

The Evolution of Transport and Sustainable Transport

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Abstract: By comparing the researches in the transport academic field, this paper comprehensively presents the evolution of transport. The Transport Evolution Model depicted the transport evolution process of several main transport infrastructures occupying the leading position in sector one after another. However, some drawbacks do exist in the model. The advancement of transportization theory provides a basic frame of explaining the relationship between transport and economic development. According to the theory, transportization is one of the important features of industrialization and the process of transportization has its stages. Through accurate depicting of railway's historic changing orbit, the recent "4-stage growth model" of railway freight demand positively verifies the progress stages of transportization once more. The periodical development theory of urban transport highly summarizes the relation between urban transport and urbanization. And according to the transportization theory, the transport evolution will inevitably meet its limitation, which is the dilemma of human's mobility versus environment, and the solution must be the sustainable transport.

The relationship between human development and the spatial movement of people and goods has always been one of the most important social economic basic relationships. However the rational degree of this knowledge is far from enough until recently. What is gratified is that the successive doctoral dissertations on Transport Economics in first part of 1990s, most of them have been published, have centrally discussed this issue, made great achievements, which has greatly propelled the theory of transport development forward.

1. TRANSPORT EVOLUTION MODEL

An Austrian scholar, Arnulf Grubler, put forward the dynamics of transport industry evolution and technological change in his work of "The Rise and Fall of Infrastructures-Dynamics of Evolution and Technological Change in Transport" published in 1990, which stood for a breakthrough in the research of transport development. Applying Evolutionary Economics models in his book, he investigated the diffusion effects of technological advancement and the substitution process among different transport modes by analyzing the historic materials of several developed countries (Grubler, 1990).

According to Evolutionary Economics, the development of human economic activities is similar to the process of biological evolution. It is only those which can adapt to the

circumstances could live through and develop in the economic circumstances which are full of uncertainty. At the same time Evolutionary Economics also accepts Schumpeterism that emphasizes that innovation is the main source to break the equilibrium, then prompts the economic growth and the economic structural change. Consequently Dr. Grubler put forward that in transport industry development, several transport modes such as canal, railway, road and air transport, sequentially combining with the substitution of main resource bases such as animal force, coal and petroleum, go through respectively their life cycles consisting of birth, growth, saturation and declination stages, take the leading position in succession and then lost it again. Dr. Grubler believes that any success of a new transport technology requires a new kind of transport infrastructure to accompany it. At the beginning, the new infrastructure is complementary to the existing formers, and then become independent, and then gradually grown up and eventually took the place of the old one. Thus Grubler's Transport Evolution Model is that dynamics of evolution and technological change in transport presents itself in the successive rise and fall of different transport infrastructures during the process of technological change in long term. In Figure 1. and Figure 2., Grubler demonstrates all kinds of transport infrastructures changed in America from 1800 onward in terms of mileage increasing and the degree of maturity (illustrated in percentage). From the figures we can see that at first railway replaced canal, then it was replaced by road; later on road is the rising of civil aviation; furthermore a new round of transport infrastructures is emerging.

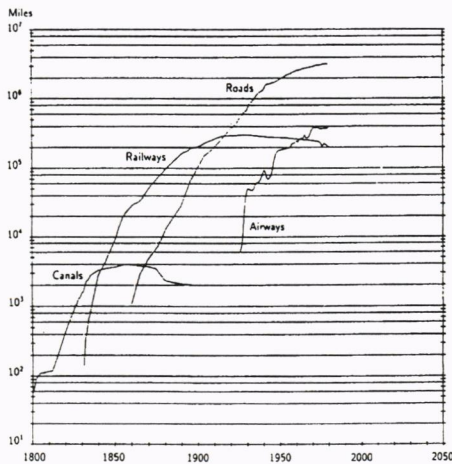


Figure 1. Mileage change for all kinds of transport infrastructures in USA.

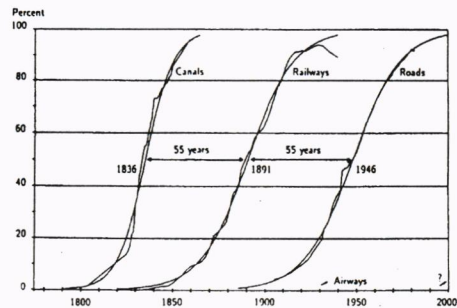


Figure 2. Growth to limits of all kinds of transport infrastructure in USA

In Grubler's transport evolution model, the growth curves of every kind of transport infrastructure could be depicted with different biological evolutionary curves or logical curves to a considerably approximate degree. The culminating point of the saturation stage for every growth curve is restricted by the natural environment and resource condition which decide the limitation, for example, the required water transport condition, the corresponding energy supply, the ground area for road building and parking and the territorial sky for flight. While the declination speed of the curve for every transport mode is decided by the competition pressure imposed on by a new emerging transport technology. To take the general transport change into consideration, Grubler believes that passengers

transport is undergoing a continuous increasing process, however freights transport turns to improve the transport quality from the quantity increase because of the present high-technological and service economic structure.

