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## 4 Application of AI, InsurTech, and Real Estate Technology

### 1. insurtech

- a. Gross Written Premium 总保费 \$4.8 trillion in 2017
- b. redefine the insurance industry
  - i. product design: customer experience
  - ii. front office: marketing, distribution, channel management
  - iii. underwriting new policies: risk analytics, automatic workflow
  - iv. policy administration: servicing, market segmentation
  - v. claim management: real-time monitoring, fraud detection
  - vi. demand modeling
- c. classifications
  - i. Milken, traditional
    1. full-stack insurers: manage from beginning to end
    2. agents: extension/partner of incumbent carrier, customer facing
    3. brokers: provide policies by multiple carriers/platforms
  - ii. Capgemini, nuanced
    1. full carriers: digital carriers, insurers
    2. distributors: marketplace, brokers, intermediaries
    3. enablers: specialists in any department, 40% of insur companies
- d. market size (from 2018 perspective)
  - i. expected \$532m in 2018, [\\$5.45 b](#) in 2022
  - ii. highest CAGR in Asia Pacific and healthcare
  - iii. 45% financing in series A, B, C in 2018 ([The State of Global Insurtech 2023](#))
  - iv. investment and aggregate deal size in InsurTech during 2017: \$3.2 billion in investments, \$2.2 billion worth of deals
- e. key tech: blockchain, smart contracts, SaaS
- f. microinsurance
  - i. Omidyar Network (eBay), BIMA (Swedish)
  - ii. for low-income, low-networth population
  - iii. mobile subscription, pay-as-you-go
  - iv. financial protection through risk pooling

### 2. RealTech Real Estate FinTech

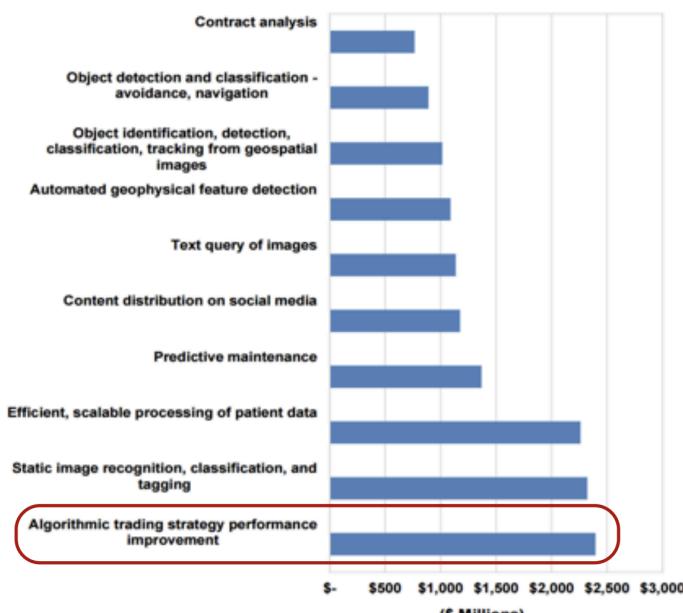
- a. real estate: “alternative investment”
- b. Capitalization Rate: expected higher return than US government bonds
- c. brings improved efficiency instead of disruption

- d. residential sector
  - i. Multiple Listing Services MLS, important database
  - ii. transactions require inspections
  - iii. 6% rule, commission fee from both buyer and seller brokerage
  - iv. tech disintermediate or force price competition
  - v. trends
    - 1. affordability: millennials spend more and stay with family, Divvy, Bungalow
    - 2. search for community: network
    - 3. flexibility: gig economy, furniture rentals,
- e. commercial sector
  - i. \$9.6b investment in CRE Tech in 2018; global sales of commercial properties \$873b in FY2017, 57% in US; institutional investment capital to CRE \$800b in 2017, doubled 2009
  - ii. more data driven than residential for complex property management and hard-to-obtain transaction details
- f. VC are a key part, recently heavyweight industry companies such as CBRE have become major investors

### 3. AI

- a. \$70 billion AI market value by 2025 (Bank of America Merrill Lynch), \$36.8 billion AI market size by 2025 (Tractica Research), \$1.2 trillion invested in cognitive computing technologies by 2020 (Forrester Research), \$8.3 trillion in overall AI market value by 2035 (Accenture)

