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Exploring the Impact of Fintech Patents on the Evolution of Mortgage Analytics in The U.S.

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Abstract

Research on patents has focused on a myriad of economic and technological problems. However, studies centering patents in the fintech industry remain elusive. Yet patents are a crucial way to display new ideas related to financial markets. This paper reports the analysis of the number and the trend of fintech patents filed and issued in the U.S. from 1972 to 2022, and discusses the consequences of the observed patenting activity on two specific areas related to mortgages: the Housing Price Index and the Affordability Index. The paper also discusses the consequences of the fintech patenting activity on the development of mortgage analytics. It focuses on four components of the development of mortgage analytics: credit assessment, capture of credit risk, design of products, hedging of risk exposure through derivative products.

Prior research has shown that patents create positive effects for society. Patents lead to specific innovations. Innovative products lead to economic growth, productivity increases, and job creation. As is the case for technology patents, fintech patents lead to technology-driven financial sector innovations. Financial market innovations become important for financial partners and for the proper functioning of the financial market economy as a whole. Mortgages are the major components of the liabilities of the household economic sector; they hence are a component of the economy. Some market innovations that fintech patents protect concern mortgages or mortgage-related financial products. Those innovations related to the functional characteristics of mortgage products don't modify the positive effects associated with increasing numbers of patents issued. On the other hand, as has happened in the past with mathematical innovations concerning mortgages, they could potentially generate problems in their use for providers or users if the innovations are just cosmetic.

Keywords: Patents, Fintech Industry, Mortgage Analytics, Housing Price Index, Affordability Index, Credit Assessment, Credit Risk, Product Design, Risk Hedging, Derivative Products, Financial Innovations, Economic Growth, Job Creation, Financial Market, Technology-Driven Innovations, Household Liabilities, Market Innovations, Mortgage Products, Financial Partners, Patenting Activity, Economic Impact.

1. Introduction

Innovation has long played a critical role in the economy. Emerging technologies often disrupt existing industries, but they can also be at the core of the competitiveness of existing ones. The financial and banking markets, like any other industry, go through periods of innovation by creating or recreating various products and services that aim to provide consumers with better options

suited to their financial needs. The Federal Reserve has shown how financial markets are no different from technology-driven industries, and have periods of disruption or innovation. The cycle of invention focusing on new ideas followed by innovation where these ideas are turned into products or services and combined with the commercialization of new production capabilities are fueled by major shocks. We apply this theory to the emergence of mortgages and the tech credit crisis of 2007–2008 to show how major events trigger the spirit of innovation in the financial sector.

Yet, while the introduction of novel ideas is sanctioned by the patent office through the granting of IP rights to companies in the field of technology, pharmaceutical, or other technology-intensive industries, it is far from the case in fintech. Banking and financial strategy are still guided by the notion of discretion and secrecy. The aim of the current study is therefore twofold: One aims to show how patents protect for the first time innovations in the area of finance and banking and in particular mortgages. Specifically, we examine the presence and roles of the regulatory and political environment for patenting behavior and patent performance. The second of our study is to build a bridge between the study of patents' effect on innovation and the academic field of residential mortgage analytics. We show that fintech patents perform quite differently not only from patents in general but also from patents in areas like business models that are close to the fintech area. We also analyze in this paper the peculiarity of the US mortgage market.

1.1. Introduction to the Intersection of Fintech and Patents

Patents have long been considered a signal of technological advance and invention, and thus play a different role in industries that are characterized by different levels of investment and innovation. Neither patents, nor recent financial technology nor mortgage analytics are new ideas. What is novel is the intersection of the three fields, which is what we hope to explore in this paper. Interestingly, there is also very little agreement between patent, fintech, and economic researchers about what it is that fintech is doing. At the broadest level, fintech is about competition in the service of lower prices and greater efficiencies in financial markets and their banks, brokers, and other players. Others take a narrower view to suggest that fintech is actually about the creation of financial services and products outside of traditional lending and deposit institutions.

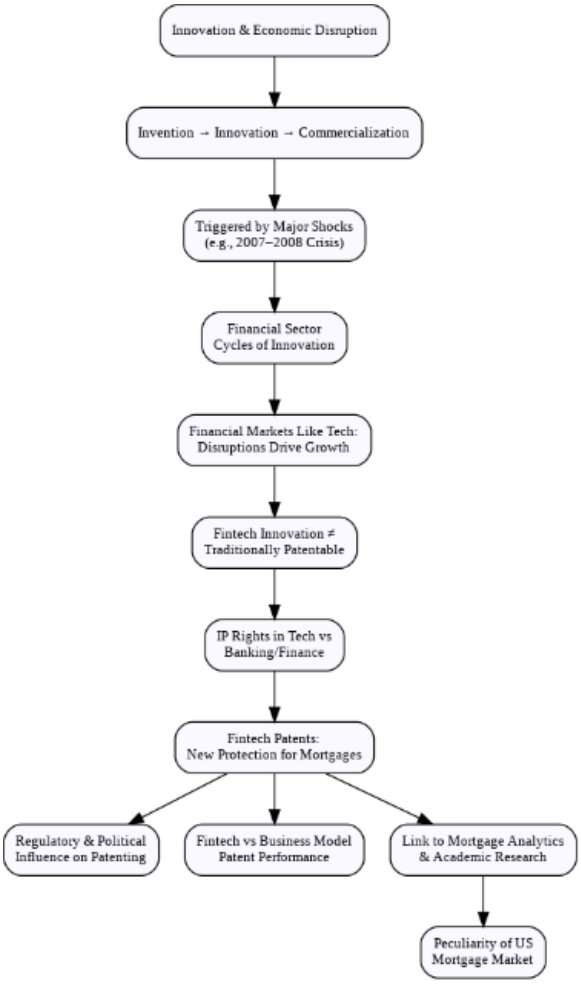

Fig 1 : Innovation & Economic Disruption

Mortgages and their services are development priorities and metrics among both established and emerging markets. Mortgages are also part of our financial ecosystem, providing housing stock, stability, liquidity, profit, and tax revenue, while participating in business cycle, political campaign, credit, and social credit issues. As with any market, new entrants, new technologies, and new ideas

should be welcome in order to increase efficient levels of exploration and exploitations in this market's search process. If historical lessons are to be learned, attention should be paid to the lessons from the development of patent systems in the latter part of the nineteenth century. But how? Searching and developing these fintech inventions is non-trivial, as patents aren't necessarily filed only by inventors within the vertical of the inventions; and identifying and coding for keyword patents can miss a significant proportion of fintech patent filings.

2. Background on Fintech and Patents

1. Definition of Fintech

The term 'FinTech' is a portmanteau of financial services and technology, and thus has been traditionally used to describe modern technology in traditional financial services. For example, corporate use of financial data transfer protocols to facilitate Merchant Export Letter of Credits would have resulted in a FinTech usage-defining software. At the end of the 20th century, with the advent of the Internet, however, the term was again attributed, and now commonly used for marketplaces, networks, and digital banks that offer specific financial services to companies and consumers digitally and often even without intermediaries. Such services include, for example, international money transfer services, peer-to-peer lending, and digital property market places.

