NAAA Webinar:

The 2022 SAAR* Outlook

WITH CLOSE LOOKS AT THE CHIP SHORTAGE AND EV DEMAND

BY GLENN MERCER

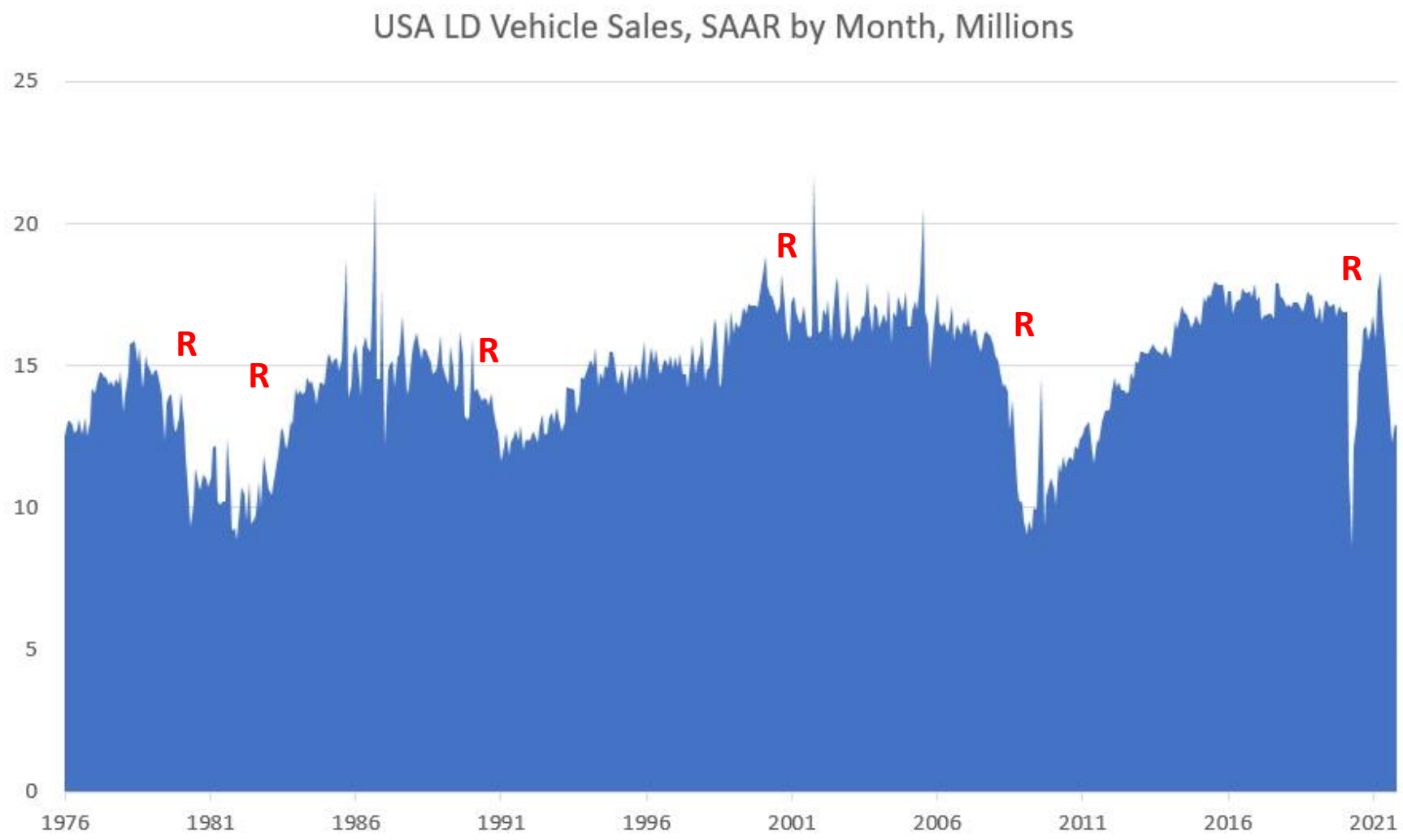
*SEASONALLY-ADJUSTED ANNUAL RATE (OF NEW CAR SALES)

Outline

(► indicates “deep dive” sections)

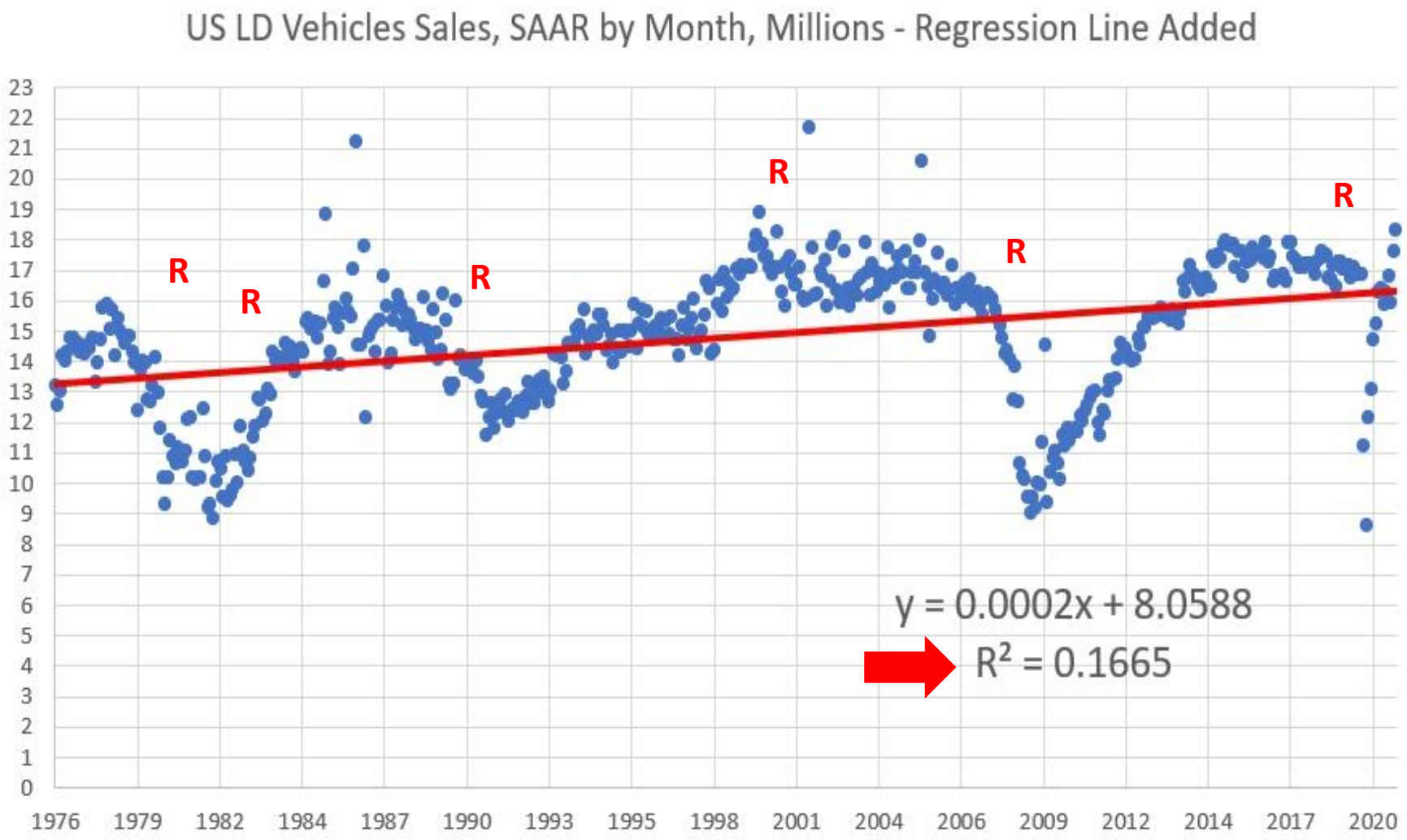
1. Background: history of new-car sales in the USA
2. Demand drivers of SAAR (looking back)
3. Supply driver of SAAR (looking ahead) ► The chip shortage in depth
4. Range of current forecasts of SAAR for 2022 (and beyond)
5. Author’s forecast
6. Potential impacts of the 2022 forecast
7. ► The outlook for EVs in the USA

History of new-car sales in the USA



Source: US Bureau of Economic Analysis; R = Recession

The historical trend forecasts poorly



Source: US Bureau of Economic Analysis; R = Recession

(Some) Drivers of SAAR Forecasts

Driver	Impact	Status
Longer-term		
Car quality	Build "quality" drives scrappage rate; features "quality" drives obsolescence	Neutral?
Hedonic/Emotional/Social Status of Car	Boosts sales beyond mere "appliance" demand for mobility	Neutral? Generational?
Population of the USA	Direct link to sales	Mildly positive
Age profile of the USA	Older people buy relatively more and relatively more expensive new cars	Positive
GDP of the USA	A wealthier population can afford more, and more expensive, vehicles	Positive
VMT (vehicle miles travelled)	More miles driven = more wear = higher replacement demand	Positive
Suburbanization	More sprawl = more VMT, also more parking (a constraint on urban demand)	Positive
Aversion to carpooling	Fewer carpools = more cars commuting	Positive
Affordability	Costlier cars are harder to buy; ameliorated by shifting demand to used cars	Negative - but by choice?
Rise of e-commerce	Reduces shopping errands but increases delivery trips	Negative?
Drivers' license penetration	Fewer DL = lower sales. Watch for shift (to older drivers) versus actual decrease.	Neutral
Rise in mobility services	TNCs, scooters, bikes, displace car VMT. Impact on car ownership less clear.	Negative
Rise of WFH (work from home)	Reduces commuting miles, increases others, adds to sprawl	Positive?
Gas prices	Higher gas price lowers car demand, but the connection is weaker than before	Negative
Shorter-term		
Used car prices	Higher UC prices shift demand to new, improve new affordability via trade-in	Positive
Covid	Pushes mobility from transit to private car ("ultimate social distancing tool"	Positive
Consumer sentiment	Economic uncertainty induces some buyers to hold off	Negative
Ease of financing	A mixture of loan rates, availability, terms	Positive
Pent-up demand	Pent-up demand provides a tail-wind to sales, up to a point	Positive
Inventory aka supply shortages	The ONLY supply-side factor here. Supply has not been a constraint for decades	Negative

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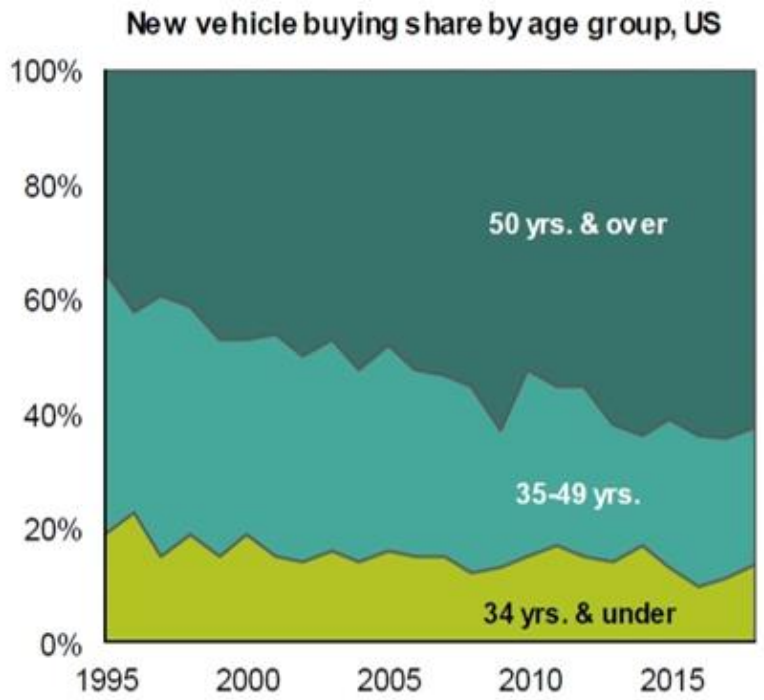
After *half a century* of sales being limited only by *demand*, we now have to deal with a *supply* constraint! This is unprecedented.

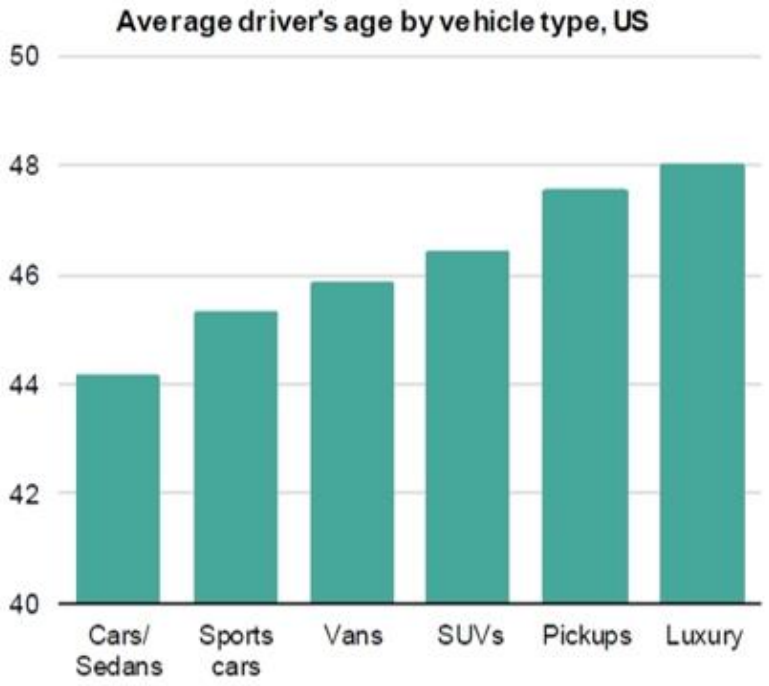
Demand Driver Detail 1: Aging America

As America ages, demand for new cars and more expensive new cars drifts upward

Older (wealthier) Americans continue to buy a larger share of vehicles, and a richer mix



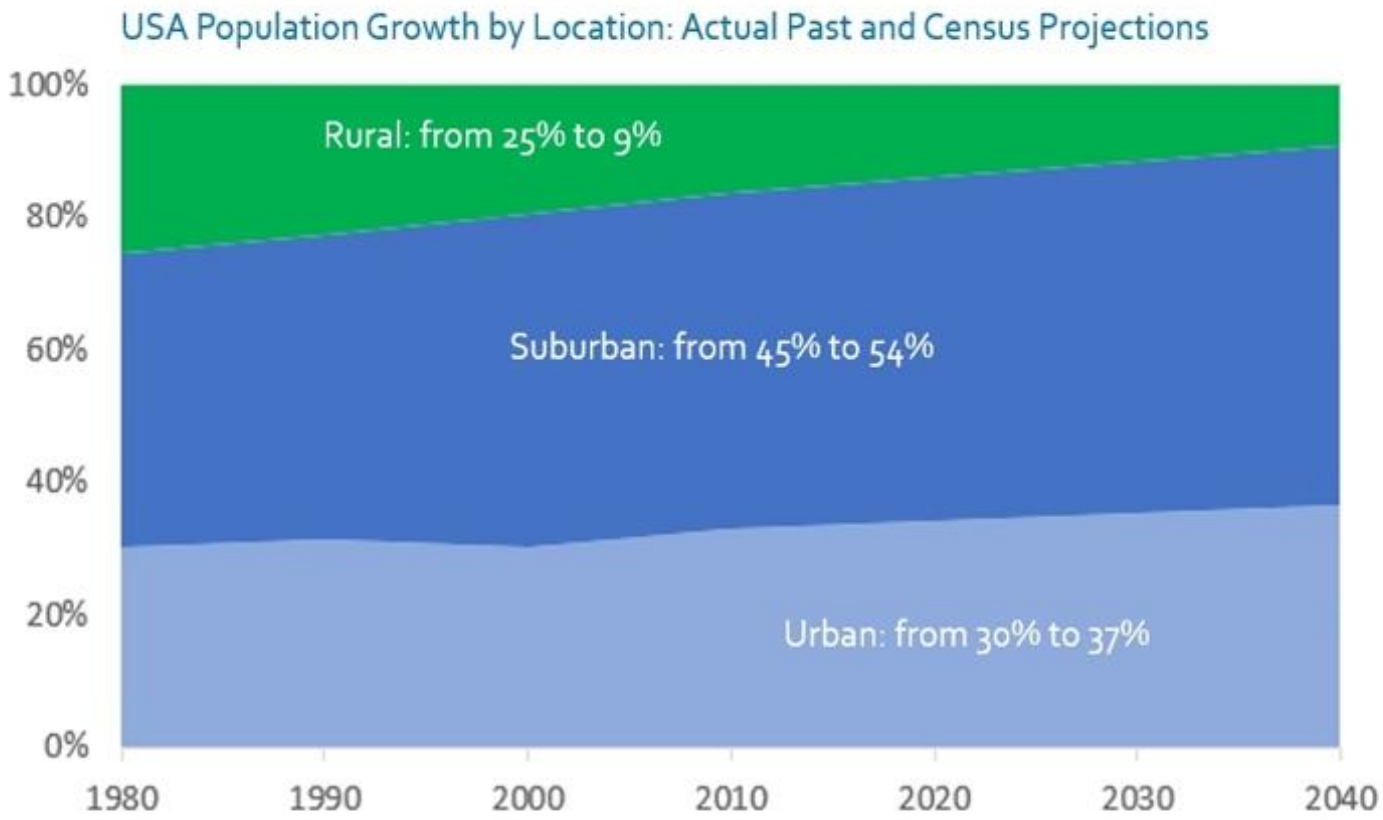
Source: Consumer Expenditure Survey, Bernstein estimates and analysis



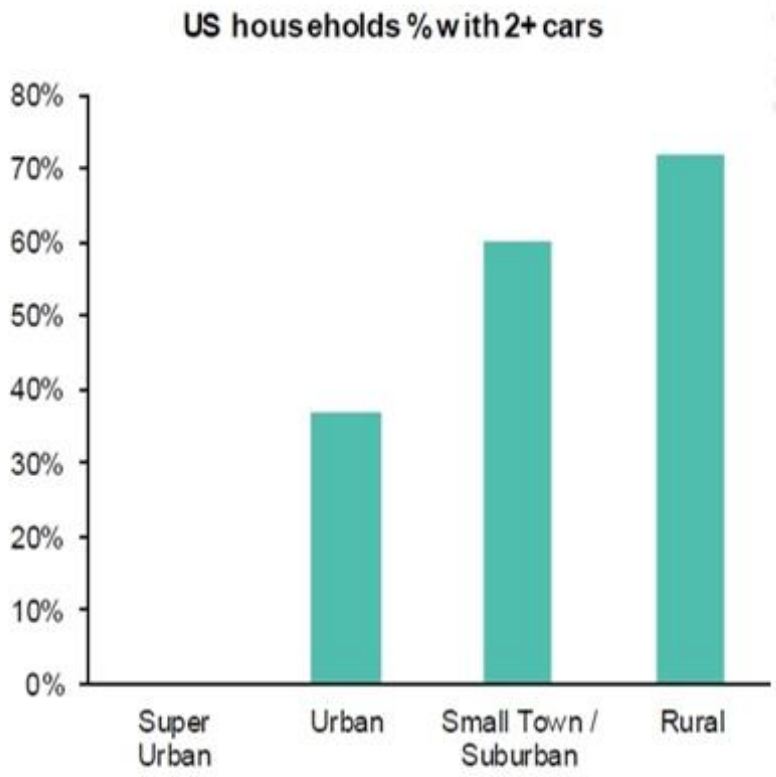
Source: National Household Travel Survey, City-Data, Bernstein analysis

Demand Driver Detail 2: Sprawling America

As America becomes more suburban, sprawl provides another lift to car sales



Source: Department of Transportation, from Census Bureau projections



Source: National Household Travel Survey (NHTS), BMW, Bernstein analysi

Demand Driver Detail 3: Ridehail tamed (for now?)

