Investment Recipes

by AtonRā Partners

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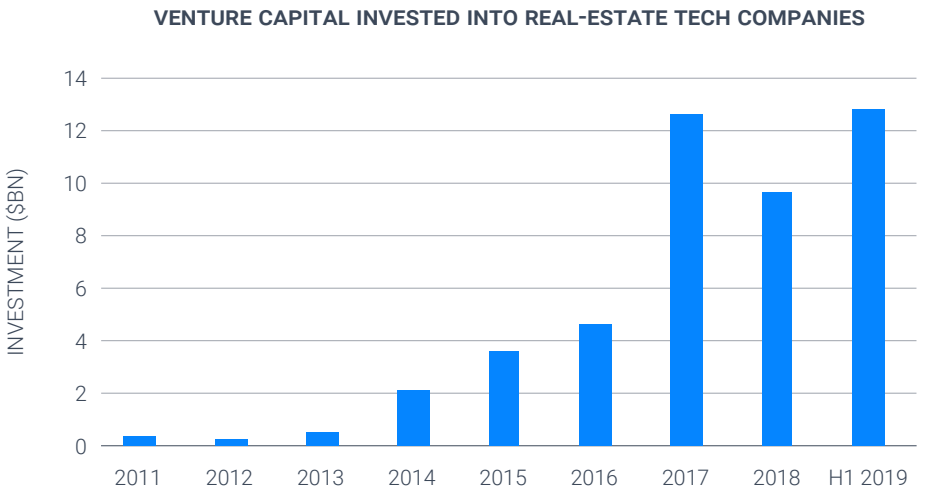
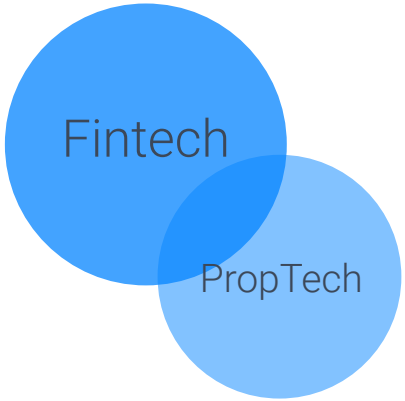
On the Menu

PROPTECH THREATS THE TRADITIONAL MORTGAGE INDUSTRY

The Digitization Of The Real Estate Industry

- Real estate is the **biggest asset class** in the world, with a value totaling $217tn at the end of 2016, according to the World Bank. However, this industry is only in the early stages of tech adoption.
- **Proptech** is a buzzword combining "property" and "technology". It refers to all companies using technology to improve how people rent, lease, buy, sell, finance, design, build, and manage properties.
- Given the huge potential of the digitization of the real estate market, **investments in startups** are speeding up.
  - According to CREtech, venture capital in proptech reached $12.9bn for the first half of 2019, i.e. more than the record level of $12.7bn in 2017.
  - Between 2011 and 2014, only **Airbnb** (**not listed, IPO expected in 2020**) crossed the $1bn mark valuation. Since then, more than 20 proptech companies have joined this club, e.g. the brokers **Compass** (**not listed**) and **Opendoor** (**not listed**), or the provider of shared workspace **WeWork** (**not listed**).
- Proptech development focuses on the following key areas:
  1. Online markets for the real estate transaction process;
  2. Data collection and analysis to make buildings smart and more responsive;
  3. Flexible and adaptative use of real estate assets in the sharing economy.
- Many proptech applications concern the **fintech industry**, e.g. online lending, marketplaces, use of blockchain to issue digital mortgages, big data to value properties, etc.



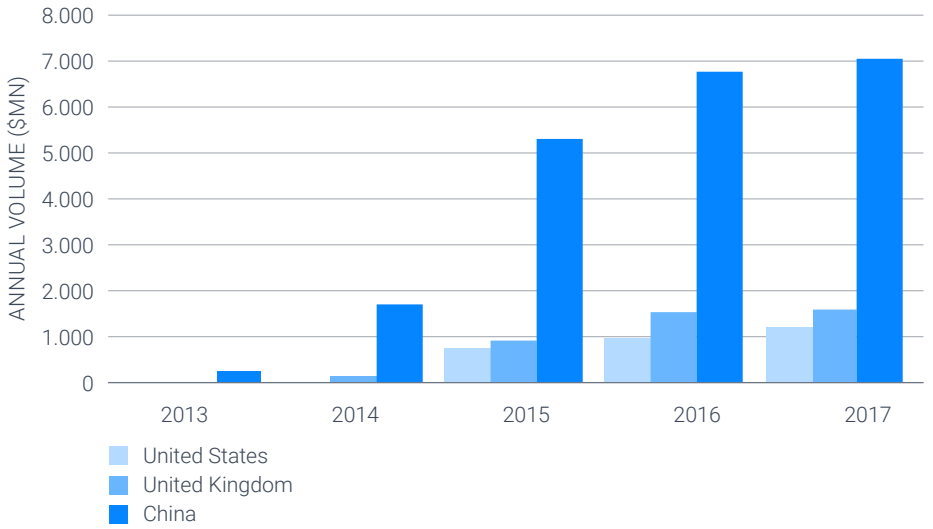


SOURCES:
World Bank, CRETech, KPMG

Overview Of Online Mortgages

- Following the financial crisis, banks and **traditional lenders** became more selective when originating loans, leaving **untapped demand up for grab**.
  - Proptech firms have not waited long to target the multitrillion dollar mortgage market.
- Online mortgage applications can be done in less than 10 minutes. Platforms are also able to provide a conditional pre-approval within minutes.
  - **Quicken Loans** (**not listed**) was among the firsts to launch such process in 2015 in the U.S., through its platform Rocket Mortgage and theresince has become the **largest U.S. retail mortgage lender**, both online and offline.
- **Mortgages originated online remain marginal** compared to the addressable market. However, they have been steadily growing.
  - China confirms its status of early adopter of all sorts of online financing, including for mortgage loans.
- The reported industry **numbers may as well be misleading**, as they do not include all fintech companies nor the on-line activities of traditional lenders.
  - Non-bank lenders who offer an entire online application process have grown their annual origination volume by 30% since 2010– from a 2% market share to more than 15% today.
  - Many U.S. customers tend to request an initial offer online, and then finalize the transaction in a physical branch of the lender or over the phone.

ONLINE MORTGAGE ORIGINATION BY REGION



MORTGAGES ORIGINATED BY SELECTED FINTECH PLAYERS IN 2018 IN THE U.S.

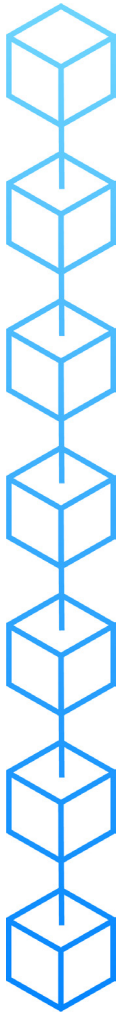
SOURCES:
PwC, Cambridge University, FFIEC Home Mortgage Disclosure Act, AtonRâ Partners

The Application Of Blockchain To Real Estate

- Mortgage lending processes around the world are **time-consuming** and involve **many third parties** to confirm the documentation – banks, lawyers, local authorities, brokers, etc.
- The potential for blockchains to **improve this process** is significant.
  - Blockchains create a quicker verification process, within minutes rather than weeks, as all parties work directly on the same shared documents on the distributed ledger.
  - Documents are more easily accessible and in a secure and transparent way, as per the nature of this technology.
  - Smart contracts limit the involvement of attorneys, and the overall process to originate mortgages costs less.
- **Governments** must still develop open-access blockchains to facilitate property transactions, but first experimental projects are already being conducted.
  - South Burlington, in Vermont, started using blockchain technology in 2018 to record real estate conveyance documents.
- Although the public sector needs to provide the appropriate framework to facilitate the adoption of the technology, companies are already developing **several applications** using blockchains.
  - For instance, **Propy** (**not listed**) is a start-up that allows blockchain-based online transactions of properties.
- **China** confirms its leading role within fintech with many real-life applications using blockchains being already on the market.
  - **Bank of Communication** (**3328 HK**) issued digital mortgages based on blockchain worth $1.3bn in September 2018.
  - **Bank of China Hong Kong** (**2388 HK**) uses blockchain to process 85% of its mortgage-related property valuations.

SOURCES:
Oxford University, homeloanexperts.com.au, AtonRâ Partners

HOW BLOCKCHAIN MORTGAGES WORK



Lisa fell in love with a property and has already been pre-approved for a loan.

Her application is represented online as a “block”.

The block is broadcasted to every third party.

Through data sharing on the blockchain, Lisa’s identity, credit history and other details are verified.

A loan offer contract is generated, and Lisa uses her private key to sign it on the blockchain.

The loan funds are transferred to Lisa.

The block is added to the chain, providing a record of the transaction on the network. Property title is also transferred. Lisa becomes a home-owner in 5 days instead of 45.

Catalysts:

- **Venture capital funding.** Money from investors is pouring into companies that want to disrupt real estate market, the largest asset class in the world.
- **Big data.** The common denominator to all technologies linked to real estate – e.g. smart home, online mortgage origination, or optimization of shared workspaces, is data analytics.
- **User experience.** The pre-approval for a mortgage can be obtained online in a few clicks and within minutes. Owners and tenants are ready to leave their traditional suppliers to get a simple and user-friendly service.

