Abstract
Urban rail transit has provided safe, convenient, fast and comfortable transport services. Its development and construction not only require a huge investment but also have a long industry chain and involve industry sectors of different types. This paper studies backward linkage and forward linkage industries of urban rail transit industry according to input-output tables for urban rail transit of subdivided sectors in 2007 and 2012.

Keywords
correlation, backward linkage, forward linkage, urban rail transit

1 Introduction
Industrial chain is a concept in industrial economics which is based on certain technical and economic relations among the various industrial sectors, and the chain type is formed based on the specific logical relationship and the relationship between the time and space distribution industrial links in the industrial chain occurred mainly between forward correlation and backward linkage (Bao, 2005; Chang and Edward, 2006). Urban rail transit has its own particularity, the industry is highly relevant to construction, metal smelting, equipment manufacturing, electronics, materials, machinery processing, computer and other industrial development, and there is a close relationship between the nontraditional industry and the city real estate (Erik and Hong, 1996). If considering the whole life cycle of city rail transit project as the main line, the rail transportation industry chain can be divided into five parts, planning and design consulting, engineering construction, equipment manufacturing, operation and value added service (Wei et al., 2013). Analysis of industry association, backward linkage industry of the rail transportation mainly included gas production and supply industry, oil processing industry, automobile manufacturing, automobile spare parts and accessories manufacturing, finance, electric power, heat supply and supply, other transportation equipment manufacturing and business services, etc. While forward correlation industry mainly included public management and social organization, aquatic products processing industry, advertising industry, geological survey, education, science technology exchange and promotion services, and tourism, etc. (Li, 2007).

According to the basic principle of the input-output, the backward linkage measure and front linkage measure of the industrial sector is the main index to measure the correlation effect between one industry and other industries. The backward linkage measures the industrial sector depending on intermediate inputs for all industrial sectors as buyers. While forward linkage measuring the impact of traffic department as a seller to all sectors analyze the whereabouts and related degree of department’s product’ as related link from supply direction. Based on the analysis of domestic and international research
status, the paper studies backward linkage and forward linkage industries of urban rail transit industry according to input-output tables for urban rail transit of subdivided sectors in 2007 and 2012 (Li, 2007; Yang, 2005).

2 Backward and forward linkage measurement models

2.1 Place of figures

Index calculation formula of direct backward linkage,

\[ \delta_j = \frac{1}{n} \sum_{i=1}^{n} a_{ij} \quad (j = 1, 2, \cdots, n) \]  

Index calculation formula of complete backward linkage,

\[ \overline{\delta}_j = \frac{1}{n} \sum_{i=1}^{n} l_{ij} \quad (j = 1, 2, \cdots, n) \]  

In the formula, \( a_{ij} \) means the direct consumption coefficient and \( l_{ij} \) refers to the value of element in row \( i \) and column \( j \) in Leontief inverse matrix \( L = (I - A)^{-1} \).

2.2 Forward linkage measurement

2.2.1 Forward linkage and complete forward linkage

Forward linkage aims to measure the influence degree of the department as a seller on all departments. It tries to measure the relationship among departments from the supply direction to investigate where the department products go. For conciseness, forward linkage measurement is worked out according to Leontief price model.

Leontief price model can be written in the following form:

\[ P' = P'A + N'\hat{X}^{-1} \]  

In the above formula, \( P' = (P_1, P_2, \cdots, P_n) \) means the row vector of setting unit price of various departments as the element; \( N' = (N_1, N_2, \cdots, N_n) \) refers to the row vector of setting initial input cost of various departments represented by physical quantity as the leading diagonal element. If the form of price index is used, price index of the base period can be set as 1. Therefore, \( P_i \) means the cost for one unit output of department \( i \), and it can be divided into intermediate input cost and initial input cost. In another word, Leontief model of the base period is as follows:

\[ P'_i = P'_i A + N'_i \hat{X}^{-1} \]  

Through conversion, Leontief model can measure the situation when production didn’t change and only the price changed leading to the output value getting changed. Assume that the input-output framework doesn’t change, and the quantity of production also doesn’t change, but the initial input cost changed (e.g. The workers want their salaries getting raised). Leontief model of the manufacturing period is changed into:

\[ P'_i = P'_i A + N'_i \hat{X}^{-1} \]  

