banks). The reason for such a limited business model range seems to be twofold:

- First, some relevant information is lacking for business models that are not captured by the balance sheet indicators. Such information may be ownership, legal structure, branch network, market segment etc. These dimensions, while not included in the financial statements, are considered by the supervisors when assessing the institutions' business models (EBA, 2014b, 2015, 2016), and hence in practice do define to some extent the business model of the institution.

- Second, many institutions do not clearly fall under a single business model category but rather combine various types of business lines of activities and funding strategies, among other elements, which makes the institutions fit into several business models. This is especially true when data is used at consolidated level, as is the case for all the studies mentioned that classify the banks by business model using clustering, as different entities in the same financial group may in fact follow different business models. On a consolidated level, this will lead to a diversified business model, while de facto the group may incorporate several individual banks with different well-defined business models.

A qualitative approach, such as that of the EBA (2014b, 2015, 2016), whereby business models are differentiated based on the expert judgement of the supervisory authorities, allows a much more granular differentiation between very narrowly specialised business models. It also provides more flexibility to the classification of institutions across business models, taking into account specificities of the national financial sectors. This type of approach, however, suffers from the drawback that it may be prone to errors and subject to human bias.

3. Methodology and data

To classify banks by business model we use a hybrid approach, which combines a qualitative categorisation of institutions by business model, with further validation of the classification using quantitative indicators. This alternative hybrid approach allows leveraging the benefits of both the quantitative and qualitative approaches described in the previous section. As opposed to the studies focused on the clustering methods, this alternative hybrid approach provides more flexibility to the classification of institutions across business models, taking into account specificities of the national financial sectors. At the same time, by using quantitative indicators it gives an additional quantitative base to confirm or challenge the initial qualitative classification.

Moreover, to apply this methodology, in this paper we make use of a unique collection of data at solo level. By using individual/solo data for the full EU banking landscape, the paper considers the specificity of each individual institution, irrespective of the business model of other institutions in the same group, which is a new approach compared with the existing literature. The benefits of such an approach are that it allows a more granular differentiation of business models.

3.1 Methodology

The methodology to classify banks by business model proposed in this paper combines a qualitative categorisation of institutions by business model, with further validation of the classification using quantitative indicators. To do this, the following steps have been taken:[9]

- Step I: Defining and classifying banks by business models (qualitative part);
- Step II: Challenging the business model categories and classification using quantitative indicators (quantitative part).

In previous studies, the business model categories were derived following a process of automatic classification of institutions based on a clustering algorithm, with a subsequent description of the resulting groups based on their descriptive statistics. The first step of the methodology used in this paper is to use a qualitative classification, where the definition of the business models is more detailed and qualitative in nature, reflecting the more practical and informal classifications used by the supervisory authorities. It is based on expert judgement of supervisory authorities and therefore allows a better differentiation between very narrowly specialised business models. This provides more flexibility to the classification of institutions across business models, taking into account the national specificities of the financial sectors. Since this approach is prone to errors and subject to human bias, allowing too much national discretion in the interpretation of business models may lead to a classification of institutions that is not harmonised and comparable across EU jurisdictions. This is minimized with the quantitative challenge.

To develop the standardised list of business model categories, the categories of the EBA (2014b, 2015, 2016) are used. Table 1 illustrates the initial proposed business model categories that are used to collect the data from supervisory authorities. Each of these business model categories is in advance described in relation to three dimensions: activities, funding and legal structure.[10] Each supervisory authority is then asked to assign each solo credit institution within its jurisdiction to one of these business model categories, using as a basis the qualitative description provided.

Table 1. Business model categories: initial proposed categories

Number	Business model	Type of business model
1	Cross-border universal banks	Cross-border universal banks
2	Local universal banks	
3	Consumer credit banks (including automotive banks)	Retail-oriented banks
4	Cooperative banks/ savings and loans associations	
5	Savings banks	
6	Mortgage banks taking retail deposits	
7	Mortgage banks not taking retail deposits – pass-through financing	
8	Private banks	
9	Merchant banks	Corporate-oriented banks
10	Leasing and factoring	
11	Public development banks	Other specialised banks
12	Central counterparties (CCPs)	
13	Custodian institutions, including central securities depositories (CSDs)	
14	Pass-through financing (excluding mortgage banks)	

[9] In practice the data for both steps was collected in one single data collection

[10] Please refer to section 4.1 for final business model categories and description. We do not provide the description of the original business model categories because it is close to the final one.

Number	Business model	Type of business model
15	Islamic finance	
16	Other specialised banks	

In the second step, we challenge the business model classification originally provided by the supervisory authorities with a set of relevant quantitative indicators with the aim of assessing the consistency of the institution's balance sheet features with the description of the business model to which the institution is allocated. Challenging the business model classification is important for two reasons. First, as the classification is conducted based on expert judgement, supervisory authorities may interpret business models in different ways, which would render the classification not comparable across jurisdictions. Second, challenging the classification provides another layer of data quality checks, minimising operational errors from the data collection exercise. Subsequent resubmissions of data reflect the changes in business model classification resulting from these challenges.

Table 2 lists 10 indicators that were chosen for testing the business model classification. These indicators closely describe the qualitative features of the business models and majority have been used as variables for clustering banks in the academic literature. Table 2 also explains how each indicator will be used to test business models.[11] For example, data is collected on the share of exposures secured by immovable property, and values of this indicator are checked for mortgage banks to ensure that it is consistent with the expectations of what the main business of a mortgage bank is.

The challenging of the business model classification is designed in the form of automatic tests that compare the values of indicators with benchmarks specific to the banks' business model. The benchmarks define the expected range of values for the indicator for the specific business model. The tests thus validate the classification of banks by business model by identifying inconsistencies between the values of the indicators and the business models to which the institutions are allocated. To develop the previous example, the share of exposures secured by immovable property in a mortgage bank is expected to be non-zero. If it is zero, then there are three possible explanations:

- the value of the reported indicator is wrong, hence it needs to be verified;
- the business model category to which the institution is assigned is not the most appropriate for the given bank, hence it needs to be verified or reviewed;
- the national supervisor has a reasonable explanation why the value of the indicator does not fit with the description of the assigned business model category.

The benchmarks are developed using as a starting point the lower and upper bounds for outliers within each business model and expectations of what the threshold should be. In this process, it is assumed that banks are allocated correctly at the outset. The benchmarks used for testing indicator values are provided in Annex 8.1. As data over more periods of time is collected, the benchmarks can be refined. However, even as more data is used, the benchmarks will remain indicative, since the methodology allows expert judgement of supervisory authorities to prevail, and the benchmarks are used only to identify banks whose classification may need to be reviewed.[12]

[11] It was not possible to use all the indicators to challenge the business models, as indicators were defined in advance, without prior knowledge of how effective and useful they would be in practice.

[12] Another way to address this drawback is to use as a basis for benchmark calculation a representative sample that is 'correctly' classified by business model. One possibility that was considered for developing benchmarks was the list of approximately 200 institutions for which CAs submit the supervisory data to the EBA. The original list can be found on the

Table 2. Indicators based on COREP/FINREP used to assess the business model classification

Indicator		Description
A0	**Total assets (balance sheet size)**	Total assets of an institution. This indicator is collected to assess the size of the institution.
A1	**Share of exposures secured by residential immovable property on institution balance sheet**	Bank's activities related to mortgage loans. The indicator distinguishes business models specialised in residential mortgages, such as mortgage banks and building societies, from other types of business models. Other banks that serve the local communities, such as cooperative, savings and local universal banks, are also likely to have such exposures.
A2	**Size of trading book**	Trading portfolio of an institution. It identifies banks that are active in trading (equity, securitisations, covered bonds, other subordinated debt instruments). These could include several business models, including investment firms, CCPs, securities trading houses and universal banks. Derivatives were excluded from the trading assets because of the different accounting treatment in International Financial Reporting Standards (IFRS) and national generally accepted accounting principles (GAAP). For completeness, derivatives were calculated as a separate indicator.
A3	**Share of derivatives on institution balance sheet**	Amount of derivative trading (hedging derivatives are not included) for reporting institutions. The indicator identifies banks that are active in derivative trading. The indicator is measured separately for IFRS and n-GAAP reporting banks because of the differences in the accounting rules for derivatives in these two frameworks.
A4	**Cross-border activity**	Share of an institution's cross-border activities in relation to its overall activity. The indicator distinguishes between cross-border (e.g. universal, some merchant banks) and domestically oriented banks' business models, such as local and small cooperative banks.
A5	**Share of retail deposits on institution balance sheet**	Amount of deposits from non-bank and private customers (households, enterprises). It distinguishes between banks with a more traditional business model, which rely on more stable sources of funding, such as savings banks and cooperative banks, and banks that rely on more diversified sources of funding, such as universal banks and investment firms.
A6	**Share of securities liabilities on institution balance sheet**	Funding by issuing securities, such as covered bonds, securitisation or other unsecured debt. In particular, this indicator identifies business models that are financed almost exclusively from issuing such securities, such as banks specialised in covered bonds or pass-through financing.
A7	**Share of interbank borrowing on institution balance sheet**	Size of interbank borrowing such as deposits and issued debt of other banks, relative to the size of the balance sheet of an institution. It identifies business models that rely on short-term funding, such as universal banks and the investment-oriented business models.
A8	**Leverage ratio**	Leverage of an institution. It distinguishes between banks that rely on higher leverage, such as cross-border universal banks and custody banks, and those that rely on lower leverage, such as small local universal banks, savings banks and cooperatives.

EBA website at https://www.eba.europa.eu/-/eba-updates-list-of-institutions-involved-in-the-2017-supervisory-benchmarking-exercise. The benchmarks based on this sample would not be adequate for several reasons. First, the classification of EBA sample institutions was based on best efforts, without it being challenged by the EBA in any way. Second, the sample was limited to approximately 200 credit institutions for which supervisory data was submitted to the EBA in 2015. These institutions are mainly large banks and therefore are not representative of the full EU banking population in terms of balance sheet size and structure. Third, the supervisory data for the EBA sample is provided at the highest level of consolidation in a Member State. This means that, in cases where the institution is not a standalone entity reporting on an individual solo basis, it reports data for a larger number of institutions consolidated in one group, and as a result may cover data for institutions that follow different business models.

Indicator		Description
A9	**Fee income relative to interest income**	Income from fees and commissions in relation to the income from interest. It identifies banks that specialise in providing services, such as asset management (private banks) and trade finance (merchant banks), as opposed to those relying on interest income (business models specialised in provision of loans).

Not all business models can be tested using these types of tests. In certain cases, balance sheet information is not sufficient to distinguish between two pre-defined business models. For example, this is the case for cooperative and local universal banks, which often have similar activity profiles but differ mainly through their ownership structure and governance. Since ownership and governance data is not covered in the data collection, a more in-depth knowledge of the institutions is required to make such a distinction. An implication of such an approach is that any classification that is determined primarily by the supervisory authority based on ownership and governance, or other information for which no data is collected, cannot be challenged and is taken as given by the authority.

3.2 Data Collection

The data on business models and indicators was collected for the entire population of credit institutions within each EU jurisdiction, specifically for the purpose of classifications of institutions by business model. This was a voluntary ad hoc data collection exercise in which 27 out of the 28 EU Member States[13] and Norway participated. The final dataset comprised 5 292 credit institutions *at solo level as of 31 December 2015*, representing the full population of credit institutions in the EU.[14] Investment firms[15] and branches[16], of either EU or non-EU parents, were not included in the scope of this analysis.

The data was collected at solo level for all EU institutions.[17] This is a novelty in the literature on business model classification. Using data at solo level is particularly useful, since it allows a more granular differentiation of business models. Institutions reporting on a consolidated level report aggregate data for a large number of members of the group, which may follow different business models. The different business models of each of these institutions cannot be distinguished within the consolidated balance sheet of the reported group data. As a result, consolidated data is more likely to lead to the allocation of the institution to a diversified universal business model category, compared with solo data, which may allow a more granular analysis bank by bank and

[13] The exception was Bulgaria.

[14] Data was received for 5 293 institutions, but an Italian credit institution was removed, as it did not report data on total assets (and did not report for the remaining indicators).

[15] Investment firms as defined in Article 4 of the CRR, including securities trading houses, were excluded from this analysis, although data for them was collected. Six large bank-like investment firms ('designated firms') were also excluded. The investment firms were not included in the analysis because of the parallel work on the Investment Firms Regime, which also addressed the issue of business model classification. According to this analysis, investment firms were classified into nine categories based on expert judgement with regard to their activities. The final report can be found on the EBA website (EBA, 2017a).

[16] Branches of foreign non-EU institutions were excluded from the data collection exercise. At the same time, any branches of foreign EU institutions are automatically included in the reporting of their EU parent (as they are one single legal entity) and therefore there is no individual data on those.

[17] Data at standalone or solo level treats each entity as if it were entirely separate – the parent unrelated to the subsidiaries, and the subsidiaries unrelated to one another. By contrast, consolidated data covers the activities of the parent company and its subsidiaries, as if they were all a single company operating under one roof.

identification of business models of individual members of the groups.[18] The drawbacks of reporting at solo level is that in some cases we may be interested in the group business model, given that strategies are often defined at group level first and then it trickles down to individual bank strategies.