2. Overview of Patent Law

Although some legal scholars are questioning it, an essential economic function of patenting is to safeguard that the returns from innovating are at least higher than the costs from it. Thus, inventors should be incentivized to reveal their inventions for the society and that disclosure is essential for future follow-up innovation in terms of science and technology. Commonly, lawyers argue that investment into patent involves certain costs, for example, patent application costs, patent attorney costs, and patent litigation costs. On the other hand, to patent on an invention provides the innovator with a monopoly or limited exclusivity and thus potentially high returns. Indeed, it is this limited exclusivity that has driven investments into FinTech in recent years, promising high returns, for at least a certain period of time.

Equation 1 : Innovation Growth Rate from Patents:

$$I_g = \frac{P_t}{T_l}$$

where:

- I_g = Innovation growth rate in mortgage analytics
- P_t = Number of fintech-related patents granted
- T_l = Time lapse since fintech patent introduction (years)

2.1. Definition of Fintech

The term "fintech" first appeared in 1980 and has since been used in various forms, but it was not popularized until it was employed as a label for startup companies focused on creating financial apps using new technology such as mobile payment products. While the term "fintech" induced popular media to refer to financial startups as disruptors of established institutions, academics, traditional banks, and international organizations have used it to refer to innovations made to the financial services ecosystem with technology-driven products or services as they have blurred the boundary between finance and technology. They have also used it to refer to a wide range of new products and services and companies, or to innovations, that make innovation in financial markets faster, easier, and more effective.

In this paper, we refer to fintech as startups that leverage technology to provide cost-effective and more efficient solutions to problems related to providing access to finance, and use it to identify fintech-related patents in mortgage analytics. Although there is a focus on disruption associated with innovations made by experienced investors or ascribed by startups to technology, we use it to reference fintech disruption. The avenues for deriving innovation-related wealth, and thus patenting, are more diversified in fintech as patents

can be derived not just from solutions directed to reducing transaction costs but also from solutions addressing the major functions of finance. The major functions of finance are liquidity provision (involving payment processing, savings, investments, and asset management), risk transfer, price-setting (involving price discovery and market-making), and information processing and analysis (involving risk assessment and credit allocation).

2.2. Overview of Patent Law

There are three types of patent protection: utility patents; design patents; and plant patents. Utility patents are the most common and cover machines; compositions of matter; articles of manufacture; processes and methods; as well as 'any new and useful improvement thereof'. Design patents protect inventions that are new, original, and ornamental and apply to the way a product looks. Plant patents protect new varieties of plants that have been asexually reproduced and introduced to the public for sale. In this paper, we only discuss utility patents. To be granted a patent, an invention must be novel, useful, and nonobvious. It cannot be a discovery or fall into one of the statutory exclusions defined in Section 101. A patent gives the inventor the right to exclude others from making, using, offering to sell, selling, or importing their invention without their permission for a period of 20 years from the date the patent application is filed. It is a permit granted by the federal government in exchange for publicly revealing to the public the details of the invention. A patent only protects the details of what is in the patent, not the general ideas behind it. Patents are published 18 months after filing.

In exchange for patent rights, inventors are required to disclose to the public complete details of their inventions. The patent process serves two purposes: to encourage inventors to publicly disclose their inventions rather than keeping their inventions secret; and to stimulate innovation by providing inventors temporary monopolies to exploit their inventions. The patent system assumes that the incentive role of patents encourages innovation overall because inventors must take financial risks when developing their new inventions. However, the patent system also recognizes that, in some industries, inventors will not patent every possible invention related to their field of expertise because of the costs of keeping track of others' developments and enforcement costs of infringing inventions, the speed at which innovation occurs, and the short lifespan of inventions.

2.3. Importance of Patents in Fintech

Patents matter in the fintech sector more than other industries. The challenge for fintech firms is to stand out in a crowded space with a specific service suite but also a growing clientele that instills trust and confidence in a complex and especially competitive area. Patents protect the innovation behind a product and an enabling financial service. Fintech is also a sector where big techs and large financial institutions have over the last few years taken an increased interest and invested resources in innovation. The play to innovate, develop, patent, and introduce services and tools into the financial services marketplace that are AI-powered, ML-driven, and incorporated with advanced technology are increasing the competition level.

In many instances, therefore fintech firms cooperate with researchers or academic centers with advanced expertise in a particular technology field, incorporate that research into their beta prototypes, and hence use patenting as a signal to investors that the innovation is unique and distinguishes itself from competitors. We identified that especially small fintech firms are far more patenting and innovation active than small firms in other industries as they seek to acquire a larger market share and market acceptance. How and when to patent innovations in the fintech sector are not well documented. Fintech focuses on a limited group of service offerings, enabling customers to interact directly with a specific solution to a financial problem related to services that are usually offered and tradable by traditional banks. By claiming the

innovation incorporated in that financial service via a patent, that firm tries and creates a switching cost for that specific solution.

3. The Evolution of Mortgage Analytics

The optimization of mortgage markets through comprehensive analytics is not a new theme. Throughout history, innovations in mortgage analytics have allowed mortgagors to get access to mortgage products that previously were unavailable or poorly priced. Said differently, using mortgage analytics, entities presented with a mortgage demand are better able to meet that demand, and do so in a way that properly prices the risk being borne.

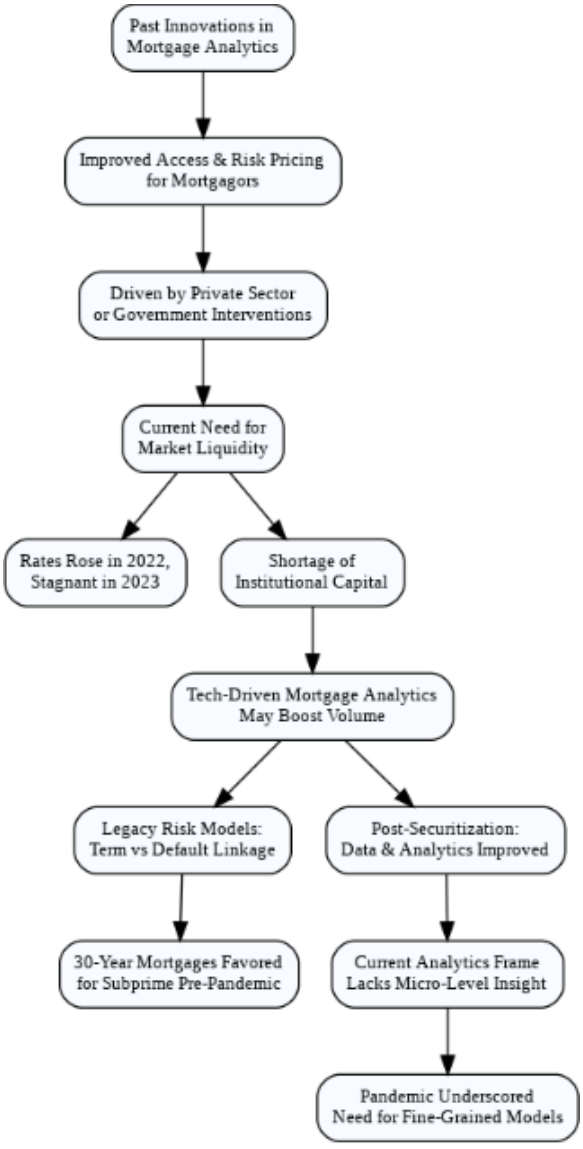

Fig 2 : Mortgage Analytics Optimization

Sometimes these innovations have come from the private sector; at other times, it has taken a government entity to enhance the analytics available. Currently, the nation's primary mortgage market could use more liquidity; while mortgage rates increased substantially in 2022, they have not changed very much in 2023. Faced with a shortage of institutional capital, it may fall to technology advances to enhance mortgage analytics in a way that will increase primary mortgage volume.