Car ownership in large cities shows no erosion from ridehail

RED = DECREASE FROM PRIOR LEVEL, GREEN = INCREASE

	2006	2011	2018	Comments
Chicago	1.16	1.08	1.12	2011 selected as approximate trough in post-recession V/H levels
Los Angeles	1.58	1.54	1.64	2018 above 2006
New York City	0.64	0.60	0.62	Lowest in America, as expected
Philadelphia	0.95	0.94	1.02	2018 above 2006
San Francisco	1.12	1.08	1.08	
Washington DC	0.90	0.84	0.88	
Boston	0.93	0.90	0.97	2018 above 2006
Seattle	1.42	1.39	1.35	Started high; biggest mass transit spending in US in last decade
Simple average	1.09	1.05	1.08	

Source: Bruce Schaller, from Census data. His view: "The evidence in these data certainly fails to support the proposition that ride-hail has produced lower levels of vehicle ownership. Rather, these trends tend to suggest that the influx of ride-hail and other new mobility options has not translated to lower vehicle ownership rates." (Schaller, *Recent Vehicle Ownership Trends in Large US Cities*, May 2020)

Demand Driver Detail 4: WFH may not cut SAAR much

Excerpts from my survey of research on WFH

Chakrabati: "***WFH, regardless of frequency, is associated with relatively more annual miles driven***. … A a telecommuting day is associated with significantly fewer miles driven relative to a non-telecommuting day, but … this reduction is not on average enough to offset the higher commute distance associated with WFH (and the additional driving for non-work purposes associated with living in distant suburban locations)."

Choo: "Our models suggest that ***telecommuting reduces VMT, [but] the reduction in annual VMT is on the order of 0.8% or less***."

Kun: "We found an overall decrease in commuting time of 41 minutes, but a 37-minute increase in personal activities, [for minimal net gain in time and possibly travel]."

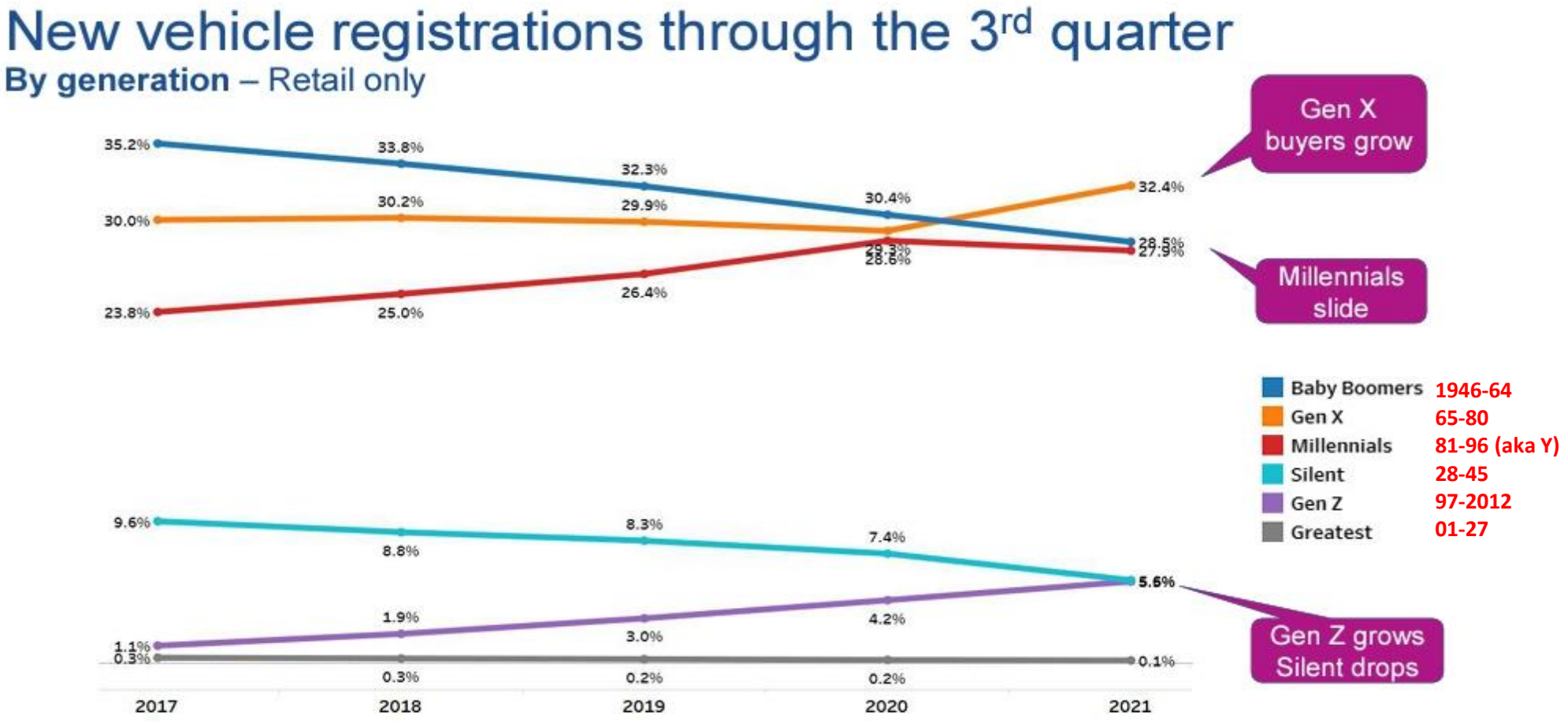
Levinson: "***The effects of telecommuting on travel in practice are limited, not noticeably affecting measures of travel behavior*** for multi-worker households and having limited effects (which are *positive*) on single-worker households' total vehicle hours of travel."

Collantes: "***Average commute lengths, are generally longer for telecommuters than for non-telecommuters,*** [possibly because] increased availability of telecommuting might cause people to relocate farther from their jobs."

Su: "***Telecommuters that have at least a trip during their workday travel more than their counterpart commuters*** but travel less driving alone. Telecommuters during a day visit a variety of locations ….using their spatio-temporal flexibility to perform work tasks anywhere they want."

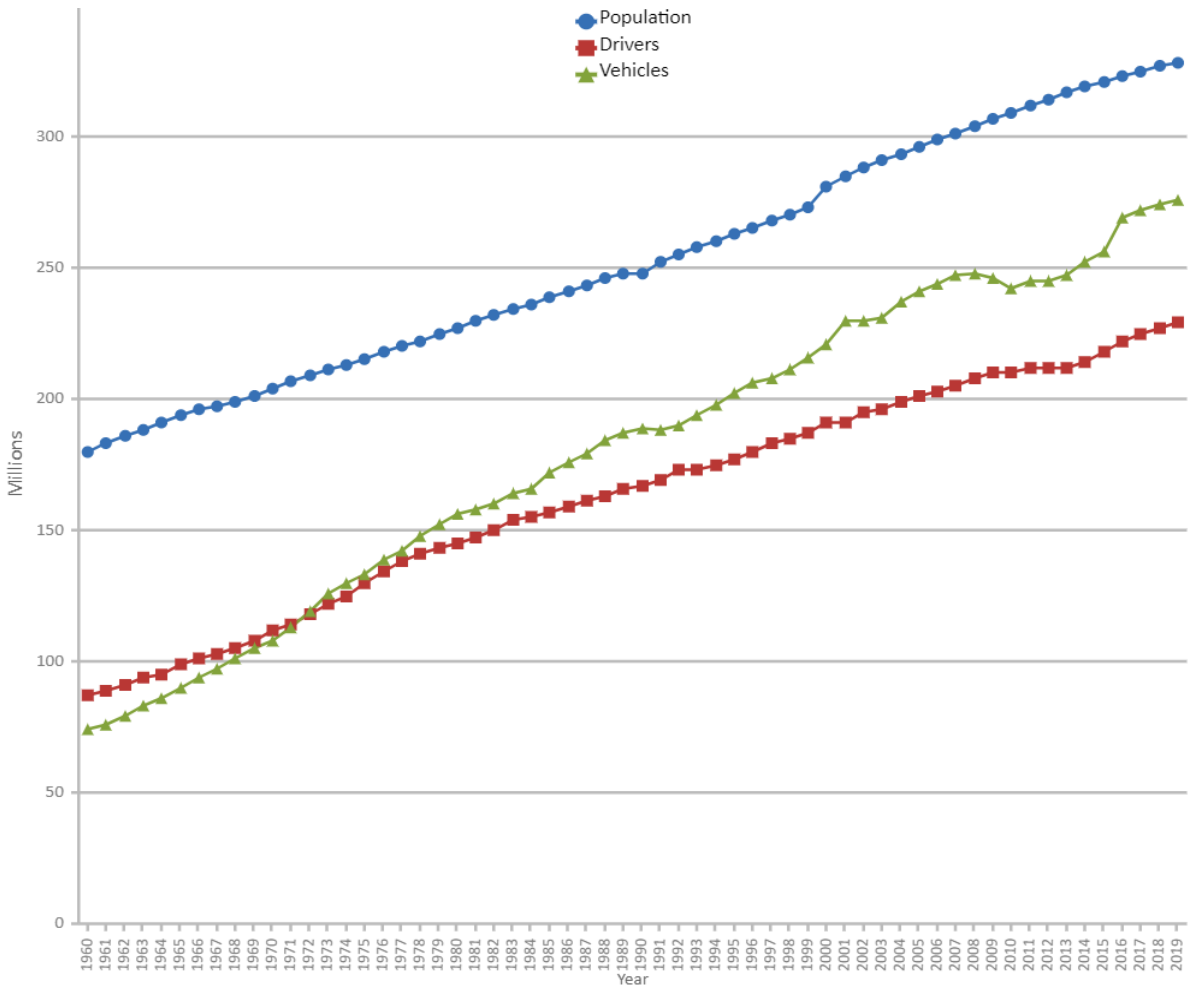
Zhu: "Telecommuters tend to choose lifestyles involving longer one-way commute, longer daily total work trips and longer daily total non-work trips than non-telecommuters, other thing being equal. This is not surprising, as WFH enables these workers to be more footloose and to live in locations that are relatively farther away from many work and non-work destinations. …***Telecommuters generally have a larger "travel budget" than their counterparts***. In this regard, policies that promote WFH may indeed increase, rather than decrease, people's travel demand. This seems to contradict to what telecommuting policies are designed for[e.g., to cut GHG emissions]."

Demand Driver Detail 5: Young people avoid cars?



Source: Experian

Demand Driver Detail 6: Driver's licenses in decline?



Source: US DOT

Comments

- Yes, fewer of the youngest Americans have their licenses (partly because 16 states have raised the minimum age for a full to DL to 18 years): under-19s are down over a million in the last decade or so
- But this has been offset and more by older Americans keeping their licenses longer: over-70s are up about 10 million in the same period
- **Share of the population that had a license in 2010-2020: 85.7%; that number in 1980-90: 85.4% (source: ALG).** To be fair, the number hit 87% around 2000.

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The Chip Shortage in Depth

1. What are chips?
2. How are they used in cars?
3. What is the “chip shortage”?
4. Why has this shortage come about?
5. How severe is the impact of the shortage on autos?
6. How long will the shortage last?
7. What steps are being taken to remedy the shortage?
8. What will be its impact on autos going forward?

What are chips?

THE PRODUCT. A microchip, aka a chip, aka an integrated circuit, is a set of electronic circuits on one small flat piece (or "chip") of semiconductor material, usually silicon. Large numbers of tiny transistors integrate into a small chip. This results in circuits that are orders of magnitude smaller, faster, and less expensive than those constructed of discrete electronic components, such as diodes or resistors. **An individual transistor is now many times smaller than a virus.** ICs are now used in virtually all electronic equipment and have revolutionized the world of electronics.

THE PROCESS. **A microchip is likely the most complex device ever constructed by humankind**. The raw materials must be almost impossibly pure: the silicon must be 99.99999999999% pure. The miniaturization is such that a cutting-edge chip may contain 50 billion transistors, with some elements only as wide as a strand of DNA. (The Apollo guidance computer had 12 thousand transistors.) Output is gigantic: over 1 trillion chips are made annually (one day's current chip production would equal all the chips that were in existence in 1985.) Lead times are long: in normal times, 6-9 months to design, test, and attain volume production (standard chip types may be ordered and delivered within 2 months or so). Suppliers tend to be specialized in order to manage complexity: a silicon wafer manufactured in Japan may be made into raw chips in the USA and then assembled into finished circuits and tested in Malaysia. As a result of all these factors, supply chains tend to be long, complex, and somewhat fragile.

How are chips used in cars? Everywhere.

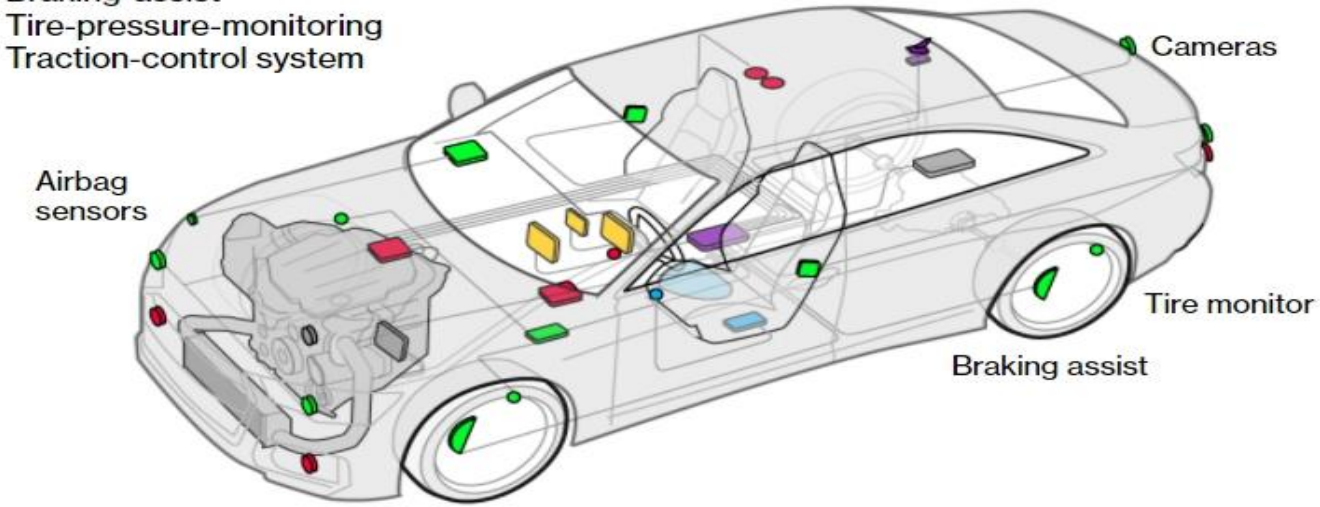
A Computer on Wheels

The average car is packed with 1,400 semiconductors that control everything from airbags to the engine. Modern cars simply cannot run without chips.

