

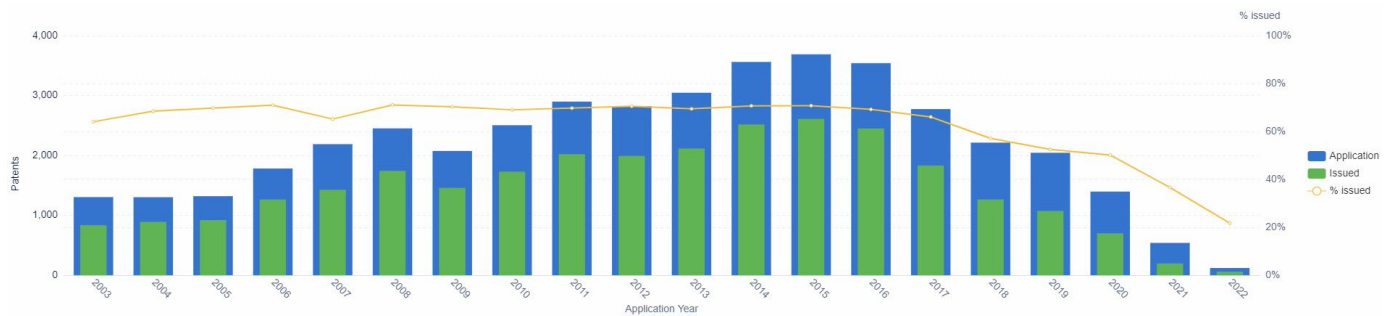
An aerial, high-angle photograph of a complex highway interchange. The image is heavily blurred to create a sense of motion and speed. The roads are multi-laned and curve in various directions. Several cars are visible, their forms streaked due to the motion blur. The overall color palette is dominated by cool blues and greens, with some warmer tones from the road surfaces and vehicle lights. The text is overlaid on the central part of the image.

