



VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF BUSINESS MANAGEMENT

DEPARTMENT OF FINANCIAL ENGINEERING

Monika Mečionytė

**RESEARCH ON FEASIBILITY OF IMPLEMENTATION OF OPEN
BANKING AS A PRODUCT OF FINANCIAL TECHNOLOGIES IN
LITHUANIAN MARKET**

Master's degree Thesis

Financial Engineering study programme, state code 6211LX060

Financial Technologies specialization

Finance study field

Vilnius, 2021

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF BUSINESS MANAGEMENT

DEPARTMENT OF FINANCIAL ENGINEERING

APPROVED BY
Head of Department

(Signature)

doc. dr. Algita Miečinskienė
(Name, Surname)

(Date)

Monika Mečionytė

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Supervisor Grigorij Žilinskij _____
(Title, Name, Surname) (Signature) (Date)

Consultant _____
(Title, Name, Surname) (Signature) (Date)

Consultant _____
(Title, Name, Surname) (Signature) (Date)

Vilnius, 2021

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY
FACULTY OF BUSINESS MANAGEMENT
DEPARTMENT OF FINANCIAL ENGINEERING

APPROVED BY
Head of Department

Finance study field

Financial Engineering study programme, state code 6211LX060

Financial Technologies (FinTech) specialization

(Signature)

doc. dr. Algita
Miečinskienė

(Name, Surname)

(date)

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For student Monika Mečionytė

Master Thesis title: Research on Feasibility of Implementation of Open Banking as a Product of Financial Technologies in Lithuanian Market

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(Day, Month) (Year)

THE OBJECTIVES:

When writing the final thesis, the student must reveal the level of available knowledge and a good understanding of the investigated object, the ability to formulate, analyze and solve relevant problems in the implementation of new financial technology products in the market. While preparing the work, the student must examine the general theoretical aspects of financial technology, reveal the place of open banking among financial technology products and to analyze earlier conducted researches on open banking implementation (development); to propose a methodology for assessing the readiness of institutions to implement new financial technology products and to investigate the possibilities of introducing new financial technologies' products to the market, to assess the readiness of Lithuanian institutions to implement new open banking functionalities and evaluate possibilities of implementing selected open banking functionalities. The additional tasks set by the author herself, which are necessary for the performance of the tasks listed above, must also be performed.

Consultants of the Master Thesis:

.....
.....

(Title, Name, Surname)

Academic Supervisor

.....

(Signature)

Grigorij Žilinskij

(Title, Name, Surname)

Objectives accepted as a guidance for my Master Thesis

.....

(Student's signature)

Monika Mečionytė

(Student's Name, Surname)

.....

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Annotation

In the Master's thesis, the research of feasibility of implementation of open banking as a product of financial technologies in the Lithuanian market is done. The thesis consists of three parts, where the first part covers a theoretical analysis of fintech and its ecosystem as a background of the financial technologies. Moreover, the fintech market is analyzed from a theoretical point of view, where open banking is analyzed as a product of financial technologies. In the second part of the research, methods for the evaluation of the possible implementation of new applications, which are based on open banking services are presented. The T-test is used to evaluate the statistical significance of the mean difference between two independent samples, a mathematical model is built for evaluation of the possibility to integrate new open banking-based applications into the Lithuanian market. In addition, in the third part of the thesis, data is collected and systemized, comparative analysis for the evaluation of open banking application programming interface technical preparation is done. Furthermore, comparative analysis for existing open banking functions availability is done, and based on newly created mathematical model, evaluation of the possible integration of new applications, based on open banking API functions is done. Finally, the results of the research are interpreted, conclusions are made, based on the theoretical literature analysis, and the conducted research results.

Keywords: Open Banking, Fintech, Application Programming Interface,

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Antrosios pakopos studijų **Finansų inžinerijos** programos magistro baigiamasis darbas

Pavadinimas **Atvirosios bankininkystės kaip finansinių technologijų produkto diegimo galimybių tyrimas Lietuvos rinkoje**

Autorius **Monika Mečionytė**

Vadovas **Grigorij Žilinskij**

Kalba: anglų

Anotacija

Magistro baigiamajame darbe atliekamas atvirosios bankininkystės kaip finansinių technologijų produkto diegimo Lietuvos rinkoje galimybių tyrimas. Darbą sudaro trys dalys, kurių pirmoji dalis apima FINTECH ir jų ekosistemos kaip finansinių technologijų pagrindo teorinę analizę. Be to, FINTECH rinka analizuojama teoriniu požiūriu, kur atviroji bankininkystė analizuojama kaip finansinių technologijų produktas. Antroje tyrimo dalyje pateikiami naujų programėlių, pagrįstų atvirosios bankininkystės paslaugomis, galimo diegimo vertinimo metodai. Dviejų nepriklausomų imčių vidurkių skirtumų statistiniam reikšmingumui įvertinti naudojamas T testas, taip pat sudarytas matematinis modelis, skirtas įvertinti galimybėms integruoti į Lietuvos rinką naujas atvirosios bankininkystės taikomas programėles. Trečioje baigiamojo darbo dalyje surenkami ir susisteminti duomenys, atliekama lyginamoji atvirosios bankininkystės taikomųjų programėlių programavimo sąsajos techninio pasiruošimo įvertinimo analizė. Be to, atliekama esamų atvirosios bankininkystės funkcijų prieinamumo lyginamoji analizė, o remiantis naujai sukurtu matematiniu modeliu atliekamas galimų naujų atvirosios bankininkystės, programavimo sąsaja pagrįstų, programėlių integravimo įvertinimas. Galiausiai, remiantis teorinės literatūros analize ir atliktų tyrimų rezultatais, interpretuojami tyrimo rezultatai, daromos išvados.

Prasminiai žodžiai: atviroji bankininkystė, FINTECH, programėlių programavimo sąsaja

(the document of Declaration of Authorship in the Final Degree Paper)

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Monika Mečionytė, 20201284

(Student's given name, family name, certificate number)

Faculty of Business Management

(Faculty)

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**DECLARATION OF AUTHORSHIP
IN THE FINAL DEGREE PAPER**

December 23, 2021

I declare that my Final Degree Paper entitled „Research on Feasibility of Implementation of Open Banking as a Product of Financial Technologies in Lithuanian Market“ is entirely my own work. The title was confirmed on November 17, 2020, by Faculty Dean's order No. 190vv. I have clearly signalled the presence of quoted or paraphrased material and referenced all sources.

I have acknowledged appropriately any assistance I have received by the following professionals/advisers:

Doctor Grigorij Žilinskij.

The academic supervisor of my Final Degree Paper is Doctor Grigorij Žilinskij.

No contribution of any other person was obtained, nor did I buy my Final Degree Paper.

(Signature)
name)

Monika
Mečionytė

(Given name, family

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Data controller details:

Vilnius Gediminas Technical University

Legal entity code: 111950243

Address: Saulėtekio al. 11, LT-10223 Vilnius, Lithuania

Tel. (+370 5) 274 5030

E-mail: vgtu@vgtu.lt

VAT payer code: LT119502413

Data protection officer tel. (+370 5) 251 2191, e-mail: dap@vgtu.lt

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INTRODUCTION

Nowadays, due to rapid change of consumers needs and wants, producers need to adjust products and services, according to the demand in the market. In the past decade, financial markets were affected by technology-based financial innovation – fintech, which is an abbreviation for financial technology. Financial Stability Board (FSB) that is monitoring global financial stability, provides such definition for fintech, as: “technologically enabled innovation in financial services that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services.” The combination of finance and technology assures faster movement of financial funds, goods, services, improvement of the products and services in the market. According to Schindler (2017), the younger generation „that has come of age with mobile technology“ is keen to demand innovations, consequently, one of the demand factors for fintech can be considered demographics. While technology, itself, in the words of the same researcher, is considered as a supply factor for fintech. The demographic environment and fast rhythm of life create conditions that are necessary for financial technology formation.

Relevance of the topic. The diversity of fintech products and their market can be considered relevant, due to the increasing interest in financial innovations that are driven by technology, especially among younger generations. As the innovations are developing at a fast pace, it is important to analyze the latest and most relevant products and services of fintech, as well as changing market for these products to be integrated. Moreover, to understand, what should be further improvement in the fintech market, it is important to analyze, what was already created, and how the fintech market accepted these innovations. Even though the fintech industry is growing rapidly, there is still a lack of scientific articles that are based on the theories of fintech. Therefore, there is a necessity for the research of existing fintech products and services in the market, to be able to understand, how the market works, and what further products could be introduced. Open banking, as a product of financial technologies, could be considered as a new phenomenon. Due to its novelty, there are not a lot of scientific articles, analyzing open banking, yet. However, more scientific literature is mentioning such phenomenon in their analysis of fintech and its existing products and services, which shows that service is evolving and becoming important part of financial technologies. This research is practically significant because Lithuania is becoming one of the hubs of the fintech, and as a financial technology’s product, open banking should be a part of the market of Lithuania. Consequently, it is important to evaluate the feasibility of implementation of OB in Lithuania.

Problem of the research is formulated by a question: whether the technical preparation and functions availability for the open banking service of the Lithuanian market is sufficient to implement new open banking-based applications?

Research objects – technical preparation of the financial institutions that are using open banking service, open banking service.

Aim of the research – to analyze if financial institutions that are using existing open banking services Lithuania are equally technically prepared, as in foreign countries and to evaluate if open banking service functions, available in the banks of Lithuania are sufficient to implement new open banking applications.

Tasks of the research:

1. To analyze the concept of fintech, its ecosystem, and existing services of financial technologies, as well as the review of the open banking concept and its ecosystem from a theoretical point of view.
2. To present the framework of methodology of the research, to provide stages of the research and to describe the methods of the research.
3. To make a comparative analysis of technical preparation of the financial institutions that are using open banking services between Lithuania and foreign countries and to evaluate the availability of the existing open banking functions.
4. To evaluate the feasibility of implementation of new applications, based on open banking, implementation into the Lithuanian market.

The logical structure of the study: the aim and tasks of the research are solved in three separate parts of the thesis. The **first part** is the scientific literature review of the general concept of fintech, its ecosystem. Moreover, analysis of the fintech market and its existing products and services is reviewed from the theoretical point of view and the concept of open banking service is presented together with the analysis of its ecosystem.

The **second part** of the thesis presents a detailed plan of further empirical research and its methodology. The stages of the research are provided, as well as data collection methods for open banking technical performance evaluation. The mathematical model is constructed for the evaluation of the feasibility of integration of new applications, using an open banking application programming interface, into the Lithuanian market.

The **third part** of the thesis presents the results of comparative analysis of the financial institutions that are using open banking, technical preparation, obtained in the empirical research, as well the comparative analysis of existing open banking functions in Lithuanian and foreign financial institutions. Finally, the results of the possible implementation of new applications to the Lithuanian market, using open banking service, based on the functions

available in the banks of Lithuania are presented. Conclusions and recommendations are provided at the end of the thesis.

Research methods. Scientific literature analysis, comparative analysis, mathematical analysis.

Source of information – scientific literature, financial institutions' developer portals.

1. LITERATURE OVERVIEW OF OPEN BANKING AS A PRODUCT OF FINACIAL TECHNOLOGIES

Financial technology in the contemporary world is thriving, as financial products and services have been always widely used, and with the growing digitalization and technological improvements, people tend to have a better understanding of their finance, as well, as businesses have easier supervision of their financial transactions. According to Puschman (2017), financial products are based on the information and do not include any physical interaction. Consequently, recent developments in the information technology sector reflect the financial technology concept, which is reorganizing “the financial services value chain with new business models and new actors entering the market.”

To understand, what new financial technologies could be implemented into the market, firstly, a theoretical analysis of the fintech ecosystem needs to be done. The fintech ecosystem is one of the most important backgrounds for the analysis of the further implementation of products and services. Moreover, existing products and services in the financial technologies market should be reviewed and one of the fintech services, that is thriving in banking sectors - open banking service, presented from the theoretical point of view.

1.1. The Concept of Fintech and its Ecosystem

To begin with, financial technology or fintech, in the Oxford dictionary refers to „computer programs and other technology used to provide banking and financial services”. Meanwhile, in previous studies, fintech is explained as the technology-based products and services, designed to improve the quality of traditional financial products and help keep pace with current trends (Vyšniauskaitė & Miečinskienė, 2020). However, Anugerah & Indriani (2018) present the concept, as „an industry composed of companies using modern technology and innovation with available resources to compete in the marketplace of traditional financial institutions and intermediaries in the delivery of financial services “. Leong, et al. (2017) refers to fintech, as „disruptive technologies in the financial services sector “.

As the phenomenon is still considered new, there is no exact definition, which would be used in all scientific material. According to Lapinskaitė & Kvedaryte (2020), the concept could be divided into the group of authors, that refer to the providers of financial service, that is based on technology, that are using innovations, to provide better financial services and products, while another one refers to the providers of financial services, based on technology,

that are developing technological innovations, to provide better quality financial products or services. In general, technologies used to provide better and faster services, are not always new. But the phenomenon, itself, is considered new, as the financial products and services, that are based on technology, were not used before. In this thesis, the definition, which is used to explain fintech, refers to the one provided by FSB, and it is explained as „technologically enabled innovation in financial services “. To sum up, financial technology is not defined in one single way yet, as it is considered as a new phenomenon, and new area of finance and technology, this is visible as the enabler of financial institutions to adapt to current trends and fast pace of the society in the market.