Data collection was limited to indicators based on readily available supervisory data in COREP and FINREP. Any other type of information would have required data gathering from other sources, which would likely have an impact on the consistency of data used. All the main dimensions were captured with the selected variables, but some dimensions of the pre-defined business models could not be tested as they were not based on balance sheet indicators. For example, information pertaining to ownership/legal structure dimension was not captured by any of the indicators, since COREP/FINREP does not have such data. Likewise, other aspects, such as the amount of activity relating to wealth management, was not collected to alleviate the burden for the supervisory authorities. Instead this information was indirectly incorporated in the business model classification by the supervisory authorities making use of the guidance given to them on the qualitative assessment. Future work may meaningfully pursue these dimensions further.

3.3 Feedback from the supervisory authorities

Using as a guidance the results of the tests challenging the initial allocation of banks to business models, the business model classification and the value of the relevant indicators are reviewed by the supervisory authorities. More specifically, the supervisory authorities provided three types of feedback:

- Review of business model categories or benchmarks:
    - After reviewing the quantitative indicators, it was possible to identify business models that initially were not reflected in the list of business model categories and also find some common features between categories that have previously been set as separate business models. As a result, the initial 16 proposed business model categories and their descriptions were modified to more appropriately reflect the EU financial market and the features of the EU institutions, resulting in 11 final business model categories. The comparison between the initial proposed business model categories, based on those of the EBA (2013, 2015, 2016), and the final business model categories is presented in Table 3. The main changes and clarifications applied to the business model categories are the following:
        - German Bausparkasse were included in the Mortgage banks taking retail deposits (BM06);
        - Merchant and leasing and factoring banks were merged into one single corporate oriented business model due to similarity of the groups;
        - German Landesbanken were included in the corporate-oriented category (BM08), because of their predominant wholesale banking and serving of the regional business;
        - German Sparkassen were included in the Cooperative banks/savings and loans associations (BM04).

[18] This can be observed in the reports by the EBA (2013, 2015, 2016), where the largest banks are classified by business model. Out of the 192 institutions for which supervisory data is sent to the EBA by the CAs, 120 institutions (i.e. 62.5 %) were identified as local or cross-border universal banks.

        - Mortgage banks not taking retail deposits where merged with the pass-through financing banks, due to their similar features.

        - It was clarified that the central bodies of cooperative banking systems are to be reported in the business model category Other specialized banks (BM11)[19].

    - The test for the indicator A8 leverage ratio was removed. This indicator was initially intended to challenge the business models to identify banks that rely on higher leverage, such as cross-border universal banks and custody banks, and those that rely on lower leverage, such as small local universal banks, savings banks and cooperatives, as identified by the EBA (2016). However, in practice, the collected data showed that the leverage ratio was very high for all business models and did not demonstrate significant differences across business models.

    - No comments were provided by NCAs on the values set for the thresholds that challenged their classification.

- Review of allocation of banks to business models and/or values of indicators: There were 881 inconsistencies found between business model allocations and values of indicators of the allocated banks. As a result of the tests, there were 68 changes in business model classifications and 233 changes in the values of the indicators.

- In cases where neither the business model nor the value of the indicator was changed (580 out of 881 inconsistencies found), an explanation was sought from the supervisory authority to justify the inconsistency between the value of the indicators and the bank business model. The supervisory authority provided a justification for the inconsistency in 233 cases and no explanation was provided for the remaining 347 cases. Most inconsistencies were connected to cooperative banks and savings and loans associations, which found amounts of retail deposits that were too low or amounts of cross-border exposures that were too high.

[19] Some cooperative banking systems have been reported on a consolidated level, as the central body (parent) serves to fund and provide other services to its members.

Table 3. Business model categories: initial proposed categories and final categories

Broad business model category	Initial proposed categories used for data collection, based on those of the EBA (2013, 2015, 2016)			Final categories (used in the paper)
Cross-border universal banks	1	Cross-border universal banks	BM01	Cross-border universal banks
	2	Local universal banks	BM02	Local universal banks
Retail-oriented banks	3	Consumer credit banks (including automotive banks)	BM03	Consumer credit banks (including automotive banks)
	4	Cooperative banks/savings and loans associations	BM04	Cooperative banks/savings and loans associations
	5	Savings banks	BM05	Savings banks
	6	Mortgage banks taking retail deposits – building societies and other mortgage banks	BM06	Mortgage banks taking retail deposits (including building and loan associations from Germany – Bausparkasse)
	7	Mortgage banks not taking retail deposits – pass-through financing		
	8	Private banks	BM07	Private banks
Corporate-oriented banks	9	Merchant banks	BM08 (including 9 and 10)	Corporate-oriented (including leasing and factoring, merchant banks and Landesbanken from Germany)
	10	Leasing and factoring		
Other specialised banks	11	Public development banks		
	12	CCP		
	13	Custodian institutions (including CSDs that are subject to the CSDR)	BM09	Custodian institutions (including CSDs that are subject to the CSDR)
	14	Pass-through financing (not mortgage banks)	BM10 (including 7 and 14)	Institutions not taking retail deposits (including pass-through financing)
	15	Islamic finance		
	16	Other specialised banks	BM11 (including 11, 12, 15 and 16)	Other specialised banks (including public development banks, Islamic finance, cooperative central banks, CCPs)

Note: Colours in this chart indicate the business model categories that have been merged to create new categories. Where there was a misalignment between the classification of banks by business model provided by supervisory authorities and outcome of indicators, supervisory authorities were asked to provide justification and/or review the initial classification.

4. Results: the EU banking landscape

This section provides an overview of the results: the final business model categories, the EU banking landscape across countries, size, and business models, as well as the quantitative characteristics of the banks allocated to each business model category.

4.1 Final business model categories

Table 4 below presents the final list of business model categories that has been produced after the banks allocation to the original list was challenged using the quantitative indicators. Like the original list of business model categories, each of these business model categories is defined in relation to three dimensions:

- activities: defining the type of activities the institution is engaged in and reflected mostly in the assets side of its balance sheet;
- funding: defining the sources the institution uses to fund its activities;
- legal structure: defining the various characteristics of the institution related to its ownership and legal structure.[20]

The business models are grouped into four broad categories – universal, retail-oriented, corporate-oriented and other specialised business models – for ease of reference.

This list is used as basis for the description of the EU banking landscape and structural features by business model in the next section.

[20] Legal structure also includes information on ownership. These two pieces of information are merged because the legal structure can often be defined by, among other things, the ownership of the institution and vice versa. For example, an institution that is owned by its clients is legally a cooperative bank.

Table 4. Final business model categories and descriptions

Broad business model category	No	Business model	Business model short name	Qualitative description of the business model		
				Main activity/ies	Main funding	Ownership/ legal structure
Universal banks	BM01	**Cross-border universal bank**	Cross-border	- Engaged in several banking activities including retail, corporate and capital market operations. - Major cross-border operations.	- Diversified source of funding including deposits from clients, wholesale funding and derivatives liabilities. - Significant part of funding can come from foreign investors. - Taking or not taking retail deposits.	- Major cross-border cooperative banks: owned by depositors. - All the others: no specification.
	BM02	**Local universal bank**	Local universal	- Engaged in several banking activities including retail, corporate and capital market operations. - Operating predominantly in its domestic market.	- Diversified source of funding including deposits from clients, wholesale funding and derivatives liabilities. - Predominantly funded in its domestic market. - Taking or not taking retail deposits.	- Major cross-border cooperative banks: owned by depositors. - All the others: no specification.

Broad business model category	No	Business model	Business model short name	Qualitative description of the business model		
				Main activity/ies	Main funding	Ownership/ legal structure
Retail oriented banks	BM03	**Consumer credit banks (including automotive banks)**	Consumer/ auto	- Originating and servicing consumer loans to retail clients.	- No specification.	- No specification.
	BM04	**Cooperative banks/savings and loans associations**	Cooperative	- Originating and servicing loans to local community individuals and businesses. - Diversified cooperative banks should be included in the category of cross-border or local universal banks. - Building and loan associations from Germany (*Bausparkasse*) should be included in the category of mortgage banks taking retail deposits.	- Retail deposits.	- Owned by depositors.
	BM05	**Savings banks**	Savings	- Retail banking (payments, savings products, credits and insurances for individuals and small and medium enterprises).	- Retail deposits.	- No specification.
	BM06	**Mortgage banks taking retail deposits (including building and loan associations from Germany – *Bausparkasse*)**	Mortgage (deposits)	- Originating and servicing mortgage loans to retail clients. - Includes the building and loan associations from Germany (*Bausparkasse*).	- Retail deposits.	- Building societies: subject to specific statutory requirements with respect to activities and purpose. - All the others: no specification.
	BM07	**Private banks**	Private	- Wealth management services to high net worth individuals.	- No specification.	- No specification.

Broad business model category	No	Business model	Business model short name	Qualitative description of the business model		
				Main activity/ies	Main funding	Ownership/ legal structure
Corporate-oriented	**BM08**	**Corporate-oriented (including leasing and factoring, merchant banks and *Landesbanken* from Germany)**	Corporate	- Specialised in financial services for businesses and projects such as financing domestic and international trade; products such as letters of credit, bank guarantees and collection and discounting of bills, leasing (asset-backed financing) and/or factoring activities (the bank pays value of receivable less a discount for commission or fees); project finance. - *Landesbanken* from Germany should be included in this category.	- Both taking and not taking retail deposits.	- No specification.
Specialised business models	**BM09**	**Custodian institutions (including CSDs that are subject to the CSDR)**	Custodians	- Custodian services (holding securities in electronic or physical form on behalf of corporate and individual investors for safekeeping). - Other services such as account administration, transaction settlements, collection of dividends and interest payments, tax support, and foreign exchange.	- No specification.	- No specification.
	BM10	**Institutions not taking retail deposits (including pass-through financing)**	Pass-through	- Originating and servicing loans (including mortgage loans). - Includes pass-through financing.	- No retail deposits. - Issuance of covered bonds or other types of securities liabilities.	- No specification.

Broad business model category	No	Business model	Business model short name	Qualitative description of the business model		
				Main activity/ies	Main funding	Ownership/ legal structure
	BM11	**Other specialised banks (including public development banks, Islamic finance, cooperative central banks, CCPs)**	Other	- Banks not included in the above categories (residual category). - This category should include among other business models: * public development banks * Islamic finance * cooperative central banks * CCPs.	- No specification.	- No specification.

4.2 The EU banking landscape

The data collection has a final sample of 5 292 credit institutions on a solo basis in December 2015. This number includes all the institutions subject to the Capital Requirements Regulation (CRR). Table 5 provides detailed information on the distribution of the number and total assets of credit institutions in the EU. Most credit institutions are concentrated in Germany (31 %), followed by Poland (11 %), Italy (11 %) and Austria (10 %).

Together, the credit institutions in the EU have approximately EUR 35.1 trillion of total assets. Most of these assets are concentrated in France (24 %) and Germany (21 %). They are followed by the United Kingdom (12 %), Italy (8 %), Spain (7 %) and the Netherlands (7 %).

Table 5. Credit institutions in the EU by country

Country code	Country	Number of credit institutions	Share in EU total number of credit institutions (%)	Total assets (EUR million)	Share in EU total assets (%)	Average size of credit institution (EUR million)
AT	Austria	544	10.3	550,296	1.6	1 012
BE	Belgium	37	0.7	848,418	2.4	22 930
CY	Cyprus	13	0.2	69,118	0.2	5 317
CZ	Czech Republic	34	0.6	184,211	0.5	5,418
DE	Germany	1 654	31.3	7 215 681	20.5	4 363
DK	Denmark	85	1.6	971 848	2.8	11 434
EE	Estonia	9	0.2	17 032	0.0	1 892
EL	Greece	17	0.3	296 135	0.8	17 420
ES	Spain	125	2.4	2 462 621	7.0	19 701
FI	Finland	249	4.7	538 891	1.5	2 164
FR	France	341	6.4	8 528 796	24.3	25 011
HR	Croatia	33	0.6	52 522	0.1	1 592
HU	Hungary	122	2.3	95 131	0.3	780
IE	Ireland	27	0.5	479 592	1.4	17 763
IT	Italy	555	10.5	2 951 159	8.4	5 317
LT	Lithuania	7	0.1	19 896	0.1	2 842
LU	Luxembourg	102	1.9	595 046	1.7	5 834
LV	Latvia	16	0.3	27 431	0.1	1 714
MT	Malta	23	0.4	24 562	0.1	1 068
NL	Netherlands	44	0.8	2 381 361	6.8	54 122
NO	Norway	153	2.9	644 393	1.8	4 212
PL	Poland	595	11.2	345 843	1.0	581
PT	Portugal	135	2.6	368 477	1.0	2 729
RO	Romania	29	0.5	74 392	0.2	2 565
SE	Sweden	123	2.3	1 279 014	3.6	10 398
SI	Slovenia	17	0.3	35 901	0.1	2 112
SK	Slovakia	13	0.2	57 758	0.2	4 443
UK	United Kingdom	190	3.6	4 026 403	11.5	21 192
TOTAL		5 292	100	35 141 928	100	6 641

Note: The data for 16 institutions in Netherlands was derived based on total assets data of 6 groups submitted to the EBA on a consolidated basis, credit Institution register data and information on the group structures. Each standalone institution within the group was included in the database with an average value of total assets (total assets of the group divided by the number of standalone institutions). In the case of these groups, the total assets of subsidiaries outside Netherlands were double counted, and hence the overall value of total assets for the institutions is overestimated.

