

Investment Recipes

by  AtonRā Partners



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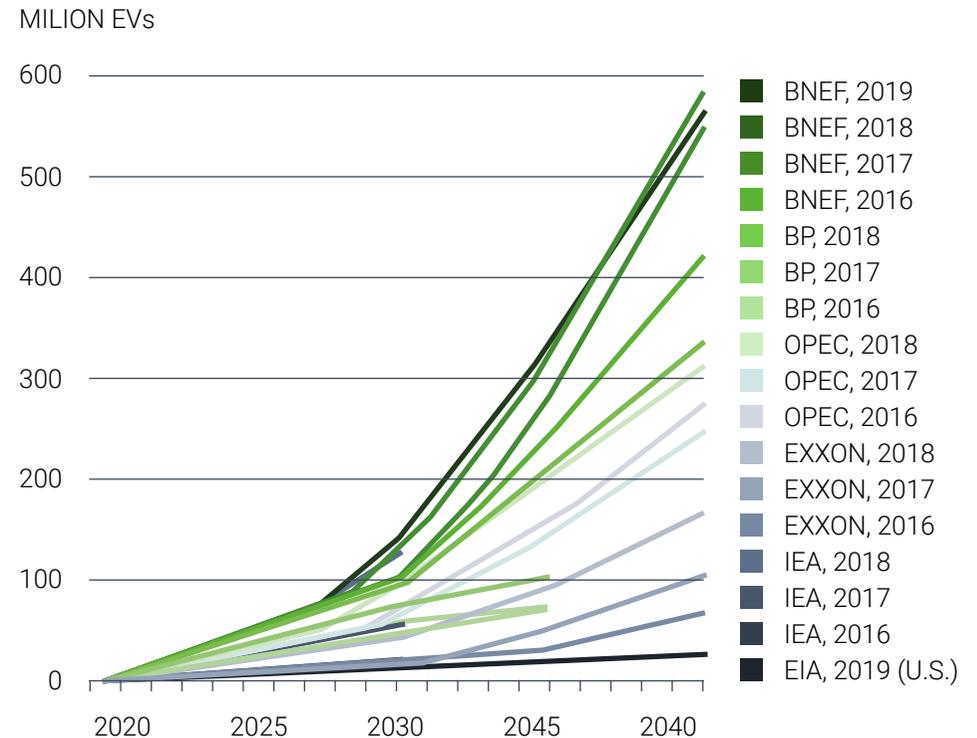
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HYDROGEN VEHICLES: DREAM OR REALITY?

Electrification of Transport is Coming at a Rapid Pace!

- The 2015 Paris Agreement established a consensus target to keep global warming “well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase even further to 1.5°C by the end of the century”.
- Transport represents about **23% of global energy-related GHG emissions** and is thus a key sector to tackle.
- To achieve the “below 2°C” target, the International Energy Agency estimates that at least **20% of all road transport vehicles** globally must be **electrically powered by 2030**.
- The global Electric Vehicles (EVs) fleet is estimated at more than 5mn in 2018 (vs. 2mn in 2017), and forecasts go up to >500mn EVs by 2040.
- The vast majority of EVs are **Battery Electric Vehicles (BEVs)**, but **Fuel Cell Electric Vehicles (FCEV)** may still benefit from the booming EV market.
 - FCEVs have a distinctive advantage in long-haul and heavy duty vehicles (trucks, buses, tractors, etc.)

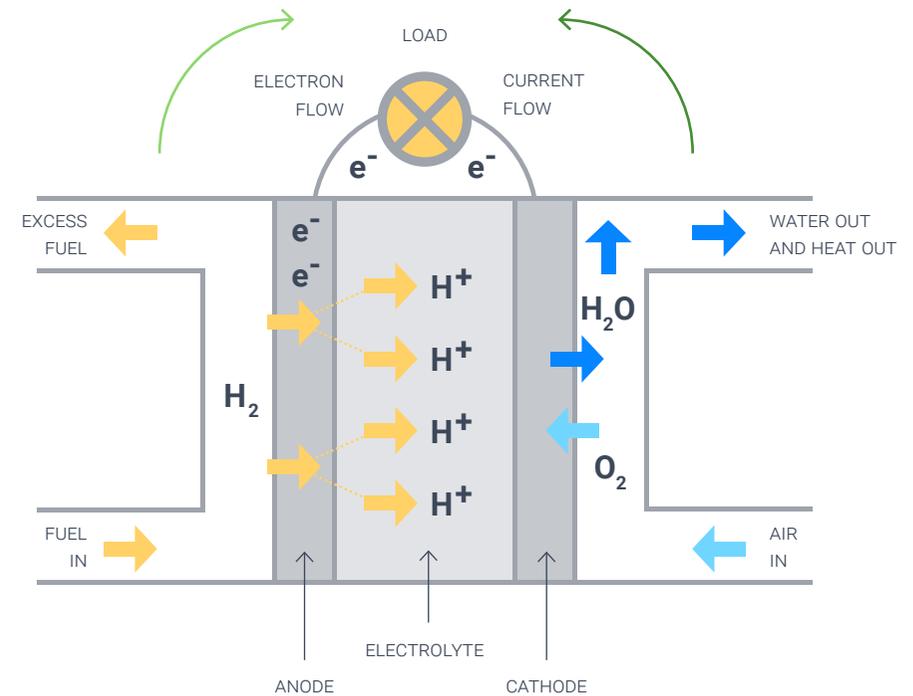


EV sales forecasts vary across organizations, but the prevailing trend is a continuous upward revision.

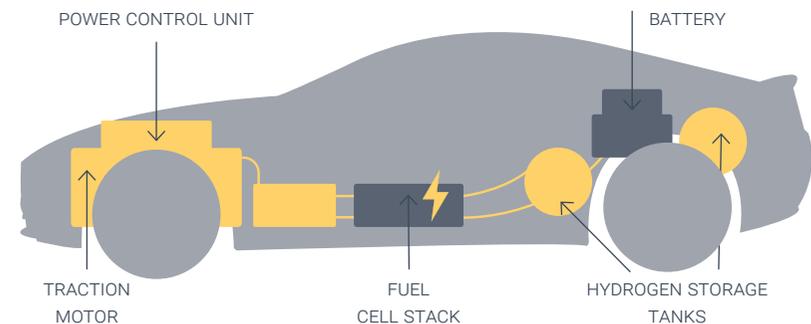
SOURCE:
BNEF, EV Outlook 2019, <https://about.bnef.com/electric-vehicle-outlook/>

FCEV: What is it about?

- FCEVs store energy in the form of compressed **hydrogen gas** which is then converted into electricity through an onboard **fuel cell**.
- The fuel cell is made of an electrolyte membrane placed between a positive electrode (cathode) and a negative electrode (anode).
- The anode is fed by hydrogen while oxygen (from the air) is introduced to the cathode.
- The electrochemical reaction breaks the hydrogen molecules into protons and electrons.
- Electrons are forced to travel through an external circuit, thus **powering the car**.
- Protons go through the membrane and recombine with oxygen molecules on the cathode side to form **water** (the only direct emission).
- A small battery is used to store energy generated by regenerative braking and provide additional power to the motor.