At this time, the output of various departments in report period is as follows:

\[ P'X = P'A\hat{X} + N'_i \hat{X}^{-1} + A\hat{X} \]  

If the row vector of output value in report period is recorded as \( X' = P'\hat{X} \), and \( H = \hat{X}^{-1}A\hat{X} \), then

\[ X'_i = X'_i H + N'_i \]  

Because, \( A\hat{X} = Z \) so

\[ H = (h_j) = \hat{X}^{-1}Z \quad \text{or} \quad h_j = \frac{z_{ij}}{X_i} \]  

Here \( h_j \) is called output coefficient or distribution coefficient, meaning the proportion of the quantity sold to department \( j \) in the total output of department \( i \). Therefore, it shows the direct dependence of department \( i \) as a seller on department \( j \) as a buyer. Direct forward linkage of department \( i \) can be defined as:

\[ F_i = \sum_{j=1}^{n} h_{ij} \]  

This is the well-known Gaussian supply-driven input-output model. It describe the relationship between the initial input and the total output, its equivalent variation form is as follows:

\[ X' = N'(I - H)^{-1} \]  

\( G = (g_{ij}) = (I - H)^{-1} \), so \( G \) is called Gaussian inverse matrix.

Complete forward linkage can be expressed with the row sum of Gaussian inverse matrix \( G \). In another word, complete forward linkage of department \( i \) can be defined as:

\[ \overline{F}_i = \sum_{j=1}^{n} g_{ij} \]  

In order to form a contrast with Leontief row demand-driven model, \( \overline{F}_i \) is also known as input multiplier or supply multiplier.

2.2.2 Calculation for forward linkage measurement of urban rail transit industry

The relative value of weighted direct forward linkage and weighted complete backward linkage is as follows:

\[ \theta_j = \frac{F_i}{\sum_i F_i} = \frac{\sum_j h_{ij}}{\sum_i \alpha_i h_{ij}} \]
\[
\bar{\gamma} = \frac{\sum g_{ij}}{\sum \sum g_{ij}}
\]  
(13)

In the above formula, \( \alpha \) means the proportion of total output of department \( i \) in total output of urban economy, i.e. the total product mix coefficient; \( \gamma \) refers to the proportion of the initial input of department \( i \) in initial input of urban economy, i.e. the initial input mix coefficient \( \gamma = \frac{a_{ij}}{\sum a_{ij}} \).

2.3 The investment multiplier model

Under certain condition of marginal propensity to be consumed, when total investment is increased (or decreased), leading to \( K \) times increased (or reduced). Assumed the national income increment being \( \Delta Y \), the invest increment being \( \Delta I \), the consumption increment being \( \Delta C \), multiplier being \( K \), marginal propensity to consume being \( b = \Delta C/\Delta Y \), then:

\[
\Delta Y = \Delta I + \Delta C
\]  
(14)

\[
K = \frac{\Delta Y}{\Delta I} = \left( 1 - \frac{\Delta C}{\Delta Y} \right) = 1/(1-b)
\]  
(15)

Usually, marginal propensity \( b < 1 \), multiplier \( K < 1 \), the infinite series expansion is carried out:

\[
K = 1 + b + b^2 + b^3 + \cdots + b^n
\]  
(16)

Thus, when total investment \( \Delta I \) is increased , the total increased amount \( \Delta Y \) is as following:

\[
\Delta Y = K \Delta I = \Delta I + b \Delta I + b^2 \Delta I + \cdots + b^n \Delta I
\]  
(17)

Thus, investment benefit formula of urban rail transit is as following (18),

\[
B_r = K \times I
\]  
(18)

Where, \( B_r \) is multiplier contribution effect value of rail transportation investment to national economy, \( I \) is the invest value, \( K \) is the investment multiplier, this multiplier is the key parameter to calculate the investment multiplier effect.

3 Correlation analysis of China’s urban rail transit industry. Backward linkage analysis of China’s urban rail transit industry

Backward linkage measurement and complete backward linkage measurement of China’s urban rail transit industry are worked out by utilizing direct consumption coefficients and complete consumption coefficients in input-output tables for China’s urban rail transit of subdivided sectors in 2007 and 2012, and applying industrial linkage theory in input-output analysis. See from Table 1 to Table 4 for the specific results.

