The Significance of Emission Trading System from the Perspective of Environmental Regulation—— Based on the Analysis of China's Environmental Pollution Control Data

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Abstract. Since the reform and opening up 40 years ago, China's economy has been growing rapidly, but the continuous GDP growth occurs at the expense of natural environment. Based on the analysis of China's environmental pollution situation and investment in pollution control since the 21st century, it can be found that there are some problems, such as serious air pollution and water pollution, deepening environmental damage, increasing economic losses caused by environmental pollution and insufficient investment in industrial pollution control. Emissions trading system, as an efficient system of pollution control, compared with the traditional pollution charge system, can effectively solve the problem of China's air pollution and water pollution. Air pollution and water pollution to realize control of total pollution so that it is likely to achieve industrial upgrading, optimize allocation of environmental resources and reduce the cost of pollution control. It is more conducive to achieving the coordination between environmental protection and economic development.

1. Introduction
Since the reform and opening up 40 years ago, China's economy has been growing rapidly, but the continuous GDP growth occurs at the expense of natural environment. If China has been developing its economy at the cost of environmental pollution, the contradiction between environmental pollution and economic development will be irreconcilable. For the first time, the sustainable development strategy in 2000 has been included in the long-term plan of China's economic and social development. In 2018, China's newly-revised environmental protection law further improves the basic system of environmental protection and sets up a new concept of ecological civilization construction and sustainable development.

Effective and reasonable environmental protection system is the premise of sustainable development and the basic guarantee of environmental protection. Therefore, effective environmental regulations are needed to reduce the external diseconomy of environmental pollution and regulate the economic activities of enterprises and manufacturers to achieve a harmonious and win-win situation between economic development and environmental protection. The traditional pollution charge system
is an environmental protection policy formulated and implemented earlier in China. It aims to reduce pollution by collecting a certain amount of fees from polluters who discharge pollutants directly to the environment according to law through the state environmental protection agency. But the traditional pollution charge system is just a political approach which cuts off the political and economic ties. Meanwhile, it is hard to eliminate the possibilities that some interest groups may escape from this restraint by rent-seeking, thus leading to incompatible conflicts among various groups and failure of achieving environmental improvement.

As a market-oriented economic incentive and a legal environmental management tool, the emission trading system has attracted extensive attention. However, in the process of exploring the emission trading system, China has encountered a series of problems, such as imperfect laws and regulations, imperfect market mechanism and obstacles in environmental pollution monitoring. Therefore, the trial of emission trading system in China has been questioned by society. So which is stronger, the traditional pollution charge system or the mission trading system? What is the state of environmental pollution control in China since the 21st century? In the context of China's environmental regulation, how will the emission trading system affect environmental protection and economic development? These problems are worthy of our study and discussion, this paper will carry out in-depth analysis of these problems.

2. Literature review

According to American scholar Dales (1968), the right of emission meant that the right holder had the right to discharge pollutants into the environment under the condition of complying with the law. The emission trading system referred to the establishment of legal emission rights and the use of market mechanism to allow the emission rights to be bought and sold like commodities by determining certain total emission control indexes according to the environmental quality objectives.

Firstly, Svendsen (1999) argued that the traditional pollution charge system separated politics from economy, and the government would pay a huge economic cost for environmental pollution control, which was not conducive to realizing the optimal allocation of environmental resources and giving play to the inherent power mechanism of the market. According to the analysis of Rogge (2011), the EU of ETS itself might not provide sufficient incentives for fundamental changes in enterprise innovation activities at the level of ensuring the achievement of long-term political goals. Milt (2017) believed that the emission trading system was not as effective as the executive order in the case of incomplete information mechanism.

In the 1990s, the Chinese government began to experiment with emission trading system and put forward the environmental regulation target of total control. Liu (2009) pointed out that the emissions trading system was conducive to optimizing the allocation of market resources and reducing the social cost of pollution control. Wang (2014) believed that the allocation of environmental resources should reduce the dependence on administrative forces, establish the market mechanism of environmental resources, and give play to the decisive role of the market in the allocation of environmental resources. Zhang (2017) and Xu (2018) believed that the emission trading system was an ideal environmental management tool that could be widely applied in the world and achieve the dual effects of cost saving and pollution control. However, Fu (2009) argued that the emissions trading system was the product of mutual compromise among various interest groups, and it was difficult to achieve the goal of effectively controlling environmental pollution with the minimum social cost. Wu (2010) pointed out that there were some problems in the mission trading system, such as the obstacles in the environmental monitoring system, the unsound emission trading market, and the dislocation of the trading subjects of emission rights.