**Chart 1.2 Artificial Intelligence Revenue, Top 10 Use Cases, World Markets: 2025**



- b.
- c. robo-advisory: unclear role for AI

### 4. Vanguard FinTech solutions

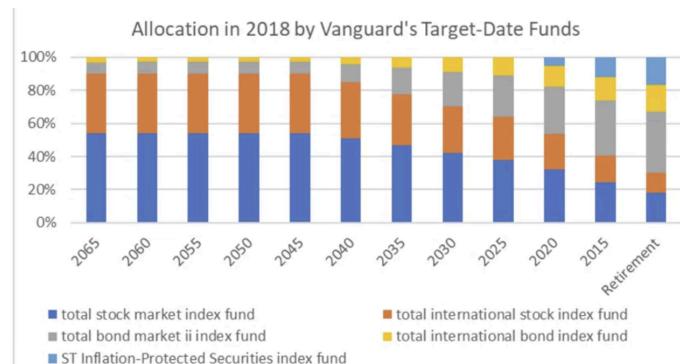
- a. personal advice service: digitizing advice, Innovation Studio

## 3 Lending, Crowdfunding, and Modern Investing

1. Which is a true statement about **defined-benefit plans**?
  - a.  Defined benefit plans define your retirement income in terms of what you paid in
  - b.  The pension plan administrators, not the employees, are responsible for investing the fund assets
  - c.  Employees will definitely get the payments due from a defined-benefit plan, even if the plan's assets aren't sufficient to cover these payments
  - d.  Defined benefit plans are a growing part of retirement savings
2. 401(k) plans: new retirement plan encourages DIY retirement savings to reduce pressure on the employers' responsibility on pension fund

3. fundamental axioms of economics - key assumptions in investing study
  - a. prefer more money to less
  - b. decreasing marginal utility: get less out of the next dollar when you already have more
4. Certainty Equivalent indicates risk aversion for robo-advising: \$970 vs. gamble between \$0 and \$2000
5. Which of the following implies that a consumer is risk averse?
  - a.  She gains more utility from an \$x increase in wealth than she loses in utility from an \$x decrease in wealth
  - b.  She gains more utility from an \$x increase in wealth now than she gains from an \$x increase in wealth later
  - c.  She **gains** less utility from an \$x increase in wealth than she **loses** in utility from an \$x decrease in wealth
  - d.  She gains less utility from an \$x increase in wealth now than she gains from an \$x increase in wealth later
6. **Portfolio Theory** contd.
  - a. Efficient portfolio: minimum risk for its expected return
  - b. easy way for mean variance optimization: take value-weighted market index (all assets based on size) e.g. S&P 500
  - c. According to Professor Musto, which of the following is NOT an element of the **Hybrid Approach** to an efficient portfolio?
    - i.  Take the value-weighted market index
    - ii.  Find the efficient portfolio of indices
    - iii.  Keep transaction costs down
    - iv.  Get some diversification benefit
7. assets
  - a. **Mutual Funds**
    - i. investment program funded by shareholders that trades in diversified holdings and is professionally managed
    - ii. active management: pay ~1% for manager to pick stocks
    - iii. index funds: simply invest in a defined index, only pay for logistics of getting the index return
      1. one trading time/day
      2. only accessible from some platforms, minimum investment limit
  - b. **Exchange Traded Funds** ETFs
    - i. buy shares on the open market, money goes to seller
    - ii. your trade doesn't directly affect the fund
    - iii. pay market transaction cost, even lower than index funds
    - iv. trade any time the market is open, minimum 1 share
    - v. access from any brokerage account
    - vi. robo-advisor can optimize ETFs with low fees
    - vii. Which is a difference between an **open-end fund** and an ETF?
      1.  An ETF trades on an exchange but an open-end fund does not
      2.  Retail investors trade open-end fund shares with each other, and trade ETF shares directly with the fund
      3.  An ETF has a pre-determined lifespan but an open-end fund does not
      4.  An ETF holds individual securities but an open-end fund does not
8. robo-advising
  - a. key customization factor: lifecycle, how many years until retirement
  - b. **target date funds**: hottest in retirement investing, guess retirement time and choose target date fund for that year

- i. rebalance investment by starting out risky, tilting toward lower risk



- ii. target date not amount

- iii. Vanguard's easy approach: 60% domestic, 40% international, just tilt from equity to bond