Backward linkage measurement considering equal weight reflects the dependence degree of urban rail transit industry as a buyer on intermediate input of other industry sectors; complete backward linkage measurement considering equal weight reflects how the change of ultimate demand influences the total output of China’s industry sectors. According to backward linkage measurement and complete backward linkage measurement results in 2007 (Table 1 and Table 2) and 2012 (Table 3 and Table 4), some upstream industries closely related to urban rail transit industry can be obtained, such as Metal product industry, Metal processing machinery manufacturing industry, Instrument industry. Other electric apparatus and equipment manufacturing industry, Steel rolling industry, Automobile industry, Auto parts and accessories manufacturing industry, Petroleum and nuclear fuel processing industry, Other flexible unit manufacturing industry, Communication device manufacturing industry.

Forward linkage measurement considering equal weight reflects the dependence degree of urban rail transit industry as a buyer on intermediate input of other industry sectors; complete backward linkage measurement considering equal weight reflects how the change of ultimate demand influences the total output of China’s industry sectors. According to backward linkage measurement and complete backward linkage measurement results in 2007 (Table 5 and Table 6) and 2012 (Table 7 and Table 8), some downstream industries closely related to urban rail transit industry can be obtained, such as Catering industry, Commercial service industry, Petroleum and natural gas exploration industries, Papermaking and paper product manufacturing industry, Animal husbandry, Professional Technical Services, Road transport, Telecommunications and other information transmission services.

4 Conclusion

Based on the input-output tables for urban rail transit of subdivided sectors in 2007 and 2012, this paper studies backward linkage and forward linkage industries of urban rail transit industry. Some upstream industries closely related to urban rail transit industry can be obtained, such as Metal product industry, Metal processing machinery manufacturing industry, Instrument industry. Other electric apparatus and equipment manufacturing industry, Steel rolling industry, Automobile industry, Auto parts and accessories manufacturing industry, Petroleum and nuclear fuel processing industry, Other flexible unit manufacturing industry, Communication device manufacturing industry. Some downstream industries closely related to urban rail transit industry can be obtained, such as Catering industry, Commercial service industry, Petroleum and natural gas exploration industries, Papermaking and paper product manufacturing industry, Animal husbandry, Professional Technical Services, Road transport, Telecommunications and other information transmission services.
Table 1  Backward linkage measurement of China’s urban rail transit (2007)

| Industry sector                                      | Backward linkage measurement |
|------------------------------------------------------|------------------------------|
| Steel rolling industry                               | 1.4297                       |
| Iron making industry                                 | 1.3835                       |
| Feed processing industry                             | 1.3718                       |
| Rubber product industry                              | 1.3646                       |
| Electronic component manufacturing industry           | 1.3641                       |
| Ramie textile, silk textile and finishing industry    | 1.3473                       |
| Other electric apparatus and equipment manufacturing industry | 1.3419                       |
| Wire, cable, optical cable and electrical equipment manufacturing industry | 1.3330                       |
| Cotton, chemical fiber textile and printing & dyeing industry | 1.3187                       |
| Wool manufacturing and dyeing & finishing industry    | 1.3175                       |
| Petroleum and nuclear fuel processing industry        | 1.3172                       |
| Knitwear, knitting and relevant product manufacturing industry | 1.3170                       |
| Automobile industry                                  | 1.3075                       |
| Non-ferrous metal rolling industry                   | 1.3047                       |
| Other food manufacturing industry                    | 1.2104                       |
| Other food processing industry                        | 1.2081                       |
| Tobacco industry                                     | 1.2048                       |
| Grain grinding industry                              | 1.1985                       |
| Daily chemical product manufacturing industry         | 1.1949                       |
| Vegetable oil processing industry                    | 1.1926                       |
| Other nonmetal mineral product manufacturing industry | 1.1893                       |
| Boiler and prime motor manufacturing industry         | 1.1862                       |
| Ceramic product manufacturing industry                | 1.1831                       |
| Instrument industry                                  | 1.1829                       |
| Metal processing machinery manufacturing industry     | 1.1825                       |
| Other dedicated device manufacturing industry         | 1.1803                       |
| Textile clothing, shoes and hat manufacturing industry | 1.1800                       |
| Papermaking and paper product manufacturing industry  | 1.1776                       |
| Press and publishing industry                        | 1.1730                       |
| Special chemical product manufacturing industry       | 1.1570                       |
| Ship and floating device manufacturing industry       | 1.1468                       |
| Catering industry                                    | 1.1453                       |
| Chemical fiber manufacturing industry                 | 1.1401                       |
| Alcohol and wine manufacturing                       | 1.1374                       |
| Special machinery manufacturing industry for agriculture, forestry, animal husbandry and fishery | 1.1339                       |
| Accommodation industry                               | 1.1221                       |
| gas production and supply industry                   | 1.1108                       |
| Glass and glass product manufacturing industry        | 1.0978                       |
| Railway transport equipment manufacturing industry    | 1.0859                       |
| Commercial service industry                          | 1.0725                       |
| Sugar industry                                        | 1.0395                       |
| Coking industry                                       | 1.0303                       |
| Warehousing industry                                 | 1.0154                       |
| Fertilizer manufacturing industry                    | 1.0228                       |
| Other electric apparatus and equipment manufacturing industry | 1.2166                       |
### Table 2 Complete backward linkage measurement of China’s urban rail transit (2007)