Based on the previous literature, it can be found that the existing research on the emission trading system is very comprehensive. However, most of the studies focus on the theoretical aspects of the emissions trading system based on the Coase theorem. Although Chinese domestic scholars mainly study the problems and solutions of China's emissions trading system, there is a paucity of studies on emission trading system from the perspective of China's environmental pollution and pollution control.
investment. Therefore, it is reliable and innovative to analyze the current situation and problems of China's environmental governance through the data of China's environmental pollution status and pollution control investment in the 21st century, and put forward directional opinions on the significance of emission trading system according to the actual situation.

3. Analysis of environmental pollution situation and investment in pollution control in China
Since the beginning of the 21st century, China has faced many environmental problems, such as air pollution, water pollution, desertification, soil erosion, drought and flood, among which the most prominent ones are air pollution and water pollution.

3.1. Emission and treatment of waste gas
According to the data of China's national bureau of statistics, China's total volume of industrial waste gas emission reached 68519 billion cubic meters in 2015, an increase of 396% compared with the 13814.5 billion cubic meters in 2000, with an average annual growth of 11.27%. China's total volume of industrial waste gas emission ranked the first in the world, leading to frequent occurrence of haze weather in China (Table 1). Air pollution is the biggest environmental problem in China at present. It has had a significant impact on the daily life and work of Chinese people and caused a series of economic losses to Chinese society. China's annual expenditure for operation was 9.37 billion yuan in 2000 and 186.6 billion yuan in 2015, with an average annual increase of 22.07%. It can be seen that China has attached great importance to the control of air pollution by increasing the capacity of industrial waste gas treatment facilities and upgrading treatment technologies. After 2006, China's sulfur dioxide emissions have been effectively controlled.

| Year | Total Volume of Industrial Waste Gas Emission (100 million cum) | Sulphur Dioxide Emission (10 000 tons) | Industrial Waste Gas Treatment Facilities (set) | Annual Expenditure for Operation (100 million yuan) |
|------|---------------------------------------------------------------|----------------------------------------|-----------------------------------------------|--------------------------------------------------|
| 2000 | 138145                                                       | 1995.1                                 | 145534                                        | 93.7                                             |
| 2001 | 160863                                                       | 1947.2                                 | 134025                                        | 111.1                                            |
| 2002 | 175257                                                       | 1926.6                                 | 137668                                        | 147.1                                            |
| 2003 | 198906                                                       | 2158.5                                 | 137204                                        | 150.6                                            |
| 2004 | 237696                                                       | 2254.9                                 | 144973                                        | 213.8                                            |
| 2005 | 268988                                                       | 2549.4                                 | 145043                                        | 267.1                                            |
| 2006 | 330990                                                       | 2588.8                                 | 154557                                        | 464.4                                            |
| 2007 | 388169                                                       | 2468.1                                 | 162325                                        | 555.0                                            |
| 2008 | 403866                                                       | 2321.2                                 | 174164                                        | 773.4                                            |
| 2009 | 436064                                                       | 2214.4                                 | 176489                                        | 873.7                                            |
| 2010 | 519168                                                       | 2185.1                                 | 187401                                        | 1054.5                                           |
| 2011 | 674509                                                       | 2217.9                                 | 216457                                        | 1579.5                                           |
| 2012 | 635519                                                       | 2117.6                                 | 225913                                        | 1452.3                                           |
| 2013 | 669361                                                       | 2043.9                                 | 234316                                        | 1497.8                                           |
| 2014 | 694190                                                       | 1974.4                                 | 261367                                        | 1731.0                                           |
| 2015 | 685190                                                       | 1859.1                                 | 290886                                        | 1866.0                                           |

