EXPLORING THE ALTERNATIVE MODES OF ECO-FRIENDLY EXPRESS FREIGHT TRANSPORT

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Abstract. Reducing pollutant emissions of transportation is an important strategy for addressing global climate change, high-speed rail (HSR) transport, an eco-friendly mode, neither emits dust, nor emits too much CO_X and NO_X due to the eclectic traction drive. Instead of focusing on passenger transport as most literatures refer to HSR, this paper addresses the strategy of goods movement, and chooses Beijing-Shanghai (B-S) HSR in China as a case study to explore a new freight transport mode to alleviate the increasingly serious environmental pollution problem. After predicting the intercity parcel demand and distribution based on AR-GM and Gravity model, the paper evaluates the supply capacity between cities based on operating schedule. The result shows Origin-Destination Pairs (ODPs) such as Shanghai-Jinan, Shanghai-Beijing, Beijing-Langfang suit for Mixed-train Mode and others such as Beijing-Tianjin, Shanghai-Suzhou, Shanghai-Xuzhou suit for freight-train mode. It concludes that operating high-speed rail freights on a large-scale is feasible and environmentally friendly due to its advantages of energy saving, land saving, low carbon emission. Since alternatives of modes are determined by the time distances, the scale of cities, flow volumes of intercity parcels, Freight-train mode should be adopted between cities with high economic density and large transportation capacity.
Keywords: *forecast, flow, capacity, mode, high speed rail, intercity transport*

Introduction

The issue of global warming and air pollution caused by greenhouse gas emission has drawn the attention of the international community. Transportation growth has become one of main factors that contributing to the negative environmental impacts (Pejić, 2017; Nanaki et al., 2016; Gong et al., 2019). With the economic development, the proportion of transportation in China's national energy consumption is on the rise, making it the second largest energy-consuming industry with heavy tasks of energy conservation and emission reduction. As regulation becomes more stringent, transport companies are more like to choose an eco-friendly mode to cope with the challenge of an internalization of environmental effects (Ferrón-Vílchez, 2015). Among all of the modes, road transport represents, through its characteristic features – high flexibility and accessibility – the mode of transport largely involved in meeting the needs of mobility, though it is answerable for polluting the environment to a significant degree (Mitran et al., 2012; Limbourg and Jourquin, 2009; Du et al.,2018).

It can be seen from *Table 1* that in comprehensive transportation system, railway has the comparative advantage in energy conservation and environmental protection, and is the only transportation can be widely used in large areas to achieve the green environmental protection of "replace oil with electricity". Many scholars believe that introducing freight transport into passenger rail network is one of the important ways to absorb road traffic (Offer et al., 2010; Van Wee et al., 2012; Van Duin et al., 2013). High speed electric trains involve a fully mature technology that can use power

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generated by the wind, solar thermal energy and geothermal sources with a carbon footprint of zero. Extensive high-speed rail (HSR) network construction and operation quickly increases the rate of the electrification of the entire railway industry, optimizes the railway energy consumption structure. In fact, HSR not only meets people's growing demand for time-sensitive goods, but also meets the requirements of sustainable development, which shows the strong competitiveness in comparison with other modes of transport.

Table 1. *Comparison of pollutants emission among different transportation mode*

Annual emission (kg/cap)	Rail			Aviation			Truck		
	CO_X	**NO_X**	**SO_X**	**CO_X**	**NO_X**	**SO_X**	**CO_X**	**NO_X**	**SO_X**
China	0.031	0.53	4.02	1.76	6.12	9.25	1.81	2.63	4.02
USA	0.17	3.69	11.49	9.62	42.11	26.43	9.9	18.08	11.49
OECD	0.096	1.98	6.45	5.43	22.6	14.86	5.58	9.72	6.47

As shown in *Figure 1*, the mileage of HSR goes up obviously, about 29,000 km in 2018, so does the total income and volume of express industry. In fact, intercity express volume accounts for nearly 70% of the total volume. However, it is difficult to organize and modernize goods transport between large cities (Dablanc, 2007; O'Connor, 2010; Li, et al., 2017; Musolino et al., 2018). Since the two megacities of China, Beijing and Shanghai, connected by HSR in 2011, the transportation and communication between the north and the south of China become more intensive. As economy development depends heavily on transport, investigating the feasibility of coordinating freight and passenger flows using existing and forthcoming rail infrastructure has been a new trend in recent years (Behiri et al., 2018; Talebian and Zou, 2015; Pazour, et al., 2010).