- c. dynamic readjustment: e.g. property ownership, mortgage, loan, ethical guideline screens

## 9. crowdfunding: started in 2016

### 10. raising capital: Initial Public Offering IPO

- a. engage an underwriter - big investment bank
- b. submit draft registration statement to the Securities and Exchange Commission SEC
- c. submit finished registration statement S1 with price range and number of shares
- d. road show, pitch institutional investors
- e. set price and place the shares
  - i. for retail investor: on average IPO goes up 18% on first trading day, but a price down is not a bargain; usually cannot get share at offer price before aftermarket

### 11. Jumpstart Our Business Startups JOBS Act: bipartisan legislation that developed in 2011

- a. titles
  - i. emerging growth companies: encourage companies with revenue < \$1b to go public, keep S1 confidential before settled
  - ii. allow fundraising in private from accredited investors after public advertisement
  - iii. crowdfunding: limited investment amount and holding time, through intermediary
  - iv. Regulation A+: mini IPO and lower requirement, sell directly to retail investor ("best effort")

### 12. cost (max \$1m allowed to raise)

- a. entrepreneur
  - i. professional cost (lawyer, accountant) \$500 100h = \$50k = 5% of \$1m
  - ii. intermediary fee 5%
  - iii. marketing
- b. investor
  - i. opportunity cost: annual budget \$10k to split for 5 -> \$50/h, 8h research = \$400, 50% chance to decide on investing ->  $E[R] = \$800$ , 40% of \$2k!
  - ii. already picked over: not the first choice for entrepreneurs; yes when used as proof of concept before meeting VC/attract shareholders as customers

### 13. Impact investing for high CSR

- a. B Corp: recognized by a private outfit B Lab
- b. Benefit Corporation: register by state law

### 14. consumer credit landscape

- a. assets: physical assets, financial assets, human capital
- b. liabilities: debt incurred in acquiring physical assets (mortgage), debt incurred in developing HC, credit card debt (non collateral)
- c. [Data and Statistics - FEDERAL RESERVE BANK of NEW YORK](#)
- d. I

### 15. from Peer to Peer P2P lending to Marketplace Lending, alternative to HELOC

- a. platforms more involved in decision, make credit granting, credit risk evaluation, and set interest rate
- b. 95% of lending does not come from the public but institutions, hedge funds etc.
- c. 80% for credit card bill
- d. borrowers allow lenders to access their bank accounts, utility bills etc. for risk score
- e. default probability is not necessarily strictly related to FICO score

16. Student Loan Debt, social finance SoFi

- a. flat 5.05%/6.6% interest rate for federal undergrad-/grad-school loan 2018-19 for easy profit opportunity to refinance focused lenders, calculated off 10-year treasury rate
- b. trend of transition away from refinancing that depends largely on interest rate (treasury rate) to be the original lender
- c. income-driven repayment of student loans
  - i.  Any loan taken out for education is eligible for this program
  - ii.  Any unpaid interest is added to the principal balance
  - iii.  After 20 years of repayment, the remaining balance is discharged
  - iv.  Monthly payments are limited to 10% of discretionary income
- d. Which is a downside of refinancing out of federal student loans?
  - i.  The principal amount will be higher
  - ii.  The new loan will not be eligible for income-driven repayment
  - iii.  The lender will need collateral
  - iv.  The interest rate will be higher

17. lending to small businesses, retailers by payment aggregators e.g. Square

- a. know every transactions, can forecast future cash flow
- b. merchant cash advance: get repaid by taking from it e.g. 10% of all receipts
- c. some money by outside investors

18. fintech dynamics by Square

- a. disaggregation between back end data and customer experience
- b. simple UI
- c. design first products
- d. blockchain infrastructure
- e. challenge: privacy, compliance to regulations in different states

## 2 Cryptocurrency and Blockchain: An Introduction to Digital Currencies

### 1. cryptocurrency summary

- a. relies on probabilistic thinking, no 100% certainty of ownership
- b. hedging asset, relative low return, but sometimes brings surprise
- c. blockchain: decentralized, transparent, secure, and immutable