Source: EBA data collection on EU financial institutions.

Table 6. Credit institutions in the EU by size

Total assets (EUR million)	Number of credit institutions	Total assets (EUR million)	Share in EU total number of credit institutions (%)	Share in EU total assets (%)	Average size of credit institution (EUR million)
Below 100	1303	62 619	24.6	0.2	48
[100 – 250)	887	146 799	16.8	0.4	166
[250 – 500)	742	265 177	14.0	0.8	357
[500 – 1 000)	652	467 855	12.3	1.3	718
[1 000 – 1 500)	341	421 866	6.4	1.2	1 237
[1 500 – 2 000)	207	364 149	3.9	1.0	1 759
[2 000 – 2 500)	125	278 698	2.4	0.8	2 230
[2 500 – 3 000)	120	326 160	2.3	0.9	2 718
3 000 and more	915	32 808 606	17.3	93.4	35 856
TOTAL	5292	35 141 928	100.0	100.0	6 641

Source: EBA data collection on EU financial institutions.

Table 7. Credit institutions in the EU by business model category (based on final business model classification)

Business model category		Number of credit institutions	Total assets (EUR million)	Share in EU total number of credit institutions (%)	Share in EU total assets (%)	Average size of credit institution (EUR million)
BM01	**Cross-border universal banks**	82	13 793 148	1.5	39.2	168 209
BM02	**Local universal banks**	552	7 933 011	10.4	22.6	14 371
BM03	**Consumer credit banks (including automotive banks)**	87	366 676	1.6	1.0	4 215
BM04	**Cooperative banks/savings and loans associations**	3 019	3 263 615	57.0	9.3	1 081
BM05	**Savings banks**	734	1 872 002	13.9	5.3	2 550
BM06	**Mortgage banks taking retail deposits**	126	818 576	2.4	2.3	6 497
BM07	**Private banks**	139	361 267	2.6	1.0	2 599
BM08	**Corporate-oriented**	143	1 653 135	2.7	4.7	11 560
BM09	**Custodian institutions (including CSDs that are subject to the CSDR)**	44	402 958	0.8	1.1	9 158
BM10	**Institutions not taking retail deposits (including pass-through financing)**	87	1 743 737	1.6	5.0	20 043
BM11	**Other specialised banks**	279	2 933 801	5.3	8.3	10 515
	TOTAL	5 292	35 141 928	100.0	100.0	6 641

Source: EBA data collection on EU financial institutions.

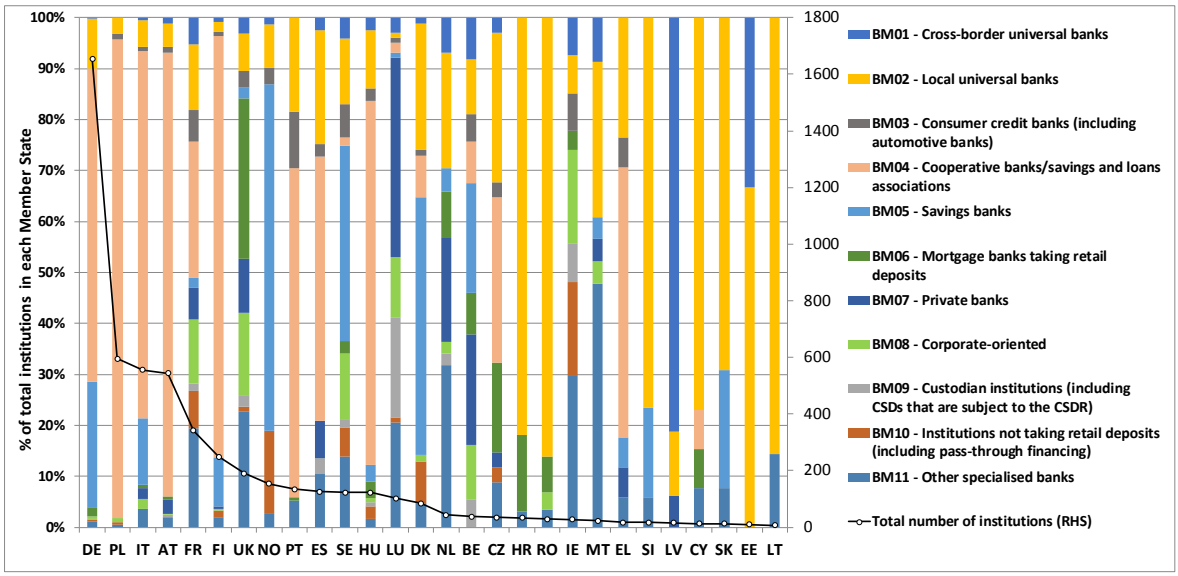
The majority of institutions – 4 377 institutions or around 83 % – have total assets below EUR 3 billion (Table 6). These institutions account for 7 % of banking sector assets (EUR 2.3 billion). The remaining 915 institutions (around 17 %) cover 93 % of total assets (EUR 32.8 billion).

The credit institutions represent a heterogeneous group with various business model categories. Referring to the 11 final business model categories as described in Table 4, 57 % are classified as cooperative banks and savings and loans associations (Table 7). The next biggest categories in terms of number are savings banks (14 % of credit institutions) and local universal banks (10 %).

The distributions of the number of institutions per business model varies from country to country (Figure 1). Based on the dominant type of institutions, four major groups of countries are distinguished. Countries in the first group, comprising Germany, Greece, Spain, Italy, Hungary, Austria, Poland, Portugal, Finland, have more than 50 % of their institutions assigned to the business model cooperative banks and savings and loans associations. The second group of countries – Estonia, Croatia, Cyprus, Latvia, Lithuania, Romania, Slovenia and Slovakia – are dominated by local universal banks or cross-border universal banks (more than 50 % of institutions). The third group of countries – Denmark and Norway – have a majority of institutions (more than 50 %) assigned to savings banks. Lastly, Belgium, Czech Republic, Ireland, France, Luxembourg, Malta, Netherlands, Sweden and United Kingdom have more diversity in the institutions' business models without any specific business model outnumbering the others.

Most of the banking assets (around 62 %) are concentrated in universal banks, either local (around 23 %; BM02) or cross-border (around 39 %; BM01) (Figure 2). In contrast, cooperative banks and savings and loans associations (BM04), which represent a large share of the banking landscape in terms of number of credit institutions, account for only 9 % of the total assets. Savings banks (BM05) represent around 5 % of the total assets.

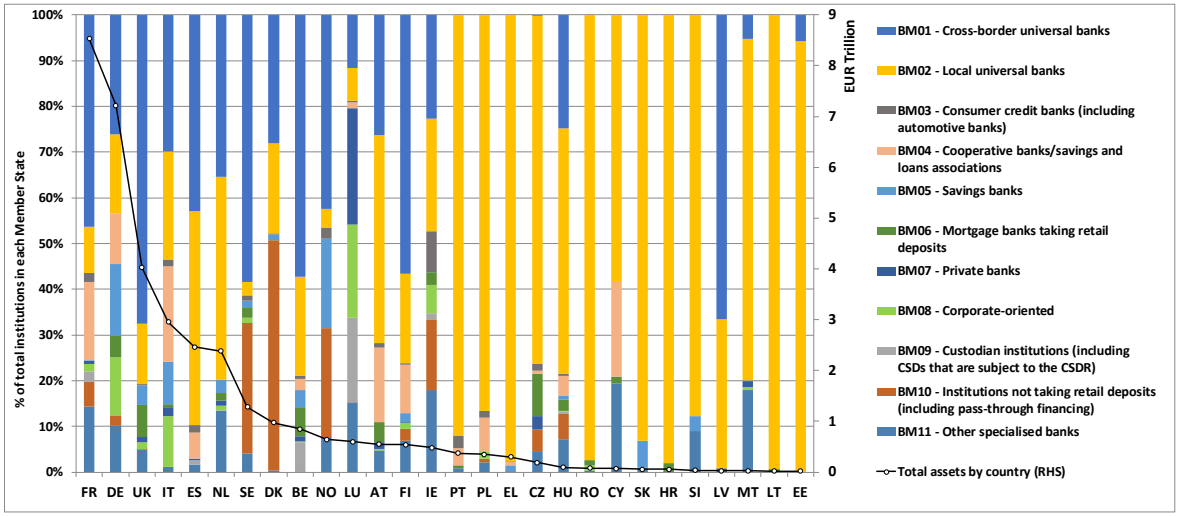
Figure 1. Number of financial institutions in the EU by business model



Note: The definition of business model categories can be found in Table 4. The primary axis shows the percentage of each business model in total number of institutions in each country. The secondary axis shows the total number of institutions in each country. Notations: RHS – right-hand side axis. Please see Table 5 for the country abbreviations.

Source: EBA data collection on EU financial institutions.

Figure 2. Total assets of the financial institutions in the EU by business model



Note: The definition of business model categories can be found in Table 4. The primary axis shows the percentage of total assets of each business model in total institutions in each country. The secondary axis shows the total assets of institutions in each country in trillion Euros. Notations: RHS – right-hand side axis. Please see Table 5 for the country abbreviations.

Source: EBA data collection on EU financial institutions.

4.3 Structural indicators by business model

This section describes in more detail the values of the indicators describing the asset, liability and income structure of individual institutions.[21] Among the selected key indicators for which the data was collected, four describe the asset side of the banks' balance sheets: share of exposures secured by residential immovable property, size of trading book, share of derivatives and cross-border exposures. Figure 3 depicts the mean, median and quartiles of these indicators per business model.

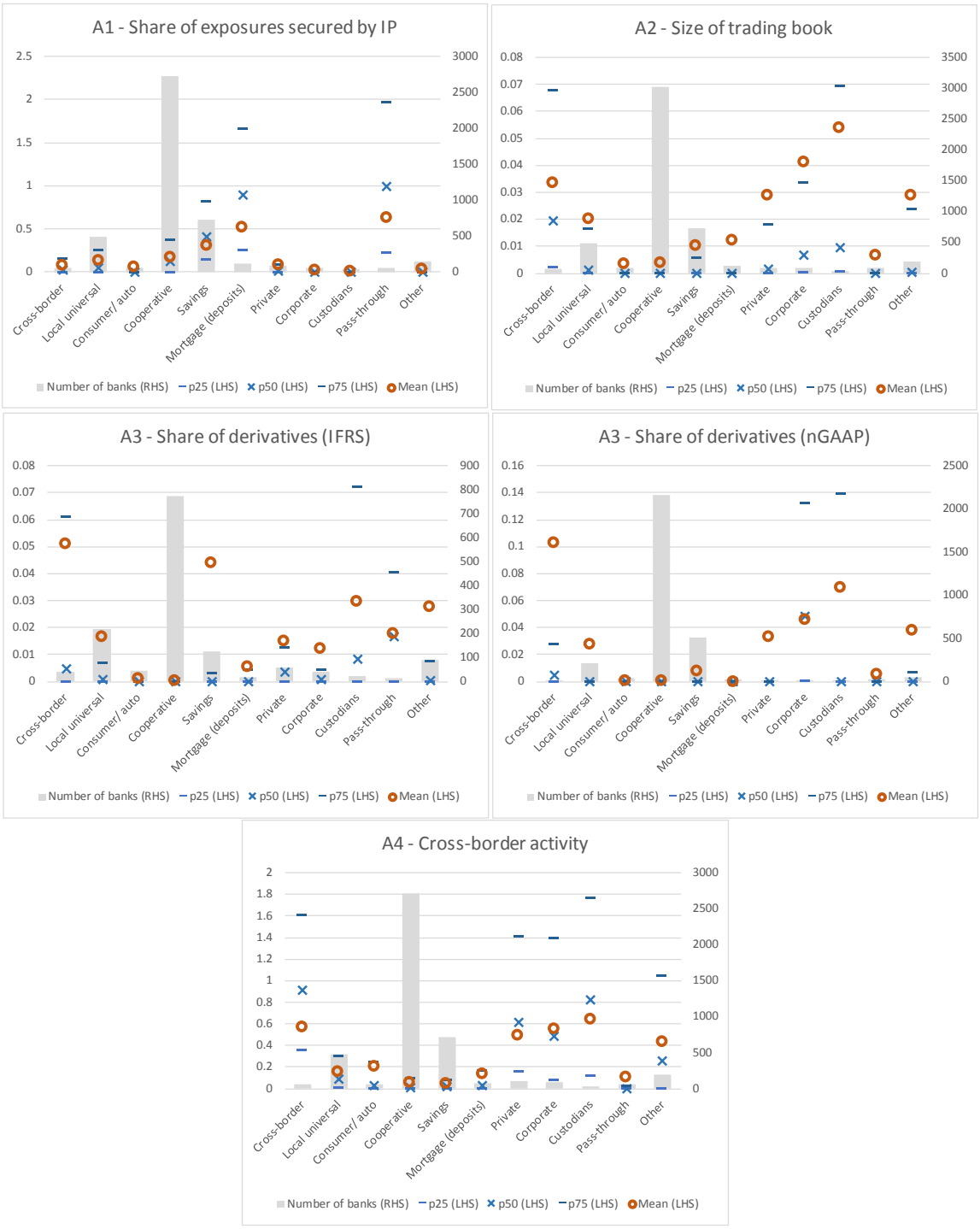
The share of exposures secured by residential immovable property (A1) measures banks' activities related to mortgage loans. On average in the sample, the exposures secured by immovable property represent 18.7 % of total assets (simple average). The share is highest for business models specialised in residential mortgages, such as mortgage banks and building societies, both those taking deposits (51.8 %) and those that do not take deposits, such as pass-through financing (63.0 %) (Figure 3).[22] In addition, other banks that are more focused on serving the local communities, such as cooperative banks and savings and loans associations, savings banks, and local universal banks, also have a high share of exposures secured by immovable property ranging from 12.7 % to 30.1 % of total assets. However, the shares are not as consistent in the latter business model groups, as they depend on the specific activity of the institution. In contrast, corporate-oriented banks and specialised institutions other than mortgage banks have zero or negligible amount of exposures secured by residential real estate.[23]

[21] One Italian credit institution was removed from the sample for the analysis in this section as did not report data for any of the indicators A0 to A9.