In the past, basic risk analysis correlated loan term and default likelihood. Consequently, pre-pandemic, subprime borrowers would usually be offered 30-year mortgages because the risk of holding a short-term balloon mortgage exacerbated the hardship upon a borrower during a life crisis. However, as loans pass through securitization portals and become part of bond reconstructions, data and analytics have improved exponentially. Micro-level mortgage decision analytics—broadly used in other credit products—is not present in mortgage loan choice. The current frame is incomplete and lacks fine sentiments. The most recent event, the pandemic, pointed to the importance.

3.1. Historical Context of Mortgage Analytics

The quantification of mortgage risk is an essential function for all lenders and is drastically different from risk on other types of loans due to the size and duration of the average mortgage, the risk of catastrophic loss due to mortgage default coinciding with the decline in collateral values, the long-run relationship between housing prices and borrower creditworthiness, and the complex derivative relationships between mortgage loans and mortgage-backed securities. Given the high stakes for industry and society alike, it is not surprising that the valuation process is both benignly and malignantly disrupted by constant technical advancement. Mortgages were first documented in Anglo-Saxon law in the 12th century, when a debtor would transfer the title of their land to a creditor until repayment of a loan at a specified time, at

which point the debtor could reclaim title to the land. Not until the 1930s, however, was the modern closed mortgage adopted, when interest rates were particularly low and lenders got burned by a high number of defaults. During the Great Depression, high mortgage default rates coincided with the collapse of the banking industry, which in turn resulted in massive declines in economic activity, so policymakers sought to rapidly increase home ownership by providing insurance covering mortgage holders against borrower default, thus introducing the reverse incentive problem. As a result of this change, the U.S. housing market started to resemble a market-driven market. By the 1960s, with the speed-up of the housing construction process, the feedback loop between mortgage risk and housing prices had been established, and with it, increasingly advanced technology for mortgage risk valuation.

3.2. Current Trends in Mortgage Analytics

Bringing together various aspects of mortgage lending and analytics, it was shown that the evolution of mortgage analytics adheres to three processes: explanatory modeling, predictive modeling and prescription modeling. Focusing on the area of interest to us, it was found that the three aspects driving the mortgage market historically still apply: on-going innovation leads to support for lenders, especially in the efficient low-risk and low-cost portion of the market, while financial stability remains prone to a boom and bust cycle painfully evidenced by the financial crisis of 2008. The inclusion of risk-taking behavioral aspects of business and borrower models in mortgage predictive analytics allows lenders to offer loans to otherwise marginalized loan applicants. Fintech applications like no money down and back to work programs are becoming increasingly popular today, as might be the linking of paid property tax records to the overall risk assessment model.

If we look at fintech help from a modeling perspective, the current trends are clear: alternative data are used more often, and there is a shift to ML-based modeling. The initial boost in fintech assistance for mortgage lenders allowed the latter to go back to basics: better explain risk on the asset as well as on the borrower side. There is a certain catch-22 here: without fintech innovation, particularly during the current economic climate, core and risky borrowers alike will be excluded from loan eligibility, especially if the modeling is performed using traditional, conservative indicators. The pandemic has led to lenders now favoring liquidity over credit risk.

3.3. Role of Technology in Mortgage Analytics

The history of mortgage analytics is the story of the mortgage industry's journey to finding balance between risk and reward while realizing the critical role that ready access to mortgage finance plays in delivering successful housing policies. Further, it is the story of policymakers and mortgage industry participants continuously responding to institutional and technological change that redefine the boundaries of the environment in which they operate. To be more specific, advances in technology impact the quality of mortgage analytics and ultimately the willingness of lenders to figure out how to do the risky business of mortgage lending. Mortgages evolve with advances in financial innovation and new data and growing computing power enable lenders to better understand and price the risk shortcuts in mortgage finance. Those additional risks become part of mortgage analytics again enabling lenders to offer new products. New factors emerge, get incorporated into lender decision-making and then become an influential part of the mortgage lending landscape driving housing finance policy. And the cycle continues.

As technology helps enable better mortgage analytics, sophisticated models have emerged estimating probabilities of default and future property prices at the ZIP code or census tract level assigning credit scores at the level of the borrower. Lenders identify how much mortgage risk they want to take and using analytics, price and select the right

customers, figure out the earnings implications of servicing and liquidity risks on their portfolio of mortgage loans, and then manage those risks accordingly. They develop funding and funding risk management strategies to ensure they have access to funds to make mortgage loans. Those models have become key elements in the management of the largest issuers of mortgage-backed securities. Over the last two decades though, fintech firms have become important players with their analytics focused on re-imagining the mortgage process and getting borrowers better access to capital while focusing on minimizing key problems occurring during the mortgage process like borrower drop-off rates.

4. Impact of Fintech Patents on Mortgage Analytics

With a market capitalization of over $80 trillion and total mortgage debt exceeding $20 trillion, the U.S. mortgage market plays a crucial role in the housing economy. Accordingly, many economic activities that singly span such wide scopes as housing demand, supply, macroeconomic variables, and many different equity, fixed, and mortgage derivatives markets, also tend to jointly influence the U.S. mortgage market. Predicting how such variables jointly evolve, however, is no simple task. Mortgage analytics deals specifically with assessing the complexities of predicting and modeling the jointly evolved path-futures of key variables influencing the U.S. mortgage market. More specifically, mortgage analytics provides a comprehensive analysis of the multifactor – multi-stage – multi-duration – multi-variable informing process for risk management by allowing an investor to assess the potential impact on the price, value, and risk of its mortgage portfolios from the inflation probability cycle, supply-demand relationships, and changes in the basic factors affecting these variables jointly and their differentials as they pertain to interest rate movements. Clearly, given the joint complexity involved, any new analytic ideas and/or technologies that can facilitate the modeling and predicting process should be both useful and welcome by professionals and practitioners involved in mortgage analytics.

Due to technological advancements in the areas of bigdata, machine/deep learning, artificial intelligence, and data accessibility, innovations such as fintech patents can potentially revolutionize traditional analytics, modelling, and predicting frameworks. While there have been many recent studies examining existing fintech patents, none embarked on exploring their impact on the evolution of mortgage analytics. Analyzing the patent histories/trends related to mortgage analytics not only fills gaps in the current patent literature, but can also help market players identify emerging/novel innovations, products, and services that could revolutionize traditional mortgage analytics/research for the creation of their existing and/or new business models.

