

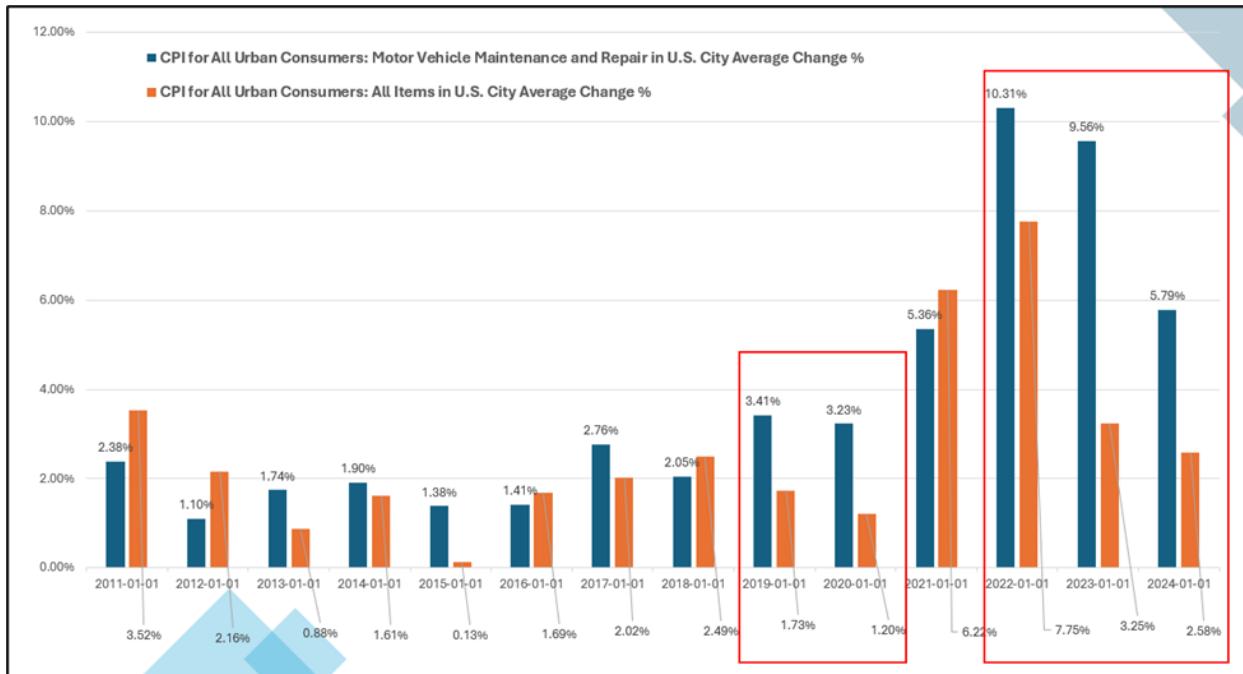
Repairing versus Salvaging in the Age of Connected Autonomous Vehicles

Car Maintenance and Repair Inflation

The Internet of Vehicles connects cars, buses, traffic signals, and parking spots. LiDAR (Light Detection and Ranging) provides cars with their own set of eyes. Now, we are no longer speaking about autonomous vehicles in isolation; we are speaking about Connected Autonomous Vehicles.

While we are excited about technological advancements in the car industry, there is an underlying trend beneath euphoria. According to the U.S. Bureau of Labor Statistics data, if someone spent \$500 in October 2010 on car vehicle maintenance and repair, the same maintenance and repair will cost \$831.78 in October 2024. In contrast, a general item of \$500 in October 2010 will cost \$720 in October 2024.