Risks:

- **Regulations.** Many parts of the real estate sector are highly regulated. Governments decisions may have a serious impact on the development of proptech – for the better or the worse.
- **Startup failures.** As we are only in the early stage of the digitization of real estate, we may see companies with interesting businesses fall flat. The recent failed IPO of WeWork is a good example. But failures may also help the entire proptech industry learn from past mistakes to better bounce back.
- **Long operating life of real estate.** Given the life-span of the underlying assets, new technologies are slow to replace the old ones.

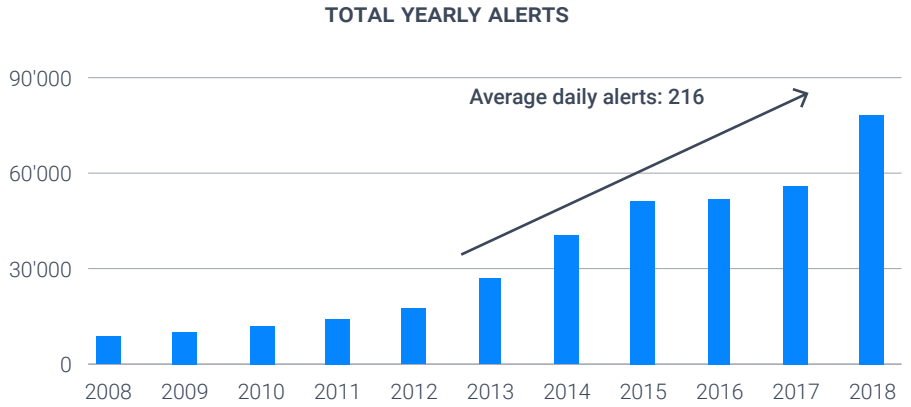
Bottom Line:

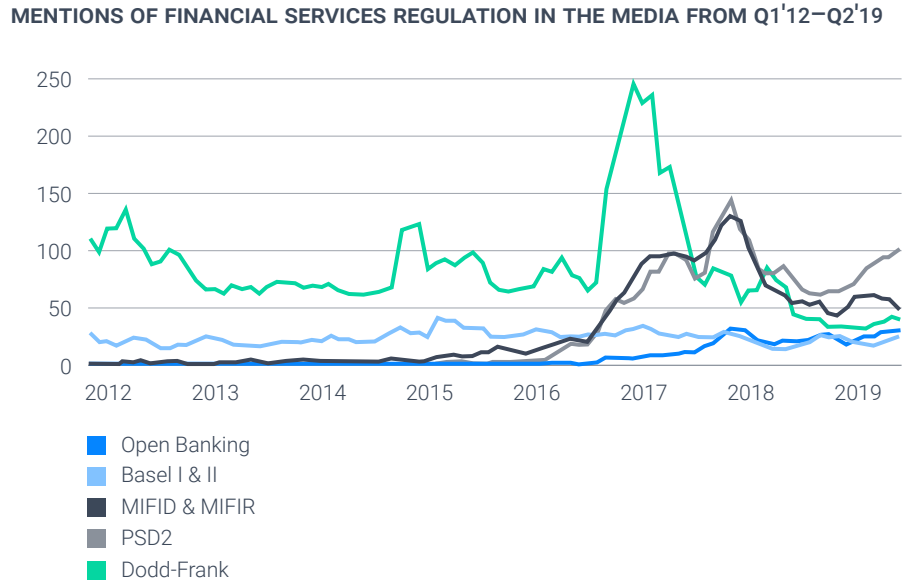
- Technologies help property owners to manage their real estate portfolio by pushing revenue up and expenses down.
- Banks and traditional mortgage companies must face the **competition of new entrants** that offer attractive conditions thanks to their **technological advantage**.
- In the mid-term, the **disintermediation of the mortgage industry** will get a boost from the use of distributed ledger technology.
- Most of the proptech players are still at the development stage. We are closely monitoring them for the potential changes they are bringing to a sector that has historically not relied on innovation.

MEET REGTECH, FINTECH'S LITTLE BROTHER

A New Solution To A Growing List Of Industry Regulations

- Regulatory technology or **RegTech is the solution to navigate the complex regulatory landscape**. This subset of FinTech facilitates adhering to compliance requirements and concentrates on audit, risk, and compliance solutions.
- **Through automation and with artificial intelligence, RegTech ensures compliance**. **At a low cost with minimized human intervention**, it delivers timely compliance alerts, analyzes regulation updates, and speeds up mundane tasks like report generation.
- Large financial institutions seek **additional assurance** on compliance processes due to a **lack of in-house compliance skills and high costs**.
  - It is estimated that a large firm is faced with respecting over 56'300 regulation updates per annum, rendering satisfactory compliance impossible.
  - On average, a firm dedicates 10-15% of staff to compliance and spends more than 10h a week just tracking and analyzing regulatory developments, and between 3h and 10h creating and amending reports for the board.
- A new regulatory alert is issued every 7 minutes and **failure to comply means additional financial burden in terms of fines**.
  - In addition to spending over $277bn per year on compliance and ethical practices, financial institutions have faced over $340bn in fines since 2008, a number likely to cross a $400bn mark by 2020.





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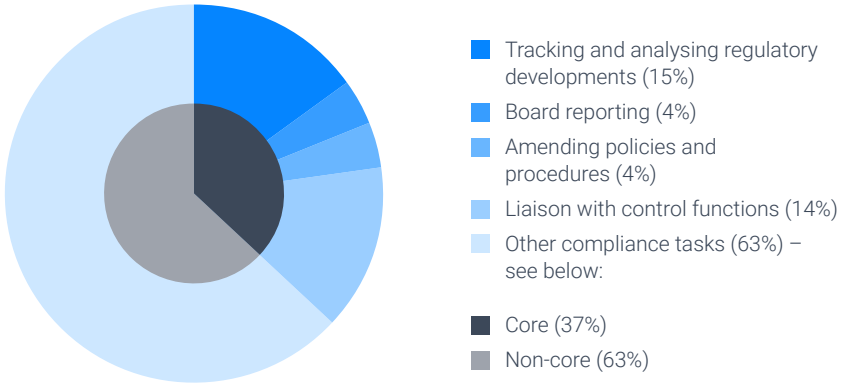
CBI Insights Global Fintech Report Q3-2019, Thompson Reuters Regulatory Intelligence - Cost of Compliance 2018

The Whole Regulation Industry Needs A "Tech" Treatment

- What differentiates RegTech from the traditional approach is its **agility**, **efficiency**, and **flexibility**.
  - Compliance officers must multitask with **limited resources with an overlay of increasing personal liability**. Instead of 'core' compliance tasks, i.e., tracking and analyzing regulatory developments, officers must focus 63% of their time on 'non-core' activities, i.e., amending reports and renewing licenses.
  - The "Tech" part helps financial services companies to become **more efficient at dealing with the regulation in addition to reducing costs**, e.g., according to Juniper Research annual gross cost savings from using RegTech for KYC verification are expected to reach $700m by 2023 and **decrease client onboarding time from days to minutes**.
- **Adoption of technology is encouraged** by the development of new regulations.
  - RegTechs may process and thoroughly implement regulations similar to the 2'300-pages long Dodd-Frank Act, satisfactory implementation of which is necessary.
  - RegTechs can automate compliance tasks such as Know Your Customer (KYC) which obliges financial institutions to identify their customers' private details.

TYPICAL WEEK OF A COMPLIANCE OFFICER IN 2018



«Non-core» tasks solved by RegTech

- Analysing enforcement cases and lessons from industry peers
- Assessing cyber resilience
- Assessing regulatory solutions
- Collating reports and reporting to senior management
- Compliance monitoring
- Cpnducting past business reviews
- Information requests from regulators
- Liaison with divisional compliance functions
- Maintenance and renewal of licences and registration for regulated business activities and individuals
- Oversight of conduct risk issues that impact customers
- Regulatory reporting

«Non-core» tasks that require a compliance officer

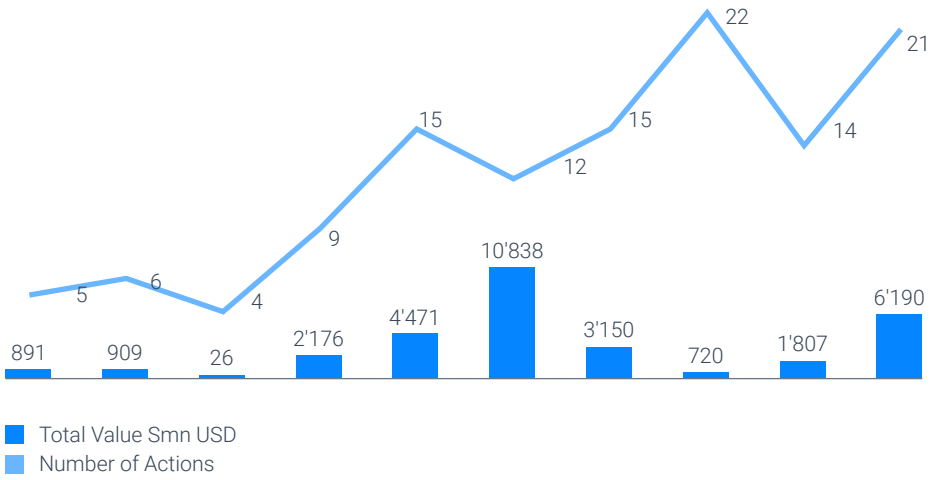
- Acting as Money Laundering Reporting Officer
- Compliance training
- Conducting internal investigations
- Lobbying and influencing emerging regulatory change
- Project management of regulatory implementation projects
- Recruitment of skilled compliance staff
- Regulatory inspection
- Representation at governance committees
- Team manageement