3.2. Water pollution problem
Water pollution is also a serious problem in China. In 2016, 38.94% of China's seven main river water river water quality did not meet Grade III. In Huanghe River, Huaihe River, Haihe River and Liaohe River, more than 40% of the water quality did not meet Grade III (Table 2). The percentage of water...
that its quality is worse than Grade V of China's seven main river is 12.97%, and it has no function. Besides, the water quality of China's freshwater lakes and urban lakes is generally poor, and the eutrophication degree of most lakes is increasing. It can be seen that the current situation of water environmental pollution in China is serious, and it is necessary to solve the water pollution problem from the source.

| Main Water System       | Number of Monitoring Sections (unit) | Proportion of Monitored Section Water Quality (%) | Worse than Grade V |
|-------------------------|-------------------------------------|-----------------------------------------------|-------------------|
| Changjiang River        | 510                                 | Grade I 2.7, Grade II 53.5, Grade III 26.1, Grade IV 9.6, Grade V 4.5, Worse than Grade V 3.50 |
| Huanghe River           | 137                                 | Grade I 2.2, Grade II 32.1, Grade III 24.8, Grade IV 20.4, Grade V 6.6, Worse than Grade V 13.9 |
| Zhujiang River          | 165                                 | Grade I 2.4, Grade II 62.4, Grade III 24.8, Grade IV 4.8, Grade V 1.8, Worse than Grade V 3.6 |
| Songhuajiang River      | 108                                 | Grade I 0.0, Grade II 13.9, Grade III 46.3, Grade IV 29.6, Grade V 3.7, Worse than Grade V 6.5 |
| Huaihe River            | 180                                 | Grade I 0.0, Grade II 7.2, Grade III 46.1, Grade IV 23.9, Grade V 15.6, Worse than Grade V 7.2 |
| Haihe River             | 161                                 | Grade I 1.9, Grade II 19.3, Grade III 16.1, Grade IV 13.0, Grade V 8.7, Worse than Grade V 41.0 |
| Liaohe River            | 106                                 | Grade I 1.9, Grade II 31.1, Grade III 12.3, Grade IV 22.6, Grade V 17.0, Worse than Grade V 15.1 |
| Mean                    | 195.29                              | Grade I 1.59, Grade II 31.36, Grade III 28.07, Grade IV 17.70, Grade V 8.27, Worse than Grade V 12.97 |

* Source: Chinese Ministry of Environmental Protection.

Although China has been adhering to the concept of sustainable development since the 21st century, and made some progress in protection by increasing investment in environmental pollution control, the effect of China's air pollution control and water pollution control is not significant enough, and the pollution situation continues to deteriorate.

### 3.3. Environmental emergency

Good ecological environment is the basic premise of economic development, but environmental pollution will also inhibit economic development. China's previous development model of mass production and mass pollution at the cost of the environment has become a bottleneck restricting China's economic development. On the one hand, China's environmental emergencies occur frequently, directly causing huge economic losses; On the other hand, China's investment in environmental pollution control has been increasing year by year, which has a certain impact on the whole national economy. Therefore, the following paragraphs analyze the number and economic loss of environmental emergencies in China from 2000 to 2009 and the investment in environmental pollution control in China from 2001 to 2016.

| Year | Number of Environmental Emergencies (times) | Direct Economic Loss for Environmental Emergencies (ten thousand yuan) | Total Compensation and Fines for Environmental Emergencies (ten thousand yuan) |
|------|---------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 2000 | 2411                                        | 17807.90                                                                | 3682.60                                                                         |
| 2001 | 1842                                        | 12272.40                                                                | 3263.90                                                                         |
| 2002 | 1942                                        | 4640.90                                                                 | 3140.70                                                                         |
| 2003 | 1843                                        | 3374.90                                                                 | 2391.50                                                                         |
| 2004 | 1441                                        | 36365.70                                                                | 3963.90                                                                         |
| 2005 | 1406                                        | 10515.00                                                                | 3082.10                                                                         |
| 2006 | 842                                         | 13471.10                                                                | 8415.92                                                                         |
| 2007 | 462                                         | 3016.50                                                                 | 927.24                                                                          |
| 2008 | 474                                         | 18185.60                                                                | 927.20                                                                          |
According to the descriptive statistics of the number of environmental emergencies and economic losses in China from 2000 to 2009 (Table 3 and Table 4), the mean of environmental emergencies from 2000 to 2009 was 1308.1, and the standard deviation was 771.85, a total of 13081. Moreover, the number of environmental emergencies decreased sharply and then gradually stabilized. It can be seen that China has effectively controlled the number of environmental emergencies. From 2000 to 2009, the average direct economic loss of environmental emergencies was 163,004,400 yuan, and the standard deviation was 136,525,800 yuan, totaling 163,044,000 yuan. Direct economic losses from environmental emergencies increased from 17,807.9 yuan in 2000 to 433,544 yuan in 2009, an increase of 143.46% and an average annual increase of 10.39%. On the whole, the direct economic loss of environmental emergencies showed an increasing trend. Therefore, the direct economic loss of environmental emergencies is not only related to the number of environmental emergencies, but also to the direct economic loss of each environmental emergencies.

