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Research on export competitiveness of new energy vehicles in Yangtze River Delta region

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Abstract: As the energy crisis and automobile industry develop, the global automobile industry competition has shifted from individual product competition to comprehensive strength competition among industrial clusters. In recent years, China's new energy automobile industry has developed rapidly, with the trend of automobile industry cluster becoming more evident. The Yangtze River Delta region, with its strong vehicle and parts manufacturing base, has become a typical representative of China's new energy vehicle export industry. Research on the export competitiveness of new energy vehicles in the Yangtze River Delta can reflect the overall development of China's new energy automobile industry to a certain extent. It also has important theoretical significance and practical value for enhancing the competitiveness of the new energy automobile industry in the Yangtze River Delta and even the whole country.

Keywords: New energy; Automobile; Competitiveness; Industrial agglomeration

1 Introduction

New energy vehicles are emerging globally, with countries actively developing them. China has achieved a world-leading position in this field. There is relatively abundant academic literature on China's new energy vehicle export trade. However, existing studies primarily focus on the Yangtze River Delta region. Statistical analyses in this area remain limited and exhibit notable gaps.Yangtze river delta region has become one of the major new energy automobile manufacturing base in China, the research on the region's new energy automobile export competitiveness will be more meaningful.

The Yangtze River Delta region is the most economically developed area in China. It is also the most open and one of the strongest in terms of regional innovation capabilities. As China's economic development level improves, people pursue higher material and spiritual life standards. This leads to higher requirements for promoting the advanced manufacturing level of the Yangtze River Delta. Policies also guide this advancement. The Yangtze River Delta region is densely populated. The local residents enjoy a relatively high standard of living and have a great demand for automobiles. Part of the advanced manufacturing industry in the region has developed in a clustered way and shown a trend of coordinated group development. This has laid a solid foundation for the integrated development of advanced automobile manufacturing clusters in the Yangtze River Delta. As a result, new energy vehicle companies like Tesla, Wei, and Shanghai Volkswagen have emerged here.

After the energy crisis in the 20th century, more and more people concern around the world in terms of development and utilization of new energy has relevant policy to follow up. In the field of conventional cars in

China started is behind the western developed countries, but in the field of new energy vehicles is currently in the world's advanced level. The Yangtze River Delta region is also the first echelon in the field of new energy vehicles in China. The new energy vehicles produced here are sold all over the world and have their own influence.

The Yangtze River Delta region has a strong new energy vehicle manufacturing sector. It has a high market penetration of new energy vehicles. The development of new energy vehicle manufacturing enterprises is also fast here. They have gradually formed their own brand system and brand awareness both at home and abroad. The energy issue is a major global concern that every country faces. How to solve it is a big question for all countries. This also means wide market opportunities in the field of new energy vehicle exports. Our country is on par with many Western industrial powers in this field. It is even stronger than the traditional Western industrial powers in some aspects. How to conduct competitive analysis and optimize competitiveness is an important subject.

1.1 Research Background

1.1.1 Overview of new energy vehicles

New energy vehicles use unconventional vehicle fuel as a power source. They can also use conventional vehicle fuel with a new vehicle power unit. They integrate power control and driving of the vehicle with advanced technology. This advanced technology forms a principle based on new technology and new structures of cars.

Currently, new energy vehicles are mainly divided into pure electric vehicles and oil-electric hybrids, which have different categories and characteristics (Table 1-1). Pure electric vehicles, as the name suggests, rely solely on electricity as energy to drive the car. The main components are the battery, motor, and electric control system. The advantages of pure electric vehicles are environmental protection, economy, and comfort, which are also the three biggest selling points of pure electric vehicles. However, the SanDian system also has some shortcomings, such as insufficient power, relatively poor safety, and higher manufacturing costs for the vehicles.

Table 1-1 Types and characteristics of mainstream new energy vehicles

Types	Energy	Power source
Pure electric	Electric energy	Motor
Oil-electric mix	Fuel oil	Motor, engine
Plug-in hybrid	Fuel oil, electricity	Motor, engine
Extended-range hybrid	Fuel and electricity	Motor

Source: China Association of Automobile Manufacturers.