4.1. Case Studies of Key Fintech Patents

We begin our exploration with a selection of notable fintech patents related to mortgage analytics and that have been granted in the last couple of decades. The patents in this section were selected based on three criteria to identify case studies of key fintech patents with substantial real-world impact. First, we consider only patents issued by the USPTO which cover fintech topics, with a particular focus on topics related to mortgage analytics. Second, while our study spans twenty years, we focus mostly on more recently granted patents, particularly those issued after the year 2000, since past a certain point they become less relevant to our analysis given the speed at which innovations occur in fintech. Third, we focus on patents that appear highly cited—indicating their influence on subsequent innovations—within the innovation domain of patents relating to mortgage analytics.

A notable example is shifting the mortgage industry from a paper-first process to more modern digital-first processes, realized by improvements to

security and identity verification processes and wireless transaction systems. Other patents, focused on tax and credit risk assessment, include methods for performing financial analysis of business and consumers' financial states and predicting default risk of individuals. Other examples address mortgage loan financial risk in the context of secondary mortgage market transactions by introducing new protocols to substantially accelerate the speed of secondary trading of residential mortgage-backed securities. Together these patents illustrate a remarkable breadth of fintech activity, innovation and impact in mortgage analytics that would likely not have been even considered possible in the earlier decades, and seem to point toward the continuing relevance of mortgages in the ever evolving landscape of financial sector products and services.

4.2. Analysis of Patent Trends in Mortgage Analytics

As a next step in our case study approach, this section outlines quantitative trends in mortgage analytics patents over the last three decades and discusses how they relate to Fintech patents. To conduct our patent analysis, we identified patent classes related to real estate mortgage and collateral risk analytics such as the following: (1) application of machine learning, (2) applicant or assignee affiliated with financial services industry, (3) description and/or claims related to mortgage risk quantification, and (4) keywords related to risk and analytics. We assess the temporal dimension from the year patent was filed.

Figure 2 shows the presence and volume of mortgage-related patents issued since 1990, which according to our analyses, had quite a modest start and has only recently ramped up. The mean time from file to grant for these patents is two years. These patents do not appear stuck in examination and many seem to clear through. The significance of the spike in 2006 is in that it almost doubles the amount of patents issued since the last spike in 2004. In addition, it is worth noting the other major spike, which occurred in 1996. This period of patenting activity coincides with a very heightened interest in mortgage origination as the GSEs resurrected their own programs for securitizing “high-risk” borrowers through subprime loans.

Moreover, there seems to exist a strong connection between Fintech patents in general and the patents related to mortgage financial risk. This comes as a surprise as Fintech simply is a subset of all Fintech patents, but more importantly, we find that it moves with the same peaks and valleys for nearly the last two decades. The correlation is visually striking.

4.3. Comparative Analysis of Patent Impact

Using textual analysis and machine learning techniques, this research identifies five distinct branches of patent litigation in mortgage analytics. By comparing the word vectors of selected U.S. patents used in the five branches, the paper innovatively builds different citation-weighted patent similarity networks of the five branches and exaggeration effect to discuss the characteristics and potential functions of patents in each branch of mortgage analytics. The study anticipates that this novel approach will stimulate additional patent research in domains where additional layers of citation-weighted patent similarity networks can provide insights and enlightenment beyond simple bibliometrics or traditional citation analysis. As the first study examining groups of patent citations, we create different citation weighted-patent similarity networks using echo, attention, and exaggeration effects at different threshold levels in a revision of the patent network methodology. To generate a different citation-weighted network for each period, we exclude self-citations and create citation weighted-networks using random and systematic samples of the patents used in the patent comparison of the five branches and their citation connections with patents in other branches. For the threshold patent sample, we include all patents from each of the five branches with citings and then add (or delete) other branch patent citings until the branches contained equal patents. We create

different citation-weighted subnetworks using 30% and 50% network wagers and threshold connection citer patents. Finally, we visualize the networks using the Kamada–Kaway algorithm.

Equation 2 : Market Penetration Driven by Patented Technologies:

$$M_p = \frac{A_m \cdot P_v}{C_m}$$

M_p = Market penetration index of patented mortgage technologies

A_m = Adoption rate of patented mortgage technologies

P_v = Value of patents in driving market innovations

C_m = Cost of technology adoption

5. Regulatory Considerations

1. Overview of Financial Regulations

The financial services industry is highly regulated in the United States. Individual products and related activities are subject to jurisdiction by multiple regulators, including the Federal Reserve Board, the Consumer Financial Protection Bureau, the Office of the Comptroller of the Currency, the Federal Deposit Insurance Corporation, the National Credit Union Administration, the Internal Revenue Service, the federal government, and corresponding state and local authorities. As examples, the Securities and Exchange Commission and the Financial Industry Regulatory Authority regulate broker-dealers and the Commodity Futures Trading Commission and National Futures Association regulate futures commission merchants and retail foreign brokers. There also are financial disclosures and reporting requirements that regulated parties must comply with. Firms outside the mandate of regulators can select to be regulated in order to facilitate large volume transactions and avoid supervision by each of the regulators governing specific product areas of activities.

The basic premise for regulating financial activities is two-fold. One tenet is to deter risk-shifting, which entails a transfer of wealth or the possibility that a market participant will be better off at the expense of others by engaging in riskier activities. A second focus is to contain systemic externalities in the event of industry disruptions. These imperfections may not transfer to the financial firm identified or that could assume the largest losses by making poor lending decisions.

2. Impact of Regulations on Fintech Innovation

By imposing heavy, prescriptive, timely compliance costs on business operations, regulations stifle innovation. This regulatory burden weighs particularly heavily on nascent innovative firms in the fintech sector, many of which have fewer than fifty employees and revenues below $1 million. Quicker and sophisticated innovation can result from the exponential increase in the return on investment from generous funding investments by both private and public equity partners to fintech companies. The market capitalization of American public fintechs exceeded $1.1 trillion in 2022, with net direct losses dropping over 125% as innovation escalated.

As fintech firms push disruptive new technologies or business models, regulators have launched new innovation-partnering programs, employing a testing-while-licensing approach model. This societal need to regulate and control is particularly focused during volatility when actual or fears develop about either the stability or integrity of the financial markets. The global credit macroeconomic crisis due to a combination of triggering factors, including excessive systemic risk, poor capital resources, and weak firm governance controls froze economy not only in the United States but worldwide. The Fed and tax stimuli and supply-side relief provided some temporary band-aids.