The significance of the transport evolution model in the transport development research is as follows: (1) it correctly points out that human transport activities is a evolutionary process and the importance of such process in the social economic development; (2) it shows that the static analysis method is unreliable to compare and analyze among different countries; (3) it has laid a more solid foundation of Economics for the transport development research through the application of Evolutionary Economics to combine the transport research with economic research; (4) it tries to use models in the transport development study; (5) it takes the environmental elements as important parameters in the transport development research; and (6) it points out the significance of new institution and organization form on the success of new transport modes.

However, some drawbacks do exist in Grubler' transport evolution model. They mainly present in the following aspects. Firstly, it mechanically applies the very same life cycle to analyze all the transport modes, and then takes them as the basis for the future deduction. Therefore it causes the conclusions forced. For instance, Grubler asserted that the social economy of the developed countries will surpass the highway and enter into a new stage relying on civil aviation as basis. And he also predicts that the brand new transport tool utilising natural gas resource will appear as the next generation of substitution. Secondly, while it emphasizes the promotion effect of new transport technology and new transport mode on the infrastructure and the overall social economy, it overestimates the substitution but neglects the complementarity among different transport technologies, and debases the function of the traditional transport modes. He relegates them to weightless and even obstructing the economical and technological progress if they continuously have been used. However, every transport mode has its own virtues and advantages and can find its live position in the comprehensive transport network. What's more, some of the traditional transport mode can even obtain complete rebirth through the technological creation, such as the development of high speed train on railway. Lastly, although he correctly mentioned the coherence between the evolution of the transport system and that of the energy system, Dr. Grubler too unitarily focused on the transport industry. So it is impossible for him to observe and analyze the change process of the overall social infrastructure from a more broad angle, thus impossible for him to point out the developing cue of the transport industry in the overall sense.

2. THE ANALYSIS ON THE TRANSPORT STRUCTURE CHANGE

In 1993, Dr. Zhao Yiping divided the main industrial countries in the world into "going ahead" countries and the "latecomer" countries, and analyses the characteristics of the latter's transport development. While the "going ahead" countries consist of UK, France, America, Germany and other main European developed countries, Japan, Russia and the main newly developing countries belong to the "latecomer" ones. Dr. Zhao put forward that it is not correct to take for granted that all countries would develop the transport industry in exactly the same order. In another word, it is too simplified to take the current

transport situation of the developed countries as that of the “latecomer” countries on tomorrow or the day after tomorrow. Dr. Zhao concluded that the characteristics of the transport development in the “latecomer” countries are as follows: “acceleration phenomena” occurring in the transport development process, the transport construction cycle is comparatively “pressed”, and the “comparatively lower saturation levels” of transport modes and their infrastructure. At the same time he believes that the later a country economically develops, the more visible of these characteristics in the transport development (Zhao, 1993).

As to the “comparatively lower saturation level” of transport infrastructure, Dr. Zhao interpreted it as the difference between the transport networks change of the “latecomer” countries and that of the “going ahead” countries. In the “going ahead” countries, when demonstrated in operation mileage change, the networks of each transport infrastructure have respectively gone through four comparatively complete stages of birth, growth, saturation and declination. After entering into the declination stage, the operation mileage of the related transport infrastructure will decline much lower than that at its maturity stage. To put America’s railway as an example, from the end of its railway expansion at about the 1930s up to the mid-1980s, the length of railway network has shortened by one third of that in its saturation level. Whereas the length of railway network has nearly shortened half in UK. Comparatively, because of the demonstrative effect on transport technology offered by the “going ahead” countries, the evolution of transport modes presents sort of simultaneity, resulting the relatively small saturation length of each transport infrastructure and of course the less visible declination stages correspondingly. For instance, the railway net in Japan reached “saturation level” in 1940s, but the operation mileage of it has hardly decreased up to nowadays. The mileage changes of the railway nets in the “going ahead” countries and in the “latecomer” ones are respectively shown in Figure 3. and Figure 4.

