

Managing, Preserving, and Unlocking Wealth through FinTech

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*“It has become appallingly obvious that our technology has exceeded our humanity.” –
A. Einstein*

In nearly every generation, a sentiment like Einstein’s has been expressed as a cautionary tale to constrain the development and application of technology. In spite of these calls, technology has time and again proven its utility and ability to improve across and upon industries, geographies, and demographics. FinTech holds this same promise. From startups to government sovereigns, FinTech has potential to modernize markets and democratize access to capital, along with creating novel mechanisms and products heretofore undiscovered.

In this chapter, we give a broad overview of 5 areas of recent FinTech development: 1.) Personal Finance, 2.) Real Estate, 3.) Insurance, 4.) Investment Management, and 5.) Frontier Asset Classes. Moreover, we then conclude by going to the edge of the frontier of current FinTech, making predictions on which areas we believe hold the most promise moving ahead.

KEYWORDS: FinTech, Robo advising, GPT, LLM, Cryptocurrency

Section I - Personal Finance

1.1 Robo-advising

Robo-advisors in the asset and wealth management industry are computer programs that automatically generate investment advice often tailored to specific investment situations, which could be for either individual investors, groups, or the entire industry.

The emergence of broker-dealer firms deploying robo-financial analysts have largely been in the past decade, starting in the early 2010s, and has quickly become a disruptive trend in advisors for individual investors. A website or a cellphone app running by the broker-dealer often collects information regarding an individual's investment style, tax status, and risk tolerance profile, using this to output investment strategies that attempt to maximize return while minimizing risk within said preferences. Most firms use ETFs as the main investment vehicle to construct a portfolio.

D'Acunto et al. (2019) examines the extent to which robo-advising reduces cognitive bias in investment by increasing portfolio diversification and automation in trading execution. This is also in line with US investors' perceptions of using robo-advisors (Agnew et al., 2019), although, for most measures, individual investors still report putting more trust in human advisors than their robo-advisor counterparts.

One of the largest benefits offered by robo-advisors are the low fees charged to clients. However, this price competition and investor fee-consciousness also could result in firms deploying robo-advising systems being unwilling (or unable) to develop highly sophisticated machine learning algorithms. An analysis by Beketov et al. (2018) shows that Modern Portfolio Theory is what is used by most robo-advisors, and that they tend to adapt and twist the existing framework rather than coming up with novel ones.

Pioneer FinTech company Wealthfront is among the first to offer automated investment services. The firm aimed for the tech-savvy millennial generation in the U.S. as its target customers, offering them digital investment services that mirror a human investment advisor. The services include asset class diversification, passive investing, dividend-based rebalancing, tax-loss harvesting, and single stock diversification. With the firm's digital platform, the business model was expected to scale easily. Yet the field of robo-advisors quickly became crowded, with new start-ups and established asset management firms eyeing it as a growing industry trend. In 2017, *Business Insider* listed 17 robo-advising firms, and *Capital Journal* listed another 13 (Beketov et al., 2018). Meanwhile, the robo-advising firm Betterment expanded customer access to human advice (*Wall Street Journal*, 2017). TradeKing, a then digital wealth management company, was acquired in 2017 by Ally Financial, a bank holding company. SoFi, a digital advisor, took this same partnership tact in acquiring Golden Pacific Bank in early

2022, a California-based community bank. And Wealthfront has agreed to be acquired by UBS in early 2022. E-Trade was acquired by Morgan Stanley in 2020. Still other wealth management companies decided to develop their own robo-advising platforms. For example, Charles Schwab, Fidelity, and Vanguard all created their own robo-advising platforms respectively named Schwab Intelligent Portfolios (2015), Fidelity Go (2016), and Vanguard Digital Advisor (2020). In fact, a previously announced acquisition of Wealthfront by UBS broke down following shareholder expectations that they could build their own platform at a cheaper price point (Shields 2022). Thus, the move to robo-advising is one that has been embraced essentially industry-wide by innovators up through large incumbents.

1.2 Bundled Savings Strategies for Wealth Accumulation

Individuals' savings rates are a major factor in retirement planning. Although culture, including the level of uncertainty avoidance and collectivism, has an impact on the overall savings rate (Shoham et al., 2012), behavioral and psychological issues such as self-control, emotions, and choice architecture have been shown to be important factors as well (Knoll, 2010). Scholz et al. (2006) found that less than 20% of American households are saving below their optimal retirement targets, mostly in the lowest level of lifetime income groups. Mani et al. (2013) found that poverty itself reduces cognitive capacity by consuming mental resources. This adds an extra challenge to the retirement planning of those with lower levels of income.

Economists have also found that households might lack the motivation to save more as that requires sufficient self-control to reduce current consumption (Thaler and Shefrin 1981). Thaler and Benartzi (2004) designed a program that allows people to commit in advance to allocating a portion of their future salary increases toward retirement savings and found that the average saving rates for those people increased from 3.5 percent to 13.6 percent. In their book, *Nudge: Improving Decisions on Health, Wealth, and Happiness* (2008), Thaler and Sunstein pointed out that people are subject to serious inertia. To reduce the bias from this in decision-making, Thaler and Sunstein proposed in their book a choice architecture that they called “nudge,” which alters people's behaviors via slight economic impacts while maintaining people's freedom of choice. Building off of Kahneman and Tversky's work on decision-making, Thaler and Sunstein posit that under their proposed system, “libertarian paternalism,” small nudges add up to higher levels of wealth and overall wellbeing – so long as prompted individuals elect to follow them.

The FinTech firm Acorns automatically invests spare change from users' purchases. Utilizing the idea that small steps accumulate to big change, the firm offers its customers options to save small, leftover sums after shopping and bundles them to increase customers' savings rates. For everyday purchases, the spending is rounded up to the next whole dollar, and the spare change is automatically collected and invested

in a pre-selected portfolio. In doing so, the firm hopes to nudge customer behavior one bit at a time, and guide them to establish good habits that can benefit their financial wellbeing.

1.3 Wealth Management Enabling Tools for RIAs/Financial Advisors

The rise of robo-advisors is disrupting the traditional wealth management industry. RIAs/Financial Advisors are responding by embracing the tools behind robo-advisors. Financial planning, portfolio optimization, and risk management can easily be streamlined by algorithms, reducing costs spent on human labor. Marketing and lead generation are benefiting from AI-based recommendation algorithms as well. These sum to result in potentially lower management fees and improved, customized, and integrated services.

The case titled “Charles Schwab Corp in 2017” documents what Charles Schwab Corp considers when using technology and data to better understand clients’ motivations. Charles Schwab, like other incumbents, gave much attention towards technologies and innovations that were seen as disruptive. Yet, decisions for incumbents like Schwab had to strike the fine balance between not missing out on the next wave of innovation while also not jumping into something prematurely, particularly something that was potentially cannibalizing existing products and services (Makinen and Siegel 2017).

1.4 Micro- and Low-Cost Investing (e.g. Robinhood)

The development of technology is enabling fast and cost-efficient trading in financial assets. Traders in stock markets have seen drops of transaction costs along with commission fees over the past century (Jones, 2002). On one hand, the liquidity of equity markets has improved over the past decades (Hasbrouck, 2009). On the other, the popularization of personal computers and the internet has also benefited traders. The decrease of trading costs coincides with the increase in trading activities (Frazzini et al., 2018). The market impact of trade execution, especially of large sizes, has been particularly reduced in recent years (Frazzini et al., 2018).

These changes have contributed to paving the way of two trends in secondary markets. One trend is the rise of index funds in delegated portfolio management in recent decades, helped through their low investment expenses (Bogle, 2014). These funds, often charging little or even zero fees in the form of an expense ratio, have popularized the idea of passive investment for both institutional and retail investors. The other trend is the emergence of online stock trading platforms. Led by Robinhood (discussed in more detail below), online platforms have cut trading commissions for retail investors to zero in many products. Trading of fractional shares has also emerged and is becoming more widely available. These have all promoted financial inclusion.

Robinhood is a financial services company headquartered in California, U.S. Founded in 2013, the company aims to cut the cost of stock trading to democratize access to investors, and in particular, retail investors, thus promoting financial inclusion. The company started the first mobile platform for trading stocks, with no minimum investment and no commission fees. The trading app quickly popularized amongst small retail investors. Tan (2021) argues that the platform incentivizes more frequent and riskier trading behaviors.

This model of zero-cost investing is also taking hold in other developed and developing markets. An example of this is Zerodha in India, which had over 9 million users in 2022, representing 15% of all retail order-volume in the country, and having user- and revenue-growth rates in the double-digits. Moreover, the entry of these zero-cost FinTech investing platforms has ignited competition across the industry. Vanguard, Charles Schwab, and TD Ameritrade, amongst other large brokerages, now also offer zero-commission trading of equities and fractional share trading.

That said, multiple regulatory organizations have brought to light concerns regarding aspects of these organizations' profit models. In particular, they have focused on the pay for order flow (PFOF) model of these companies. The PFOF model is one which these zero-cost brokerages would sell the "right" to execute and clear the trades of retail investors. Regulators, such as the United States Securities and Exchange Commission (SEC) worry that the firms purchasing this order flow are using it to potentially front-run, or, otherwise, opportunistically trade at the detriment of retail investors (*Wall Street Journal*, 2022).