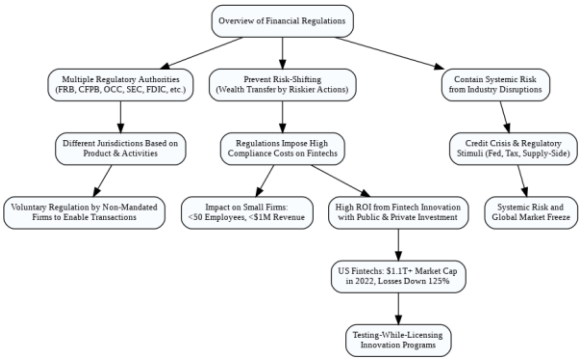

Fig 3 : Fintech Regulations and Innovation

5.1. Overview of Financial Regulations

Fintech is at the center of regulations because it targets the transformation of the financial intermediation and increases the access of the general public to financial services which effect major macroeconomic activities, such as consumption, savings, and investment as well as their stability. Modern society demands secured protection of sensitive information, such as identification data and financial data, as a premise for easier everyday transactions and lives. Fintech allows the provision of financial services in a far-reaching manner by lowering transaction and access costs as well as potential risks. The demand for easy, fast, and cheap access to financial services by consumers has sharply risen with the development of society and economy. This further strengthens the need for lower transaction costs and a larger consumer base, the latter of which drives demand for financial regulations on established providers to allow for fair competition with less-monopolized market share.

A growing recognition that a vibrant, healthy economy requires a sophisticated, stable infrastructure to mediate among savers, borrowers, and investors led to increasing economic interest in the evolution of financial regulations. The industrial revolution advanced the interest of regulators in opening a voice for consumer protection as well as the provision of economy-wide stability at the macro level. Market failures where relative costs and benefits diverged and information were limited brought upon the creation of regulatory controls which, over the years, have become more targeted but also deeper to stave off the factors which led to the Great Depression. The ensuing regulations met with discontent by some groups during some phases of development. For instance, banks argued against the act which created a strict separation between commercial banking and investment banking services while securities regulators were opposed to the deregulation of government securities trading.

5.2. Impact of Regulations on Fintech Innovation

The relationship between fintech innovation and regulations is complex, leading to arguments both for and against regulations. The proponents argue that regulations hinder the pace of innovation while critics point to regulatory frameworks which provide competitive advantages and entry barriers against large, experienced players. Banks often appreciate the regulatory oversight because it dissuades potential competitors. The net impact appears to be that regulations tend to limit fintech innovation at the early stages but promotes it once a strategy has been developed. R&D tax credits, government funding and preferential treatment by regulations can create a meal for early-stage startups to develop prototypes and implement ideas. At the later stages when these startups develop unique offerings that need to scale, it is natural for regulatory approvals to expedite and ease the pace of scaling these activities. Understanding how recent changes in a regulatory landscape aimed at spurring fintech innovation have affected innovation strategy will help design effective policy for the coming years. Digital finance will play a critical role in the economy post-COVID as demonstrated by changes in consumer behaviors of contactless and digital payments and the development of central bank owned digital currencies. It is necessary to study whether the fintech patenting strategy of firms, which document the methods that will be implemented in the future, compound or unpack the regulatory changes that spur the development of digital finance.

5.3. Compliance Challenges for Fintech Patents

The compliance requirements for financial institutions and their technology partners are a critical topic in fintech innovation research and practice, with implications for the technological design and implementation of fintech solutions to expand financial access. For fintech patents, compliance poses a particularly acute challenge. Patents are legal rights related to the particular design and implementation of technology and not

the outcome that the invention enables. The specifications of patents are often truncated information about an invention's implementation, which may exacerbate the compliance challenges for financial services innovators and patent examiners alike. In particular, patents may not describe how a particular technology complies with regulating obligations.

For traditional financial institutions, responsibility for meeting the compliance obligations is unconditional and unlikely to be reviewed after the fact. But for other non-bank fintechs who partner with banks to deliver compliance-heavy financial products services, their compliance pathways will be curated by the banks. Given the importance of partner banks, however, researchers have argued they should ideally be dynamically matched to address the specific purpose of the design innovation. Regulatory alignment may also be the reason our sample included an unusually high number of patents assigned to business services firms. Despite the developmental priorities of the legal certification, compliance orientation can result in vertically-iterated design solutions with only niche specialization differentiating their commercialization. Thus the second pair of hypotheses we test explore if compliance regulations can create co-evolutionary selection pressures in the fintech patenting landscape.

6. Future Trends in Mortgage Analytics

1. Emerging Technologies in Mortgage Analytics

As we discussed in Sections 3 and 4, the impact of fintech patents on mortgage analytics adoption and development is modest today. Still, several emerging technologies in relatively early stages of development promise to change the market for mortgage analytics tools in ways that provide original equipment manufacturers in the larger fintech analytics ecosystem with either value or volume opportunities. There are three key domains of emerging technology that are likely to have essential implications for the dynamics of innovation and competition in the U.S. mortgage finance climate. These include:

Predictive analytics, particularly around the area of borrower default behavior, Natural language processing as applied to borrower-specific documents and Digital platforms as applied to the transaction dynamics between both borrowers and lenders as well as investors and market makers.

2. Predictions for Fintech Patents

We could predict that the supply of validated insured mortgage risk prediction models will soon proliferate, either from universities on behalf of their researchers or from commercial analytic firms. That said, it appears that mortgage analytics—particularly those targeted at legal document verification or flow prediction—remain modestly patentable. At last count, there were only 880 fintech patent applications directed against mortgage analytics, easily within the range of even modestly comprehensive research budgets. Commercial mortgage analytics firms can, within reason, expect the domain of patent protection to remain open to their business models for at least the next twenty-four months.

3. Potential Market Disruptions

Technological promulgation in several emerging analytic disciplines with relevance to acquiring and maintaining secured mortgages, including natural language processing and digital cyber-physical systems application development, make the possibility of disruption in origination and servicing both probable and potentially debilitating in the short-run. We believe that, in the case of the mortgaged secured by finite claims pools, there is sufficient return potential to warrant increased computational exploration supporting cyber-physical market solutions relative to probability models. The mortgage market—particularly the underlying physical collateral—appears sufficiently large to warrant these efforts—both at an individual fintech firm level and collective economic policy direction levels.

6.1. Emerging Technologies in Mortgage Analytics

As the more traditional methods of analytics continue to advance, novel areas are appearing at the adaptive fringe of mortgage analytics. The integration of emerging technologies such as AI, Blockchain, Quantum computing, Metaverse and others, are enhancing existing strategies or enabling completely new frameworks.

Artificial intelligence (AI) broadly defines technologies that induce machines to "think" by emulating executive functions normally associated with the human mind, such as interpreting natural language, recognizing visual images, solving problems, making decisions, or handling other data-dependent processes. Machine learning is the branch of AI that investigates and develops algorithms and statistical models that computer systems use to gradually improve their performance on a specific task through experience. Deep learning is a subfield of ML that uses artificial neural networks to model data with complex relationships. Natural language processing (NLP) is a subfield of AI and computational linguistics that explores the creation of algorithms capable of understanding, analyzing, manipulating, and/or generating natural language. AI is being developed to enhance many established elements of decision analytics including risk, finance, and operational performance. By enabling better decisionmaking, lowering costs, and enhancing profitability, embedded AI is allowing customers to obtain credit evaluations more efficiently. Based on rapid advances in machine learning, it is expected that AI capabilities will increasingly be embedded into business processes and decision systems, as well as the financial products themselves.