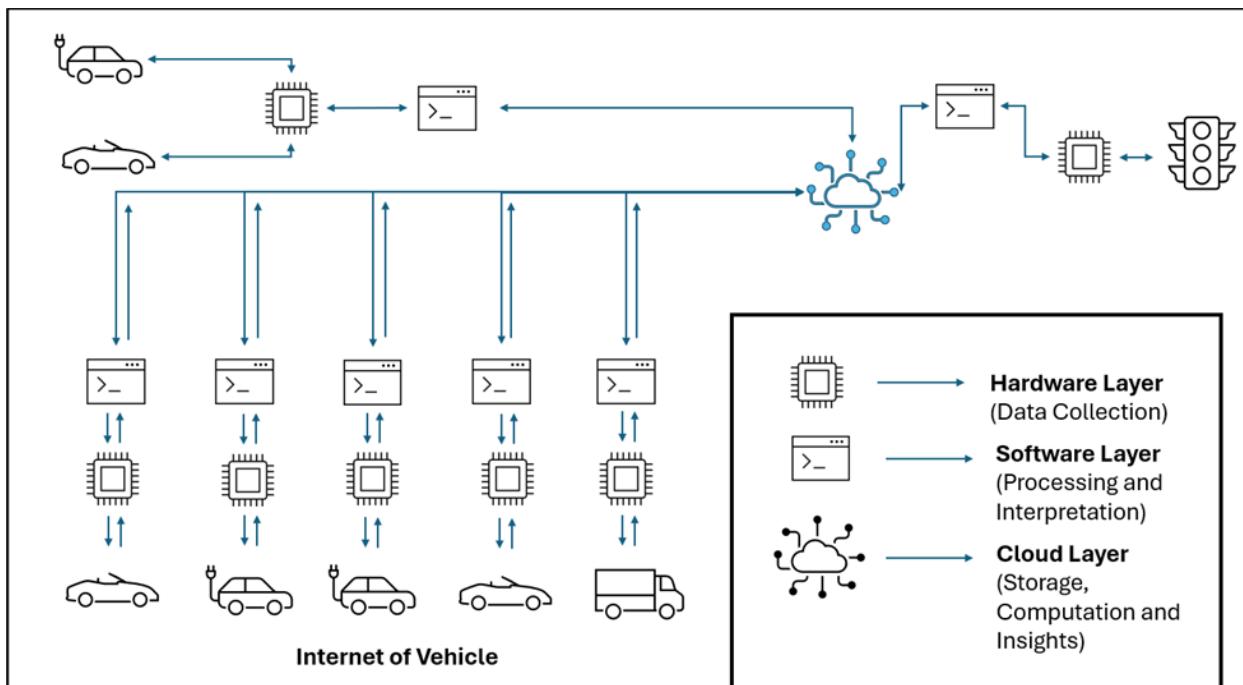
As *Figure 1* shows, Vehicle Maintenance and Repair CPI Inflation has comprehensively outpaced CPI Inflation for all items for 5 years in the last 6 years (2019 -2024):



Increasing Complexity of Cars

Out of the many factors contributing to excessive car repair inflation, one of the major factors, that is here to stay is the increased complexity of Cars.

For over a decade, the technological advancements in the Vehicle industry have begun to culminate into an ecosystem called the Internet of Vehicles - which we are witnessing taking its shape more rapidly than anticipated. *Figure 2* attempts to capture this synthesis:



Hardware Layer:

The hardware layer performs the task of data collection, using:

- **Sensors** like – LiDAR (Light Detection and Ranging), Eye-tracking cameras, Gyroscopes, fatigue sensors etc.
- **Actuators** Like - Airbag Deployment Actuators, Electric Seat Actuators, Window and Door Lock Actuators, Adaptive Cruise Control Actuators, Lane Keep Assist Actuators, etc.
- **Communication** Systems like - DSRC (Dedicated Short-Range Communication) to facilitate, V2V (Vehicle-to-Vehicle) or V2I (Vehicle-to-Infrastructure) communications
- **Telematics and Onboard Diagnostics**

Software Layer:

The software layer processes, controls and orchestrates, using

- **Operating System** - Google Android Automotive, Automotive Grade Linux (AGL), Tesla's proprietary OS.
- **Vehicle Management Software** - Autonomous driving algorithms, Advanced Driver Assistance Systems (ADAS).
- **Human-Machine Interfaces (HMI)** like - Dashboards, voice assistants, and touch controls for user interaction.

Cloud Layer:

The cloud layer stores data, trains and helps generating meaningful analytics, using

- Cloud Infrastructure Platforms – AWS IoT, Microsoft Azure or Google Cloud
- Models for autonomous driving, route optimization etc.

But how is this increased complexity related to high car repair cost inflation?

- Car Parts have become more expensive.
- Advanced sensors and actuators used in cars are patented and produced by few.
- The development costs and technical expertise required to produce high-performance automotive sensors and actuators create significant barriers to entry for new players.
- Finding issues in the connected ecosystem of connected vehicles requires expensive skill sets.