VEHICLE TYPE	Battery Electric	Fuel Cell Electric
STORAGE MEAN	Battery	Hydrogen
REFUELING TIME	30min–8hrs	3–4 min
CHARGING STATIONS	~170'000	381
ENERGY DENSITY	~200Wh/L	~350Wh/L
FUEL COST	1.5–2 \$ / 100 km	7–7.5 \$/ 100 km
CAR COST	from ~ 30k\$	from ~60k\$
DRIVING RANGE	100 – 400km	>450km



SOURCES:

<http://www.benzspirit.com/fa91913a0e871e46-fuel-cell-diagram-rtds-technologies-inc.html>

<https://www.cartrade.com/blog/2016/greens/fuel-cell-vehicles-benefits-and-challenges-1757.html>

Public & Private Commitments to Boost the Take Off

Governments

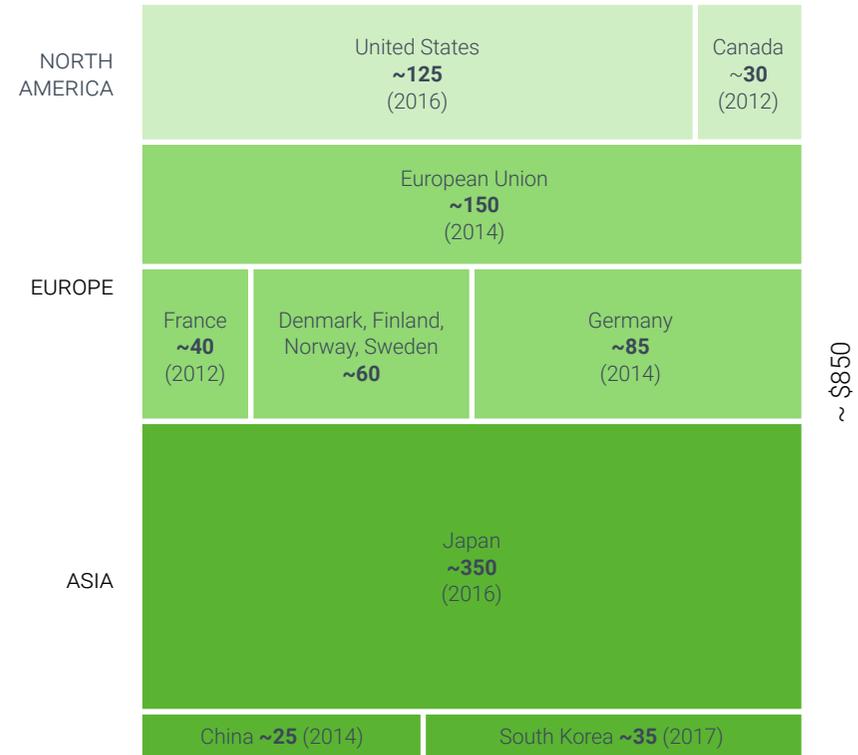
- According to a recent study by McKinsey, global commitments into hydrogen and fuel cell technology total about \$850mn annually.
 - Japan, South Korea, Germany, and USA (California) lead the race.
 - Japan intends to become the world's first hydrogen society and plans to have **900 stations** and **800'000 FCEVs** by 2030.
 - South Korea recently unveiled a roadmap for boosting its hydrogen economy and targets production of 100'000 FCEVs by 2025, 1.8mn by 2030 and **6.2mn** by 2040.
- The Hydrogen Council, a global initiative of 60 leading energy, transport, and industry companies, estimates that **\$280bn** are needed to improve production, storage, distribution of hydrogen and build up refueling infrastructure.

Companies

- The leading manufacturers currently are **Toyota, Honda, and Hyundai**, who sold respectively 75%, 13% and 11% of all 11'200 FCEVs produced so far.
 - Toyota plans to move to **"mass production"** starting in 2020 with a target of **30'000 FCEVs per year**.
 - Hyundai recently announced in its "FCEV Vision 2030" an annual production target of 500'000 FCEVs by 2030
- Eleven automakers have already committed on launching new FCEVs by 2021, including Toyota, Honda, Hyundai, Kia, Lexus, Mercedes-Benz, and BMW.

SOURCES:
<https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/hydrogen-the-next-wave-for-electric-vehicles>
 IEA Global EV Outlook 2019

SELECTED GOVERNMENT SPENDING ON HYDROGEN AND FUEL-CELL PROGRAMS, \$ MN



Governments are investing around \$850mn annually in hydrogen

Catalysts:

- **Government incentives** could speed up the adoption of FCEVs enabling carmakers to reach **economies of scale**.
- FCEVs could benefit from the emergence of “**shared mobility**” where uptime (and thus reducing charging time) is increasingly important.
- BEVs and FCEVs could play **complementary roles** and grow together, as they would equip different types of vehicles.
 - BEVs mainly for personal cars, FCEVs for long-range and heavy duty vehicles (trucks, buses, etc.)

Risks:

- **High Cost of Vehicle:** the competitiveness of FCEVs depends on the ability to bring down costs of fuel cells and on-board hydrogen storage.
 - For FCEV to catch up with BEV in terms of price competitiveness, significant investments in R&D are still needed.
- **Limited Distribution Infrastructure:** FCEVs will require the deployment of a new infrastructure to cover the entire hydrogen value chain, from transport, through storage and delivery to vehicles. Lack of infrastructure remains an obstacle to adoption.
- **Non-Ecological Hydrogen Production:** Ecological footprint of FCEVs will depend on primary energy used to produce hydrogen
 - Use of non-renewable resources to produce hydrogen could tarnish the image of FCEVs.
- **Breakthrough in Battery Tech:** any new-coming technological breakthrough in batteries which would provide the same benefits of FCEV (charging time and energy density) at a lower price.

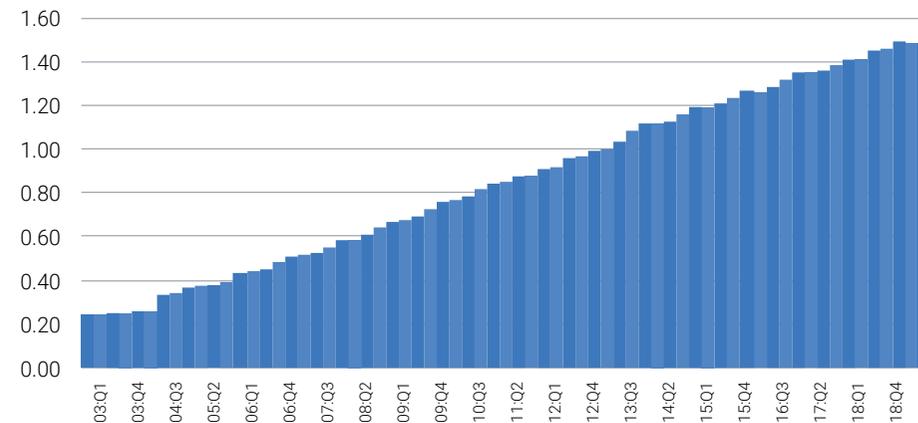
Bottom Line:

- The global zero-emission vehicles trend is firmly in place.
- BEVs profit from a “first-mover” advantage and are currently the primary beneficiaries in the short term.
- FCEVs are likely to gain more and more traction over the long term thanks to growing investment in technology and infrastructure.
- FCEVs have a distinct advantage in **heavy-duty vehicles** given the longer driving ranges allowed by on-board storage tank size and quicker refueling time.