6.2. Predictions for Fintech Patents

In this concluding section, we evaluate the renewed interest in fintech patents specifically, and we suggest how this growing interest will filter into the mortgage industry. The evolution of the fintech ecosystem that has recently emerged includes players such as banks, financial technology providers, credit bureaus, and big-tech companies that are involved in the monetization of consumer financial data. The integration of new technologies into the financial infrastructure and the direct-to-consumer model that is increasingly being adopted by fintech companies reduces the importance of banks in consumer financial services, thereby increasing consumer savings. The democratizing of access to funding, and the flattening of firm boundaries across financing and funding, given the increased participation of non financial intermediaries, further highlights the unique nature of the fintech ecosystem. This renewed interest comes in the form of increased direct commerce and investments in fintech ideas, but also tangentially in fintech patents. Products and ideas are more easily transformed into reality as a result of patents being used to attract investment, support licensing, and provide a legal framework for negotiation, collaboration, and merger of fintech efforts. In this space, we see the growing intersection of fintech ideas and solutions and patents dedicated to these ideas.

Given the growing interest in fintech patents, we can make the following predictions in the mortgage space—around disruption, the increasing importance of friction-forging technologies in the ecosystem, and the increasing volatility of financial markets. First, there will be more mergers, acquisitions, and collaborations in the mortgage fintech space. Massive investments in mortgaging fintechs have been funneled into lending process automators, decision process innovators, and underwriting automation offerings.

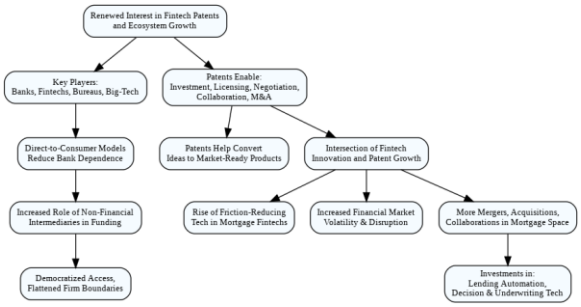

Fig 4 : Fintech Patents in the Mortgage Industry

6.3. Potential Market Disruptions

Information asymmetries have caused frequent market failures in the mortgage sector. While fintech solutions have helped alleviate some of these inefficiencies, the market might not operate at an optimal level. For example, market interest rates primarily react in the upward direction, while they do not follow the same logic in the downward direction. As a downside risk, lenders do not pass refinancings through due to prepayment penalty clauses. Additionally, lenders care more about loan defaults than borrowers, as they will often sell loans to get rid of default risk. The presence of asymmetric information might also lead lenders to reject qualified borrowers. Future mortgage analytics should be amenable to change contingently on changing business rules, optimal model usage, and historical prepayment experiences. They should also accommodate loan sales, mortgage pools, and private securitization. Moreover, future innovations have to emphasize combination systems with cloud-computing capabilities in conjunction with other information on micro-level default data.

It would be prudent to address such deficiencies with future innovations. In terms of possible developments, a few applications come to mind. Coordination problems might occur when an item owned by different financial institutions is subject to different classes of risk, where one class or component of a risk has a low premium. In this case, other classes might need to be valued at a discount, which might lead to a sudden and severe drop during a crisis situation. Then, the future of household finance might largely depend on the private provision of risk. It is not entirely impossible to have a highly competitive hedge fund-led configuration dominating the mortgage business, focusing on refinancing and optimizing consumption choices. Alternatively, nationalization of particular classes of risk has happened in the past and might become reintroduced. Yet, in the absence of major changes, as it is commonly concluded, entities might simply continue to exist.

7. Methodology

1. Research Design

This research employed a combination of quantitative and qualitative research, known as a mixed-method approach. The specific qualitative approach utilized is referred to as exploratory research through a patent analysis. The quantitative approach was performed by generating a visual analysis of the number of mortgage analytics patents granted over time. Exploratory research can be examined at the intersection of the research questions with an exploratory purpose and an exploratory strategy, and it is particularly useful when little or no prior knowledge exists in the research area. Since to-date there is no prior research correlating fintech patents to the development of mortgage analytics, exploratory research was utilized to begin to establish a relationship between the two entities. Patent data was obtained for the number of patents granted in the U.S. for mortgage analytics as defined through the patent classification codes. Patent data was further refined by extracting only claims that contained a keyword search strategy of mortgage, home loan, or home mortgage. Patent keyword data was then visualized through a number of plotting functions with the goal of establishing a timeline of development of the patent data.

2. Data Collection Techniques

Data was obtained for the number of patents granted in the U.S. for mortgage analytics as defined through the patent classification codes utilized by the United States Patent Office. Further patent data was extracted to include only claims that contained a keyword search strategy of mortgage, home loan, or home mortgage. The strategy of the two data extraction methods allows for an analysis on two levels: an established U.S. patent code classification search and a broader cross-domain search based on claimed keywords. The two sources will be referred to as the keyword search data and the classification

code data, respectively. Exhaustive keyword search strategies are available.

3. Analysis Framework

Data was then visualized through a number of plotting functions with the goal of establishing a timeline of development of the patent data. Various temporal visualizations revealed interesting analysis questions about the data.

7.1. Research Design

This study adopts the patent-based econometric model of invention capital to test whether three specific mortgage analytics equate to invention capital, which responds positively to patents of income prediction, risk assessment and property valuation, and whether variations in their invention capital across time relate to variations in the use of patents as points of reference of credit scores. The screening of patents is purposely limited to several particular functions of fintech patents, which we defined based on a systematic thematic analysis of the abstract and full text. The fintech patents mapped to these functions are the foundation of our invention capital measure. Three names of these mortgage analytics are also the variable labels.

The econometric analyses performed are premised on the proposition that the country's supply of unique inventions and patents constitutes a capital stock which grows in a time and composition dependent fashion. The year-by-year counts of unique patents in a specific area, such as risk assessment in mortgage underwriting, scaled by the geographical extent of the patenting system are important indicators of local patenting potential. We adjust the counts by allocating these unique patents to technological functions of predicted relevance to fintech since irreplicable functions represent invention capital that could be extracted from geographic areas which show particular concentrations of relevant patenting activity. Technological change tends to be rooted in certain technological fields and regions, and individual regions and patenting offices have particular characteristics which make them more suited to undertake certain types of patenting functions than others. Thus, our empirical approach pays special attention to the area distribution of these unique compound patents.

7.2. Data Collection Techniques

This research uses secondary data and empirical methods to investigate how the effects of fintech patents influence the evolution of mortgage analytics. The collected data for this analysis consists of two parts that match along a common time axis. The first data set, fintech patent data, is constructed from the patent database of patents that fall into one designated patent class. The second data set, mortgage analytics volume over time, is created from a database of mortgage analytics, derived from recent publicly available content on the homepages of various available mortgage analytics vendors in the United States. A clear description of the data collection techniques regarding patents data collection, mortgage analytics collection, and other data preparation techniques, is elaborated on below.