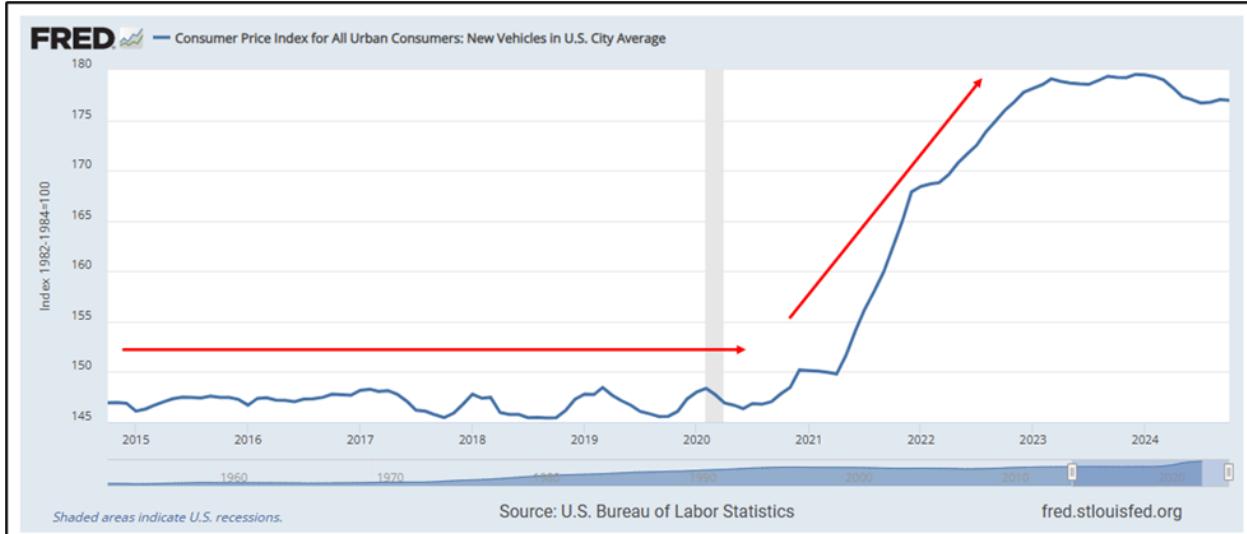
Salvaging, ACV and Total Loss Threshold

Salvage Value:

Salvage value is the cost of equipment at the end of its useful life. It is calculated as:

Salvage Value = Market Value of Vehicle at Purchase \times (1 - Total Depreciation Rate) \wedge Age in Years.

All else equal, one of the main factors in the above formula which drives the salvage value is the “Market Value of Vehicle at Purchase”. As per the U.S. Bureau of Labor Statistics, the CPI index of new car prices has jumped significantly in the last 5 years:



However, this increase is highly correlated with high overall inflation during the same period. Hence, this trend is not here to stay, and I assume this factor alone is not going to affect the trend of car Salvage Value in any meaningful way.

Actual Cash Value:

When a car is damaged or stolen, an insurance company calculates the actual cash value (ACV) of the car – which is the fair market value of the car, just before the damage or theft. The Actual Cash Value of the car just before the damage or theft forms a major part of the cost which insurance company pays out to the insured, in the case of totaling, apart from the salvage value/deductibles.

Let us now look at a scenario using some numbers.

Person A buys a car for \$30,000 on 01-Oct-2010. Let us consider, this is the market value of a vehicle at purchase in 2010 for person A.

As per the CPI Index of “Consumer Price Index for All Urban Consumers: New Vehicles in U.S. City Average” Published by *U.S. Bureau of Labor Statistics*, below is the Y-o-Y inflation of a New Vehicle in U.S.:

Observation Date	CPI of New Vehicles	Change %
2010-10-01	138.442	
2011-10-01	143.095	3.36%
2012-10-01	144.547	1.01%
2013-10-01	146.233	1.17%
2014-10-01	146.928	0.48%
2015-10-01	147.481	0.38%
2016-10-01	147.784	0.21%
2017-10-01	145.474	-1.56%
2018-10-01	145.457	-0.01%
2019-10-01	145.596	0.10%
2020-10-01	147.811	1.52%
2021-10-01	162.368	9.85%
2022-10-01	175.981	8.38%
2023-10-01	179.247	1.86%
2024-10-01	176.966	-1.27%

Considering the above data, if Person B buys the same car on 01-Oct-2024, the price of the car would be \$38,348.04.

Let us assume that Person A and Person B use the car for 5 years, after which they approach the insurance company due to damage. Now we have the Market Value of Vehicle at Purchase for both the cars and the number of years they have been used. The only other missing piece which we must assimilate is the depreciation rate of these cars for calculating the actual cash value of the car which an insurance company will consider.