Safety
Airbag controls
Collision-avoidance
Parking-assist
Power locks
Braking-assist
Tire-pressure-monitoring
Traction-control system

Powertrain
Engine control
Fuel-injection system
Hybrid-electric control
Transmission control

Electrical
Starter
Lighting system
Vehicle-diagnostics



Comfort
Window/mirror controls
Seat controls
Climate control

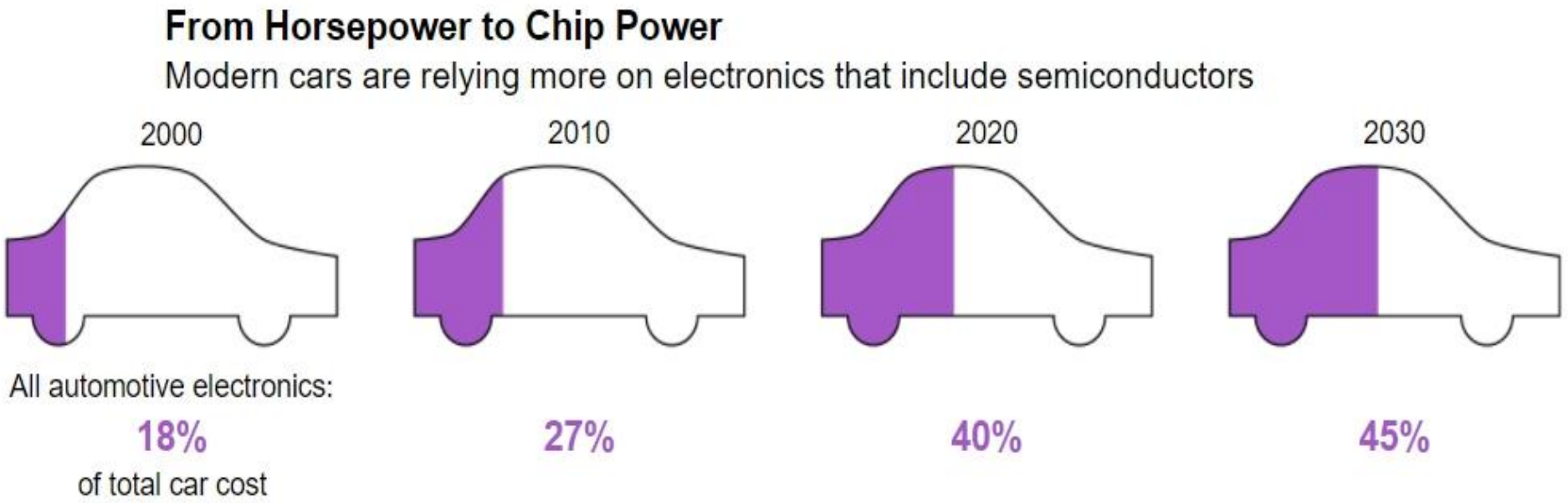
Infotainment
Audio/video
Driver display
Navigation

Connectivity
CAN (controller area network)
Broadband, Wifi, Bluetooth
Over-the-air software updates

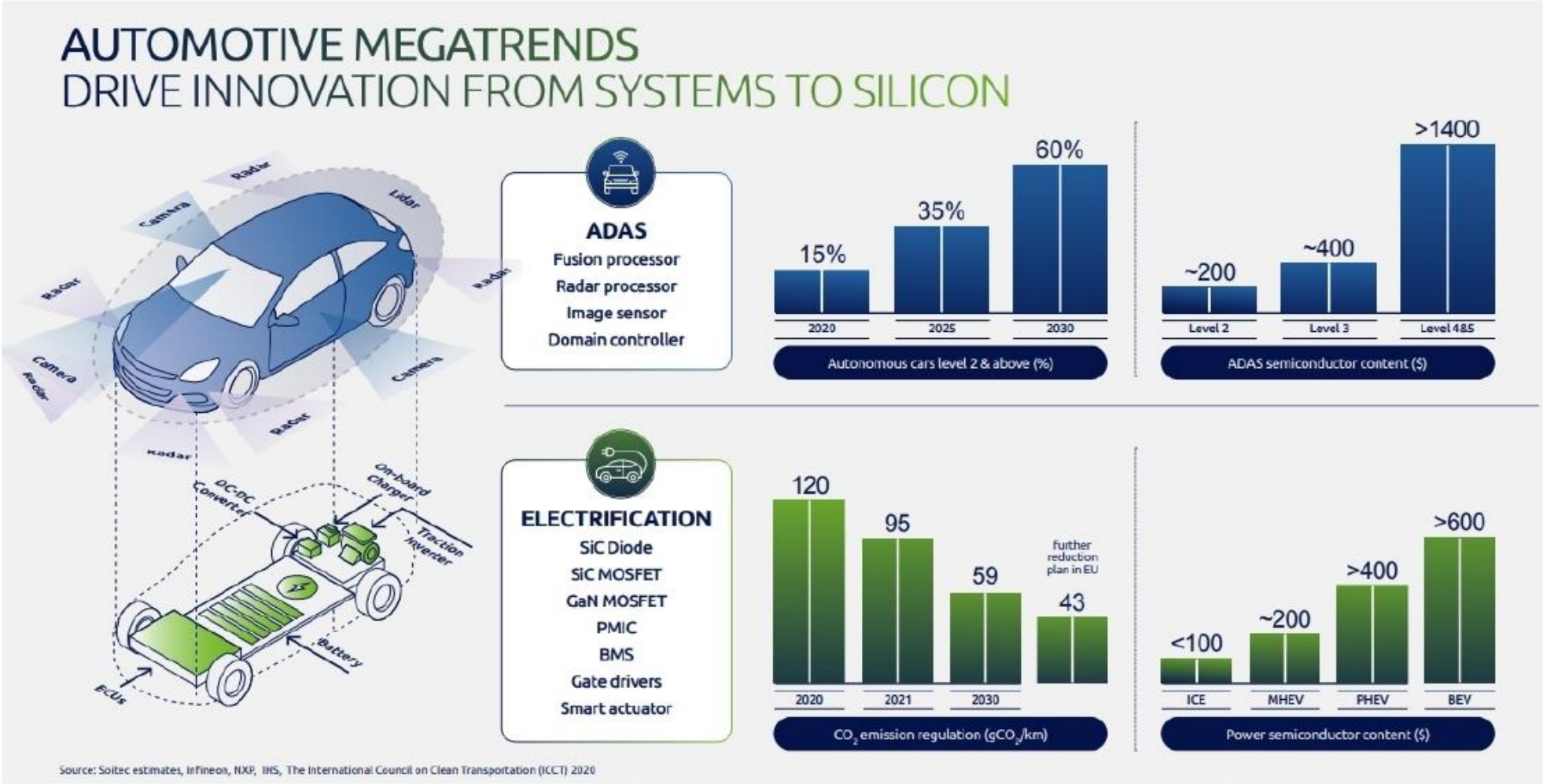
Source: AlixPartners

How are chips used in cars? Increasingly.

Almost half the value of a car may be electronics (and software) by 2030.



ADAS and EV growth drive car chip use.



Source: Soitec Estimates, Infineon, NXP, IHS, The International Council on Clean Transportation (CCT) 2020

What is the chip shortage?

"The 2020–2021 global chip shortage is an ongoing crisis in which the demand for integrated circuits (commonly known as semiconductor chips) is greater than the supply, affecting more than 169 industries, and has led to major shortages and queues amongst consumers for cars, graphics cards, video game consoles, and other products that require semiconductors." (Wikipedia)

Why has this shortage come about?

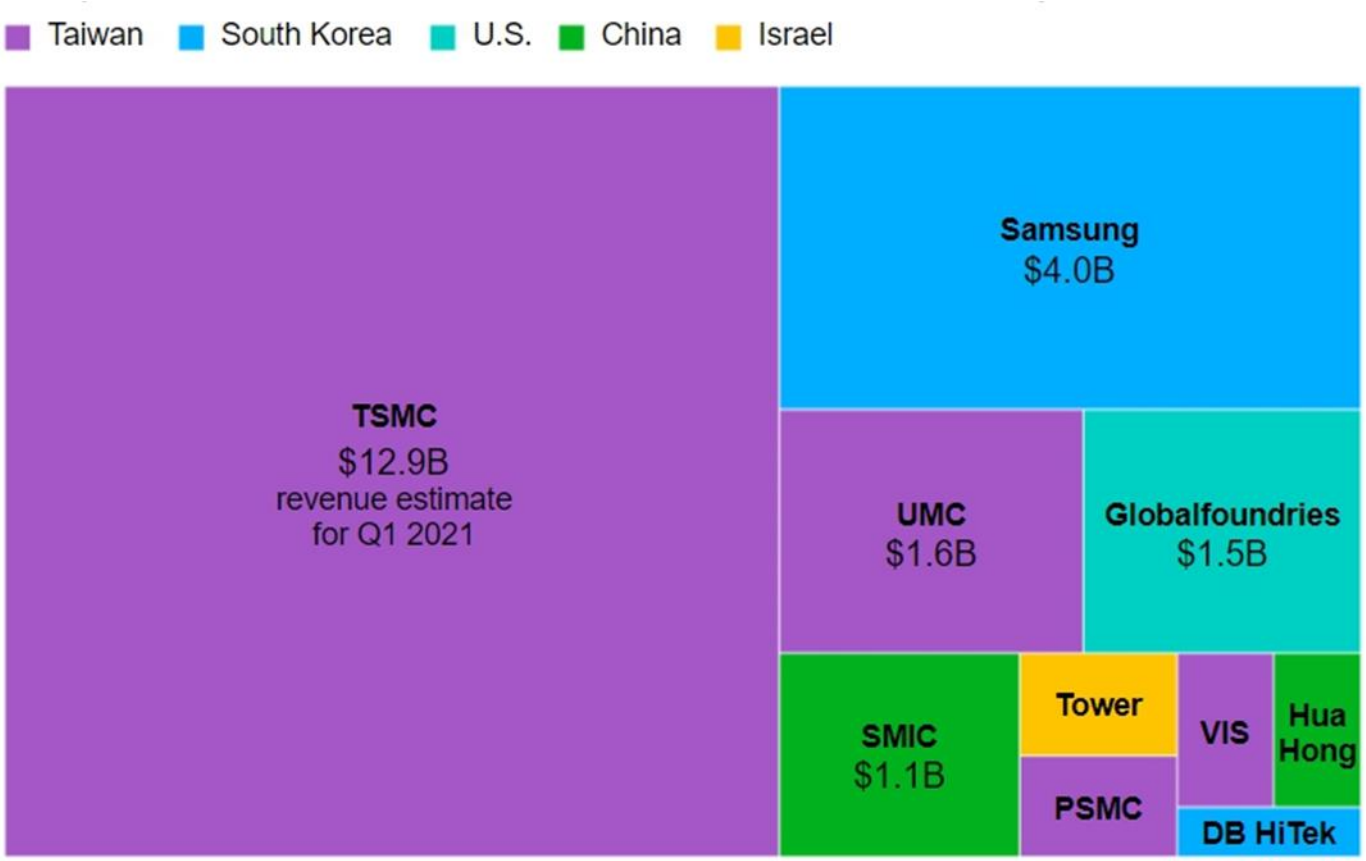
It began in 2020, thanks to the pandemic. In early 2020 auto sales collapsed and OEMs, assuming demand would remain depressed, cancelled chip orders. When car demand bounced back, OEMs were unable to recover lost orders, which had been diverted to consumer electronics (e.g., laptops), whose consumption had soared during global lockdowns.

Other factors exacerbated the situation:

1. Cars use mostly "legacy" chips (e.g., 28 nm, $3,000/wafer) which are less profitable for suppliers than newer chips (e.g., 5 nm, $17,000/wafer), making it harder to induce them to expand supply.
2. Auto chips can be highly specified, making it hard to find multiple suppliers…
3. … and there are few suppliers, so OEMs cannot easily "shop around."
4. It can take 2 years to build a chip "foundry" (and $10-$20 billion), so supply is hard to expand rapidly.
5. Chips are crucial to cars, but cars are not crucial to chip makers (autos are <10% of total demand)...
6. … though the shortage hit just as chip content per car was starting to soar (e.g., for EVs, ADAS, etc.)
7. There have been other supply chain disruptions (e.g., floods in Taiwan, power outages in Texas…)
8. US sanctions (under both Trump and Biden) against China induced many chip customers (e.g., Huawei, Apple) to lock in large chip orders as insurance against any trade-war disruptions.
9. Past low profits make suppliers wary of building capacity that may soon be excess (chip prices historically fall 5-7%/year: most Asian chip plants are only built if government subsidies are in place).

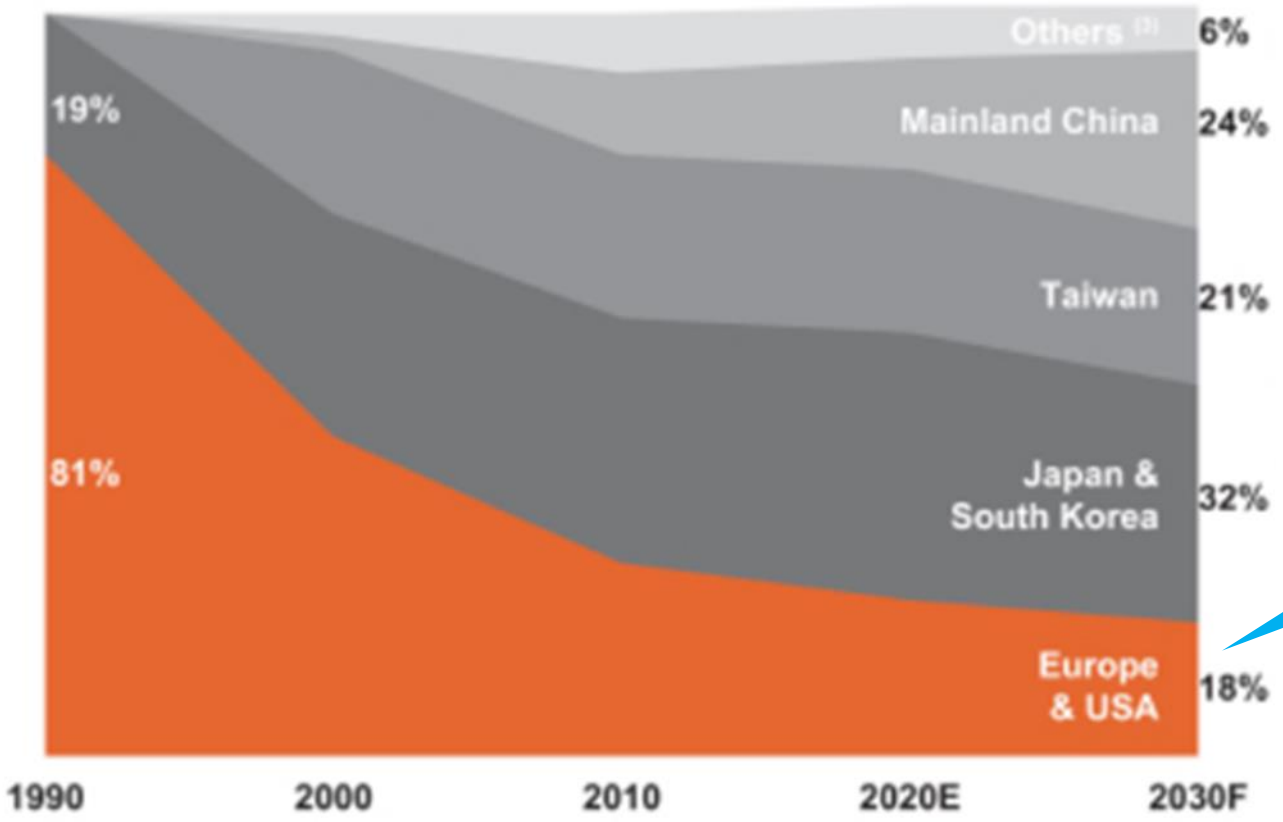
3. There are few suppliers, mostly Asian

Three Asian and one American firm supply about 85% of all outsourced chips.