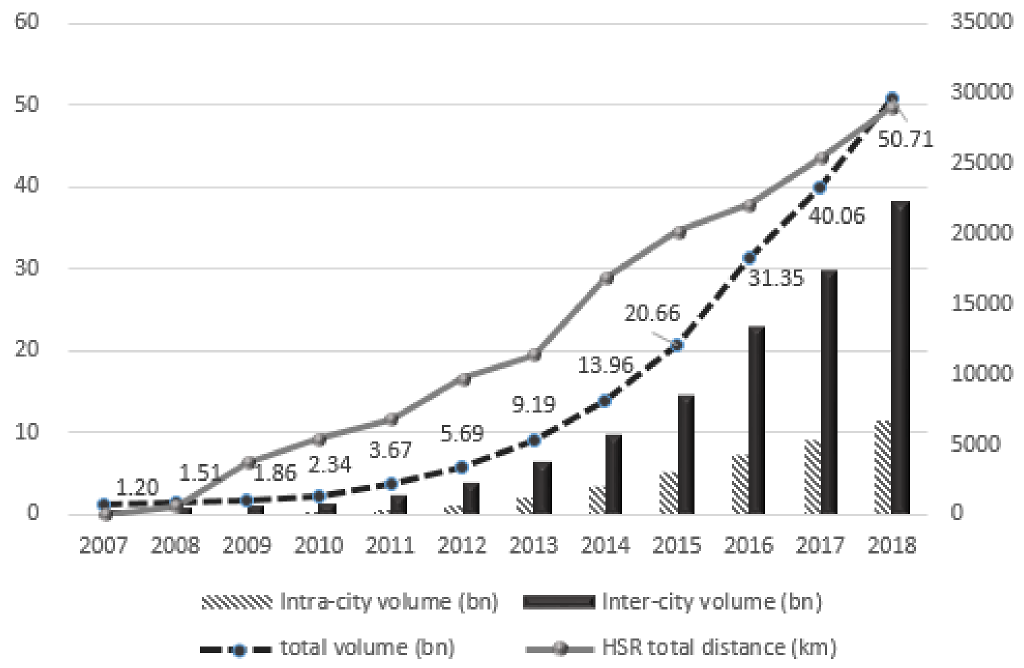

Figure 1. *The development trend of express industry and HSR*

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Currently, there is no unified specific definition about high speed freight transportation (Troche, 2005), this paper supposes the modes can be basically divided into two: Mixed-train Mode, using passenger High Speed Train (HST) for freight transportation, including reserving or adding a couple of carriages; Freight-train Mode, adding exclusive high speed freight train or remoulded existing passenger HSTs for freight transport. Generally, compared with conventional transport modes, the main advantage of HSTs is cheaper than aviation and faster than truck. High speed rail is often touted as a means to reduce congestion of passengers transport instead of freight, but this paper offers a new method to quantitatively analyse the feasibility of such a sustainable freight mode and its positive influence to environment.

In the next section, the paper sets out method and algorithm adopted for forecasting Origin-Destination (OD) parcels demand. Section 3 shows a case study of about future freight distribution and the feasibility of adding HSTs on B-S HSR to transport parcels. Section 4 and 5 respectively presents the results and discussion about the adoption of the two modes. Section 6 ends the paper, setting out the conclusion.

Materials and methods

Forecasting demand based on ARMA model

In order to estimate the feasibility of operating high-speed freight on Beijing-Shanghai (B-S) corridor, freight distribution in future should be considered initially. Urban freight demand forecasting has been a crucial part of analysing the quantity of OD flow matrices (Nuzzolo and Comi, 2014; Börjesson, 2014; Jiang et al., 2014; Garrido, 2000), this paper presents a modelling system that tries to point out the freight relation among cities. Auto-Regression Model has been widely used for forecast analysis of time series (Wang, et al., 2013).