SOURCES:
AtonRâ, Juniper Research
Thompson Reuters Regulatory Intelligence - Cost of Compliance 2018
https://a-teaminsight.com/the-rise-and-rise-of-regtech-bringing-asset-management-into-the-digital-age/?brand=rti

Artificial Intelligence Untangles Growing Regulation Complexity

- **Artificial intelligence (AI) is the recent addition to the RegTech toolbox** enabling many previously impossible tasks to be solved.
  - **Better identification of frauds** – with 90% of fraud alerts ignored and 8% flagged erroneously, firms face an immense waste of time and resources. With machine learning and AI, a system will learn from confirmed fraud instances and reduce compliance workload.
  - **Efficient transaction monitoring and money laundering (ML) detection** – ML remains a significant cost to the economy (approx. 5% of global GDP or $4tn). RegTech can detect frauds in real-time thanks to AI's ability to work with unstructured data.
  - **Improved behavioral monitoring** – individual wrongdoing remains an important risk despite existing personal transaction monitoring. AI enhances identification of frauds for compliance, e.g., the autonomous supervising of customer-employee interactions with a possibility to flag non-compliant conversations for review. Companies such as **Behavox** (**not listed**) are already offering this technology.
- Through cloud computing and AI, any of the systems above may be scaled up. In combination with a subscription-based payment model, **RegTech solution requires no additional costs for compliance infrastructure expansion if the firm decides to grow**.

MONEY LAUNDERING ENFORCEMENT ACTIONS ARE ON THE RISE



- KYC
- Regulatory data
- External data
- Historical data
- Location
- Transaction monitoring
- Suspicious activity reports

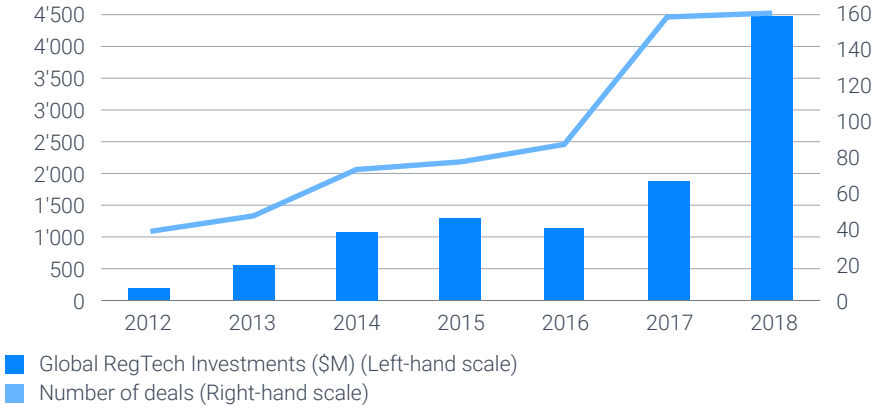
- Artificial Intelligence
- Cloud Computing
- Machine Learning
- Blockchain
- Biometrics
- Big Data
- Chatbots

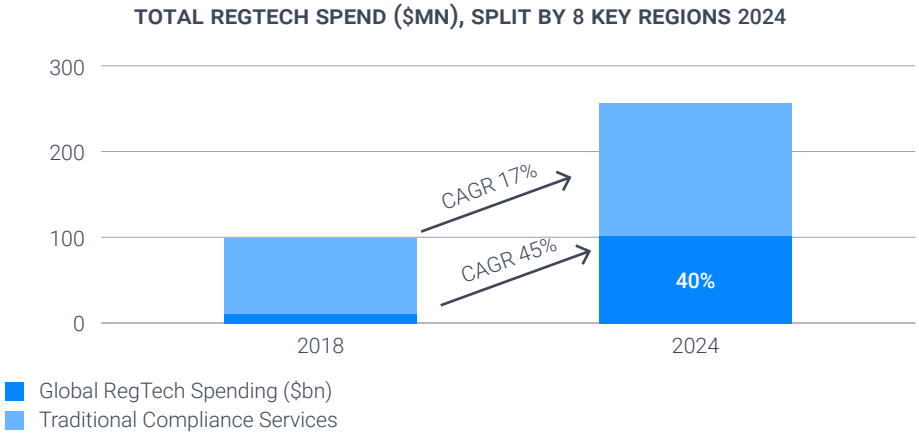
- Audit
- Risk alert
- Reporting
- Fraud prevention
- Employee surveillance
- Robo automation

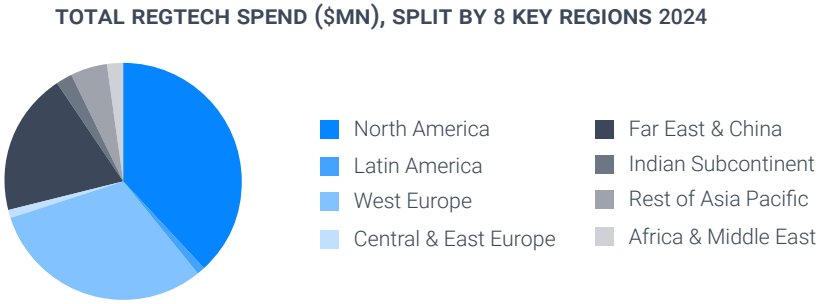
SOURCES:
Juniper Research, McKinsey AML Research
https://www.juniperresearch.com/document-library/white-papers/opportunities-for-ai-in-regtech-whitepaper
https://www.visualcapitalist.com/why-anti-money-laundering-should-be-a-top-priority-for-financial-institutions/mckinsey-aml_shareable-1/

A Huge Market With Countless Opportunities To Fill

- **RegTech is a fragmented market**, with low barriers to entry and strong support from numerous regulators. Growth in the RegTech industry usually comes from significant external funding and M&A activity. One of the few exceptions expanding at 100% YoY organic growth with no external funding is FundApps (not listed).
  - **Global RegTech funding investments increased twenty-fold between 2012 and 2019** with a CAGR of 49%. By 2018 investments reached a cumulative total of $11bn
- **RegTech spendings are projected to be higher than overall compliance spendings** (CAGR of 45% versus CAGR of 17% between 2019 and 2023, respectively), highlighting the **industry transition from traditional compliance to RegTech solution**.
  - **Growing at a 5-year CAGR of 24%**, RegTech market is expected to deliver $17bn in revenues by 2024 from an estimated $4.9 billion in 2018.
- **North America and Europe are among the largest investors in RegTech** (both accounting for 2/3 of total investment). Europe has achieved the highest adoption rate of RegTech owing to strict, compulsory directives and procedures for financial transactions and data protection.







SOURCES:
AtonRâ, Juniper Research, CBI Insights Global Fintech Report Q3-2019
https://kyc-chain.com/what-is-regtech-your-guide-for-2019/
https://www.riverpartnership.com/documents/RegTech%20in%202019%202.pdf
https://www.grandviewresearch.com/industry-analysis/regulatory-technology-market

Catalysts:

- **Increasing need to identify financial crimes.** Stricter compliance demands and transaction monitoring requirements, rising instances of money laundering, complex existing regulations, and rising personal liability and penalties for non-compliance will continue to nurture RegTech's growth.
- **Rising needs to quickly resolve compliance issues.** Financial institutions seek cost-reducing solutions with an ability to detect any compliance breach before the regulators.
- **Market globalization.** With a significant increase in the number of regulations and customers to check, traditional systems will be incapable of handling all the data analytics effectively, and institutions will have to rely on new solutions like RegTech.
- **Regulatory support and low barriers to entry.** Numerous regulators are catching-up and including RegTech into their strategy, inviting many new companies to enter the market and join the regulatory sandbox.

Risks:

- **Technologies not delivering as expected.** RegTech is in its infancy and many obstacles lie in the way, e.g., reliance on new technology that may fail and current tech solutions not covering all compliance challenges.
- **Regulatory divergence.** Inconsistent regulation between different jurisdictions may hinder interconnectedness between economies, firms, and regulators.
- **Cyber resilience and data privacy.** Data security and safety concerns remain important concerns when implementing automated solutions involving customers' private information.

Bottom Line:

- With over 750 global regulators, countries are pushing for "developing a more transparent and controlled global financial system". **RegTech infrastructure has the potential to disrupt and improve the current regulatory landscape.**
- **RegTech market is expected to account for 40% of global compliance spending by 2023**, as advanced analytics, automation, and deep learning computing achieve regulatory compliance more efficiently and at lower costs.
- The RegTech industry represents an **attractive investment opportunity**. After financial institutions across the globe have found robust and lasting compliance solutions in RegTech, investments in regulation technology magnified and sparked a **double-digit growth rate**.
- We favor this subindustry by having exposure to RegTech and technologies it utilizes in our **Fintech certificate**.