On average, the depreciation rates of cars have followed the same pattern over the years. Whatever, little ups and downs happened in the depreciation rate, in my view, can be considered immaterial for the purpose of this exercise.

As per a blog – “Visualizing Car Depreciation: Charts and Curves” in www.econoautosale.com the below pattern is presented as average depreciation pattern of a car over 5 years:

Time Period	Depreciation (%)	Value Retained (%)
0-1 Year	20%	80%
1-2 Years	15%	68%
2-3 Years	12%	60%
3-4 Years	10%	54%
4-5 Years	8%	50%

Thus, considering the above depreciation rates, after 5 years of usage the ACV of the car belonging to person A (bought in 2010) and ACV of the car for Person B (bought in 2024) is **\$14,864.26** and **\$19,000.51** respectively.

Depreciation of the Car for Person A			
Year	Beginning Value	Depreciation Rate	Ending Value
0	\$30,000.00	20%	\$24,000.00
1	\$24,000.00	15%	\$20,400.00
2	\$20,400.00	12%	\$17,952.00
3	\$17,952.00	10%	\$16,156.80
4	\$16,156.80	8%	\$14,864.26

Depreciation of the Car for Person B			
Year	Beginning Value	Depreciation Rate	Ending Value
0	\$38,348.04	20%	\$30,678.44
1	\$30,678.44	15%	\$26,076.67
2	\$26,076.67	12%	\$22,947.47
3	\$22,947.47	10%	\$20,652.72
4	\$20,652.72	8%	\$19,000.51

Total Loss Threshold:

Insurance companies use a formula: (Repair Cost + Salvage Value)/ACV * 100 to derive, what is called Total Loss Ratio.

If the Total Loss Ratio exceeds 70%-80%, insurance companies consider the car as total loss, which means the car is economically no longer viable to repair. Now, here is the thing – the car may still be drivable – but repairing the car is too costly in comparison to its ACV. In the case of total loss, if the owner of the car agrees to settlement, the insurance company pays the owner an amount equal to – (ACV – Salvage Value) and gathers a salvage certificate for the car from the Department of Motor Vehicles (DMV).

Hence, an increase in repair cost of the cars due to reasons discussed at the beginning of the article has a significant impact on the Total Loss Ratio.

Change in Total Loss Ratio due to Car Repair inflation

Let us see how the total loss ratio of Person A and Person B differs considering the car repair inflation rate.

In the case of the calculation shown in Figure 8, I have made few considerations:

- A reasonably high repair cost to start with, because we are looking at a total loss assessment scenario – which normally occurs when the repair requirement is much higher than normal.
- The Salvage Value used in total loss calculation, is the scrap value of the car, assuming the car is unusable or approaching end of useful life.
- The fair value calculation of the cars is already shown in section – “Actual Cash Value”
- The Forecasted inflation rate of the Car Repair and Servicing cost considers the rolling geometric mean of the last 5 years

	Observation Date	Car Repair and Servicing Index	Change	High Value Repair Cost	Age (in Years)	Market Value at Purchase	Fair Value (ACV)	Salvage Value	Total Loss Ratio
Known Data	2010-10-01	249.824		\$7,000.00		\$30,000.00			
	2011-10-01	255.774	2.38%	\$7,166.72	1		\$24,000.00	\$2,000.00	38%
	2012-10-01	258.578	1.10%	\$7,245.28	2		\$20,400.00	\$2,000.00	45%
	2013-10-01	263.085	1.74%	\$7,371.57	3		\$17,952.00	\$2,000.00	52%
	2014-10-01	268.094	1.90%	\$7,511.92	4		\$16,156.80	\$2,000.00	59%
	2015-10-01	271.804	1.38%	\$7,615.87	5		\$14,864.26	\$2,000.00	65%
	2016-10-01	275.645	1.41%	\$7,723.50					
	2017-10-01	283.257	2.76%	\$7,936.78					
	2018-10-01	289.057	2.05%	\$8,099.30					
	2019-10-01	298.925	3.41%	\$8,375.80					
	2020-10-01	308.569	3.23%	\$8,646.02					
	2021-10-01	325.095	5.36%	\$9,109.07					
	2022-10-01	358.597	10.31%	\$10,047.79					
	2023-10-01	392.861	9.56%	\$11,007.86					
	2024-10-01	415.598	5.79%	\$11,644.94		\$38,348.04			
Forecasted Data	2025-10-01		6.29%	\$12,377.42	1		\$30,678.44	\$2,000.00	47%
	2026-10-01		7.19%	\$13,267.20	2		\$26,076.67	\$2,000.00	59%
	2027-10-01		7.62%	\$14,278.78	3		\$22,947.47	\$2,000.00	71%
	2028-10-01		7.18%	\$15,303.82	4		\$20,652.72	\$2,000.00	84%
	2029-10-01		6.78%	\$16,341.39	5		\$19,000.51	\$2,000.00	97%