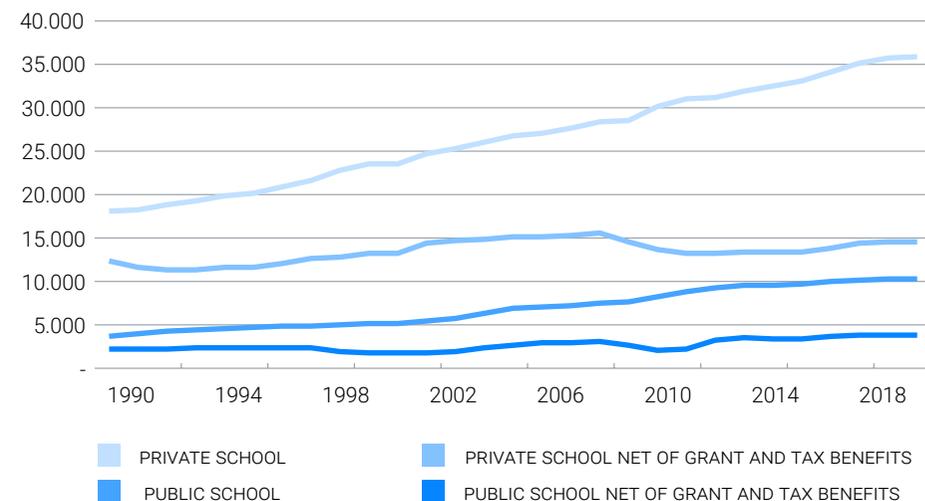
CAN FINTECH TACKLE THE U.S. STUDENT DEBT PROBLEM?

- Student debt in the United States has become a **significant issue**.
 - It currently amounts to \$1.5tn and accounts for 10.8% of the total debt outstanding (vs. 3.3% in 2003).
- Tuition fees at private institutions **doubled between 1990 and 2018, on an inflation-adjusted basis**.
 - The average cost to attend a single year at a private university exceeded \$35k in 2018-2019, to which an estimated extra \$12k would be added for room and boarding fees.
- Net of grants, the **real cost of attending private university has remained the same since 1990**.
 - The increase in tuition fees has been fueled by government and schools grant aids.
 - Private schools can give large grants thanks to their endowment funds (over \$600bn).
 - Moreover, it relates to consumer psychology: students feel more comfortable to attend a school with a \$35k tuition reduced by \$15k aid, than a \$20k education with no aid.
- **75% of students borrow money** to be able to attend their chosen school.
 - There are 44.7mn people with a student loan in the U.S. who pay an average monthly installment of \$393.

EVOLUTION OF STUDENT LOAN



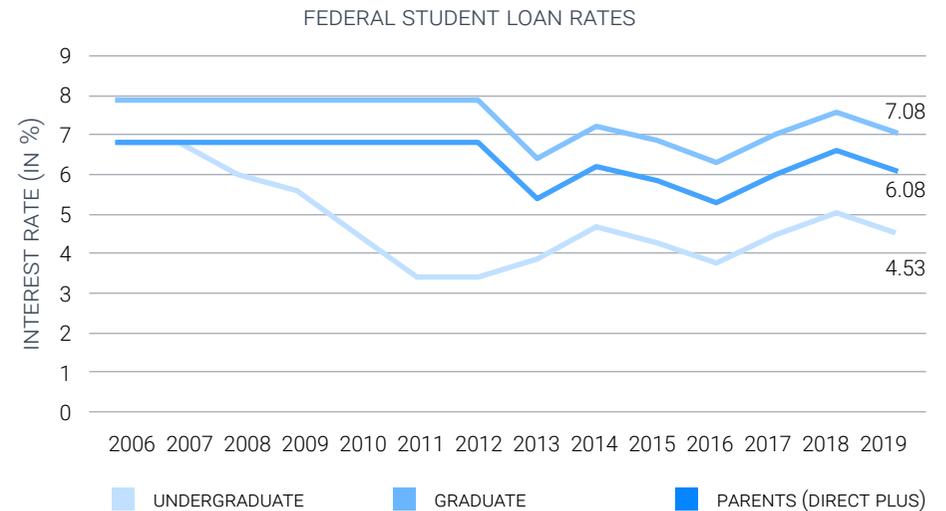
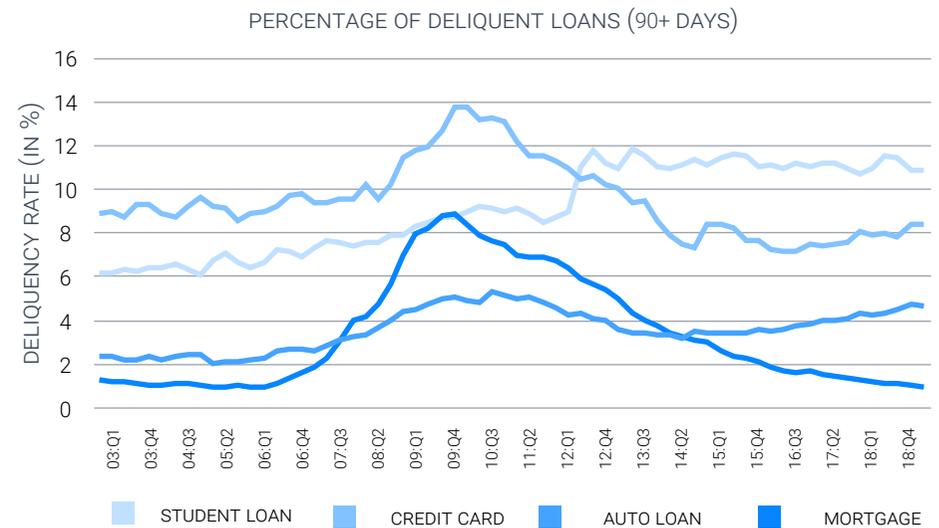
EVOLUTION OF TUITION FEES (INFLATION ADJUSTED)



SOURCES:
 AtonRā Partners, New York Fed, as of Q2 2019
 AtonRā Partners, College Board Trends in College Pricing 2018, as of October 2018

CAN FINTECH TACKLE THE U.S. STUDENT DEBT PROBLEM?

- Student loan debt has a **significant impact on society**.
 - The financial burden limits savings (e.g., retirement plans) and investments (e.g., housing), and puts pressure to accept a job even if underpaid or not matching the skillset
- **The U.S. Federal Government** originates 90% of student loans.
 - The rates offered by the government are set annually and do not change over the life of the loan.
 - The average interest rate on outstanding student loans is 5,8%.
- Student loans have the **highest delinquency rate in the U.S.**
 - The loans become a financial burden for those students who do not graduate, and those who graduate from predatory college models providing little or no marketable skills.
- Fintech companies see the **business opportunity**.
 - A national problem generating billions of interests paid per year.
 - Dealing with federal agencies is far from easy.
 - They aim at simplifying the process and improve the user experience.



SOURCES:
AtonRā Partners, Federal Student Aid, as of September 2019

CAN FINTECH TACKLE THE U.S. STUDENT DEBT PROBLEM?