[22] This figure excludes data from institutions that did not report A1 because of institutional waivers or because it was not available. Missing A1 values due to its being technically zero or immaterial (e.g. for custodians) were replaced with zero.

[23] For several institutions in the sample that were classified as mortgage pass-through banks, the value of indicator A1 (the share of exposures secured by residential property on the balance sheet) is above 1. The reason is the fact that the numerator is an exposure value, which includes off-balance-sheet assets, while the denominator is an asset-based value

Figure 3. Values of indicators describing the asset side of the balance sheet



Note: p25, p50 and p75 refer to the 25th, 50th (median) and 75th percentiles respectively. For more details on the full name of each business model category, refer to Table 4. The mean in a number of cases is dominated by a few large banks. Notations: RHS – right hand side, LHS – left hand side, IP – immovable property, nGAAP – national GAAP.

Source: EBA data collection on EU financial institutions.

(i.e. only on-balance sheet items). Hence, if the off-balance sheet assets are sizable, the indicator can take values higher than 1.

Two indicators are used to measure trading activity: the size of the trading book (A2) and the share of derivatives (A3). The first indicator measures the trading portfolio of an institution, excluding derivatives, as the share of the capital charge for market risk. It is generally highest for custodians (5.4 %), as well as other business models that may be active in trading instruments (equity, securitisations, covered bonds, other subordinated debt instruments), such as corporate-oriented banks (4.1 %), cross-border universal banks (3.4 %) and private banks (2.9 %) (Figure 3). Nevertheless, the differentiation of institutions across business models by trading book is not as clear-cut as for other indicators, such as exposures secured by immovable property. The reasons for this is that almost all institutions have at least a small trading book.

Derivatives are excluded from the trading assets because of the different accounting treatments in IFRS and national GAAP.[24] Instead they are calculated as a separate indicator, which identifies banks active in derivative trading. In the data collection, 32.5 % of the institutions follow IFRS accounting standards, and 65.5 % the national GAAP.[25] Across business models, most institutions – cooperative banks and loans and savings associations, savings banks, and banks not taking deposits (including pass-through financing) – have the largest share of institutions following national GAAP: 72 %, 73 % and 75 % respectively. Among Member States, all the credit institutions in Belgium, Germany, France, Hungary and Austria follow the national GAAP standard for accounting. The Czech Republic, Denmark, Ireland, the Netherlands, Poland, the United Kingdom and Norway have both institutions that follow IFRS and institutions that follow national GAAP. In the remaining Member States – Estonia, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Portugal, Romania, Slovenia, Slovakia, Finland and Sweden – their credit institutions follow the IFRS accounting standards. The share of derivatives is highest for cross-border universal banks: 5.1 % and 10.3 % for IFRS and national GAAP banks respectively (Figure 3). In addition, among banks following the IFRS accounting framework, the average share of derivatives is also high for savings banks (4.4 %), custodians (3.0 %) and other specialised banks (2.8 %). Among banks following the national GAAP, the average share of derivatives is high for custodians (7.0 %), corporate-oriented (4.5 %) and other specialised banks (3.8 %).[26]

Cross-border activity (A4), which measures an institution's share of foreign exposures in relation to its overall balance sheet size, is largest for custodians (63.9 %), cross-border universal banks (57.4 %), corporate-oriented banks (54.2 %) and private banks (49.7 %) (Figure 3).[27] In contrast, it is lowest for domestically oriented banks with business models that usually serve the local communities, such as savings (4.2 %) and small cooperative banks (6.0 %). The value of this indicator, however, is not consistently in line with the business model descriptions, as an institution can be cross-border oriented or domestically oriented, regardless of its business model. It is also important to note that the ratio divides exposures including off-balance-sheet items by on-

[24] There may be differences in the measurement of derivatives under IFRS and certain national GAAPs. For example, under IFRS all derivatives are recognised at fair value in the balance sheet. At the same time, in certain national GAAPs derivatives may be recognised off balance sheet at their notional amounts and measured at the lower of cost or fair value.

[25] The accounting framework was unknown for 2 % of institutions, which were added manually by the EBA using only information on the business model category and total assets.

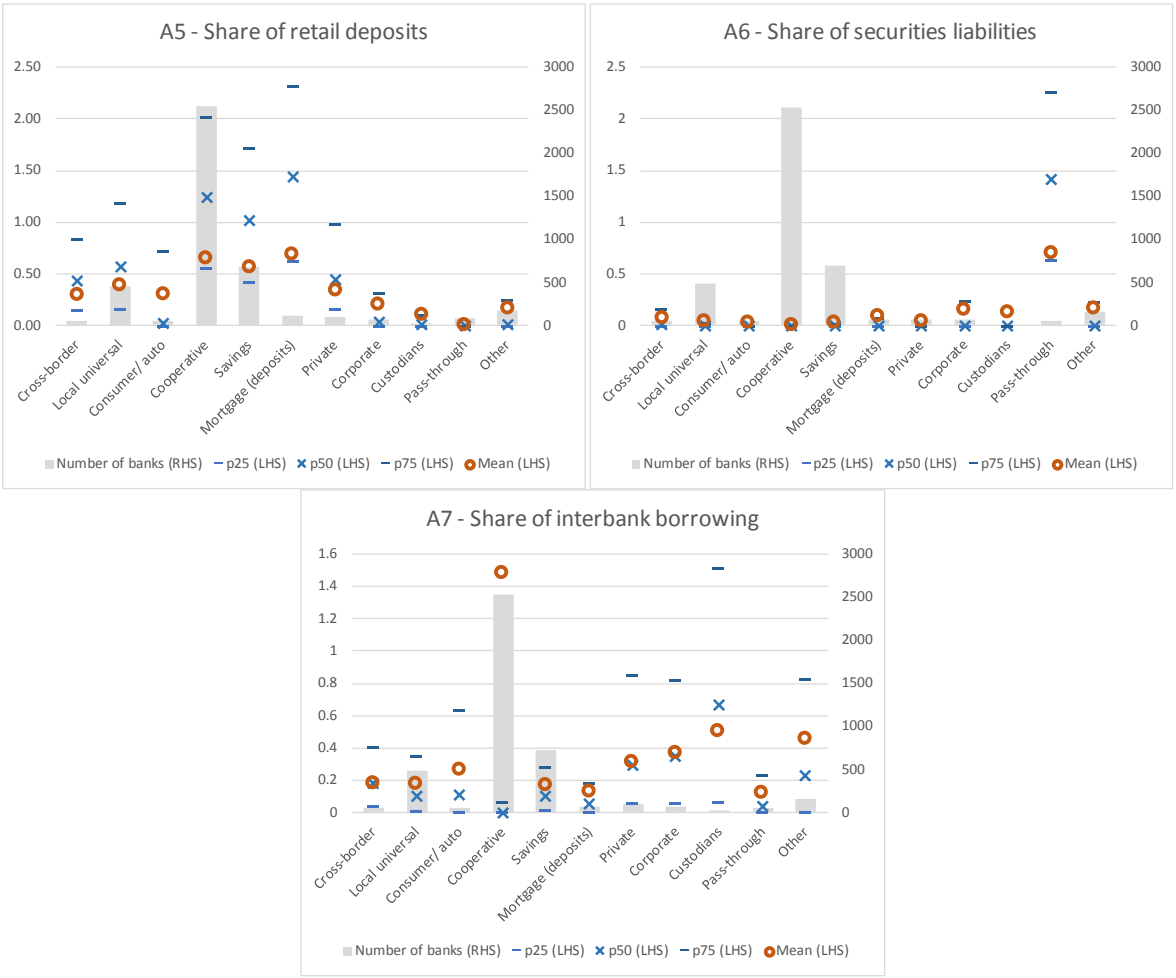
[26] This figure excludes data from institutions that did not report A3 because of institutional waivers or because it was not available. Missing A3 values due to its being technically zero or immaterial (consumer credit banks (including automotive banks), cooperative banks/savings and loans associations) were replaced with zero.

[27] Given that the numerator is an exposure value (i.e. also includes off-balance-sheet assets), while the denominator is an asset-based value, the indicator can take values higher than 1. Many institutions have a very high level of cross-border activity because of the way this indicator is calculated. The ratio divides exposures including off-balance-sheet items by on-balance-sheet total, leading to a potential overestimation of the cross-border activity, especially for institutions that have significant off-balance-sheet exposures.

balance-sheet total, leading to a potential overestimation of the cross-border activity, especially for institutions that have significant off-balance-sheet exposures, such as merchant banks.

On the liability side, three indicators are used, the share of retail deposits (A5), the share of securities liabilities (A6) and the share of interbank borrowing (A7) on the balance sheet (Figure 4).

Figure 4. Values of indicators describing the liability side of the balance sheet



Note: p25, p50 and p75 refer to the 25th, 50th (median) and 75th percentiles respectively. For more details on the formulas used to calculate each indicator, consult the Annex. For more details on the full name of each business model category, refer to Table 4. Notations: RHS – right hand side, LHS – left hand side.

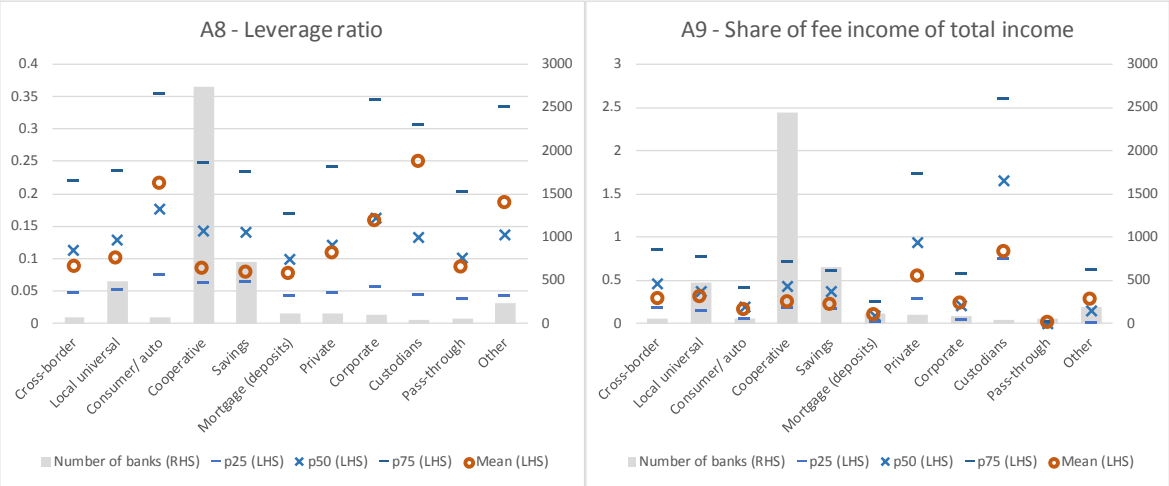
Source: EBA data collection on EU financial institutions.

The share of retail deposits (A5) measures the amount of deposits from non-bank and private customers (households, non-financial corporations) on the institution's balance sheet. Banks with a more traditional business model, which rely on more stable sources of funding, have higher values for this indicator. This includes savings banks (56.4 %), cooperative banks, (64.5 %) and mortgage banks taking retail deposits (68.5 %) (Figure 4). In contrast, banks that rely on more diversified sources of funding, such as cross-border or local universal banks, have lower values (30.4 % and 39.5 % respectively). For certain business models, such as custodians and pass-through, this indicator is generally not relevant or is very low, as they are not financed from deposits.

The share of securities liabilities (A6) identifies banks that rely on funding by issuing securities, such as covered bonds, securitisation or other unsecured debt. This indicator is highest, in particular, for business models that finance themselves almost exclusively from issuing such instruments, e.g. banks specialised in covered bonds or pass-through financing (70.6 %) (Figure 4). For other business models, this indicator is not relevant, and, depending on the specific funding strategy of the institutions, its value is variable within the business model category.

The share of interbank borrowing (A7) intends to identify business models that are mostly reliant on wholesale funding. There is not one single business model that consistently had a large share of wholesale liabilities. Nevertheless, it is observed that among cooperative banks there are a few with a very large degree of wholesale funding (Figure 4). Thus, this indicator is not very robust in distinguishing between the business model categories as defined in Table 4. Two more indicators were used to analyse additional features of the business models: the leverage ratio (A8) and the share of fee income (A9) (Figure 5).

Figure 5. Values of other indicators



Note: p25, p50 and p75 refer to the 25th, 50th (median) and 75th percentiles respectively. For more details on the full name of each business model category, refer to Table 4. Notations: RHS – right hand side, LHS – left hand side.