Furthermore, to analyze the risks and the needs of the market of financial technologies, an important part, to be comprehended is its ecosystem, which refers to a network of interconnected participants of the fintech, that all have an impact on the functioning. Muthukannan et al. (2020) explained the fintech ecosystem as a “heterogeneous, non-linear, dynamic and complex network of agents that interact with each other to provide a wide array of financial products and services to end customers.” Without one of the elements of the ecosystem of fintech, it could not exist and improve rapidly, as elements from the ecosystem should relate to each other. Diemers et al. (2015) suggested that the main elements of the fintech ecosystem include governments, entrepreneurs, and financial institutions. Each of the element is an equally important part of the ecosystem, and the financial technologies sector could not exist without one of them, as the government is responsible for regulations, entrepreneurs for innovations and financial institutions is the market for innovations of financial technology. However, Lee & Shin (2017) and Muthukannan et al (2020) agree, that there are five main elements of the fintech ecosystem, that “work together synergistically to stimulate the economy, enhance customer experience and promote social inclusion”, including fintech startups, technology developers, government, financial customers, and traditional financial institutions. Based on Lee & Shin (2018), financial customers could be classified to individuals and organizations; traditional financial institutions to traditional banks, insurance or stock brokerage firms, venture capitalists; government to financial regulators and legislature; fintech startups to payment, wealth management, lending, crowdfunding companies; technology developers to social media developers, big data analytics, cloud computing and cryptocurrency (Fig 1):

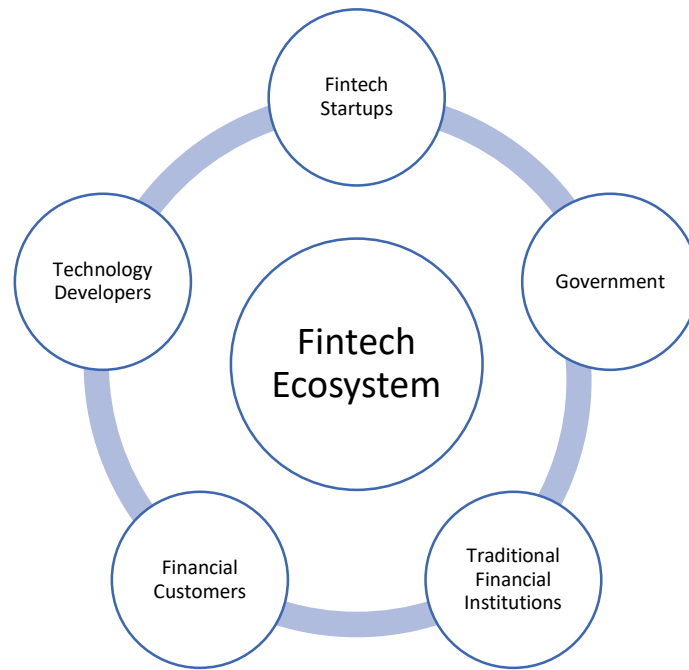


Fig. 1. Main Participants of Fintech Ecosystem

Source: based on Lee & Shin (2017)

- Fintech startups** are explained, as “newly established businesses that offer financial services based on fintech” (Gimpel et al., 2018). They are important, as they are the center of the fintech ecosystem. The functional domain of the fintech startups includes account management; asset management, investments, and savings; crowdfunding and crowd investing; cryptocurrencies; financial planning; insurance; lending and financing; payment and money transferring; peer-to-peer lending; trading and others (Dietz et al., 2016, Dany et al., 2016, Chuen & Teo 2016). These companies are either integrating innovations into existing financial institutions, and creating efficiency and work at a rapid pace, or creating alternative products and services for these traditional financial institutions, to ease the way of their work. According to Lee & Shin (2017), fintech startups could not be developed without considering other fintech ecosystem actors. On the other hand, Svensson et al. (2019) suggest, that “they confront a “liability of newness” (Stinchcombe, 1965) while struggling for visibility, influence, and legitimacy in a competitive market.” Financial technology startups could be classified Business to Business (B2B) or Business to Customer (B2C) type of startups and “cover many consumer-facing elements of the financial value chain” (Gimpel et al., 2018).
- Technology developers** – “digital platform providers, which enable fintech startups to create and evolve innovations in a favorable environment” (Lee & Shin, 2017). It is an important part of the fintech ecosystem, and according to Puschmann (2017), “fintech

reflects the development of an IT-induced transformation”. Based on research of Alt & Puschmann 2012, Puschmann & Alt 2016, one of the drivers of this transformation is changing role of IT, including such developments as “social computing, big data, internet of things or cloud computing enable financial services companies to not only automate their existing business processes but offer the possibility to provide entirely new products, services, processes and business models for the financial services industry”. Technology developers are as important in the ecosystem of fintech, as startups, since startups could not exist without an environment that is provided by technology developers. This part of the ecosystem provides digital platforms that can be used by fintech startups to provide innovative financial products and services for consumers.

- **Government** is one of the key components in the fintech industry, as it creates regulatory framework, according to which fintech companies should work, “make innovative decisions and stay in the competition with other companies.” (Lee & Shin, 2017). He et al., (2017) suggest, that regulatory authorities “need to ensure that trust is maintained in an evolving financial system”, meaning, that with the fast pace of fintech development, regulators should increase attention to emerging new financial services, the governance should be maintained strong, new policies developed, as well as legal principles. Government, as an actor of fintech ecosystem could have positive impact on other dimensions of the ecosystem, such as reducing some regulations. On the other hand, Diemers et al., 2015 stated, that it could also have a negative impact by creating more rigid regulations. However, as regulatory framework mostly depends on the government of the country, some of the countries are developing national economic development plans that create fintech-friendly environment for entrepreneurs, to develop financial sector in the country. As suggested by Diemers et al., (2015), in the countries where fintech ecosystem is more developed, the government and regulation agencies only fulfil the function of defining regulation, policies and property development. On the other hand, in the countries where the fintech ecosystem is less mature, as Saudi Arabia and Jordan, the government and regulation agencies must be connected across the whole ecosystem. To sum up, it is important to study the regulatory framework of the country before emerging a fintech startup, as it creates the possibility to integrate fintech products and services.

- **Financial customers** are individuals or companies that use fintech products and services that are based on innovations. They are the main source of revenue for fintech. As the phenomenon is new, mostly financial customers are from younger generations, as they grew up with technologies. An important fact that was analyzed by Schindler (2017) and Lee & Shin (2017), is that financial customers of fintech products and services are usually from the younger generation, so-called “millennials”. Authors highlight, that demographics is an especially crucial factor of demand for fintech, as the younger generation is used to technologies since they grew up with it. Fintech can offer fast and innovative products and services for these financial customers to satisfy their demands.
- **Traditional financial institutions** are an important part of the fintech ecosystem, the basis for “fintech startups.” Financial institutions reorganize development and are attracted by the implementation of fintech innovations in businesses. Fintech companies either adapt their innovations to traditional financial institutions, to provide better service or offer an alternative service, which could change the traditional financial institutions.

To sum up, these five elements of the fintech ecosystem are equally important, and fintech could not exist without one of them, as they collaborate synergistically. They can be treated as a chain, as fintech startups could not exist if technology developers did not provide a favorable environment for them, as well as government regulatory platforms. If there were no financial customers, fintech did not have revenue, and would not be able to create innovations without funding, as well, as without the basis of the innovations.

1.2. Theoretical Analysis of Fintech Market

As previously mentioned, the fintech ecosystem is the main background of the financial technologies field, where different products and services have been already introduced, and the financial technologies market is created. Based on five main elements of the ecosystem – fintech startups, technology developers, government, financial customers, and traditional financial institutions, the existing services of the fintech market were created and could be divided into several major segments. The segmentation differs in different sources. For example, the Financial Stability Board (FSB) differentiate fintech into four areas, based on the type of innovation:

1. Payments, Clearing, and Settlement

2. Market Provisioning
3. Deposits, Lending, Capital Raising
4. Investment and Risk Management

Meanwhile, Dorfleitner et al., (2017), segment fintech by service inclusion with financing, asset management, or payments service. These segments will be analyzed from the theoretical point of view (Fig. 2). Despite the fact, that the fintech market looks like a good opportunity to create startups, promote new technological ideas and innovations, related to the financial sector, it is also threatening traditional financial institutions, as customers interest is becoming low, once it comes to financial institutions that cannot offer innovations based on technology (Kalmykova & Ryabova, 2016).

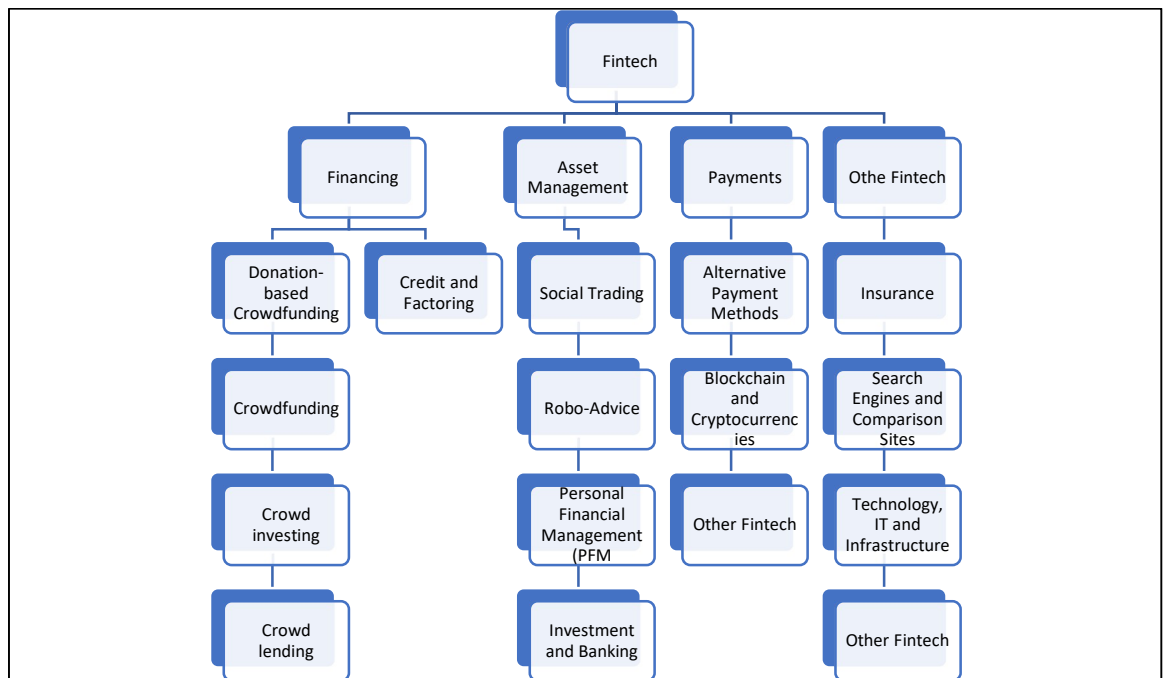


Fig. 2. Segments of Financial Technology

Source: Dorfleitner et al., (2017)

Based on Fig. 2, the fintech market is analyzed from the perspective of each segment of the fintech industry, including financing, asset management, payments areas, and other fintech.

1.2.1. Financing

To begin with, one of the main segments of fintech is financing, which according to Dorfleitner et al., (2017), have such sub-segments as crowdfunding, credit, and factoring. Haddad & Hornuf (2019), agree, that the financing segment can be conceptualized as “the

category financing entails, for example, startups that provide crowdfunding, crowdlending, microcredit, and factoring solutions.”

Moreover, crowdfunding is explained as “the practice of funding a project or venture by raising monetary contributions from a large number of people” (Committee on Banking Supervision, 2018). Other explanations of the phenomenon vary. For example, Cruz (2018), refers to crowdfunding as „an alternative mode of financing, that has provided monetary support for projects “, Hornuf and Schwienbacher (2015), explains similarly, but distinguish, that there might be several models of crowdfunding, including philanthropic projects, such as donations, where no return is expected, and reward-based, “where backers are promised tangible or intangible perks”. Meanwhile, Haas et al. (2014) provide the principle of crowdfunding (Fig. 3), which includes three stakeholders: project initiators, the backers or the capital givers, and the crowdfunding platforms. Project initiators are the ones, who require funds, to be able to start their project, capital givers are the ones, who are willing to invest in a particular project, and the platform works as an intermediary (Bruntje & Gajda, 2016). Crowdfunding is beneficial for entrepreneurs, as they can realize their idea, by attracting a variety of investors. Meanwhile, capital givers can be benefited from crowdfunding in two ways. Haas et al. (2014) suggest a classification of the return type for investors, into two types: reward-based return and interest-based return.

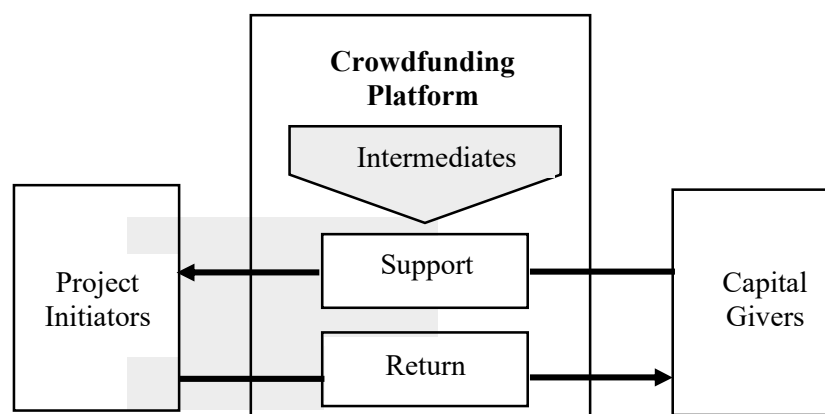


Fig. 3. The Crowdfunding Principle

Source: Haas, Blohm & Leimeister (2014)

Crowdfunding, according to Dorfleitner et al., (2017), could also be categorized to two more sub-segments, such as:

Crowd investing often refers to equity crowdfunding, investment-based crowdfunding, or securities-based crowdfunding, “where firms issue financial securities to satisfy their capital needs. The capital raised this way goes directly to developing a sustainable firm and is not necessarily restricted to a particular product or service “(Hornuf and

Schwienbacher, 2015). The authors were analyzing, how crowd investing dynamics differs from other sub-categories of crowdfunding. Unlike in reward-based return crowdfunding, in crowd investing, investors are focused on the future startup that would bring financial returns. Moreover, crowd investing differs from other sub-segments of crowdfunding, as there is a limited number of shares that could be used in the offer, as an opposite from reward-based return, where, which is open-ended, in terms of offers, that can be proposed.