1.5 Retirement

The retirement market holds enormous potential, with assets over USD 56 trillion worldwide by the end of 2020 (OECD, 2021). Yet this market is largely untapped. In the U.S., pre-retirees (age 55+) and retirees hold 76% of total investable assets (2016 Survey of Consumer Finances, Federal Reserve Board, 2017), but the generation is not particularly financially literate. Polansky et al. (2018) emphasized generating retirement income is particularly challenging for many Americans, with one reason being that they often have multiple accounts held by different financial institutions. Besides the health and wealth aspects of retirement, several behavioral factors may have also influenced retirement decisions and retirement income (Knoll, 2011). Financial technology is impacting retirement planning, saving, investment, and decumulation. Some financial technologies that have emerged in asset management and tools for financial advisors, as discussed in previous sections such as robo-advising, have also been used in financial products in the retirement market.

Retired homeowners tend to dissave more slowly than renters (Nakajima et al., 2019), largely because of the illiquidity of this asset. The attitude towards and methods of using

home equity as a supplement in generating retirement income have been well documented in the literature (Munnell et al., 2007; Sacks et al., 2012; Hanewald et al., 2016).

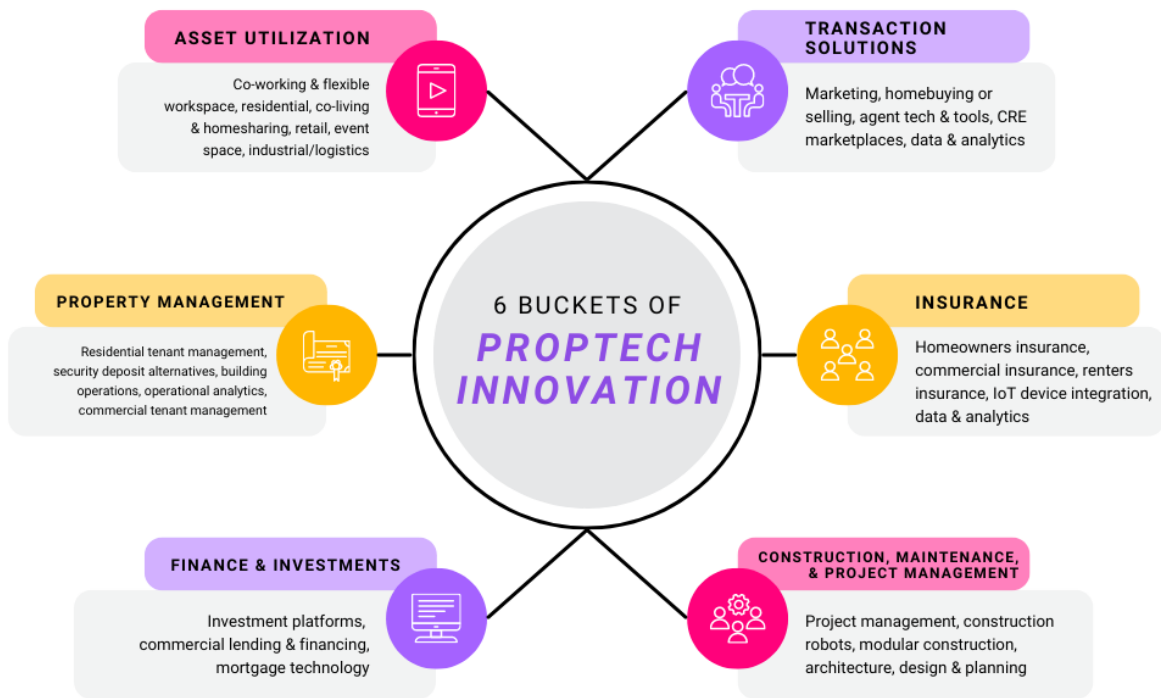
The “Dimensional Fund Advisors Entry into the Retirement Market” case documents how technologies add value to DFA when offering retirement solutions to its clients. The firm focused on defined contribution plans. This often placed a huge burden on employees, most of whom had neither the time nor the expertise to effectively manage their retirement assets. By using a digital platform that allowed inputs of various dimensions from users, including their personal and financial background, retirement age and target income, risk, and inflation, Dimensional Fund Advisors created a highly customized solution for defined contribution plan participants, which could be easily scaled up. Yet implementation challenges existed. The firm had seen inertia from employees in signing up for its product, with evidence showing that individuals were unlikely to be active consumers of the optimal retirement solution. Resistance from employers, especially from small companies, because of the potential burden on the cost and time for the extra administrative work, was also an issue.

Section II – PropTech & InsurTech

2.1 PropTech’s Disruption of Real Estate Markets

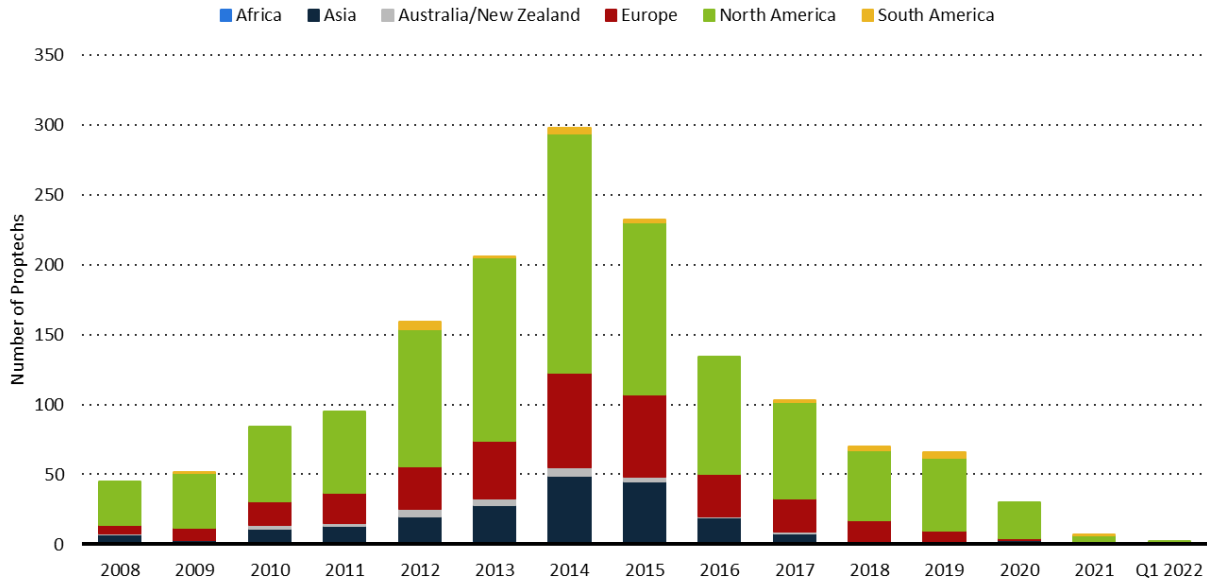
As the real estate industry enters a new wave of digital disruption, new technologies have upended the traditional relationships between homebuyers and real estate agents, home insurance companies and homeowners, and even renters and landlords. PropTech – or property technology – has altered real estate’s historical properties as an alternative asset class, which offers the opportunity for higher returns, diversification, and a hedge against inflation. From new innovative construction materials and methods to artificial intelligence and machine learning, emerging technologies have reshaped the landscapes of international cities and suburbs. However, while real estate’s adoption of new technologies has been slower than the transitions of other asset classes, COVID-19 and other second order impacts means that there has been a quicker adoption of PropTech tools in recent years. For anyone who owns, rents, or uses physical space, PropTech promises to increasingly make waves throughout the industry’s needs, expectations, and investments of tomorrow.

Exhibit - PropTech Innovation Buckets



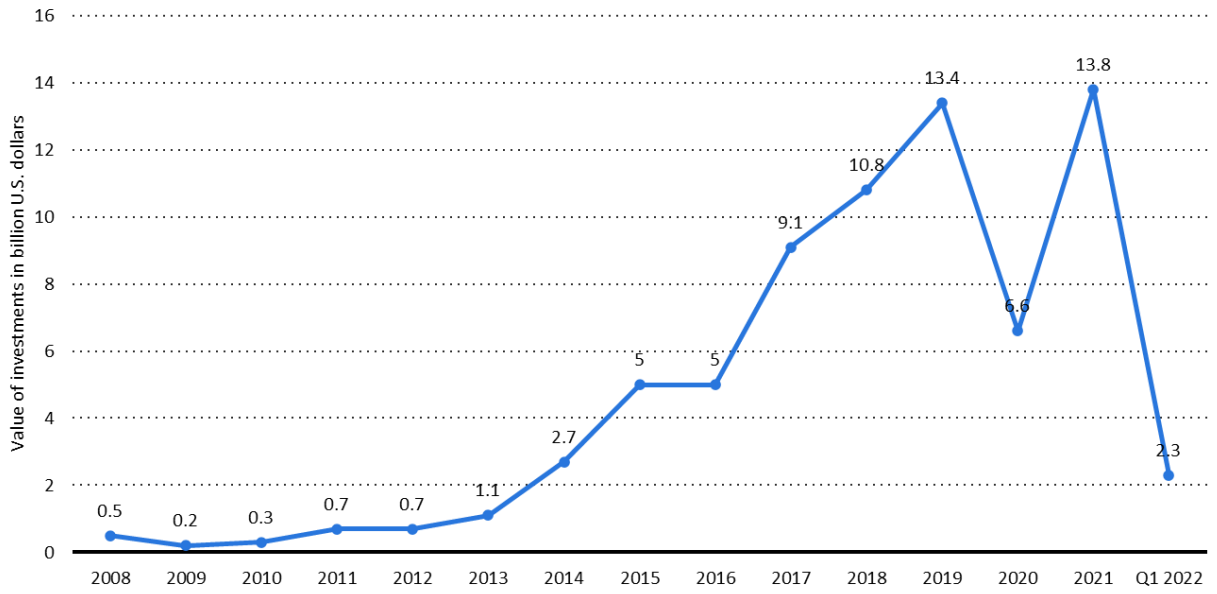
Source: Created by authors from *The Present & Future of PropTech*, Bank Leumi USA, March 2022, https://www.valley.com/VNB/media/Library/PDFs/March-2022-Bank-Leumi-Whitelabel_RC1_web.pdf, p. 24-25, accessed August 2022.