| Industry sector                                                                 | Complete backward linkage measurement |
|---------------------------------------------------------------------------------|---------------------------------------|
| Home audio and video equipment manufacturing industry                            | 1.3808                                |
| Rubber product industry                                                          | 1.3760                                |
| Steel rolling industry                                                            | 1.3428                                |
| Wire, cable, optical cable and electrical equipment manufacturing industry        | 1.3316                                |
| Automobile industry                                                              | 1.3308                                |
| Electronic component manufacturing industry                                       | 1.3254                                |
| Wool manufacturing and dyeing & finishing industry                                | 1.3179                                |
| Other electric apparatus and equipment manufacturing industry                     | 1.3089                                |
| Leather, fur, feather (down feather) and product industry                        | 1.3071                                |
| Plastic product industry                                                         | 1.3058                                |
| Electronic computer manufacturing industry                                        | 1.3058                                |
| Knitwear, knitting and relevant product manufacturing industry                   | 1.2923                                |
| Communication device manufacturing industry                                       | 1.2872                                |
| Synthetic material manufacturing industry                                        | 1.2657                                |
| Machine building industry for culture and office                                  | 1.2514                                |
| Cultural, educational and sporting goods manufacturing industry                   | 1.2429                                |
| Made-up textile product industry                                                  | 1.2346                                |
| Instrument industry                                                              | 1.2275                                |
| Other transportation equipment manufacturing industry                             | 1.2223                                |
| Cotton, chemical fiber textile and printing & dyeing industry                    | 1.2180                                |
| Textile clothing, shoes and hat manufacturing industry                           | 1.2065                                |
| Ramie textile, silk textile and finishing industry                                | 1.1971                                |
| Pesticide industry                                                               | 1.1892                                |
| Metal processing machinery manufacturing industry                                 | 1.1813                                |
| Iron making industry                                                             | 1.1774                                |
| Cement, lime and gypsum manufacturing industry                                    | 1.1703                                |
| Paints, inks, paints and similar products manufacturing industry                 | 1.1665                                |
| Other dedicated device manufacturing industry                                     | 1.1625                                |
| Non-ferrous metal rolling industry                                               | 1.1622                                |
| Insurance industry                                                               | 1.1622                                |
| Metal product industry                                                           | 1.1620                                |
| Fertilizer manufacturing industry                                                | 1.1581                                |
| Basic chemical raw material manufacturing industry                                | 1.1385                                |
| Papermaking and paper product manufacturing industry                              | 1.1281                                |
| Ship and floating device manufacturing industry                                   | 1.1272                                |
| Ceramic product manufacturing industry                                            | 1.1190                                |
| Chemical fiber manufacturing industry                                            | 1.1157                                |
| Other drinks manufacturing industry                                              | 1.1142                                |
| Daily chemical product manufacturing industry                                     | 1.1095                                |
| Press and publishing industry                                                    | 1.1077                                |
| Other nonmetal mineral product manufacturing industry                             | 1.1054                                |
| Railway transport equipment manufacturing industry                                | 1.0907                                |
| Boiler and prime motor manufacturing industry                                     | 1.0899                                |
| Other food manufacturing industry                                                 | 1.0770                                |
| Glass and glass product manufacturing industry                                    | 1.0693                                |
| Special machinery manufacturing industry for agriculture, forestry, animal husbandry and fishery | 1.0669                                |
| Accommodation industry                                                           | 1.0579                                |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.0468                                |
| Alcohol and wine manufacturing                                                   | 1.0452                                |
| Feed processing industry                                                         | 1.0356                                |
| Special chemical product manufacturing industry                                   | 1.0258                                |
| Electricity, heat production and supply industry                                  | 1.0206                                |
| Tobacco industry                                                                 | 1.0176                                |
| Warehousing industry                                                             | 1.0145                                |
| Other flexible unit manufacturing industry                                        | 1.0065                                |
| Gas production and supply industry                                                | 1.0056                                |
| Commercial service industry                                                      | 1.0056                                |
| Industry sector                                                                 | Backward linkage measurement |
|--------------------------------------------------------------------------------|-------------------------------|
| Chemical fiber manufacturing industry                                         | 1.3088                        |
| Petroleum and nuclear fuel processing industry                                 | 1.3072                        |
| Grain grinding industry                                                        | 1.2904                        |
| Wire, cable, optical cable and electrical equipment manufacturing industry     | 1.2851                        |
| Paints, inks, paints and similar products manufacturing industry               | 1.2813                        |
| Non-ferrous metal rolling industry                                             | 1.2754                        |
| Steel rolling industry                                                         | 1.2675                        |
| Other electric apparatus and equipment manufacturing industry                  | 1.2648                        |
| Basic chemical raw material manufacturing industry                             | 1.2631                        |
| Home appliance manufacturing industry                                          | 1.2571                        |
| Synthetic material manufacturing industry                                      | 1.2549                        |
| Feed processing industry                                                       | 1.2540                        |
| Vegetable oil processing industry                                              | 1.2520                        |
| Vegetables, fruits, nuts and other agricultural food processing industry       | 1.2482                        |
| Aquatic product processing industry                                           | 1.2476                        |
| Slaughter and meat processing industry                                         | 1.2469                        |
| Machine building industry for culture and office                               | 1.2426                        |
| Cotton, chemical fiber textile and printing & dyeing industry                  | 1.2404                        |
| Special chemical product manufacturing industry                               | 1.1794                        |
| Plastic product industry                                                       | 1.2232                        |
| Electric manufacturing industry                                               | 1.2192                        |