Crowdlending often refers to peer-to-peer lending or P2P. The definition of peer-to-peer lending (P2P), as per understanding of Wei (2017), is explained, as “Internet lending or person-to-person online lending that involves individuals or “peers” who use online platforms without the involvement of a financial institution as a middleman”. Analogously, Lenz (2016) explains the definition, where he introduces P2P, as the lending platform, without intermediaries standing in between individual, that is lending capital (crowd funder) to another individual, that is borrowing capital (borrower). According to the author, the mediation process of P2P lending works as follows:

1. It starts from the request of a borrower to the lending platform of a loan, required.
2. Then, the P2P platform evaluates the risk assessment and pricing, as well as credit rating.
3. If it is confirmed from the lending platform, the offer is published to crowd funders.
4. The next step is for the crowd funder to choose the borrower that could be financed.
5. If crowd funders do not collect the required amount for the borrower, the request is declined, otherwise, lender’s fee is paid to the platform, as well as borrower’s fee is made for the platform.
6. The borrower is responsible for interest payment and redemption.

Even though P2P lending is becoming a popular fintech industry, it has advantages and disadvantages as a lending platform. According to Milne & Parboteeah (2016), the advantages of P2P lending include low interest, the higher possibility to receive a loan, faster service, and better-quality service. In addition, Kalmykova & Ryabova (2016) suggested, that cross-border personal loans are becoming one of the interests and advantages of P2P lending. On the other hand, there are negative aspects of P2P lending, as well, such as platforms experiencing “cash shortage, fraud, run-away and shut down” (Wei, 2015). Lenz (2017) adds that the standards of information disclosure of borrowers to crowd funders are missing, as well as from the side of regulators, there are no equal rights and opportunities for crowd funders. Other disadvantages might include credit risk, as borrowers in most cases do not receive

traditional bank loans due to low credit ratings, consequently, they are trying to use a P2P lending platform, and due to minimal information disclosure, investors could be endangered into the loss of their investment. As well, there is not enough protection from the government side, which is a huge risk both, to investors and borrowers.

In general, crowdfunding is one of the segments of the financing part of fintech. However, there are different categories of crowdfunding that include reward-based return, interest-based return, crowd investing, and crowdlending or P2P lending. The main attribute of these segments is, that they all have a shared platform, where several individuals (a crowd) are participants of the funding system. However, there are main dynamic differences among these categories, as some are of them are based on reward, while others are based on interest or equity.

Another big part of the financing segment in the fintech market is factoring. Even though factoring is not a new phenomenon, fintech shapes it differently. Factoring is a service by third parties that should provide intermediate solutions for liquidity problems, which are caused by delayed payments. The traditional factoring mechanism is explained by Michalski (2008) in Fig. 4. As the author explains, the supplier (factor client) sells products or services to a purchaser, that is buying on trade credit terms. At the same time, the information of the purchase is transmitted to the third party – factor (financial firm). The factor pays to the supplier about 80-90 % of the amount for products or services due directly after a transaction, while the remaining amount, which will be reduced due to commissions, later. Finally, the purchaser transfers the amount for purchased products or services to the account of the factor.

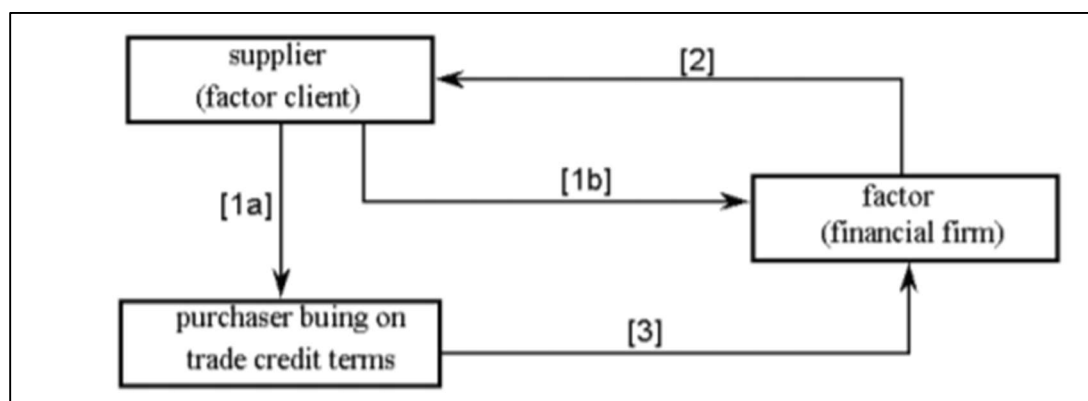


Fig. 4. Mechanism of the Factoring

Source: Michalski (2008)

On the other hand, fintech is trying to transform factoring, by making it digital, transparent, and easy. Factoring is moving to Internet, where fintech startups offer online applications for the service of factoring, making it easy to use for every company. As factoring is being automated, the startups create a platform, as well as in crowdfunding, platform is one

of the tools for service users, to find, what they are looking for. All factoring clients are being checked, if they can receive the service of factoring, and if they do, they are able to see, how much it is possible to use.

To conclude, even though, factoring is an old phenomenon, used in financial sphere, fintech is shaping new attitude towards it, as fintech startups are trying to simplify the process, automate it and to provide availability to different companies to use this financial service.

1.2.2. Asset Management

Another important area of fintech is asset management. According to Haddad & Hornuf (2019), fintech companies that can be classified as asset management companies, should provide such services as robo-advice, social trading, wealth management, personal financial management apps, or software. In addition, Kato (2020) suggests, that nowadays fintech is widely used in asset management business, for example “fintech provides with automated wealth management, which has contributed to the expansion of asset management business for small-sized and inexperienced investors with robot advisors. In addition, the application of big data is progressing even in ESG investment, which has recently attracted a lot of attention.”

One of the main subcategories of asset management in fintech includes automated consultants, known, as robot-advisers. The European Supervisory Authorities joint report defines the phenomenon of automation in financial advice as “a procedure in which advice is provided to consumers without, or with very little human intervention and with providers relying on computer-based algorithm and/or decision trees.” According to Giudici (2018), “robot advisors build personalized portfolios for investors, on the basis of algorithms that take into account investors' information such as age, risk tolerance and aversion, net income, family status.”

Other important sub-segment of asset management in fintech is considered social trading. Doering et al. (2015) explained such phenomenon as “online social networks that allow making investment decisions based upon information gathered in online communities”. Meanwhile, Oehler et al. (2016), suggest, that social trading could be considered the idea to signal providers make their investment decisions available to other investors who follow them. In general, social trading is the form of investment that provides a possibility to observe, how peers or experts are making trading, and what is the behavior of them. The main goal of it is by observing strategies used, to use copy trading or mirror trading. This form of investment can be compared to mutual fund investment (Roder, Walter, 2019). The principle of work includes social trading platform, which is the main tool for private investors and successful traders.

Private investors can search for successful traders in the platform, according to the suitable for them investment strategy. At the same time, professional traders share their strategies on the platform for those investors. Once there is a match between investor and trader, regarding strategy, investor works by using copy trading or mirror trading, while trader earns commissions through active followers. Therefore, there is generated profit for each of the parties (Fig. 5).

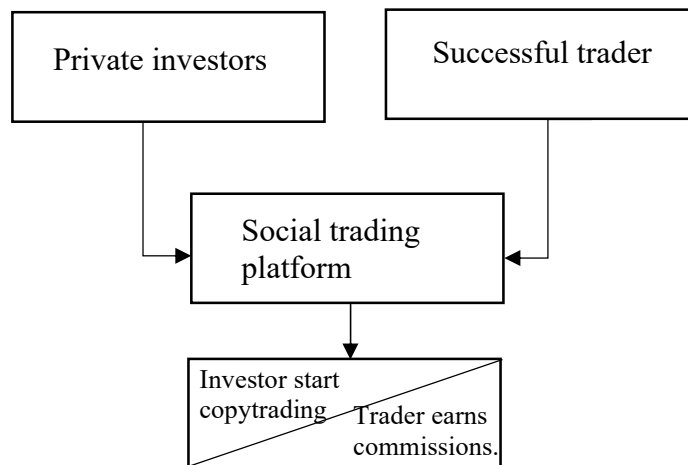


Fig. 5. Mechanism of Social Trading

Source: created by author

As researchers disagree on mutual concept of fintech in general, where some state, that it is no harm to traditional financial institution, and others agree, that fintech industry is competing with traditional banks, there is one more sub-segment of asset management in fintech, that is – banking. Romanova, Kudinska (2016) noticed, that financial technologies are becoming an integral part of banking process, recently, which led banks to the competition from non - financial institutions, providing payment services. Buchak et al. (2018) in their paper include technology-assisted products provided by banks, while others exclude banks from their definition of fintech. Consequently, it is difficult to define, what is the role of banking in fintech industry, as the concept of fintech varies in various sources.

To sum up, asset management includes several sub-segments of fintech, that are becoming more popular nowadays, as people tend to do everything faster, automation and robo-advisers come to help. As well, for easier investment, social trading platforms are becoming more popular. However, even though, in most of the source's banks are an integral part of fintech, it is not agreed unitedly, that banking should be improved by financial technologies, and there are still researchers, who agree, that there is a competition between traditional financial industries and fintech industry, itself.

1.2.3. Payments

As already discussed in the previous research, fintech can be seen from different perspectives. From one side, it can improve traditional financial institutions, as their services and products can become technology based, and adapted to the fast pace of society. On the other hand, it can be seen as a threat, as new financial institutions are evolving, and threaten to diminish the impact and usage of traditional financial institutions, as customers interest becomes lower, if these institutions cannot offer technology-based products and services. According to Dortfleitner & Hornuf (2016), the biggest area of fintech, nowadays, is payments area. To better understand the segment of payments in fintech, the scientific literature overview is presented.

To begin with, Lee & Shin (2018) distinguish payments industry as a separate fintech business model that could be divided into two markets: “consumer and retail payment and wholesale and corporate payment”. These categories also include banking area, where fintech recently is having significant impact. For the analysis of payments segment, one of the consumers and retail payment sub-categories is mobile wallets, or electronic wallets. This product, according to Gomber et al. (2017), is the equivalent of a physical wallet, as a digital storage. Such product “holding identification information, facilitating cash and credit payments, and storing temporary tokens.” Peer to peer payments, on the other hand, are payments between private individuals (Gomber et al., 2017). Meanwhile, Bradford & Keeton (2012), suggested, that there are three models of P2P transfers, including non-bank centric model, bank-centric model, and card centric model. Non-bank centric model of P2P payment is based on non-bank intermediary intervention between two individuals for a payment transaction. This is the example of fintech product, such as PayPal. Bank-centric model includes bank transfer from account of sender to account of recipient via bank. Card-centric model is processed without any intermediaries and is based on transaction over credit or debit card. Digital currencies, as explained by Ali et al. (2014), theoretically could serve as money in a digital way, to anybody, who has availability to internet. There are few alternative names, such as digital money, electronic money, or cyber cash. Although name shows that it can be considered as money in digital form, the same author suggests, that it can be used as money only partially. As it is stated from his perspective, there are three following purposes of money:

- **A store of value**, where the main idea of this purpose of money is to be able to buy goods and services. It means, money must have purchased power. In the case of digital currency, as author suggested the worth of cyber cash is decided on people believes of future supply and demand.

- **A medium of exchange.** The purpose of it is to make payments. In case of digital currency, author suggested, that, since this measure shows, how many retailers would accept money as a payment, digital currency is not the perfect example of money, as it has only several thousand retailers for this purpose. On the other hand, this currency could be considered as money of the future, where the number of retailers can be much greater, and cyber cash would have status of money, then.

- **A unit of account.** The purpose of it is to measure the value of an item that is for sale. Author suggests that digital currency is seldom used for this purpose, as there is no evidence for it. In general, digital currency is not regulated by central bank, which might be the reason for this purpose not to be valid for cyber cash.

In general, payments sector include not only digital money and online transactions but also highlights the importance and purpose of money, which is the main objective for creation of new products and services of fintech.

1.2.4. Other Fintech

As fintech development is fast, new areas of financial technologies evolving, which, based on Dortfleitner et al., (2017) scheme is presented as “other fintech” area. These include groups of financial products and services as insurance, search engines and comparison sites, technology, IT, and infrastructure and remaining other fintech areas. One of the most evolving areas in this category is insurance technological development, which is also called insurtech. As digitalization is progressing in the very fast pace, its disruptive nature leads to the need of contemporary strategies and organizational risks. Based on this need, insurance companies are becoming more and more digitalized to be able to clear digital business cases (Stoeckli et al., 2018). However, the growing uncertainty of global economics and social impact to the customers and society, it is very important to be insured nowadays. According to that, insurance companies are using information technology to increase the digitalization in the traditional insurance industry, which is important not only to incumbents but also to new market entrants. As insurtech is a new term, the body of literature is scarce, however, as a phenomenon it was already mentioned by Puschman (2017), where author reveals, that most of the approaches in fintech focus on banking, while only a few consider insurance. Meanwhile, Alt and Ehrenberg (2016) discuss that more specific conceptualizations such as “Banking Innovations”, “Insurtech” for insurance technologies or “Regtech” for regulatory technologies are domain-oriented but have not yet become as established as fintech. In the PricewaterhouseCoopers report (2016), it is already separated as the insurance-specific branch of fintech, which is

emerging as a game-changing opportunity for insurers to innovate, improve the relevance of their offerings, and grow.

Another emerging area of fintech industry is search engines and comparison sites. Based on Dorfleitner et al. (2017) explanation, fintechs of the search engines and comparison sites subsegment enable the Internet-based search and comparison of financial products or financial services. Digitalization also brings more and more customers to buy products and search for financial information online. Findings based on online retailing trends also suggest that both search engines and infomediaries are beginning to play a strong role in leading consumers to online retail sites. Additionally, some practitioner studies find that about half of online consumers use comparison shopping sites before choosing a retailer. According to Romanova & Kudinska (2016), search engines have expanded their services “interfering” in the fields traditionally covered by banks and changing the business landscape. Moreover, Zveryakov et al. (2019) agree, that search engines have changed the architecture of the market and mediation and led to transformation of business models of financial market entities, in particular banks.