The general form of an ARMA model can be listed in *Equation 1* and transformed into *Equation 2*:

$$x_t = \delta_0 + \delta_1 x_1 + \delta_2 x_2 + \cdots + \delta_p x_{t-p} + \tau_m - \theta_1 \varepsilon_1 - \theta_2 \varepsilon_2 - \cdots - \theta_p \varepsilon_{t-q} \quad \text{(Eq.1)}$$

$$(x_t - \mu) - \delta_1 (x_1 - \mu) - \cdots \delta_p (x_{t-p} - \mu) = \varepsilon_t - \theta_1 \varepsilon_1 - \theta_2 \varepsilon_2 - \cdots - \theta_q \varepsilon_{t-q} \quad \text{(Eq.2)}$$

where $\mu = \frac{\delta_0}{1 - \delta_1 - \cdots - \delta_p}$, usually, μ would be estimated by the sample mean $\bar{x} = \frac{1}{N} \sum_1^N x_t$, and the variance will be shown as *Equation 3* if the series is stationary:

$$Var[\bar{x}] = E[\bar{x} - \mu]^2 = \frac{1}{N^2} E\left[\sum_{s=1}^{N} (X_s - \mu) \cdot \sum_{t=1}^{N} (X_t - \mu)\right] = \frac{1}{N^2} \sum_{s=1}^{N} \sum_{t=1}^{N} c_{t-s} \quad \text{(Eq.3)}$$

Assume k = t-s, then c (k) is an even function leads to *Equation 4:*

$$Var[\bar{x}] = \frac{1}{N^2} \sum_{k=-(N-1)}^{N-1} (N - |k| c_k) = \frac{1}{N} \sum_{k=-(N-1)}^{N-1} (1 - \frac{|k|}{N}) c_k \quad \text{(Eq.4)}$$

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When the N is large enough, from *Equation 4* it may be expressed as *Equation 5:*

$$Var\left[\bar{x}\right] \approx \frac{1}{N}\sum_{k=-\infty}^{+\infty} c(k) = \frac{\gamma(0)}{N}\left[1+2\sum_{k=1}^{+\infty}\rho(k)\right] = O\left(\frac{1}{N}\right) \quad \text{(Eq.5)}$$

If $\bar{x} \in \left[-2\sqrt{Var\left[\bar{x}\right]}, 2\sqrt{Var\left[\bar{x}\right]}\right]$, the stable series can be considered as a series with a zero mean, if not, a new series $\left\{x_t = x_t - \bar{x}, t = 0, \pm 1, \pm 2, \cdots\right\}$ can be generated as a zero mean stationary sequence.

In order to build a suitable ARMA model, we need to observe the character of partial autocorrelation sequence τ_{kk} and autocorrelation sequence σ_k (*Eq. 6*).

$$\hat{\sigma}(k) = \frac{\frac{1}{N}\sum_{i=1}^{N-|k|} X_i X_{i+|k|}}{\frac{1}{N}\sum_{i=1}^{N} X_i^2}, (k = 0, \pm 1, \pm 2, \cdots) \quad \text{(Eq.6)}$$

If $\hat{\sigma}(k) \sim N\left[0, \frac{1}{N}\left(1+2\sum_{l=1}^{q}\hat{\sigma}_l^2\right)\right], (k > q)$, then $P\left[\left|\hat{\sigma}_k\right| \le \frac{2}{\sqrt{N}}\left(1+2\sum_{i=1}^{q}\hat{\sigma}_i^2\right)^{1/2}\right] = 95.5\%$, thus MA (q) should be established if $\left|\hat{\sigma}_{q+i}\right| \le \frac{2}{\sqrt{N}}\left(1+2\sum_{i=1}^{q}\hat{\sigma}_i^2\right)^{1/2}$, $i = 1, 2, \cdots M - q$. Similarly, AR (p) should be established if $\tau_{kk} \sim N\left[0, \frac{1}{N}\right], (k > p)$ and $\left|\hat{\tau}_{(p+i)(p+i)}\right| \le \frac{2}{\sqrt{N}}, \left(i = 1, 2, \cdots, M - p\right)$.

For ARMA (p, q), estimated residual sequence $\{\varepsilon_t\}$ can be estimated as *Equation 7*:

$$\tilde{\varepsilon}_t = x_t - \tilde{\delta}_1 x_{t-1} - \tilde{\delta}_2 x_{t-2} - \cdots - \tilde{\delta}_p x_{t-p} + \hat{\theta}_1\tilde{\varepsilon}_{t-1} + \hat{\theta}_2\tilde{\varepsilon}_{t-2} + \cdots + \hat{\theta}_q\tilde{\varepsilon}_{t-q} \quad \text{(Eq.7)}$$