Note: Estimates as of February. Figures for Samsung include its System LSI unit; for Globalfoundries include the manufacturing unit acquired from IBM; for PSMC its foundry business only.
Source: TrendForce

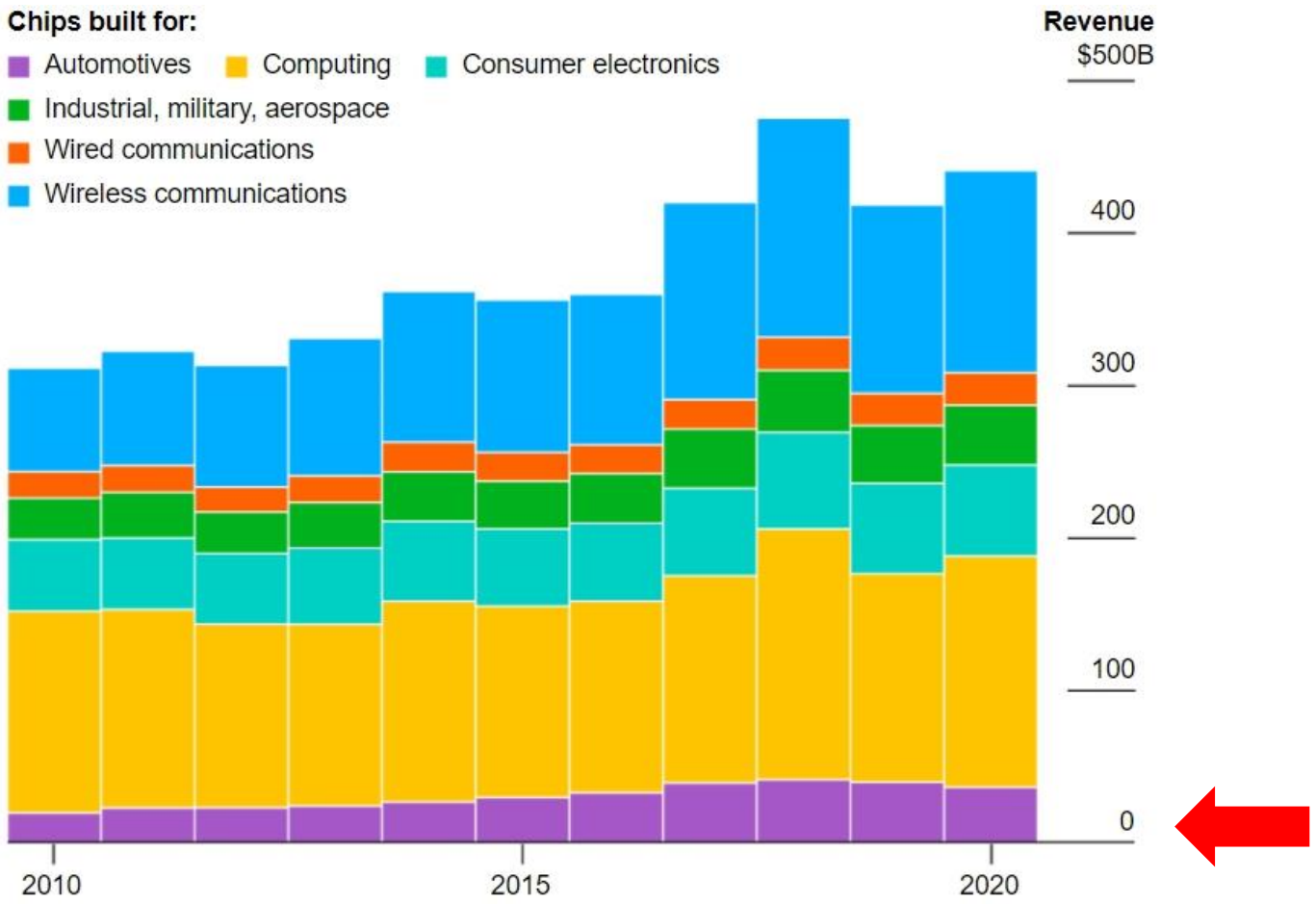
3. The move to Asia has been dramatic



The USA is about 12%

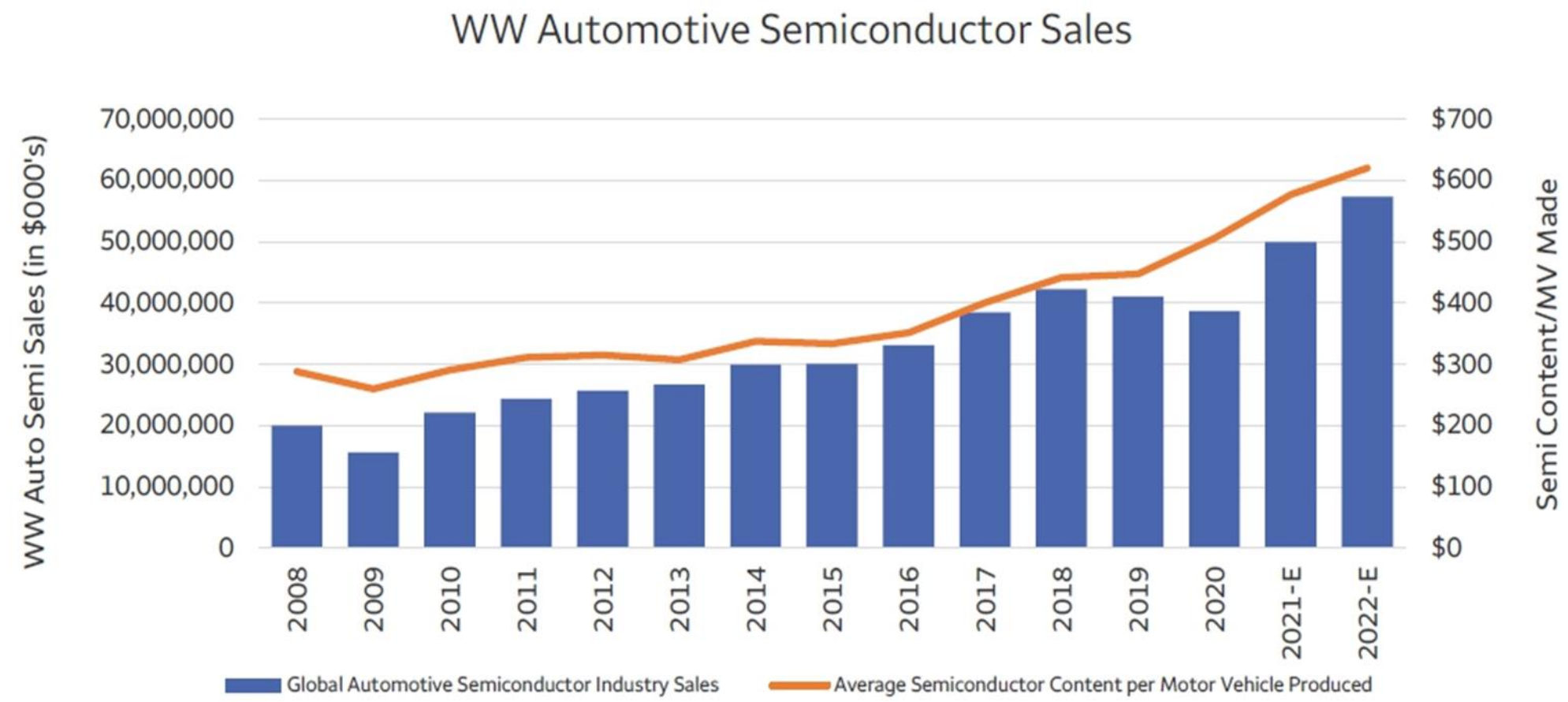
Source: BCG and SIA; Gartner
Note:
1. Based on Gartner data on worldwide foundry revenue
2. All values shown in 8" equivalents; excludes capacity below 5 kwpm (thousand wafers per month) or less than 8"
3. Others includes Israel, Singapore, and the rest of the world

5. Cars have not been crucial to chip makers…



Note: Data does not include foundry-only businesses such as TSMC or Globalfoundries.
Source: IDC

6. …but chips are increasingly crucial to cars.



Source: Wells Fargo Securities LLC, WSTS, OICA, IHS

How severe is the impact on autos?

“Negative overall, but it depends how you look at it.”

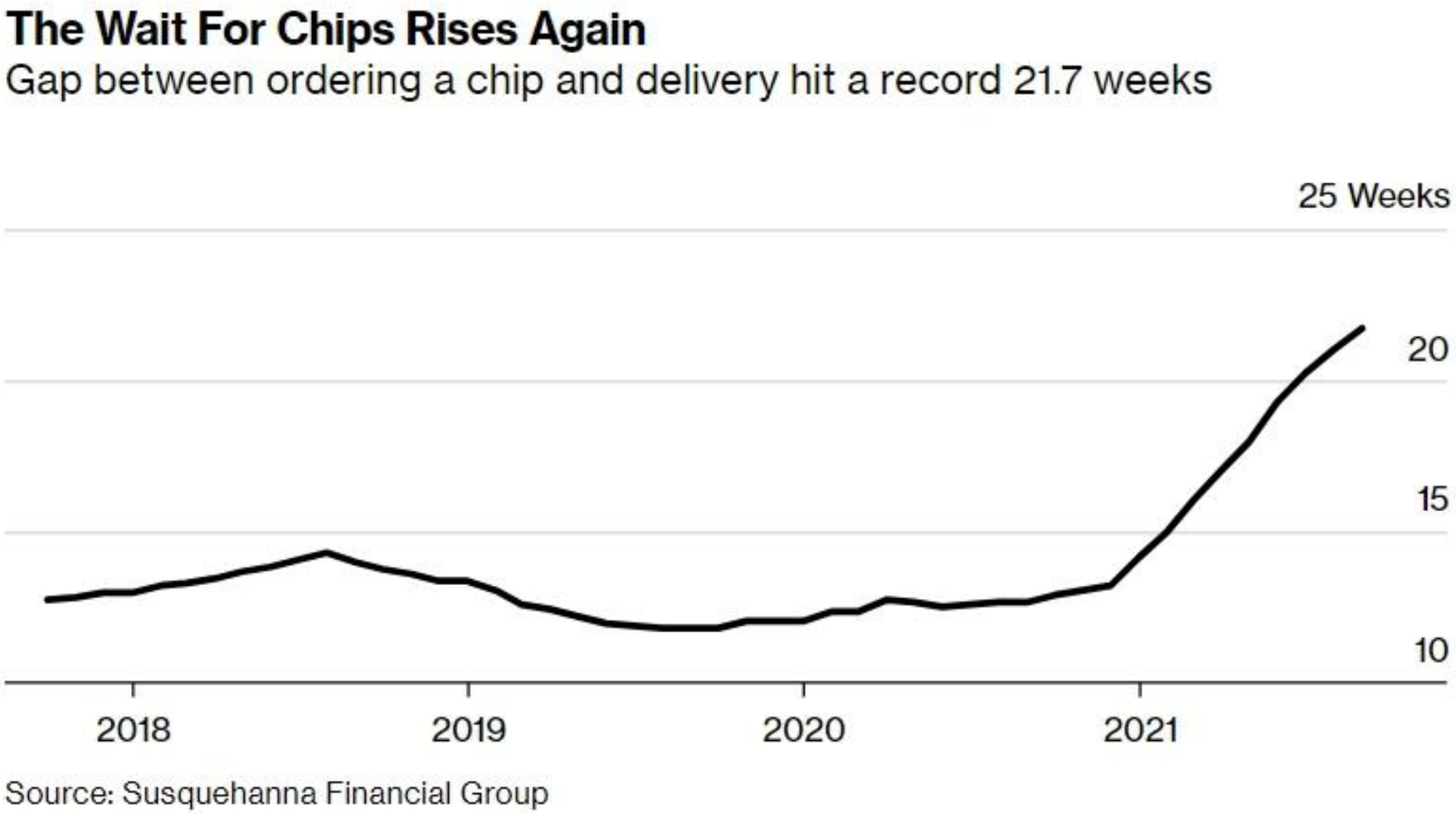
- Experts’ estimates of **lost unit sales** due to the shortage vary quite a bit (see IHS, Strategy Analytics, AFS, Alix Partners), but a reasonable guess could be 10%, or in US terms, possibly 1.5 million units for all of 2021 (versus expectations for 2021, not versus 2020).

- Offsetting this unit sales loss is a **surge in prices**, as customers pay up to get the car they want (or even just “any car”). JD Power sees current transaction prices at $44,000, up some $7,000 from one year ago’s $37,000, or roughly 20%. Dealers get more margin, OEMs pay out fewer incentives.

- As a result of the price surge, even though YTD unit volumes are up only about 10% versus 2020, total **customer spending on new cars is up** almost 25%, from about $350 billion to about $430 billion. This amount is of course shared between OEMs and dealers…

- Another impact is of course **increased cost to the OEMs**, of chips (up possibly 20% this year, on average), of stopping and starting production, and of managing thousands of vehicles produced but not available for sale until crucial chips arrive.

Another impact: extended chip lead times



Stockpiling of unfinished cars: example

Stockpiles of unfinished Ford pickup trucks at the Kentucky Speedway. Left photo is from April 18 this year, right photo from May 1. Courtesy of *The Drive*, May 5.

Sidebar: a gap between auto chip sales and auto sales

Analysts are confused by the intersection of these two facts: car production is roughly 10% below 2019 levels, but chip sales to automotive are up 25%. How can this be?

Optimists assert OEMs are stockpiling chips and so the shortage will be over soon, once ample "JIC" (just-in-case) chip inventories replace the lean "JIT" (just-in-time) inventories of the past.

Pessimists assert that the 35% (10+25) gap is illusory:

- First, 2019 was an unusually lean year for chips. Use 2018 instead. Gap falls to 29%
- Next, remember that chip content per average car is up sharply, perhaps 10%. Gap falls to 19%
- We know chip makers have been (finally) raising prices, perhaps 15%. Gap falls to 4%
- Finally, add in a mix shift to premium cars and EVs, which use more chips*. Gap is closed.

Which camp is correct? Is the shortage real or are we just stockpiling? See next section

* BEVs and PHEVs use about twice as many chips per car as ICE vehicles.

How long will the shortage last? Into 2022 at least

A selection of estimates from the industry, from the last few months:

- IBM: “more likely than not” to extend into 2023
- Intel: “a couple of years:” 2023
- J P Morgan: “into mid-2022”
- Jim Farley of Ford: “this will last through 2023 to some extent”
- Chip producer TSMC: “the worst is behind us, but the shortage will persist into 2022”
- Omdia Research: “the shortage will be ending in the Spring of 2022”
- VLSI Research: “Beyond auto, already over; in auto, defini[illegible] in 2024”
- NVIDIA: “far into 2022”
- AMD: “better by the second half of 2022”
- NXP: “for auto chips, until 2022”
- Wells Fargo: “2023”
- Global Foundries: “We’re sold out through 2023”
- Elon Musk: “okay by 2022”

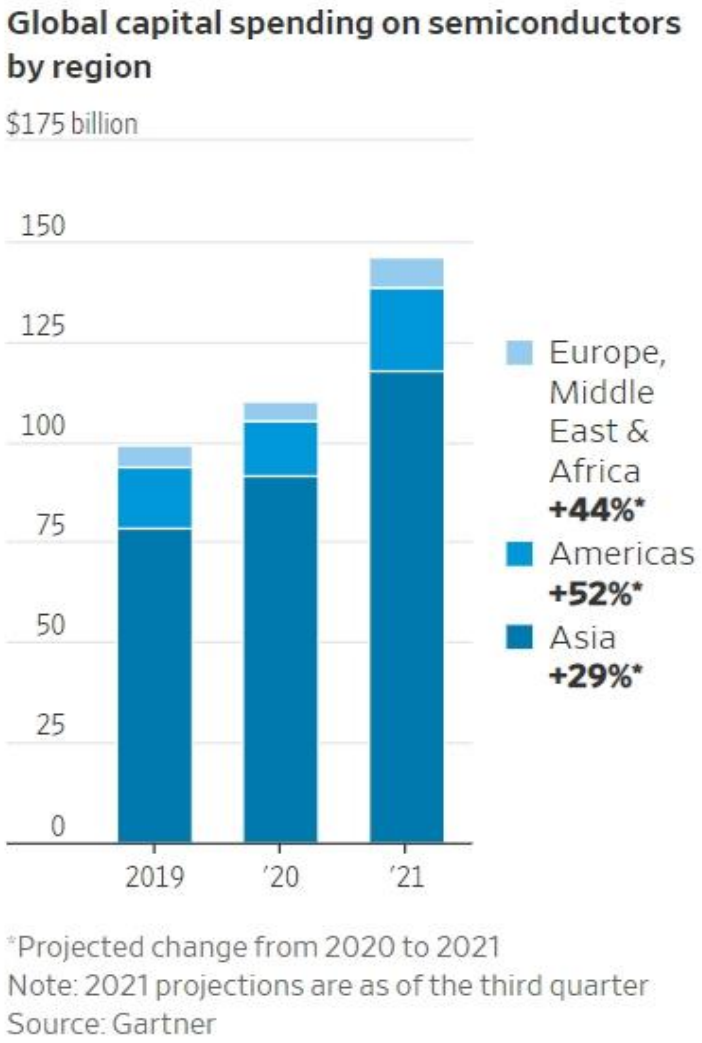
There is some consensus that as of late 2021 *supply* is slowly improving, but the *shortage* will still persist, as OEMs both ramp production to fill pent-up demand, and to build JIC inventories.

What steps are being taken to end the shortage?

"It's all hands on deck!"