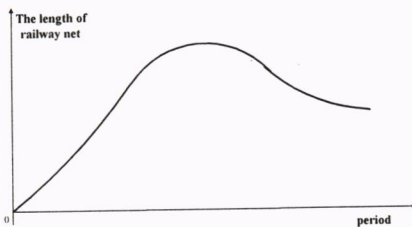


Figure 3. the railway network change in the “going ahead” countries

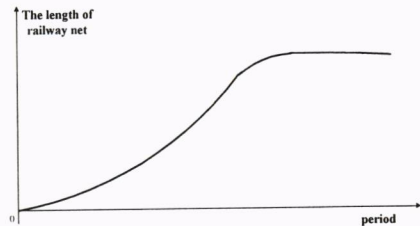


Figure 4. the railway network change in the “latecomer” countries

Dr. Zhao Yiping’s argument of the “comparatively lower saturation level” in “latecomer” countries is an important achievement in the comparison research on transport development. It reminds us that we should not simply compare the situation on today and tomorrow in the developing countries with that on yesterday and today in the developed countries. It is also helpful to make correct transport development strategy and policies in the developing countries.

3. THE TRANSPORTIZATION THEORY

The transportization theory was first put forward by Rong Chaohe in 1990 and presented in later works such as "On Transportization" (Rong, 1991) in details. It also depicts the relationship between transport and social economic development in the angle of long term change. A growth curve of transport industry can also be derived from this theory. When its observation angle is similar to that of Grubler' transport evolution model, the theory of transportization has broken the limitation of only analyzing the individual transport model. It includes the whole transport system as its analysis objects, thus it is easier to obtain the conclusion which has overall significance in the transport development study.

According to the Theory of Transportization, transportization is one of the important features of industrialization, it is also a kind of economic process accompanied with industrializing. In the process of transportization, the scale of spatial movements of people and goods has sharply expanded as a result of the use of recent and modern means of transport; transport has become the most principal basic industry and infrastructure conditions, on which economy depends for entering into modern expansion. When discussing the characteristics of industrialization, we used to put more stress on specialization, mechanization, large-scale production, electrification, urbanization and so on, but actually, in its relation to industrialization, transportization at least has the same importance as the others. Transportization and industrialization accompanied with each other in their emergence, and there would be no industrialization without transportization.

Transportization in the national economy concretely manifest in the following aspects: (1) the use of steam or motor-driven means of transport; (2) the freight transport changed from handicraft goods to industrial materials, energy and products; (3) the total volume of spatial movement of people and goods increase rapidly; (4) much lower transport cost and price; and (5) transport take up more and more economic resources, and constitute the most important basic conditions and infrastructure.

The process of transportization in economic development has its stages. Before the advent of industrial revolution, from primitive nomadic times, the traditional agricultural age to the workshop and handicraft period, the economy in various countries had remained for long in a "pre-transportization" state. That which runs parallel to big industry is the period of transportization; and the feature of transportization itself gained full growth amid the two quasi-stages of "primary transportization" and "perfect transportization". With the gradual shift towards post-industrial economy in the developed countries, the importance of transportization has, relatively speaking, begun to give place to the application of "informization", thereby giving rise to a trend of "post-transportization". To be simple, the development of social-economy may be divided into three stages of pre-transportization, transportization and post-transportization; of these, the stage of transportization can also be divided into two quasi-stages of primary transportization and perfect transportization. Figure 5. is a diagrammatic sketch showing the transportization stages in developed countries. From this sketch we can see the responding relationship among transportization, industrialization and the improvement of transport technology. In this sketch, the general volume of freight transport is a curve that first increases acceleratively in the primary

transportation stage, then increases deceleratively in the consummating transportation stage, and then decreases slowly in the post transportation stage.

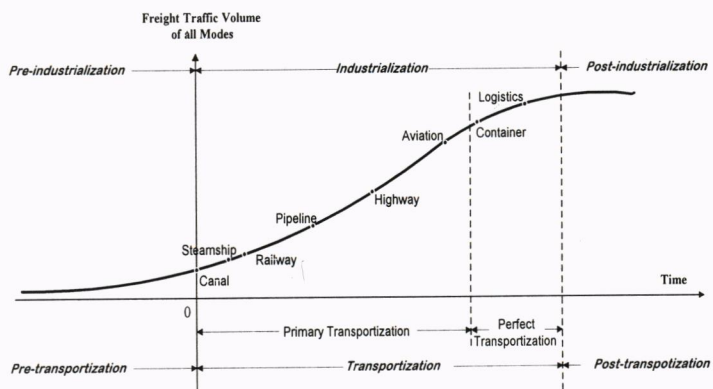


Figure 5. The Stages of Transportization

The organic combination of transportization and industrialization process is not an accidental historical phenomenon. It reflects the special status and function of transport to industrialization and the development of economy and society. The reason of transportization accompanied with industrialization's emerging and developing is that industrialization made an economy of manufacturing while the modern manufacture industry is characterized using mineral fuels and processing and selling material with mechanized way. Industrialization also made a lot of presents leave their land and enter into cities. Therefore, industrialization will certainly result in the demand of movement of people and freight in scale and speed greatly increased. It also demands transport to be reformed revolutionarily in order to meet the need of it. To a certain extent, industrialization means plunging more people and goods into spatial movement through an even faster and more economical means. Thus, the development of transport is not just a pure product of technology improvement and traffic flow, it simultaneously promoted the whole country's industrialization as the leading industry. So in regard to the scale and capability for the spatial shift, the kind of means and speed to be engaged for fulfilling the movement of people and goods would become an important symbol in measuring the level of industrialization of a country.