A Review on Internal Combustion Engines

A PatSnap Report

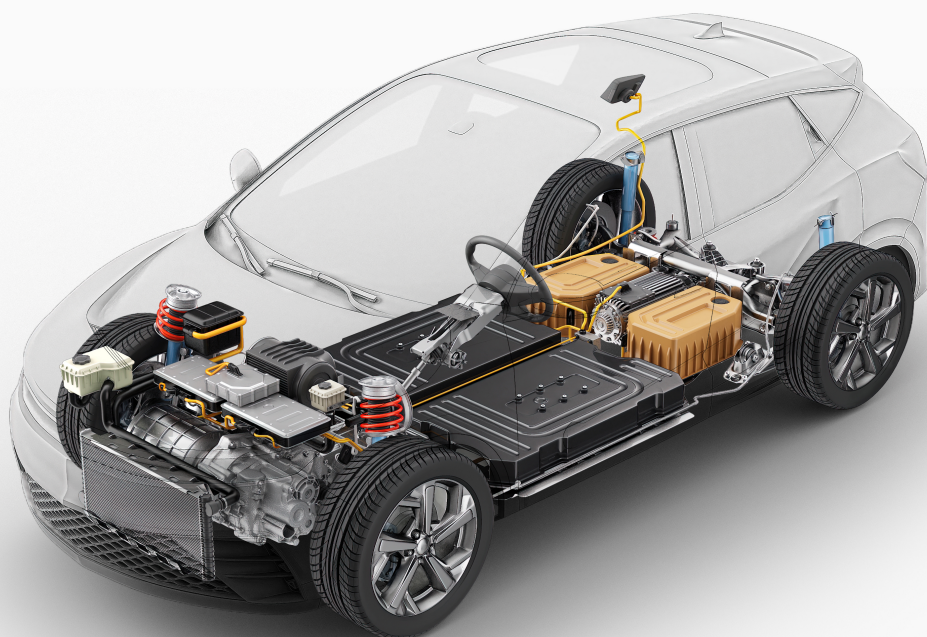
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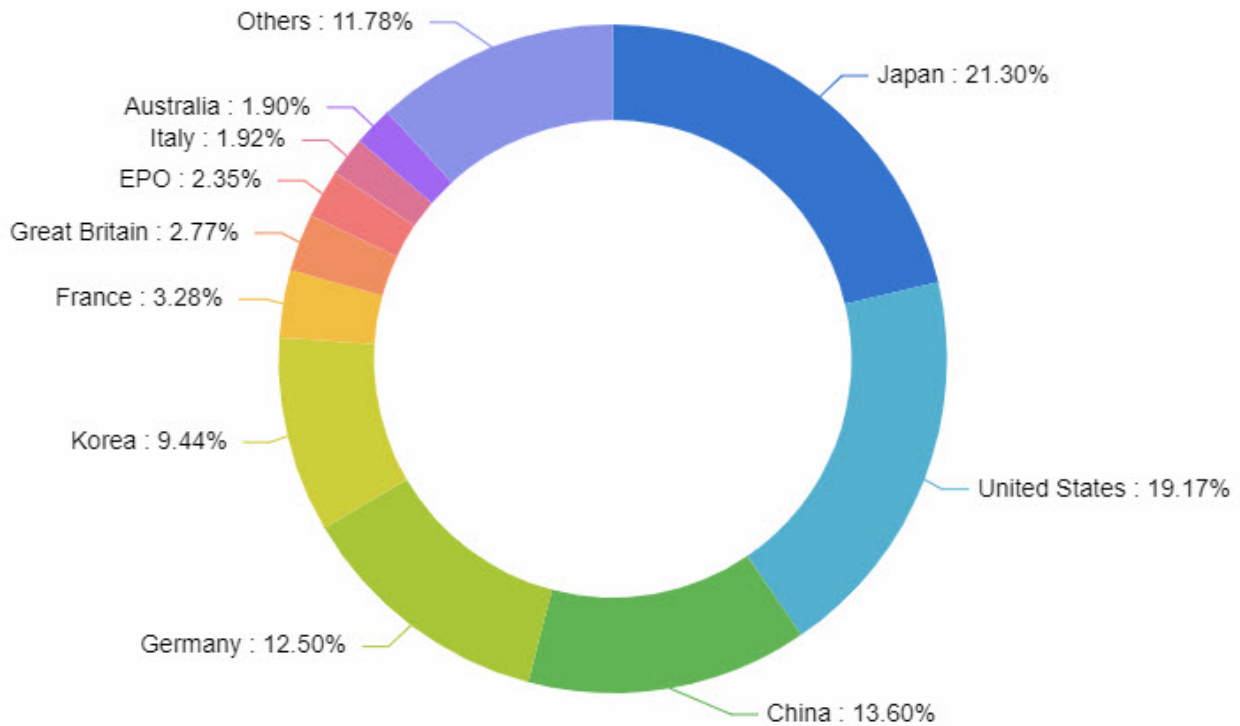
Internal Combustion Engine Automotive



ICE Patent Application and Grant Trends, PatSnap Insights

As the cost of oil continues to rise, and access to oil becomes strained (due to the War in Ukraine and tensions with Russia – one of the largest oil producers in the world), it’s important to examine internal combustion engines. The global innovation trend for internal combustion engines (ICEs) has remained steady over the past 20 years. And although Electric Vehicle (EV) innovations are trending in recent years, the reality is this new era of “smart cars” are still in the early stages of market disruption. The global CAGR for ICE vehicles is 4.5% – set to grow from \$23.0 billion USD in 2022 to \$28.7 billion USD in 2027. In contrast, the EV market, which has a CAGR of 19% is expected to be worth \$354.80 billion USD by 2028. The stark difference in both CAGRs implies that although ICE vehicle patents currently dominate the market, EV patents are likely to surpass the ICE market in the next decade.