### 2. bitcoin

- a. decentralized system of **property rights**
  - i. transaction is expensive in current system since need to deal with different jurisdictions/sovereigns
- b. key: notion of identity - digital signature, ensure impossible to forge or replicate
- c. private key: 256 bit number in hexadecimal from pseudo random number generator
- d. public key: address, for transaction
- e. only valuable for exchange, but not for tax, stock etc.
- f. prevent tamper on **ledger**: a memory system, contains all bitcoin transactions
  - i. make it recursive - keep all previous transactions in each digest
- g. equilibria for using bitcoin
  - i. major value
    1. not relying on a centralized intermediary
    2. not manipulated by a central bank

- ii. no one uses - worth 0
  - iii. used by a narrow group
  - iv. dominant medium of exchange
  - v. alternative for dollar (even Federal Reserve seems solid now)
3. **blockchain:** cryptographic method of the tamper proof ledger, and store transactions into blocks
- a. implementation: linked list of transactions as blocks, use hash pointer SHA-256 that generates cryptographic digest pointing to the previous transaction
    - i. collision-resistance
    - ii. hiding: impossible to reverse engineering
    - iii. puzzle-friendliness: for mining
  - b. issue
    - i. *double-spend attack*: require sign-off of a certain address (person) for the transactions - tend to be centralized
    - ii. *distributed consensus*: use randomness and avoid honest assumption on any node, only extend on the longest fork - some node may try to include both correct and malicious transactions
- Bitcoin Distributed Consensus Algorithm – First Pass**
1. New transactions are broadcast to all nodes
  2. Each node collects these transactions into a block
  3. At a fixed interval, a *random* node gets to propose its block
    - Including a hash pointer to this previous block
  4. All nodes check the block to make sure the transactions are valid

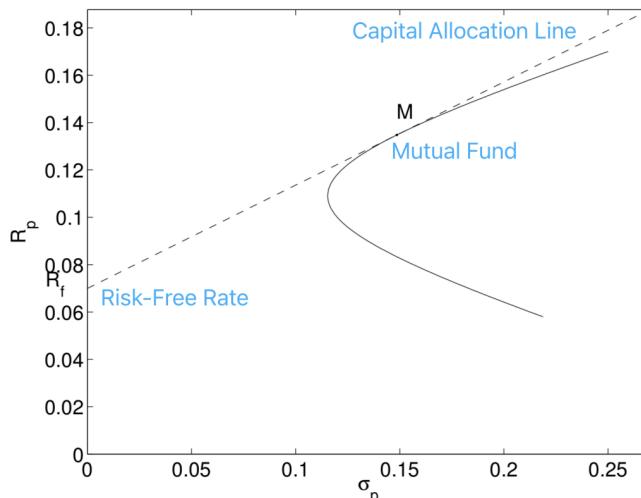
Repeat steps 1 - 4

  - First pass through Bitcoin's distributed consensus protocol
    - Transactions are broadcast to the network
    - Nodes collect the transactions into a block
    - Nodes are chosen at random to propose a block
    - In subsequent rounds, other nodes accept or reject that block
    - Disagreements become forks in the blockchain
    - Short forks are usually abandoned – it is the policy of honest nodes to extend the longest fork
- iii. *Proof of Work PoW*: incentivize honest behavior when a node extends on your block
    1. challenges: concentrating mining power, not likely; high energy use, 6% of banking; low scalability
    2. breakthrough: incentivize so that tampering is unprofitable instead of making tampering impossible
  - c. architecture: Base layer, Application protocol, Application layer at the top of the “stack”
  - d. decentralization pros: reduces entry barriers, creates potentially much more competitive ecosystem of products and services
  - e. investors: Initial Coin Offerings ICO: fundraising for projects
4. **mining:** for rewards due to PoW, a block is mined every 10 minutes
- The Hash Puzzle**
- Nodes compete to have a chance to propose the next block
  - They succeed if they are the first to solve a hash puzzle
  - The hash puzzle is a cryptographic puzzle
  - Puzzle-friendliness implies that these puzzles can be found
- a. The only way to solve the cryptographic puzzle is through trial and error
  - b. a block contains: a timestamp, a nonce/hash referring to previous block, and list of all previous transactions
  - c. after a block is mined and puzzle solved, the transaction is confirmed
  - d. a process can be both deterministic (given initial conditions) and random (unpredictable)
5. **Staking:** address low speed of mining with Proof of Stake PoS
- a. amount of crypto held determines the amount one can mine