Overview of the fintech segments active on student loans:

- **Refinancers & Loan Providers:** These companies propose to aggregate and refinance existing student loans. Refinancing is eventually executed in-house or through a traditional player. They aim at providing:
 - better interest rate
 - lower monthly payment
 - single counterparty
- **Rates comparison / Marketplace:** After filling out a single form, students receive several offers from traditional players.
- **Employee benefits:** Some fintech firms propose payroll services to employers to match the employee's monthly installments.
- **Aggregator / Advisor:** The only company in this category offers a platform to view all outstanding debts on a mobile app; an algorithm then proposes solutions to optimize the student's situation.
- **P2P lending:** Although P2P lending was not originally designed to cover student loans, some users have been using these platforms to refinance their debt.

REFINANCERS & LOAN PROVIDERS



RATES COMPARISON/MARKETPLACE



EMPLOYEE BENEFITS



AGGREGATOR / ADVISOR

P2P LENDING



TRADITIONAL & HISTORIC PLAYERS (EXAMPLES, IN COMPLEMENT TO MOST BANKS)



NB – Certain companies may be offering several services targeting student debt. Non-exhaustive list.

CAN FINTECH TACKLE THE U.S. STUDENT DEBT PROBLEM?

- Some notable names in the sector, which have received attention (and substantial seed money) from investors are:
- **SoFi** generates revenue estimated to be north of \$500mn.
 - In its latest financing round this year, the company raised \$500mn from the Qatar Investment Authority.
 - An IPO is expected for 2020 or 2021.
- **Laurel Road** has already refinanced \$4bn of student debt.
 - The company was acquired by **KeyBank** (KEY US) in April 2019.
- **LendingTree** (TREE US) operates the leading online loan marketplace.
 - In July 2018, it announced the acquisition of **Student Loan Hero** for a total consideration of \$60mn in cash.
 - Before the deal, Student Loan Hero had refinanced \$3.5bn in student loans for 200'000 borrowers.
- **Goodly** is still an early-stage start-up that raised USD 1.3mn in its series A financing round.
 - It proposes to automate student loan repayment through a matching contribution from the employer
 - Only 4% of companies use such employee benefits, but estimates indicate that 32% will do so by 2021.



\$4.8bn valuation
\$18bn of student debt refinanced
800'000 members



\$4bn of student debt refinanced
Acquired by KeyBank (KEY US)
in April 2019



Leading online loan marketplace
Acquired Student Loan Hero
to gain market shares



Innovative service
49% of millennials prefer student loan
benefits over 401(k) contributions

Catalysts:

- **Interest rate:** The rates charged by the Federal Government hardly match the recent evolution of the long-term rates.
 - The spread provides compelling opportunities to companies who can leverage their technological advantage and their lighter cost structure.
- **M&A potential:** Fintech companies are disrupting traditional financial companies by offering platforms with better user experience.
 - Traditional players must adapt to these new entrants who are gaining market shares and eroding the margins of the well-established companies. The most natural solution will be through partnerships or M&A activity.

Risks:

- **Politics:** a significant change to the system could take place, impacting Fintech companies focusing only on student debt.
 - The current situation is not sustainable and could put the U.S. economy at risk in the future.
 - The three leading Democrat contestants in the 2020 presidential race have made significant proposals, that go as far as wiping out 75% of outstanding debt or offering free education.
- **Image/communication:** Fintech companies could be perceived as capitalizing on social misery.
 - When a private entity refinances a federal loan, the borrower loses certain rights, e.g., access to the Federal Student Loan Forgiveness Program.
 - Moreover, people who need to refinance their loans are often those who are likely to be already in delinquency or who go through life difficulties – unemployment, divorce, disease, etc.

Bottom line:

- As credit apps and start-ups are being launched, the penetration rate should increase as more people will trust and use these services.
- We monitor the M&A activity of the listed company and the potential IPOs looking for the emergence of a niche leader in the student debt market and the online credit market in general.
- We maintain our view that the traditional credit providers will see a more intense competition and will experience lower margins.

THE “BAD” CHOLESTEROL: LOWER IS BETTER

Cholesterol: Vital For Life....

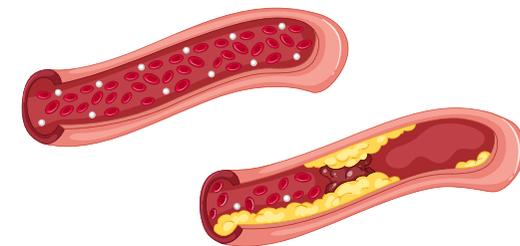
- Cholesterol is a type of lipid present in the body and comes from 2 sources:
Food and Biosynthesis (produced by liver's cells or other cells)
- Despite its bad reputation, cholesterol is an **essential component of the membranes of every cell in the body.**
- **Lipoproteins** are responsible for the transportation of cholesterol in the bloodstream, and there are 2 types:
 - Low-density lipoprotein (**LDL**): carries cholesterol from the liver to peripheral tissues. When levels are too high, LDL particles accumulate in the blood → the “bad” cholesterol
 - High-density lipoprotein (**HDL**): carries cholesterol back to the liver. It clears cholesterol from peripheral tissues → the “good” cholesterol

ALMOST 100MN PEOPLE IN THE US ARE AT HIGH RISK*

LDL CHOLESTEROL (mg/dl)	CATEGORY
<100	DESIRABLE
100–129	NEAR OPTIMAL
130–159	BORDERLINE HIGH
160–189	HIGH
190+	VERY HIGH

...But Many Diseases Linked to Hypercholesterolemia

- Hypercholesterolemia, high levels of LDL-c in the blood, contributes **to fatty build-ups in the arteries.**
- Although hypercholesterolemia is asymptomatic, it can significantly increase the risk of:
 - Cardiovascular diseases (coronary heart disease, stroke, peripheral vascular disease...)
 - High blood pressure
 - Diabetes
 - **NASH**, the fatty liver disease



SOURCES:

healthmetrics.heart.org

National Center for Chronic Disease Prevention and Health Promotion, *Division for Heart Disease and Stroke Prevention

A Huge Market with Important Unmet Medical Needs

An analysis of the US population shows that :