Residual sum of squares is listed as *Equation 8:*

$$Q = \sum_{i=1}^{N}\tilde{\varepsilon}_i^2 \quad \text{(Eq.8)}$$

The variance of a sequence of residuals can be expressed as *Equation 9:*

$$\tilde{\rho}_\varepsilon^2 = \frac{Q}{N_1 - k} \quad \text{(Eq.9)}$$

N_1 is the number of observations actually used in fitting the model, k is the number of parameters that used in building the model. Akaike Information Criterion (AIC) is

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the most popular criterion for identifying the optimal model, which has been used in this paper to find out the suitable model for forecasting the values *Equation 10:*

$$x_m = \delta_0 + \delta_1 T + \delta_2 x_{m-1} + \delta_3 x_{m-2} + \cdots + \delta_p x_{m-p} + \tau_m \quad \text{(Eq.10)}$$

Forecasting demand based on gray model

Liu and Deng (2000) proposed the first-order one-variable gray model (GM (1, 1)) derived from gray system theory, which can be established based on a small amount of incomplete information to describe the fuzzy rule of the development of things in the long term. Since express delivery was only emerging in recent years, which leads to lacking data, the gray model adopted in this paper can help to produce effective results.

We assume the original data sequence is $x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \cdots x^{(0)}(n)\right)$, and generate a new sequence: $x^{(1)} = \left(x^{(1)}(1), x^{(1)}(2), \cdots x^{(1)}(n)\right)$, then use accumulated generating operation since $y^{(0)}(m)$ is strictly positive and corresponds to time m. And we can have *Equation 11*:

$$x^{(0)}(m) = x^{(1)}(m) - x^{(1)}(m-1), m = 1, 2, \cdots n-1 \quad \text{(Eq.11)}$$

where $x^{(0)}(1) = x^{(1)}(1) \quad x^{(1)}(m) \in x^{(1)}$. If $n \geq 4, x^{(0)}, x^{(1)} \in R^+$, then the GM (1,1) can be expressed by an one-variable, first-order differential equation as *Equation 12:*

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \quad \text{(Eq.12)}$$

where a and b are called the development and gray input coefficients respectively. The whitening version of *Equation 5* is shown as $x^{(0)}(m) + az^{(1)}(m) = b$, substitute all values and get *Equation 13*:

$$\begin{aligned} x^{(0)}(2) &= -az^{(1)}(2) + b \\ x^{(0)}(3) &= -az^{(1)}(3) + b \\ x^{(0)}(4) &= -az^{(1)}(4) + b \\ &\cdots \\ x^{(0)}(n) &= -az^{(1)}(n) + b \end{aligned} \quad \text{(Eq.13)}$$

where $z^{(1)}(m)$ is called the background value of $dx^{(1)}/dt$ and is calculated by *Equation 14:*

$$z^{(1)}(m) = \frac{1}{2}\left(x^{(1)}(m) + x^{(1)}(m-1)\right) \quad \text{(Eq.14)}$$

Equation 14 is established based on discrete data and equal spacing in time, by using least-squares method, the coefficients a and b can be obtained as $\begin{bmatrix} a \\ b \end{bmatrix} = \left(B^T B\right)^{-1} B^T x_n$

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where $B=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \vdots & \vdots\\ -z^{(1)}(n) & 1\end{bmatrix}$ and $x_n=\begin{bmatrix}x^{(0)}(2)\\ x^{(0)}(3)\\ \vdots\\ x^{(0)}(n)\end{bmatrix}$, then the values a and b can be solved, $a=\frac{CD-(n-1)E}{(n-1)F-C^2}$, $b=\frac{DF-CE}{(n-1)F-C^2}$, $C=\sum_{k=2}^{n} z^{(1)}(k)$, $D=\sum_{k=2}^{n} x^{(0)}(k)$, $E=\sum_{k=2}^{n} z^{(1)}(k)x^{(0)}(k)$, $F=\sum_{k=2}^{n} z^{(1)}(k)^2$.

Finally, the predicted equation is expressed as *Equation 15:*

$$\hat{x}^{(0)}(m+1)=(x^{(0)}(1)-\frac{b}{a})(1-e^{a})^{-am} \quad \text{(Eq.15)}$$

Matlab has been widely used to solve the research problems related with gray system theory, in this paper, the class-compare verification and remnant verification are used to validate data, then we deal with data by translating the jumping type sequence into monotonic increasing type sequence, and used Matlab R2018b to complete prediction process.