Geographic Distribution, ICE Vehicles, PatSnap Insights

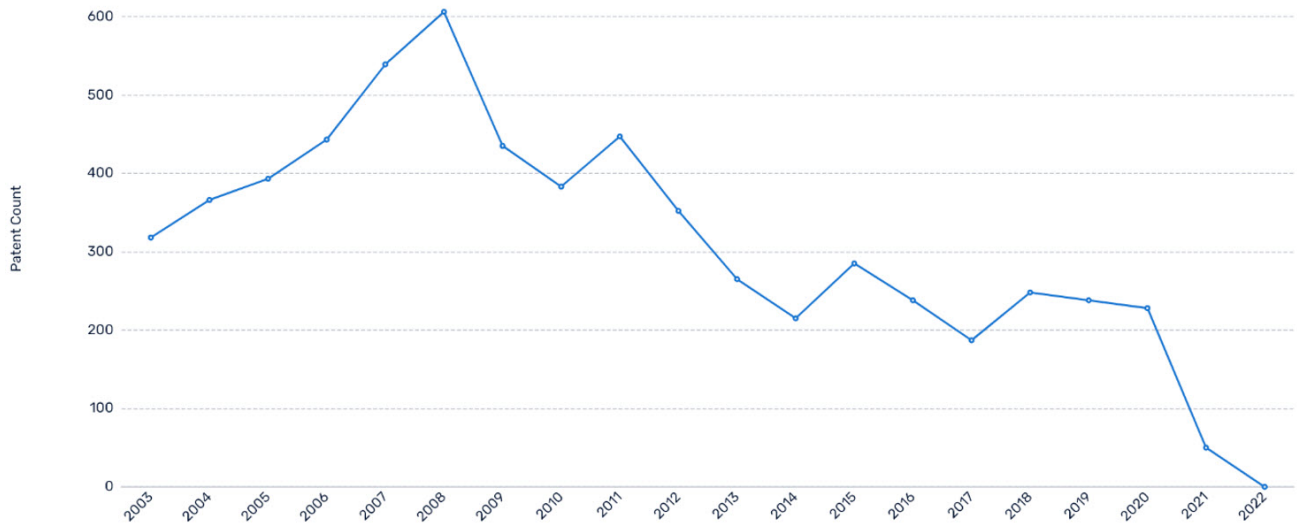
As this the above graph illustrates, the geographic distribution of innovation related to ICE vehicles originates in Japan. In 2017 Japan’s top automotive company, Toyota, sold 10.4 million vehicles globally, finishing ahead of Volkswagen and Hyundai. In terms of sales, 1.52 million units were EVs. Unsurprisingly, at the conclusion of 2021, EV sales as a share of total units had grown 72% to 2.62 million units compared to 9.6 million total units (down 7.7% overall), total.

Rank	Group	Country	Vehicles
1	Toyota	Japan	10,466,051
2	Volkswagen Group	Germany	10,382,334
3	Hyundai	South Korea	7,218,391
4	General Motors	United States	6,856,880
5	Ford	United States	6,386,818
6	Nissan	Japan	5,769,227
7	Honda	Japan	5,236,842
8	Fiat Chrysler Automobiles	Italy/United States	4,600,847
9	Renault	France	4,153,589
10	PSA Group	France	3,649,742
11	Suzuki	Japan	3,302,336
12	SAIC	China	2,886,913
13	Daimler	Germany	2,549,142
14	BMW	Germany	2,505,741
15	Geely	China	1,950,382