| Knitwear, knitting and relevant product manufacturing industry                | 1.2181                        |
| Metal product industry                                                         | 1.2166                        |
| Iron alloy smelting industry                                                   | 1.2132                        |
| Pesticide industry                                                             | 1.2130                        |
| Rubber product industry                                                        | 1.2117                        |
| Electronic component manufacturing industry                                    | 1.2078                        |
| Fertilizer manufacturing industry                                             | 1.2040                        |
| Other dedicated device manufacturing industry                                  | 1.1836                        |
| Papermaking and paper product manufacturing industry                           | 1.1831                        |
| Other transportation equipment manufacturing industry                          | 1.1792                        |
| gas production and supply industry                                            | 1.1743                        |
| Other food production                                                          | 1.1723                        |
| Communication device manufacturing industry                                    | 1.1673                        |
| Boiler and prime motor manufacturing industry                                  | 1.1595                        |
| Other flexible unit manufacturing industry                                     | 1.1556                        |
| Instrument industry                                                            | 1.1480                        |
| Metal processing machinery manufacturing industry                              | 1.1443                        |
| Ceramic product manufacturing industry                                         | 1.1409                        |
| Made-up textile product industry                                               | 1.1362                        |
| Warehousing industry                                                           | 1.1329                        |
| Glass and glass product manufacturing industry                                 | 1.1293                        |
| Furniture manufacturing industry                                               | 1.1245                        |
| Daily chemical product manufacturing industry                                  | 1.1229                        |
| Cement, lime and gypsum manufacturing industry                                 | 1.0964                        |
| Leather, fur, feather (down feather) and product industry                     | 1.0949                        |
| Ship and floating device manufacturing industry                                | 1.0773                        |
| Other nonmetal mineral product manufacturing industry                          | 1.0745                        |
| Sugar industry                                                                 | 1.0657                        |
| Other drinks manufacturing industry                                           | 1.0491                        |
| Coking industry                                                                | 1.0154                        |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.2025                        |
| Ramie textile, silk textile and finishing industry                            | 1.2007                        |
| Home audio and video equipment manufacturing industry                          | 1.1998                        |
| Automobile and parts and components manufacturing industry                     | 1.1906                        |
| Industry sector                                                                 | Complete backward linkage measurement |
|-------------------------------------------------------------------------------|----------------------------------------|
| Chemical fiber manufacturing industry                                       | 1.3138                                 |
| Wire, cable, optical cable and electrical equipment manufacturing industry   | 1.3017                                 |
| Machine building industry for culture and office                             | 1.2928                                 |
| Home appliance manufacturing industry                                        | 1.2886                                 |
| Other electric apparatus and equipment manufacturing industry                | 1.2771                                 |
| Home audio and video equipment manufacturing industry                        | 1.2759                                 |
| Electronic component manufacturing industry                                  | 1.2654                                 |
| Electric manufacturing industry                                             | 1.2573                                 |
| Plastic product industry                                                     | 1.2550                                 |
| Paints, inks, paints and similar products manufacturing industry             | 1.2509                                 |
| Knitwear, knitting and relevant product manufacturing industry               | 1.2439                                 |
| Non-ferrous metal rolling industry                                           | 1.2369                                 |
| Communication device manufacturing industry                                   | 1.2321                                 |
| Automobile and parts and components manufacturing industry                   | 1.2256                                 |
| Other transportation equipment manufacturing industry                        | 1.2183                                 |
| Other dedicated device manufacturing industry                                 | 1.2103                                 |
| Synthetic material manufacturing industry                                    | 1.2061                                 |
| Metal product industry                                                       | 1.2050                                 |
| Instrument industry                                                          | 1.1969                                 |
| Pesticide industry                                                           | 1.1963                                 |
| Rubber product industry                                                      | 1.1863                                 |
| Boiler and prime motor manufacturing industry                                 | 1.1841                                 |
| Chemical fiber manufacturing industry                                        | 1.3138                                 |
| Wire, cable, optical cable and electrical equipment manufacturing industry   | 1.3017                                 |
| Machine building industry for culture and office                             | 1.2928                                 |
| Home appliance manufacturing industry                                        | 1.2886                                 |
| Metal processing machinery manufacturing industry                             | 1.1763                                 |
| Cotton, chemical fiber textile and printing & dyeing industry                | 1.1716                                 |
| Steel rolling industry                                                       | 1.1619                                 |
| Fertilizer manufacturing industry                                            | 1.1582                                 |
| Basic chemical raw material manufacturing industry                           | 1.1562                                 |
| Ship and floating device manufacturing industry                               | 1.1414                                 |
| Furniture manufacturing industry                                             | 1.1248                                 |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.1121                         |
| Daily chemical product manufacturing industry                                | 1.0978                                 |
| Glass and glass product manufacturing industry                               | 1.0929                                 |
| Iron alloy smelting industry                                                 | 1.0903                                 |
| Papermaking and paper product manufacturing industry                         | 1.0898                                 |
| Ceramic product manufacturing industry                                       | 1.0764                                 |
| Ramie textile, silk textile and finishing industry                           | 1.0726                                 |
| Leather, fur, feather (down feather) and product industry                   | 1.0600                                 |
| Cement, lime and gypsum manufacturing industry                               | 1.0413                                 |
| Other food industry                                                          | 1.0330                                 |
| Slaughter and meat processing industry                                       | 1.0307                                 |
| Other nonmetal mineral product manufacturing industry                        | 1.0162                                 |
| Made-up textile product industry                                             | 1.1830                                 |
| Other flexible unit manufacturing industry                                   | 1.1823                                 |
| Special chemical product manufacturing industry                              | 1.1794                                 |
### Table 5: Forward linkage measurement of China’s urban rail transit (2007)