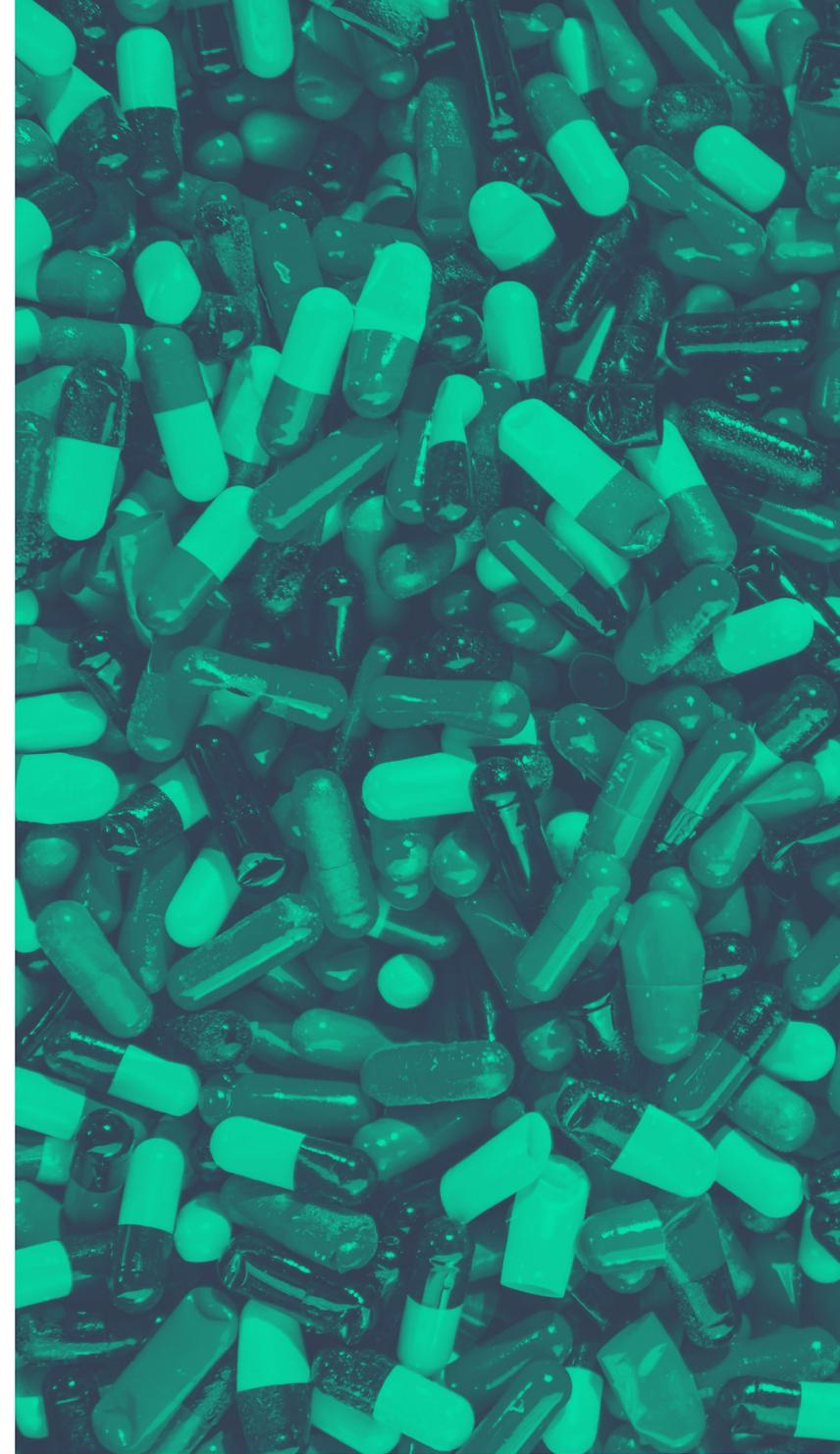
- There is about 37% prevalence rate, or about 97mn people with Hypercholesterolemia
- Only about 45% are diagnosed, which means about 44mn patients with high ASCVD risk
 - 80% (or about 34mn) are on statins, but 3 out of 10 are under the desired LDL-c goal levels
 - 15-20% (or about 10m people) do not tolerate statins

DISEASES RELATED TO HIGH LDL-C	CAUSE	FORMS	DIAGNOSIS
Familial Hypercholesterolemia (FH)	Genetic: Most patients have variants in one of three genes: LDLR gene, APOB gene, and PCSK9 gene.	Homozygous: the mutation is passed from both parents → The more rare and severe form Heterozygous: the mutation is passed from one parent	Genetic confirmation or clinical LDL-C ≥ 500 mg/dL Genetic confirmation or clinical LDL-C ≥ 190 mg/dL
Atherosclerotic cardiovascular (ASCVD)	Lifestyle	–	Physical & blood test

SOURCE: Esperion presentation Q2 2019

Existing Therapies: Still A Lot Of Room For Improvement

- 1st line of treatment: Statins, which usually lowers LDL-c levels by 30-60%
 - 15/20% patients can not tolerate statin therapy because of side effects. 3 out of 10 adults on statin therapy don't reach their LDL-C targets
 - Side effects: intestinal issues, muscle inflammation, high blood sugar, type 2 diabetes
- 2nd line of treatment: Ezimibe (Zetia, by Merck) which usually lowers LDL-c levels by some 20%
 - Zetia prevents the absorption of cholesterol in the intestine.
 - The drug has modest power in lowering LDL-c levels, but it is very safe, therefore is used in combination with other treatments.
- 3rd line of treatment: PCSK9 inhibitors (Praluent, by Sanofi and Repatha, by Amgen) which usually lower LDL-c by 36-72% and also reduce cardiovascular risk
 - PCSK9 is an enzyme that binds to the LDL receptor and ultimately causes its intra-cellular degradation.
 - They changed the landscape of LDL-c market reducing bad cholesterol to very low levels .
 - However, they are injectable and very expensive drugs.
 - Most patients are already taking more than one medicine per day: they want an easy to take pill.
 - PCSK9 inhibitors are recommended for patients with very severe forms of hypercholesterolemia



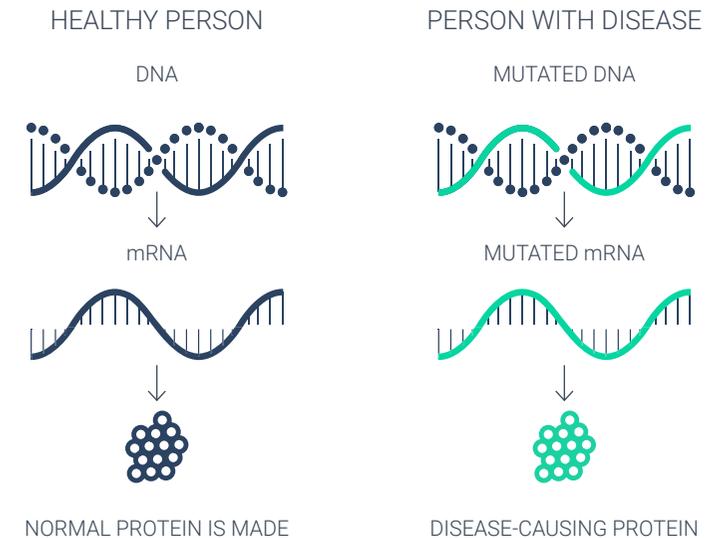
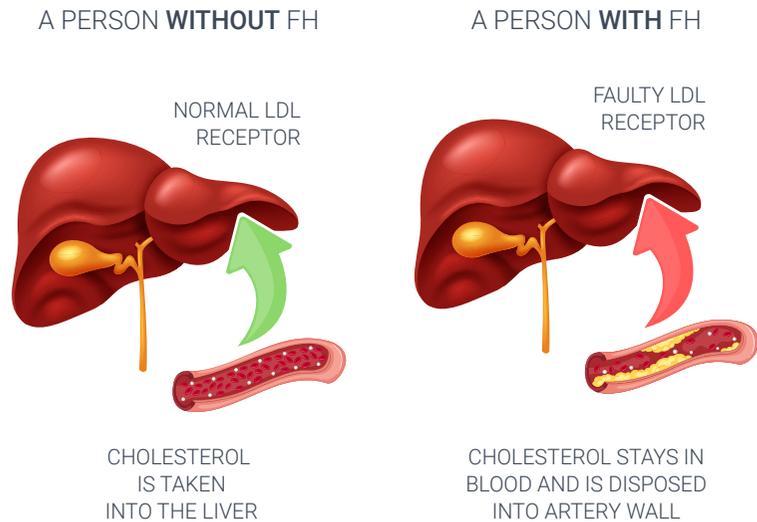
Promising Treatments In Development: New Mechanisms Of Action