Forecasting distribution of parcels demand between cities

In fact, Auto-Regression Model has been widely used for forecast analysis of time series, and Gray Model is better at dealing with systems that are characterized with poor information and stable trend data. Jia et al. (2016) find the accuracy degree increases obviously after combining two methods together. Based on the prediction express demand results of GM and AR model, a new combination model can be created as *Equation 16:*

$$X_m=\varepsilon_1\left(\delta_0+\delta_1 T+\delta_2 x_{m-1}+\delta_3 x_{m-2}+\cdots+\delta_p x_{m-p}+\tau_m\right)+\varepsilon_2\left(x^{(0)}(1)-\frac{b}{a}\right)\left(1-e^{a}\right)e^{-am} \quad \text{(Eq.16)}$$

where ε_1 and ε_2 are respectively the weight of demand variable based on the accuracy of forecast value of two methods.

This study assumes intercity parcels of every city are delivered through a nationwide network, and focuses on trunk transport and assumes stations of cities as origin and destination nodes, which leads to the formation of ODPs. By modifying the gravity model, the paper builds *Equation 17* to measure the attraction degree ω_{ij} between city i and city j.

$$\omega_{ij}=\frac{\sqrt{POP_i\times GDP_i\times N_i}\times\sqrt{POP_j\times GDP_j\times N_j}}{S_{ij}^2} \quad \text{(Eq.17)}$$

where S_{ij} indicates the minimum high speed rail distance between city i and city j, i = 1,2,……n, j = 1,2,……n, I ≠ j. POP_i, GDP_i and N_i respectively indicates the population, GDP and the average amount of HSTs stop by the station of city i per day.

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A case study

Now the paper tries to estimate the feasibility of operating freight trains on Beijing-Shanghai HSR from supply and demand perspective based on the methods shown above.

Demand: attractive amount of parcels distributed on B-S HSR corridor in future

The data used in this section is based on the intercity volume of main cities along B-S HSR from the official website of the cities' post office from 2010 to 2017. In order to forecast the demand of the main cities on B-S HSR corridor in next seven years, AR-GM model has been adopted by using Eviews 8.0 and Matlab R2018b, the accuracy grade of fitted values are shown in *Table 2*.

Table 2. *The accuracy grade of fitted values of main cities*

	Relative error	Variance ratio	Little probability of error	Development coefficient	Accuracy grade
Beijing	0.00081	0.0059	1	-0.0875	First
Tianjin	0.00072	0.1424	1	-0.0340	First
Jinan	0.00018	0.0776	1	-0.0225	First
Nanjing	0.00054	0.1136	1	-0.0455	First
Shanghai	0.00601	0.0301	1	-0.1391	First

It can be seen from *Table 2* that the model is fitting well, the difference and little probability of error reached the "first class" precision. The absolute values of all the development coefficients are smaller than 0.3, which indicates the model is suitable for mid-long term prediction. Therefore, the intercity volume of each city from 2019 to 2025 is shown as follow (*Table 3*).

Table 3. *The forecast of intercity express volume of main cities (mt)*

	2019	2020	2021	2022	2023	2024	2025
Beijing	3.35	3.82	4.33	4.89	5.48	6.13	6.83
Tianjin	0.95	1.09	1.24	1.41	1.59	1.80	2.10
Jinan	0.59	0.72	0.82	1.01	1.15	1.43	1.63
Nanjing	1.01	1.13	1.26	1.40	1.54	1.68	1.83
Shanghai	6.17	7.68	9.38	11.62	14.15	17.59	21.48

As shown in *Table 3*, nowadays only the intercity parcels of Beijing and Shanghai are over 1 mt, but most of main cities will transcend the figure soon. Nanjing owns the lowest express volume growth rate with about 10.5% per year on average, and it will be surpassed by Tianjin in 2022 whose volume will reach 1.41 mt. Beijing's is also lower than national average level recently and the rate will keep dropping based on the consistent policy of emphasis on decentralization made by government, but the amount (6.83 mt) in 2025 will be twice bigger than current volume (3.35 mt). Shanghai, the biggest volume owner, also with the highest average growth rate, 23.10%, has shown