AUGMENTED AND VIRTUAL REALITY – A FOCUS ON RETAIL AND EDUCATION

The Difference Between Augmented Reality And Virtual Reality

- In simple terms with Augmented Reality (AR) you can watch virtual objects in the real-world environment (Pokemon Go or Google SkyMap), while with Virtual Reality (VR) you are fully immersed in a digital world (Playstation VR).
- **Augmented Reality** uses information acquired using video and other imaging sensors, simultaneous localization and mapping (SLAM), and 3D depth-sensing technologies to show on a device digital content relevant to what the user is looking at.
- In order to create an immersive 3D environment, **Virtual Reality** simulate vision, sound and movement through a VR headset. The hardware includes headphones, eye and head tracking as well as an accelerometer, a gyroscope and a magnetometer to sense respectively 3D, angular movement and the position relative to the Earth.
- The staggering surge in **consumption of video content among millennials** and the **growing popularity of gaming** as a form of entertainment across different age groups has boosted the AR/VR industry.

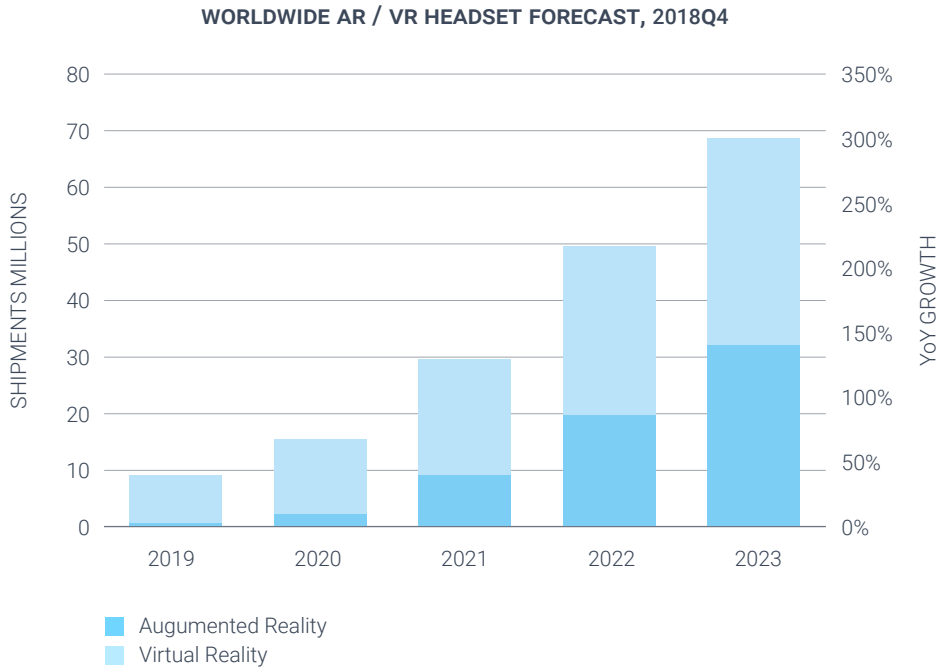
VIRTUAL REALITY

AUGMENTED REALITY

SOURCES:
https://www.alliedmarketresearch.com/augmented-and-virtual-reality-market

VR Is For Games And It's Now

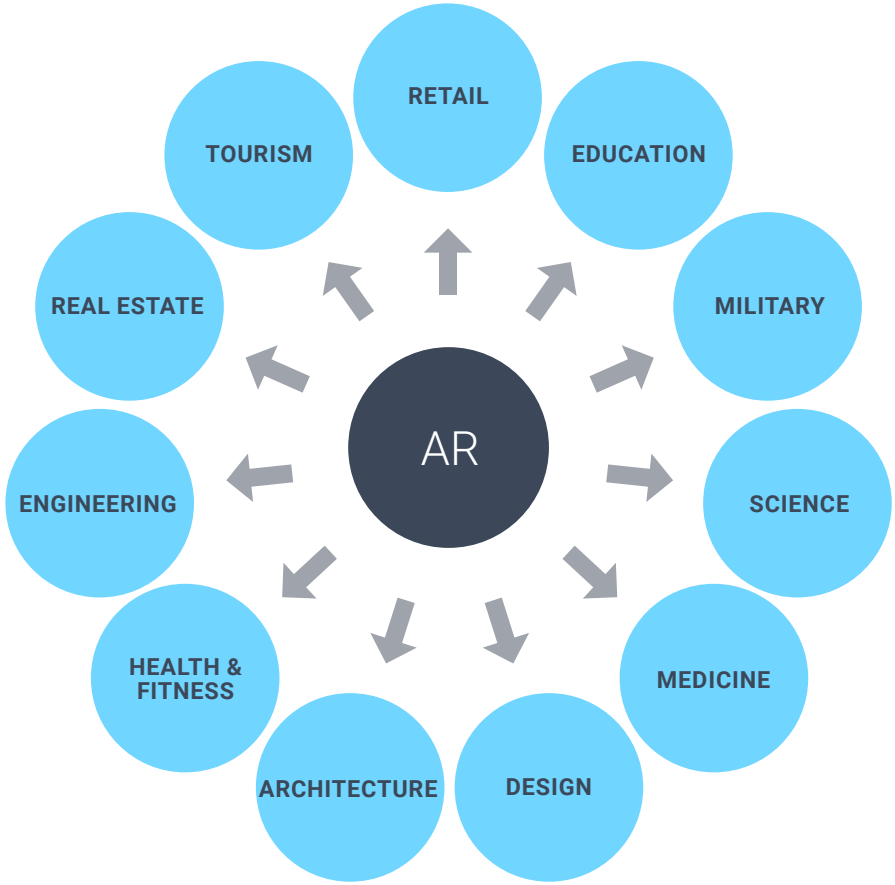
- The AR/VR market is still quite small, despite the first head mounted display dates back to 1968 (created by Ivan Sutherland, it was used to show virtual simple wire-frame model rooms), but growing fast.
  - According to Allied Market Research, the market size was just $18.5bn in 2018, but it's projected to reach more than **$570bn by 2025** with a **CAGR >60%**.
  - International Data Corporation (IDC) expects worldwide shipments of AR/VR headsets to reach 68.6mn units in 2023 from 8.9mn in 2019 or a CAGR of 66%.
- Currently the biggest part of headsets shipments (43%) is driven by **console gaming VR**, but there are some clouds on the horizon for this segment.
  - **Microsoft** (**MSFT US**) has recently stated that their new console will not support VR adding that technology needs to improve further before they begin to adopt it.
  - China has recently imposed a time-limit on online gaming for minors. This is part of China's latest move to restrain video game addiction, which officials say is damaging to children's health.
- The Augmented Reality dedicated headset market has been and remains for the time being largely driven by specific demands for enterprises users and large institutions (like military), while most consumers are experiencing some sort of AR through their smartphones, tablets and magic mirrors.



SOURCES:
https://www.idc.com/getdoc.jsp?containerId=prUS44966319
https://www.viar360.com/virtual-reality-market-size-2018/

AR Is For Everything And It's The Future

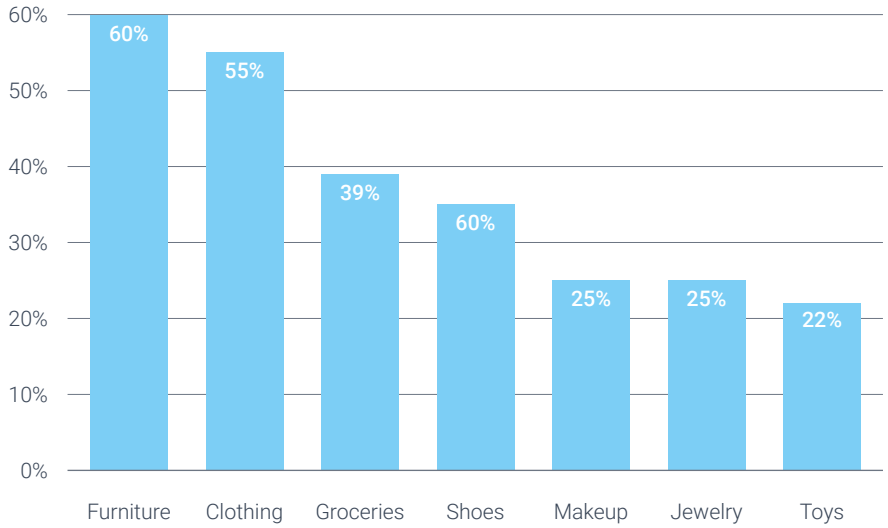
- We believe that the **future growth of headsets / smart-glasses sales will be driven by Augmented Reality**.
  - Only with smart-glasses you can take advantage of AR while keeping the hands free to interact in a natural way with the environment.
- The rapid evolution of core technologies and the subsequent reduction of the cost of the device incorporating those technologies are the most important drivers.
  - **Microsoft's** (**MSFT US**) HoloLens or **Facebook's** (**FB US**) Oculus Rift, introcuced in 2016, didn't attract a large client base due to a bulky hardware, technical glitches and an expensive price. The just launched Hololens 2 has a better technology, but the $3500 or $125 per month price tag is still a large barrier for the average consumer. US Army is currently testing a modified version of it.
  - **Apple** (**AAPL US**), after having acquired Israeli-based 3D body sensing firm **PrimeSense** in 2013, augmented reality start-ups **Metaio**, **Facshift** and **Flyby Media** between 2015 and 2016, cybersecurity and machine learning company that specializes in facial recognition technology **RealFace** and a mixed reality headset developer called **Vrvana** in 2017, seems to be ready to launch in 2022 its first "system-on-a-package" AR-focused product.
- Besides gaming, where VR has already established a significant presence, **AR has the potential to be in almost every industry**: e-commerce/retail, education, military and defence, science, medicine, design, architecture, health & fitness, engineering, real estate and tourism.