- **ACL Inhibitor** (*Bempedoic Acid; Esperion*): represents a novel therapeutic approach.
 - *in phase 3*, an easy-to-take pill, Bempedoic Acid reduces cholesterol synthesis and therefore the level of bad cholesterol. It has no important side effects. It also reduces the risk of cardiovascular disease. However, in high-risk patients, the treatment may not be strong enough.
- **ANGPTL3 Inhibitor** (*Regeneron*): Mutations on the ANGPTL3 gene reduce the good cholesterol. A drug inhibiting the ANGPTL3 gene may increase HLD-c levels.
 - *in phase 2 and 3*: for “genetic” forms of Hypercholesterolemia (FH) where there are mutations on this gene. The inhibitor restores the level of HDL (the good cholesterol). This drug is a good candidate for HoFH, the rare and most severe form of FH where there is an urgent need of additional therapies to lower life-threatening cholesterol levels.
- **Thyroid hormone (TH) beta receptor** (*Madrigal; Viking Therapeutics*): TH beta receptor activity lowers LDL cholesterol, lowers triglycerides and lowers liver fat.
 - *in phase 2*: oral form and once-daily formulation. Potential benefits in multiple indications (CVD, NASH), beyond Hypercholesterolemia. However, the reduction of LDL-c levels are less impressive than other candidates.



Promising Treatments In Development: Treat The Root Cause by Gene Therapy

- **DNA Gene Therapy for LDL receptor gene** (*Regenxbio*): for homozygous familial hypercholesterolemia (HoFH) – a monogenetic disorder.
 - *in phase 1/2a*, this gene therapy is designed to deliver the LDL receptor gene. The production of LDL receptors is then restored. LDL receptor represents an ideal target as it contributes to >90 % of the capture and breakdown of LDL. It has received an orphan drug product designation.
- **Small interfering RNA (siRNA) drugs** (*The Medicines Company*): PCSK9 inhibition is associated with low bad cholesterol levels and low cardiovascular risk.
 - *in phase 3*, siRNA directly targets the original source by cleaving mRNA. The mRNA is degraded and thus unavailable for PCSK9 protein production. The main potential advantage compared with direct injection of PCSK9 proteins is the dosing frequency as it remains active over a long duration of time.
- **Generation 2+ ligand-conjugated Antisense drugs** (*Ionis/Akcea*):
 - *in phase 2*: Antisense drugs also bind to mRNA like siRNA and therefore the amount of disease-causing protein is dramatically decreased.



Catalysts:

- **Huge market** with still a significant unmet medical need.
- **Rising incidences** of Hypercholesterolemia due to an increase of obese and geriatric population and healthcare awareness.
- **A high level of “bad cholesterol”** increases the risk of developing cardiovascular diseases, a major health problem and the leading cause of mortality in the world.
- **Better diagnostic techniques** will increase the number of patients.
- **Several mechanisms of action** are being investigated and new technologies such as DNA / RNA gene therapy could provide new solutions.
- **Treatments for high cholesterol** could be used in combination with other drugs to treat diseases such as NASH or cardiovascular diseases.

Risks:

- **Competition risk:** The market for LDL-C lowering agents is large with several players in the space.
- **Commercial risk:** high cholesterol is a silent killer so commercial risk is higher than for drugs.
- **Mechanism of Action risk:** we do not know exactly how cholesterol and lipids (fatty acids and triglycerides) biosynthesis works. The relationship between cholesterol and other diseases (NASH, cardiovascular diseases, etc.) is also unclear.

Bottom line:

- Too much bad cholesterol in the blood can lead to fatty plaques which obstruct arteries and could lead to cardiovascular diseases. It is a huge market, for “bad” cholesterol-lowering drugs. Novel approaches could provide a solution for patients unable to take statins, who represent 15 to 20% of patients.
- New mechanisms of action have been identified, and drugs in development have the potential to be more effective and safer. DNA and RNA Gene therapy offer the possibility to treat the root cause of the disease. As is often the case, drugs combination are usually the most successful, resulting in strong M&A / partnership activity.

Appendix: Summary Of Players

COMPANY + COMPOUND	PHASE	INDICATION	RESULTS	MOA
Esperion (Bempedoic acid)	3	Hypercholesterolemia	30%+ reduction in LDL-C; 20%+ reduction in addition to Statins*	ACL Inhibitor – small molecule
The Medicines Company (ORION-9, ORION-10 and ORION-11)	3	Hypercholesterolemia	NA	Small interfering RNA (siRNA) therapy
Akcea/ Ionis / Novartis (AKCEA-APO(a)-LRx)	2	Hypercholesterolemia/ Hyperlipoproteinemia	Reduces Lp(a) levels by 79-92%*	Lp(a) knock out (antisense technology)
Regeneron (EVINACUMAB)	2 and 3	Hypercholesterolemia (both HeFH and non-FH) + HoFH	Reduces Lp(a) levels by 79-92%*	ANGPTL3 Inhibitor
Regenxbio (RGX-501)	1/2a	HoFH	NA	Gene therapy for LDL receptor gene
Madrigal (MGL-3196)	2	HeFH, HoFH, NASH	~30% reduction of LDL-c in MAD study in healthy Volunteers*	Thyroid hormone beta receptor agonist
Viking Therapeutics (VK2809)	2	Hypercholesterolemia, NAFLD, X-ALD	15%-37% pbo adjusted LDL Reduction*	Thyroid hormone receptor beta (TR β) agonist

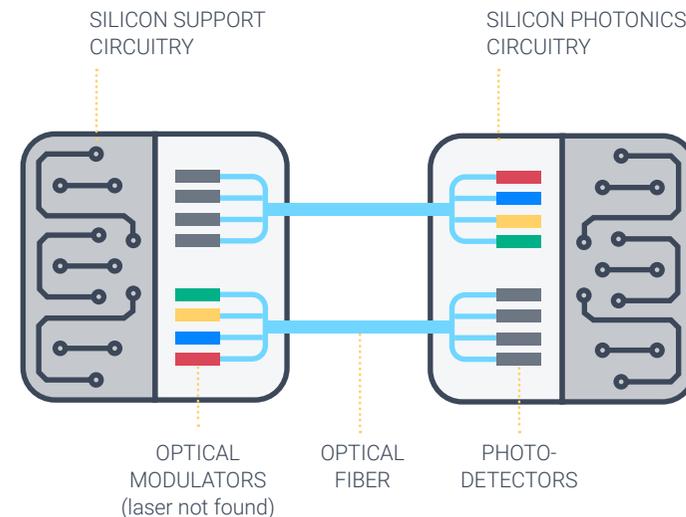
SOURCE:

*Companies annual reports

OPTOELECTRONICS : ENABLING THE FUTURE OF COMMUNICATION

SiPho: the future of communications

- The semiconductor industry has long relied on silicon (Si) – a stable, resistant and very abundant material – for building its components.
- Production know-how has developed and attained high-efficiency levels.
- Silicon chips use electrons to transmit data – despite the ability of the semiconductors industry to improve its capability of treating data exponentially, there are physical limits that impact bandwidth and power density, i.e., speed of transmission.
- That opened the way to optical systems (like optical fibers and lasers), which use photons, i.e., light, instead of electrons.
- Optical systems have a distinct advantage in long distance communications.
- But the manufacturing of photonic devices is still very complex and costly.
- Photonic devices are made with exotic and costly materials, (e.g., erbium), and they are yet assembled in hundreds of pieces by hand.
- **Photonic devices made from Silicon (SiPho) address this problem by combining the positive aspects of Si fabrication (high volume assembly, low cost) and those of optical system (lossless and efficient data transmission)**



Silicon photonics (SiPho) is the latest breakthrough in optoelectronics, embedding optical technologies into Si chips: the results are lossless transmission of information and cost effective manufacturing techniques.