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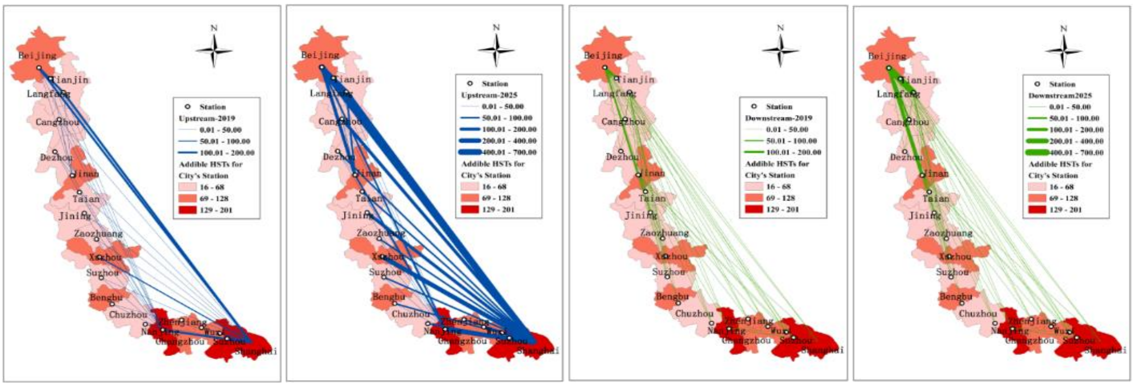
the potential to triple the amount after seven years and dramatically increase to 21.48 mt.

This paper chooses B-S HSR as a case coz if the most crowded HSR in China has space to operate freight train, other HSRs can operate more. The application of method in section 2 leads to the distribution of Origin-Destination Pairs (ODPs) on B-S HSR corridor. The thickness of lines in *Figure 2* indicates the upstream and downstream of ODPs in 2019 and 2025. The different color depths of cities on map indicates numbers of addible HSTs for cities' station.



2019-upstream | 2025-upstream | 2019-downstream | 2025-downstream

Figure 2. *ODPs distribution of main cities along B-S HSR corridor*

Most of upstream flows are from Shanghai, which has been more obvious over time. The flow volume from Shanghai to other cities in 2025 will be three times as big as the volume in 2019. Among all the flow of ODPs, the volume of Shanghai-Jinan and Shanghai-Beijing are always at top 2, and both of them have been over 200 kt parcels in 2019. Besides, the number of flows over 100 kt has been raised from 6 in 2019 to 12 in 2025. As for downstream flows, most are relative small and varies slightly, but they can still be double in next seven years. Besides, the top 5 pairs are always Beijing-Tianjin, Beijing-Langfang, Beijing-Jinan, Beijing-Cangzhou, Nanjing-Shang. However, only two pairs of which are over 100 kt in 2019, and the third pair cannot break the line until 2025.

Supply: the addible bullet trains among stations along B-S HSR

This paper believes if China Railway Corportation (CRC) can add more trains to solve the peak congestion, it must own the capacity to add freight trains on workdays if it is necessary. The paper collected the amount of operating trains among 24 stations of B-S HSR from February 9 to March 18 in 2018, which includes the peak time of spring festival and the workdays after. The difference of a high speed station between the peak and workdays indicates that station's capacity of adding freight trains on usual, which has represented by the thickness of line in *Figure 3.*

In general, the densest sheaf of addible trains are among Shanghai city and Jiangsu province. The top of the ODP list is Shanghai-Nanjing, which owns the capacity of adding 50 pairs on usual. And for upstream and downstream addible pairs, there are respectively 13 and 9 ODPs of adding HSTs over 10. Upstream distribution also has similar situation, among all of the cities in northern and southern part, only the ODPs

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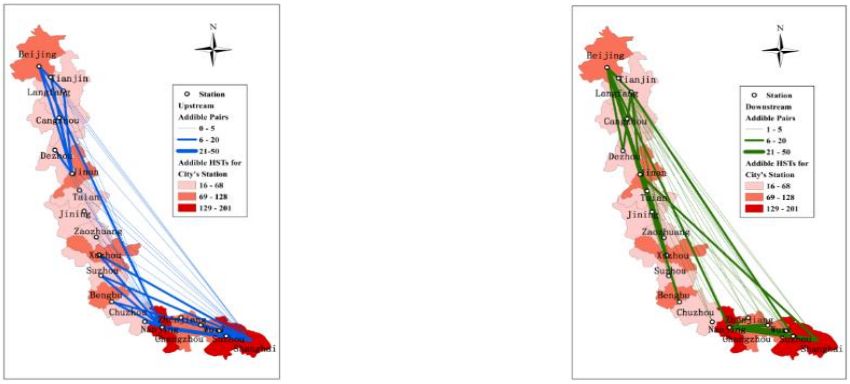
between Beijing and Nanjing are over 5. Thus, it is feasible for CRC to appropriately add various HSTs based on stations' capacity to transit express parcels on usual.