From 2000 to 2009, the average environmental emergencies compensation and fines amounted to 319,632 million yuan, and the standard deviation was 21,1064 million yuan, a total of 319,6316 million yuan. Thus, compensation and fines for polluters are much lower than the direct economic losses of sudden environmental events. Although compensation and fines for polluters can control the number of environmental emergencies, they cannot contain the severity of each environmental emergency, resulting in the direct economic loss for environmental emergencies is still growing.

3.4. Investment in Treatment of Environmental Pollution

| Number of Environmental Emergencies (times) | Direct Economic Loss for Environmental Emergencies (ten thousand yuan) | Total Compensation and Fines for Environmental Emergencies (ten thousand yuan) |
|--------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Mean                                       | 1308.1                                                                  | Mean                                                                          |
| S.E.mean                                   | 227.0038399                                                             | S.E.mean                                                                     |
| Median                                     | 1423.5                                                                  | Median                                                                       |
| Std deviation                              | 717.8491717                                                             | Std deviation                                                                |
| Kurtosis                                   | 1.482283838                                                             | Kurtosis                                                                     |
| Skewness                                   | 0.032923328                                                             | Skewness                                                                     |
| Range                                      | 1993                                                                    | Range                                                                        |
| Minimum                                    | 418                                                                     | Minimum                                                                      |
| Maximum                                    | 2411                                                                    | Maximum                                                                      |
| Sum                                        | 13081                                                                   | Sum                                                                          |
| Confidence (95.0%)                         | 513.5183624                                                             | Confidence (95.0%)                                                          |

According to the calendar year "China statistical yearbook of the tertiary industry". There are no statistics on the direct economic losses and the total compensation and fines for environmental emergencies after 2009.
Table 5. Investment in the treatment of environmental pollution in China (2001-2016)*. (100 million yuan)

| Year | Total Investment in Treatment of Environmental Pollution | Investment in Urban Environment Infrastructure Facilities | Investment in Treatment of Industrial Pollution Sources | Environmental Protection Investment in the Environmental Protection Acceptance Projects in the Year | Investment in Anti-pollution Projects as Percentage of GDP (%)b |
|------|------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| 2000 | 1010.3                                               | 515.5                                                | 234.8                                               | 260.0                                                              | 1.02                                                              |
| 2001 | 1166.7                                               | 655.8                                                | 217.4                                               | 336.4                                                              | 1.05                                                              |
| 2002 | 1456.5                                               | 878.4                                                | 188.4                                               | 389.7                                                              | 1.2                                                               |
| 2003 | 1750.1                                               | 1194.8                                               | 221.8                                               | 333.5                                                              | 1.27                                                              |
| 2004 | 2057.5                                               | 1288.9                                               | 308.1                                               | 460.5                                                              | 1.27                                                              |
| 2005 | 2565.2                                               | 1466.9                                               | 458.2                                               | 640.1                                                              | 1.37                                                              |
| 2006 | 2779.5                                               | 1528.4                                               | 483.9                                               | 767.2                                                              | 1.27                                                              |
| 2007 | 3668.8                                               | 1749.2                                               | 555.4                                               | 1367.4                                                             | 1.36                                                              |
| 2008 | 4937                                                 | 2247.7                                               | 542.6                                               | 2146.7                                                             | 1.55                                                              |
| 2009 | 5284.4                                               | 3245.1                                               | 442.6                                               | 1570.7                                                             | 1.51                                                              |
| 2010 | 7612.2                                               | 5182.2                                               | 397                                                 | 2033                                                               | 1.84                                                              |
| 2011 | 7114                                                 | 4557.2                                               | 444.4                                               | 2112.4                                                             | 1.45                                                              |
| 2012 | 8253.5                                               | 5062.7                                               | 500.5                                               | 2690.4                                                             | 1.53                                                              |
| 2013 | 9037.2                                               | 5223                                                 | 849.7                                               | 2964.5                                                             | 1.52                                                              |
| 2014 | 9575.5                                               | 5463.9                                               | 997.7                                               | 3113.9                                                             | 1.49                                                              |
| 2015 | 8806.4                                               | 4946.8                                               | 773.7                                               | 3085.8                                                             | 1.28                                                              |
| 2016 | 9219.8                                               | 5412                                                 | 819                                                 | 2988.8                                                             | 1.24                                                              |