Exhibit - Global PropTech Companies Launched From 2008 to 2022Q1



Source: Deloitte & Venture Scanner, via Statista, <https://www-statista-com.ezp-prod1.hul.harvard.edu/statistics/951859/number-of-prop-tech-launches-globally/>, accessed August 2022.

Exhibit - Value of VC Investments in Global PropTech Companies from 2008 to Q12022



Source: Deloitte, via Statista, <https://www-statista-com.ezp-prod1.hul.harvard.edu/statistics/1060470/global-propotech-venture-capital-investment-value/>, accessed August 2022.

2.1.a Real Estate Brokerage

This section will address FinTech disruptions across four primary real estate markets: residential real estate sales, residential real estate rentals, commercial real estate, and the sharing economy.

Home Sales Market

The housing market has traditionally been mediated through imperfect search and matching processes that are fraught with market tensions and search frictions. However, in recent years, many new PropTech companies have launched to more closely approach a hedonic pricing model in which a property's sale price is a true function of its characteristics rather than relative bargaining power or imperfect timing.

To remove typical matching problems between buyers and sellers, multiple listing services and other aggregators such as the U.S.'s Zillow or the U.K.'s Zoopla have democratized access to real estate listings. Buyers and sellers no longer necessarily require a broker in order to view available properties, which thereby allows a wider scope of access to all available listings within a desired area. However, instead of fully disintermediating real estate agents from their previous gatekeeper roles, these new platforms have instead transformed it with sophisticated marketing tools. Empowered

with new AI chatbots that can automate answers to simple questions, real estate agents are now freed from such mundane, repetitive tasks, allowing them to focus on the profitable part of a sale – the closing process.

Some platforms have taken their matching role even further by rolling out robo-purchasing and selling models themselves. iBuyers such as Opendoor and Redfin have risen to attempt to tackle the timing friction for selling and buying homes within the U.S. By automatically assessing the value of a house based on its public characteristics, whether that be building plans or the surrounding neighborhoods, an iBuyer can quickly send a purchasing offer to a homeowner. For a percentage-based fee, the company will conduct any necessary renovations, facilitate showings to prospective buyers, and ease the closing process for both the final buyer and seller. Although the model promises to remove many home-to-home frictions within the housing markets where it is present, an iBuyer's success relies on its automated valuation model. This valuation process raises a risk of the traditional lemons problem due to the asymmetric proportion of information available in the public domain compared to that known by the prospective seller, such as a crumbling foundation, faulty electrical wiring, or poor maintenance history. In this way, owners of properties with highly valued, intangible qualities that are difficult to quantify, such as a pleasant view, may be less willing to sell to an iBuyer, whereas owners with lower-value properties that may have undisclosed faults may be more willing to sell to a model with no questions asked. Many iBuyers, such as Opendoor, have sought to minimize these risks by limiting their purchases to certain criteria, such as within a specific housing market or a construction age after 1950.

However, despite their models being premised upon aggregating housing stock to reduce timing and information frictions for buyers and sellers, they have also aggregated many of these risks. For example, whereas the relative bargaining power between sellers and buyers is initially weighted towards the seller when a house is first listed for sale, this balance flips the longer the house remains on the market (Albrecht et. Al. 2007). In short, the house's value, on average, decreases in relation to its duration on the market. While iBuyers have the opportunity to keep larger amounts of housing stock available for their perfect matches, in many cases they have also priced in this depreciation risk into their fee-based models, oftentimes charging higher fees the longer a house is listed on a market – even though the home's intrinsic value remains the same. As a consequence, although iBuyers offer some possible advantages to approaching a hedonic pricing model, they are still encountering many of the headwinds dealt with by traditional broker-dealers.

In addition, for real estate credit and equity markets, PropTechs have enjoyed advantages in speed and accuracy over established banks, who have largely been slower to adopt new technologies. For example, a 2019 study found that FinTech lenders processed loans approximately 10 days faster than their established competitors (Fuster et al 2019). In addition to offering marginal improvements on a time-intensive process,

the incorporation of standardized, big data, and automated valuation into underwriting models has led some PropTech companies to expedite their mortgage originations and sell them to third parties, such as Freddie Mac and Fannie Mae, for securitization (Saiz p. 338).

In particular, given that the U.S. market requires available credit financing for many first-time homebuyers, PropTech companies providing a smoother and speedier mortgage process for consumers have seen particular growth in recent years. One such company, Ribbon, has enabled homebuyers to make all-cash offers without home-sale contingencies by directly purchasing the home for a buyer if financing is not yet secured and pending an acceptable inspection. If a buyer does not yet have a mortgage secured, Ribbon and the buyer sign a one-year lease contract, and Ribbon gives homebuyers up to 180 days to secure the financing to buy the home back from the company for a fee of 2-2.75%, split between the buyer and seller's closing costs. If the house is not sold in time, then real estate investment companies partnered with the start-up would purchase the property. Nevertheless, Ribbon has reported low levels of defaults, which it credits to its predictive data systems. These assess a buyer's mortgage eligibility, likely mortgage amount, and creditworthiness in under one hour - a relatively short amount of time compared to the industry-wide average of the fifty business days it takes to secure a mortgage from a bank (DiMaggio & Gulick 2020). By simplifying the financing process for buying a home, PropTechs offer the opportunity to remove another friction from the homebuying process for buyers and sellers alike.

Rental Market

From the 1995 launch of Craigslist, arguably one of the first PropTech listing services, new advances in technology have increasingly disintermediated real estate brokers from the landlord-rental relationship. Since the initial real estate listing services, rental housing markets have also seen disruptions from customer relationship management systems to automatic tenant screening services, the use of photogrammetry, and drones used for marketing purposes. Due to higher turnover compared to the residential real estate market, many of these technologies have seen a wider adoption by large commercial and smaller landlords alike. In particular, PropTech advances have been most prevalent in the tenant search and matching process and the development of advanced property management software, with an increased focus on tenant satisfaction and security.

Tenant Search and Matching Process

For landlords, locating a responsible tenant can be a time-intensive and fraught annual cycle of application, evaluation, and management. Meanwhile, for prospective tenants, finding a well-maintained and price-conscious apartment can be a time-consuming process in a market with less-than-perfect accessible information. As a consequence of

these demands, the PropTechs that have seen the widest adoptions within this market have often tackled the landlord-tenant matching process in one form or another.

For prospective tenants, PropTech rental platforms such as Trulia and apartments.com offer a crowd-sourced knowledge base of apartment listings across a city, complete with geolocation features, walkability assessments, past rental listings, and personalized data matching to help decide on a place to live. As prospective tenants are deciding on their next move, new technologies such as digital twin representations or virtual reality can enable tenants to “walk through” available rentals without organizing an in-person showing – an adoption that has been particularly sped up due to the danger of in-person tours during COVID-19.

For smaller and commercial landlords who want to minimize tenant turnover costs, tenant application and management systems speed up time- and energy-intensive screening processes. The automation and digitization of back-office tasks, such as online chatbots to answer basic introductory questions from prospective tenants, digital contract signing, and online reference and background checks have reduced existing frictions in identifying and onboarding new tenants. In some cases, PropTechs have sought to use machine learning to improve matching between prospective tenants and landlords. These systems integrate data from various metrics such as a tenant’s verified income and other available financial intelligence on the prospective tenant to produce an overall tenant score for applicants.

Concurrently, the privatization and digitization of tenant screening processes at scale holds the potential to reproduce and potentially magnify many issues endemic to the power imbalance between tenants and landlords, particularly in localities with imperfect rental competition (Landau-Ward & Porter 2019). PropTech companies that seek to mediate landlord-renter relationships - and that of their investors - must grapple with these challenges by nature of automating judgements seeking to identify the ‘ideal’ tenant. In particular, by relying on personalized private data that scores a tenant’s suitability and ability to pay, this model creates a *de facto* private tenant scoring system, akin to a credit score, that risks perpetuating existing inequities and access to property rentals, along with potentially infringing current regulatory standards on real-estate access.

Without transparency and governance over the scoring criteria and the accuracy and reliability of the data feeding automated tenant screening processes, PropTechs could lock certain tenants out of rental markets, sometimes at no fault of their own. For example, a tenant could receive a lower score for past bankruptcy, personal issues that caused a disturbance at a past residence, or the exercise of their tenant rights by withholding rent payments over poor maintenance conditions, which is often poorly enforced despite being a tenant right in many localities. In tight rental markets, even a slightly lower score could mean the difference between hundreds of dollars in annual rent or not being accepted for an apartment at all, especially where platforms may take

a ‘neutral approach’ and leave fair housing and antidiscrimination compliance to its users, as illustrated through fines incurred by Facebook marketplace for permitting discrimination in violation of the U.S. Fair Housing Act (Feiner 2022).

Still, in other cases, rental platforms could represent a power shift back to tenants by also identifying the best landlords. Wainwright explores how, through investor mediation, RPPs not only mediate access to landlord properties but also assist renters by promoting landlords with a positive reputation, particularly among not-for-profit rental platforms. At the same time, the paper hypothesizes that poorly ranked landlords may only gain access to poorly rated tenants, and vice versa, although it identifies that such mechanisms have limited efficacy in constrained housing markets. Nevertheless, this research highlights the need for greater insight into algorithmic judgements and their applications in landlord-tenant relationships within the private rental sector.