Upstream Downstream

Figure 3. *The supply capacity of high speed stations along B-S HSR corridor*

Results

The optimum alternative of operation mode between cities is determined by demand volume and supply capacity in this paper, we admit that the result will be more convinced if more influential factors are fully considered.

As shown in *Table 4*, those ODPs such as Beijing-Tianjin, Shanghai-Suzhou, Beijing-Jinan, Shanghai-Xuzhou adapt to Freight-train mode because of vast parcels demand and a mass of addible HSTs existing there. Those ODPs like Shanghai-Jinan, Shanghai-Beijing, Beijing-Langfang only have large demand, barely HSTs could be added on usual, so these ODPs suit for adopting Mixed-train mode.

Table 4. *Supply and demand of intercity express volume between cities in 2019*

Origin-destination	Parcels demand (kt)	Addible HSTs	Origin-destination	Parcels demand (kt)	Addible HSTs
Freight train mode			**Mixed-train mode**		
Beijing-Tianjin	320.3	11	Shanghai-Jinan	207.87	1
Tianjin-Beijing	133.55	12	Shanghai-Beijing	196.11	0
Shanghai-Suzhou	127.17	16	Beijing-Langfang	160.22	0
Shanghai-Xuzhou	72.61	8	Shanghai-Tianjin	111.18	0
Shanghai-Wuxi	54.4	7	Shanghai-Nanjing	102.47	1
Beijing-Jinan	54.08	13	Shanghai-Jining	38.08	1
Jinan-Beijing	40.18	14	Nanjing-Jinan	34.31	4
Shanghai-Changzhou	35.79	6	Nanjing-Beijing	32.37	4
Beijing-Cangzhou	30.06	9	Shanghai-Cangzhou	30.91	0
Shanghai-Zhenjiang	26.41	8	Shanghai-Taian	26.41	0

Discussion

The high speed rail freight's emission of dust, NO_X, CO_X, land use and energy consumption are all much lower than truck and air freight, such eco-friendly mode deserves to be applied in a wider scope since environment protection and sustainable development are key issues for the policy-maker (Garau et al., 2011). In fact, Mixed-

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train mode has been widely adopted in China, France, Turkey and many other European countries due to the barely extra cost by loading the parcels on the vacant carriage, but the shortcoming is obvious too, for example, the transport capacity is limited and varies too much because of the frequent fluctuation of passenger flow. Particularly, HSTs in China only stop for about 2 min at most stations, which leaves no time for loading or unloading, therefore, such mode can only operate from the departure station to terminal station. Conversely, Freight-train mode does not have the defect and is able to demonstrate bigger advantage and stronger competitiveness in the areas where own large freight demand (Liang et al., 2016).

Interestingly, the cost of Freight-train mode is hardly accepted by both most enterprises and governments when freight demand is low, but if they do not take this mode, it is hard to get more cargo business from freight market. Faced with the considerable investment required for HSR construction, the determination of policy-maker will play an important role in promoting the process of HSR freight, and clearly, Chinese government has shown more ambition on HSR than other countries', which provides more chances for further research into such eco-friendly transport modes.

Conclusion

This paper improves the accuracy of forecasting by combining ARMA and Gray Model, and discusses the feasibility of operating freight on Beijing-Shanghai HSR corridor and offers the solution with reasons for different Origin Destination pairs. Besides, the flow demand of intercity parcels will keep a growth rate vary from 10% to 23% in the next seven years, and the application of high-speed freight, especially the Freight-train mode, will alleviate the severe air pollution and traffic congestion among those big cities.

However, this paper ignores the possibility of operating freight transport on the checking-train at night since the research is based on the daytime schedule. Moreover, "Door to Door" express freight service cannot be accomplished only by HSR, the multimodal transport needs to be considered in future research. Above all, finding the appropriate routes, identifying the potential hub cities for cargo transfer, optimizing the rail network structure to minimize the transport time are all important ways to improve the efficiency and possibility of operating express freight transport. Apparently, we can not take all of the problems into consideration, but we believe focusing on HSR freight helps people make better use of resources and protect environment well.

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