Moreover, as previously mentioned, there is a significant impact of fintech on the banking sector because banks are considered as traditional financial institutions, and as mentioned before, they accept fintech as enabler of technology-based approach, or as a threat, which could reduce the interest of consumers in traditional banking. According to Vives (2017), fintech sector is small in Europe, compared to United States and China. However, there is a huge fintech hub in United Kingdom, especially in banking area. The same author suggests - “With the generation of new business models based on the use of big data, fintech has the potential to disrupt established financial intermediaries and banks in particular.” Different researchers have different opinions on banking and fintech cooperation, and most of them argue, if this is a good combination, which originates revenue, or the opposite. Romanova & Kudinska (2016), suggest, “The rapid rise of fintech has changed the business landscape in banking asking for more innovative solutions. These tendencies require the banks to increase investment in fintech, rethink service distribution channels, especially the business-to-consumers models, increase further standardization of back-office functions.” One of the emerging fintech services that has an impact on banking area is open banking, which emerged in 2018, when European Commission revised the PSD direction, and implemented open data concept to the sphere of financial technologies. The service of open banking is new, however the emergence of it reflects the fintech ecosystem, which was presented earlier in the thesis and separated to such members of ecosystem:

- Fintech startups, which are being created and operate based on open banking principle
- Technology developers, who are creating and supervise the technical part of the service of open banking
- Government, which started with the revision of PSD2 direction by European commission, and later was implemented to all of the countries of European Union by, meaning that open data sharing enables open banking as a service
- Financial customers, who always are prepared for new financial technologies, and creating demand for new and fast financial solutions, services and products
- Traditional financial institutions, in this case – banks, that is the basis for the open banking services and start operating based on “bank as a service” principle.

To sum up, fintech is thriving with new solutions and ideas for the new products and services. All of them are unique and offer different possibilities to customer. Moreover, already existing services and products are being developed at a fast pace, as well, including open banking service, which was already introduced, however, new products based on open banking service are being created and accepted by society. For further analysis, the concept and market research of open banking will be analyzed in the thesis for the possible implementation of new open banking – based products into the market of Lithuania.

1.3. The Concept of Open Banking and its Ecosystem

As mentioned before, United Kingdom is one of the biggest fintech hubs in the world and has implemented various products and services related to the traditional financial institutions. Another country that is boosting fintech implementation is Lithuania, where different fintech startups are being created, as well, as the companies, which are related to financial institutions. Thus, one of the emerging business fields in the financial system, which was pioneered in UK, is open banking. As Liou (2021) explains, “Open banking (OB) is an emerging business field in the financial sector, which relies on intensive collaboration between banks and non-banking service providers”. From this perspective, fintech is an enabler of the technologies on traditional financial institutions and is thriving increasingly in European countries. According to Brodsky & Oakes (2017), “while open banking stands to benefit end users as well as to foster innovations and new areas of competition between banks and nonbanks, it is also likely to usher in entirely new financial service ecosystem, in which banks’ roles may shift markedly. It also raises issues around regulation and data privacy, which helps to explain why global markets have taken varying approaches to governance, contributing to

disparate levels of progress.” Open banking has the potential to reshape the competitive landscape and consumer experience of the banking industry and this system is becoming more popular worldwide. Bank of Lithuania, that is the main organizer and regulator of fintech expansion in the country, explained open banking as „a system, based on application programming interface (API) and intended for sharing financial information necessary for the development of financial products and services“. This phenomenon, relies on a technological network of different financial institutions, enabling them to exchange information more efficiently, as an opposite to the centralized management of the financial data. In other sources, open banking is defined, as the system of allowing access and control of consumer banking and financial accounts through third-party applications. Omarini (2018) defines that open banking in practice would mean, that instead of using different banking firms for different services, „customers could have their current account with one provider and then bolt on other financial services such as an insurance, mortgage and investments through other providers, all under the user interface of their choosing” (Fig 6). This innovation is beneficial not only for customers, but also for businesses. For customers, open banking gives a choice to freely select multiple service providers, as well as to manage their finance safely. For businesses, open banking gives the field for competition between different financial institutions.

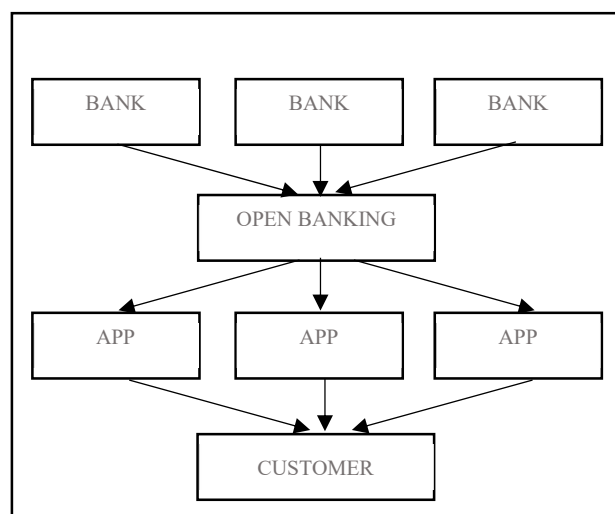


Fig. 6. Open Banking Principle

Source: created by author

Moreover, open banking platform, is already implemented in different countries of the world that are the hubs of fintech. In the past few years, the open banking service has been developing, as society is becoming more digital, and seek for new products, services, applications, that open banking APIs could provide.

Furthermore, according to Camerinelli (2020), the global market of open banking can be segmented, based on different areas, such as financial services, distribution channel and region (Table 1).

Table 1. Segmentation of Open Banking in the Global Market

Global market of open banking segmentation	
Financial services	Bank and capital market, payments, digital currencies
Distribution channel	Bank channels, app market, distributors, aggregators
Region	North America (U.S., Canada, Mexico), Europe (UK, Germany, Netherlands, Spain, and Rest of Europe), Asia – Pacific and LATAM (China, Singapore, Australia, Hong Kong and Rest of Asia-Pacific and LATAM)

Source: Based on Camerinelli (2020)

In addition, there are three main participants in the market that are mandatory in the open banking ecosystem, including regulators, banks, and Third-Party Providers (TPPs). This ecosystem is based on the ecosystem of fintech, as regulators include government, which in open banking case reviews the directive, letting share banks their customers data openly with third-party providers, banks represent traditional financial institutions from the ecosystem of fintech and third-party providers reflect fintech. Additionally, consumer is also part of open banking service, as well as technology developers, who are evolving new applications based on open banking APIs. As previously mentioned, open banking is based on the idea, that “consumers and businesses can now easily share their data with banks and third parties to manage personal accounts and compare banking services” (Gozman et al., 2018)

Based on Passi (2018) findings, three main OB ecosystem participants are necessary for service to exist. First participant of open banking ecosystem is regulator, which changed the idea of open data and is the main participant, that enabled open banking as a service. While some countries were already preparing open banking strategy, European Parliament, in 2018 presented revised payment services directive (PSD2), which requires banks to share customer’s financial data with third parties via Application Programming Interface (API), (Ec. Europa, 2021). This revised directive made payments for customers, easier, faster, and more innovative. The PSD2 directive is beneficial not only to customers, but also to fintech, that are focusing on the payments field, which now have a possibility to provide the competitive applications, where consumers, can easily find the best offers from different banks in different services, that bank can offer. The main principle of PSD2 revised directive is to promote innovations in payments,

where access of customer data to third party providers, in this case, fintech companies, while ensuring enhanced security and strong customer protection (Romanova et al., 2018). Based on European Commission issued directive, PSD2 requires all payment account providers across the EU to provide third-party access. PSD2 does provide the legal framework within which the OB future efforts at creating other national OB standards in Europe will have to operate (Ec. Europa, 2021).

Second participant in open banking market is bank. Based on Minofiev (2017), banks could be differentiated as market players into such groups as large banks that are treating OB as an important program, both for regulatory compliance and strategic reasons. In addition, mid-sized banks that do not have enough funds to invest into high-level propositions of open banking, and digital banks that have the main threat that incumbent banks develop equivalent digital platforms and customer mistrust hinders adoption. For traditional banking, open banking models are more of a challenge, than a benefit. The main threat for the banks is to fall behind more technologically advanced competitors, while the opportunity example is to develop greater customer understanding and increase market share. However, after the PSD2 directive, was revised and presented, banks should prepare to integrate, one of the open banking business models that could be separated into four different archetypes: aggregator, distributor, platform enabler and data provider (Donker & Loenen, 2016).

Third participant in open banking ecosystem is third – party provider (TPP). This is the main participant that enables easier access to different bank services to consumers, via APIs, which allows customer data sharing, such as transactions, bank statements, history of payments (Premchand & Choudhry, 2018). The TPP usually is the private fintech company, which offers applications to the customers, where they can compare different bank platforms, and choose the best option, given. Based on Cortet et al., (2016), these TPPs are visible as challenge to bank institutions, as they need to compete among other bank institution to become better service providers to their consumers. Although the initial objectives of the Open Banking standards were to increase competition in banking and increase current account switching, the intent is continually evolving with a broader focus on areas including reduced overdraft fees, improved customer service, greater control of data and increased financial inclusion. However, there are also main threat for fintech, that there will be increased competition due to the emergence of more third – party providers, while the main opportunity is to increase customer base through access to integrated platforms and marketplaces.

Table 2. Key Threats and Opportunities for Open Banking Main Participants

	Key threats	Example opportunities
Banks	Falling behind more technologically advanced competitors (new and existing)	Develop greater customer understanding and increase market share
Payment providers	Reduced use of debit and credit	Become part of the core payments infrastructure for Open Banking participants
Digital banks	Incumbent banks develop equivalent digital platforms and customer mistrust hinders adoption	Become the platform of choice due to first mover advantage and superior customer engagement
Third Party Providers	Increased competition due to the emergence of more third-party providers	Significantly increase customer base through access to integrated platforms and marketplaces

Source: created by author

To sum up, market for open banking include three main participants – regulators that set the legal rules for the service, traditional financial institutions - banks, which are obliged to share access to customers data, according to PSD2 directive, they also include digital banks, and additional payment providers could be separated. Moreover, fintech companies, or third-party providers (TPPs), that are the intermediary between banks and customers via help of APIs. There are various threats and opportunities for these market participants (Table 2). For banks, payment providers and digital banks the main threats consist of the new competitors, which appears with the help of open banking, these institutions need to become more technologically advanced, to remain competitive. However, all of them fall into huge new platform of open banking. For fintech companies, the competition also increases, as with open banking, more third-party providers emerge, but at the same time, the customer's base increase, as the new service is implemented.

2. RESEARCH METHODOLOGY OF FEASIBILITY OF IMPLEMENTATION OF OPEN BANKING INTO THE MARKET

Open banking is a relatively new financial service that is referring to financial technologies or fintech. This financial service is promoting competitiveness among banks, as the banks, after implementation of open banking are becoming service platforms, and refer to the definition “Banking as a Service.” As the service is mainly built on the use of open APIs, there is a huge importance to evaluate the technical preparation of financial institutions of Lithuania, as well as to compare the performance of open banking APIs, used in open banking with a performance of open banking APIs, in foreign banks, that are considered mostly technically advanced. Moreover, different financial institutions can provide different functions of open banking that have an impact on the availability of products and services that can be derived from the usage of open banking. The comparison of services, provided by banks in Lithuania should be compared to the functions of the most advanced banks that enabled open banking, to evaluate, if there is availability to introduce new applications into the market.

Aim of the research – to analyze if financial institutions that are using existing open banking services Lithuania are equally technically prepared, as in foreign countries and to evaluate if open banking service functions, available in the banks of Lithuania are sufficient to implement new open banking applications.

Based on the data sample, for further analysis, such hypotheses should be checked:

H1: Technical preparation for open banking services is not worse in Lithuanian banks, than in foreign banks.

H2: Lithuanian banks have all functions and technical availability to implement suggested applications of open banking.

In this part of the master thesis, methodology of the research of open banking will be presented. Firstly, the aim of empirical analysis, then sample size and indicators of the sample together with the period of the data collected. Moreover, source of data is provided, as well data processing methods and logical structure of the empirical analysis (Fig 7).

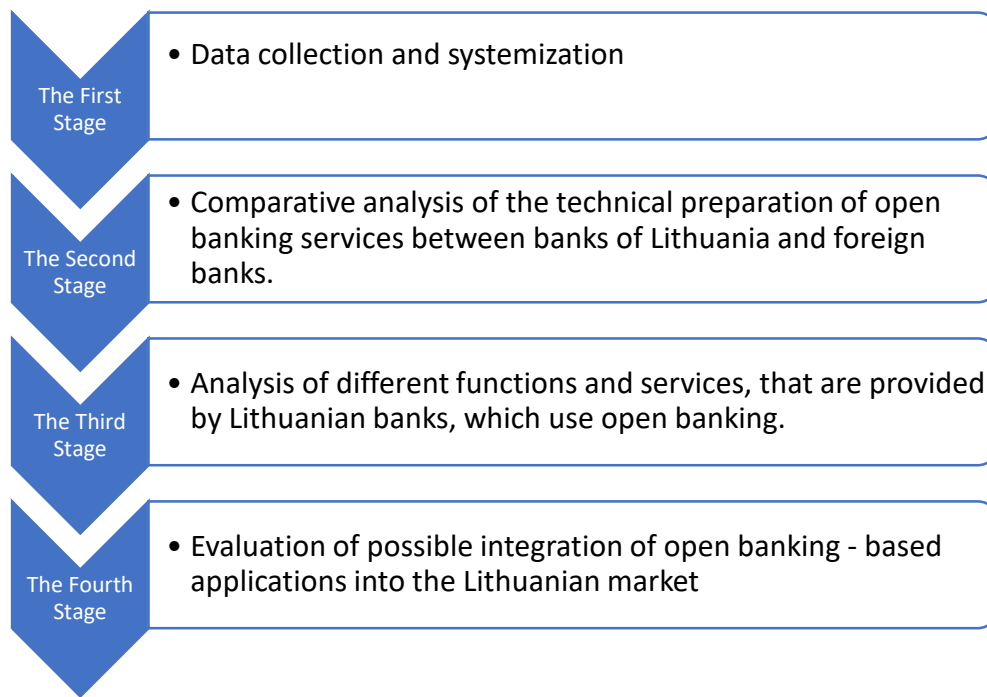


Fig. 7. Stages of the Research

Source: created by author

Stages of research:

Stage 1, collection, and systematization of statistical data. In this part, data sample will be presented, as well as the period of collected data and source. Data will be collected for specific financial institutions that are using open banking services, then for foreign financial institutions data will be collected for comparative analysis of the technical availability between countries. Data will be aggregated, to have the same measurement and sample sizes.