The main difference between the transportization theory and the transport evolution model is that the transportization theory argues that transportization is only a stage in the long-term process of social economic development. The relationship between transport and social economy in the transportization stage has great change compared to in both pre-transportization and post-transportization stage. Especially the transportization theory disagrees with the predication from the transport evolution model that after the transport industry has greatly advanced, there would be generations of new transport technology one after another greatly promote the social economy as canal, railway, highway and air once did or do just now. In the most developed countries, the post-transportization trend occurred in succession after 1980s, accompanying the service trend and the high-technological trend of the economic structure and the high additional value trend of industry. Of course, this does not mean that transport has no use to exist in the information society or will be substituted by other new industries very soon. Post-transportization only

points out that the relative importance of transport industry as a kind of infrastructure in the information society will decline a little due to the more rapidly increasing demands of the society on the other infrastructures. According to the transportization theory, the growth curve standing for the transportization development will not rise limitlessly.

As for the occurrence and development of transportization in the developing countries, there are some common characteristics: First, transportization began compulsorily under the external military and economic aggression, and transportization in the colonies was the dependencies of the economic transportization of imperialist countries. Secondly, as the national industrialization in its true sense generally started very late, the stage of primary transportization dragged on for a fairly long time. Thirdly, there was an uneven space distribution in transport, with a part of modern transport and a considerable portion of traditional transport existing side by side over a long period. And finally, the demonstrative effect of transportization in developed countries and the impact of varied high-tech and information revolution will inevitably give rise to new characteristics in the process of industrialization in the developing countries, and advance their need for modern telecommunication facilities. This is in accordance with "comparatively lower saturation level" argued by Dr. Zhao Yiping. Rong Chaohe argues that China's transportization still is in the primary stage in which the transport capacity needs rapid expansion. Transportization is not only an inevitable stage for economic development for us, but also an arduous task which must be completed at the same time.

4. ANALYSIS MODEL ON DEMAND GROWTH OF RAILWAY FREIGHT TRANSPORT

The reason of causing transport demand is very complicated. In order to analyse the issue, Dr. Wang Jixiang (1995) divided the economic factors influencing transport demand into two kinds. One is the quantitative factors of national economy, the other is the economic structure factors. He names the freight demand growth caused by the former factors as "quantitative transport demand growth" and the latter as "structural transport demand growth". Assuming that the influence of economic growth to transport demand is the same proportion and direction with that of transport demand, Dr. Wang Jixiang raises the following growth model of railway freight demand:

$$FDR_t = QDR_t + SDR_t = GR_t + SDR_t \quad (1)$$

here: FDR--freight demand growth rate of railway transport; QDR--growth rate of quantitative demand; SDR--growth rate of structural demand; GR--growth rate of gross national product; t--a particular year.

There are some features in this model: (1) quantitative effect is the positive driving force of freight demand growth all the time; (2) structural effect has different functions in different periods: in the former half, it is the positive force, pushing the demand growth; in the latter half, it is the negative force decreasing the demand; (3) the quantitative and structural influences play leading role alternately in different periods, which determines the direction of freight demand growth.

According to the different degrees and directions of quantitative and structural influence in different periods, the railway development courses of the main western developed countries

can be divided into four stages, Table 1. shows the influencing directions and degrees of quantitative and structural factors as well as the stages of railway freight demand growth.

Table 1. Influential factors and stages on demand growth of railway freight transport

Stage	Influential direction		Influential degree		Demand growth	
	quant.	struc.	quant.	struc.	Direction	speed
I	positive	positive	small	big	go up	quick
II	positive	positive	big	Small	go up	quick
III	positive	negative	big	Small	go up	slow
IV	positive	negative	small	big	Down	slow

In the 1st stage, structural factor is the leading factor, the growth of railway freight demand was mainly emerged from the structural influences, the bigger positive structural influence and smaller quantitative influence bring about the rapid growth of demand; in the 2nd and 3rd stages, quantitative factor became the leading factor, from it the demand growth was mainly emerged, the positive growth of structural demand in 2nd stage and the negative growth in 3rd stage respectively quicken and slow down the speed of demand growth; in the 4th stage, structural factor has again become the leading factor, it's influence of negative growth has exceeded the influence of positive growth of quantitative demand, which brings about the negative growth of railway freight transport (Figure 6.). Each developed country has gone through the 1st, 2nd and 3rd stages respectively, and got in succession into the 4th stage during which the demands of railway transport decrease gradually.