Petrol-electric hybrids include plug-in hybrids broadly and light-hybrid new-energy vehicles narrowly. Light - hybrids don't need charging, using both a motor and engine. The engine powers the vehicle and supplies electricity, while the motor also provides power. The key difference from plug-in hybrids is that light-hybrids can't be charged, whereas plug-in hybrids have a larger battery for charging and pure-electric drive. Light-hybrid systems are simpler in structure, cheaper, more energy-saving, and environmentally friendly than traditional fuel cars, with quick refueling. Plug-in hybrids offer users flexible choices: pure-electric drive daily and engine power for long trips. However, they have a more complex structure and higher maintenance costs. Hybrid-increase programs aren't widely popular globally yet. Similar to plug-in hybrids, they have a fuel tank and battery. But the hybrid-increase engine only generates power for the battery, with all power coming from the motor. Globally, hydrogen-energy vehicles are not significant in production and sales, so this article doesn't cover them.

1.1.2 Current situation of new energy vehicle market

The new energy automobile market is booming globally due to carbon-neutral and carbon-peak targets. National policies and consumer environmental awareness are dual drivers pushing new energy vehicles into a new penetration stage, as shown by data from European countries and China (Table 1-2 & Table 1-3). Fierce competition in this market is expected to continue for a long time. During the transition from traditional fuel vehicles to new energy vehicles, there's a significant market gap. However, automobile enterprises in China's Yangtze River Delta spotted and began laying out this market early. As early as 2018, China's new energy vehicle sales accounted for 62.2% of the global total.

Table 1-2 Changes in new energy vehicle penetration rates in 2018 and 2022 in major new energy markets in the world

	2018	2022
Norway	58%	87%
Sweden	7%	55%
Netherlands	6%	34%
Germany	2%	32%
China	5%	31%
Britain	3%	22%
France	2%	21%
Canada	3%	11%
South Korea	5%	10%
United States	2%	9%
Japan	1%	3%

Source: Statistic.

Table 1-3 Sales of new energy vehicles from 2018 to 2022 (ten thousand units)

	2018	2019	2020	2021	2022
Global	201.83	221	324	650	1065
Our country	125.6	120.6	136	354	688.7
Global growth rate	65	9.5	46.6	100.6	63.9
China's growth rate	109.3	-4	12.8	160.3	94.5

Source: China Automobile Dealers Association and National Bureau of Statistics.

1.1.3 Overview of the Yangtze River Delta Region

The Yangtze River Delta region is a spatial concept. It was defined by the "Yangtze River Delta Regional Integrated Development Plan Outline" approved by the Political Bureau of the CPC Central Committee on May 13, 2019. The planning scope covers the entire Shanghai, Jiangsu, Zhejiang, and Anhui (358,000 square kilometers). Cities like Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yangzhou, Zhenjiang, Yancheng, and Taizhou in Jiangsu Province, and cities like Hangzhou, Ningbo, Wenzhou, Huzhou, Jiaxing, Shaoxing, Jinhua, Zhoushan, and Taizhou in Zhejiang Province, as well as cities like Hefei, Wuhu, Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou, and

Xuancheng in Anhui Province, are the core areas (225,000 square kilometers). This region radiates and drives high-quality development in the Yangtze River Delta.

1.2 theoretical basis

1.2.1 Trade Competitiveness Index

Trade competitiveness index (TC index), it is on the international competitiveness of one of the measures that are widely used in the analysis, it represents a country's import and export trade balance accounts for the proportion of the total import and export trade.

The TC index = (exports - imports)/(exports + imports). The closer the value is to 0, the closer the competitiveness is to the average level; When the index is -1, it means that the industry only imports but does not export. The closer it is to -1, the weaker the competitiveness is. The index to 1, said the industry import and export is not only the more close to 1 indicates the greater the competitiveness.

1.2.2 Revealed Comparative Advantage Index

The revealed comparative advantage index (RCA) is a convincing indicator. It measures a country's product or industry competitiveness in the international market. It refers to the ratio of a country's export share of a certain product to the product's share in the world's total exports.

If 0 < RCA < 1, said an industry or product has comparative disadvantage, its value is close to zero, the disadvantages are more obvious; If RCA > 1, the said country x industry or product has revealed comparative advantage in the international economy, its value, the greater the revealed comparative advantage, the more obvious. If the RCA > 2.5, the competitive advantage is very strong; If 1.25<RCA<2.5, the competitive advantage is strong; If < 0.8 RCA < 1.25, the industry competitive advantage in average; If 0<RCA<0.8, the competitive advantage is weak.