Augmented Reality In The Retail Sector

- The e-commerce/retail is one of the sectors where a smartphone is enough to enjoy and take advantage of AR, without the need for an expensive headset or smart-glasses.
- According to a November 2019 WBR Insights Report, only 1% of retailers are currently using AR, but **63% are either investing on it or are considering adopting the tech in the next two years**, and according to Gartner, by 2020 already 100 million consumers are expected to shop using AR either online or in-store.
  - For example, apps like IKEA's Place or Decor Matters enable customers to virtually place furnitures in their rooms while the WannaKicks app allows customers to try on ten pairs of shoes in 10 seconds.
- Merchants can use AR **analytics to learn more about individual** customers, and personalize their offerings to increase conversion rates.
  - By tracking the time spent on each virtual product, merchants can adapt their specific product offering to each customer.
- The possibility of a 'try-before-you-buy' digital experience is also a big driver to **reduce returns**, a major cost source for e-commerce players.
  - Economic cost of returns are estimated at $550bn in 2020 in the US alone, according to Statista.
- We are monitoring private companies involved with AR in retail, like **Augment** (**not listed**) and **Fisherman Labs** (**not listed**).

PRODUCT TYPES WHICH U.S. INTERNET USERS WANT TO SHOP USING A.R.



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AR/VR In Education

- As a survey conducted by the law firm Perkins Coie and the XR Association confirms, **education is one industry in which AR/VR is most applicable**.
- The use of **augmented and virtual reality** in education has a **positive impact on learners**, as reported by many researchers.
  - Content based on AR/VR increases pupils' attention in the classroom, as well as motivation.
  - Technology can render animated 3D objects and allow to interact with them, making it easier to understand abstract and difficult content like math or physics.
  - Museums could use AR/VR to provide visitors more information or three-dimensional animations that they can interact with.
- Also in this space we are monitoring the more prominsing private companies.
  - **zSpace** (**not listed**), present in over 800 school districts in North America with over 1M users for its main product, an all-in-one AR/VR laptop with content that can be manipulated with a stylus pen and viewed through smartglasses.
  - **Merge** (**not listed**) sells durable, kid-friendly products, like the Merge-Cube (a cube that displays a hologram allowing interaction with objects like the human heart, an aquarium or the solar system) or the Merge-headset (compatible with almost every smartphone).
  - **Alchemy VR** (**not listed**) produce high-quality, immersive, engaging educational experiences for all ages.

zSpace

MERGE® VIRTUAL REALITY

ALCHEMY VR

SOURCES:
https://romisatriawahono.net/lecture/rm/survey/computer%20vision/Radu%20-%20Augmented%20reality%20in%20education%20-%202014.pdf
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Catalysts:

- **Software development kits.** GAFAs have realeased AR/VR software development platforms over the past two years that are driving a huge increase in content production from developers, stimulating demand from final users.
- **Retailers.** Investments in AR are spreading fast, as the technology helps retailers present their customers with an ad-hoc offer and a tailored experience making them more likely to stay loyal.
- **Cost reduction.** Affordability of VR/AR technology will be an important driver for increased adoption in any sector, but mainly in Education where tight budgets are always an issue

Risks:

- **The AR/VR technology still presents limitation.** The Field of View (FOV) is the biggest limit. To create a good immersive experiences AR/VR devices must capture as much of the FOV as possible, but they are still very far from a normal human vision.
- **The form factor is not yet ready for mass adoption.** Form factor refers to the size, shape, and other physical specifications of electronic devices and components. Due to the need to have a decent FOV, the headsets are bulky, heavy and sometimes uncomfortable.
- **Increased attack surface.** AR/VR could increase the risk profile of any users as the huge amount of data generated by this technology could be a valuable target for criminals.

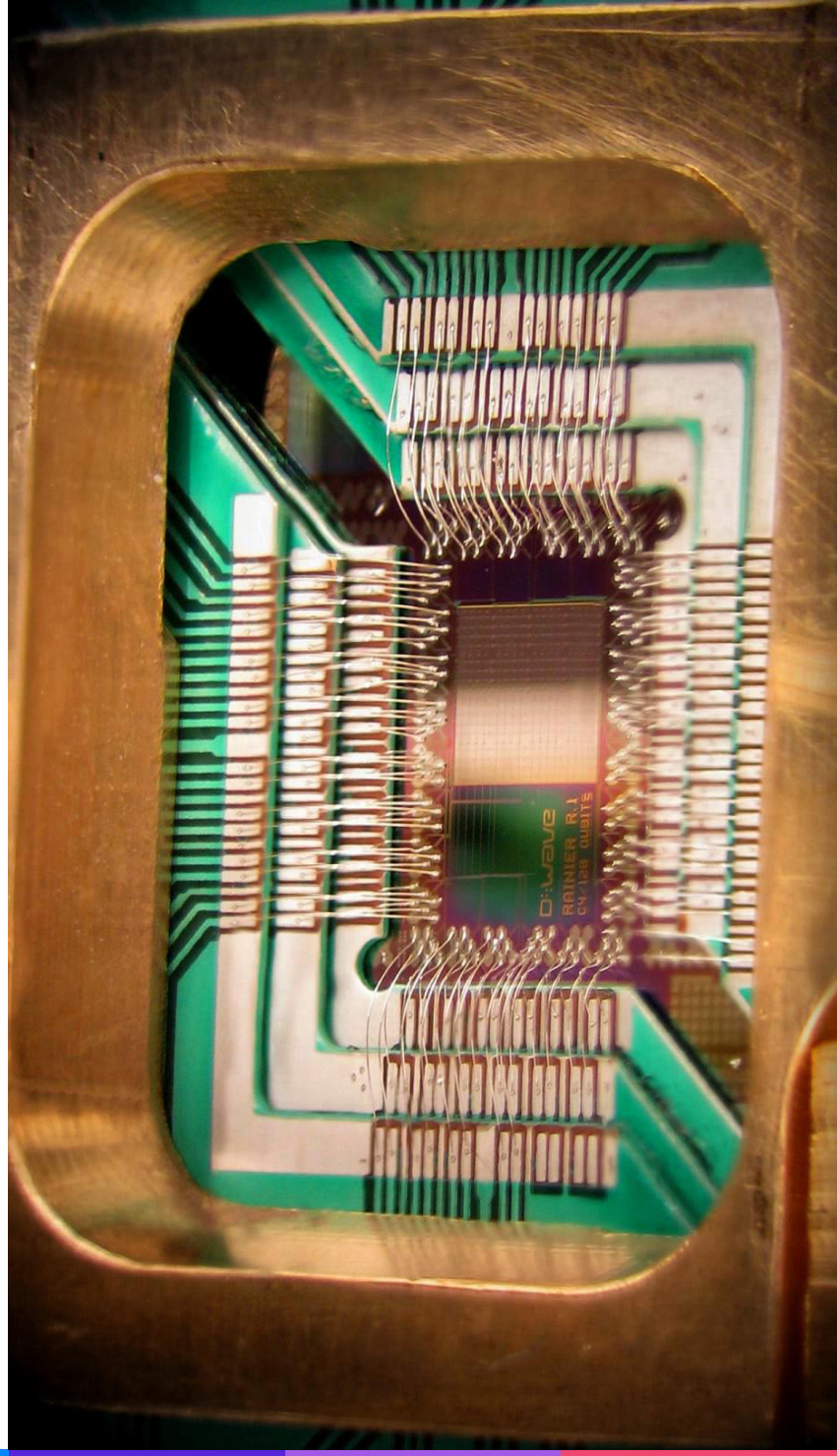
Bottom Line:

- Augmented Reality is **potentially a huge market**, or a "big idea like the smartphone" as Apple's Tim Cook said, when the technology, the form of the device and the price will converge to an optimal balance.
- Besides Gaming, where the AR/VR is already presents and where we see the highest growth potential, VR and especially **AR will be present in a variety of industries**. Retail and Education are just two of those.
- The key players operating in the global AR/VR market are **Sony** (**6758 JT**), **Magic Leap** (**Private**), **HTC** (**2498 TT**), **Microsoft** (**MSFT US**), **Amazon** (**AMZN US**), **Google** (**GOOGL US**), **Osterhout Design Group** (**Private**), **Facebook** (**FB US**), **DAQRI** (**Private**), **Samsung** (**005930 KS**) and **Wikitude** (**Private**).

QUANTUM COMPUTING, THE NEXT IT REVOLUTION

Quantum Technology: Where Do We Stand

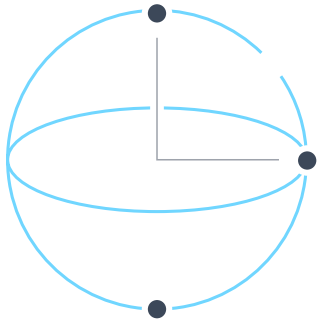
- In the last couple of years, the buzz around AI has shadowed the field of quantum computing, that nevertheless continued to develop.
- Silence was broken last month, when the Google AI Quantum team, a workforce within **Google** (**GOOG US**), announced it has achieved the so-called **quantum supremacy**.
  - Quantum supremacy is about demonstrating that a quantum computer can solve a problem that would be impossible for a classical computer, either because there are too many variables in the problem or because it takes too long (literally years of computation) to solve it.
- As classical high-performance computing (HPC) is moving towards a dead end, represented by the end of Moore's law, new paradigms are being developed, such as design optimization, new architectures and dedicated accelerators.
  - Quantum devices (using quantum bits as their fundamental units, rather than the classical 0 and 1) are the most promising way to solve complex computing problems.
- Quantum computing (QC) will surely revolutionize our life and its impact will be similar to that of electronics in the past century: **"Quantum computing is to the 21st century what microelectronics or semiconductor technology were to the second half of the 20th century"** – Chad Rigetti, founder of Rigetti computing.