| Industry sector                                      | Forward linkage measurement |
|------------------------------------------------------|----------------------------|
| Agriculture                                          | 7.0144                     |
| Electricity, heat production and supply industry      | 6.6084                     |
| Electronic computer manufacturing industry            | 5.5695                     |
| Petroleum and nuclear fuel processing industry        | 4.8684                     |
| Electronic component manufacturing industry           | 4.5196                     |
| Steel rolling industry                               | 4.4783                     |
| Papermaking and paper product manufacturing industry  | 3.8560                     |
| Animal husbandry                                     | 3.8503                     |
| Commercial service industry                          | 3.7279                     |
| Road transport                                       | 3.7050                     |
| Plastic product industry                             | 3.3778                     |
| Special chemical product manufacturing industry       | 3.0181                     |
| Metal product industry                               | 2.8657                     |
| Cotton, chemical fiber textile and printing & dyeing industry | 2.8584               |
| Fisheries                                            | 2.7376                     |
| Basic chemical raw material manufacturing industry    | 2.6029                     |
| Catering industry                                    | 2.4530                     |
| Mining and Dressing of Ferrous Metals                | 2.1148                     |
| Leather, fur, feather (down feather) and product industry | 1.8498                   |
| Textile clothing, shoes and hat manufacturing industry | 1.8308                    |
| Chemical fiber manufacturing industry                 | 1.8256                     |
| Other food production                                | 1.6156                     |
| Telecommunications and other information transmission services industry | 1.5559                 |
| Accommodation industry                               | 1.4944                     |
| Automobile industry                                  | 1.4917                     |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.4774              |
| Cement, lime and gypsum manufacturing industry        | 1.4574                     |
| Instrument industry                                  | 1.4130                     |
| Rubber product industry                              | 1.2741                     |
| Non-ferrous metal rolling industry                    | 1.0644                     |
| Nonferrous Metals Mining and Dressing                | 1.0193                     |
| Banking                                              | 2.3390                     |
| Synthetic material manufacturing industry             | 2.2459                     |