Property Management Software & the Internet of Things (IoT)

Property management software displaced paper-based management processes when they debuted in the hospitality industry in the 1980s. Particularly for at-scale landlords who manage multiple units, such software enables them to collect rent automatically, keep rental and accounting documents within a single system, and manage maintenance concerns. In more recent years, software packages have started to integrate with Internet of Things (IoT) devices, or physical hardware with embedded sensors or other processing abilities that can connect to transmit data to a software program. Their emergence alongside software-as-a-service solutions have continued to enhance property management and maintenance systems, particularly for landlords. Smart device advancement has further enabled digital twin technology to virtually replicate existing building systems to better optimize space, automate operations, and predict maintenance requirements. For example, one of the largest-scale digital twin projects, Virtual Singapore, is digitally mapping the entire city-state to enable researchers to experiment with and solve urban planning and development projects. Similar 3D-scaling technology may be adopted by commercial landlords in new construction in the near-term to communicate suggested improvements to tenants, or to monitor building systems. By allowing landlords to better monitor tech-enabled building-wide systems, management may more quickly and efficiently address routine problems and potential maintenance issues before they become costly emergencies.

In regulated markets, PropTech companies, such as New York City start-up Jones, have also enabled smoother logistic processes and easier compliance management for landlord-tenant relationships. Some of the parties’ legal obligations include property insurance, local authority licenses, safety and identity checks, public housing compliance, and automated disclosures mandated by local law. As digital innovations expand the scale and geographic dispersion of a single landlord’s units, property management tools may also permit the automation of certain compliance tasks to more efficiently comply with regulatory burdens.

Tenant Satisfaction and Security

In addition to smoothing over frictions in onboarding new tenants and managing existing ones, more recent PropTechs have also launched to enhance the tenant experience. In luxury dwellings, these companies promise small touches that add value for tenants, particularly for high-income earners. For example, Amenify in the U.S. provides professional cleaning, car washing, housekeeping, dog walking, food delivery, and other lifestyle services for residents by contracting with vetted vendors in professionally managed buildings. Other space-tracking PropTech companies have enabled professionally managed buildings to analyze the usage and floor traffic of common areas, thus maximizing the value their amenities provide to residents. Even in lower-end residences, some forms of PropTech solutions designed to enhance tenant satisfaction complement the ‘social’ component of ESG considerations, such as enhanced air quality monitoring in building monitoring systems or tenant or building security systems. Despite wide applicability, there is less of a clear ROI on tenant satisfaction and security, whereas other innovations have a clearer business case for making operating tasks much more efficient.

Other Novel Uses

Furthermore, while most PropTechs in the rental market are marketed towards landlord convenience, a few have adopted a truly tenant-centric approach. For example, whereas landlords have banded together in some cases to vet prospective tenants, other recent companies have created rating systems for landlords. In New York City’s crowded rental market, Open Igloo serves as an anonymous Yelp for former tenants to rate their landlords and access city records on bedbug complaints, building violations, and litigation history.

Finally, some PropTech companies have leveraged automated software platforms to become co-living intermediaries akin to landlords themselves, including U.S. companies such as HubHaus, Common, and Campus. These models have tended to be concentrated in densely-populated urban areas with high rents, where co-living can be an affordable alternative, such as New York City and San Francisco. Both Campus and HubHaus failed early on in 2015 and 2020 respectively, due to economically non-viable models, as they would sign long-term rental agreements themselves on large properties, and then recruit prospective tenants to live together with other recruited housemates. HubHaus in particular became insolvent after COVID-19 led to a brief urban exodus and made co-living an unattractive model for prospective residents. However, Common has billed itself as a management firm for landlords instead of a middleman. The company acquired Starcity, one of its co-living competitors, in 2021, despite COVID-19 pressures (Matsuda 2021), and it has continued to survive despite reported tenant complaints of poor security and communication lapses (Kirsch 2022). Whether co-living will either thrive in a post-pandemic world like Airbnb or wither like WeWork remains to be seen.

Commercial Real Estate Market

Although many U.S. real estate investors shifted away from commercial real estate markets to residential real estate markets after the 2008 subprime mortgage crisis, many PropTech companies have successfully gained traction in disrupting the commercial real estate market. As seen in the residential and rental markets, many PropTechs have focused on streamlining traditional business processes through the automation and digitization of traditionally paper-based processes. For instance, in Australia's commercial real estate market, Lygon has digitized bank guarantees for retail property leases on the blockchain such that securing a commercial lease can take a few seconds, as opposed to the days- or weeks-long authentication process that signing such a lease used to take (Poser 2020, Hemsley 2022). However, new applications of technology in this sector have permitted two particularly novel uses to emerge: crowdfunding of commercial real estate projects and space-as-a-service (SPaaS) platforms.

Crowdfunding of real estate projects pools investor money to fund a real estate development project. In the U.S., these funds often take the form of private REITs, which are real estate funds exempt from SEC registration and are usually limited to institutional investors. For example, Realty Mogul has built a digital platform that enables accredited investors to invest in both an income and a growth REIT across private offerings in commercial real estate. As of May 2022, its offerings were worth approximately \$5.2 billion in nearly 30,000 private real estate investments across the U.S. However, new PropTech crowdfunding platforms have enabled retail investors to gain access to private real estate development projects. For example, Fundrise enables retail investors to purchase shares of REITs with low minimums of \$1,000, automated portfolio management tools, and diversification across different development projects and localities. Whereas this offers small non-institutional investors the possibility of higher returns and greater liquidity than owning a property oneself, its private REIT offerings may charge penalties for early withdrawal, and withdrawals may not be possible in an economic downturn, when small-scale investors may need to access liquidity the most. As one of the first platforms to offer options for the lower end of the investment spectrum, the economic success of its model and impact on users remains to be seen.

In another development, SPaaS has transformed retail real estate by pricing retail space offerings based on time used and service quality tiers – as opposed to locked-in, long-term leases. Consequently, this model opens multiple lines of business for a single square foot as well as a new focus on user experiences and hospitality for attracting new users. One form of SPaaS, brandboxing, offers all-inclusive set-ups and flexible contract terms to enable digital-first brands to open their first physical retail presence with little commitment and upfront risk. Its namesake, Brandbox, is a software package that partners with digitally native brands to open their first physical retail presence on a trial

basis. Bundled with an individual success team, premium locations around the country, and pre-packaged store formats and themes, Brandbox's in-store data analytics tools calculate metrics such as daily footfall, dwell time, and sales data to help new store owners make better decisions about whether and how to grow their small business from its ecommerce beginning. Another brandboxing company, Showfields, retains two marketplace-like showrooms in New York City and Miami that rotate their pop-up space between new founders who want to test out a physical store presence for their digital brands. With a similar trial-based concept and a limited physical footprint, this innovation offers the potential for digital native brands to test out a brick-and-mortar presence, perhaps upending the hype around an inevitable transition to the future of online shopping.

The Sharing Revolution: Fragmentary Ownership & Coexistence

Since the late 2000s, many PropTech companies have arisen that permit consumers to purchase the temporary use of a property. This form of property-sharing has enabled property owners to monetize their real estate assets more successfully. There are a multitude of both coworking examples - such as Spacious, Breather, WorkBar, WeWork, Knotel, and Industrious - as well as hospitality examples - such as Airbnb, Lyric, Sonder, Pillow, Zeus, and Recharge - that all have similar pay-per-use models. However, in more recent years, PropTechs have disrupted not just the temporary use of space but the very ownership of a property. Investment schemes such as Australia's BrickX divides a property into 10,000 bricks which may be purchased on the PropTech's platform in exchange for passive rental income. Similar to creating a time share market, other PropTechs such as Pacaso have enabled fractional ownership of a second home between as many as eight parties.

PropTech companies have also generated formal non-traditional renters' agreements that may have existed in informal capacities in the past, such as intergenerational housing or housesitting for free accommodation. Other companies enable homeowners to seek out tenants that will help around the house. In the case of the intergenerational Nesterly, elderly homeowners can advertise an open room in their house for a lower rent in exchange for help with household chores that they are unable to complete on their own (O'Neill 2017). Similar schemes, such as Workaway, Nomador, or helpStay, enable travelers to receive free accommodation in exchange for completing small tasks, such as caring for the homeowner's pets or plants. However, due to their formalization of previously under-the-table work-for-accommodation schemes, these PropTech companies run the regulatory risk of governments considering these schemes to be equivalent to paid work and therefore subject to immigration and tax-withholding should they grow to a sufficient scale.

2.1.b Construction Tech

In the U.S., housing demand has far outstripped the production of new homes to such an extent that there is a shortage of approximately 3.8 million homes across hundreds of cities and small towns alike (Kingsella & MacArthur 2022). While this has led to the appreciation of home prices by approximately 30% since 2020 (Arnold 2022), this trend also illustrates the immense demand for new housing in the U.S. Some PropTech companies have sought to automate the creation of new real estate assets. By lowering traditional construction costs through greater material and labor efficiencies, they have the opportunity to not only expand existing construction capacity but also capitalize on creating new assets in high-valuation markets. While many of the operational technologies, such as prefab homes, have been utilized for over a century, new technologies such as 3D printing of home construction products and the use of VR and AR in architecture modelling may unlock new value propositions. Two primary PropTech models in this space include (1) startups that seek to mass produce new construction and (2) startups that seek to integrate complicated construction management processes among various stakeholders.