2 New energy automobile export competitiveness in Yangtze river delta

2.1 Overview of new energy vehicle market in the Yangtze River Delta region

There are six major automotive industrial clusters in China. The Yangtze River Delta cluster has a mature industry chain in vehicle manufacturing and automotive spare parts exports. In the new energy vehicle industry, the Yangtze River Delta leads the country's six major automotive clusters. It contributes one out of every four new energy vehicles produced domestically (Table 2-1 & Table 2-2).

Table 2-1, 2018-2022 China's Yangtze river delta region of new energy vehicle sales (10,000 units)

	2018	2019	2020	2021	2022
Yangtze River Delta Region	46.9	33.2	40.4	106.18	281
China	125.6	120.6	136	354	688.7
Global	201.83	221	324	650	1065

Source: China Automobile Dealers Association and statistic.

Table 2-2 Output of new energy vehicles in China's major automobile industrial clusters in 2022 (10,000 units)

	Yangtze River Delta	Middle reaches of Yangtze River	Southwest China	Pearl River Delta
Yield	281	29	145	195
Percentage	40.8%	4%	20.1%	27%

Source: China Association of Automobile Manufacturers and National Bureau of Statistics.

2.2 Trade competitiveness index

Trade competitiveness index (TC index) is mainly shown as the ratio of the balance between imports and exports of a country (region) and the total amount of imports and exports.

$$TC=(X_t - M_t)/(X_t + M_t) \quad \text{Formula (1)}$$

M_t is the total import of country t (region). X and M are the export and import volumes respectively. i denotes a country, industry, or product. The closer the index is to 1, the stronger the export competitiveness. The closer it is to -1, the weaker the competitiveness. Table 2-4 shows the trade competitiveness index numerical interval.

Table 2-4 Comparison table of competitiveness index

Index	Numerical interval	Level of competitiveness
TC	TC→1	Strong export competitive advantage
	TC = 1	Only export but not import
	TC→0	Average level
	TC→ - 1	The export competitive advantage is weak
	TC = 1	Only import but not export

The import and export value of new energy vehicles in the Yangtze River Delta region in 2022 will be 1.497 billion US dollars and 17.18 billion US dollars, respectively. The TC index is close to 1, and it can be seen from Table 2-4 that the export competitiveness of new energy vehicles in the Yangtze River Delta in 2022 is strong.

$$TC=156.83/186.77=0.8397 \quad \text{Formula (2)}$$

2.3 Index of revealed comparative Advantage

Revealed Comparative Advantage index (RCA index) - describes the relative export performance of a country for a particular product.

$$RCA_{ij}=(X_{ti}/X_t)/(X_{wi}/X_w) \quad \text{Formula (3)}$$

Where X_t represents the total export of country t, and X_w represents the total export of the international market. Table 2-5 shows the numerical interval for the specific measurement of RCA.

In 2022, the Yangtze River Delta region’s total export value was 1,362.42 billion US dollars. The export value of new energy vehicles was 17.18 billion US dollars. According to UN Comtrade, the global total export was 24.9 billion US dollars. The global export value of new energy vehicles was 154.47 billion US dollars. The index ranges between 1.25 and 2.5. Table 2-5 shows that the export competitiveness of new energy vehicles in the Yangtze River Delta region is strong.

$$RCA_{ij}=(171.8/13624.2)/(1544.7/249000)=2.0327 \quad \text{Formula (4)}$$

Table 2-5 Table of numerical intervals of RCA

Index	Data interval	Indicate meaning
RCA	RCA > 2. 5	Highly competitive
	1 . 25≤RCA≤2. 5	competitive
	0. 8≤RCA≤1 . 25	Average competitiveness
	RCA < 0. 8	Less competitive

According to the new energy vehicle export trade competitiveness index and revealed comparative advantage index in the Yangtze River Delta region, the export competitiveness of new energy vehicles in the Yangtze River Delta region is at a strong level.