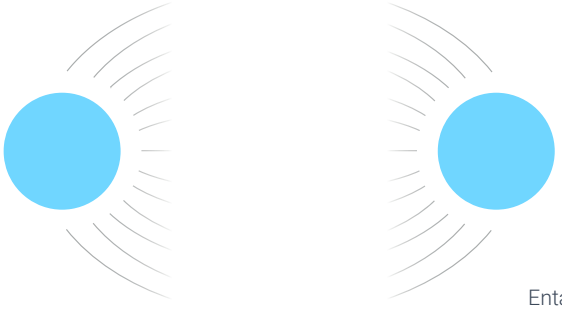
SOURCES:
https://ai.googleblog.com/2019/10/quantum-supremacy-using-programmable.html
https://commons.wikimedia.org/wiki/File:DWave_128chip.jpg | Creative Commons Attribution 3.0 License

Quantum Computing 101: A Few Important Notions

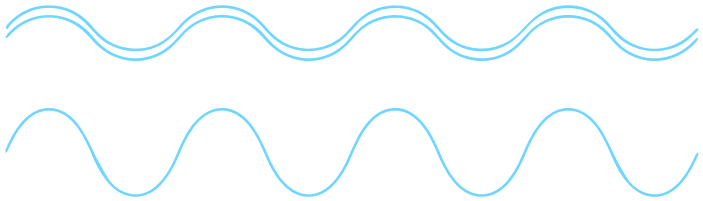
- There are three main features that distinguish quantum from classical computing:
  - **Superposition**: a quantum bit (qubit) can be set to 0 OR 1, like a classical bit, but it can also be set to 0 AND 1 at the same time.
  - **Entanglement**: two or more qubits can have a "special relationship" that connects them, and that does not have a classical analogy. You can think of entanglement of two qubits as two telepathic twins: you can ask one what the other is doing.
  - **Interference**: two qubits can interfere thanks to a property called phase, similarly to when two waves meet at a water surface.
- The advantages of QC originate from the above features: for instance, the superposition allows, with n qubits, to store information on 2^n states, compared to n states with n classical bits,
- On the more negative side, QC is more prone to error than classical computing. Existing qubits are easily perturbed by their environment, while classical computers are incredibly reliable, the difference between the two being about 20 orders of magnitude.
  - However, there are techniques that use additional qubits to assess the misbehavior of the “computing” qubits. These two types of qubit (computing + assesing) form a “logical qubit,” (in other terms, the theoretical concept of the perfect qubit).



Superposition



Entanglement



Positive Interference

SOURCES:
https://www.ibm.com/quantum-computing/learn/what-is-quantum-computing/

Who Wants The Holy Grail Of Future Computing

- The race about QC is not only run by universities and research centers but, given its importance, stakeholders come from transverse sectors:
- At a national level, the U.S. have launched the National Quantum Initiative, a plan funded with $1.2bn, the E.U. has its Quantum Flagship program that will invest €1bn, and China has formally engaged to invest $10bn.
- Known tech behemoths like **IBM** (**IBM US**), **Google** (**GOOG US**), **Intel** (**INTC US**), **Honeywell** (**HON US**), **Microsoft** (**MSFT US**), **NEC** (**6701 JP**), **Fujitsu** (**6702 JP**) and **Alibaba** (**BABA US**) are among the corporations that invest the most in QC.
- Private companies are also very active and, in same cases, lead the technological development: **Rigetti**, **D-Wave System**, **IonQ**, **Quantum Circuits**, **Qilimanjaro**, **Xanudu** and **IDQ**.
- Research centers and universities are obviously also extensively involved: QUTech, NQIT, IQC, Silicon Quantum, imec, Fraunhofer are being known for their effort in developing quantum technologies.

	END-TO-END PROVIDERS	HARDWARE & SYSTEMS PLAYERS	SOFTWARE & SERVICES PLAYERS	SPECIALISTS
SERVICES	IBM Google		Zapata Computing Cambridge Quantum Computing QC Ware	Tellus Matrix Group Quantika Entanglement Parents h-bar Quantum Consultants
APPLICATIONS LAYER SYSTEM SOFTWARE LAYER	Rigetti Computing Microsoft			Quantum Benchmark Strangeworks Q-CTRL Qindom ProteinQure QbitLogic
SYSTEMS	Alibaba Group D-Wave Systems	IconQ QuTech		SeeQC
QUANTUM COMPUTER HARDWARE	Emerging: Honeywell Xanadu Qilimanjaro	Intel Quantum Circuits BraneCell TundraSystems Global		Silicon Quantum Computing PsiQ Alpine Quantum Technologies

SOURCES:
BCG – The Next Decade in Quantum Computing and How to Play

Impact: Sectors In Which QC Will Change Our Life

The first practical use of QC was demonstrated by Peter Shor at MIT in 1994 when he showed that a quantum algorithm could hack any current cryptography.

Since then national governments started to invest in quantum technologies to prevent any possible threats to their institutions.

- The interest in QC has shifted from national governments to industrial players, given the potential of QC that are evident in many applications.
  - QC for classically intractable problems, such as those problems that would require centuries to be solved by a classical computer.
  - QC for simulation of complex systems, such as those needed to simulate new drugs or new materials.

COMPANY	USE CASES	ENTERPRISES (EXAMPLE)
High Tech	• AI: ML and neural networks • Search • Bidding strategies • Cybersecurity • Software verification and validation	IBM, Alibaba, Google, Baidu, Samsung, Microsoft
Industrial goods	• Logistics: scheduling, planning, routing (salesman dilemma) • Automotive: traffic simulation, e-charging station and parking search, autonomous driving • Semiconductors: Manufacturing and layout optimization • Aerospace: R&D and manufacturing, fault analysis, new materials discovery • Materials science: effective catalytic converters for car, battery cell research, solar cells and properties engineering for OLED and other applications	Airbus, BMW, NASA, VW, Daimler, Lockheed Martin, Bosch, Honeywell, Raytheon
Chemistry and Pharma	• Catalyst and enzyme design • Faster drug discovery • Bioinformatics, such as genomics • Patient diagnostics for health care	BASF, Roche, Novartis, Dow Chemical, Biogen, DuPont
Finance	• Trading strategies • Portfolio optimization • Asset pricing • Risk analysis • Fraud detection • Market	JP Morgan, Barclays, Goldman Sachs
Energy	• Network design • Grid simulation • Energy distribution	BP, Dubai Electricity and Water Authority

SOURCES:
BCG – The Next Decade in Quantum Computing and How to Play

Catalysts:

- **Partnerships.** Collaborations between universities, research centers and enterprises is strengthening the ecosystem and accelerating the development of QC.
- **Cybersecurity.** Quantum technology will help to better protect ourselves, our organizations and institutions from cyber threats. This is why governmental institutions are investing and deploying resources for QC.
- **Moore's law.** Development costs for the next generation of transistors have become so high that it starts to make more sense to develop QC instead.

Risks:

- **Security issues.** This technology has an undeniable high strategical value for every country. Wikileaks and other espionage stories will seem very small when the first QC would break into some systems; this might generate security concerns at international scale.
- **Entry barriers.** Quantum is a whole new world, with little or any analogy to classical computing. The understanding of the technology is and will be limited to experts and this might slow down adoption and take-off.
- **Decoherence.** It is the process through which a qubit loses its information: it might take a while, before an error-free QC will be created.

Bottom Line:

- **Impact.** QC will certainly change our life, but it will take time. For the decade to come we do see QC more as supercomputers, which are limited to industrial, governmental and academic applications. It will be after 2030's that QC may start to directly pervade our life.
- **Supremacy.** Quantum is delivering results above expectations and it is maintaining its promises, but the results still remain mostly conceptual, closer to proof of concept than effective run.
- **Strategic importance.** The opportunities that QC will enable are countless, this is why its run is so important, both economically but also for the society: its implications in our daily life are still out of our mind's reach.

RARE DISEASES: THE NEW ELDORADO FOR BIOTECHS

Rare Diseases Are Not That Rare...

- **400 million people** worldwide are affected by one of the 7'000 rare diseases.
  - The definition varies according to geographical regions. A rare disease is defined as such when it touches **fewer than 200,000 people in the US** and **250,000 people in Europe**.
- Rare diseases affect **all therapeutic areas**, but more than half of the orphan pipeline is targeting oncology indications, while white blood cells, CNS (Central Nervous System), and infectious diseases are the leading other therapeutic areas.
  - Medicines developed for the treatment of rare diseases are called **Orphan drugs**, in accordance with the FDA's designation status.
- By 2024, orphan drugs' sales are expected to reach **$242bn, growing at a CAGR of 12.3%**, which is about **double** the expected growth rate for the non-orphan drugs market.