Fintech Patent Data Collection

The largest electronic database of US patents has been developed. A patent is a legally enforceable right to exclude others from making, using, selling, or distributing the patented invention for a period of years. The analysis uses utility patents that are classified under the following designated patent class. To keep the analysis targeted, various qualifiers are used for the search to ensure the inquiry is on behalf of the fintech sector and not another sector. The patents are chosen such that they fall into the following categories. At the culmination of this process, the patents that comprise this analysis are pulled from the patent database and compiled. A common temporal delimitation prevents any distortions originating from temporal asymmetries in the data, as elucidated in the mortgage analytics time series description below, necessitating the creation of the data set to include only patents that were filed between 1991 and 2022.

7.3. Analysis Framework

In the last decades, patents have attracted attention from a variety of research fields as indicators of different dimensions of technological achievement. Many scholars first focused their efforts on the relationship between patents and innovation and then on the relationship between firm performance and patents; or self-citations. More recently, scholars have also studied the relationship between financial investment market performance and patents. Scholars from other research fields have used patent databases as proxies for different industries, including the business investment decision, the national government R&D policy mix, and lateral innovation technologies. Scholars have also proposed to use citations as metrics of "knowledge flows". The attention raised by patents and their potential role in the management of technological innovation has led to calls for the design and development of technological innovation measurement frameworks that allow companies to enhance their technological capabilities and develop competitive advantages.

Additionally, the fast-growing fintech companies have increasingly started to introduce relatively new underwriting parameters into the mortgage underwriting process. Their patent portfolios provide a detailed outlook on such automotive underwriting innovations being employed. This study utilizes patent data, developed from the methodology previously proposed. Patent examination lists mortgage underwriting classifiers with a representative example, including applicant credit scores and debt-to-income ratios. Moreover, as an example of mortgage underwriting automation, the amount of patents held by fintech companies in the five aforementioned sub-categories is shown. Based on existing research and the relevant literature, there are five components of patent innovation that need to be described regarding each of the five sub-categories: patent activity, patented technology networks, patent impact, economic importance of patented technologies, and technological origins and future trajectory.

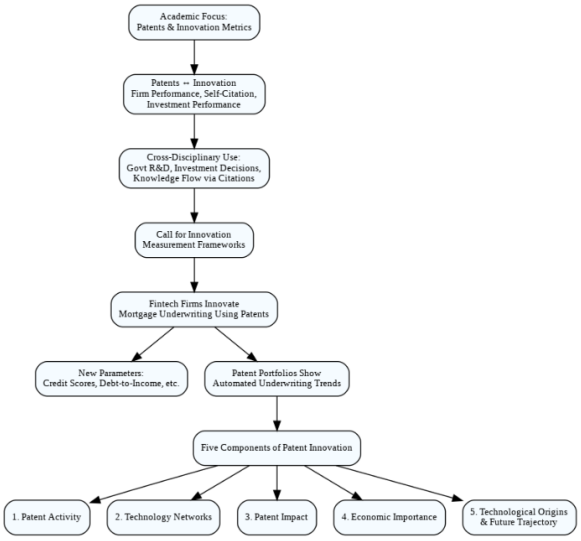

Fig 5 : Patents and Mortgage Underwriting Innovation

8. Findings and Discussion

1. Key Findings from Data Analysis

We began our empirical analysis of the resulting dataset examining the share of mortgage analytics patent filings to total fintech patent filings. This exercise revealed that 0.63% of all fintech patent filings in the United States pertain to sub-class mortgage analytics. Next, we created two simple trend plots to start discerning the role of the mortgage analytics sub-category in overall fintech innovation in the US. We plotted the number of total fintech patents versus the number of mortgage analytics patent filings from 1997 onwards on the two y-axes of the same plot.

The fintech patent dataset is not completely uniform over time and is missing some patents from the earlier years. A review of both graphs reveals that, after a steady but small growth between the early 1990s and the onset of the Great Recession in 2007, the number of issued fintech patents grew explosively after 2008. The pattern we observe coincides with the aftermath of the Great Recession, during which the global economy entered a period of financial instability and uncertainty.

Interestingly, the share of these total fintech patent filings that are classified under the mortgage

analytics sub-category has remained narrowly stable over time, declining slightly after 2004. In practical terms, this means that the fintech patents added after the financial crisis have not contributed meaningfully to innovation in mortgage analytics and new housing-related products. This result leads us to further investigate the specific fintech patent filings related to mortgage analytics. Who or what was behind these mortgage analytics patents? Were these patents filed by new firms coming up with innovative products and services, or were they filed by entrenched firms, or at least by well-known and established players?

2. Implications for Stakeholders

Our analysis reveals that, after the explosion of new fintech patents after the 2008 financial crisis, those related to mortgage analytics have decreased over time. Not only that, but the vast majority of mortgage analytics patents have been filed by established players collaborating with other established players. The major implication of this result is that innovation in mortgage analytics seems to be stagnant. The mortgage market in the United States has been heavily affected by the oversupply of "easy money" that persisted in the economy for over a decade after the last crisis. Housing prices reached very high levels during that period, and they're still on the high end today. Regardless of the causes of these high prices, this necessary condition has created a massive and rich market for an entirely new area of mortgage analytics services: those that identify, analyze, and predict the level of mortgage fraud in the mortgage origination process.

8.1. Key Findings from Data Analysis

This paper centers on the relationship among FinTech patent issuance, FinTech investment, and advancements in mortgage analytics over the past two decades. This study applies co-word and co-citation analysis to understand the evolution of cutting-edge technologies and invest future resources smartly. Our co-word analysis maps the landscape of issued FinTech patents through keywords and identifies four out of six breakthrough innovation clusters, including Smart Agents, Distributed Ledger, Distribution Ledger Technology, and Smart Contracts. These clusters are provisionally identified not on the actual technological breakthroughs, but by the use of similar terminology found in the latter parts of the entire timeframe period. Our co-citation analysis extracts the thematic intellectual reference links in Finance papers related to mortgage analytics. Both analyses – co-word and co-citation – have distinct differences and proceed different converging pathways, yet their results create a rich decision-support resource funnel based on Temporal Dispositions and Dynamic Resource Capabilities approaches. Together, they help to answer the "what?", "how?", and "when?" questions related to technological and historical innovation developments. Both research methodologies operate in conjunction on different concepts; co-word analysis correlates and identifies FinTech keywords, while co-citation analysis collates and presents leading intellectual reference resources.

We confirm there is a consistency relationship between issued mortgage analytics Query Search Financial Technology keywords and the patenting clusters and cycles. For query keywords, we incorporate into our study the seven key mortgage analytics measurement areas and a combination of subareas; the fitted model parameters establish the respective periods support the validity of the theoretical and practical groundwork. Since technological innovation changes are increasingly prevalent and rapid, future researchers can improve their understanding of innovations by assessing the resources involved. Finally, the developed research methods can be extended to other business areas to investigate forthcoming mercurial changes, risky situations, or resource constraints, thus creating significant resonance internationally.