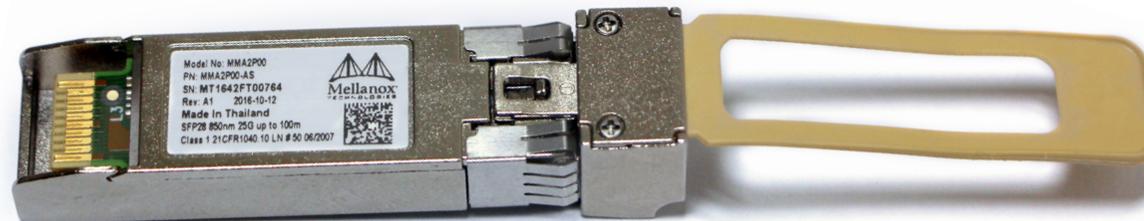
SOURCES:

<https://spectrum.ieee.org/semiconductors/optoelectronics/silicon-photonics-stumbles-at-the-last-meter>

<https://community.mellanox.com/s/article/what-is-silicon-photonics-x>

Example of SiPho device: the transceiver

- When a Netflix video is streamed, or a picture is posted on Facebook, the digital content flows through a **transceiver** (see image), a device that converts an electric signal into an optical one and *vice versa*.
- **Transceivers** are found at both ends of an optical fiber and are composed by the following elements:
 - **Optical modulators**, the core; it modulates light with the shape of a given digital electric input
 - **Transmitters/receivers**, they are simple laser/photodiodes that convert light into voltages and vice versa
 - **CMOS logic IC**, circuitry used to encode and decode data
- SiPho transceivers bring two main advantages: Silicon modulators are extremely efficient and compact, and the fabrication methods allow to integrate all the above elements on the same wafer, therefore reducing overall size.
- The most appealing application for such devices is in the connections between racks and servers within a datacenter
 - SiPho are a much better alternative to the currently and widely used copper wires, which suffer from **bandwidth and heating limitations**.
 - This represents a **high-volume market**.



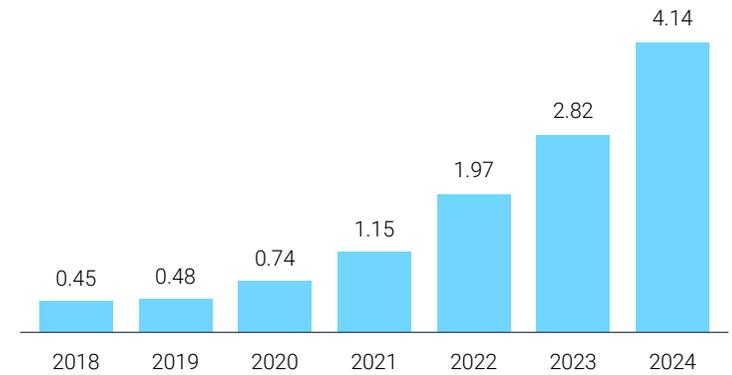
Courtesy of Mellanox Technologies

SOURCE:
<https://ieeexplore.ieee.org/document/8540501>

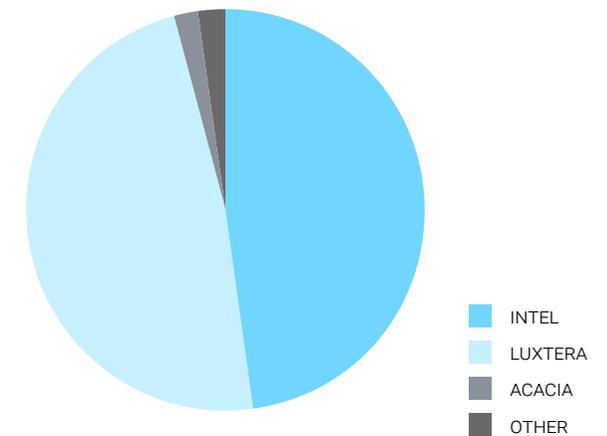
SiPho: the biggest opportunity in the PIC market

- SiPho market is expected to reach \$4bn in 2024, representing a **CAGR** of **44%**.
- Units sold were 1.3mn in 2018 and are estimated to be 23.5 mn in 2024 (**CAGR** of **53%**).
 - The most significant driver will be datacenter interconnects (DCI)
- The market is very concentrated: Intel, Luxtera (Cisco) and Acacia have a combined 98% market share.
- New entrants are: Neophotonics, Inphi, Oclaro (Lumentum), Finisar, POET, Sicoya, to mention a few.

SIPHO REVENUES (\$ BN)



MARKET SHARE IN UNITS



SOURCE:

https://yole-i-micronews-com.osu.eu-west-2.outscale.com/uploads/2019/04/YD19015_Silicon_Photonics_SiPh_and_Photonic_IC_PIC_yole_sample.pdf

2019 Silicon photonics supply chain*



* Non exhaustive list of companies

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https://yole-i-micronews-com.osu.eu-west-2.outscale.com/uploads/2019/04/YD19015_Silicon_Photonics_SiPh_and_Photonic_IC_PIC_yole_sample.pdf

Catalysts:

- **Datacenters:** The world's largest datacenters owners GAFAM and BAT are moving towards silicon photonics solutions because of the **technology's inherent advantages** over legacy optics.
- **Design ecosystem:** TowerJazz, a foundry, Cadence, an EDA company, and Lumerical, a software company, have partnered to deliver a **silicon photonics integrated** process design kit.
- **5G:** fiber and high-speed transceivers are required to reach the multi-Gbps speeds promoted by wireless carriers.
- **Autonomous Vehicles:** AVs will be filled with sensors, among which many will be optical, and SiPho will provide the performance and cost advantage.
- **AI:** Deep neural networks (DNNs) using SiPho have already been demonstrated at the research level and have reached the development phase. Energy greedy algorithms will find **SiPho-based DNN** as greener and faster alternatives to a classical accelerator

Risks:

- Traditional electronics may keep a cost advantage if Moore's law keeps on scaling, and physical limits are pushed over.
- Market cannibalization by big players (Intel, Cisco,...) might hinder the development of a competitive landscape.
- New materials, for instance two-dimensional materials, like graphene, or other semiconductors, like indium phosphide InP, represent a substitutional threat to Silicon.

Bottom line:

- Optics will be more pervasive than ever as we approach traditional electronics physical limitations – SiPho will largely benefit as it represents the ideal platform to interface optics and electronics
- SiPho technology is reaching maturity in terms of cost efficiency, and it represents a better technological alternative to existing solutions.