1. OEMs (e.g., Ford) have started **co-investing** with suppliers in chip capacity
2. OEMs have started signing **long-term agreements** to guarantee supply (formerly anathema)
3. OEMs have become **more transparent** in sharing future demand picture with suppliers
4. There is certainly at least **some stockpiling** going on (moving from JIT to JIC)
5. Semiconductor firms are **investing aggressively in capacity** (despite some misgivings)
6. OEMs are just **paying more** (also anathema!)
7. Some OEMs may be **negotiating directly with chip firms**, not just through their Tier One suppliers
8. OEMs may be **"de-spec'ing"** their chips, in order to use more available standard chips
9. **Governments are starting to take action** (e.g., Chips for America)
10. Suppliers are starting to **pivot away from consumer electronics** (over-bought during lockdowns)

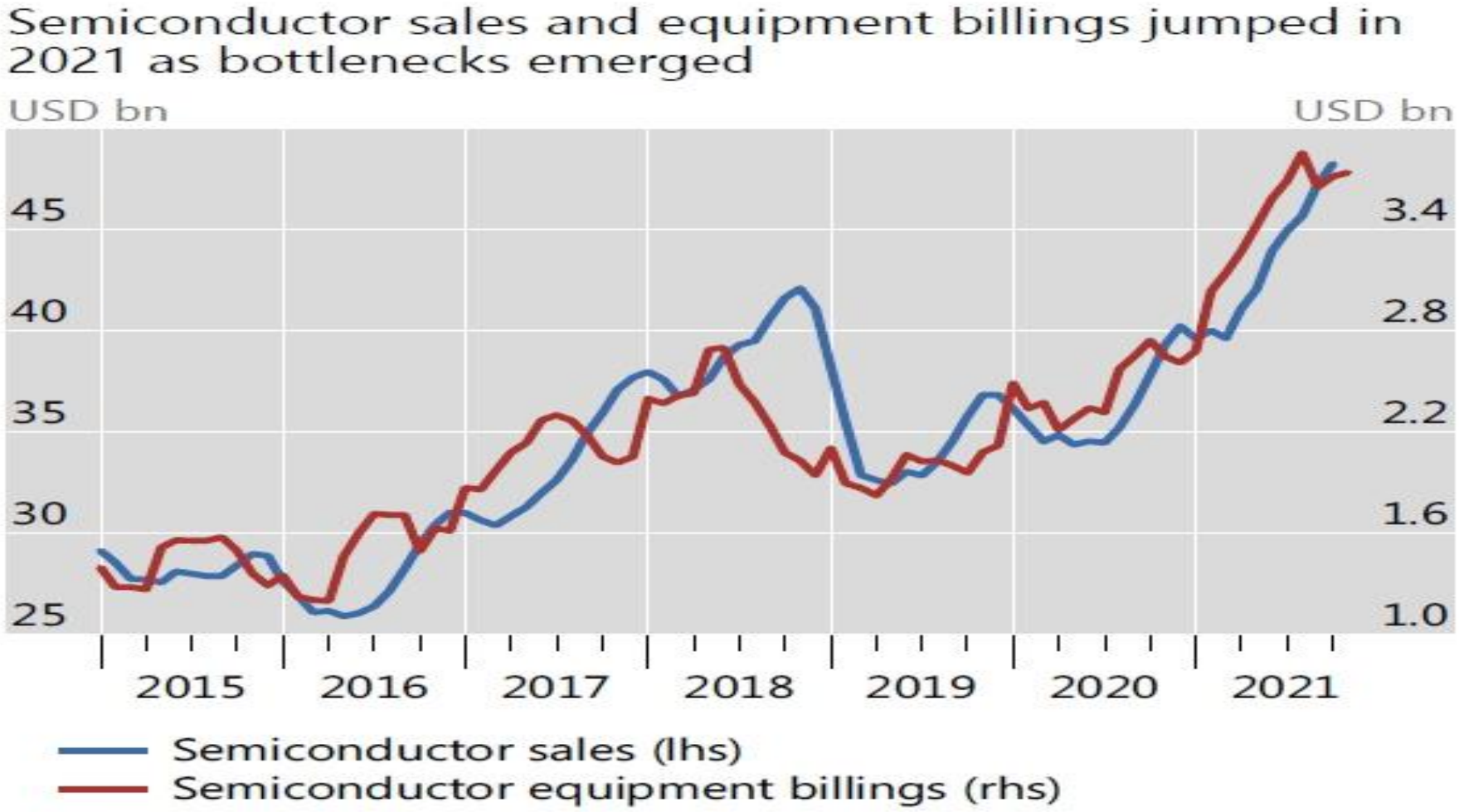
5a. Chip firms are investing in capacity, and…



Comments

- Semiconductor suppliers are stepping up capacity investment to alleviate the shortage
- This is despite misgivings about potentially generating a financially-disastrous oversupply situation by 2023 or 2024
- Crucially, investment in the older, cheaper (and NB *more reliable*) "legacy" chips automotive is dependent on is lagging. As one exec put it "Why would invest in new capacity for 10-year-old tech where my competition is fully-depreciated older fabs?"

5b. …driving plants *very* hard: often over 100%



Source: BIS

9. Government action example: Chips for America

Partial summary of the $50 billion Act (from Congress.gov, edited):

Creating **H**elpful **I**ncentives to **P**roduce **S**emiconductors for America Act: CHIPS for America Act

This bill establishes investments and incentives to support U.S. semiconductor manufacturing, research and development, and supply chain security. Specifically, the bill provides for:

- an income tax credit for semiconductor investment through 2026
- negotiating with other countries for alignment in chip trade and incentive policies
- carrying carry out a program of R&D to accelerate the design, [illegible] urability of next generation microelectronics in the USA
- establishing a program to match state and local go[illegible] the purposes of building fabrication facilities rela[illegible]
- including provisions for the Department of Defer[illegible] for programs, projects, and activities
- establishing a subcommittee on matters relating to U.S[illegible] nd innovation, which shall develop a national strategy on semicon[illegible]

But note – as of December 10, 2021, the Act *remains unfunded*

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Current Forecasts for SAAR 2022 (and beyond)

Forecaster	2022 Sales, millions
A	16.2
B	15.7
C	16.3
D	17.2
E	15.5
F	16.7
G	16.5
H	17.5
I	16.2
J	17.3
K	17.5
Average	**16.5**

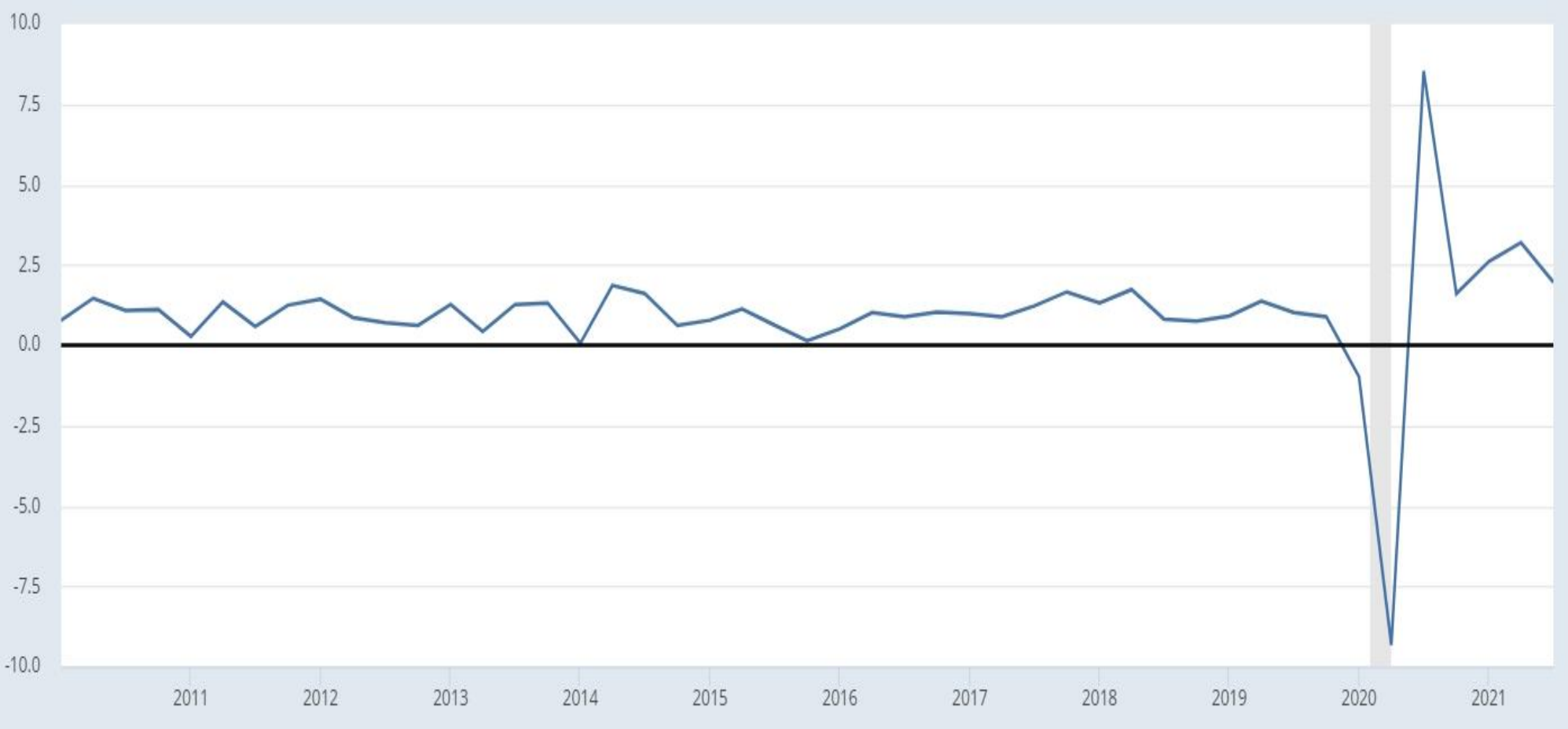
Comments

- Baseline: 2021 to finish out at 15.2 or so.
- Anonymized to "protect the innocent:" that is, to not penalize forecasters whose last update was many months ago
- My view is that an individual forecast is driven by the forecaster's view of the chip shortage: 17 and above implies its end in early 2022.
- BEYOND 2022 there is surprising unanimity around a +/- 17 mm SAAR
- Virtually all forecast revisions in the last few months have been downward, with all citing the chip shortage as the reason for adjustment

Sources: Federal Reserve, LMC, Cox, Alix Partners, IHS, SEMA, CAR, ALG, BoA/ML, UBS, S&P

In defense of forecasters, we're in volatile times

USA GDP, Quarterly Percentage Change



Source: US Bureau of Economic Analysis

Author's Forecast for 2022

Green=high confidence, Yellow=moderate confidence, Red=low confidence

=====

Assuming the chip shortage continues in 2022, but gradually eases…

Assuming only slow/steady EV share growth, as faster growth will prolong the shortage…

Assuming the economy stays roughly on track (GDP, unemployment, etc.)…

Assuming pent-up new-car demand is high (well over 1,000,000 units)…

Assuming any new Covid wave is not *highly* disruptive…

… my forecast would be: 16,000,000 new units in 2022, with upside to 16,500,000

Potential Impacts of this forecast

1. Given demand will still exceed supply in 2022, assume **continued strong new-car pricing**, though likely not continuing the trajectory of the past few years (2018 October CFTP $33K, 2020 $37, 2021 $44), via price hikes, mix shift, options loading.
2. **Dealer profits should remain strong** (given recovering volume and high prices), but assume front-end margin cuts (= wholesale price hikes) by OEMs, to capture more of price gains
3. Similarly, **used-car prices are very likely to stay high** in 2022 (see Cox, KAR, etc. for forecasts)
4. **Strong residual values should persist in 2022**, fueling the new-car market, but when supply recovers RV declines may leave many owners "upside down" on their financing in 2023, potentially leading to a downward price trend, as we have seen many times before
5. America will continue to **split into two car markets: new for the well-off and used for the rest**. Pre-pandemic the top half of the USA income distribution was buying 95% of new cars sold, and this is only going to go further.

Outline

(► indicates “deep dive” sections)

1. Background: history of new-car sales in the USA
2. Demand drivers of SAAR (looking back)
3. Supply driver of SAAR (looking ahead) ► The chip shortage in depth
4. Range of current forecasts of SAAR for 2022 (and beyond)
5. Author’s forecast
6. Potential impacts of the 2022 forecast
7. ► The outlook for EVs in the USA

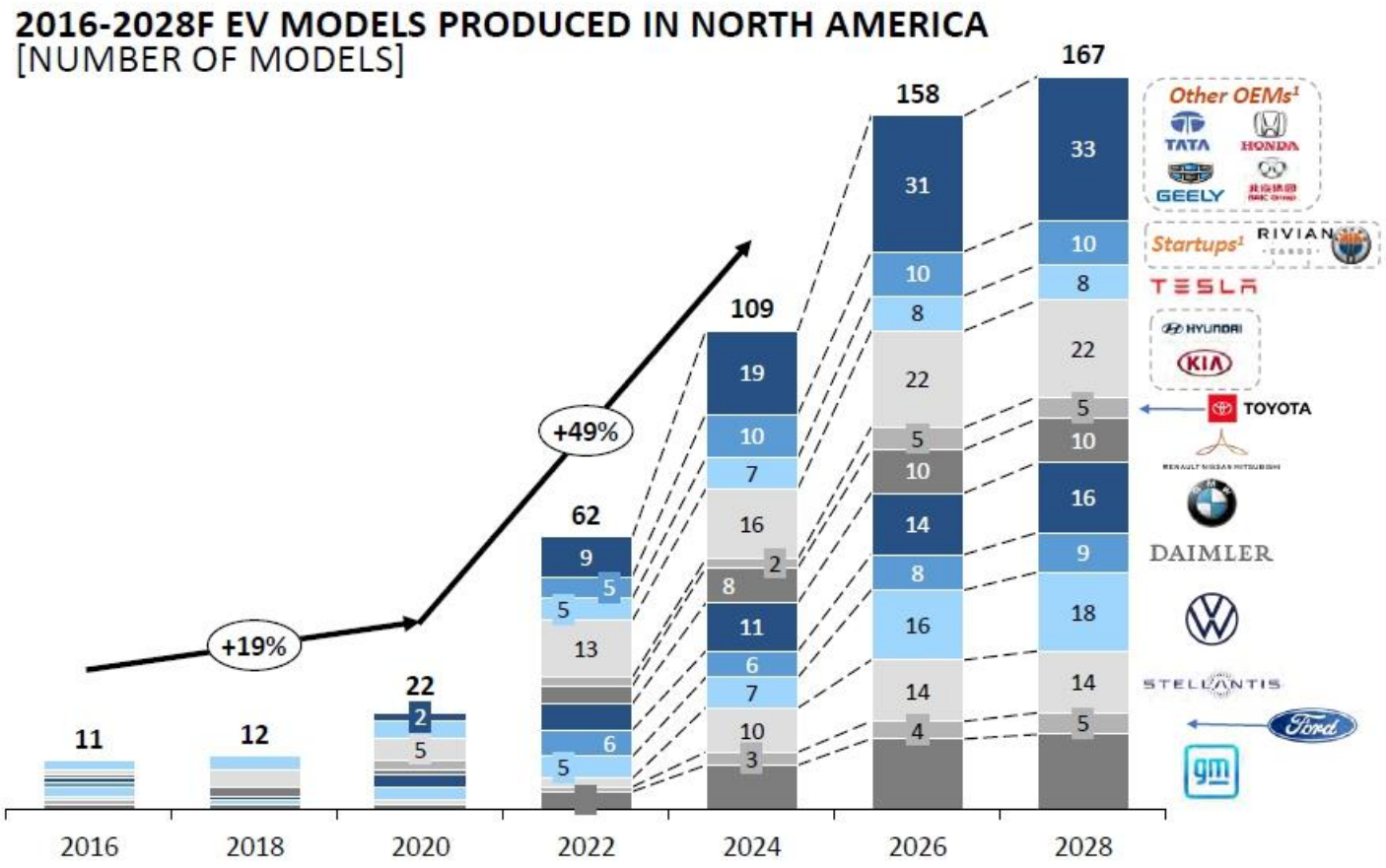
Outline

1. **The EV Situation in the USA Today**
2. **Research Findings:**
   - **Inputs**
   - **Impacts**
   - **Outcomes**
3. **Conclusion and Forecast**

Recent Developments flagged in blue

The EV Situation in the USA today (1)

***The* EV puzzle today is one of strong supply growth…**



Discussion

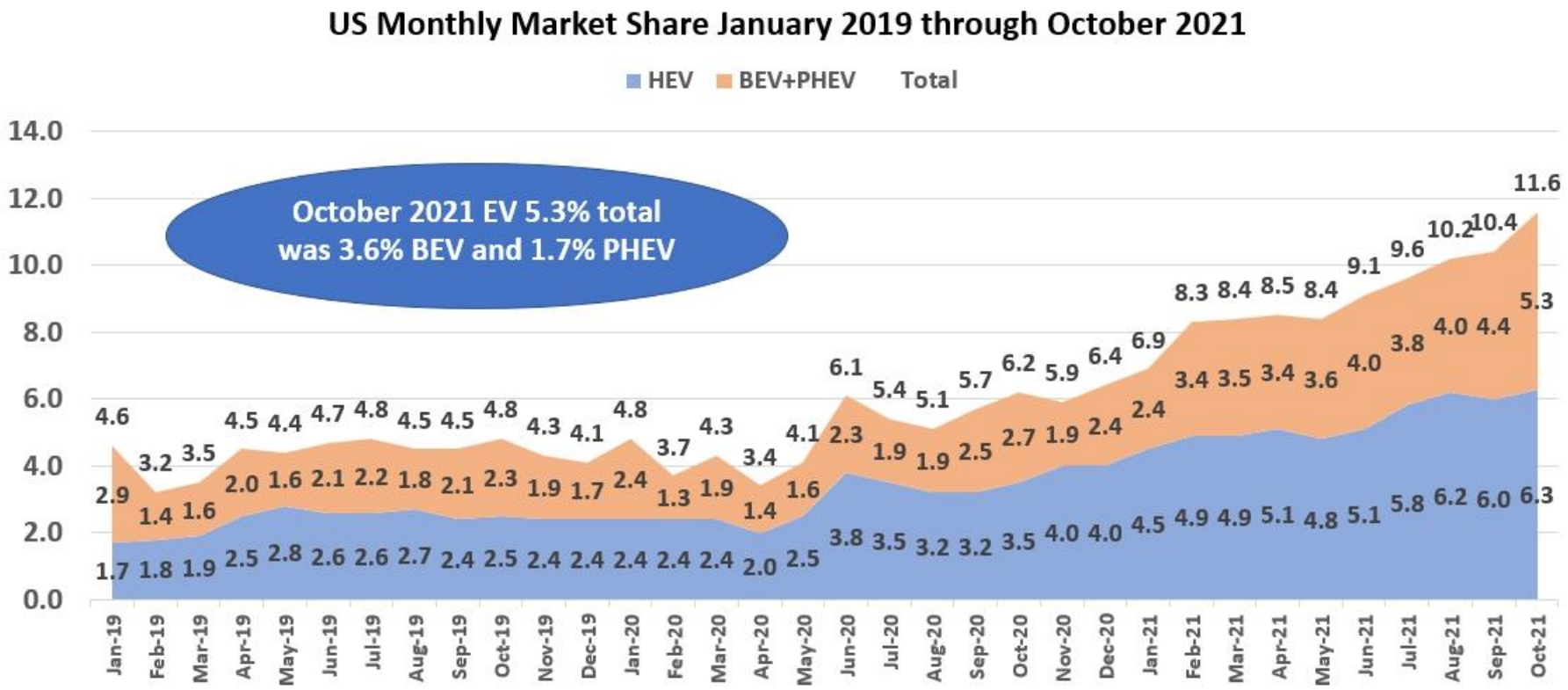
- Nearly **90 new EV models** are expected between 2020 and 2024
- **Various EV startups** intend to release **10 new models** between 2020 and 2024
- **Major OEMs** such as GM, Stellantis, and VW intend to introduce the **bulk of their EV models in 2024+**
- Other OEMs intend to introduce BEV models later in the decade

Source: IHS, ACA, AASA

The EV Situation in the USA today (2)

…. meeting weaker demand growth.