Source: EBA data collection on EU financial institutions.

The first indicator measures the leverage ratio (A8) of an institution and distinguishes between banks that rely on higher leverage, such as cross-border universal banks and custody banks, and those that rely on lower leverage, such as local universal banks, savings banks and cooperatives. This distinction is based on the conclusion of the analysis by business model in the EBA Leverage Ratio calibration report (EBA, 2016). However, the data illustrates a relatively high leverage ratio for most institutions, which may be a result of the relatively recent introduction of this measure in the regulation (Figure 5).[28]

Finally, the share of fee income (A9) in the total fee and interest income measures how the income from fees and commissions relates to the income from interest. It identifies banks that specialise in providing services, such as asset management, including private banks, which have share of fee and interest income of 54.9 %, as well as custodian institutions, whose share is 82.3 %, as opposed to those relying on interest income from more

[28] The new leverage ratio framework was introduced with BCBS (2014).

traditional business models and specialised in provision of loans (Figure 5). Corporate-oriented institutions are somewhere in between, with 23.2 % of income gained in the form of fees, because some of them are specialised in trade finance, which is a fee-based service. It should be noted, however, that loans and other traditional activities, such as overdraft facilities, can yield fee income as well. Hence, if one assumes that this indicator approximates the size of non-lending activities, it may in general overestimate the degree to which institutions engage in non-lending activities. This was the case of, for example, local universal banks; cross-border universal banks; and cooperative banks and savings and loans associations, for which this indicator ranged from 23.9 % to 30.2 %, indicating the amount of fee-based activities of these institutions.

5. Comparison with clustering results

Clustering is a technique for data analysis that groups a set of objects in such a way that objects in the same group (called a cluster) are more similar to each other than to those in other clusters. This method has been used for business model classification in several papers including by Roengpitya et al. (2014) and Ayadi et al. (2015). In this paper, clustering is used to compare its results with the classification of banks by business model based on the hybrid approach.

5.1 Data preparation

To ensure the robustness of the clustering analysis, it is necessary to have as much available data as possible. Since many indicators have not been reported for various reasons, the dataset was filled in with additional data based on assumptions.[29] After filling in the missing data, we have reduced the sample to keep only the observations for which all the data is available, which represents 66 % of the original sample size of 5 292 credit institutions. The reduced sample consists of 3 503 credit institutions and accounts for 45 % of the total assets of the full population of credit institutions. The reduced sample remains representative of the full population in terms of business model allocation, but is less representative in terms of distribution across countries (see Annex 8.2). In particular, for the following countries the sample has been reduced significantly (more than 50 %): Belgium, France, Luxembourg, Hungary, Portugal, Finland and the United Kingdom. There are two main reasons for data being missing in these countries:

- Institutions are part of groups and are exempted from reporting data at solo level either on liquidity or on both liquidity and own funds.

[29] The dataset was filled with information based on the following assumptions: (i) Exposures secured by immovable property are irrelevant or immaterial to the following business models: custodian institutions and CCPs. (ii) If for a certain business model category the 75th percentile of the size of trading book is below 1 % based on the available data, then, for the observations with missing data, the size of trading book was assumed to be immaterial and replaced with zero. This was the case for the business model categories: consumer credit banks (including automotive banks), cooperative banks and savings and loans associations, mortgage banks taking retail deposits, mortgage banks not taking retail deposits (which is a subset of Institutions not taking retail deposits, including pass-through financing) and public development banks (which is a subset of other specialised business models). (iii) The share of derivatives in total assets is zero or immaterial for the following business models and missing data was hence replaced with zero: consumer credit banks (including automotive banks), and cooperative banks and savings and loans associations. (iv) Retail deposits are irrelevant or immaterial to some investment-oriented business models and for pass-through financing institutions. This indicator has been replaced with zero when missing in the following business model categories: institutions not taking retail deposits, including pass-through financing, public development banks (which is a subset of other specialised business models), consumer credit banks (including automotive banks), and cooperative banks and savings and loans associations.

- One or more variables were not reported for institutions, and it was not possible to make any assumptions about their values.

5.2 Clustering approach

The clustering methodology uses an algorithm that assigns banks to clusters in such a way as to minimise the distance between the banks within one cluster and maximise the distance between the averages/median/centroids of the clusters.

As part of the clustering methodology, several methodological choices need to be made, which also have an impact on the final results. The methodological choices in this study are as follows:

- clustering method: complete linkage and Ward's linkage;
- instruments used: all indicators, excluding total assets and leverage ratio; all indicators were normalised and no weights were applied (i.e. equal weights were applied);
- stopping rule: 4, 7 and 12 clusters.

In line with previous studies, we used complete linkage and Ward's linkage clustering methods. Compared with other clustering methods, these two methods are the most appropriate for business model analysis and have been used by Ayadi and De Groen (2014), Ayadi et al. (2011, 2012, 2016) and Roengpitya et al. (2014, 2017). The choice of the method is subjective, and depends on the data and goals of the study. In this study, the intention is to have clusters that are compact and are distinguished from each other across several dimensions. The complete linkage method considers that clusters are formed as a result of identifying the smallest distance between the two most distant points of two groups. This produces spatially compact clusters. Ward's linkage method applies a general hierarchical clustering approach whereby groups are joined to maximise an objective function: the error sum of squares. It does well with groups that are multivariate normal and spherical but does not do well if the groups are of different size or have unequal numbers of observations.

These methods have the following formulas that measure the distance between two distinct points, or between a point and an already formed cluster:

complete linkage: $d_{k,i\cup j} = d_{k,i\cup j} = \frac{n_i+n_k}{n_i+n_j+n_k} d_{ki} + \frac{n_j+n_k}{n_i+n_j+n_k} d_{kj} + \frac{-n_k}{n_i+n_j+n_k} d_{ij}$,

Ward's method: $d_{k,i\cup j} = \frac{n_i+n_k}{n_i+n_j+n_k} d_{ki} + \frac{n_j+n_k}{n_i+n_j+n_k} d_{kj} + \frac{-n_k}{n_i+n_j+n_k} d_{ij}$

where n_i, n_j and n_k represent the sizes of clusters C_i, C_j and C_k respectively.

Other hierarchical methods, such as single linkage method, would not fit this requirement because, according to this approach, clusters are formed as a result of identifying the closest points between two groups, which can result in chaining, i.e. long, thin clusters, which is not what we would expect from business models. A k-means partitional clustering method was not used either, because the assumptions required for this method – that all variables have the same variance and that each cluster has a roughly equal number of observations – do not hold. Moreover, the enhanced partitional approach of Farne and Vouldis (2017) requires a wider multidimensional dataset (e.g. more variables than institutions), which is not available to us.

To neutralise the impact of the absolute values on the clustering results, the variables were normalised around their mean. After normalisation, all the variables will have equal weight in the final outcome. Equal weights is an assumption that generally does not hold in practice. One variable may have a bigger influence on determining an institution's business model than other variables. The approach could be improved by applying a weighting mechanism. Since the purpose of the clustering analysis is to check the robustness of the hybrid approach and since we do not have any knowledge on the weights of each variable in determining the business model, the equal weighting is preserved.

The intention is to use as many variables as possible in order to differentiate among the business models. The clustering was conducted first using all variables and then excluding total assets and leverage ratio. Total assets were excluded because they are an indicator of size, rather than business model. While size can be considered a separate business model dimension, it should be analysed separately from other indicators. Using total assets as an indicator among others would risk having a separate cluster with large institutions irrespective of their underlying balance sheet structures. Leverage ratio was excluded from the clustering because, from the analysis, it has been observed that leverage ratio is relatively high for most institutions and does not give any indication of their business model, which may be a result of the relatively recent introduction of this measure in the regulation and significant deleveraging effort of the banks after the financial crisis.[30]

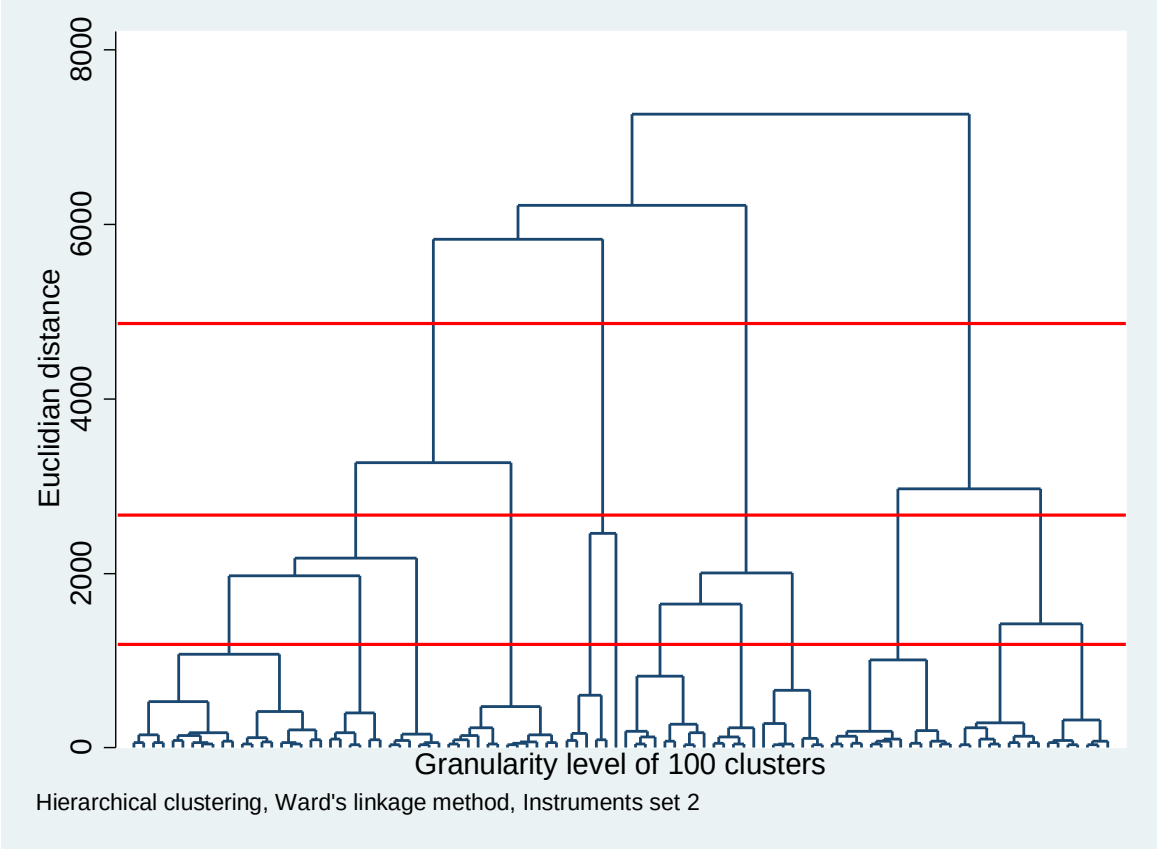
The Euclidean distance was used as the dissimilarity measure. It measures how far or how different two items are far from each other using the square root of the sum of squared differences of their attributes. The Euclidean distance is the most commonly used dissimilarity measure because it is the straight-line distance between two points and hence is more intuitive than alternatives. This measure has also been used in all previous papers using clustering methodology for classification of banks by business model, including those by Ayadi and De Groen (2014), Ayadi et al. (2011, 2012, 2016), and Roengpitya et al. (2014, 2017).

The algorithm starts with 3 503 clusters, each consisting of a single item (institution), which are step by step merged with each other into clusters based on the dissimilarity between them. The algorithm ends when all the groups are merged into one group. Between the start and the end of the algorithm, the number of clusters may vary between 3 503 and 1. A stopping rule is used to get a snapshot of the clusters at a certain point in time between the beginning and the end of the clustering algorithm.

Figure 6 shows the dendrogram for Ward's method, using a restricted number of variables describing only the balance sheet structure. The dendrogram depicts the way the clustering algorithm proceeds. The vertical lines in the dendrogram represent the distance between the clusters; i.e. the longer the vertical line, the more dissimilar the clusters are. The dendrograms for other clustering methods (complete linkage) and those using Ward's method but with a more extensive number of variables are shown in Annex 8.3 for comparison.

[30] We have also conducted the clustering excluding in addition cross-border activity and fee income as a share of total fee and interest income. Cross-border activity (indicator A4) is relevant across all the business models, as any business model can be either local or universal. This dimension, hence, does not distinguish or define any particular category on its own. In our business model classification, this distinction is made only in the case of cross-border universal and local universal banks, for which cross-border activities would be an important indicator. However, including this indicator in the cluster analysis would divert the clustering algorithm and create clusters that have high levels of cross-border activity irrespective of the underlying balance sheet. This indicator is not relevant to other business models, and hence it is simply another dimension of business models that applies across business models on top of the balance sheet structure and other dimensions. Fee income relative to interest income (indicator A9) was excluded from the clustering, because this indicator can be considered a performance indicator, rather than a structural one.

Figure 6. Dendrogram for the hierarchical clustering using Ward's linkage method applied to all indicators excluding total assets and leverage ratio



From the chart, it can be seen that there are multiple possible stopping rules, i.e. places where we cut off the clustering algorithm to observe the number of clusters and their characteristics.[31] In this particular case, we set the stopping rule at 4 clusters (in line with previous literature), and also at 7 clusters and 12 clusters, where, as indicated by the length of the vertical lines, the clusters are most dissimilar from each other. These points have been marked by red lines. Looking at different levels of granularity – 4, 7 and 12 clusters – rather than only one level is helpful to understand the composition of the clusters and identify sub-categories of business models.