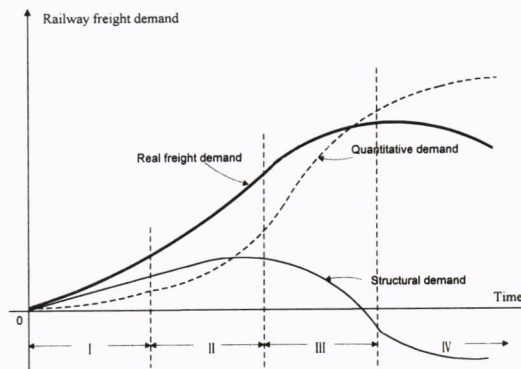


Figure 6. The Stage of Railway Freight Demand Growth

Dr. Wang Jixiang's model of railway freight demand growth can well explain the relationship among the elasticity changes of freight demand growth, mode-shares in transport markets, increase or decrease of demand intensity and changes of railway network scale of each developed country from the beginning stage to the present time. For example, according to the main influences of quantity and structure and the difference of above-mentioned four stages, the change trend of elasticities of railway freight demand of various countries can be analyzed and explained. The elasticities are above 2 in the 1st stage, between 1 and 2 in the 2nd stage, between 0 and 1 in the 3rd stage, and negative in the 4th stage. The changes of share rate of railway freight transport and demand intensity have

corresponding relationship with the four stages of freight demand growth, increasing in the 1st and 2nd stages and decreasing in the 3rd and 4th stages. As from the development courses of railway network, the expansion period corresponds with the 1st stage and earlier 2nd stage of demand growth; the largest periods of railway network corresponds with the later 2nd stage and earlier 3rd stage; the reduction period corresponds with the later 3rd stage and the 4th stage. In the 1st and 2nd stage, the main way of railway development is expanding the railway networks; in the 3rd and 4th stage, the main way is raising the traffic intensities of railway networks.

The curve shapes of actual railway freight demand growth of each country are not the same completely, and the lasting time of every stage is not identical either. The reasons of the differences are the diversities of the countries' environment conditions, besides the disparities of their economic scales and economic structures, and the hard environmental factor bring into its influence by transport structure mainly. For instance, territory area takes decisive effect on time spans of railway development stages in different countries. The lasting time in the 3rd stage in Britain was 20 years, but 60 years in America, this reflects the differences of dependence degree on railway freight transport in the countries with different territory areas.

The 4-stage model verified the development of each stage of transportization from another angle by describing the historical development orbit of railway accurately. In western countries, the primary transportization stage began from the high tide period of canal construction in the latter of 18th century and the beginning of 19th century. Figure 7. shows that the primary transportization stage is consisted of canal period and the 1st, 2nd and 3rd stages of railway development course. In the earlier half period of the 4th stage, the railway freight demands have begun to decrease slowly, but the total freight demand still increase continuously because the demand increases of highway and other transport modes exceed the decrease of railway freight demand. This period is called as "perfect transportization stage" in transportization theory. When the economy develops to a certain degree, not only the railway freight demand decrease continuously but also the total freight demand of all transport modes appears the trend of gradual decrease. By that time, the economy growth has begun to get into the "post-transportization stage".

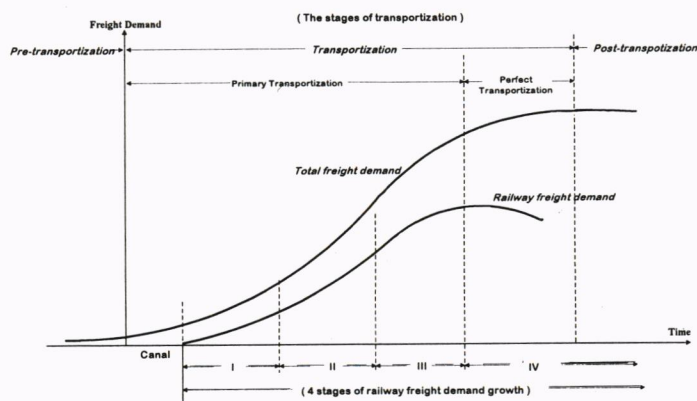


Figure 7. The Stages of Railway Freight Demand Growth and Transportization

According to the study, the state of freight demand growth of China's railway from the beginning of 1950s to the end of 1980s was similar to the 2nd stage level of main developed countries. From the early 1990s, China's railway freight demand growth has changed progressively from the 2nd stage to the 3rd stage. In the 3rd stage, the China's railway freight demand will increase continuously, but be slower than the growth speed of national economy. This stage will last about 60 years by estimation. But I render that the conclusion about the lasting time of China's railway third stage should be modified according to the argument of the "comparatively lower saturation level" in Zhao Yiping's theory.