Hybrids versus Electrics: Where Headed?

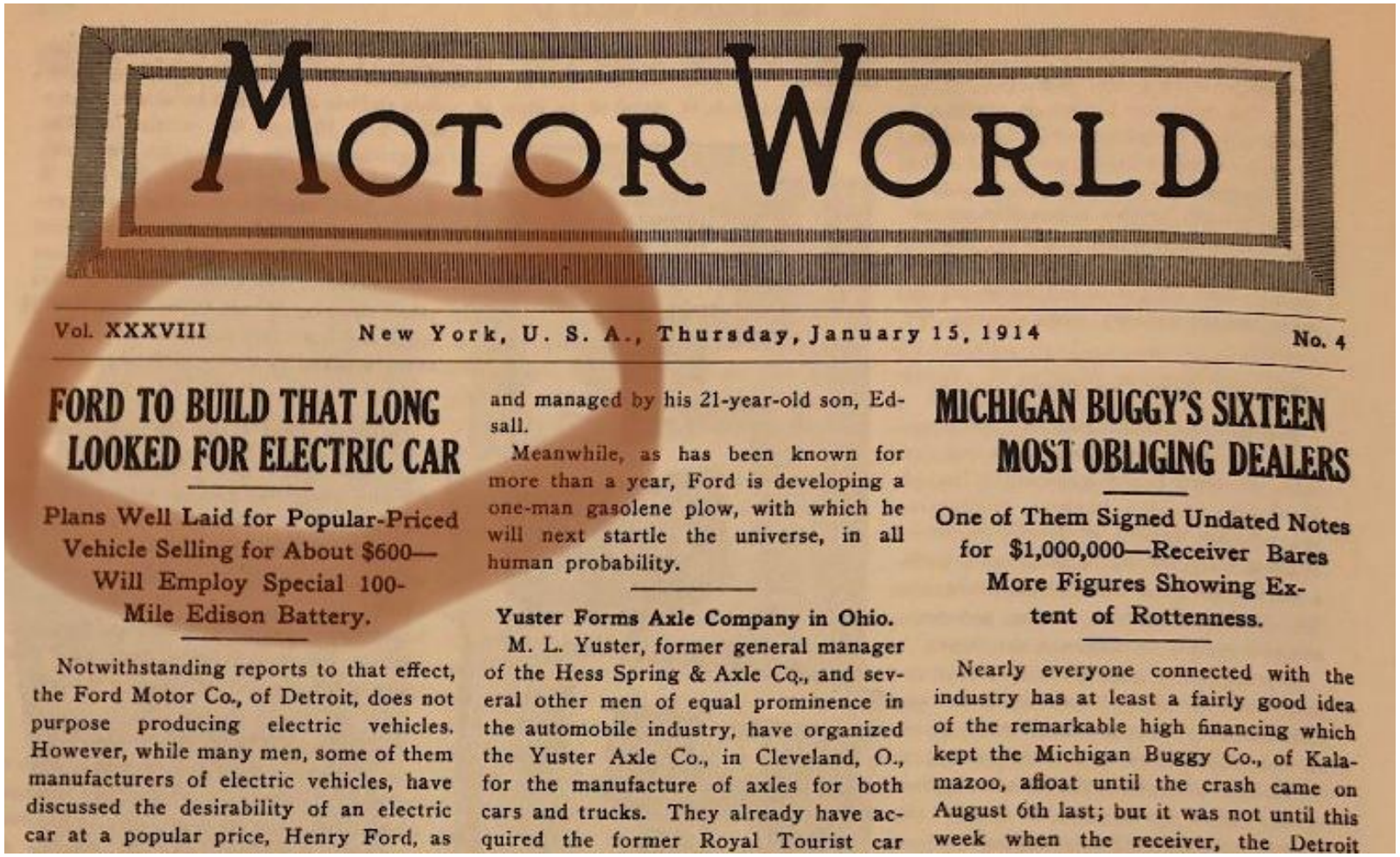


This was NOT supposed to happen!

Source: Ward's Auto, via Jeffries

Note: PHEV fluctuates around 20%-40% of BEV+PHEV total

So… is today different than a century ago?



MOTOR WORLD

Vol. XXXVIII New York, U. S. A., Thursday, January 15, 1914 No. 4

FORD TO BUILD THAT LONG LOOKED FOR ELECTRIC CAR

Plans Well Laid for Popular-Priced Vehicle Selling for About $600—Will Employ Special 100-Mile Edison Battery.

Notwithstanding reports to that effect, the Ford Motor Co., of Detroit, does not purpose producing electric vehicles. However, while many men, some of them manufacturers of electric vehicles, have discussed the desirability of an electric car at a popular price, Henry Ford, as

and managed by his 21-year-old son, Edsall.

Meanwhile, as has been known for more than a year, Ford is developing a one-man gasolene plow, with which he will next startle the universe, in all human probability.

Yuster Forms Axle Company in Ohio.

M. L. Yuster, former general manager of the Hess Spring & Axle Co., and several other men of equal prominence in the automobile industry, have organized the Yuster Axle Co., in Cleveland, O., for the manufacture of axles for both cars and trucks. They already have acquired the former Royal Tourist car

MICHIGAN BUGGY'S SIXTEEN MOST OBLIGING DEALERS

One of Them Signed Undated Notes for $1,000,000—Receiver Bares More Figures Showing Extent of Rottenness.

Nearly everyone connected with the industry has at least a fairly good idea of the remarkable high financing which kept the Michigan Buggy Co., of Kalamazoo, afloat until the crash came on August 6th last; but it was not until this week when the receiver, the Detroit

Research Findings: Organization

1. *Inputs* to the EV market

- Customers
- Vehicles
- Batteries
- Charging
- Governments
- Economics

3. *Outcomes*

- For Sales
- On Dealers

2. *Impacts* of EVs elsewhere

- Environment
- Grid
- Employment
- Geopolitics

Color coding: green = favorable, orange = neutral, red = negative

Customers

EV shoppers and owners are evolving from wealthy tech-focused pioneers adding cars to their driveway, to still-well-off but more differentiated adopters who more often use their EV as a primary vehicle.

1. **Interest in and approval of EVs is growing, though consideration still lags**
2. **In terms of key buying factors:**
   - **EV cost matters, but it is unclear *how much* it does: general appeal and suitability for purpose tend to trump price**
   - **Charging baffles customers, and time-to-charge is a major issue**
   - **Range is crucial: so crucial that we can skip the rational arguments ("you don't *need* 400 miles!") and accept that Americans *want* big range numbers**
   - **Choice of vehicle (e.g., CUV) is improving and raising consumer interest**
   - **The "greenness" of EVs is widely accepted and so may no longer be a factor**
3. **Converting EV considerers to buyers will require *confidence*, obtained both from *education* (learning about EVs) and *trial* (experiencing EVs). Dealers can help!**

Vehicles

1. **Emissions regulations drive EV adoption globally, and thus – inevitably - the US**
2. **This will happen despite good arguments for the steady improvement in ICE fuel economy and emissions, especially in a PHEV format**
3. **A flood of new EV models is headed our way, which should drive demand ("People buy what they see on the road or in their neighbors' driveways.")**
4. **These new models are entering new segments, further increasing appeal: if an EV pickup truck succeeds, this may be an inflection point for demand**
5. **Dealers are eager to receive – and show to customers – newer EV models that are more competitive in both performance and in body style.**

EV pickups may be the market turning point

Batteries

1. Range is improving fast, to levels that may be broadly acceptable to Americans
2. Range degradation is a problem, but to date manageable. However, if impatient drivers insist on frequent use of fast-charging, battery life can shrink
3. Battery technology is advancing rapidly, such that *if* materials prices do not spike, OEMs may be able to make profits on these cars in a few years
4. However, battery materials pose issues (environmental, political, humanitarian)
5. As for safety, EV battery fires are not more likely than ICE engine fires. But media coverage of EV fires may solidify the perception that the danger is high.
6. Solid-state battery tech is a hot topic - but may not arrive in force for years.
7. Fuel Cell Vehicles (FCV) remain serious [illegible] but consensus is that they will not arrive [illegible]
8. Dealers again can ed[illegible] improved battery life, [illegible]

Sidebar: insistence on long EV range leads to heavy batteries: the Hummer EV's battery weighs over 2,000 pounds, about the same as an entire Mitsubishi Mirage. EVs use a lot of power just hauling around their "fuel."

Charging

An enormous network of chargers (beyond home units) will be required to fuel an expanding EV fleet. That network is growing rapidly, while bottlenecks do exist. However, from a customer perspective, charging presents additional issues which makes charging inconvenient relative to gasoline pumping:

1. **There are multiple types of charger… gas pumps are standardized**
2. **Charging rate depends on vehicle capacity as well as charger output… while every car receives gasoline at the same rate**
3. **Gas prices vary over time but tend to a narrow range at any given time… but electric rates can vary dramatically and in unexpected ways**
4. **There are numerous "front line" issues with charging, from charger time limits to billing complexities and out-of-service units**
5. **Overall, the charging network will continue to expand and improve, but it remains not as easy for customers as pumping gas.**

While dealers cannot resolve the charging problem on their own, they can inform customers as to where, both in their home areas and on the road, they can charge, how they can charge, which apps can find them chargers while traveling, etc.

Government Incentives

House Proposed Changes to Plug-In Electric Drive Vehicle Credit IRC 30D		
Proposed Change	**Effective**	**Notes / Potential Impact**
Current non-refundable tax credit becomes refundable.	Jan 1, 2022	If taxpayer owes the IRS less than the amount of the EV tax credit, the IRS will reduce the owed taxes to zero and pay the remaining amount of the credit.
Manufacturer sales cap phaseout at 200,000 EVs sold is eliminated.	Jan 1, 2022	Purchase or lease of a GM or Tesla qualifying EV once again are eligible for a tax credit.
Amount of credit is reduced by $200 for each $1,000 (or fraction thereof) by which the taxpayer's modified AGI exceeds the threshold amount.	Jan 1, 2022	AGI thresholds: $500,000: Joint returns or surviving spouse, $375,000: Head of household, $250,000: Any other case. Shall not exceed 1 per taxpayer per taxable year.
No credit for EVs with a MSRP in excess of the applicable limitation. Tax credit cannot exceed 50% of purchase price.	Jan 1, 2022	MSRP limits are: Vans: $80,000, SUVs: $80,000, Pickup Trucks: $80,000., Other: $55,000.
Current tax credit formula is replaced with base credit amount of $4,000. EVs must have a battery of at least 10 kWh.	Jan 1, 2022	5 PHEVs would not meet this threshold: Toyota Prius Prime, Subaru Crosstrek Hybrid, Hyundai IONIQ, Kia Niro PHEV, Ferrari SF90 Stradale (which exceeds MRSP cap anyway).
Additional tax credit amount of $3,500 for EVs with a battery of 40 kWh or more.	Jan 1, 2022	4 BEVs available in 2021 or 2022 would not meet the 40 kWh threshold: Hyundai IONIQ EV, Mini Cooper EV, Mazda MX-30, and Kandi K27.
EVs which satisfy the domestic assembly qualifications would receive an additional credit amount of $4,500.	Jan 1, 2022	Final assembly must occur at a plant, factory, or other place which is operating under a collective bargaining agreement negotiated by an employee organization. By the end of 2022, possibly only 4 BEVs and 4 PHEVs will qualify for the additional $4,500 credit.
EVs which satisfy the domestic content qualifications would receive an additional credit amount of $500.	Jan 1, 2022	Vehicles are powered by battery cells manufactured in the US.
"Transfer of credit": Taxpayer can opt to have a qualified dealer apply the qualifying tax credit amount in payment at POS.	Jan 1, 2023	Dealer (licensed by a state, etc. to engage in the sale of vehicles) payment can be in cash or in the form of a partial payment or down payment for the purchase of such vehicle.
Final assembly must be at a US facility to qualify for tax credit. "Final assembly" in this case does not include the union (collective bargaining agreement) requirement.	Jan 1, 2027	EVs not assembled in the US would no longer qualify for ANY tax credit. EVs assembled in the US, but not in a union plant would not qualify for the $4,500 bonus credit. An estimated 10 of 190 EVs available in 2027 would qualify for the maximum $12,500.
Battery size increases to 50 kWh or more for additional credit amount of $3,500.	Jan 1, 2027	In addition to those BEVs not meeting the 40 kWh threshold, currently the Nissan LEAF S and Kandi K23 would not meet the 50 kWh threshold.
Expiration of EV tax credits.	Dec 31, 2031	There is no phase out, the tax credit program ends at the end of 2031.

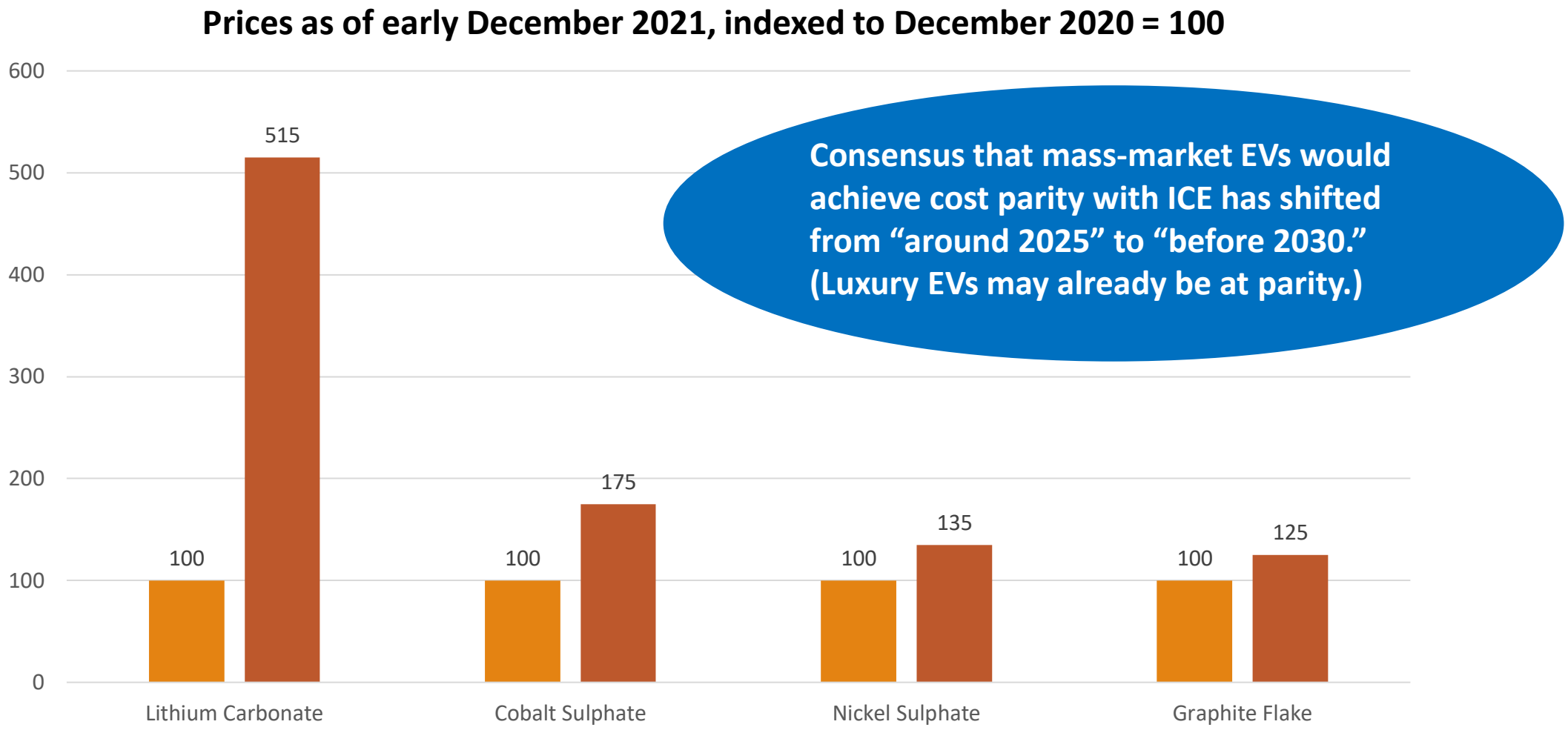
Source: H.R. 5376: BUILD BACK BETTER ACT — November 3, 2021 | Research & Chart: Loren McDonald / EVAdoption | November 24, 2021

Economics – recently worsening

Incentives can temporarily boost the market by "buying down" expensive EVs to make them retail-price-competitive with ICE. But in the long run EVs must become economically competitive with ICE costs in two ways: from the customer point of view (the Total Cost of Owning and a car (TCO)); and from the manufacturer point of view (the cost of producing an EV versus an ICE).