TOP 5 DISEASES (IN TERMS OF # OF DRUGS IN ACTIVE DEVELOPMENT)

INFECTIOUS DISEASE	NEUROLOGICAL	ALIMENTARY / METABOLIC	CANCER	BLOOD AND CLOTTING
Tuberculosis	Amyotrophic lateral sclerosis	Gaucher's disease	Pancreatic	Haemophilia A
Malaria	Huntington's disease	Acromegaly	Ovarian	Haemophilia B
Tetanus	Duchenne's muscular dystrophy	Pompe's disease	Liver	Idiopathic thrombo cytopenic purpura
Pertussis	Uveitis	Cushing's disease	Myeloma	Sickle cell anemia
Haemophilus influenza	Spinal Muscular Atrophy	Primary Biliary cirrhosis	Renal	Waldenström's hypergamma globulinemia

RARE DISEASES IN NUMBERS

Rare diseased affect 30 million Americans (that's one in ten)

Approximately 7000 rare diseases are known to exist today

The FDA has approved 600 orphan drugs since the passage of the Orphan Drugs Act

There is still a huge unmet need with treatments available for only 5% of all rare diseases

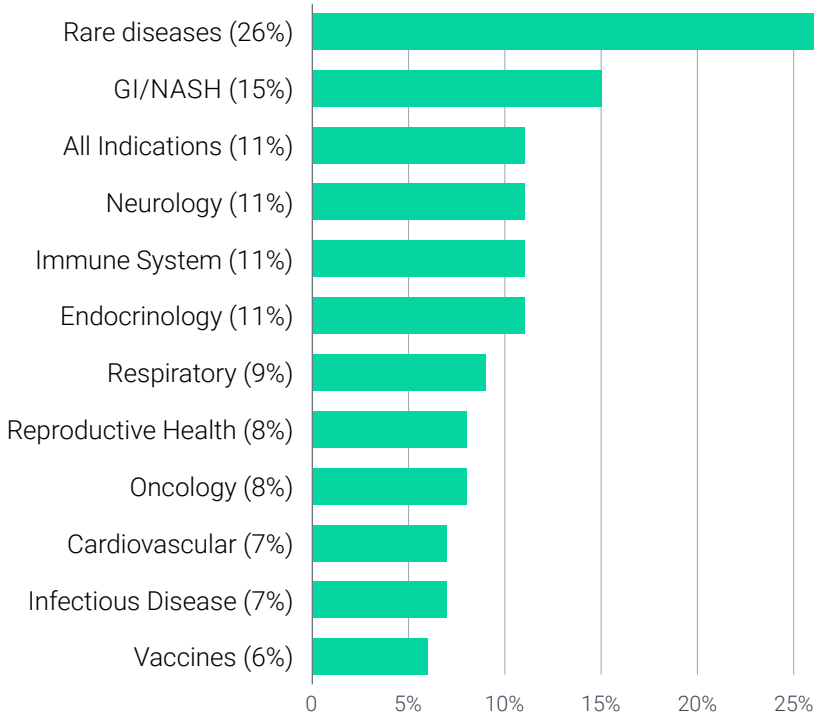
Currently there are more than 560 medicines in development for rare diseases

SOURCES:
https://pharmaboardroom.com/articles/investments-and-deal-activity-in-orphan-drug-products/
EvaluatePharma Orphan Drug Report 2019 – www.evaluate.com/OrphanDrug2019
https://6erxg60qvo1qvjha44jrgpan-wpengine.netdna-ssl.com/wp-content/uploads/2019/02/Rare-disease-day--e1551360777322.jpg

An Attractive Space With Strong Governments' Incentives...

- Rare diseases are generally **severe**, **fatal** and **often affect children**, providing an added incentive to R&D investments and a willingness to reimburse such drugs.
- Orphan drugs usually benefit from very high prices.
  - Prices range from **$200,000 to $400,000 per year / person and can exceed $1,000,000 for some gene therapies**.
  - They are justified by the fact that there is only a small population of patients and some drugs are administered through lifelong injections (or at least over a 10-year span).
- **Approval time** is also an essential factor to consider, as **the faster the better**. The FDA provides special assistance through different schemes that help companies obtain drug approval in a much quicker way than for non-orphan drugs.
  - The US has been the trailblazer in this area, with the approval of the original **Orphan Drug Act** back in 1983 – Japan (in 1993) and Europe (in 2000) have been following suit and playing catch-up.
  - Consequently, orphan drugs have higher **approval success probabilities**.
- Beyond tax incentives, the most significant "enticers" for drugs granted the orphan drug status are an **extended market exclusivity** (granting monopoly status for the first drug filed for a specific disease) and simplified/ fast approval tracks.

COMPOSITE SUCCESS RATES VARIED BY THERAPY AREA BETWEEN 6-15% IN 2018, WITH RATES FOR RARE DISEASES AND GI/NASH EXCEEDING AVERAGES



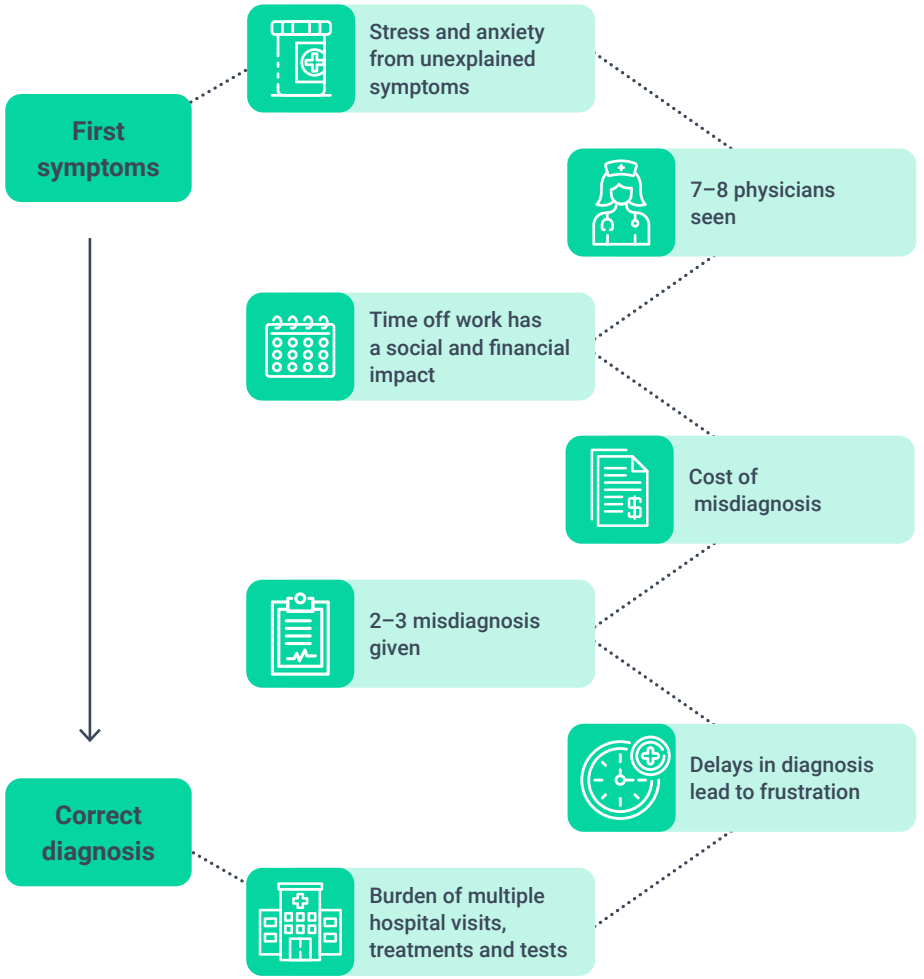
COUNTRY	UNITED STATES	EUROPEAN UNION	JAPAN
Prevelence Criteria For Orphan Designation	200.000 people	5 / 10.000 people	50.000 people
Market Exclusitivity	7 years	10 years	10 years
Tax Credits For Clinical Research	Yes (50% of clinical costs)	Not at EU level	Yes (6% of clinical and non-clinical costs)
Application Process For Waivers	Yes	Reduced fees	No

SOURCES:
https://www.ddw-online.com/library/sid32/21-table-1.jpg
https://www.healthindustryhub.com.au/wp-content/uploads/2019/05/the-changing-landscape-of-research-and-development.pdf

... But Not Without Overcoming Specific Hurdles

- Identification of patients is still long and not efficient, making it difficult to recruit patients for clinical trials.
  - AI and genome sequencing will help increase the number of diagnosed patients, thus improving the recruitment process for clinical trials.
  - During clinical trials, the evaluation of rare disease drugs could be biased due to **small size of patients' samples**.
- On the commercial side, high prices hamper access to orphan drugs.
  - Flexible payment models based on efficacy and through staggered payments are likely to be implemented to avoid burdensome upfront payments.
  - Reimbursements are spread over an agreed period and could be based on clinical outcomes measured in the real world.
- But over the long term, these "permanent" treatments could even save money to the healthcare system.
- For instance, Spinal Muscular Atrophy costs today more than $375,000 per year per patient and if there are complications, it can even reach $1mn!