5. THE PERIODICAL DEVELOPMENT THEORY OF URBAN TRANSPORT

In 1995, Dr. Cao Zhongyong posed his Urban Traffic's Stage-character Developing Theory. It stated that, being the political, economical and cultural centers of the areas, modern cities are also the traffic original and focusing sites of national and international transport systems, and according to the differences of spatial scales, urban transport can be divided into city's external transport and intra-city transport. The city's external transport also can be divided into international inter-cities transport, domestic inter-cities transport and city-countryside transport. The intra-city transport, which is the urban transport in the narrow sense, also can be divided into city-suburb transport and inner-city transport (Cao, 1996). Figure 8. is the frame of urban transport system.

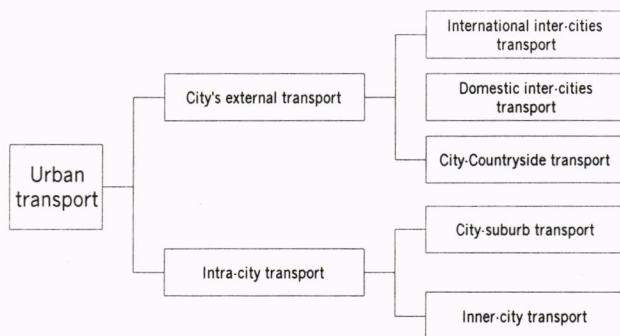


Figure 8. The frame of urban transport

Generally speaking, urbanization refers to the procedure of changing countryside society to city society after the industrial revolution. In this procedure, the city economy gradually went beyond the rural economy and the city culture surpassed the countryside culture. In the human's long course, the emergence and development of cities have a history of thousands of years, while the urbanization only has passed 200 years. The forming and developing of urban transport have very close relations with the forming and developing of city and with the procedure of urbanization. Corresponding to the primary, intermediate and senior stages of the forming and developing of city and urbanization, the urban transport can also be divided into primary stage, intermediate stage and senior stage. The urban transport primary stage, coincident the city's primary developing stage before the real procedure of urbanization, can be divided into primitive-equilibrium period and basic forming period; the intermediate stage can be divided into growing period and maturing

period; the senior stage is the matured-equilibrium period. Different periods in different stages have their different characters.

The periodical development theory of urban transport highly summarizes the relation between urban transport and urbanization. In its primary stages of growing, the urban transport was mainly for city-countryside and inter-cities relation, that is the exploiting of cities' external transport network. The industrial revolution promoted the urbanization and the use of recent and modern transport facilities also made the urbanization develop with fast speed, which is also a procedure in which very large number of people and enormous economic wealth gather in the cities. The city-countryside and inter-cities transport system developed and perfected very soon. When there was a certain spatial flowing of people and material in every city, for example when the city's population reached to more than one million, the traffic flows of people, raw material, energy and consumer goods increased greatly, the inner-city transport problem would emerge, and modern transport facilities once just being used in inter-cities network now are being used in the cities transport. When urbanization comes the matured period, the increasing speed of passenger and freight traffic in city-countryside and inter-cities transport slowed, but the big cities exploit to their suburb area and there are more satellite town emerging around the big cities, besides the transport in the city, the transport between cities and their suburbs become more important. When modern cities developed from centralized point mode to expanding area mode and the regional cities-belt, which included a number of big cities and some middle and little scale cities and towns nearby, this kind of traffic demands have promoted the modern transport relations more developed and perfected in transport vehicles, network infrastructure and facilities.

Figure 9. expresses the development stage of urban transport. From the curve in the picture we can see that in the long period before industrial revolution the total traffic inward and outward city was at a very low level; in the growing period of urban transport, the traffic began to increase rapidly; and in the matured period, the traffic increasing went down.

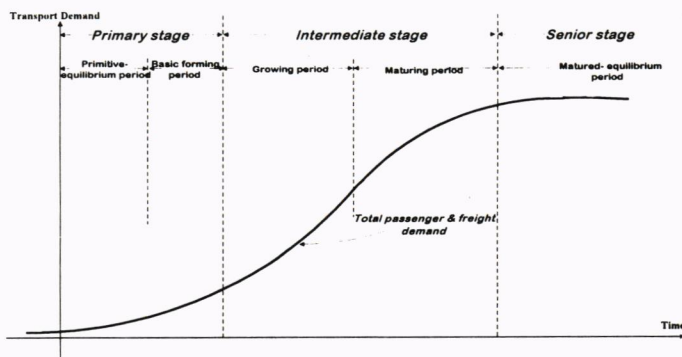


Figure 9. The development stages of urban transport

The development stages and periods of urban transport have close relations with the stages described by the theory of transportization. From Figure 10. we can see that the primitive-equilibrium period of urban transport was wholly in the pre-transportization stage, some part of the basic forming period was in primary transportization stage which approximately