One early example of the former, Katerra, was a construction startup that raised \$2 billion in funding via SoftBank but closed due to its business model's struggles with increasing labor and material costs. Its model relied on manufacturing construction parts, such as custom panels of walls, windows, lights, and cabinets in factories (Leslie and Saucedo 2019). It further sought to integrate various aspects of the homebuilding process from architecture to plumbing under its roof. However, delays, cost overruns, locality-specific building and zoning codes, construction unions opposed to lower-cost automation of their skilled labor, and a high debt load due to an aggressive growth strategy ultimately made the PropTech unfeasible, and it folded in mid-2021 (Matney 2021, Brown & Kusisto 2019, Putzier 2020).

However, PropTech companies in the latter category have received more success in recent years. One example, Procure, is a construction management SPaaS company that allows companies, property owners, project managers, contractors, and partners to work together on its cloud-based platform. The platform's features include integrations of many pre-existing and emerging technologies, such as data and video integrations with the use of drones, the use of document storage for all stages of construction, and integrations with 300+ partners to better manage production processes. Furthermore, as a construction software company focused on environmental sustainability, it also enables its users to assess their environmental impacts more easily through a materials database that compares the environmental footprints of alternative construction products, as well as tracking embodied carbon in a way that measures the contributions of construction materials to global greenhouse gas emissions (Procore 2022, Thibault 2022). Because tracking accurate and interoperable data remains a challenge of integrating ESG metrics into construction processes, the integration of such features

alongside the streamlining of other traditional construction processes offers the opportunity for construction companies to consider their choices in material and construction techniques alongside other factors such as material quality and cost. Nevertheless, this light-touch model capitalizes on existing industry processes and may systematize the analysis of existing inefficiencies in a way that complements rather than disrupts existing modes of business.

2.1.c Greentech: Real Estate under Climate Change

With climate change expected to lead to large, property-damaging events across the world in the next few decades, and the rise of ESG investing that has increased the attention given to sustainability data within real estate investment portfolios (Credit Suisse 2022), GreenTech companies have entered the PropTech space with sustainability and environmental missions. Extreme weather events are predicted to cause mass environmental damage and even make swathes of land uninhabitable, while changes in natural resource availability are expected to make procuring construction materials more costly and time inefficient. As a consequence, climate change will further impact the valuation of real estate and its development and operation as an asset class. Furthermore, a newfound emphasis on sustainability within investment portfolios have placed either a formal legal or informal social obligation on investors, particularly in regions of the world that have adopted carbon targets and other regulatory requirements. Whether to use smart technology to reduce a building's negative environmental impacts, or improve the building's resiliency, GreenTech has adopted two main innovations that enable property owners to overcome these challenges: monitoring of a building's environmental impacts, and the bolstering of a building's resiliency against adverse environmental events.

Firstly, smart building technologies have facilitated the management of buildings to both make their operations more environmentally friendly and to provide data in fulfillment of ESG goals for institutional investors. Some companies, such as Dabel in Germany or Prescriptive Data in New York City, leverage cloud-based software to enhance existing building management systems in order to improve operational functions, such as energy efficiency savings that mitigate their environmental impact. Others utilize IoT devices on top of existing systems to livestream data regarding certain aspects of their environmental friendliness, lowering both energy usage and operating costs.

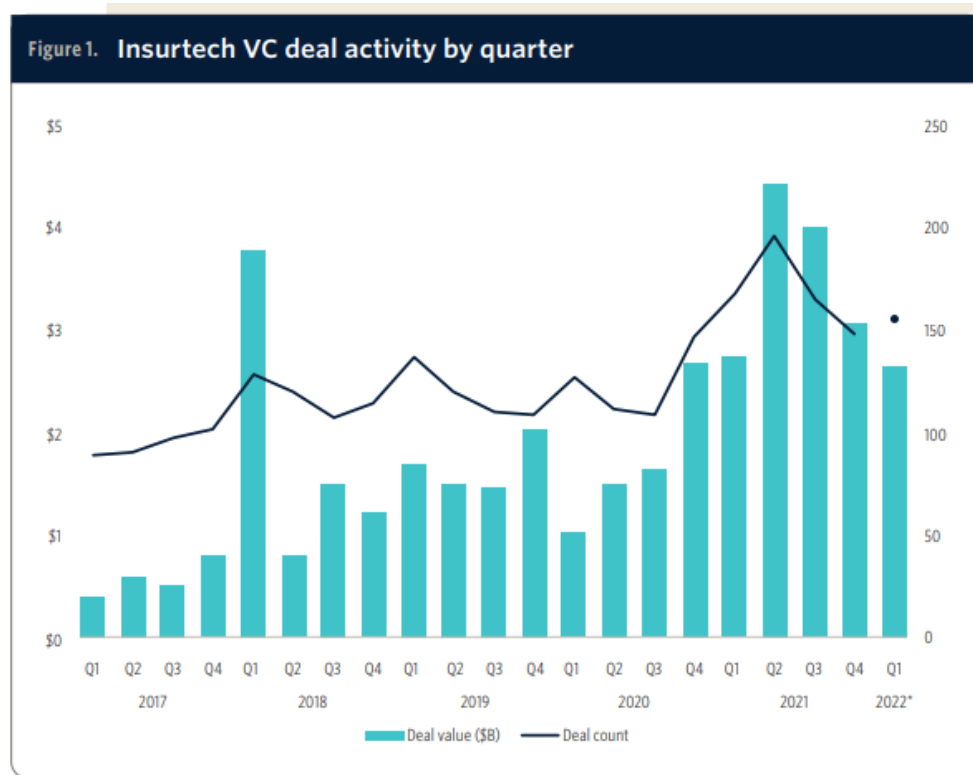
Secondly, other GreenTech companies have focused on building resiliency in old-construction buildings. In 2021, natural disasters caused \$56.9 billion worth of property damage in the U.S. market alone (TRD Staff 2022). One example, R-Zero, integrates AI, machine learning, and IoT hardware into a biosafety technology platform to create a healthier building for occupants, particularly to improve air quality within a property. Other commercial data platforms exist, such as Risilience, that seek to inform businesses about climate risks to their operations. While few, if any, platforms exist

specifically for property markets, there is an additional opportunity for new GreenTech companies in this resiliency space as natural disasters continue to become more recurrent, damaging, widespread, and costly.

2.2 Insurance Tech

The insurance industry has so far resisted the widespread adoption of many technological innovations into their processes, but recent start-ups have emerged that demonstrate the potential such technology has for industry players who choose to do so. At its core, insurance shares risk between customers and insurers, and insurers price this risk accordingly when underwriting their policies. Across the two primary sectors of property casualty insurers and life annuity insurers, there are three primary models: the distribution model, the carrier model, and the self-governing model. Particularly in the U.S., insurance markets are dominated by established, incumbent players that have been slow to update their underwriting models, while a patchwork of regulatory markets across state lines have also hindered established firms' technological rollouts alongside InsurTech start-up expansion. Nevertheless, in the first three quarters of 2021, global investment in InsurTech topped \$10 billion USD (Le 2022).

Exhibit - Insurtech VC deal activity by quarter



Source: Pitchbook, *Emerging Technology Research: Insurtech Report*, March 2022, https://files.pitchbook.com/website/files/pdf/Q1_2022_Insurtech_Report.pdf#page=1, p. 3, accessed August 2022.

2.2.a Predictive Analytics & IoT Devices

With the rise of the Internet of Things (IoT), insurers possess greater capabilities to track their policyholders' daily habits and are able to more accurately assess their risk factors such that they can offer more accurate, individualized prices. For example, wearable technology such as Apple Watches and Fitbits are able to accurately measure a person's daily activity level and fitness, which can then enable health and life insurance companies to better assess potential health risks and predict longevity. In the auto insurance industry, start-ups such as Root Insurance utilize telematics to more accurately track and measure drivers' real-time driving behaviors, and similar innovations in smart home products have been adopted by property insurance companies, such as home insurance start-up Hippo. In the U.S. property insurance market, Hippo has sought to upend the traditional selection bias dilemma that established insurance companies face by focusing on underwriting potential new customers who share their 'total home protection mindset' and will take advantage of their preventative home inspections and services. Their assumption is that they can proactively select positive risks by underwriting for those more attracted to adopting preventative habits, thus improving their loss ratio. However, it remains uncertain as to whether or not these new methods can surpass the tried-and-tested underwriting processes of established players, as research has shown that users modify their behavior to be more risk-averse with the knowledge that said behavior is being tracked. In addition, tracking customer behavior remains dependent upon the terms and conditions of tracking behavior. An ethical dilemma exists in the trade-off between customer privacy and accurate assessments of their behavior, wherein many customers may prefer the anonymity of past risk-assessment metrics.

2.2.b Technological Innovation in Insurance Sales & Claims Handling

While in other sectors FinTechs have more frequently sought to disrupt incumbents, on the whole, InsurTechs have sought to partner with established insurance companies. This is due to many reasons, including regulatory limitations (e.g. in the Managing General Agent model) within certain markets and poor Insurtech underwriting models. However, by working together to make processes such as claims processing and AI fraud detection more efficient, InsurTechs can avoid becoming a full-stack insurer – at least immediately. For example, carriers allow third-party agents to integrate APIs, or application programming interfaces that function as a connector between different service platforms directly into their checkout process. This increases the efficiency of traditional quoting processes that require significant time for both agents and carriers, and it also creates a seamless purchasing experience for customers who might otherwise get confused at the nuanced variety of insurance product offerings through other channels. For both companies, this also provides data analytics and consumer

management intelligence that can be used for future marketing drives. At the same time, this risks bancassurance problems arising due to misaligned interests between the insurance company and its Insurtech partner.