- b. encourages honesty to each node's interest in holding value for their own value
- 6. interoperability: ensure blockchain implementations can work with each other
  - a. cross chain messaging: relays messages about blockchain state
  - b. cross chain atomic swaps: exchange tokens w/o third party
- 7. other extensions/parties
  - a. Smart Contracts: algo performs contract terms
  - b. Oracles: submit real-world occurrences (e.g. data) to a blockchain for smart contracts
  - c. legal audit
  - d. security and audit
  - e. distributed data privacy platforms
- 8. crypto finance
  - a. Crypto payment: effectuate real-time payments
  - b. Crypto Privacy: use ring signature by anyone from a group to obscure identity
  - c. Crypto wallet: work for multiple currencies, interact with blockchains
  - d. Crypto exchange: for fiat currency based on current market price
  - e. Stable coins: linked to currencies or indices, avoid price volatility
  - f. Hardware wallet: reduce large scale vulnerabilities
  - g. Blockchain merchant: accept cryptos as payment
  - h. Crypto FinTech: trading, insurance (but lack data), lending (high interest), investment funds
- 9. cryptocurrency **return** measurement: price determined by exchange rate to dollar
  - a. median return usually < mean return
  - b. if return is normally distributed, **volatility** measures risk
  - c. subject to survivor bias (top 3 cryptocurrencies have positive mean return)

## 10. Portfolio Theory 投资组合理论 (more in 3.4)

- a. key: there are gains from diversification, transcends the normal distribution assumption
- b. assumptions
  - i. investor prefer more to less
  - ii. investors are risk averse
  - iii. returns are *normally distributed*
- c. all risky assets lie inside of the **risky asset frontier**
- d. efficient frontier is part of the minimum variance frontier that gives high expectation
- e. **Tangency Portfolio**



- i. M has the attainable highest tangent slope so optimal and efficient
- ii. **Sharpe ratio:**  $(E[R] - R_{FR})/\sigma$ , describes extra return you receive per unit of standard deviation or risk return trade off, reach highest at Capital Allocation Line
- iii. **Mutual Fund Theorem:** solve portfolio allocation problem
  1. determine M
  2. determine where you want to be on the Capital Allocation Line based on risk tolerance

iv. consequence: Capital Asset Pricing Model **CAPM**

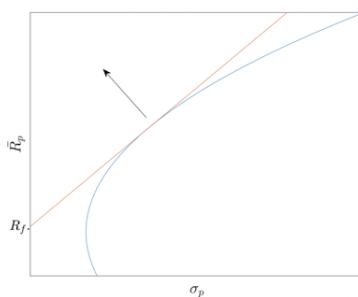
1. market portfolio, the portfolio that holds assets each one's market weights, is an efficient portfolio
2. the market portfolio has the highest Sharpe ratio possible
3. security market line/ security characteristic line: can take  $R_{F,R} = \text{Treasury Bill return 国库券收益}$

$$E[R_i] = R_{F,R} + \beta(E[R_M] - R_{F,R})$$

$$\beta = \text{Cov}(R_i, R_M) / \text{Var}(R_M)$$

11. asset allocation with cryptocurrency

- a. CAPM: Sharpe ratio of top 3 cryptos do no yield better result than S&P 500, unfavorable
- b. **Alpha**: abnormal return that CAPM does not explain,  $\alpha = E[R] - E[R_i] = 0$  if CAPM holds
  - i. cryptos has positive  $\alpha$  higher than many other investments
  - ii. actually you can push the Sharpe ratio higher by including an asset with positive  $\alpha$



- c. Gordon Growth Model: price of an asset is determined by next year's dividends, expected

$$P = \frac{D}{r - g}$$

return and annual dividend growth rate

- i. cryptos value is 0 all the time since  $D = 0$
- ii. consider D as convenience of exchange (convenience yield) - cryptos serves as a hedging security in bad economic times

12. business use cases of blockchain

- a. value exchange
  - i. content monetization
  - ii. marketplaces of goods, services, jobs etc.
  - iii. energy: relevant data services, smart grid management etc.
- b. shared data
  - i. IoT
  - ii. Supply chain/logistics: increase transparency, security, efficiency and scalability
  - iii. attribution for collaboration: for artistic content production, verify and authorize
  - iv. reputation system: reward accurate info, create reputation score
  - v. healthcare info: access control of personal info
- c. authenticity: ownership transfer
  - i. data and title (real estate)
  - ii. ticketing
- d. diversified financial
  - i. legal
  - ii. accounting
  - iii. middle and back office functions
  - iv. payroll, lending and trading, market analytics etc
- e. gaming: artistic personalization, gambling, VR