corresponding to the recent canal period before railway's emerge. Other part of the primary transportization stage corresponds to the growing period of urban transport, in which the passenger and freight traffic increased rapidly. The matured period of urban transport began almost at the same time with perfect transportization stage but lasted longer than the latter. In this period the increasing speed of freight traffic lowed down and finally went to the saturation state, while the passenger traffic still increased quickly until entering the matured-equilibrium period of urban transport, then the total passenger traffic gradually saturates. So the late matured period has went into the post transportization stage. Through analysis about all kinds of transport issues related to cities, the periodical development theory of urban transport explains where the passenger and freight traffic come from and where they go to in different transportization stages.

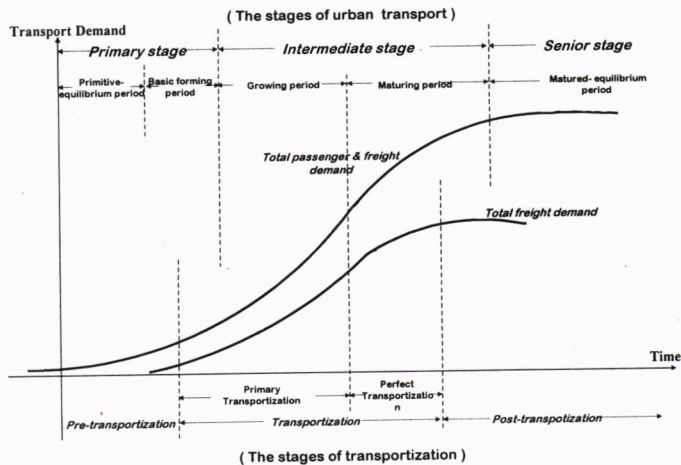


Figure 10. The comparing of the development stages and periods of urban transport with the stages of transportization

And according to the dividing standard of urban transport development, China's urban transport is now in its growing period. This conclusion is quite the same with the judgment got from the transportization theory and the 4-stage model of railway freight demand.

6. THE ENVIRONMENT LIMITATION AND SUSTAINABLE TRANSPORT

Transport, as an important component of national economy, benefits the economy greatly and at the same time seriously threatens the biological environment, but people often neglect the latter. Its effects on environment include energy depleting, great land occupying, air polluting, noising, jamming, as well as transport accidents, soil erosion, destruction of natural scenery and the unbalance of biological environment. Any development is not unlimited, so does the transport development. Its limitation is affected by lots of factors, both in demand and supply aspects. Human being should set up the sense of sustainable development and constrain the transport activities within a rational level.

The man's transport activity volume has a critical point, which protects the long term and sustainable development of human from being destroyed. The critical volume of transport activities is determined by environment capacity. Seen from the static angle, the

environment capacity of an area is the pollution density standard permitted by the area circling the pollution source, or the capacity of containing waste of the area's environment. Seen from the waste acting mechanism in the environment, environment capacity is a dynamic concept, a change capacity according to many conditions, including the pollution's physical spreading speed in the environment, the environment's chemical or biological purging and decomposing capability. Some scholars claim that the biological results and influences should also be considered, i.e., environment unit capacity for one kind of pollution source is influenced by its earth and chemical characters, the environment conditions, and the human and other living beings' standing capacities for this harmful material.

With the expanding of environment research, besides the environment capacity of natural biological system to the pollution sources, the limit caused by all kinds of material resources especially unrecoverable resources to the human being are also considered. The energy, especially oil, and many kinds of mineral resources needed by transport are facing the danger of exhaustion, the lands needed by the constructions of airports, highways and parking areas are limited, even the water and air ways as the natural transport resources of a country or region also have their utmost capacities. This broad concept of environment capacity has more important meaning to human beings' sustainable development. In brief, there is a limit of general resource and environment capacity in the whole social and economic system, and the transport branch system is also restricted, so it could only coordinately develop under the resources and environment restrictions (Rong, 1995).

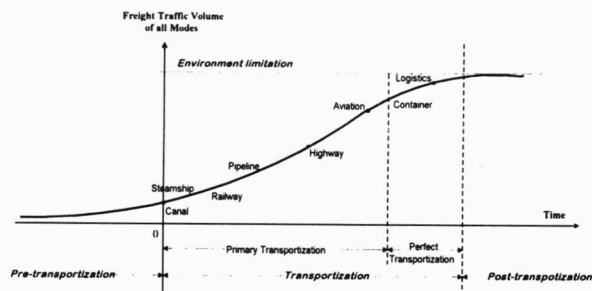


Figure 11. The limitation of transport activities and Transportization

In the process of transportization, human beings' transport activities have been approaching and some even exceed the environmentally critical volume of the earth (see Figure 11; Rong, 1996). At least, in the big cities, which have long term and serious traffic congestion and air pollution, the critical volume in fact has already been exceeded. These situations happen in both developed and developing countries, and in latter group the problem is more serious, because the developed countries have already recognized the importance of environment protection and with their better strength of technology and finance, they could probably resolve their problems by and by. However, a great number of developing countries are sinking into more and more stern transport problems. Developing countries' transportization process have their own characteristics, of which resources and environment limits are important aspects, they could impossibly repeat the developed countries' transportization process, and shouldn't take the latter's already existing living standard as their own aim. The mobility's goal of transport and human beings'