On the other hand, Insurtechs have started to build bridges between traditional insurance providers and the producers of goods that require insurance – in some cases enabling the goods producers to offer insurance products themselves packaged with a user’s purchase. Insurance products have been integrated into the home purchasing process for new construction real estate, while car manufacturers, such as Tesla, have started to offer auto insurance with their self-driving vehicles, including special coverage for accidents stemming from autonomous driving features. As insurance products are integrated into a customer’s purchasing journey, similar to an extended warranty product purchased with a new computer, consumers may enjoy easier access to appropriate products while insurers may wrap in a new population of previously uninsured policyholders.

In some cases, this takes the form of insurance-as-a-service, or IaaS, in which a Insurtech startup will serve as an intermediary insurance operator for specific practices, such as underwriting, claims processing, fraud detection, customer service, or distribution. For example, Slice Labs offers an on-demand insurance cloud platform provider that displaces traditional insurance agents by providing customer support, automatic underwriting and pricing, and automated claims and settlement processes directly to on-demand insurance customers – initially those who were part of the gig economy (Goldenberg et al 2021). However, with the automation of claims handling also came the automated processing of potentially fraudulent claims at a time when automated fraud detection was still in its nascent stages.

In addition to removing frictions from the insurance sales process, many other Insurtechs have leveraged new technology platforms to provide an improved customer experience for claims processing while attempting to minimize fraud. Growth in technological capabilities to make insurance companies more responsive to customer needs offers a possibility to improve low customer trust in the insurance industry, particularly in emerging markets (Holliday 2019). Similarly, the application of AI, biometric identification, and mobile payment mechanisms to reduce fraud also offers the opportunity to restore companies’ trust in customers and keep insurance prices affordable. For example, U.S. Insurtech Lemonade has turned to behavioral science, as opposed to its 18 fraud detection algorithms, to reduce fraudulent claims by making its users sign ‘honesty pledges’ on its app to prime honest behaviors, and by donating excess unclaimed premiums to charity (Harris 2017, Mannes 2017). While the Insurtech company is recognized among younger policyholders for its seamless customer service experience, its innovations in fraud reduction offer potential lessons for the rest of the industry, particularly established incumbents that may excel on other metrics.

2.2.c Technological Innovation in Insurance Execution

Smart contracts have been readily deployed in parametric insurance markets in the execution of insurance contracts. Parametric insurance, or index-based insurance, is an insurance contract that pays a policyholder a specific amount based upon the occurrence of a specific event and its magnitude. This contrasts with traditional indemnity policies, which insure a policyholder based upon their loss magnitude (NAIC 2022) Typically, parametric insurance is deployed for natural disaster related events in order to expedite disaster response assistance. For farmers, this means that if it rains so much that their field floods, then the insured farmer would receive a near-immediate payout according to the insurance policy's smart contract (Berende 2021). This innovation removed the need for assessing the good faith efforts of farmers to take care of their crops by instead focusing on an independent variable over which potentially fraudulent insurance clients would have no control.

Due to the automated nature of parametric insurance contingent upon an event, such as the magnitude of a flood, as opposed to assessing the property damage of one specific policyholder, smart contracts offer the capability to replace insurance assessment processes with an automated payout process that can lower costs and allow payments to reach policyholders at a much greater speed (Zhou 2021). For example, Arbol offers decentralized insurance policies that settle in two weeks for weather related events, including risks such as rainfall, temperature, wind speed, crop yield, or snow, for the agricultural, energy, maritime transport, and hospitality industries. Furthermore, due to the low costs of executing decentralized insurance policies, institutions could expand their ability to cover remote, underinsured locales, particularly in emerging economies where low adoption rates of insurance products persist.

At the same time, while extreme weather events or other large-scale catastrophes are typically easily verifiable using satellite imagery and other methods, parametric insurance dependent upon human processes remains open to fraud, particularly if automated in this manner. For example, the Indian national government has offered its citizens a basic life insurance policy that pays out the equivalent of 2 years wages after a person's death. However, since 2012, India's life insurance industry has lost approximately \$28 billion to scams as beneficiaries have produced death certificates for policyholders - sometimes without the policyholder's knowledge - due to easily faked documents (Poonam & Naqvi 2022). As a consequence, although technology offers new promises and quicker efficiency, trust on both sides of the insurance partnership remains essential and firmly intermediated.

Section III – AI Changes Traditional Investment Management

3.1 AI and ML in Finance

In the past decade, machine learning has become an exploding trend across many industries just as it has in academia (Table 3.1). The development of machine learning tools have dramatically improved the state-of-the-art and even surpassed human performance in speech recognition (Graves et al., 2013; Vaswani et al., 2017), text generation (Brown et al., 2020), object detection (Redmon et al., 2016), image processing (Krizhevsky et al., 2012), complete information games (Silver et al., 2017), multi-agent games (Brown et al., 2019), and drug discovery and genomics (Jumper et al., 2021). The boom in the research and development of machine learning and artificial intelligence has led to an increase in patent filings and investment on a global scale. As an example, consider the area of natural language processing (NLP). By October 2021, there were 46 independent machine translation services, compared to only 9 in May 2017 (Intento, 2021, <https://try.inten.to/machine-translation-report-2021/>). More than 300 applications were built over the gigantic language model GPT-3 across various industries (<https://openai.com/blog/gpt-3-apps/>).

Many models, especially large-scale models with pre-trained parameters, are often implemented by machine learning users who can download such models and simply port them into their user-specific applications. Yet users of machine learning models have difficulty detecting whether there are backdoors in such widespread downloaded models (Goldwasser et al., 2022). This challenges the trust needed in building machine learning pipelines.

Bollen et al. (2011) analyzed large-scale Twitter feeds and found that Twitter sentiment was correlated with the value of the Dow Jones Industrial Average over time. Although researchers attempting to replicate the data set and method were unable to recover robust, statistically significant relationships between Twitter sentiment and the stock market return (Lachanski and Pav, 2017), the work of Bollen et al. (2011) still opened a research direction that utilizes information, including sentiment, derived from text data for financial analysis.

Table 3.1 Development of AI in the past decade

Year	Image recognition*	Training cost (ImageNet, USD)	Number of AI publications	Number of AI patent filings	Global investment (billion USD)
2012	0.846	-	176611	2949	-
2013	0.868	-	183656	3175	5.23
2014	0.92	-	192310	3676	29.17
2015	0.944	-	194000	4617	14.99
2016	0.963	-	194194	6077	19.83
2017	0.962	1112.64	206392	10216	47.33
2018	0.972	12.6	237482	18282	45.58
2019	0.973	19	281659	39840	66.98
2020	0.976	7.43	311675	81472	119.54
2021	0.979	4.59	334497	141241	176.47

Note: *human baseline: 0.949.

Data source: AI index, Stanford University, 2022, <https://aiindex.stanford.edu/report/>

3.2 Usage of Big Data and NLP Tools to Predict Future Returns

Language is the primary tool in human communications. It not only contains data pertaining to specific factual topic conveyances, such as earnings in a company's financial report, but also rich information between the lines, reflecting sentiment, expectations, and the relative intensity of each. In addition, non-verbal information can also be obtained from speech, body gestures, or movements – which are yet subtler to analyze. Gupta et al. (2020) reviewed how textual data and its analyses could be applied

in various domains in finance. One challenge with textual data analysis is the high dimensionality and the computational challenge it brings. Kelly et al. (2021) developed a high dimensional selection model with multinomial regression that allows for parallel estimation. The model was applied to newspaper text and was able to forecast macroeconomic indicators.

Through mining information in the rich textual data released by public companies in their regulatory filings, Cohen et al. (2020) discovered that changes to the 10-Ks could predict future earnings, profitability, future news announcements, and even future firm-level bankruptcies; meanwhile, firms that do not make changes would experience positive abnormal returns. Similarly, Mayew et al. (2011) examined the emotion embedded in vocal communications obtained from company conference call audio files, finding that positive and negative managerial affect measured by vocal emotion was, respectively, positively and negatively related to contemporaneous stock returns and future unexpected earnings. Both of these works also discovered that analysts did not fully incorporate such information when forecasting near-term earnings.

Companies and start-ups have put machine learning tools into practical uses. Recorded Future utilized data across the web to forecast future events and applied their data products to financial markets. Specifically, the firm combined news momentum and news sentiment to generate a sentiment score for each firm in the S&P 500, establishing a trading method based on this. Back testing on the trading strategy showed a Sharpe ratio of 3.12, and out-of-sample test gave a positive performance of an 11.1% return while the S&P 500 went down by 10.6% over the same period.

Business Intelligence Advisors is another firm targeting the hidden information in publicly available data. The firm put forward a product focusing on the utilization of verbal and non-verbal behaviors that could reveal whether a presenter (e.g. a CEO in a conference call, or a financial statement released by a company) was hiding certain information. This predictive power allowed the firm to further expand its services to the financial market, enabling the possibility to team up with current market participants and investors, or even become a hedge fund itself.

3.3. Large Language & GPT Models

Since ChatGPT's launch in November 2022, early research on the use of large language AI models, in comparison to previous models, represents a promising step forward. In particular, recent studies have begun to explore whether the model's improvements in the integration of language and text-based inputs improves investment decision-making. Lopez-Lira and Tang (2023) found that ChatGPT outperformed traditional sentiment analysis models in predicting stock price movements based upon newspaper headlines, thereby suggesting a role for ChatGPT and other large language models in quantitative trading. Hansen and Kazinnik (2023) came to similar conclusions, as

applied to the Federal Reserve’s monetary policy announcements, in which GPT models outperformed human classifications of policy stances.