Stage 2, comparative analysis of technical preparation of open banking. T-test or difference between mean method will be presented for comparative analysis of two independent means. The approach will be presented as separate four parts, including the statement of hypothesis, analysis plan preparation, analysis of sample data and the interpretation of the results. Comparative analysis of API metrics will be done, according to the financial institution category and country. Firstly, the technical preparation of the banks of Lithuania will be compared. Secondly, the comparison between banks of Lithuania and other financial institutions will be compared. Finally, technical preparation for open banking of Lithuanian banks will be compared to technical preparation of foreign bank institutions.

Stage 3, comparative analysis of existing functions of open banking between banks of Lithuania and foreign banks. Data of different API functions will be collected for five banks of Lithuania and two banks of United Kingdom. Comparative analysis between Lithuanian and foreign banks open banking API functions will be done and evaluated with the aim to see, if there are additional functions suggested in foreign banks, and what is the tendency. Moreover,

mean value of the functions availability of Lithuanian banks will be calculated by using numerical values 0 and 1 (0, when the function does not exist in the bank, 1, when the function exists in the banks) which will be used for further mathematical model creation.

Stage 4, evaluation of possible integration of open banking-based applications into Lithuanian market. For this part of the research, new mathematical model will be created, which seeks to evaluate the possible integration of new open banking-based applications into Lithuanian market. Moreover, new applications will be presented and later evaluated their possibility to exist in Lithuanian market, based on the calculations of the newly presented mathematical model.

2.1. Data Collection and Systemization

As analysed in the theoretical part of the thesis, open banking is new area in fintech, which was introduced in 2018, when PSD2 directive was revised by European Commission. For this reason, the research and evaluation, of the technical preparation of Lithuanian banks and other financial institutions is needed, to understand the capability of Lithuanian banks, that use open banking APIs, to integrate new services and products.

For the empirical analysis, data collected, will be classified into four types of institutions – banks of Lithuania, foreign bank branches of Lithuania, credit unions, and foreign banks.

The sample of empirical analysis will be collected, based on the report, provided by bank of Lithuania, which is called API register. This report classifies the financial institutions of Lithuania, which are using open banking services, according to financial sector. Financial sector, using open banking service, is classified to banks authorised in the Republic of Lithuania, foreign bank branches and payment institutions holding a payment institution license. Sample will include API metrics for four banks of Lithuania, one foreign bank branch and one credit union, as these institutions in Lithuania provide publicly available statistical API metrics for different periods. Bank of Lithuania report for classification of API financial sectors is chosen due to the reason, that it is the main regulator and supervisor of fintech fostering innovations. Based on the statement, provided by bank of Lithuania, “development of a fintech-conducive regulatory and supervisory ecosystem as well as fostering innovation in the financial system is one of the Bank of Lithuania’s strategic directions”. Moreover, for the comparative analysis of open banking technical performance, the sample for the foreign countries’ banks will be collected. For this sample, based on Deloitte annual report, United Kingdom is chosen as a country for comparative analysis, due to the reason that it is one of the pioneers of open

banking, as well has one of the best technical performance results worldwide. Two banks of United Kingdom will be included in the sample, which are chosen as the best technical performance shown banks of UK in 2020, which share public metrics for open banking APIs.

Furthermore, data in the sample, for the evaluation of open banking technical performance, will include three application programming interfaces (API) metrics, which needs to be measured. Different financial institutions publicly provide such API metrics as account information service provider (AISP) response time, payment information service provider (PISP) response time, error response rate (Table 3). AISP response time shows the daily average time for the transactions of account API, PISP response time shows daily average time for transactions of payments API, error response time shows if any errors occurred during the performance of APIs. Based on this data sample, comparative analysis of the banks and other financial institutions will be done by calculating difference of the means of collected statistical data for API metrics.

Table 3. Open Banking API Metrics

Metrics	Definition
AISP response time	The daily average time (in milliseconds) taken, per request, for the ASPSP to provide the account information service provider (AISP) with all the information requested
PISP response time	The daily average time (in milliseconds) taken, per request, for the ASPSP to provide the payment initiation service provider (PISP) with all the information requested
Error response time	the daily error response rate – calculated as the number of error messages concerning errors attributable to the ASPSP sent by the ASPSP to the PISPs, AISPs and CBPIIs.

Source: <https://standards.openbanking.org.uk/operational-guidelines/availability-and-performance/key-indicators-for-availability-and-performance/performance/latest/>

In addition, based on Fig. 8, PISP model principle could be explained as follows: as previously mentioned, PISP stands for Payment Initiation Service Provider, this provider is authorized to initiate a payment on behalf of a customer, if the permission to do so, was given. From the provided model before open banking service was integrated, customer was paying directly to the merchant, however payment flow included acquirer bank/processor, card network and finally reached issuer bank. Based on new PISP model, such intermediaries as acquirer bank/processor and card network are eliminated, instead customer pays directly to merchant via PISP, which reaches directly to the issuer bank. This model makes payments faster and eliminates unnecessary parts of the flow. Meanwhile, based on AISP model, the customer compliant with PSD2 open data directive, shares the data with third party provider, in this case

account information service provider, and this data is available for all the banks. In before existing model, customer shared the data separately with each of the banks. The benefits of open banking in this case are, that customer has the advantage of the bank's competitiveness in between, as all the banks now are trying to offer the best services and products, as well as the advantage for banks is that they can compete and develop new technology-based products faster and in more efficient way.

In addition, the main purpose of open banking models, such as PISP and AISP, is faster customer service in accordance with the customers' needs. For this purpose, it is important to provide technical capabilities for the service to operate. Technical capabilities, as explained before, are measured by AISP and PISP response rate and error response rate. The faster the response rate for each of the models is, as well as the lower error rate, the better is the technical performance of the open banking API.

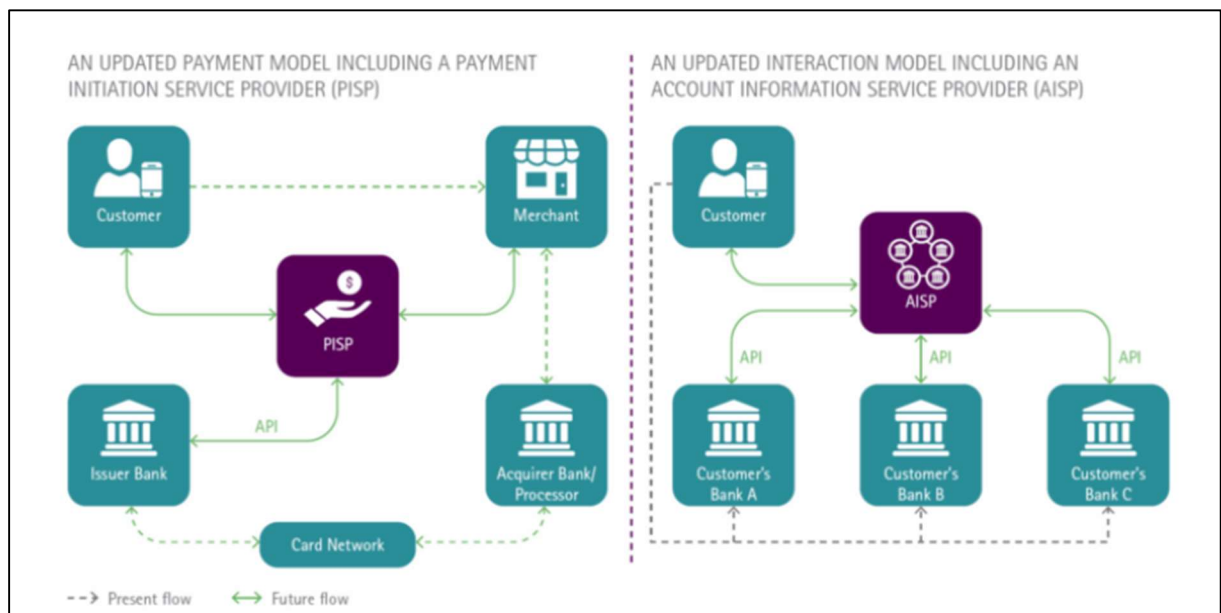


Fig. 8. PISP & AISP Payment scheme

Source: Courtesy Website. <https://paymentscardsandmobile.com>

For the sample, data aggregation must be done, as some financial institutions provide data in different units of measurement. AISP and PISP response times are most often expressed as milliseconds (ms), however, in this analysis data for some financial institutions for AISP and PISP is expressed in seconds, and will be transformed to milliseconds, to be of the same unit of measurement.

Period of empirical analysis – as previously mentioned, open banking as a service was implemented in 2018, when PSD2 directive, regarding open data sharing for banks with third party providers, was reviewed by European commission. However, most of financial

institutions that provide publicly available API performance statistical data, show the metrics from 2019, Q4. The period for the empirical analysis varies in different financial institutions, due to data availability. Moreover, some banks provided daily statistical metrics, while others provided quarterly based data. All data in the sample will be aggregated to the quarters and mean difference will be calculated, accordingly in the comparative analysis.

Source of data – data is collected from each financial institution’s developer websites. For the empirical research data was gathered for four banks of Lithuania, including „Šiaulių Bankas“, „SEB“, „Swedbank“ and „Medicinos bankas“, as well for one foreign bank branch – „Luminor“ and one credit union – „Lietuvos centrinė kredito unija“. Each of the Lithuanian institutions has their developer portal, where they keep publicly available statistics and metrics for open banking usage. For the banks of United Kingdom, statistical data is gathered from each bank developers’ website, where they provide information and statistics for open banking performance during implemented period.

To sum up, data sample is collected for a further analysis, where the comparative analysis of technical preparation of existing open banking services will be done, as well as the existing open banking API functions availability will be analyzed to evaluate the possibility of new application integration into Lithuanian market.

2.2. Methodology for Comparative Analysis of the Technical Preparation for Open Banking Services

For the comparative analysis of technical performance of open banking services, the mean difference statistical test will be used, to evaluate if there is a significant difference of API metrics between two financial institutions. The method, also called two-sample t-test is used, as the conditions for the method are met, based on the data sample. The conditions include such criteria:

- The sampling method for each sample is simple random sampling
- The samples are independent
- Each population is at least 20 times larger than its respective sample

The analysis consists of four separate steps, where firstly, the hypothesis is stated, secondly, the analysis plan is formulated, thirdly, the sample data is analysed and fourthly, the results are interpreted.

For the t-test, the null hypothesis states, that the difference between two population means is 0, while the alternative hypothesis would reject null hypothesis and they are stated as follows:

$$H_0: \mu_1 = \mu_2$$

$$H_a: \mu_1 \neq \mu_2$$

Where μ_1 – mean of one population, μ_2 – mean of second population

For the analysis, significance level with 95% confidence interval is calculated between different financial institution samples. This means, that there is 95% confidence that the observed results are correct and not an error caused by randomness. Moreover, as previously mentioned, test method used for the analysis is two-sample t-test, which determines, whether the difference between means in the hypothesis is different from difference between means in the sample.

Moreover, for the analysis of the sample data, firstly mean value is calculated for each of the samples.

The equation for mean value is concluded as:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n} \quad (1)$$

Where $\bar{x}$ sample mean, x_i – i_{th} element from the sample, n – number of elements in the sample

Secondly, standard deviation for the sample, which indicates, how widely individuals in a group vary, is required for the t-test. Standard deviation is also explained as “a measure of the amount of variation or dispersion of a set of values” (Bland, J.M.; Altman, D.G., 1996).

The equation for standard deviation is concluded as:

$$sd = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad (2)$$

Where sd – standard deviation, $\bar{x}$ – sample mean, x_i – i_{th} element from the sample, n – number of elements in the sample

Source: Bland & Altman (1996)

Furthermore, once standard deviation is obtained, for further data analysis, that is required to obtain t-test and evaluate the statistical significance, pooled standard deviation is calculated.

The equation for pooled standard deviation concluded as follows:

$$s = \sqrt{\frac{(n_1-1)sd_1^2 + (n_2-1)sd_2^2}{n_1+n_2-2}} \quad (3)$$

Where s – pooled standard deviation, n_1 & n_2 – sample sizes, sd_1 & sd_2 – standard deviations of the samples

Source: Beckert et al. (2013)

In addition, the standard error of the sampling distribution needs to be calculated for evaluation of statistical difference between means difference by obtaining t-test.

The standard error of the difference between the two means is calculated as:

$$se(\bar{x}_1 - \bar{x}_2) = s * \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \quad (4)$$

Where se – standard error, $\bar{x}_1$ & $\bar{x}_2$ – means, n_1 & n_2 – sample sizes, s – pooled standard deviation

Source: Beckert et al. (2013)

Finally, t-test can be obtained, once all the values are calculated for the evaluation if there is a difference between mean values of the sample. For t-test P value is calculated with the confidence level of 95%.

The P-value is calculated using the t-test, with the value t calculated as:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{se(\bar{x}_1 - \bar{x}_2)} \quad (5)$$

Where t – P-value, $\bar{x}_1 - \bar{x}_2$ – means, se – standard error

Source: Source: Beckert et al. (2013)

The results should be interpreted based on the results of P-value. If P value is lower than 0.05 with a confidence level of 95%, the result is statistically significant, and null hypothesis should be rejected, if P-value is higher than 0.05 with the confidence level of 95%, the result is statistically insignificant, and null hypothesis is accepted.

The comparative analysis of the technical performance of open banking service for the empirical analysis consists of three parts, including:

1. Comparative analysis of the technical performance of open banking services between banks of Lithuania
2. Comparative analysis of the technical performance of open banking services between banks of Lithuania and other financial institutions of Lithuania
3. Comparative analysis of the technical performance of open banking services between banks of Lithuania and banks of United Kingdom

To sum up, the empirical analysis aims to evaluate, if there is difference between technical preparation of open banking services, firstly, between the banks of Lithuania, then between financial institutions of Lithuania, finally, between Lithuanian and foreign banks that provide such service. The analysis will include four Lithuanian banks, one foreign branch in Lithuania, one credit union and one foreign bank, that publicly provided statistics. The research is done by using standard deviation and P-value, to evaluate if the difference is statistically significant.