1. **The manufacturer perspective. As battery costs continue to drop and as OEMs get more experience building EVs, we are moving to a point where EV and ICE will cost similar amounts to produce. (Again, depending on the behavior of raw material prices, battery supply and demand, etc.)**
2. **The customer perspective. The TCO advantage of ICE over EV is shrinking and will continue to shrink, but focus on TCO may be misplaced: on the one hand TCO calculations are complex and unreliable; and on the other, buyers do not seem to pay much attention to TCO. Dealers can educate customers as to how an EV may indeed pay off for them over time, on a TCO basis.**

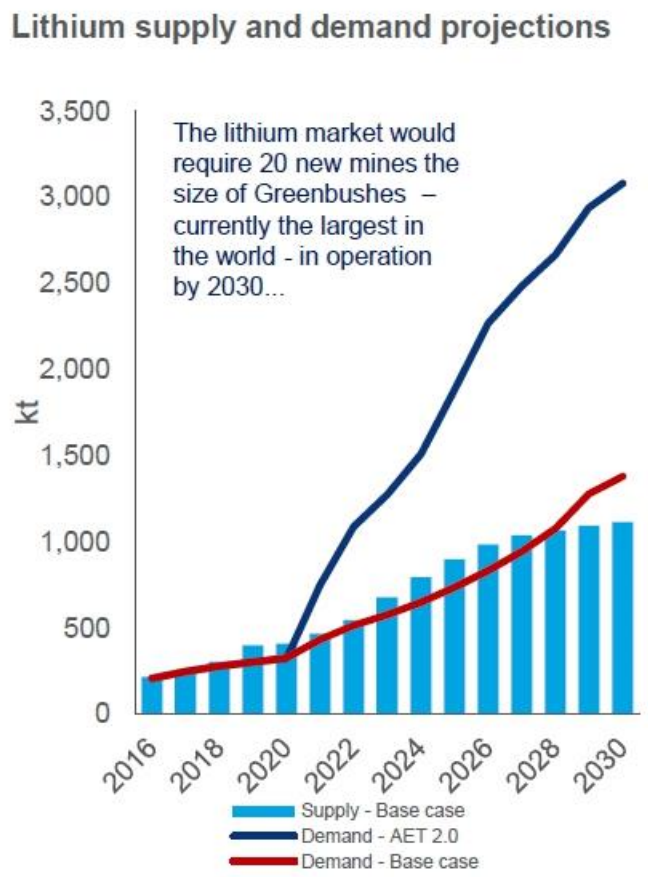
EV Battery Raw Materials Prices Rising

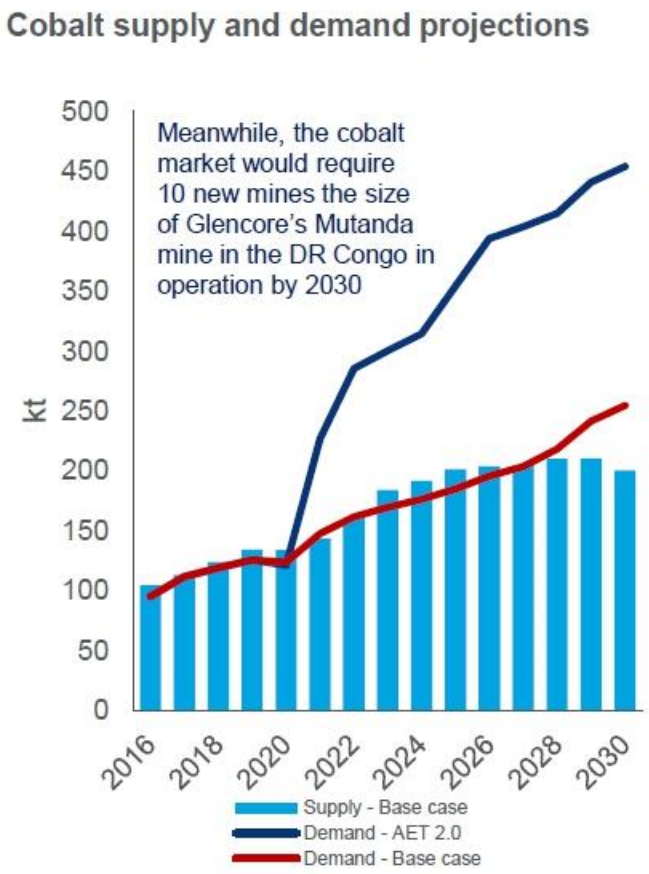


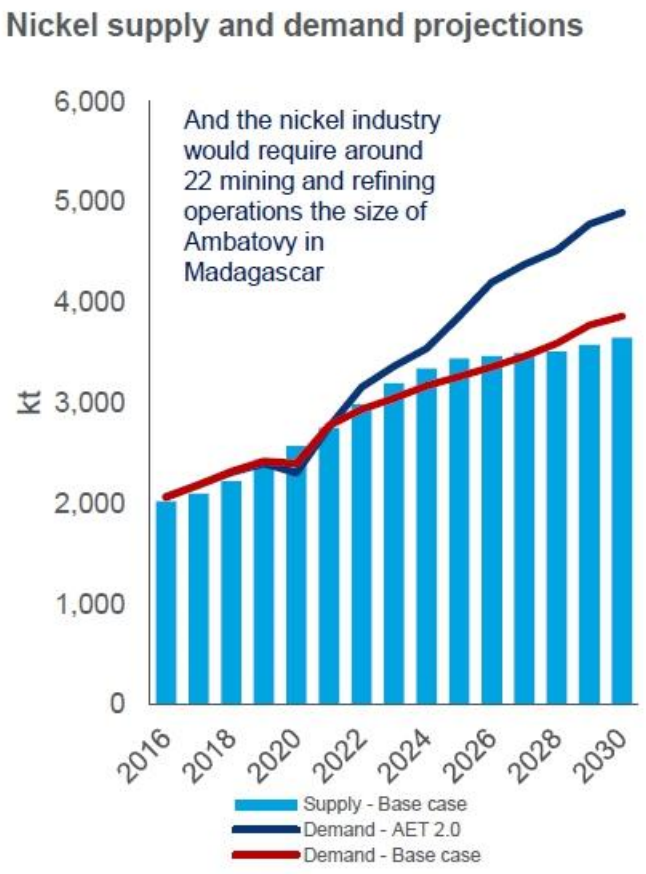
Source: Benchmark Minerals

EV Battery Raw Materials Shortages May Emerge

Given long mine development cycles, producing cathodes sufficient to meet demand may be infeasible.







Source: Wood Mackenzie

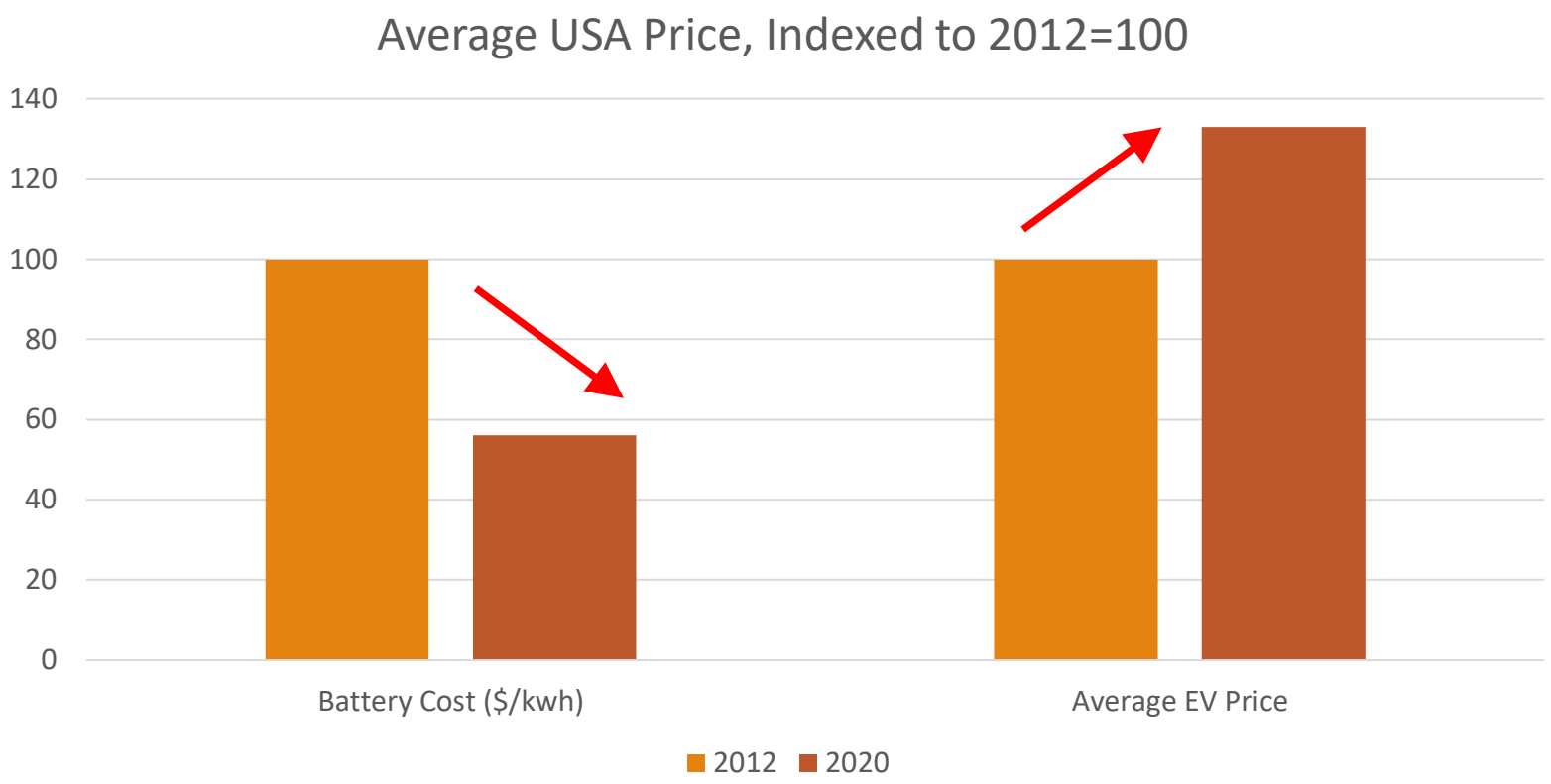
Background: EV/ICE Cost Parity Forecasts

Source	$100/kWh date	Cost parity date	Basis
Bloomberg	2023-2024	2023-2024	Purchase
JP Morgan		"Mid 2020s or earlier"	Purchase(?)
Boston Consulting	2030	2022-2023	TCO
Wood Mackenzie	2027	2027	Purchase(?)
Deloitte		2022 (UK?)	TCO
Morgan Stanley	"early 2020s"	~2025	Purchase(?)
DNV GL	2021-2022	2024	TCO
McKinsey	2025	~2024	TCO
		2025	Purchase
OPEC		Mid-late 2030s?	Purchase
ICCT	2026	2024-2028	Purchase
		2022-2026	TCO
Rocky Mountain Institute	2024-2025	2029-2030	Purchase
MIT	Well after 2030	never	Purchase
		~2029	TCO

Source: US EPA

An EV Paradox

Even as battery costs have been **falling**, EV prices have been **rising**, as customers seek longer range.



Sources: Alliance Bernstein for batteries, “A perspective on equity in the transition to EVs,” Hardman et al., for cars

Environment

The environmental impact of any vehicle comes in three pieces:

1. **MANUFACTURING (and recycling) the vehicle: because of the massive amount of mining that must be done to extract the raw materials needed for EV batteries, producing an EV generates more GHG emissions than does making an ICE.**
2. **However, OPERATING an EV is more energy-efficient than running an ICE, as the EV converts more of its fuel (electricity) into useful power than an ICE does.**
3. **And POWERING the EV (creating the electricity it uses), is generally lower in emissions than for the ICE. If the grid is "dirty" electrical grid, then the ICE may have the advantage. But for the US grid as a whole, EVs are greener.**

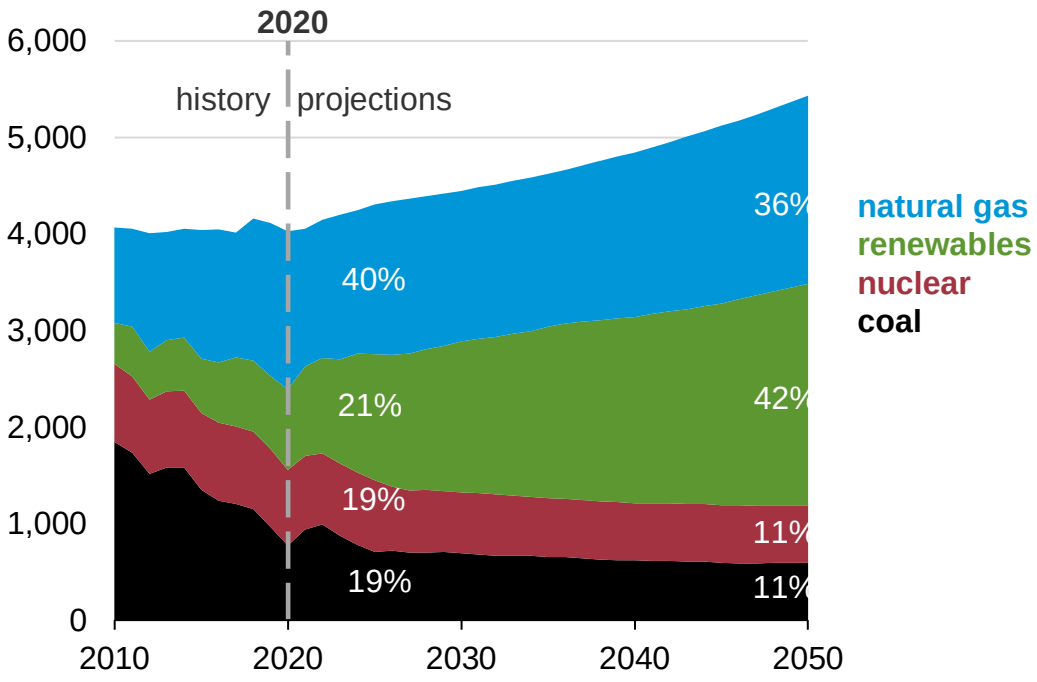
Net, therefore, the consensus is that EVs are better for the environment than ICE. However, USA GHG emissions are so huge, and the fleet turns over so slowly, that growing EV sales may not make a big difference to total emissions for years.

American consumers generally already consider EVs to be "green," but dealers may have a role in discussing with consumers the issues involved (e.g., BEV vs. PHEV).

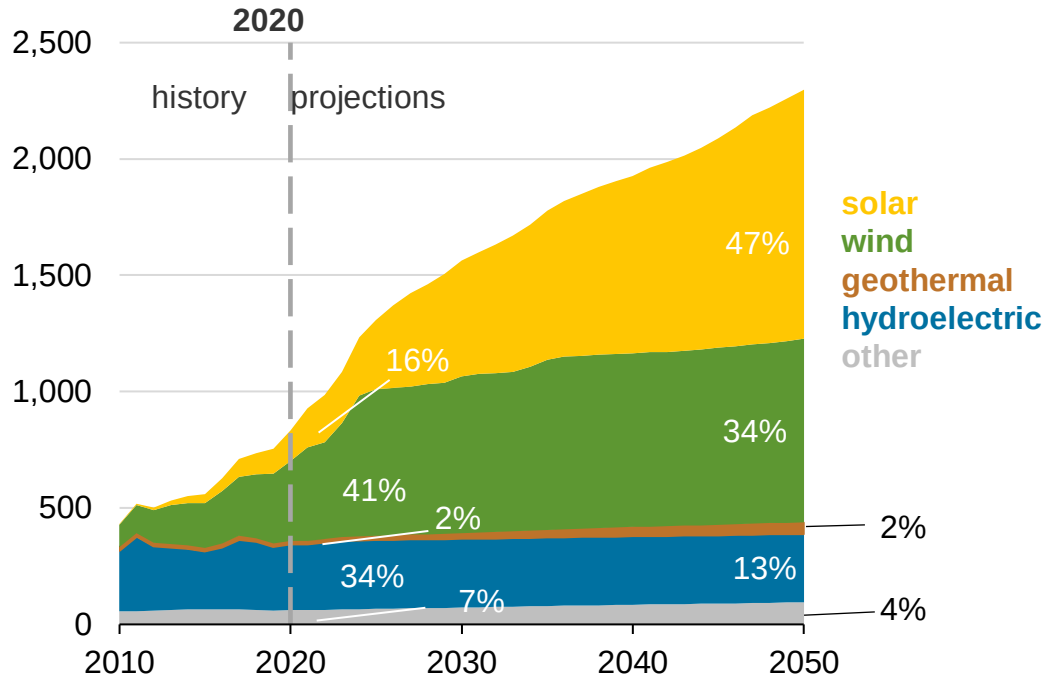
The US power grid is getting “greener”

Zero-emission sources (nuclear+renewables) are projected to grow from 40% of generation in 2020 to over 50% by 2050, due primarily to an upsurge in solar power.