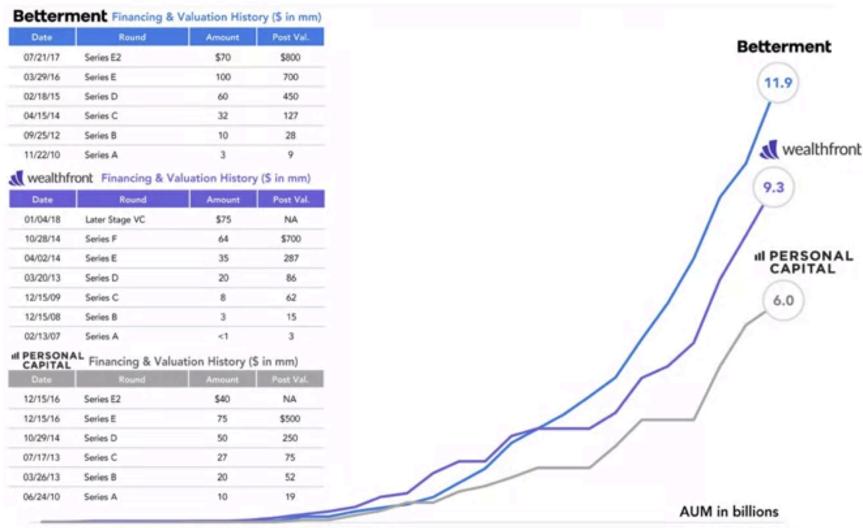
13. 'Securitize' takeaway

- a. public blockchain is the trend
- b. digitization trend
- c. marketing is highly needed in FinTech

- d. FinTech industry will be more decentralized

## 1 FinTech: Foundations, Payments, and Regulations

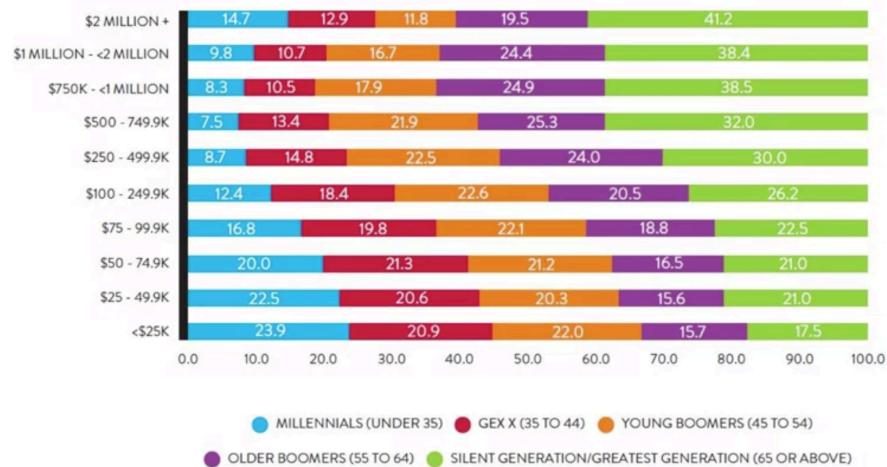
1. robo-advisory: a financial advisory firm, a practice that uses an algorithm to build a customer allocation, based on automated inputs (to build an investment strategy approach)
  - a. deprecated definition: Business models that reduce costs of client service by disintermediating humans
  - b. largest: Vanguard (\$150-200 b AUM), Schwab, Wealthfront, Betterment etc