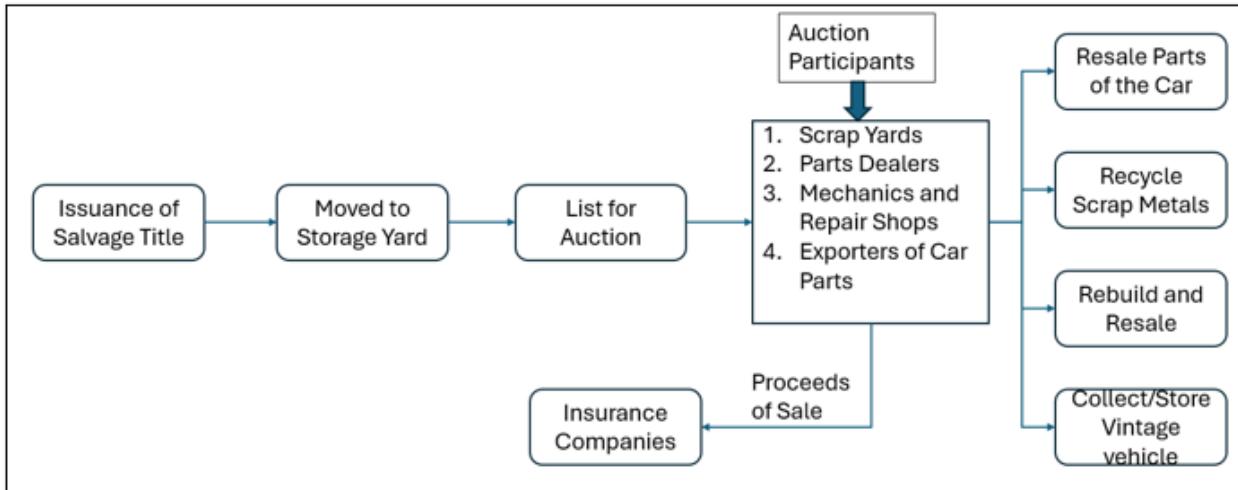
As you can see from the above calculation, due to the repair and servicing cost inflation outpacing purchase price of new vehicles – the same car bought by person B breaches the total loss ratio of 75% in 3rd year. Whereas the car bought by person A in 2010, never breaches the total loss ratio.

In the case of any of the above scenarios, If the insurance company decides to total, it must pay the insurer an amount equal to Actual Cash Value – Any other deductibles, if the insurer accepts the settlement amount and agrees to transfer the title to the insurance company. If the insurer wants to retain the title of the salvaged car, then additionally, the salvage value of the car is deducted from the final settlement by the insurance companies.

But what happens next. What about the scrap car. Does it just lie there unattended in the junkyard? The answer is - No. In fact, it gets more or equal attention from here on.

Post Salvaging

Once the insured accepts the settlement amount and agrees to transfer the ownership title to insurance companies, the below series of steps follow:



So, as the above figure depicts, the valuation of salvage car is dependent on several moving factors:

- The individual parts of a salvaged vehicle are priced separately.

This brings us to the initial topic which we started with – the increasing complexity of cars. The same factors which cause the repair cost of cars in recent times to increase, and is making totaling more lucrative, has the potential of adding to the value of a salvaged car.

- Electric Vehicles command higher salvage value due to the recycling properties of rare metals like lithium, cobalt and nickel.
- The prices of scrap metals like steel, aluminum and copper are determined by market cyclicalities.

Conclusion

The intention of this article is to scribble some disparate thoughts and form a shape (as much possible) of thought. I feel there are multiple attractive parts in this puzzling ecosystem which can be explored further. For example, apparently the most boring part of the entire ecosystem – the auctioning of salvaged car parts is performed online, through open auction, where bidders from across the globe participate. Thus, trying to derive one single tangible conclusion will not be fair.

However, just to wrap the chain of thoughts – I strongly feel, as vehicles get more technically complex – they will be less economical to repair and maintain over a longer period. But their scrap value may continue to remain attractive or even rise, due to its individual parts being more valuable than before.