U.S. electricity generation from selected fuels
AEO2021 Reference case
billion kilowatthours



U.S. renewable electricity generation, including end use
AEO2021 Reference case
billion kilowatthours



Source: EIA Annual Energy Outlook 2021

Geopolitics: no good options

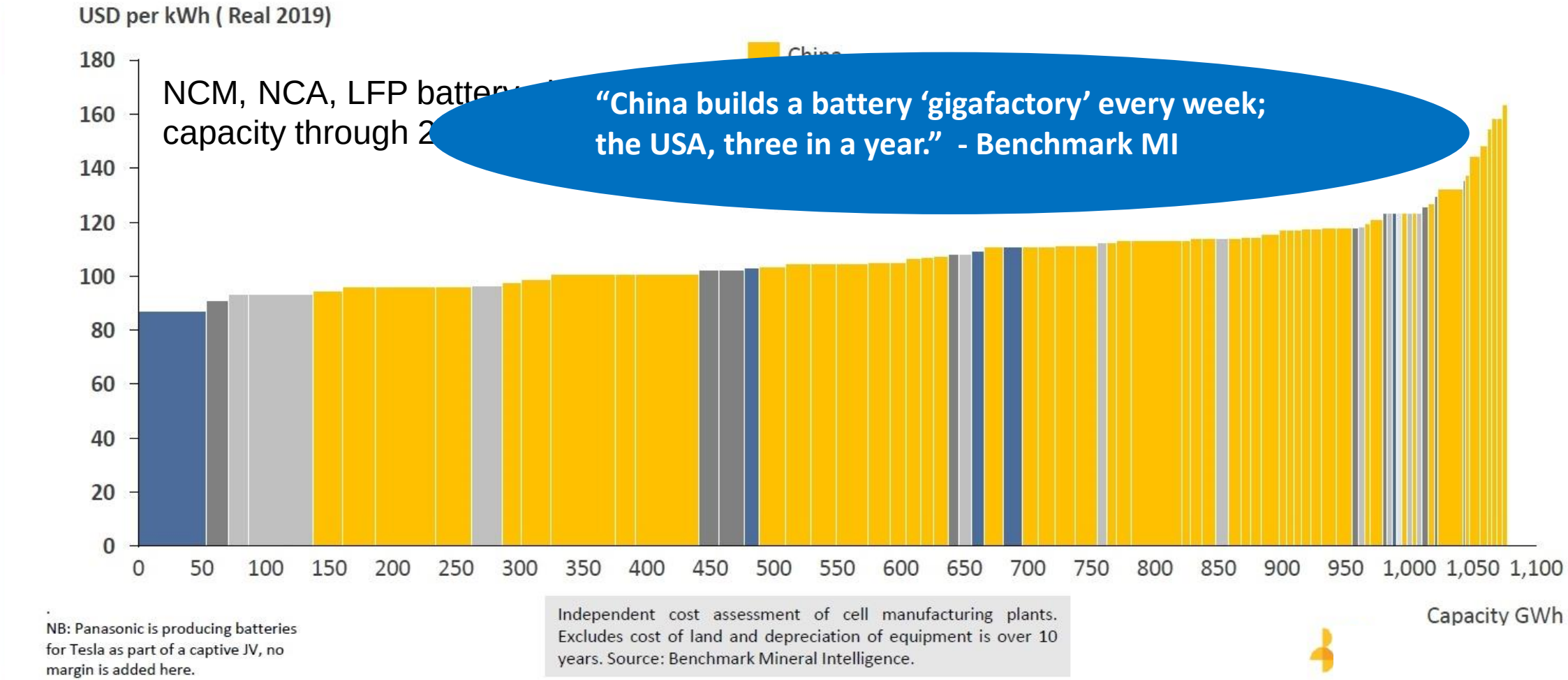
Leaving aside the environmental issues involved in sourcing battery materials, there are at least two geopolitical concerns regarding the present EV transition:

1. **Unless the USA undertakes dramatic action, it will find its car market, to the extent it shifts to EVs, more dependent on Chinese supplies**
2. **Beyond that, to the extent that EVs become globally dominant, the USA could find its leadership in the automotive industry "hollowed out," as has happened before in the production of textiles, furniture, appliances, and more.**

Both these issues are being addressed by the current administration, but the author has no view on the adequacy of those actions.

China is to batteries as OPEC was to oil

China dominates both upstream and downstream EV battery supply



Source: Benchmark Mineral Intelligence; cathode chart from Roskill

Recap of Inputs and Impacts, with Recent Movements

1. *Inputs* to the EV market

- Customers ▲
- Vehicles ▲
- Batteries ▼
- Charging
- Governments ▲
- Economics ▼

3. *Outcomes*

- For Sales
- On Dealers

2. *Impacts* of EVs elsewhere

- Environment
- Grid ▼
- Employment
- Geopolitics

EV Sales: Trending Up, But How Far?

There are so many factors that go into the EV equation, each of which itself must be forecast, that it is inevitable that EV sales forecasts will vary widely. Is there any consensus at all around the predicted USA EV sales rate?

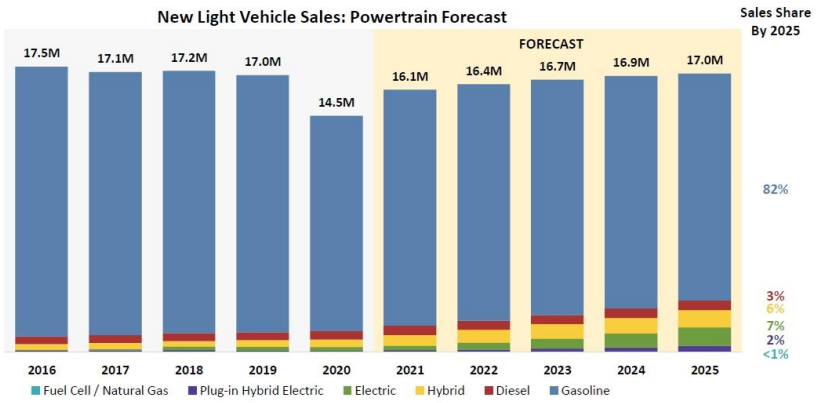
At the basic level, yes: *every* EV sales forecast sees growing EV market share. Beyond that, there is some consensus that EV* share in 2025 will be 5-10%. Further, there is some consensus that EV share in 2030 will roughly double that

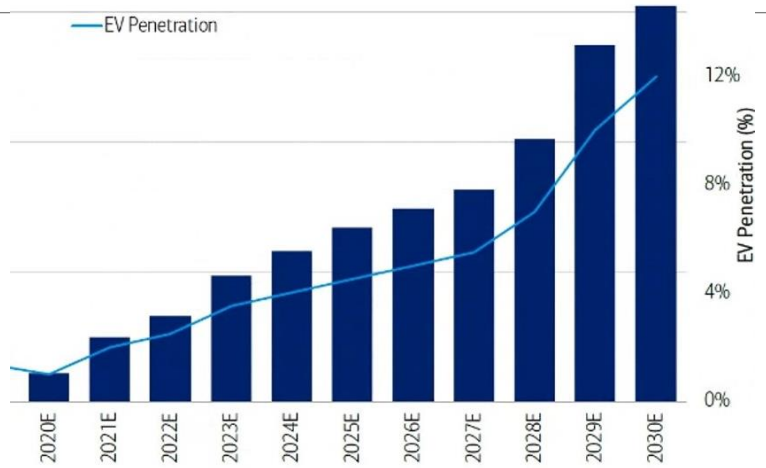
Here are the forecasts we've collected (in %, EV market share):

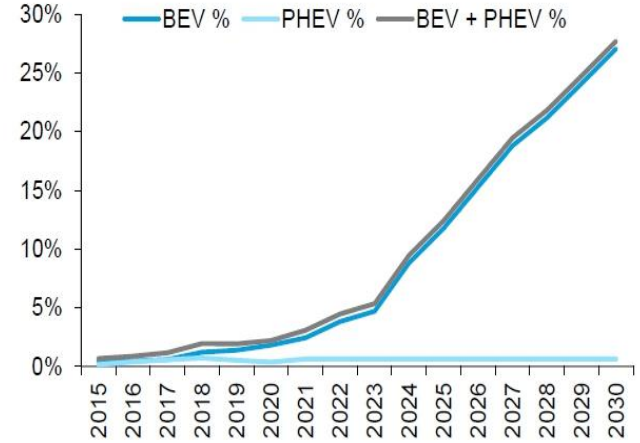
- 2025: 9, 6.5, 8, 5+, 7-10, 8, 7, 5, 8, 10, 12, 10, 7, 8-20 (!) – average ~9.5%
- 2030: 13, 12, 20, 17, 11.5, 8, 20, 30, 34, 20, 17, 17-40 (!) – average ~19%
- The sources for these projections include: IHS, McKinsey, CAR, EIA, Goldman Sachs, BNEF, UBS, Alliance Bernstein, LMC, AutoPacific, Morgan Stanley, BCG, Citigroup, Navigant/Guidehouse, PWC, DB, Jeffries, Boston U., etc.

*Note again that some forecasts bundle PHEV in with BEV to forecast "PEV" (plug-in vehicles), while others forecast only BEV. No forecaster sees PHEV as more than 15% or so of eventual total PEV sales, so this variance does not have material impact on the overall forecast levels.

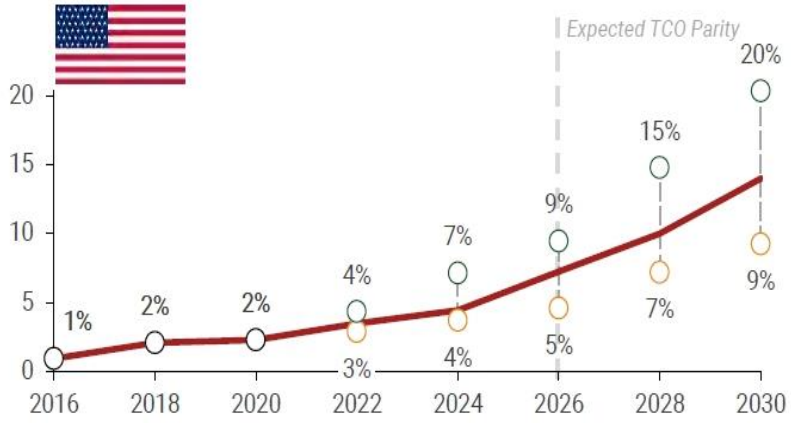
EV sales: a few recent (2021) forecasts





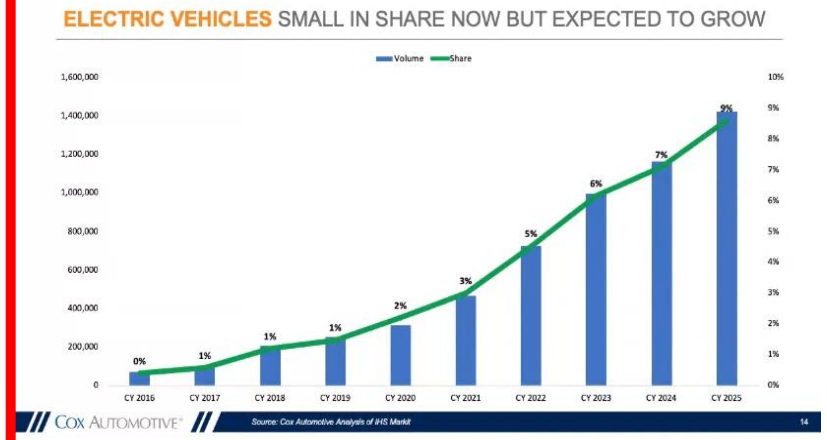


Source: Citi Research



2025 USA BEV % of SAAR:
BofA/ML: 5%
Citi: 12%
Cox: 9%
PWC: 5-8%
SEMA: 7% (BEV only)

NB: in some cases, the author estimated numbers from graphics: any errors as a result are his alone.



EV Sales: What Could Change Consensus?

Are there "wild cards" that might alter the consensus of steadily upward? A few…

- "Hindenburg Event:" a major multi-car EV battery fire (e.g., in a parking garage)

+ "ICE Age:" one or more major cities bans ICE downtown (*now*, not in 2035)

- "China Syndrome:" political friction throttles supply of batteries to US market

+ "Apple Cart:" Apple enters the market: >110 million Americans have iPhones

-/+ "Gas Shock:" oil prices move sharply: gas goes to $1.50 (-) or $5.00 (+)

+ "Convoy:" one or more EV pickup trucks becomes a major success

- "Green Backlash:" public turns against EVs due to raw material issues

+ "OEM Shock and Awe:" one or more incumbent OEMs (VW?) becomes very aggressive, e.g., free home charger, free charging, 500-mile range

+ "Money Changes Everything:" Biden admin. launches massive EV incentives and tightens MPG/GHG limits drastically

and…?

Dealers: Impact of Higher EV Sales

As EV sales grow, what is the impact on dealers? The answers vary by function.

A. Sales: mildly negative?

- Some volume loss to new EV entrants, to the extent they do not use dealers
- Some investment required in sales force training
- Possibly F&I upsides, e.g., extended battery warranties

B. Service: probably negative… eventually

- Likely decline in most service revenue, relative to ICE (this is not new, for dealers)
- Some investment required in tech training, and in special EV service equipment
- Possible increase in service retention, given the advanced technology of EVs
- Possible increase in collision repair revenue, and a likely increase in tire sales

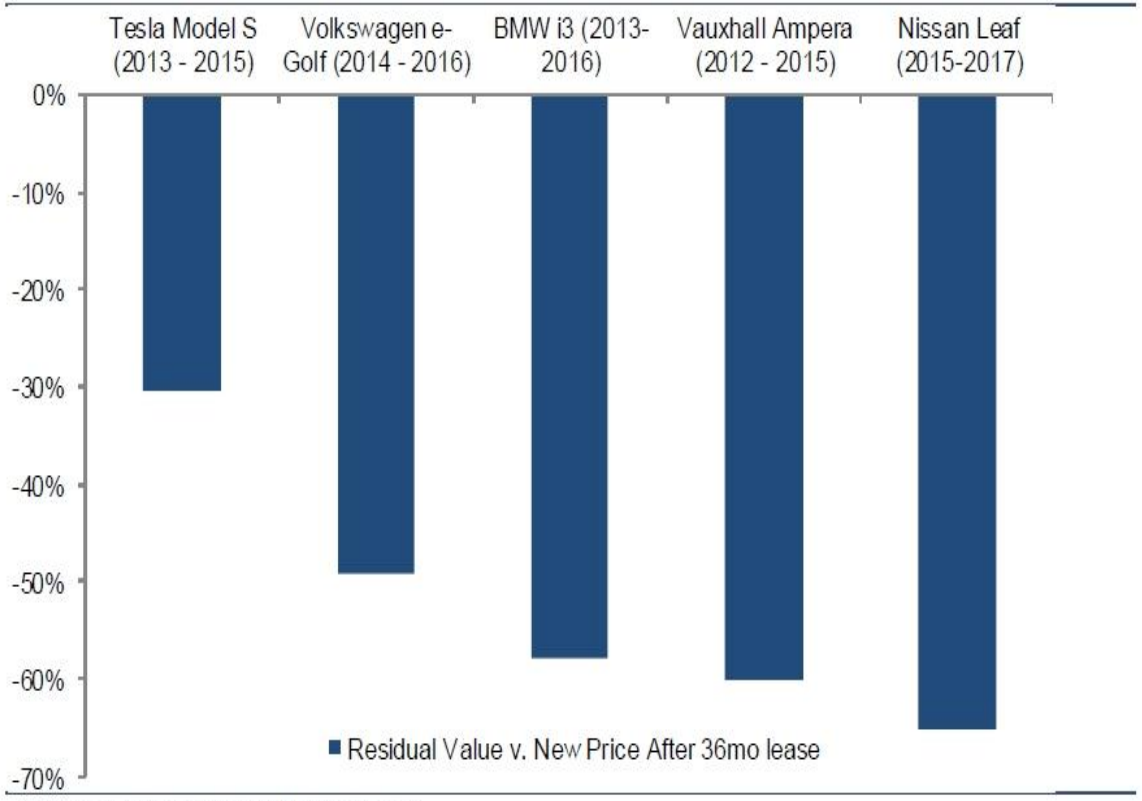
C. Overall role: possibly negative, if not managed well

- Proliferating OEM attempts to alter the way dealers interact with customers can make sense (to the extent customer needs are indeed evolving), but can also be counter-productive (by reducing the dealer's role at the very point in time when dealers' proven ability to communicate, market, and *sell* the benefits of new vehicle technologies is most required, in order to advance America's EV transition)

Remarketing: Trends in EV Residuals

EV RVs, other than for Tesla, have lagged ICE RVs. But the gap is closing.

Recent EV Residual Values (European data)



Source: DrivingElectric and Autonomous

Analysts' Commentary:

- EVs historically have lower RVs than ICE (except Tesla)
- For other brands, short range and rapid tech change depressed RVs
- Cox and ALG both report the gap with ICE RVs is closing
- RVI in fact predicts that EV RVs will eventually (2023?) exceed those of ICE, as the transition moves ahead

Concluding Remarks and Forecast (author's opinions!)

1. The EV transition in America now seems inevitable: we are only discussing speed
2. China is moving faster (as a matter of national policy), as is Europe (especially PHEV)
3. The most favorable recent change is customer enthusiasm: both Alix and JDP report significantly more Americans aware of and considering EVs than in recent years
4. The most negative recent development is in battery raw materials, in terms of availability and therefore price, delaying the point at which EV and ICE are at cost parity
5. The role of China in the American EV transition remains problematic: to the extent we buy more EVs, we send more money, jobs, and political power to Beijing
6. The impact on dealers of the transition is likely overall negative, but dealers have time to act, and given the early warning, an understanding of the need to make plans now
7. **My forecast: 8% of US LDV sales in 2025 (1.4 mm cars) are EV, twice today's level.**

   NB: This forecast has been revised upward three times since 2016!

Overall Summary: Three Key Numbers

16-16.5 million: new car sales in the USA in 2022

8%: PEV (BEV+PHEV) market share in the USA in 2025

2023: year when the chip shortage is definitively over

(Please contact me at gmercer2@gmail.com in 2025, to either congratulate me on my accuracy, or mock me for my utter failure!)