However, due to the newness of the technology and its application, the literature remains inconclusive. Additionally, further research could examine how other uses for generative AI models, such as company communications teams adopting generative AI tools to nudge investors’ algorithms in a certain direction, could pose a risk to the veracity of such modelling inputs in quantitative trading. Nevertheless, as ChatGPT and other advances see more widespread applications, this area of research shall continue to evolve.

3.4. High-Frequency Trading

In financial markets that support electronic trading, machines and the algorithms behind them have much higher capacities for information processing than human traders. Chakrabarty et al. (2022) discovered that by incorporating fundamental information such as corporate earnings announcements into prices, high frequency traders could reduce price inefficiencies by 65%–100%, mitigating the human bias of limited attention, which may affect asset prices.

Yet critics remain for high frequency traders (HFTs). One critique comes from their need for high speed, a hardware-driven dimension that requires huge inputs in technical infrastructure. Budish et al. (2015) mentioned how this arms race could damage financial markets and investors. Another critique comes from using algorithms that may not be able to identify risks that have not occurred historically. Mankad et al. (2013) applied a dynamic machine learning method to identify various types of traders in a liquid financial market based on transaction-level data and simulated data. Further applications of the designated trader categories on transaction-level data and statistical analysis over the trading patterns of each trader group indicated that high frequency traders can lead to adverse events such as “flash-crashes” of entire financial markets (Kirilenko et al., 2017).

Domeyard is an example of a high-frequency trading hedge fund. Domeyard established its business on tradable signals at the millisecond level in the stock market. The business relied heavily on both hardware and software technologies, and often required continual, heavy investments on infrastructure, software platform, data, and fresh technical talent. At the order-book level, the data flowed as a huge and fast torrent. This required an incredibly quick-responding execution platform, and a model that calculated patterns and predicted moving directions at extremely fast speeds. This is a challenge for machine learning tools, not only in terms of their accuracy, but on the efficiency of computational time-costs as well. Even so, Domeyard was far from alone, with the arena even becoming somewhat crowded. Other examples of prominent HFT firms included Citadel Securities, Tower Trading, Hudson River Trading, Jump Trading,

Jane Street, and others – all investing heavily (and competing) in their trading strategies, hardware, software, and talent acquisitions.

Section IV – New Investment Classes

4.1 Cryptocurrency as an Investment Class

Since the invention of Bitcoin by Satoshi Nakamoto in 2009 (Nakamoto, 2009), there has been an explosion in this asset class of cryptocurrencies over the past decade. The market capitalization of Bitcoin and the total of all cryptocurrencies have also grown tremendously and have attracted the attention of investors worldwide. Table 4.1 gives a summary of the market capitalization of some major cryptocurrencies.

Table 4.1 Market capitalization and trading volume of some major cryptocurrencies

Name	Market capitalization	Trading Volume (24h)*
Bitcoin	\$1.2T	\$37.4B
Ethereum	\$447.7B	\$16.7B
Binance Coin	\$81.7B	\$2.1B
Cardano	\$70.0B	\$2.8B
Tether	\$69.0B	\$63.4B

* Data from coinbase.com, on Oct. 19, 2021.

The total market value of cryptocurrencies hit \$1 trillion on Jan. 6, 2021, and quickly rose above \$2 trillion by Apr. 5, 2021. As shown in Table 4.1, the daily trading volume of the market is large enough to provide the liquidity necessary, even for institutional investors, to step in and establish a presence.

Cryptocurrencies have historically enjoyed low correlations with other asset classes (Bianchi, 2020), compounding their attractiveness to investors. Despite this fact, the cryptocurrency market itself has undergone huge price volatility. This resulted in numerous episodes of large swings in prices, both upward and downward (e.g., substantial price crashes in 2018 and 2022).

That said, as mentioned, the cryptocurrency market has grown widely in both depth and breadth of acceptance. On Dec. 17, 2017, the Chicago Mercantile Exchange (CME) launched its own Bitcoin futures contract, with further crypto-derivative contracts following. Moreover, in a signal of Bitcoin's even wider acceptance as an investment opportunity, Bitcoin Exchange Traded Funds (ETFs) now trade in a number of U.S. and international markets. The first Bitcoin ETF, Purpose Bitcoin ETF (BTCC), started trading on the Toronto Stock Exchange on March 1, 2021. On Sep. 29, 2021, Evolve Cryptocurrencies ETF (ETC), which consists of cryptocurrencies Bitcoin and Ether, then also launched on the Toronto Stock Exchange. The U.S. Securities and Exchange Commission gave the green light for the first Bitcoin futures ETF months later (by ProShares), which then began trading on the New York Stock Exchange on Oct. 19, 2021. Within a few days of its launch, it became one of the most popular ETF launches ever, attracting over 1 billion dollars in assets traded (The Bank for International Settlements (BIS) 2021). These financial instruments increased the exposure of institutional investors to the largest cryptocurrencies.

Some cryptocurrencies inherently provide investors with leverage. For example, the stable coin called DAI was supervised and operated by MakerDAO in order to invest in Ether with leverage. DAI was structured such that it was issued when an investor placed a certain amount of Ether as collateral into a smart contract system. The collateral rate was decided upon by MakerDAO and could vary over time. For example, assume that Ether's price was \$3,000 and there was a collateral rate of 150%. If an Ether is put into the smart contract and thus locked, \$2,000 worth of DAI, or 2,000 DAI tokens (a DAI is, by design, always worth a dollar), are generated and released. The locked Ether cannot be released until the 2,000 DAI tokens are returned to the smart contract. Now the generated 2,000 DAI may be used to buy 0.66 Ether, resulting in a 1.66x leverage on the investment on Ether, given the set 150% collateral rate.

The regular, high volatility – along with extreme peak and crash cycles - in the cryptocurrency market are consistent with the expected symptoms of market speculation. However, there are several drivers of potential fundamental values for cryptocurrencies as well. For example: transactional value, as stores of values, hedges against political unrest, hedges against inflationary pressures, and hedges against destructive monetary regimes. Moreover, Larrios-Hernández (2017) posits blockchain and cryptocurrencies as a way of furthering financial inclusion. For example, in emerging markets, cryptocurrencies may be valued as a low-cost alternative to cross-border remittances with low bureaucratic barriers.

Lastly, the crypto asset market had broadened to also provide formally mirrored versions of traditional assets. For example, a blockchain project called Terra created what it called the “Mirror Protocol” on Dec. 4, 2020. This protocol allowed the buying and selling of synthetic tokens, which mirrored a specific stock's price - such as Apple, Tesla, or Microsoft - to be traded on the blockchain system. The tokens did not have other rights

within the mirrored stock, such as voting, yet the project still attracted many investors both within and for event ticketing.

Despite the potential, regulatory risk has continued to call cryptocurrency's potential as an investment asset class into question in the U.S. From 2017 to 2022, the U.S. Securities and Exchange Commission (SEC) has claimed oversight of digital coins and their trading platforms with a right to determine whether a digital coin is classified as a security. Over this five-year period, the SEC and the U.S. court system determined 76 cryptocurrencies to be securities, after which only 16 were still listed on a major U.S. crypto exchange (Santilli, Ostroff, & Michaels 2023). Under investor protection laws, publicly-traded securities must be registered with the SEC and given appropriate financial and risk disclosures, and in late 2023 the SEC filed two lawsuits against Binance and Coinbase arguing that the platforms were in violation of federal oversight requirements (Michaels & Huang 2023). While the lawsuits' long-term impact on crypto markets remains uncertain, we do expect that regulatory clarity will only assist the industry's viability in the long-term.

4.2 NFTs and Securitized Arts

Non-fungible tokens (NFTs) are blockchain-based virtual assets. They are different from the other blockchain-based tokens in that individual token is unique, and cannot be replicated, nor split into a smaller unit (Wang et al. 2021). The uniqueness embedded in its design gives NFTs a natural scarcity similar to collectable artwork. This has made the art domain as one of the first to gain widespread adoption within the NFT asset-domain. An NFT generated from a piece of artwork is often the digitized form of the artwork, with the digital information stored on blockchain. Information within the NFT also includes its creator, current owner, and its entire ownership and transaction history. Because an NFT is based in the blockchain, people can very easily view and verify such information. This enhances the protection of the copyright of digital artwork. It also prevents buyers from purchasing counterfeit work, and owners from having their works replicated or stolen. The blockchain system also makes it easy to trade NFTs, transforming the traditional art auction market into a lower-cost, more efficient, and more open one.

As an NFT cannot be split into smaller units, it cannot be taken as a general equivalent, a standard of value, or a unit of account. This has made NFTs different from common cryptocurrencies, or fungible tokens. Chohan argues that the value of NFT may well rise from the "leisures of blockchains" (Chohan, 2021). Dowling explored the relationship of NFT pricing to that of cryptocurrencies and found, via a spillover index, that the volatility transmission effect between the markets are actually quite modest, with limited cross-correlation (Dowling, 2021a). Dowling also examined the inefficiency in pricing in the NFT market and found an improvement in market efficiency over time (Dowling, 2021b).

NFTs can be minted from digitizing a unique object without much limit on the underlying object. The NFT markets already contain digital artworks, music tracks, concert tickets (Regner et al. (2019), and even land parcels in a virtual world (e.g., a blockchain project named Decentraland, (Dowling, 2021a)). Table 4.2 lists some NFT examples with their auction prices and dates. Before the NFT era, it was hard to imagine that an art image with only 24x24 pixels could be sold at more than \$7 Million USD.