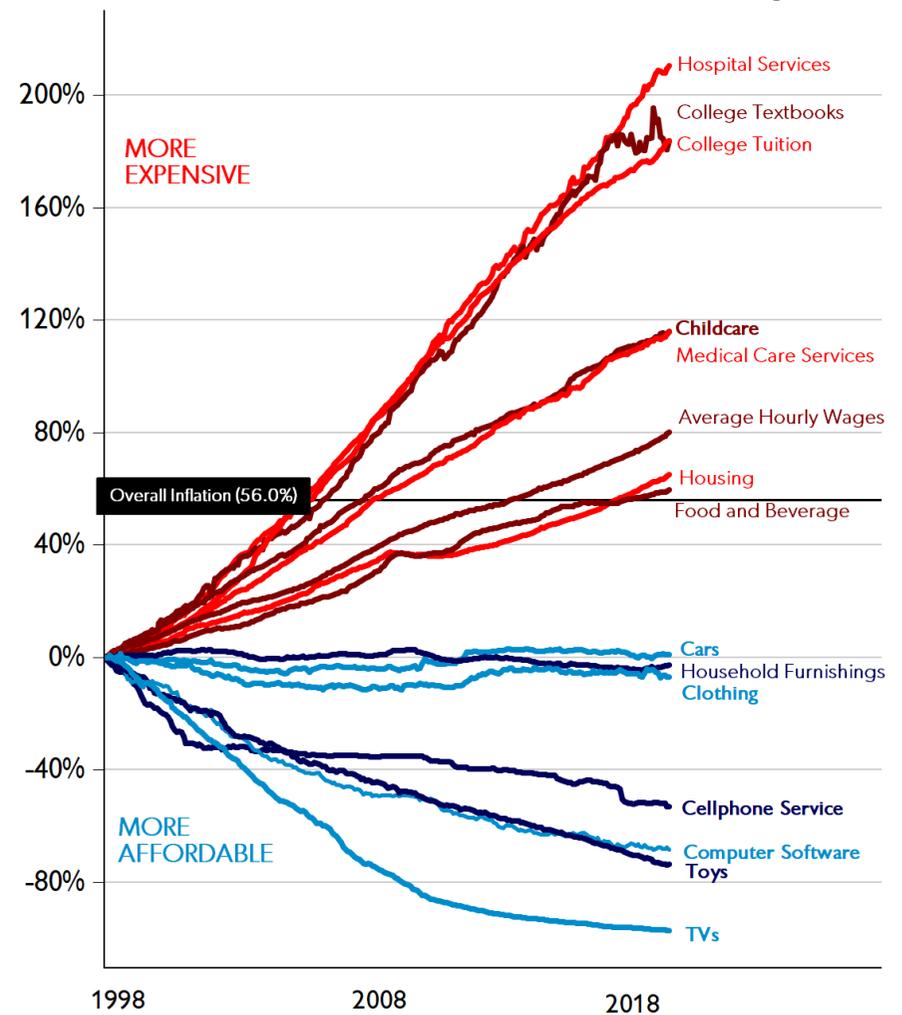
CHARTS FOR THOUGHTS

When inflation is not equal for all

- The chart here, courtesy of Mark Perry, professor at the University of Michigan and author of the CarpeDiem Blog, has been largely referenced to
- There are various ways to explain the big differences among the selected sectors in terms of price inflation, but it all boils down to the **sources (or lack) of pricing power**
 - Government involvement, level of international competition, tradability of goods vs. services
- From an investment perspective, pricing power is desirable but not necessary
 - **Volume growth** can offset price erosion
 - Lower prices may stimulate volume growth (e.g., adoption of new technology accelerates as it becomes more affordable)
- **Bottom line:** sectors with little or no volume growth and weak pricing power are the most vulnerable

SOURCE:
<http://www.aei.org/>

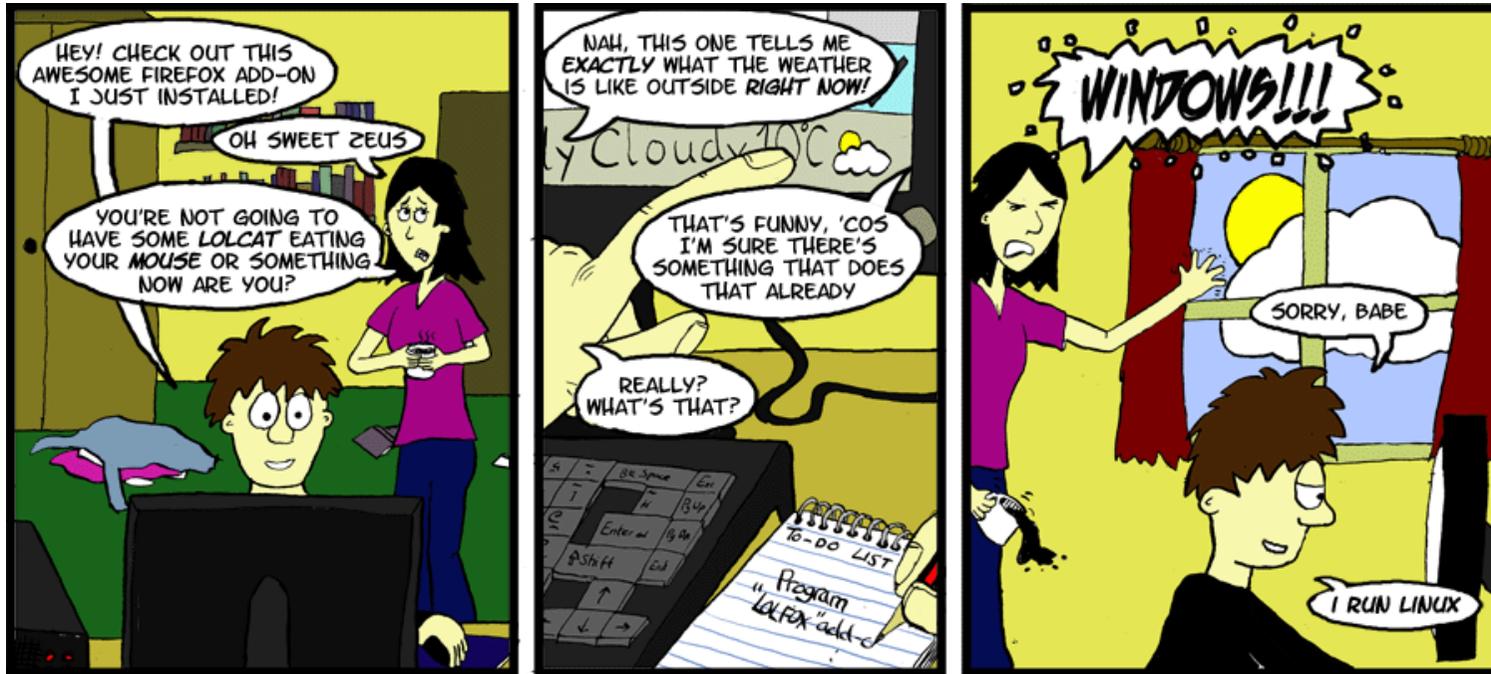
Price Changes (January 1998 to December 2018)
 Selected US Consumer Goods and Services, Wages



Source: BLS

Carpe Diem **AEI**

CASUAL FRIDAY



SOURCE:
<http://www.lukesurl.com>
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Invest Beyond The Ordinary

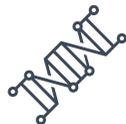
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