Equation 3 : Impact of Patent Protection on Analytics Accuracy:

$$A_c = \frac{A_s}{E_r}$$

A_c = Analytics accuracy improvement from patented technologies

A_s = Accuracy of mortgage analytics post-patent introduction

E_r = Error rate in mortgage analytics before patent

8.2. Implications for Stakeholders

The results provide evidence that fintech patents relate more closely to the propagation of traditional analytics compared to the emergence of new analytic types. This suggests that new tools created from these patents are used to extend existing solutions and not necessarily create something that is entirely new. It relates to the concept of knowledge spillovers and in this case the findings imply that the different stakeholders, such as policymakers and venture capital investors should take into account that the majority of fintech innovations steer away from the creation of corporate and consumer products that offer an increased demand for novel analytic solutions. Rather, the emphasis on the propagation of tools related to the improvement of existing analytics suggest that new fintech products will follow existing analytic solutions that they optimize, and therefore investors and policymakers should pay attention to where these activities concentrate in order to be able to evaluate what products are likely to be successful.

Also, for incumbents in the mortgage analytics space, high coverage of patent documents from fintech companies can be taken as a signal that they should expect new firms to build products that use their research covering existing tools and analytics, and that these new solutions can lead to increased competition in some parts of the analytic solution space. On the other hand, for fintech stakeholders, these results also suggest that the majority of forthcoming products from fintech companies are likely to aim at optimizing preexisting solutions and therefore the competition from these companies is likely to shape industry dynamics but initial product positions are less likely to be challenged. Therefore rather than looking for disruption, incumbent mortgage analytics developers should view the new product innovations as waves of new financial products with a small contribution to the analytics behind the product offering.

8.3. Limitations of the Study

The results presented above should be viewed in light of the limitations of our study. First, we have chosen to focus solely on patents related to mortgage analytics. The focus is not the mortgage technology applied by Fintech companies alone. Other aspects of mortgage technology, such as online borrowing or robotic processing, are not the main focus of the present study. Our aim is to see how Fintech companies can create value in the mortgage process through more effective and efficient decision making. Therefore, patents that fall under a different taxonomy, while they may relate to external aspects of the mortgage process, are not included in the present effort; nor do we attempt to analyze and interpret more general aspects of Fintech patents. Second, of the more than 3,600 Fintech patent classes, subclasses and groups identified, less than 15 percent are employed in the Fintech patents identified for the United States. Within this small universe of Fintech patenting, the components identified in our analytical taxonomy are decidedly small in number. Yet, the impact on the economy and consumers in terms of lowering fees, making lending decisions more facile, and simultaneously creating a win-win outcome, from the adoption of Fintech companies is arguably large. Taken together, these limitations warrant caution in interpreting our findings about the role of Fintech patents in improving underwriting, credit risk assessment, and default probability prediction capabilities. It is important to note that the analytical taxonomy of the 68 patent classes, subclasses and groups related to mortgage analytics is neither exhaustive nor final. There may be errors of omission and commission when applying the present analytical taxonomy. Finally, there may also be other classes and subclasses collectively capturing patenting in mortgage analytics.

Notwithstanding these comments, we believe that the misuse of loans and other associated factors could be able to seize pointers from our work to more rapidly classify technology adoption.

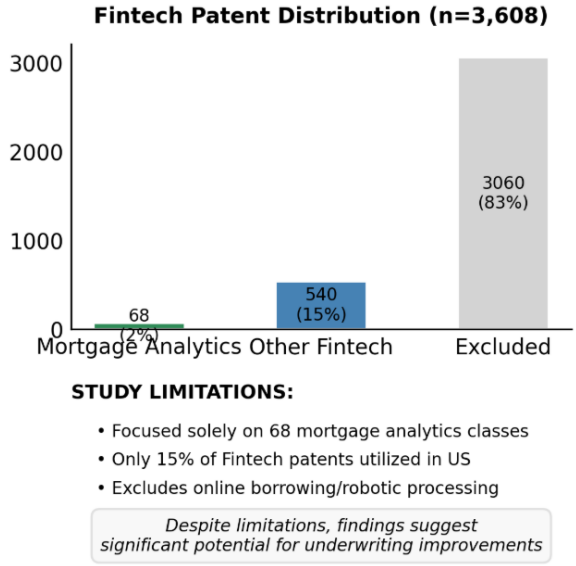

Fig 6 : Fintech Patent Distribution (n=3,608)

9. Conclusion

This study is organized into two parts. The first introduces an innovative lens through which to study emerging innovations in fintech industries. We define a new theoretical construct, patent impact, and explore the domains related to fintech patents and their patent impact. We specify that patent impact is a signal of the potential for new fintech innovations to disrupt and influence a market ecosystem in finance, creating both opportunities and also threats for legacy FI participating in the current market ecosystem for finance. We illustrate the use of patent impact as a foundation for tracing the evolution of innovation in fintech sectors with an empirical analysis of municipal energy finance patents. The second part develops a proxy of patent impact and illustrates its potential to enrich patent data and help in the discovery of new theories of the patenting innovation process in financial services. It further explains the utility of the proxy with a case study of state of the art mortgage analytics innovations that are patented. It finds that the quantum of state of the art patents in a market sector is larger than previously thought and states of the art are more numerous than mainstream innovations in mortgage analytics. The case study is guided by three questions.

How do the score distributions of mortgage analytics fintech patents change over time and what is the significance of these changes? How do the patents in the patenting innovation process in the mortgage analytics sector break out according to relative patent quality categories? Do these patents support landscapes of state of the art innovations in mortgage analytics, and if so how?

9.1. Summary of Insights and Future Directions

This essay explores the relationship between fintech patenting and the incorporation of artificial intelligence in mortgage analytics, the purpose of which is to enhance decision-making and risk assessment capabilities through the establishment of mortgage analytics firms' patent portfolios. By assessing what has been patented in mortgage-related fintech, which firms have collaborated with these analytics startups, and the degree of knowledge impact dependency and patent strength, we shed light on the direction of collaboration in terms of how the two 'types' of firms complement each other, and we also reflect on how fundamental this potential partnership is to the advancement of the domain. Overall our findings suggest that increased amount of patenting in the mortgage domain, particularly by AI and ML innovative firms, plays a substantial impact on the technology development of mortgage analytics startups, which in turn enables a more sophisticated utilization of AI-driven methods, help lenders assess borrower risk, origination delay, and subsequently default risk.

In this research, we have developed a framework to study the technology domain and positioning of the published patenting activities, focusing in particular on patents that were published prior to, and in a timeline following the financial crisis. We adopt a technology-driven focus in our methodology to

identify the impact of increases in patented knowledge upon innovation in the domain of mortgage analytics in the United States. In addition, we explore the potential of existing mortgage fintech patenting activity to enhance and improve innovative development of close and collated technology spaces that are related, or adjacent to the mortgage domain. Future research may utilize alternate methodologies to enhance the analysis of more granular and specific connections of patenting technology impact across potentially related domains of development and knowledge creation within the financial technology sector.

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