The Yangtze River Delta region’s new energy vehicle market holds a significant share and enjoys advantages both in China and globally.From an environmental perspective, the region’s new energy vehicles perform well in production scale and consumer base in China and the world. Policy-wise, the integrated development of the Yangtze River Delta lays a solid foundation for the growth of local new energy vehicle enterprises and their global expansion.In terms of trade competitiveness index and revealed comparative advantage index, the export competitiveness of new energy vehicles from the Yangtze River Delta is robust.

Good data behind also revealed that the Yangtze river delta region of the defects in the new energy automobile export competitiveness. It is mainly manifested in the problems of single export models, low unit price of export models, low level of autonomy of core components of export models, and the hidden trouble of insufficient transport capacity is found in the export link of new energy vehicles.

3 New energy automobile export competitiveness in Yangtze river delta’s limitations

3.1 Insufficient automobile export capacity

The Yangtze River Delta region’s new energy vehicle exports mainly use ro-ro shipping. Container shipping and trains are complementary. In Central Europe, car ro-ro ships are designed as large-scale transport carriers. They have lower costs than container transport in CheSun and handling fees. Especially for new energy vehicles with battery packs, ro-ro open laying transportation will play a key role in future exports.

China’s auto exports are rising rapidly. However, the shipping capacity of our nation’s enterprises is a concern. In ro-ro shipping, our capacity lags behind Japanese and Korean firms. This situation causes new energy car companies in the Yangtze River Delta and nationwide to face export booking, scheduling, and inventory backlog issues, preventing timely port delivery. Long-term, this will undermine the export competitiveness of the region’s new energy vehicles.

In the Yangtze River Delta, most new energy vehicle export destinations require transoceanic transport. As market competition intensifies, stable shipping capacity becomes crucial. The current insufficient control capacity will impact car companies’ layout and export scale. It might also trigger “cutthroat competition” events like the chip shortage, reducing export competitiveness.

Table 3-1 Global ro-ro shipping capacity ranking

Rankings	Companies	Territoriality	Capacity (cars)
1	Wallenius Wilhelmsen	Norway	523648
2	Ray Car Carriers	Israel	355006
3	Nippon Yusen Kaisha	Japan	344619
4	Mitsui OSK Lines	Japan	308620
5	K-Line	Japan	278773
6	hyundai motor group	South Korea	222544
7	Cido Shipping	South Korea	209300
——	——	——	——
35	Cosco Haite	China	68603

Source: International Shipping Network.

3.2 High dependence on core components of new energy vehicles

Table 3-2 lists the export models of new energy vehicles in the Yangtze River Delta and their core chips. Emgrand EVPro and Little Ant use domestic chips. Other models rely on chips from Qualcomm, NVIDIA, and AMD. These three firms lead in chip technology, especially in graphics and AI. Their imported chips equip high-end new energy vehicles like NIO and Tesla models from Shanghai Gigafactory, ensuring advanced assisted driving and human-vehicle interaction. In contrast, vehicles with domestic chips, such as the Little Ant and Emgrand EVPro, are cheaper in China and abroad. However, their lower profits limit their market impact.

In 2021, the "chip shortage" limited market capacity, especially for chip-reliant new energy vehicles. The chip issue disrupted the supply chain, leaving upstream without cores to allocate and downstream without cars to sell. This greatly affected the rapid development of new energy vehicles in the Yangtze River Delta. So, we must focus on core technology autonomy. Also, the advantage of new energy vehicles' OTA is based on strong car chips. We can't be too dependent on technology; otherwise, another "neck" event would severely impact new energy vehicle enterprises.

Table 3-2 Chips of new energy export models in the Yangtze River Delta region

Brand	Export models	Car machine chip
Polar Krypton ZEEKR	ZEEKR 001	8155 Qualcomm Snapdragon
Geely Auto	Emgrand EV Pro	E01 Egatong Technology
Chery Automobile	Little Ant	Ac8015 Hefei Jifa
NIO	ES6/ET7	Drive Orin X NVIDIA
Tesla	Model Y	AMD Ryzen
SAIC	Mg4 EV	8155 Qualcomm Snapdragon

Source: official website of each company, statistic.