Table 4.2 Examples of NFT auction prices

Name	Auction Price	Date
Everydays: The First 5000 Days	USD\$69,346,250	Mar. 11, 2021 [a]
Basketball player Lebron James slam dunk NFT card	USD\$210,000	Mar. 20, 2021 [b]
One Hundredth Stream from Linkin Park’s Mike Shinoda	USD\$30,000	Feb. 07, 2021 [c]
CryptoPunk #7804	ETH 4,200 (USD\$7.57M*)	Mar. 11, 2021 [d]

[a] <https://onlineonly.christies.com/s/first-open-beeple/beeple-b-1981-1/112924>
 [b] <https://nbatopshot.com/listings/p2p/a494c64e-9e93-418c-8934-f331ee47a39b+768166e3-f4bb-4395-9b48-4c545aebc95c>
 [c] <https://zora.co/collections/zora/337>
 [d] <https://opensea.io/assets/0xb47e3cd837ddf8e4c57f05d70ab865de6e193bbb/7804>
 * At the time of the transaction, 1 ETH = 1802 USD

Researchers have proposed other use cases for NFTs, including for wildlife protection (Mofokeng et. al 2018), and authentication for IoT devices (Sghaier et al. 2020). More broadly, the ownership of an object backing an NFT is oftentimes detached from the ownership of the NFT itself. Some NFT creators have tried to solve this by literally burning the artwork before its NFT is minted on the blockchain, such as in the case of Leng Jun’s oil painting, whose NFT then sold for 400,000 yuan at auction (HKT 2023).

When the creator of an NFT is different from the artist of the original artwork, intellectual property disputes may arise. The artist may claim the right of making digital copies and request the NFT be destroyed, in which case the investor of the NFT could lose their investment.

4.3 Tokenized Commodities

Lastly, the expansion of the crypto space and the development of its underlying blockchain technology has structurally allowed for the emergence of tokenized commodities. The crypto versions of gold and crude oil are generated by several companies, with their tokens traded on blockchains and crypto-focused exchanges. These products mostly serve as bridges between traditional commodity markets and the crypto market, making it easier for investors to exchange from crypto assets to popular commodities and vice versa.

Start-ups are further stepping in to tokenize new assets as well. For instance, a firm named Diamond Standard has tokenized one of the world's largest asset holdings currently not exchange traded (<https://diamondstandard.co/>). The idea of making – for the first time - diamonds available in small, tradable, fragments, electronically on blockchains has gained regulatory approval. Relatedly, but in a contrasting asset structure, other firms have treated diamonds as collectibles rather than commodities and created NFTs out of the same diamond asset class. Thus, the competition between crypto asset structure could see intensification moving forward across other similar types of assets.

Section V – The Fundamental Research and Practice of FinTech

Due to the nascent nature of FinTech, namely the application of the aforementioned emerging technologies to the financial services industry, empirical work remains to be completed. In part, in industries such as PropTech and Insurtech, this is because disruption has not yet fully penetrated the industries in question; the empirical data does not yet exist at adequate scale to conduct systematic research.

At the same time, FinTech has been lauded throughout both popular media and developmental economics as a way to broaden financial market participation. Many scholars have written extensively on the existing and potential benefits of technology applications to financial inclusion efforts. For example, following the introduction of widespread internet access, numerous studies showed large jumps in stock-market participation rates across time and geographic locations (e.g., Bogan (2008), Glaser and Klos (2013)). In fact, even the adoption of faster internet access (in the form of broadband) has been shown to have an incrementally positive impact on individual investors (Hvide et al. (2022)).

Moreover, while FinTech has the possibility to incorporate behavioral financial components to lead to more desirable outcomes (such as nudges discussed above in Acorns case), it can equivalently enter in the opposite direction. For example, mobile trading platforms and applications often utilize false consensus, immediacy, and other

biases to incentivize trading behavior amongst participants (Greenwood et. al (2023)), which can cause large price run-ups of stocks and other asset market securities.

In terms of investment in frontier asset classes and the use of frontier technology, while there is some burgeoning theory and market design work exploring justifications for certain aspects of blockchain and decentralized crypto-assets (Cong and He (2019), Cong, Li, and Wang (2021)), there has again been limited empirical evidence established thus far. That said, there has been some early work, largely finding that there appears to be some common return dynamics driven by correlated investor demand shocks (Shams (2020)). Moreover, a fair amount of investor interest and volume has coalesced around the concept of “stablecoins” – crypto assets meant to maintain stability in value, usually pegged to other stable non-crypto asset values (e.g., the US Dollar). This said, much of the research has found these to not be backed by fundamental valuations (Griffin and Shams (2020)), along with a number of very public collapses of supposed stablecoins (e.g., terraUSD (UST)-LUNA in 2022). Lastly, there is evidence that outside influences - such as celebrity endorsements, through the use of social media tools and dissemination, have had an outsized influence on adoption and even price dynamics in many crypto-asset markets (Merkley et al. (2023)).

Section VI – Conclusion and Looking Ahead

6.1 FinTech - Where We Have Been

Stepping back, we have surveyed a number of burgeoning areas of FinTech in-depth, taking each to the boundary of thought and practice. In particular, one can bifurcate FinTech’s impact into two broad categories:

Category (I) The first category encompasses areas wherein FinTech has already been deeply ingrained into the ethos of the sector itself. Examples of these sectors include investment management and real estate. These sectors have seen FinTech entrants not only standing the test of time, but becoming true disruptors of the **entire business model of the sector:**

- a. Wealthfront disrupting financial advising through robo-advisory services
- b. Robinhood disrupting trading and market access
- c. Zillow and Opendoor disrupting and democratizing the flow of housing information along with purchasing and selling;

In each of these cases, the firms above have innovated new products, services, and methodologies that have become industry standards to which existing incumbents have converged. These innovations are unlikely to ever be undone, representing a permanent thumbprint of FinTech on the evolution of these sectors.

Category (II) The second category comprises more nascent sectors into which both the current (and eventual) impact of FinTech are less clear with regards to both the impact and the potential form of that impact. Examples of these sectors include InsurTech and asset tokenization. Both of these sectors have seen shaky entry, with new firms and products blossoming and withering (sometimes in serial successive iterations):

- a. Many InsurTech entrants such as Root and Hippo have attempted to bring cutting edge technology to the established and slow-moving space. However, both have seen stock price declines of more than 90% from IPO – over a period when the industry as a whole – and incumbents in particular - have done far better.
- b. Many of the markets that have claimed to be the most promising for tokenization (e.g., real estate, yachts, diamonds), have yet to find widespread adoption (OECD 2021). Moreover, even assets that have been tokenized (in the physical space, NFT space, or virtual spaces such as Decentraland in the Metaverse) have not seen systematic trading or deep and repeatably liquid markets.

6.2 FinTech - Where We Are Going: 3 Markets to be Disrupted

While we have demonstrated the depth and breadth of FinTech’s impact on the space, there are still many areas that remain less penetrated and are ripe for potential disruption. A number of those that we consider less-impacted and most likely to see FinTech’s impact blossom most powerfully in the short- to medium-term are:

1.) Reverse mortgages

- An individual’s single most valuable physical asset remains housing, by a long shot. Housing, however, remains ineffectively utilized and tapped over investors’ lifecycles. Through reverse mortgages, HELOCs, or partial cash-outs, this market represents a sizable total addressable market (TAM) for any FinTech that can penetrate it.

2.) Human capital

- As firms across industries rely more heavily on intangible assets, such as human capital, the opportunity to invest in and monetize this form of capital represents potentially the largest total addressable market in existence. All markets from student loans to tokenizing human capital and diversification to the funding and tokenizing of ideas are potentially ripe for disruption.

3.) Diversification of Large Financial Risks

- One of the first-order *raison d'être*’s of any financial market is risk-sharing. This is especially true of large potential negative shocks that are otherwise hard to predict, hedge, or plan for. Everything from natural disasters to

large personal risks such as disability, job loss, cyber/identity theft, or other personal shock represent novel and valuable markets to focus upon.

Moreover, it is worth mentioning that all 3 markets mentioned apply to both physical and virtual manifestations of these assets. As the virtual asset world has exploded, entirely novel markets such as the Metaverse have emerged. While the exact definition of the Metaverse varies, it can be understood as an immersive virtual world in which not only any physical idea, experience, or asset can be replicated, but also novel experiences impossible in the physical world can be created, experienced, and traded. Indeed, firms from McDonalds to Walmart have been quietly amassing trademarks in the Metaverse space in preparation of its expansion (Irwin 2022).

6.3 FinTech – Final Note and Closing

In many ways, the story of FinTech is a never-ending and evolving one. Finance - like all human endeavors - will always continuously innovate to provide novel products and services, and “technology” will be a large catalyst and enabler of that innovation. While the past decades have seen a historically substantial amount of FinTech innovation, we believe that the future holds significantly more. This all said, the world - academics, practitioners, regulators, and consumers alike - will do well to learn from the successes and failures of the past decades in the renaissance of FinTech that we have observed.

We believe FinTech will follow the path of much of technology throughout human history, which is that initially it will draw skepticism and mistrust via the displacement of norms of life, (e.g., ‘robots taking over...’). For instance, Swiss physician and philologist Conrad Gessner wrote an entire book warning that the modern world has created a *data overload* – the deluge overwhelming and confusing individuals to the point of paralysis of action. You might not be familiar with this milestone work, as Gessner published his work in the mid-16th century, dying in 1565. However, Gessner was far from the first to voice this concern. Socrates famously warned against the literal act of writing things down, as he opined that it would, “create forgetfulness in the learners’ souls, because they will not use their memories.”

In the end, technology will become a powerful *enabler* for humans. In this way, it will allow the field of finance to progress in ways we could have never imagined, benefitting all humankind and bettering society in the process.

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