The results of the clustering for all three chosen levels of granularity are presented in Table 8. At the lowest chosen level of granularity, the four major clusters of credit institutions are in line with the results of the existing literature that uses clustering approach to classify banks by business model. The cluster names are based on the descriptive statistics of each identified cluster and may not necessarily reflect exactly the entire range of values taken by the key indicators within the clusters. An overview of the values of each indicator for each of the four clusters is presented in Annex 8.4.

[31] Previous studies used the pseudo F-index of Calinski and Harabasz (1974) to identify the optimal number of clusters. This index is measured as the sample estimate of between-cluster variance over within-cluster variance, and the higher the index the more distinct the clusters relative to each other. In all papers where this index was used (Ayadi and De Groen, 2014; Ayadi et al., 2011, 2012, 2016'; Roengpitya et al., 2014, 2017), this led to a stopping rule of three to five clusters.

Table 8. Clustering results for granularity levels of 4, 7 and 12 clusters

4 clusters			7 clusters			12 clusters		
Cluster		**Number**	**Cluster**		**Number**	**Cluster**		**Number**
1	Cross-border and mixed funding	921	1.1	Cross-border and mixed funding with lower cross-border activity	817	1.1.1	Some exposures secured by immovable property (IP); different mixes of securities liabilities, interbank borrowing and retail funding	694
						1.1.2	No exposures secured by IP; high fee income; different mixes of securities liabilities, interbank borrowing and retail funding; 2 groups: high and low interbank borrowing	79
						1.1.3	No exposures secured by IP; very high interbank borrowing, no securities liabilities or retail funding	44
			1.2	Cross-border and mixed funding with very high cross-border activity	104	1.2.0	No exposures secured by IP; 2 groups: high and low interbank borrowing	104
2	Pass-through	51	2.1	High securities liabilities and immaterial retail deposits	50	2.1.0.1*	No or immaterial exposures secured by IP; some cross-border activities	22
						2.1.0.2*	High exposure secured by IP; no cross-border activities	28
			2.2	OUTLIER: no securities liabilities and high retail deposits	1	2.2.0	OUTLIER: no securities liabilities and high retail deposits; extremely low or negative value of its fee versus interest income	1
3	Retail and trading	114	3.0	Large retail deposits and large trading book and/or derivatives	114	3.0.1	Average trading book; zero/immaterial to average derivatives	88
						3.0.2	Large trading book; high fee income; zero/immaterial derivatives	13
						3.0.3	High share of derivatives; small to large trading book; very high retail funding	13
4	Retail traditional (with no or little trading)	2 417	4.1	Low level of exposures secured by IP and low cross-border activity	1 394	4.1.0	Low level of exposures secured by IPIP and low cross-border activity	1 394
			4.2	Average/high exposures secured by IP	1 023	4.2.1	Average exposures secured by IP; slightly more cross-border activity	811
						4.2.2	High exposures secured by IP; some securities liabilities	212
Total		**3 503**		**Total**	**3 503**		**Total**	3 503

Note: The description provided for each cluster is based on the descriptive statistics of each of the collected indicators. *At the level of granularity of 12 clusters, cluster 2.1 does not yet separate into sub-clusters. This division happens at a higher level of granularity. We chose to show it because it was interesting from the point of view of business models. This does not affect the final results.

Cluster 1 (Cross border and mixed funding) among the four major clusters includes banks with high cross-border activity and a mix of retail and wholesale funding (921 banks). Because of its rather broad definition, and large range of values of indicators, we look into a lower level of granularity and identify that the cluster is divided into two sub-clusters: one with very high cross-border activity (104 banks) and another with slightly lower cross border activity (817 banks).

Cluster 2 (Pass-through), which we define as pass-through financing, is characterised on the liabilities side by a high share of securities liabilities, and low level of retail deposits, as well as low fee income relative to total fee and interest income (51 banks). This business model also has generally small trading book and low share of derivatives in total assets. There are two sub-clusters identified, namely the typical pass-through category defined by high securities liabilities and immaterial retail deposits (50 banks) and an outlier (1 bank). In the first, the institutions may or may not have exposures secured by immovable property. This sub-cluster is further grouped into two sub-clusters: one with significantly more exposures secured by immovable property as a share of total assets than the other one. The second sub-cluster at the level of granularity of 7 clusters represents an outlier, which was identified based on the very low (or negative) value of its fee versus interest income.

Cluster 3 (Retail and trading) includes institutions that have large retail deposits and a large share of derivatives and trading book, and hence we call them trading oriented (114 banks). In the clustering algorithm, these institutions were classified in three sub-clusters: two of them with immaterial shares of derivatives, but average (88 banks) and high (13 banks) levels of trading book, and a third sub-cluster with high shares of derivatives in total assets (13 banks).

Cluster 4 (Retail traditional) includes traditional retail banks, i.e. retail banks with no or little trading book (2 417 banks). This cluster is the largest in terms of number of items and is characterised by high levels of retail deposits on their balance sheets. The institutions in this cluster have a small trading book, few derivatives and low levels of securities liabilities or wholesale funding, for which reason they were not classified in clusters 2 and 3. This cluster is split into two sub-clusters: one with significantly more exposures secured by immovable property as a share of total assets (1 023 banks) than the other one (1 394 banks).

5.3 Comparison of clustering results with the business model classification

As the business model categories classification is based on both qualitative and quantitative information, while the clustering is based only on quantitative indicators, the groups of institutions resulting from these approaches are not the same. The reason is that none of the business models is defined solely by balance sheet indicators and additional information is required to judge whether a bank belongs to one business model or another. This additional piece of information is captured in the qualitative approach to the business model classification.

Despite the differences in the methodology in allocating banks to business models, the classification of banks by business model category is mostly consistent with the clustering methodology. This can be seen in Table 9, which maps the clusters for the granularity level of 4 clusters against the 11 business model categories identified earlier in the paper based on qualitative information and quantitative indicators. The compatibility of the clusters with the business model categories is marked in this table using colours. In particular:

- green means that the institutions from one cluster are expected to have been assigned to a certain business model category;
- yellow means that the institutions are not expected to be assigned to the business model category, but nevertheless it is possible, although less likely;

- red means that the institutions are not expected to be allocated to the category and that the cluster's features are not compatible with the business model category's definition.

Across the sample of institutions used for clustering, 2 663 banks, or 76 %, were allocated to clusters that would correspond to the definitions of the final business model categories assigned to them. This includes, for example, institutions from cluster 1.1 'Cross-border and mixed funding' that were allocated to the final business model categories of local universal banks and consumer credit banks, as these banks are expected to have cross-border operations and be funded from various sources on their liability side. These cases are marked with green in Table 9.

Table 9. Clustering results for granularity level of 4 clusters vs business model classification based on hybrid approach

No	Business model category	Cluster 1: Cross-border activity and mixed funding		Cluster 2: Pass-through*	Cluster 3: Retail and trading	Cluster 4: Retail traditional	
		Cluster 1.1: Cross-border and mixed funding with lower cross-border activity	Cluster 1.2: Cross-border and mixed funding with very high cross-border activity			Cluster 4.1: Low level of exposures secured by IP and low cross-border activity	Cluster 4.2: Average/ high exposures secured by IP
BM01	Cross-border universal banks	9	20	0	11	3	0
BM02	Local universal banks	226	28	1	44	65	48
BM03	Consumer credit banks (including automotive banks)	26	4	0	0	13	2
BM04	Cooperative banks/savings and loans associations	236	3	0	7	1 211	666
BM05	Savings banks	216	1	0	32	86	277
BM06	Mortgage banks taking retail deposits	6	3	0	1	5	27
BM07	Private banks	20	11	0	3	4	0
BM08	Corporate-oriented	17	7	0	6	4	0
BM09	Custodian institutions (including CSDs that are subject to the CSDR)	7	1	0	2	0	0
BM10	Institutions not taking retail deposits (including pass-through financing)	5	0	37	0	0	0
BM11	Other specialised banks	49	26	12	8	3	3
	Total number	817	104	50	114	1 394	1 023

*The outlier from cluster 2 (pass-through) was excluded

Legend:

Expected

Not expected, but compatible

Not expected and not compatible

In 780 cases (22.3 % of the sample), the classification from the cluster analysis is not expected but nevertheless possible. For example, this includes the institutions in cluster 1.1 'Cross-border and mixed funding' that that were

allocated to the business model categories of cooperative banks or savings banks. In the case of cross-border banks, cooperative banks are expected to be operating locally with limited cross-border activity. Nevertheless, there are also cooperative banks that do operate across borders, such as cooperative banks that operate in communities close to borders between two EU countries and serve communities on both sides of the border. In the case of mixed funding, saving banks are expected to be largely funded by deposits; hence the mixed funding of the respective cluster is not fully compatible with the business model allocation. Nevertheless, it is also not a totally incompatible situation, as there could be savings banks that partially use wholesale funding or sell securities, such as certificates of deposits, to fund their operations. These cases are marked with yellow in Table 9.

Finally, in 59 cases (1.7 % of the sample), the final allocation of banks by business model categories is not expected and not compatible with the identified clusters. These cases are marked with red in Table 9. A detailed description of the cases where banks were allocated to business model categories and clusters that are incompatible with each other is provided in Annex 8.5. In the cases identified, the incompatibility stems from two reasons:

a) Exceptions or national specificities. The exceptions are identified when an institution has balance sheet indicators that do not correspond to the business model assigned to it by the supervisory authority. These cases are picked up by the tests designed to identify such inconsistencies and to challenge the original classification provided by the supervisory authorities. They were allocated to a different business model nonetheless, because of the case-by-case specificities that were justified by the supervisory authorities. Such cases related to institutions in Germany, Spain, Cyprus, Malta, Austria, Poland, Portugal and Norway.[32]

b) Institutions for which the main indicator for the categorisation of a business model is fully compatible with the business model category that supervisory authorities have assigned, but does not fit with the cluster description, i.e. with the average values of its key indicators. This results from the fact that, in clustering, equal weights were assigned to indicators, so that the impact of a single indicator, which may be the most important in determining the business model in the clustering outcome, can be diluted when other indicators are very similar and lead to two banks being clustered together. Such cases related to institutions in Germany, Poland, Sweden and Norway. This drawback could be fixed by assigning weights to indicators, but this is not straightforward; different indicators may have different weights depending on business model and there is still the question of how to measure/define these weights. None of the existing studies on business model classification used weights for clustering.

To conclude, by using a qualitative nature, the business model classification proposed in this paper is more nuanced to reflect the business models of the institutions. Such a business model classification is largely compatible with a clustering methodology but provides a more granular classification of institutions across business model categories.

[32] In some cases, the main indicators for the categorisation of a business model do not correspond to the business model classification that supervisory authorities have assigned, but are very close to the benchmark used to test/challenge the business model classification. It means that, in the event of a different, e.g. less conservative, calibration, this inconsistency would not have come up. Out of 58 cases, 5 were of this type.

6. Conclusion, policy recommendations and future research

This paper proposes a novel approach to business model classification that can provide a benchmark for classifying banks for analysing trends, risks, regulatory impact assessment, proportionality and supervisory peer reviews. The proposed business model classification will allow a more structured approach to future analysis by taking into consideration the banks' business models in a consistent way. This approach could, for example, be part of the EBA methodology for business model analysis in future work.

Given the benefits and shortcomings of the quantitative and qualitative approaches, a hybrid approach to classifying banks by business model is used in this paper, by combining a qualitative categorisation of institutions by business model with further validation of the classification using quantitative indicators. Compared to clustering method for business model classification, which is mostly used in the literature, this hybrid approach provides more flexibility to the classification of institutions across business models, taking into account specificities of the national financial sectors. By using individual/solo data for the full EU banking landscape, it considers the specificity of each individual institution, irrespective of the business models of other institutions in the same group, which is a new approach compared with the literature mentioned. At the same time, by using quantitative indicators it gives an additional quantitative base to confirm or challenge the initial qualitative classification.

The results of the business model classification show that, out of 5 292 credit institutions on a solo basis in the EU as of December 2015, the majority of banks – 57 % – were classified as cooperative banks and savings and loans associations. The next biggest categories in terms of number were savings banks (14 % of credit institutions) and local universal banks (10 %). The distributions of number of institutions per business model varied from country to country. Based on the dominant type of institutions, four major groups of countries could be distinguished. The first group, comprising Germany, Greece, Spain, Italy, Hungary, Austria, Poland, Portugal, Finland, had more than 50 % of their institutions assigned to the business model of cooperative banks and savings and loans associations. The second group of countries – Estonia, Croatia, Cyprus, Latvia, Lithuania, Romania, Slovenia and Slovakia – were dominated by local universal banks or cross-border universal banks (more than 50 % of institutions). The third group of countries – Denmark and Norway – had a majority of institutions (more than 50 %) assigned to savings banks. Lastly, Belgium, Czech Republic, Ireland, France, Luxembourg, Malta, Netherlands, Sweden and United Kingdom had more diversity in the institutions' business models without any specific business model outnumbering the others.