2.3. Research Methodology for the Comparative Analysis of Functions Prevalence of Open Banking Service

To evaluate the feasibility to implement new open banking-based applications into Lithuanian market, comparative analysis of the functions' prevalence provided in the banks, using open banking service, needs to be done. In this stage, for the analysis such steps will be done:

1. All available open banking APIs listed.
2. All available open banking functions of the banks of Lithuania listed and classified according to the API.
3. All available open banking functions of the banks of Lithuania compared between the banks.
4. All available open banking functions in the banks of Lithuania compared with available open banking functions of the foreign banks.
5. The mean value for the open banking functions in banks of Lithuania is calculated.

For the comparative analysis, the information of functions availability is extracted from each bank's developer's portal API documentation. Each function is classified according to the API class, including AIS API, PIS API, Consents API, Confirmation of funds API and Events notification API (Table 4).

Table 4. Definitions of Open Banking APIs

API	Definition
Account Information Services (AIS) API	It enables businesses and institutions to share their data with other financial providers, banks, and Third-Party Providers.
Payment Initiation Services (PIS) API	It lets service provider to execute a payment transaction on behalf of a customer
Consents API	It manages data related to consent and privacy across the area of configuration information
Confirmation of funds API	It enables the application to initiate, check available funds within customer's online payment account
Events notification API	It describes the flows and common functionality to allow a TPP to receive event notifications

Source: created by author

Moreover, the functions of open banking are compared between five banks of Lithuania. Then, using the numerical values of 0 and 1 (where 0 means, that function is not available in the bank, and 1 that function is available in the bank), the function support value $s(f_i, b_j)$ for each function f_i (where i is the i -th analysed function) in each bank b_j (where j is the j -th analysed bank in Lithuania).

Finally, the average value of $s(f_i, b_j)$, which define the popularity $pl(f_i)$ of the APIs function f_i between analysed Lithuanian banks is calculated based on the following formula:

$$pl(f_i) = \frac{\sum_{j=1}^k s(f_i, b_j)}{k} \quad (6)$$

Where $pl(f_i)$ – mean popularity of i th analyzed function f_i , k – the number of analyzed Lithuanian banks APIs, b_j – j th analyzed bank in Lithuania.

The result of the popularity $pl(f_i)$ of the APIs function (f_i) between analysed Lithuanian banks calculation is used in the further implementation of mathematical model, to evaluate the service coverage and possibility to integrate new open banking-based applications to Lithuanian market.

2.4. Modelling Method of Evaluation of Possible Integration of Applications Based on Open Banking Functions into the Market

In this part of thesis, mathematical model will be built to evaluate if it is possible to implement new open banking-based application into Lithuanian market by considering all possible functions of open banking APIs.

To build a new open banking based application, a set of APIs functions (noted as $F(n)=\{f_1, f_n, \dots, f_n\}$, where n is the number of needed functions) is required. All available functions prevalence in the banks of Lithuania is analyzed in the comparative analysis of functions availability between the banks, where the presence of a function in a bank is equal to 1, while absence of function is equal to 0.

At the same time some of the API's functions (f_i) from the set of functions might be needed by at least one bank, while the other function from the set of functions might be needed to be supported by all banks (if there is a need to exchange data between or get from all banks at the same time – for example to get the best solution for a loan, all banks should be included into this analysis). In cases when function f_i is required and available for the application m , the function requirement value $r(f_i, m)$ will be equal to 1, otherwise it will be equal to 0.

To evaluate the service coverage and possibility to integrate application, they should be calculated by analysing a set of needed functions $F(n)$. For each of the function f_i the function suitability $fs(f_i, m)$ for application m should be calculated. The calculation formula depends on the function requirement value $r(f_i, m)$ – whether the function is necessary in all analyzed banks to be applied for application m (when the exchange of data between banks required) or only in one bank (when the exchange of data between banks is not required):

$$fs(f_i, m) = \begin{cases} \prod_{j=1}^k s(f_i, b_j) \cdot \left(1 - \prod_{j=1}^k (1 - s(f_i, b_j))\right), & r(f_i, m) = 1 \\ 1 - \prod_{j=1}^k (1 - s(f_i, b_j)), & r(f_i, m) = 0 \end{cases} \quad (7)$$

Where fs – function suitability, f_i – analyzed functions, m – application, r – function requirement value

By having function suitability $fs(f_i, m)$ values for all functions, needed to implement the application m , the service coverage sc for application m with set of functions $F(n)$ can be calculated. It is calculated as average of function suitability of n analyzed functions:

$$sc(m(F(n))) = \frac{\sum_{i=1}^n fs(f_i, m)}{n} \quad (8)$$

Where sc – service coverage, m – application, $F(n)$ – set of functions in a bank,

The possibility to integrate application a_i for application m with set of functions $F(n)$ can be calculated as product of function suitability for application m :

$$ai(m(F(n))) = \prod_{i=1}^n fs(f_i, m) \quad (9)$$

Where a_i – the possibility to integrate application, m – application, $F(n)$ – set of functions in the bank.

The detailed process map for the mathematical model presented in this part is shown in Fig. 9.

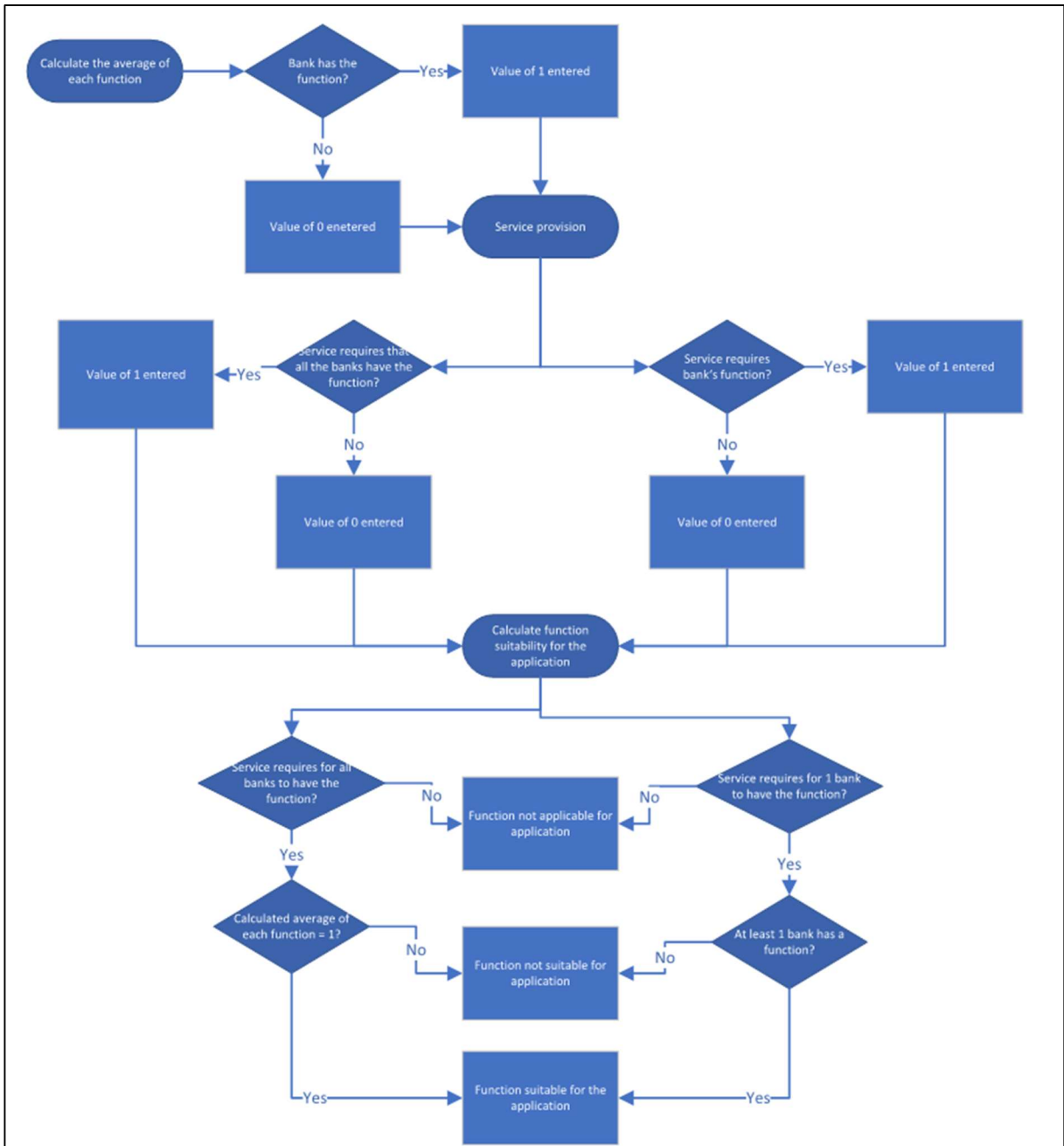


Fig. 9. Process Map for Mathematical Model

Source: Created by author

To sum up, the service coverage shows, what part of the application, the available functions in banks of Lithuania could cover. Meanwhile, the possibility to integrate application shows if based on the function's requirements and availability in the banks of Lithuania, it is possible to integrate new open banking-based application with a set of functions required for this application. If the value is 0 – it is not possible, if the value is 1 – it is possible.

3. EMPIRICAL RESEARCH OF FEASIBILITY OF IMPLEMENTATION OF OPEN BANKING IN LITHUANIAN MARKET

Empirical part of the master thesis consists of the collected data analysis, comparative analysis, and evaluation of technical open banking service performance in Lithuania and foreign countries, comparative analysis of existing open banking functions, and modelling of new applications based on open banking API, the analysis of their possible implementation into Lithuanian market. For the research, the data is collected from developers' websites of the financial institutions, as mentioned in the methodological part of the thesis.

3.1. Empirical Data Analysis

As provided in the methodological part of the research, the aim of empirical analysis – to evaluate, if Lithuanian market is technically prepared for suggested applications, that could be integrated into the market, where banks using open banking APIs. For this aim empirical data is analysed in this part of the thesis.

The sample of empirical analysis - according to the official website of Bank of Lithuania, financial institutions, that have the service of open banking, integrated, include four banks – AB „SEB bank“, AB „Šiaulių bankas“, UAB „Medicinos bankas“ and AB „Swedbank“, from which all banks are included in the sample of research, as they provide public statistics for the metrics analysed. Moreover, there are two foreign bank branches in Lithuania, however, only „Luminor“ bank is included in the research, as AB „Svenska Handelsbanken“ stopped its operations in Lithuania. Furthermore, there is one credit union in Lithuania that provides open banking service – „Lietuvos centrinė kredito unija“, which is included into the sample, as it provided public statistic for open banking metrics. Finally, there are 6 payment institutions holding a payment institution licence in Lithuania, according to the data of bank of Lithuania, including AB „Neo Finance“, UAB „Revolut Payments“, UAB „Satchel Pay“, UAB „Paysera LT“, and UAB „NIUM EU“. However, they are not included in the research due to not providing public statistics of open banking metrics and are included into the list of limitations for this master thesis (Table 6). Moreover, the sample include two best performing open banking using banks of United Kingdom, according to 2020 open banking metrics, including “Bank of Ireland” and “Allied Irish Bank”.

Period of empirical analysis – in the empirical analysis, different financial institutions provide different periods of open banking service metrics (Table 5). For Lithuanian banks, AB “Šiaulių bankas” provided data for the period of 2019 Q4 – 2021 Q2, however, for

the period of 2019 Q4 – 2020 Q1, AIS performance and PIS performance are non-applicable for the bank. AB “SEB” provided data for the period of 2019 Q4 – 2021 Q2. UAB “Medicinos bankas” provided data for the period of 2019 Q4 – 2021 Q1, however, for the period of 2019 Q4 – 2020 Q1, AIS performance and PIS performance are non-applicable for the bank. AB “Swedbank” provided data for the period of 2021 Q1 – 2021 Q2. “Luminor” publicly available data includes period of 2021 Q1 – 2021 Q2. “Lietuvos centrinė kredito unija” provided data for the period of 2021 Q1 – 2021 Q3, however, they do not provide PISP, thus only AISP and error response time can be compared. The “Bank of Ireland” provides data for 2021 Q1 - 2021 Q2 and “Allied Irish Bank” provides data for 2019 Q4 – 2021 Q2.

Table 5. Data Sample Size and Period for Financial Institutions of Lithuania

Table 3: Data Sample Size and Period for Financial Institutions of Lithuania				
	Data sample			Period
Banks authorized in the Republic of Lithuania				
	AIS performance	PIS performance	Error response rate	
AB SEB bankas	595	595	595	2019 Q4 – 2021 Q2
AB „Šiaulių bankas“	5	5	7	2019 Q4 – 2021 Q2
UAB „Medicinos bankas“	4	4	6	2019 Q4 – 2021 Q1
„Swedbank“, AB	181	181	181	2021 Q1 – 2021 Q2
Foreign bank branches				
Luminor Bank AS Lithuania branch	150	150	150	2021 Q1 – 2021 Q2
Credit unions				
Lietuvos centrinė kredito unija	745	745	745	2019 Q4 – 2021 Q3
Foreign banks				
The Bank of Ireland	181	181	181	2021 Q1 – 2021 Q2
Allied Irish Bank	656	656	656	2019 Q4 – 2021 Q2

Source: created by author

Furthermore, as previously mentioned, while collecting data, there were some limitations, that could influence the analysis accuracy (Table 6):

Table 6. Limitations of the Research

Limitation	Explanation
Absence of data	Not all financial institutions in Lithuania that have open banking service provide statistical data for API. None of the fintech institutions provided any metrics for comparison. Most of the foreign banks also do not provide statistics publicly, so the sample of foreign banks is small.
Data structure	Data structure, provided by various financial institutions is different, as well as period. Some institutions provide data daily, while others the average of quarters.

Source: created by author

To sum up, data used for the comparative analysis include data for five banks of Lithuania and two banks of United Kingdom that are evaluated best for the open banking technical performance in the country. The period of empirical analysis varies due to the limitation of absence of data and starts from 2019 Q4 for some of the banks, ends at 2021 Q2 for most of the banks.