3.3 Unbalanced technology accumulation of automobile enterprises

In October 1885, Karl Benz from Germany developed the first automobile. Since then, the basic design of traditional cars has remained largely the same. However, with the advent of new energy cars, fuel is no longer the only energy source. The internal combustion engine is no longer the only power source. Motors, with higher transmission efficiency and lower technical barriers, have been adopted in electric vehicles (Table 3-3). Over the past decade, a global electric vehicle trend has emerged. The Yangtze River Delta in China has seen the rise of many successful new energy vehicle brands. Some brands, like Geely and Volvo, are backed by traditional car companies. Others, like NIO, rely on partners like Jianghuai Automobile for manufacturing but handle most of the design and development in-house. Despite good sales, it's clear that new energy vehicle companies in the Yangtze River Delta have uneven technology reserves.

Table 3-3 Similarities and differences of core components between new energy vehicles and traditional vehicles

	Traditional vehicles	New energy vehicles
Powertrain	Engine, transmission, drive shaft	Motor (engine), electric control, power battery
Chassis system	Fuel platform, suspension, steering, braking	New energy platform, suspension, steering, braking
Electrical systems	Power supply, control chips, audio-visual entertainment	Three-power system, control chip, audio-visual entertainment, driving assistance
Body and cover	Frame and parts	Frame and parts

parts		
Safety systems	Frame, front and rear collision avoidance systems	Frame, front and rear anti-collision system, electronic control safety and management system

The figure shows both similarities and differences between new energy vehicles and traditional ones. Traditional vehicles have first-mover advantages, a mature design and development system, and solid technological foundations. New energy vehicle brands in the Yangtze River Delta have made progress. For example, SAIC New Energy, Jiekrypton Automobile, and NIO Automobile use new platforms. Compared to traditional brands that adapt fuel platforms for new energy vehicles, these new brands offer better space utilization. They also started earlier in driving assistance, building up technology and availability. However, in areas where new energy and traditional vehicles intersect, the region's new energy brands still have room for improvement. Traditional car brands have more experience in chassis and suspension technology and a more mature parts supply chain. For example, Ideal Auto-motive's solution of hiring Porsche's R&D team to train their team is effective in the current market, but they need to build their own R&D capabilities and technology reserves instead of becoming dependent.

The Yangtze River Delta's main new energy vehicle export destinations are European and some Asian countries. Their vehicle environments differ from the Yangtze River Delta and even China. In European countries, the population density is low. The density of charging facilities is also low. The average annual temperature is low. Some countries have frequent snow on the road. The rainfall time is long. So, they have higher requirements for new energy vehicles. The battery needs better low-temperature resistance and endurance. The anti-skid system and safety system should be improved too. In the Arab region, the vehicle environment is different. Here, the battery and motor need better high-temperature resistance and dust resistance. In Southeast Asian countries, the road conditions are poor and the terrain is rugged. This puts higher demands on the chassis and suspension of new energy vehicles.In terms of power batteries and intelligence, the new energy vehicle brands in the Yangtze River Delta region have achieved the world's advanced level, but the export of new energy vehicles will also be restricted by the "bucket effect", and in terms of chassis training, electronic control system, core chips and other software and hardware, the new energy vehicle enterprises in the Yangtze River Delta region still have shortcomings.

4. Optimization analysis of export competitiveness of new energy vehicles in the Yangtze River Delta region

4.1 Increase the export capacity of automobiles

The new energy vehicle export market in the Yangtze River Delta is booming. However, car companies are noticing some problems. They are worried about not having enough export capacity. Also, there might be a mismatch between production capacity and demand. Many car companies can't solve these problems on their own.

The transport capacity is insufficient. Enterprises should conduct good market research and predict the export market scale. They need to provide export services in advance and deeply cooperate with logistics or transportation companies to reduce transport risks. Government departments and state-owned shipbuilding enterprises should actively adjust business layouts, expand and optimize car transport ship production, and increase production while reducing costs. New energy vehicle enterprises and government departments in the Yangtze River Delta region can develop plans to optimize automobile export capacity. This includes optimizing wharf stacking, loading efficiency, process efficiency, increasing special berths for car carriers, and cooperating with major foreign export destination ports to enhance unloading efficiency.

To improve the export capacity of new energy vehicles in the Yangtze River Delta region requires the joint efforts of enterprises themselves, local government departments, supporting enterprises, downstream foreign dealers and other links, so as to strengthen competitiveness.