A clustering methodology was applied to a reduced sample (3 503), to compare for robustness with the results of the hybrid approach described above. The classification that resulted from this hybrid approach is largely compatible with a clustering methodology: around 76 % of results are fully compatible, and an additional 22.3 % are compatible but not expected. The qualitative approach, however, provides a more granular classification of institutions across business model categories.

While the business model classification has already been done based on the data collected and therefore can be used in practice, it can be further enhanced. Improvements can be made in the refinement of the business model categories list, selection of key indicators and the extension of tests applied to challenge the qualitative business model classification.

From the analysis, it became clear that some indicators that were collected were less useful in identifying business models (interbank borrowing, leverage ratio), while other important indicators may have been missing (corporate loans, individual loans and exposures secured by commercial real estate to test for corporate-oriented

business models). Other indicators may need to be modified to ensure they adequately describe the business model. For example, share of cross-border exposures should be calculated as a share of total on- and off-balance-sheet exposures, rather than total assets. For future research, we believe that it would be also interesting to refine the business model classification, and hence to increase the number of indicators that can be used to test those business models.

Since the EU market of credit institutions is still fragmented, and there are many exceptions and national specificities, it would not be possible to rely on quantitative indicators only. However, the qualitative factors can be to some extent minimised if adequate quantitative proxies can be found for them. Therefore, as far as possible, qualitative information, such as the legal ownership and legal form, should be incorporated in the input for the indicators used to test the business model classification.

Another improvement to the current classification could be a review of the definitions of the business models, enhancing them with more qualitative and potentially quantitative guidance. For example, cross-border activity is currently one of the indicators used to identify some business models (although it was later removed from the analysis). This indicator could be used as a horizontal dimension that cuts across business models.

In addition, the process of defining benchmarks that challenge the initial classification of business model could also be refined. Once more historical data is available, benchmarks can be calculated based on the business model classifications of this extended time series dataset.

Similar business model analysis at solo level would be interesting to conduct over time to assess the evolution of business models, especially around the financial crisis of 2008, when a trend of reverting to traditional business models was observed, like the analysis conducted in Mergaerts and Vennet (2016) and Roengpitya et al. (2014). Finally, a natural next step would be the analysis of performance and profitability by business model, as has been done by Ayadi et al. (2016) and Roengpitya (2014).

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8. Annex

8.1 Tests to challenge the business model classification

Test No	Business model (initial proposed categories)	Indicator	Average for all institutions (%)	25th, 50th and 75th percentiles for all institutions (%)			Average for the business model (%)	25th, 50th and 75th percentiles for the business model (%)			Lower bound IQR (%)	Upper bound IQR (%)	Benchmark used (%)	Justification
				P25	P50	P75		P25	P50	P75				
1	**Cross-border universal banks**	**A4 (Cross-border activity)**	11	0	2	12	57	35	56	70	-16	122	< 20	An institution classified as having a universal cross-border bank business model is expected to have high cross-border activity. Otherwise it may need to be reclassified to the local universal bank category.
2	**Local universal banks**	**A4 (Cross-border activity)**	11	0	2	12	16	1	8	22	-30	53	> 50	An institution classified as having a local universal bank business model is expected to have low cross-border activity. Otherwise it may need to be reclassified to the universal cross-border bank category.
3	**Cooperative banks/savings and loans associations**	**A2 (Size of trading book)**	1	0	0	0	0	0	0	0	0	0	> 10	An institution classified among cooperative banks/savings and loans associations is expected to have a small trading book.
4	**Cooperative banks/savings and loans associations**	**A4 (Cross-border activity)**	11	0	2	12	6	0	1	9	-14	23	> 20	An institution classified among cooperative banks/savings and loans associations is expected to have low cross-border activity. Please note that large cooperative banks with significant cross-border diversified activities should be classified as universal cross-border banks, as indicated in the qualitative description of the business models.
5	**Cooperative banks/savings and loans associations**	**A5 (Share of retail deposits on institution balance sheet)**	41	0	47	70	65	56	69	76	26	106	< 20	An institution classified among cooperative banks/savings and loans associations is expected to have significant amounts of retail deposits on its balance sheet, as indicated in the qualitative description of the business models.

Test No	Business model (initial proposed categories)	Indicator	Average for all institutions (%)	25th, 50th and 75th percentiles for all institutions (%)			Average for the business model (%)	25th, 50th and 75th percentiles for the business model (%)			Lower bound IQR (%)	Upper bound IQR (%)	Benchmark used (%)	Justification
				P25	P50	P75		P25	P50	P75				
6	**Cooperative banks/savings and loans associations**	**A9 (Fee income relative to interest income)**	30	18	23	31	24	20	24	28	7	41	> 1	An institution classified among cooperative banks/savings and loans associations is expected to have less income from fees than from interest, given the focus of such institutions on originating and servicing loans to local community individuals and businesses, as indicated in the qualitative description of the business models.
7	**Savings banks**	**A5 (Share of retail deposits on institution balance sheet)**	41	0	47	70	56	42	59	70	2	110	< 20	An institution classified among savings banks is expected to have significant amounts of retail deposits on its balance sheet, as indicated in the qualitative description of the business models.
8	**Consumer credit banks (including automotive banks)**	**A9 (Fee income relative to interest income)**	30	18	23	31	16	6	14	22	-19	47	> 1	An institution classified among consumer credit banks (including automotive banks) is expected to have less income from fees than from interest, given the focus of such institutions on originating and servicing consumer loans, as indicated in the qualitative description of the business models.
9	**Mortgage banks taking retail deposits – building societies and other mortgage banks**	**A1 (Share of exposures secured by residential immovable property on institution balance sheet)**	14	0	3	21	50	23	62	76	-57	156	< 20	An institution classified among mortgage banks taking retail deposits – building societies and other mortgage banks is expected to have significant amounts of exposures secured by residential real estate due to its originating and servicing mortgage loans, as indicated in the qualitative description of the business models.
10	**Mortgage banks taking retail deposits – building societies and other mortgage banks**	**A5 (Share of retail deposits on institution balance sheet)**	41	0	47	70	65	54	81	87	5	136	< 20	An institution classified among mortgage banks taking retail deposits – building societies and other mortgage banks is expected to have significant amounts of retail deposits on its balance sheet, as indicated in he qualitative description of the business models.

Test No	Business model (initial proposed categories)	Indicator	Average for all institutions (%)	25th, 50th and 75th percentiles for all institutions (%)			Average for the business model (%)	25th, 50th and 75th percentiles for the business model (%)			Lower bound IQR (%)	Upper bound IQR (%)	Benchmark used (%)	Justification
				P25	P50	P75		P25	P50	P75				
11	**Mortgage banks not taking retail deposits – pass-through financing**	**A1 (Share of exposures secured by residential immovable property on institution balance sheet)**	14	0	3	21	70	48	86	100	-30	177	< 20	An institution classified among mortgage banks not taking retail deposits – pass-through financing is expected to have significant amounts of exposures secured by residential real estate due to its originating and servicing mortgage loans, as indicated in the qualitative description of the business models.
12	**Mortgage banks not taking retail deposits – pass-through financing**	**A5 (Share of retail deposits on institution balance sheet)**	41	0	47	70	0	0	0	0	0	0	≠ 0	An institution classified among mortgage banks not taking retail deposits – pass-through financing is expected not to have retail deposits on its balance sheet because of its financing of loans from issuing securities, as indicated in the qualitative description of the business models.
13	**Mortgage banks not taking retail deposits – pass-through financing**	**A6 (Share of securities liabilities on institution balance sheet)**	3	0	0	0	71	63	79	85	-17	28	< 20	An institution classified among mortgage banks not taking retail deposits – pass-through financing is expected to have significant securities liabilities on its balance sheet due to its financing of loans from issuing securities, as indicated in the qualitative description of the business models.
14	**Merchant banks**	**A4 (Cross-border activity)**	11	0	2	12	67	18	58	95	-97	210	< 20	An institution classified among merchant banks business model is expected to have high cross-border activity due to its financing of international trade, as indicated in the qualitative description of the business model. This is not the case if the institution focuses on domestic trade only.
15	**Pass-through financing (not mortgage banks)**	**A6 (Share of securities liabilities on institution balance sheet)**	3	0	0	0	53	25	53	80	-56	162	< 10	An institution classified as pass-through financing is expected to have significant securities liabilities on its balance sheet due to its financing of loans from issuing securities, as indicated in the qualitative description of the business models.

Test No	Business model (initial proposed categories)	Indicator	Average for all institutions (%)	25th, 50th and 75th percentiles for all institutions (%)			Average for the business model (%)	25th, 50th and 75th percentiles for the business model (%)			Lower bound IQR (%)	Upper bound IQR (%)	Benchmark used (%)	Justification
				P25	P50	P75		P25	P50	P75				
16	**Custodian institutions (including CSDs that are subject to the CSDR)**	**A2 (Size of trading book)**	1	0	0	0	5	0	1	6	-9	15	> 10	An institution classified as a custodian institution is expected to have a small trading book, mainly because of the practice of having custodians separated from retail and investment banking and not taking speculative positions.
17	**Custodian institutions (including CSDs that are subject to the CSDR)**	**A9 (Fee income relative to interest income)**	30	18	23	31	82	76	90	95	47	124	< 1	An institution classified as a custodian institution is expected to focus on custodian services and hence have a fee income significantly higher than any interest income.
18	**Investment firms dealing on own account/underwriting ('bank-like')**	**A2 (Size of trading book)**	1	0	0	0	19	0	7	30	-9	15	< 20	An institution classified as an investment firm dealing on own account or underwriting is expected to have a significant trading book due to its ability to trade on own account.
19	**Securities trading houses**	**A2 (Size of trading book)**	1	0	0	0	5	0	0	7	-11	18	> 10	An institution classified as a securities trading house is expected to have a small trading book, because its main activity is around operating a multilateral trading facility (MTF), which is fee based.
20	**Securities trading houses**	**A9 (Fee income relative to interest income)**	30	18	23	31	90	97	100	100	93	104	< 100	An institution classified as a securities trading house is expected to have a fee income significantly higher than any interest income, because its main activity is around operating an MTF, which is fee based.

Note: This list also includes tests applied to investment firms, as these business models were also included in the data collection although not considered for the results of this paper, as previously explained. The medians and averages are based on the original data collection, before any review of the business model classification was conducted, as this classification was used to identify benchmarks. The averages and medians for all institutions are based on the full sample, including investment firms.

8.2 Representativeness of the clustering sample

Distribution of credit institutions by country in the reduced sample vs the full population of credit institutions

Country code	Reduced sample		Full population	
	Number of institutions	Share (%)*	Number of institutions	Share (%)*
AT	542	15	544	10
BE	5	0	37	1
CY	12	0	13	0
CZ	13	0	34	1
DE	1 651	47	1 654	31
DK	65	2	85	2
EE	9	0	9	0
EL	17	0	17	0
ES	91	3	125	2
FI	23	1	249	5
FR	0	0	341	6
HR	32	1	33	1
HU	14	0	122	2
IE	1	0	27	1
IT	0	0	555	10
LT	7	0	7	0
LU	0	0	102	2
LV	13	0	16	0
MT	23	1	23	0
NL	26	1	44	1
NO	152	4	153	3
PL	595	17	595	11
PT	41	1	135	3
RO	18	1	29	1
SE	120	3	123	2
SI	17	0	17	0
SK	13	0	13	0
UK	3	0	190	4
TOTAL	**3 503**	**100**	**5 292**	**100**

* The shares do not add up to 100 % due to the rounding.

Note: Please see Table 5 for the country abbreviations.

Distribution of credit institutions by business model in the reduced sample vs the full population of credit institutions

No	Business model category	Reduced sample		Full population	
		Number of institutions	Share (%)*	Number of institutions	Share (%)*
BM01	Cross-border universal banks	43	1	82	2
BM02	Local universal banks	413	12	552	10
BM03	Consumer credit banks (including automotive banks)	45	1	87	2
BM04	Cooperative banks/savings and loans associations	2 123	61	3 019	57
BM05	Savings banks	612	17	734	14
BM06	Mortgage banks taking retail deposits	48	1	132	2
BM07	Private banks	38	1	139	3
BM08	Corporate-oriented	35	1	144	3
BM09	Custodian institutions (including CSDs that are subject to the CSDR)	10	0	44	1
BM10	Institutions not taking retail deposits (including pass-through financing)	35	1	80	2
BM11	Other specialised banks	101	3	279	5
TOTAL		3 503	100	5 292	100

* The shares do not add up to 100 % due to the rounding.

Note: The definition of business model categories can be found in Table 4.