3.2. Comparative Analysis of the Technical Performance of the Financial Institutions for the Possible Implementation of New Open Banking Services

To begin with, the analysis of the data collected is presented visually, where AISP, PISP and error rate response tendency among Lithuanian banks is visible. For AIS performance tendencies (Fig 10), it is visible, that AISP for “Šiaulių bankas” was decreasing from 2020 Q2 to 2020 Q3, then was steady until 2021 Q1, when it started increasing, and reached maximum in 2021Q2, when the metrics was highest among all banks of the research. This information provides the conclusion, that “Šiaulių bankas” open banking performance in account information service became worse recently. For “SEB” bank, AISP was decreasing from 2019 Q4 until 2021 Q1, when it started to slowly increase, which reflects the improving performance of account information service. For “Medicinos bankas”, the AISP was increasing constantly from 2020 Q2, however, it is not clear, what is the status for 2021 Q2, as bank did not provide data for this quarter publicly, yet. However, the results show, that the performance is getting worce. For “Swedbank”, AISP decreased from 2021 Q1 to 2021 Q2, as well, as for “Luminor”, however the numbers were much higher for “Luminor” in these quarters, which shows, that “Swedbank” open banking performance is getting better, while “Luminor” status became worse recently.

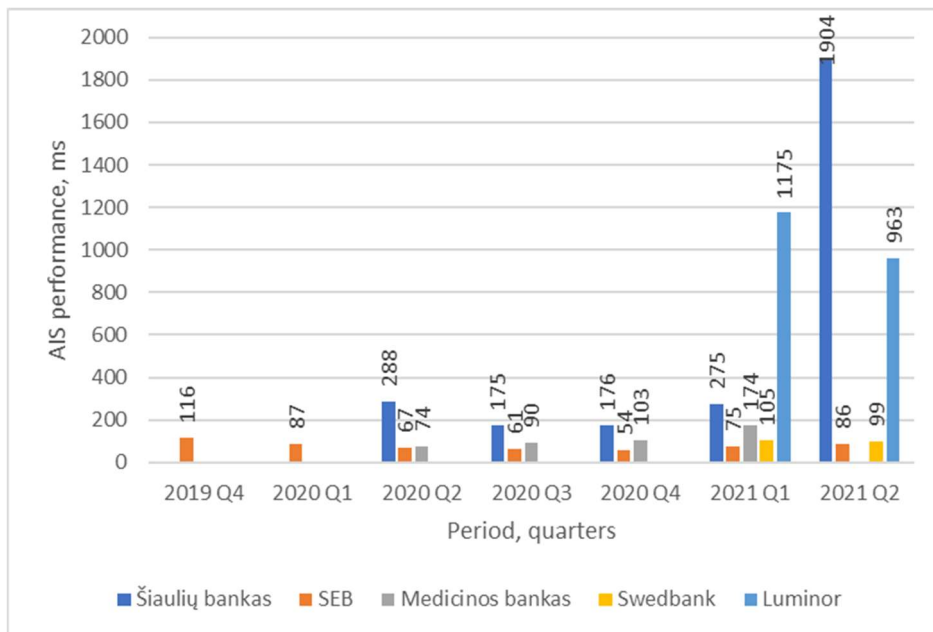


Fig. 10. Comparison of AISP between Banks of Lithuania

Source: created by author

For PIS performance tendencies (Fig. 11), it is visible, that PISP for “Šiaulių bankas” highly increased from 2020 Q2 to 2020 Q3, however it was decreasing from 2020 Q3 to 2021 Q1, when started increasing again. The results show that performance is getting worse. For “SEB” bank, PISP was increasing from 2019 Q4 to 2020 Q2, then became fluctuating by decreasing and increasing again each quarter. For “Medicinos bankas” PISP was almost steady from 2020 Q2 to 2021 Q1, when it increased exponentially. Moreover, for “Swedbank”, PISP increased from 2021 Q1 to 2021 Q2, the same happened to “Luminor”.

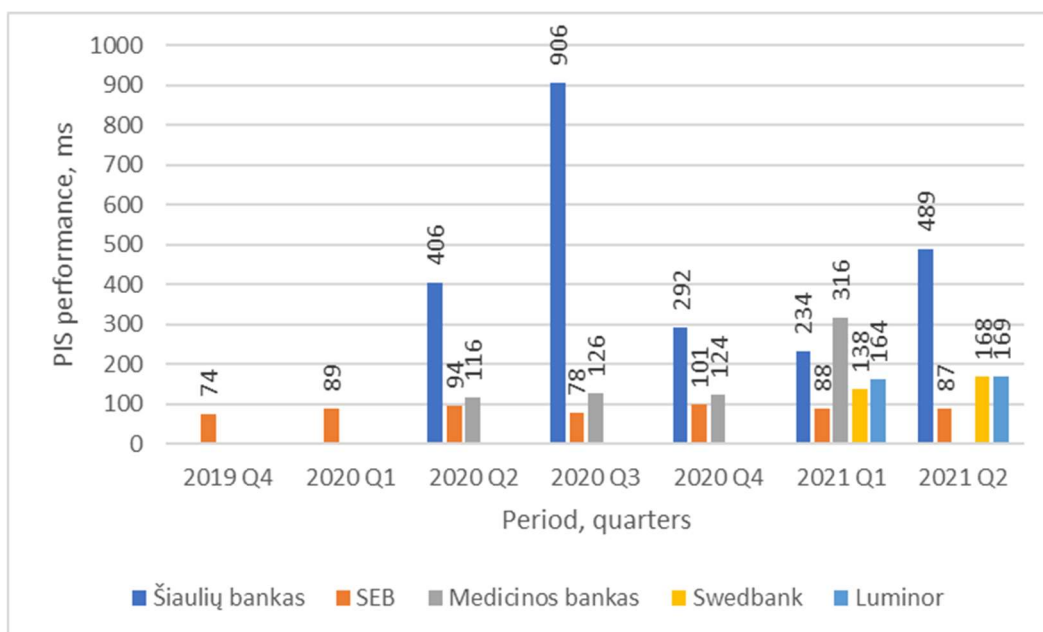


Fig. 11. Comparison of PISP between Banks of Lithuania

For error response time (Fig. 12), the highest error response rate was estimated for „Šiaulių bankas“, which was fluctuating from 2019 Q4 until 2021 Q2, the only quarter without error response was 2020 Q2. Meanwhile, for „SEB“ error response time in all periods were less than 0.1 %. For „Medicinos bankas“, the highest rate was in 2019 Q4, however for 2020 Q2, Q3 and Q4 it was 0%. For „Swedbank“ error response in last 2 quarters were less than 0.1%, and finally for „Luminor“, it was decreasing from 2.054 % to 1.136 % for the last 2 quarters.

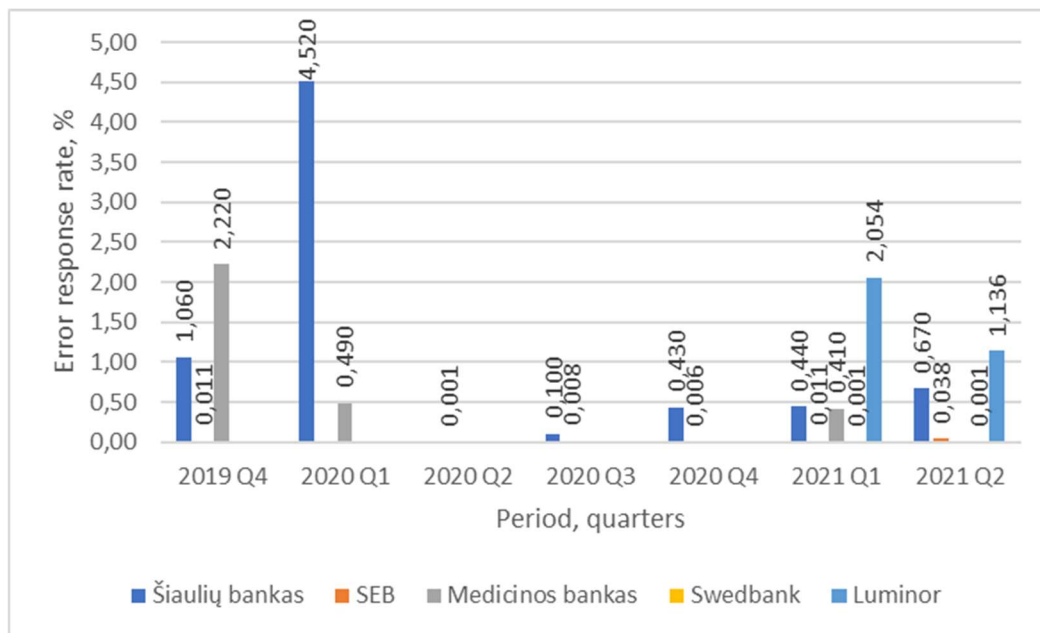


Fig. 12. Comparison of Error Response Time between Banks of Lithuania

Source: created by author

To sum up, for data analysis of open banking performance in Lithuania, three different metrics are used, including AIS performance, PIS performance and error response rate. The data provided publicly differs in the format, units of measurement, and periods, thus it was aggregated. The performance of Lithuanian banks vary, however visible tendency is, that for „Šiaulių bankas“ the performance in all three metrics was the worst, while “SEB” bank could be considered the best performing recently, according to the statistics provided.

Moreover, in this part, the comparison of the API metrics between the banks of Lithuania is done. The results include the difference, and the significance level, which shows, if the result is statistically significant or not. A p-value, which is lower or equal 0.05 shows, that result is statistically significant, otherwise it is statistically insignificant. In addition, all Lithuanian banks metrics are compared with the credit union institution, results are reviewed and concluded. The results also show the difference and significance level.

The difference of API metrics was calculated for four banks of Lithuania – “Šiaulių bankas”, “SEB”, “Medicinos bankas”, “Swedbank” and one foreign branch – “Luminor”. The

results are conducted in (Table 7) for each bank's AISP, PISP and error response rate. Firstly, the mean value for each banks metrics was calculated by adding all values of the metric and dividing by the number of the metrics. Then, standard deviation was calculated. Moreover, the difference, and statistical significance was calculated and are reflected in the table.

Table 7. Comparison of API Metrics of Lithuanian Banks

		SEB			Medicine Bank			Swedbank			Luminor		
		AISP	PISP	Error response rate	AISP	PISP	Error response rate	AISP	PISP	Error response rate	AISP	PISP	Error response rate
Bank of Šiauliai	<i>Difference</i>	-483,32	-379,1	0,15	-453,09	-294,82	-0,51	-461,66	-312,16	-1,029	480,39	-298,16	0,46
	<i>Significance level</i>	P<0,0001	P<0,0001	P=0,0198	P=0,2736	P=0,0752	P=0,4964	P<0,0001	P<0,0001	P<0,0001	P=0,6654	P<0,0001	P=0,8836
SEB	<i>Difference</i>				30,23	84,28	-0,66	21,72	66,94	-1,179	963,71	80,94	0,31
	<i>Significance level</i>				P=0,146	P<0,0001	P<0,0001	P=0,0002	P<0,0001	P<0,0001	P<0,0001	P<0,0001	P=0,3599
Medicine Bank	<i>Difference</i>							-8,51	-17,34	-0,519	933,48	-3,34	0,97
	<i>Significance level</i>							P=0,8906	P=0,4977	P<0,0001	P=0,4521	P=0,9487	P=0,7750
Swed	<i>Difference</i>										941,99	14	1,489
	<i>Significance level</i>										P<0,0001	P=0,1050	P=0,0159

Source: created by author

Firstly, “Šiaulių bankas” metrics were compared with “SEB,” where it is visible, that there is statistically significant difference in AIS performance and PIS performance, as well as statistically significant difference for error response time. “Šiaulių bankas” is performing worse, then “SEB”. When comparing “Šiaulių bankas” with “Medicinos bankas”, the results for AISP, PISP and error response time were statistically insignificant. Moreover, compared with “Swedbank,” the results for all three metrics were statistically significant and showed, that “Šiaulių bankas” is performing worse, then “Swedbank” in AISP, PISP but better in error response rate. Finally, compared with the foreign branch bank – “Luminor,” “Šiaulių bankas” has only PISP worse than “Luminor,” which is statistically significant, while AISP and error response rate were statistically insignificant.

Moreover, “SEB” was firstly compared with “Medicinos bankas.” The results showed, that AISP is statistically insignificant, while PISP is better, then in “Medicinos bankas,” and error response rate is better. Then, “SEB” was compared with “Swedbank.” The results for all metrics were statistically significant, showing, that “SEB” is better on AISP and PISP and error

response rate. Finally, “SEB” was compared with “Luminor.” The results were statistically significant for AISP, showing, that “SEB” is performing better, as well as for PISP. However, it was statistically insignificant for error response time.

Furthermore, “Medicinos bankas” was compared with “Swedbank,” where the results for AISP and PISP were statistically insignificant, however the result for error response time showed, that “Medicinos bankas” has a better result here. Then “Medicinos bankas” was compared with “Luminor”. However, the results for AISP, PISP and error response time were statistically insignificant.

Finally, “Swedbank” was compared with “Luminor”. The results for AISP and error response rate were statistically significant, and showed, that “Swedbank” performance is better, however it was statistically insignificant for PISP.

To sum up, it could be said, that “SEB” is performing the best from Lithuanian banks, however, for some statistics the results were statistically insignificant, and “Šiaulių bankas” could be considered as the worst from the banks of Lithuania.

In the second part of the empirical analysis, the mean of the means of Lithuanian bank (including “Luminor”) was compared with credit union financial institution – “Lietuvos centrinė kredito unija”. The main purpose of the comparison was to see, if another type of institution metrics is better or worse than API metrics of the banks. However, as mentioned in the methodological part of the coursework, “Lietuvos centrinė kredito unija” has publicly available metrics only for PISP and error response rate, thus it was not possible to compare AISP in this case. The results (Table 8) showed, that, PISP difference between banks of Lithuania and credit union institution is statistically insignificant, while error response rate is statistically significant and better in banks of Lithuania.