Top ICE Organisations

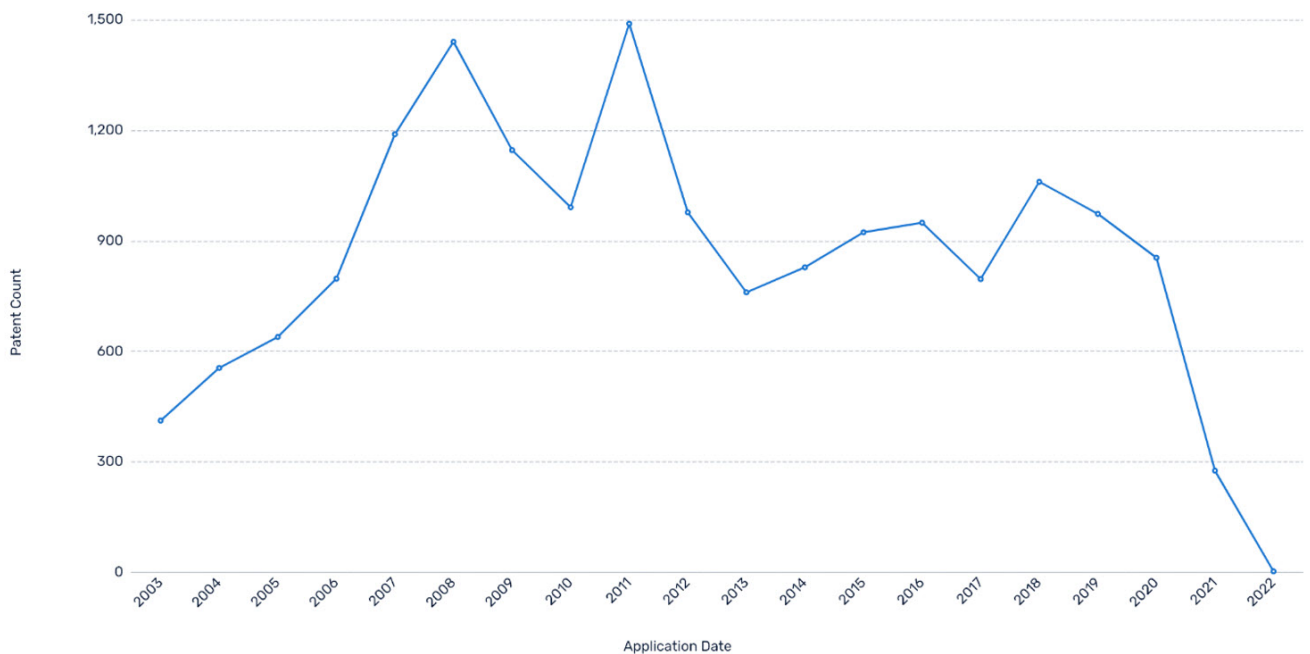
Japan maintains the largest share of patent filings in relation to ICE vehicles, so it comes as no surprise that Toyota ranks as number one on the ICE sales chart. Even though Toyota leads sales and handles the lion's share of internal combustion engine patents, the number of patents Toyota files in this area is steadily declining and has been since 2007.

Take a look:



Toyota Patent Count, ICE Vehicles, PatSnap Insights

Naturally, this begs the question: is Toyota shifting away from ICES to focus on electric power? Analyzing the data around Toyota's innovation in EVs help us to reveal the answer:

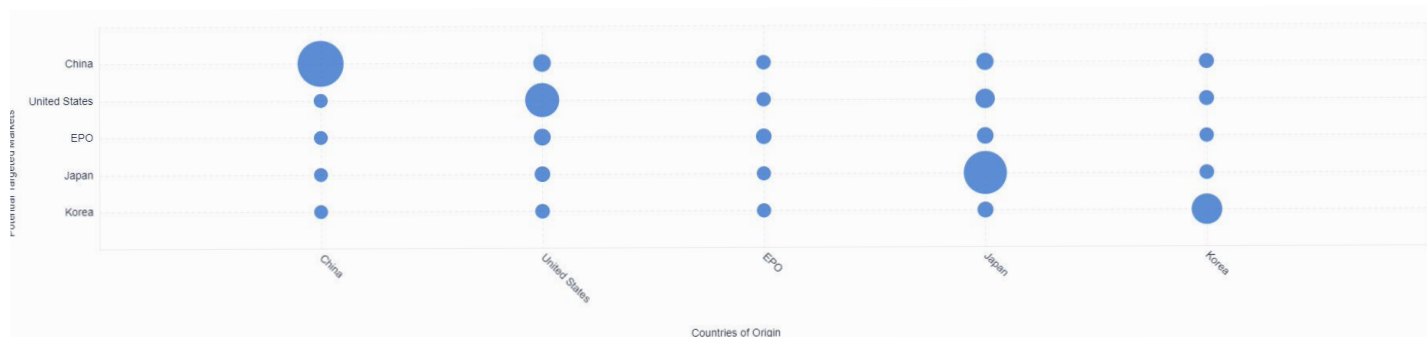


Toyota Patent Count, EV Vehicles, PatSnap Insights

Although there isn't a strong upward trend (yet), the volume of the patents currently being filed coupled with the steady year-over-year growth suggests this is the case.

As an industry leader, it's crucial to protect your position in the market and follow competitor trends. After all, how can competitors dominate if you can always anticipate and mirror their moves? This may be the case with Toyota. With larger organizations, cross-licensing happens frequently, as opposed to individual filing strategies which may slow the innovation process.

Furthermore, below, we see the international penetration of patents originating in their respective jurisdictions. There are a few commonalities with other technologies here, for example, technology originating in the United States having generally good international penetration due to the political and economic relationships between the US and Europe. As we continue to follow our Japanese thread however, we see that by and large, patents originating in Japan tend to stay there.



Top 5 IP Jurisdiction Analysis, ICE Vehicles, PatSnap Insights

This is interesting because for companies like Toyota, 85% of their vehicle sales occur outside of Japan.

	Record High	Toyota	Daihatsu	Hino	Record High	Total
Worldwide Sales		761,466 (-9.4)	44,939 (-15.1)	12,567 (9.7)		818,972 (-9.5)
Sales inside of Japan						
Incl. minivichles		86,544 (-20.9)	33,504 (-23.7)	3,002 (-23.7)		123,050 (-20.9)
Market Share		33.1 (-1.2)	-	-		47.0 (-1.6)
Excl. minivichles		84,328 (-20.5)	-	-		-
Market Share		52.5 (-2.5)	-	-		-
Sales inside of Japan		674,922 (-7.7)	11,435 (5.4)	9,565 (27.1)		695,922 (-7.1)

Toyota, Dalhatsu, Hino Sales Inside and Outside of Japan, May 2022

It logically follows that a company with such a large percentage of its sales occurring internationally would want to protect its innovation outside of its home jurisdiction. This prevents competitors from taking too much inspiration from patented and protected vehicles.

To unpack the reasoning behind this strategy, we'll need to be aware of a few things. First, patents cost money. The costs of supporting a giant patent portfolio add up quickly. Second, a company doesn't need to protect everything, everywhere, all at once.

For example, if some special technology is needed in a vehicle for it to drive on the left-hand side of the road, is it necessary to spend money protecting that IP in right-driving countries? Although this is a simplistic example, it captures the essence of the problem. A more viable strategy is to always file in your home jurisdiction first, validate the technology, and once proven to be successful, export it to the rest of the world.

It's worth noting that there are certain time limitations around filing a patent in multiple jurisdictions so your mileage may vary with the order you choose to follow those steps. To understand if our hypothesis is true, we'll refer to Toyota's patent portfolio, illustrated in the table on page 4. We can see that the Japanese applications with the highest citations also have the most international penetration, showcasing that the more successful technologies are most likely to be supported worldwide.

In conclusion, although innovation in EVs maintains a higher CAGR rate than ICE innovation, without radical shifts and incentives from national and worldwide governmental bodies, ICE innovation will remain steady, and investments will continue.



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