DIAGNOSING A RARE DISEASE CAN TAKE UP TO 7 YEARS



SOURCES:
Pfizer
https://www.newscientist.com/article/2191977-the-rare-disease-challenge-meeting/
https://www.rxre2018.com/
https://images.newscientist.com/wp-content/uploads/2019/01/28092123/rxre2018-infographic.jpg

New Strategies To Target Rare Diseases

- 80% of all rare diseases are due to genetic mutations and a large portion is monogenic, i.e., caused by a single gene mutation. Thus, they are attractive candidates for gene and cell therapies.
- Treatments under development today target the root of the disease and not only the symptoms, providing a long term and even a permanent solution.
  - So far, 7 diseases have at least one approved gene therapy treatment, but more than 100 diseases are currently being studied.
  - We are just at the beginning. With about 1'800 gene therapies actually in clinical trials, we are likely to see several products approved in the next 5 to 10 years.
- Some companies, such as **Orchard Therapeutics** (**ORTX US**), are focused on really rare diseases, affecting just a few thousand patients, giving them a huge competitive advantage.
  - The market is certainly small but being the first and often the only one developing a drug for a specific disease, gives the company a higher probability to be the first to the market, and thus capture all patients and command a high price.
- RNA-Based therapeutics like mRNA (RNA messenger), RNAi (RNA interference), or antisense drugs are the latest advancement in gene therapy.
  - Lower manufacturing costs and more flexibility compared to DNA-based gene therapies explain their high popularity.
  - Notable players in the area are **Moderna** (**MRNA US**), **CureVac** (**Not listed**), **BioNTech** (**Not listed**), **Translate Bio** (**TBIO US**), **Alnylam Pharmaceuticals** (**ALNY US**), **Ionis Pharmaceuticals** (**IONS US**), and **Sarepta Therapeutics** (**SRPT US**).

GENE THERAPY AS A NEW OPTION FOR MONOGENIC DISEASES

VERTEX

Cystic Fibrosis
Between 70.000 and 100.000
people worldwide

bluebirdbio

Beta- Thalassemia
1 in 100.000
people worldwide

BIOMARIN

Cystic Fibrosis
More than 400.000
people worldwide

Spark THERAPEUTICS

Retinal Dystrophy
1.5 million
people worldwide

bluebirdbio

Sickle Cell Anemia
250 million
people worldwide

Amicus Therapeutics

Batten diseases
1 in 12.500
people worldwide

Sangamo THERAPEUTICS

Fabry Disease
1 in 80.000
people worldwide

IONIS PHARMACEUTICALS

Huntington disease
30.000 people
in the United States

Catalysts:

- **Diagnosis tools.** As explained in our 06/11/19 issue of Investment Recipes, genome sequencing costs are coming down. Coupled with AI-powered tools, we are entering into a much faster discovery-to-treatment cycle.
- **FDA incentives.** Several rare diseases drugs are eligible for priority review programs, including the orphan drug status or rare pediatric disease designation.
- **Insurers reimbursement.** The expansion of coverage, coupled with higher reimbursements for costly therapies, will boost their use.
- **Proof-of-concept of new biotechnologies after years of research.** More data confirming the long term effect of gene therapy treatments will expand their adoption.

Risks:

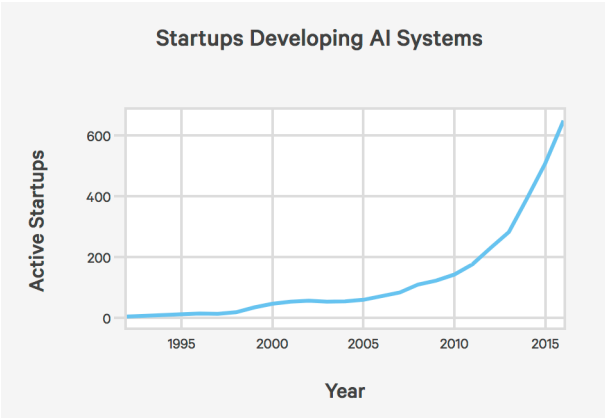
- **Manufacturing.** New technologies such as gene therapies tend to be complex and time-consuming to manufacture, keeping costs (and thus prices) high.
- **High prices.** Raise ethical issues and questions about the ability of health systems to support substantial upfront payments for small portions of the population.

Bottom Line:

- New kinds of therapeutics open the way for **one-and-done cures** offering hope finally for 400 million people living with a rare disease. These drugs could provide to biotech companies a **multi-billion revenue opportunity**, especially if they are first to the market.
- Rare diseases are progressively becoming **very "attractive"** for biotech and pharma companies due to **supportive government policies**, **high-profit margins** and **M&A potential**.
- In our biotechnology certificate, the "rare diseases" area accounts for about **15% of our allocation**. A **well diversified portfolio** is required, as it is a highly volatile, “boom or bust” industry.

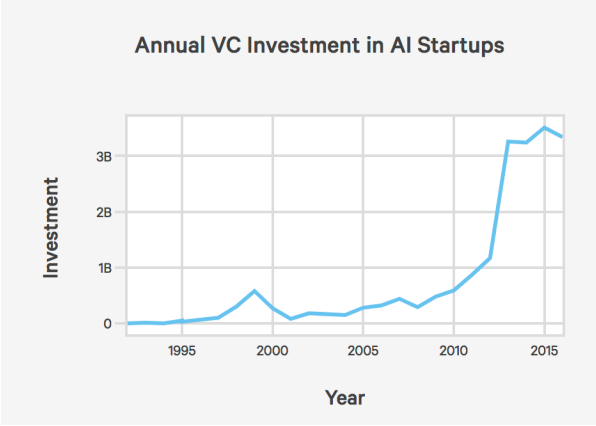
CHARTS FOR THOUGHTS

- **Artificial Intelligence** has been rising in importance and awareness about it is just beginning to take hold of the general public.
  - More and more start-ups are developing AI models.
  - Funded by massive inflows of Venture Capital.
- As investment fuels demand for talent, it appears that there is a clear lack of AI skills in the job market today.
  - People with knowledge about Machine Learning and Deep Learning command premium salaries.
- Schools are responding by increasing their AI-courses offering, and pupils are enrolling in droves.
  - But education takes time – sometimes years are needed to acquire appropriate skills.
- In the battle between superpowers, solving the talent bottleneck is key to lead the AI race.



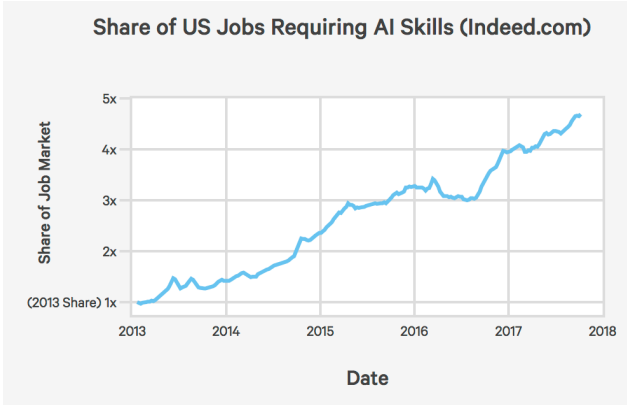
14x *The number of active US startups developing AI systems has increased 14x since 2000.*

Sources: Crunchbase, VentureSource, Sand Hill Econometrics



6x *Annual VC investment into US startups developing AI systems has increased 6x since 2000.*

Sources: Crunchbase, VentureSource, Sand Hill Econometrics



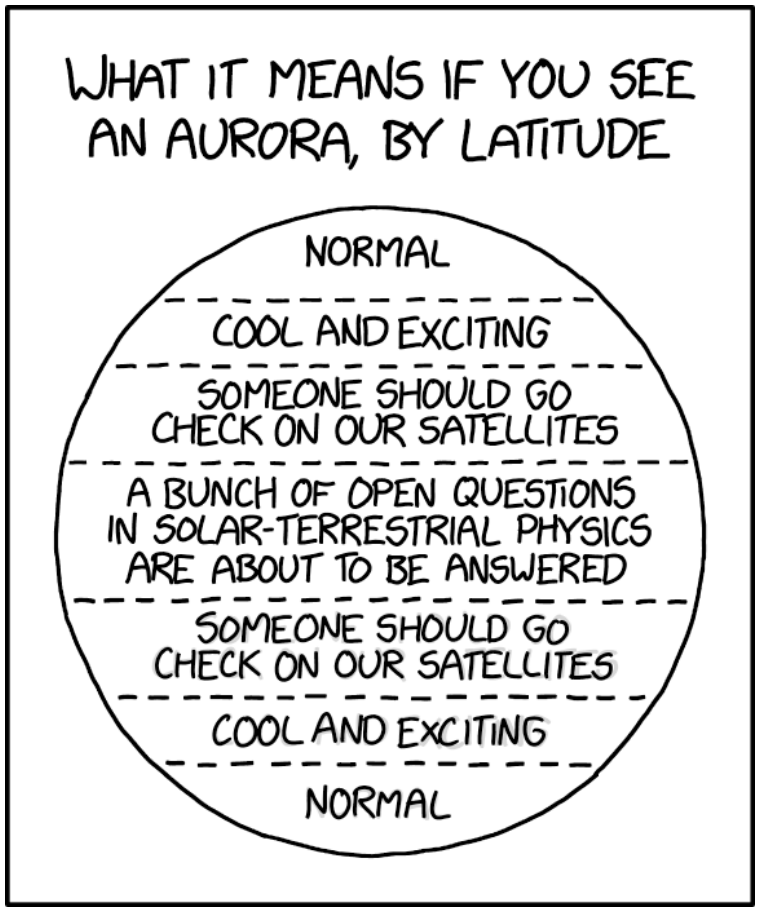
4.5x *The share of jobs requiring AI skills in the US has grown 4.5x since 2013.*

Sources: Indeed.com

AIINDEX.ORG

SOURCE:
AI Index, Annual Report 2017 – www.aiindex.org

CASUAL FRIDAY



SOURCE:
https://xkcd.com/2233/

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