Table 8. Comparison of the API Metrics between Banks of Lithuania and Credit Union

		Credit Union	
		<i>PISP</i>	<i>Error response rate</i>
Banks of Lithuania	<i>Difference</i>	55,629	-0,583
	<i>Significance level</i>	P=0,1257	P=0,0040

Source: created by author

To sum up, there were compared three metrics, including AISP, PISP and error response time for open banking API service performance measuring between four banks of Lithuania, one foreign bank branch, and later between banks of Lithuania and credit union

financial institution. Some of the results were statistically insignificant, but it is visible, that “SEB” performance is better than most of the banks of Lithuania, however “Šiaulių bankas” open banking technical performance is the worst. There are also such limitations, as absence of data, different sizes of samples and missing AISP data for credit union, which might have influenced the results.

In addition, to evaluate, if Lithuanian banks are equally technically prepared for open banking services as foreign banks, the comparison of the means should be done. In this case, the mean of the means of 4 banks of Lithuania and 1 foreign branch were calculated, as well as the mean of standard deviations of all the banks and compared with the mean of the metrics for AISP, PISP and error response rate of the two banks of United Kingdom, which were chosen, as they are some of the bests performing foreign banks, in terms of open banking services. The results (Table 9) showed that the difference between AISP, PISP and error response rate is statistically insignificant.

Table 9. Comparison of the API Metrics between Banks of Lithuania and Bank of United Kingdom

		Banks of Lithuania		
		AISP	PISP	Error response rate
Banks of United Kingdom	<i>Difference</i>	-542.939	-355.370	0.288
	<i>Significance level</i>	P=0.0740	P=0.0956	P=0.5873

Source: created by author

In conclusion, the H₁- technical preparation for open banking services is not worse in Lithuanian banks, than in foreign banks, is rejected, as the results are statistically insignificant.

3.3. Comparative Analysis of Existing Open Banking Functions Availability between Lithuanian and Foreign Banks

To model new applications with a usage of open banking that could be implemented into the Lithuanian market, firstly the comparative analysis of existing OB functions was done. For the analysis, five banks of Lithuania, including AB “SEB”, AB “Šiaulių bankas”, UAB “Medicinos bankas”, AB “Swedbank” and “Luminor” are chosen, as well as two banks of United Kingdom, including “Bank of Ireland” and “Allied Irish Bank”. For the analysis, five mostly used APIs are analysed, their functions presented and compared among different banks (Table 10).

Table 10. Comparison of the Existing Open Banking Functions Availability

	API Function	Banks of Lithuania					Average	Banks of United Kingdom	
		SEB	Šiaulių bankas	Medicinos bankas	Swedbank	Luminor		Bank of Ireland	Allied Irish Bank
AIS API	Account list	1	1	1	1	1	1	1	1
	Account list from different banks	1	0	0	1	0	0,4	1	1
	Account information	1	1	1	1	1	1	1	1
	Account balance	1	1	1	1	1	1	1	1
	Account statement	1	1	1	1	1	1	1	1
	Account statement per currency	1	0	0	1	0	0,4	1	1
	Account transaction	1	1	1	1	1	1	1	1
	Account information of the credits, loans, and mortgages	0	0	0	0	0	0	1	1
PIS API	Initiate payments from another app/service provider	0	0	0	1	0	0	1	1
	SEPA payments	1	1	1	1	1	1	1	1
	International payments	1	1	1	1	1	1	1	1
	Instant payments	1	0	0	1	0	0,4	1	1
	Recurring/periodic payment (redirect only)	1	1	1	1	1	1	1	1
	Variable recurring payments	0	0	0	0	0	0	1	1
	Future dated payment	0	0	0	1	0	0,2	1	1
	Post bulk payments	0	0	0	1	0	0,2	1	1
Consents API	Quick balance check	1	1	1	1	1	1	1	1
	Good for card-based transactions	1	1	1	1	1	1	1	1
	Secure upcoming transactions	1	1	1	1	1	1	1	1
Confirmation of Funds API		1	1	1	1	1	1	1	1
Events Notification API		0	0	0	0	0	0	1	0
Average		0.7	0.5	0.5	0.9	0.5	0.6	1	0.95

Source: created by author

The results could be separated for each of the APIs provided:

- For **AIS API**, account list function is available in all banks of Lithuania, as well as in both banks of United Kingdom, as well as account information, account balance, account statement and account transaction. Meanwhile, such function as account list from different banks is not available in “Šiaulių bankas”, “Medicinos bankas” and “Luminor” but it is available in both banks of UK. For the function of account statement per currency, the banks that declared such function in API documentation, include “SEB” and “Swedbank”, while it is

available in both banks of UK. Finally, account information of the credits, loans and mortgages, based on API documentation is not available in any banks of Lithuania, however, it is available in both banks of UK.

- For **PIS API**, such functions as SEPA payments, international payments and recurring/periodic payments are available in all banks of Lithuania as well, as in banks of UK. However, the function to initiate payments from another app/service provider is available only in “Swedbank” from the banks of Lithuania and in both banks of UK. Moreover, instant payments are not possible in “Šiaulių bankas”, “Medicinos bankas” and “Luminor”, while they are possible in both banks of UK. Variable recurring payments as a function is not available in any banks of Lithuania, while UK banks have such a function. Finally, such functions as future dated payments and possibility to post bulk payments are available only in “Swedbank” and also in the banks of UK.
- For **Consents API**, three functions were listed, including quick balance check, good for card-based transactions and secure upcoming transactions. All of these functions are available in all banks of Lithuania as well as in banks of United Kingdom.
- For **Confirmation of Funds API**, the principle of API is to confirm the funds in the customers bank account and from the data analysis it is visible, that this function is available in all banks of Lithuania, as well as in the banks of United Kingdom.
- For **Events Notification API**, which describes the flows and common functionality to allow a third-party provider to receive event notifications, the availability in Lithuania is equal to 0, as none of the banks of Lithuania has such API covered. On the other hand, comparing banks of UK, only Bank of Ireland is using this API for open banking services.

Finally, the average of the Lithuanian banks functions is calculated, which is used for the further modelling of new applications and evaluation of their implementation into the Lithuanian market. To conclude, based on the among banks of Lithuania, “Swedbank” has the most available functions of open banking APIs, while other banks functionality is similar between each other. For the banks of UK, the functions availability is much higher than for banks of Lithuania, for this reason, further analysis needs to be done to evaluate the possibility of new open banking-based applications integrations to Lithuanian market with the available functions of open banking APIs.

3.4. Evaluation of the Technical Possibility to Integrate Selected Open Banking Applications into Lithuanian Market

Furthermore, for the empirical analysis three open banking-based applications are suggested, and according to the functions needed, their possibility to be implemented into Lithuanian market is evaluated. Required functions are listed and evaluated, if there is a need of a function for certain application, and if this function needs to be available in all banks of Lithuanian for the application to be successfully integrated. Finally, service coverage is calculated by counting the average of value of the averages of each function. Moreover, possibility to integrate application shows the product value (Table 11).

Table 11. Model for the Possible Integration of New Open Banking Applications to the Lithuanian Market

	API functions	Subscription management			Charitable round ups			Notification of the availability to pay a loan		
		Need of function	Need of all banks	Function suitability for the application	Need of function	Need of all banks	Function suitability for the application	Need of function	Need of all banks	Function suitability for the application
AIS API	Account list	1	1	1	1	0	1	0	0	
	Account list from different banks	1	1	0	0	0	0	0	0	
	Account information	1	1	1	0	0		0	0	
	Account balance	1	1	1	1	0	1	1	0	1
	Account statement	0	0		0	0		0	0	
	Account statement per currency	0	0		0	0		0	0	
	Account transaction	0	0		1	0	1	0	0	
	Account information of the credits, loans, and mortgages	0	0		0	0		1	0	0
PIS API	Initiate payments from another app/service provider	0	0		1	0	0	0	0	
	SEPA payments	1	1	1	1	0	1	0	0	
	International payments	0	0		1	0	1	0	0	
	Instant payments	0	0		0	0		0	0	
	Recurring/periodic payment (redirect only)	1	1	0	0	0		0	0	
	Variable recurring payments	1	1	0	0	0		0	0	
	Future dated payment	0	0		0	0		0	0	

Continuation of Table 11

	Post bulk payments	0	0		0	0		0	0	
Consent s API	Quick balance check	0	0		0	0		0	0	
	Good for card-based transactions	0	0		0	0		0	0	
	Secure upcoming transactions	0	0		0	0		0	0	
Confirmation of Funds API		0	0		0	0		1	1	
Events Notification API		1	1	0	0	0		0	0	
Service coverage				0,57			1			0,5
Possibility to integrate application				0			1			0

Source: created by author

The applications, suggested, include subscription management, charitable round ups, and notification of the availability to pay a loan.

- Subscription management.** The application is based on the events notification API, as well as PIS API and AIS API, which are part of open banking. Subscription management is a part of subscription economy, which includes everything from financial management apps to automated savings services. As banks are suggesting the function of recurring payments, subscriptions are possible in different accounts of a consumer, meaning, that after a while some of the subscriptions, even if they are not used, are still being transacted as recurring payment. Required functions for the application's integration include such AIS APIs as account list and account list from different banks, account information, account balance, For PIS APIs, SEPA payments are required, as well as recurring/periodic payments and variable periodic payments. Moreover, events notification API is necessary for the application to work.
- Charitable round ups.** The application is based on open banking principle of shared open data. The application received information about a payment or transaction made. It calculates roundup and initiate a donation payment to chosen charity. The costs of application should be covered by 5% of all roundups going towards the platform. The application is already implemented in United Kingdom and became very popular, as it is for a good cause. The technical functions, required for the application to work, include such AIS APIs as account list and account list from different banks, as well as account balance and account transaction. For PIS APIs, initiation of payments from another app/service provider is required, as well as SEPA payments and international payments.

- **Notification of the availability to pay a loan.** The main principle of application is to send the notification to the customer, regarding payment of the loan in a specific period before the loan needs to be paid to the bank. This lets a customer to take care of the balance for the loan until the deadline. There are two main functions of open banking, required, including account balance, for the application to check the availability to pay the loan and account information of the credit, loans, and mortgages, for the application to check, what is the amount of the loan.

Based on the results, it can be stated, that there is still lack of functions of open banking APIs in Lithuanian market, which are required for the proposed applications to start functioning in the market. However, the results of empirical research showed, that for the integration of subscription management application into Lithuanian market, the events notification API is missing, as none of Lithuanian banks has implemented it, yet. Moreover, looking at AIS APIs, required functionality of account list from different banks is not available in several banks of Lithuania, meaning, that the application could be adapted only to those banks, that has this functionality, however it would not manage the mutual budget of accounts in different banks without this functionality. From PIS API, not all the banks have recurring/periodic payments functionality, and most importantly, none of the banks in Lithuania has variable recurring payments functionality, so the integration of subscription management application is not possible, yet.

On the other hand, integration of the application of roundups would be possible in the Lithuanian market, as at least one bank has all the required functions, including such functions of AIS APIs, as account list, account balance and account transaction, as well such functions from PIS APIs as, payments initiation from another app, SEPA payments and international payments. However, not all the banks could be included into the application, and customers, using banks without required functions could not integrate the application to the daily budget management.

Furthermore, integration of the application for notifications of the availability to pay a loan could not be integrated into Lithuanian market, yet, as open banking APIs do not provide information about the loans, credits and mortgages. Such function is not available in any of the financial institutions of Lithuania.

To conclude, H₂ - Lithuanian banks have all functions and technical availability to implement suggested applications of open banking, is accepted only for charitable round ups application, however it is rejected for subscription managements and notification of the availability to pay loan applications.

CONCLUSIONS

1. The scientific literature analysis showed that even though, fintech is evolving fast, it could not exist without five main participants of its ecosystem, including government, traditional financial institutions, financial customers, technology developers and fintech start-ups. Moreover, based on the classification of existing literature, open banking is not separated as one of the segments of financial technologies, yet, as it is rather new service, enabled only in 2018. Consequently, there are not much research conducted for the analysis of open banking, as a financial technologies product, which emphasizes this research novelty.
2. A four – stages methodology has been developed for the study. Comparative analysis was chosen, to evaluate existing open banking service technical performance, using means difference between two independent samples, as all data was divided into separate samples, according to the financial institution and country. Moreover, mathematical model for evaluation of possible integration of OB-based applications was created, which aimed to calculate the possibility of new applications integration, based on available open banking functions in Lithuania.
3. Comparative analysis of the technical performance of open banking APIs showed, that firstly, between the banks of Lithuania, the best performing bank is “Swedbank” based on AISP response rate, PISP response rate and error response rate. Secondly, when compared banks of Lithuania with other financial institutions (credit union in the sample), the performance of banks of Lithuania based on the same metrics is better than the performance of open banking in credit union. Thirdly, the comparative analysis of the banks of Lithuania and banks of United Kingdom showed, that there is no statistically significant difference, so the hypothesis H_1 -technical preparation for open banking services is not worse in Lithuanian banks, than in foreign banks, is rejected, as the results are statistically insignificant.
4. Comparative analysis of existing open banking functions, based on the classification according to the API, showed that banks of United Kingdom have access to higher number of functions, compared with the banks of Lithuania, however between banks of Lithuania, the highest number of functions is available in “Swedbank”, which was also the best performing in terms of technical open banking performance.

5. Based on the mathematical model, that was presented in the methodological part of the thesis, three new open banking-based applications were evaluated from the perspective of existing open banking functions, based on the APIs availability. The applications include subscription management, charitable round ups, and notification of the availability to pay a loan. The results showed that based on the available open banking functions in the banks of Lithuania, it is not possible to integrate subscription management and notification of the availability to pay a loan due to the lack of obligatory functions. However, there is a possibility to integrate charitable round ups-based application, as all the functions required are available in the banks of Lithuania.

Research development opportunities and limitations: To evaluate possible integration of OB-based applications into Lithuanian market, sample should include remaining financial institutions of Lithuania that use open banking service, data. These institutions do not provide data publicly, however, there should be available databases, where these financial institutions provide historical metrics of open banking service technical performance and available OB API functions. Moreover, the results of technical performance of the financial institutions would be more accurate if period for the analysis was equal, however, for this information, each of the institutions should be contacted, regarding historical data availability. Furthermore, all available open banking API functions could be analyzed more deeply, as some of these functions consist of separate parts and functionalities, which might influence possible integration of new applications into the market. Finally, suggested applications could be separated into few categories such as for business and for private consumers, to evaluate if there is a significant difference based on the origin of the application usage.

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