8.3 Dendrograms for different clustering methods and set of instruments

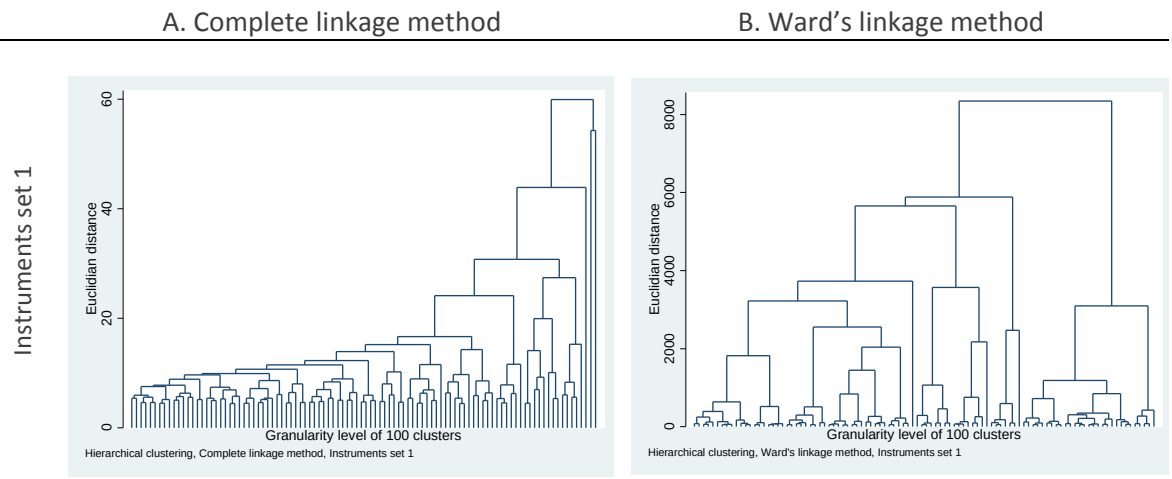
This sections shows the dendrograms resulting from applying the hierarchical clustering, complete linkage and Ward's linkage methods to the data using three sets of indicators.

Subsets of indicators used in clustering

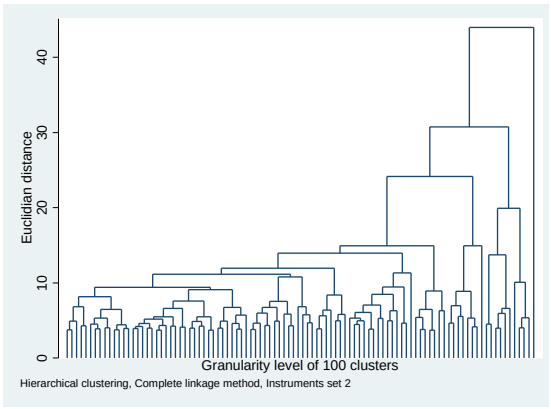
Indicator		Set 1	Set 2 (used in final analysis)	Set 3
A0	**Total assets (balance sheet size)**	x		
A1	**Share of exposures secured by residential immovable property on institution balance sheet**	x	x	x
A2	**Size of trading book**	x	x	x
A3	**Share of derivatives on institution balance sheet**	x	x	x
A4	**Cross-border activity**	x	x	
A5	**Share of retail deposits on institution balance sheet**	x	x	x
A6	**Share of securities liabilities on institution balance sheet**	x	x	x
A7	**Share of interbank borrowing on institution balance sheet**	x	x	x
A8	**Leverage ratio**	x		
A9	**Fee income relative to interest income**	x	x	

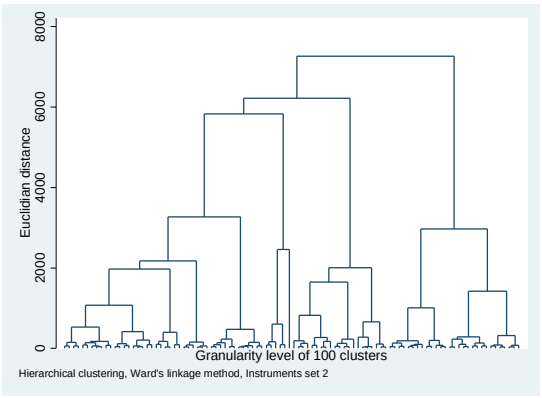
The dendrograms for the clustering using the complete linkage method are shown in the first column of the figure below. The dendrograms for the clustering using Ward's linkage method are shown in the second column.

Dendrogram: hierarchical clustering

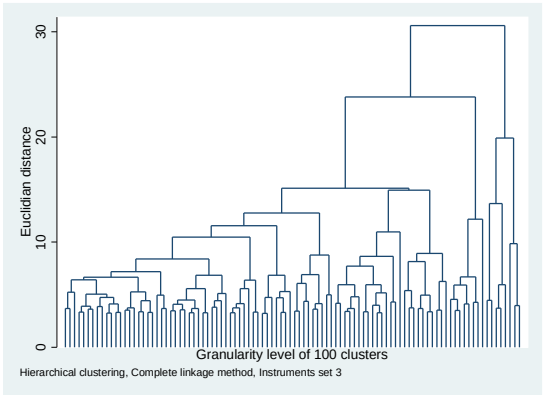


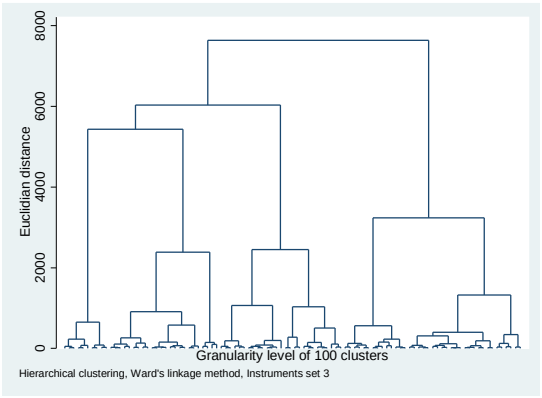
Instruments set 2





Instruments set 3





8.4 Descriptive statistics for the indicators by cluster

Cluster	Number of institutions	Indicator	TA* (EUR million)	A1 (%)	A2 (%)	A3 (%)	A4 (%)	A5 (%)	A6 (%)	A7 (%)	A8* (%)	A9 (%)
1	921	Average	6 629	11.4	0.6	0.2	16.7	32.2	2.3	17.3	11.7	27.1
		Minimum	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.7	-38.3
		1st quartile	247	0.0	0.0	0.0	0.6	15.6	0.0	0.2	6.3	15.0
		Median	1 061	4.0	0.0	0.0	5.4	37.0	0.0	10.4	8.1	20.5
		3rd quartile	3 434	22.4	0.6	0.0	17.3	46.9	0.3	25.9	10.9	29.4
		Maximum	392 444	60.1	13.3	9.8	177.9	93.3	59.0	99.2	478.1	114.8
2	51	Average	17 634	53.5	0.7	1.0	12.9	1.4	77.1	8.6	6.3	-11.7
		Minimum	38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	-638.8
		1st quartile	1 100	0.0	0.0	0.0	0.0	0.0	66.9	0.0	3.3	0.0
		Median	3 282	71.0	0.0	0.0	0.0	0.0	79.9	1.8	5.0	0.0
		3rd quartile	27 873	98.2	0.0	1.8	15.0	0.0	85.5	12.0	7.4	0.6
		Maximum	121 490	128.9	14.2	7.3	118.6	59.4	98.0	77.3	31.0	9.2
3	114	Average	54 883	8.5	12.5	17.9	14.2	43.0	5.2	8.9	11.6	35.9
		Minimum	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-18.4	0.0
		1st quartile	295	0.0	6.8	0.9	0.5	11.3	0.0	0.0	6.3	23.0
		Median	987	6.3	10.7	13.4	5.7	47.5	0.0	1.8	9.0	30.5
		3rd quartile	10 738	11.3	14.0	26.2	26.0	71.4	8.2	16.4	12.0	37.9
		Maximum	1 436 029	73.9	63.7	107.8	66.4	85.2	40.5	54.2	80.9	103.2
4	2 417	Average	1 123	18.4	0.4	0.0	7.3	70.6	0.9	2.7	8.8	23.2
		Minimum	4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-4.8	0.0
		1st quartile	65	0.0	0.0	0.0	0.0	64.5	0.0	0.0	6.9	18.9
		Median	225	13.5	0.0	0.0	2.8	71.4	0.0	0.0	8.3	22.7
		3rd quartile	704	28.5	0.4	0.0	11.6	77.3	0.0	3.5	10.3	27.6
		Maximum	147 788	95.6	8.4	5.1	71.9	98.0	42.0	25.8	29.0	63.5

Cluster	Number of institutions	Indicator	TA* (EUR million)	A1 (%)	A2 (%)	A3 (%)	A4 (%)	A5 (%)	A6 (%)	A7 (%)	A8* (%)	A9 (%)
Total	3 503	Average	4 560	16.7	0.9	0.7	10.1	58.6	2.5	6.8	9.7	24.2
		Minimum	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-18.4	-638.8
		1st quartile	90	0.0	0.0	0.0	0.0	48.1	0.0	0.0	6.7	17.8
		Median	332	11.1	0.0	0.0	3.4	66.1	0.0	0.3	8.2	22.3
		3rd quartile	1 291	26.6	0.6	0.0	13.1	75.0	0.0	8.3	10.4	28.1
		Maximum	1 436 029	128.9	63.7	107.8	177.9	98.0	98.0	99.2	478.1	114.8

*Indicators TA (total assets) and A8 (leverage ratio) were not used in the clustering algorithm. Hence, their values did not define the allocation of banks to clusters and are presented here only as an outcome.

Note: Using the Ward's linkage method, instruments set 2 (see Annex 8.2)

8.5 Cases where banks were allocated to business model categories and clusters that are incompatible with each other

The inconsistencies are discussed briefly below:

- Nine cross-border universal banks were allocated to cluster 1.1 (Cross-border and mixed funding with lower cross-border activity). Among the nine institutions, the cross-border activity varies between 16 % and 79 % of total assets. The diversity in values of this indicator is a result of the clustering approach whereby all variables have the same weight in determining the business model category. The similarity of other attributes may have led to some items with high levels of cross-border activity being included in this cluster, even though a separate sub-cluster with very high cross-border activity has been identified as well. In other words, the clustering does not take into account the different weights the indicators have in determining the business models.

- Thirty-one local universal banks and cooperative banks/savings and loans associations were allocated to cluster 1.2 (Cross-border and mixed funding with high cross-border activity). There are 31 local universal banks in the sample that have cross-border exposures ranging from 39 % to 90 % of total assets. Reasons why these institutions were still classified as local universal banks, despite high levels of cross-border activity, are:

    - The cross-border activities (non-domestic exposures) of the institution are mainly composed of placements in foreign institutions and not loans and advances granted overseas. These institutions conduct the bulk, if not all, of their operations/main services domestically.

    - An on-line commercial bank operates domestically. However, most of the deposits taken domestically are invested in its parent company located abroad, hence the high value of cross-border activity.

    - Finally, in some case the CAs would simply confirm that, even though the cross-border indicator reveals the existence of a significant share of exposures to counterparties located outside the country of residence, local universal bank is still the business model that fits best the institution.

- Nine mortgage banks taking retail deposits were classified in cluster 1 (Cross-border activity and mixed funding):

    - Eight institutions that were allocated to this cluster are mortgage banks in Germany that have low levels of retail deposits:

        - Four of these institutions identified are, to a large extent, institutions with specialised functions, with banking business not necessarily directed to retail depositors, but that nevertheless may take retail deposits.

        - For two institutions, for which the share of securities liabilities was non-zero, while retail deposits were zero, the supervisory authority specifically specified that changing the business model to ‘mortgage banks not taking retail deposits’ is not correct, as that would not reflect the correct business model, given that the banks are not pass-through financing.

- One institution was allocated to cluster 1 because of the very high cross-border activity indicator, despite it clearly being a mortgage bank with high retail deposits. This again shows the importance of weights in allocating banks to business model categories.

- One institution had retail deposits of 31 %, with other funding coming from wholesale debt and securities liabilities. The decision of the supervisory authority to classify the bank as a mortgage bank taking retail deposits relies on the information from the asset side of the balance sheet, i.e. high exposures secured by immovable property, despite the clustering approach that puts more weight on the mixed funding information. For the purposes of business model classification, the business model category suggested by the supervisory authority was used as final.

  - One institution that fell in this group was allocated by the supervisory authority to mortgage banks taking retail deposits, despite having low deposits, because the institution is a subsidiary of another credit institution and is focused on the management of the mortgage legacy portfolio. Since it belongs to a wider banking group, the institution is funded by the group itself and does not rely on retail deposits. Nevertheless, mortgage banks taking retail deposits is the business model that best fits the institution according to the supervisory authority.

- Five pass-through financing institutions were allocated to cluster 1 (Cross-border activity and mixed funding). Two of these institutions are from Norway and three from Poland.

  - The two Norwegian banks were classified by the supervisory authority as mortgage banks not taking retail deposits – pass-through financing as per the banks' reports in official statements, even though they do not have any exposures secured by immovable properties, and their share of securities liabilities is below 20 %. For both institutions, the share of exposures secured by residential real estate is zero, because the cover pool consists of loans secured by commercial real estate (information not collected and therefore not considered), so they were not included in the mortgage banks cluster. One of the institutions is mainly wholesale funded, while the other institution has zero reported for retail, securities and wholesale funding. In both cases, the institutions are not funded by retail deposits.

  - The three Polish banks were classified by the supervisory authority as mortgage banks not taking retail deposits – pass-through financing, and in the clustering methodology were allocated to cluster 1. The reason is that mortgage banks in Poland do not take retails deposits, but they are also not entirely pass-through financing. The banks provide mortgages to retail and business customers and finance themselves with covered bonds and from wholesale markets; however, there is no direct link with the mortgage payments and covered bond payments. They are also subject to an extensive set of additional prudential requirements to ensure safety of the covered bonds issued. Moreover, mortgage banks are distinctive legal entities, as no other banks in Poland can issue covered bonds.

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