* Source: By the calendar year "China statistical yearbook on environment".

b As methodology of R&D expenditure accounting is reformed, data of GDP of all years are adjusted systematically.

Table 6. Descriptive statistics on investment in the Treatment of Environmental Pollution in China (2001-2016). (100 million yuan)

| Total Investment in Treatment of Environmental Pollution | Investment in Urban Environment Infrastructure Facilities | Investment in Treatment of Industrial Pollution Sources | Environmental Protection Investment in the Environmental Protection Acceptance Projects in the Year | Investment in Anti-pollution Projects as Percentage of GDP (%) |
|--------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| Mean 5074.62                                            | Mean 2977.55                                           | Mean 493.488                                       | Mean 1603.59                                                      | Mean 1.36588                                                      |
| S.E.mean 782.161                                        | S.E.mean 474.017                                       | S.E.mean 59.3192                                   | S.E.mean 268.830                                                  | S.E.mean 0.04890                                                  |
| Median 4937                                             | Median 2247.7                                         | Median 458.2                                       | Median 1570.7                                                    | Median 1.36                                                      |
| Std deviation 3224.93                                   | Std deviation 1954.42                                  | Std deviation 244.580                              | Std deviation 1108.41                                             | Std deviation 0.20162                                              |
| Kurtosis -1.7536                                        | Kurtosis -1.9207                                      | Kurtosis -0.3900                                   | Kurtosis -1.7024                                                 | Kurtosis 0.71169                                                  |
| Skewness 0.13617                                        | Skewness 0.15746                                      | Skewness 0.60235                                   | Skewness 0.11706                                                 | Skewness 0.37735                                                  |
According to descriptive statistics of China's investment in environmental pollution control from 2000 to 2016 (Table 5 and Table 6), China's average investment in the treatment of environmental pollution totaled 507.462 billion yuan, with a standard deviation of 322.493 billion yuan, totaling 8626.86 billion yuan. Total investment in the treatment of environmental pollution increased from 101.03 billion yuan in 2000 to 921.98 billion yuan in 2016, basically on an upward trend, with an average annual increase of 14.82%. From 2000 to 2016, the average investment in anti-pollution projects as percentage of GDP was 1.37%, and the standard deviation was 0.20%. It can be seen that China's investment in environmental pollution control is quite large.

From 2000 to 2016, the average investment in urban environmental infrastructure facilities was 297.755 billion yuan, accounting for 58.68% of the average investment in the treatment of environmental pollution. From 2001 to 2016, the average investment in industrial pollution control was 49.3488 billion yuan, accounting for only 9.72%. It can be seen that China's investment in the treatment of environmental pollution is mainly used for urban environmental infrastructure facilities, while less than 10% of the investment is used for the treatment of industrial pollution sources. The majority of the investment in the treatment of industrial pollution sources is used for the treatment of air pollution and water pollution.

At present, environmental protection and economic development are not only independent, but complementary. In October 2017, the general secretary of the communist party of China put forward: we must establish and practice the idea that green water and green mountains are mountains of gold and silver, and adhere to the basic state policy of saving resources and protecting the environment. Environment and economic development are interdependent, mutually promoting and mutually restricting. To realize sustainable development is to promote the coordination and harmony between them and make progress together. Only by protecting the natural environment while developing the economy can we promote the steady development of the Chinese economy.