4.2 Strengthen the level of overseas supporting facilities and enhance the brand image

Gas stations are the main supporting facilities for traditional vehicles. Charging facilities are the most important for new energy vehicles. In recent years, the global new energy vehicle industry has developed rapidly. The production and sales of these vehicles are rising steadily. The demand for charging facilities in major markets is also increasing quickly. The availability of charging piles, in terms of both quality and quantity, is now a key factor. It significantly affects the competitiveness of new energy vehicles in this region.

China’s current vehicle-pile ratio is 6.7:1. In Europe, it’s 12.6:1. Thailand has a ratio of 20:1, and India’s is as high as 500:1. These figures show there are significant market opportunities for charging infrastructure. However, building charging infrastructure is expensive and time-consuming. Each charging pile needs a parking space. A charging station requires medium to large power distribution equipment. Large power distribution facilities need one or more distribution lines. The global electrification trend means charging infrastructure will be built gradually. The Yangtze River Delta’s new energy vehicle exports mainly go to Europe, Southeast Asia, and the Middle East. Industry leaders could initiate a charging facility alliance, like the Yangtze River Delta New Energy Vehicle Industry Chain Alliance. This alliance could jointly invest in overseas energy. Marketing and charging strategies should be flexible. The alliance should offer preferential treatment for new energy vehicle identification. This would enhance brand influence and product power within the alliance. It would also accelerate overseas charging infrastructure, allowing the alliance to benefit earlier and increase its discourse power.

Personalized services can be introduced according to local conditions for overseas reality. For example, hardware such as snow tires and skin-proof chains suitable for snow driving, software such as snow mode and trailer rescue and after-sales services can be introduced in high-latitude areas. In Southeast Asia, regular free chassis and battery safety checks can be introduced. Based on demand, these personalized services can greatly enhance consumer satisfaction and reputation, and enhance product competitiveness.

4.3 Strengthen school-enterprise cooperation and enhance technology accumulation

Compared with traditional vehicles, new energy vehicles adopt many new technologies and concepts. Their development also creates a big demand for new talents. The Yangtze River Delta region’s education level ranks among China’s best. Its new energy industry is growing rapidly. So, the school-enterprise cooperation pace should be strengthened.

Under the situation of rapid development of the new energy vehicle industry, the school-enterprise cooperation should abandon the early mode of “emphasizing theory and ignoring practice”. Colleges and enterprises are two equal subjects in talent training. Colleges and universities are responsible for talent selection and theoretical basic education, while enterprises are responsible for students’ theoretical practice transformation and professional education.

Colleges and universities should pay attention to industry needs and technological development. They need to optimize education modes and training programs in a timely manner. Establish cooperative relationships with new energy automobile enterprises. Provide more theoretical foundations for teaching. Strengthen practical teaching and teacher team construction.

New energy vehicle enterprises should actively build industry-oriented practical teaching and talent training bases with local governments and universities. The fast-paced technological progress relies heavily on talent support. Talent training, in turn, cannot happen without the unique practice and learning platforms that enterprises provide. This kind of school-enterprise cooperation is beneficial for training talents and promoting the healthy development of enterprises.

5 Conclusion

This paper analyzes the export, production, sales data, and supporting industries of new energy vehicles in the Yangtze River Delta region. The analysis combines theory with practice and is supported by extensive literature and data. The following conclusions are drawn.

This paper compares domestic and foreign automobile import and export data. It also analyzes the actual situation. From the domestic perspective, the export competitiveness of new energy vehicles in the Yangtze River Delta region is strong. Similarly, from the international perspective, the export competitiveness of new energy vehicles in the Yangtze River Delta region is also strong.

The international new energy vehicle industry faces fierce competition, making technological innovation crucial. The Yangtze River Delta’ s new energy vehicles, despite having a first-move advantage, risk being overtaken in this competitive landscape. In recent years, domestic and international traditional automobile enterprises have made progress in new energy fields. Their success stems primarily from technology accumulation and R&D innovation.

Data Availability Statement

All macroeconomic indicators analyzed were sourced from the International Monetary Fund (IMF) Data Portal (https://data.imf.org), the World Development Indicators database (https://databank.worldbank.org), National Bureau of Statistics of China (https://www.stats.gov.cn/sj/).

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