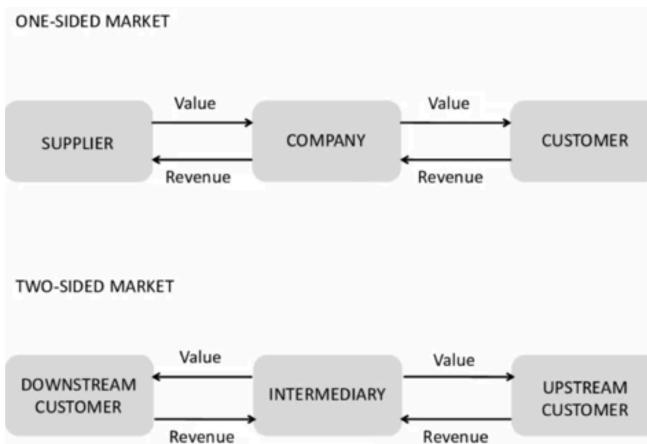
- c. reported valuations
2. market sizing
  - a. factors
    - i. Assets under management AUM
    - ii. flows of funds
    - iii. valuations of businesses in a sector or sub sector
    - iv. number of competitors
  - b. global fintech funding ~ \$111.8 billion in 2018
    - i. \$20.7 b in UK, 2018
    - ii. \$18.2 b in China, 2018
    - iii. \$34.2 b in Europe, 2018
  - c. digital payments is the largest component of fintech by transaction volume, ~\$3.6 trillion in 2018
3. Insurtech: property, casualty, life and health, financial product insurances like variable annuities etc.
4. Millennials/Gen Y 1977-1995 are critical fintech target group
  - a. 25% of US population, 83 m, in 2015
  - b. 40% of global adult population in 2015
  - c. median income \$25k for 18-27, \$47k for older

- d. more double millionaires

### Generational Wealth Distribution



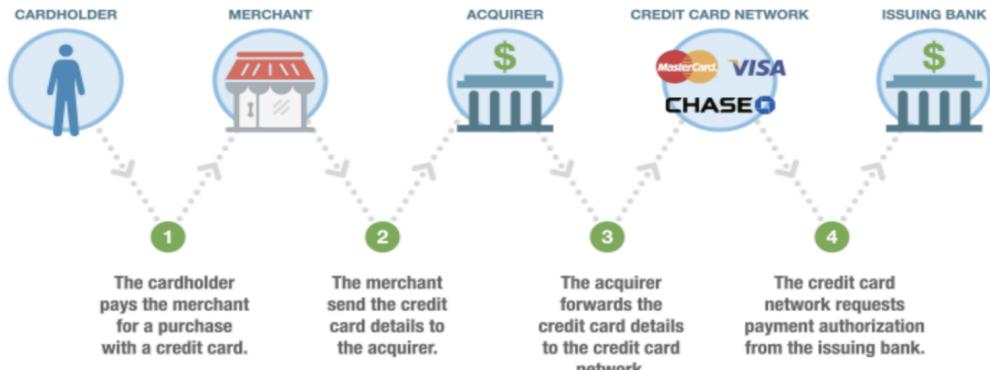
- e. less confident in managing family money
  - f. lower trust in others
  - g. interested in entrepreneurship, heavily attached to social network
  - h. optimistic about financial future
  - i. highly affected by previous experience, low risk tolerance if experienced financial crisis
5. discrepancy of important aspects of advisors between financial advisors and clients (see slides 1-2): trustworthiness, knowledge, friendliness etc
6. People trust humans more than algorithms - practical implication for the digital human application?
7. challenge: choice architecture
  - a. as choices increase, decision-making paralysis happens, and people tend to be less happy at the result
8. **card** dominates modern payment
  - a. card networks are more than a two-sided market



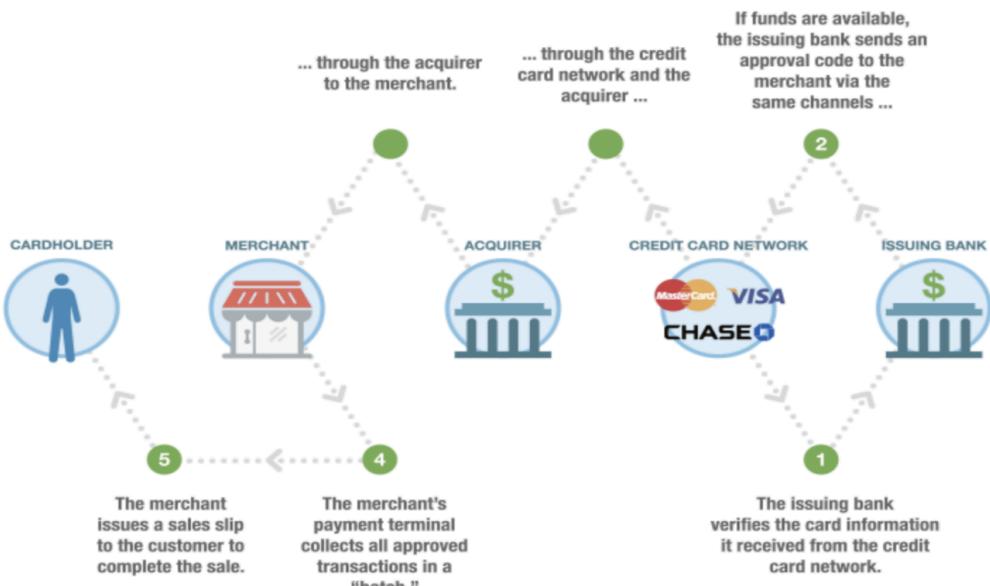
- b. transaction fee is usually the second highest cost for merchants after labor