environment goal are conflicting: to fit the developing of economy, transport must be improved to provide better mobility; however the increase of traffic volume will enlarge its bad environmental effects, so the total transport activities must be controlled (Hansson and Tamburrino, 1992). Therefore, transport development is facing a dilemma and has to reset its direction. Activities exceeding limit are dangerous. Transport activities exceeding environment critical volume will also lead to punish or revenge of environment. If now we can not recognize this and take measures immediately, human beings will have to pay much for it.

Someone thinks that technological progress will finally resolve the dilemma faced by human beings, therefore it's unnecessary for men to worry about the coming of transport limits. But from the example of "intelligent transport", we can see the confined effect the technology has in resolving the traffic congestion problem. The intelligent transport system can increase the passing capacity and the efficiency of the current road system, someone expects that it could reduce 20% traffic congestion. However, our point is that we shouldn't lay much hope on the intelligent transport system, especially in developing countries where intelligent transport system shouldn't and could impossible become the main method to resolve the urban transport problems. The reason is that in developed countries the increase of cars was a gradual process and there was not big gap between the increase of cars and that of roads, until today these countries' necessary roads have already been built and their cars have been in the state of saturation. Therefore, after the set up of their intelligent transport system, the transport congestion then could be resolved by some degree (In the same time, other methods of reducing traffic volume should be taken into effect.) . However, in developing countries, the increase of cars is a sudden process while the increase of road is much more difficult. Considering the population pressure and their financial situation, it's nearly impossible for the developing countries to build enough roads within a short time. The too fast increase of cars is the main reason of traffic jam or even palsy in big cities in developing countries. If it could not be controlled effectively, neither building more roads nor setting up intelligent transport system could change the worse situation of transport.

People invent cars for providing convenience, but the result is that traffic congestion provides inconvenience to most of us; people meet an unsolved problem set by themselves, and have to pay much for it. This tells us that man's capability is limited and his irrational behavior could probably lead himself to disaster. If after man think out all kinds of ways including the most advanced technology and still not be able to resolve problems such as traffic congestion, then maybe we can say that man has already lost some of self-adjusting and self-restoring functions. Facing the great contradiction and conflict between man and nature, the future is pessimistic.

To get the coordination of mobility's goal and environment goal, the only way is to realize the sustainable transport. The aim of sustainable transport is to ensure the best transport activities level to fulfill the need of social economic development and at the same time won't hurt biological environment, to maximize social welfare and won't lower the living standard of descendants. Therefore, the effect of sustainable transport should: (1) improve the efficiency of transport system and lower the transport cost; (2) ensure enough transport service to fulfill the social demand; (3) promote the regional balance and trade development; (4) reduce the environment pollution; (5) protect the living environment for

all living beings; (6) ensure public and environment friendly transport mode develop prior; and (7) improve the safety level and promote the social welfare.

Transport development is restricted by many factors. Because the countries' different environment capacities, resources conditions (including transport resources) and population pressure, the critical levels of transport development and the time needed to get that level are also different. China is a country with greatest population and very serious environment situation, therefore, its resources and environmental capacities is relatively more scarce, its transport supply limit level and traffic critical volume will come earlier. During recent ten years, China's cars have been increasing 12% to 14% annually, which is more than twice of the increase of urban road construction and has led to more and more serious traffic congestion problem. The average speed becomes lower and the quality of the city's air becomes worse in the same period. Sustainable development is the necessary choice for China's transport development, otherwise, we will pay great economic and social price and leave an unaccountable "environment deficit" for our later generation, and finally make the environment lose last economic supporting ability.

Without doubt, the putting forward of these theories and models, has made the study in the transport development field rise to a new rationalization level. The practical meaning of these theories' progress lies in that they demonstrate with convincing strength: That the transport problems in economic development can not be ignored; The development of transport has its progress stages; The evolutionary growth curves could be approximately depicted with some ecological evolutionary curves or logical curves; This evolution process also has its stages and order; The culmination point in the saturation stage of transportization is restricted by the natural environment and resources condition, so the scale of the transport activities should not overpass the limitation no matter how more advanced the human society and technology are.

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