4. Analysis on the significance of emission trading system

Based on the analysis of China's environmental pollution and investment in pollution control, the following four conclusions can be drawn.

- Air pollution and water pollution are the most serious problems in China, and the pollution situation is getting worse.
- The number of environmental emergencies in China has been effectively controlled, but the direct economic losses of each environmental emergency continue to deepen.
- The compensation and fines imposed on polluters are far from enough to cover the direct economic losses caused by environmental emergencies, thus causing China's economic losses.
- The amount of investment in environmental pollution control in China is quite large, but the share of investment in industrial pollution control is less than 10%.

Based on the above conclusions, the significance of emission trading system in the context of environmental regulation is analyzed.
4.1. Effectively solve the problem of air and water pollution

Emission trading system is used for air pollution and water pollution control. In the practice of emission trading system, EPA first adopted emission trading system in air pollution and water pollution treatment. Since it was used to control the total emission of sulfur dioxide in 1990, remarkable environmental and economic benefits have been achieved in practice. Later, Germany, Australia, Britain and other countries carried out the practice of emission trading one after another, which proved that the emission trading system could achieve the coordination and win-win of economic development and environmental protection. In the 1990s, China began to try and explore the emission trading system in the field of air pollution and water pollution, mainly implementing the pollutant emission permit system and emission trading pilot in some cities. Establishing emission trading system is an effective way to solve air and water pollution problems in China.

4.2. Achieve total control and industrial upgrading

The direct economic loss of environmental emergencies is caused by the deepening of environmental damage, and controlling the discharge of pollutants is conducive to the prevention of environmental damage. China generally adopts the traditional pollutant discharge charging system. When the marginal rate of pollutant discharge is lower than the marginal cost of pollution control, the pollutant discharging enterprises would rather pay the pollutant discharge fee than spend more money to improve equipment or upgrade pollutant discharge technology to reduce pollution emissions. In addition, polluters will have little incentive to further reduce their emissions once they meet government standards. Due to the existing environmental penalty standards in China, the penalty payment is insufficient. For pollution-discharging enterprises, the cost of breaking the law is higher than that of abiding by the law, and the cost of pollution is difficult to be internalized, which makes it difficult to effectively regulate the emission of pollution. The primary premise of the emission trading system is the total emission control, which can effectively control the degree of environmental pollution and reduce the direct economic loss of environmental emergencies. At the same time, the emission trading system makes the pollutant discharging enterprises face the increasing marginal cost when they exceed the prescribed emission quantity, which urges the pollutant discharging enterprises to reduce the cost through industrial optimization and upgrading.

4.3. Optimize allocation of environmental resources

China's environmental problems have caused huge economic losses and, to some extent, curbed economic growth. The emission trading system plays a decisive role in the allocation of environmental resources. It can motivate polluters to trade excess emission rights by reducing emissions, and then obtain economic returns by trading surplus emission rights, so that polluters can change from passive emission to active emission. Under the emission trading system, the right to discharge pollutants for companies which are not effective in pollution control can be obtained from enterprises which have effective pollution control. By setting a price on this trade automatically through market mechanism, it will sharply reduce administration cost for governments and realize win-win situation of the environmental benefits and economic benefits. Thus emission with information and optimizing the environment resources, realize win-win situation of the environmental benefits and economic benefits.

4.4. Reduce the cost of environmental pollution control

China has limited investment in the treatment of industrial pollution sources, so it needs to achieve air and water pollution reduction targets at a lower cost. Under the emission trading system, when the emission capacity of enterprises is fixed, the pollutant discharging enterprises with lower cost of pollution control find that it is more economical to control pollution than to buy the emission right, while the pollutant discharging enterprises with higher cost find that it is more economical to buy the emission right than to control pollution. Therefore, the task of pollution control can be automatically traded to enterprises with low cost of pollution control through the emission right trading market, and the pollution control cost can be minimized through the market trading.
Acknowledgments
Special thanks to the teachers of College of Literature Law & Economics for their support. We would also like to thank the innovation and entrepreneurship fund for graduate students of Wuhan University of Science & Technology funding.

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