	Merchants	Cardholder
<b>Benefits</b>	Customers that don't carry cash can buy products/services	Credit care rewards (points, airline miles, etc.)
	Cash-based theft reduced	Ease-of-payment A credit line
<b>Costs</b>	Pay 1-3% of transaction value in fees	Possibility of fraud Interest if late on a statement payment

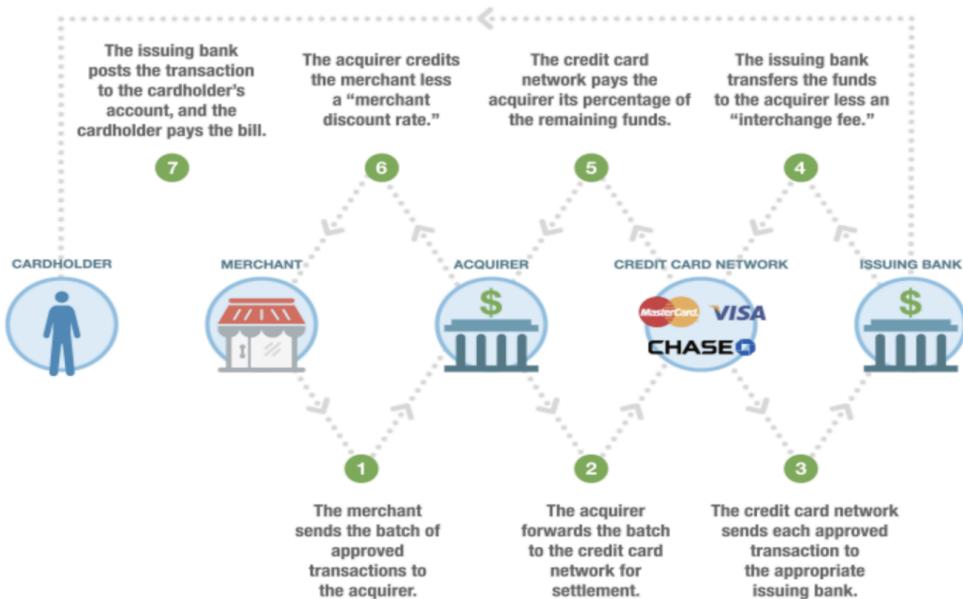
- i. starbucks solution: pay processing fee for gift card purchase instead of every time a coffee is sold
- ii. venmo: initially P2P transaction, now allows C2B without fee
- iii. paystand: reduce fees for B2B transactions
- c. complex card payment process - far from real time processing in US
  - i. authorization



### ii. authentication



### iii. clearing & settlement



- d. credit card reward comes by high processing fee e.g. American Express
- e. debit card **overdraft fees**: started with case-by-case practice, then spread due to significant revenue potential - protection regulations and opt-in rules - cut or eliminated

- f. 2009 USA Credit Card Accountability, Responsibility and Disclosure (CARD) Act: reduce excessive **late fees** charged, limit interest increase rates without fair warning
- 9. regulatory sandbox: framework to allow small scale live testing of innovations in a controlled environment under the regulator's supervision
- 10. global fintech regulations
  - Clearly defining internal regulatory authority is a necessary step for coherent FinTech regulation (USA)
  - Regulatory sandboxes have been found to increase value and capabilities of participating firms (UK)
  - While absent regulation can spark a boom, it also gives rise to a market full of scams and high-risk financial models (China)
  - Active and collaborative regulation can be encouraged through innovation hubs that help FinTechs navigate the regulatory landscape (Australia, Singapore)
- 11. RegTech: tech to address regulatory challenges and facilitate delivery of compliance