### Table 6: Complete forward linkage measurement of China’s urban rail transit (2007)

| Industry sector                                      | Complete forward linkage measurement |
|------------------------------------------------------|--------------------------------------|
| Agriculture                                          | 6.7487                               |
| Electricity, heat production and supply industry      | 3.4602                               |
| Steel rolling industry                               | 3.4340                               |
| Electronic component manufacturing industry           | 3.1489                               |
| Basic chemical raw material manufacturing industry    | 3.1075                               |
| Petroleum and nuclear fuel processing industry        | 3.1040                               |
| Papermaking and paper product manufacturing industry  | 3.0418                               |
| Electronic computer manufacturing industry            | 2.8520                               |
| Road transport                                       | 2.7383                               |
| Plastic product industry                             | 2.6566                               |
| banking                                              | 2.5747                               |
| Special chemical product manufacturing industry       | 2.5509                               |
| Cotton, chemical fiber textile and printing & dyeing industry | 2.5374             |
| Synthetic material manufacturing industry            | 2.2602                               |
| Animal husbandry                                     | 2.1558                               |
| Commercial service industry                          | 1.9943                               |
| Petroleum and natural gas exploration industries      | 1.6609                               |
| Nonferrous Metals Mining and Dressing                | 1.5165                               |
| Catering industry                                    | 1.4401                               |
| Textile clothing, shoes and hat manufacturing industry | 1.4050                    |
| Mining and Dressing of Ferrous Metals                | 1.3736                               |
| Chemical fiber manufacturing industry                 | 1.3382                               |
| Instrument industry                                  | 1.2550                               |
| Automobile industry                                  | 1.2334                               |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.1774             |
| Rubber product industry                              | 1.1511                               |
| Other food manufacturing industry                     | 1.1488                               |
| Telecommunications and other information transmission services industry | 1.1020                 |
| Other nonmetal mineral product manufacturing industry | 1.0541                    |
| Non-ferrous metal rolling industry                    | 1.0329                               |
| Accommodation industry                               | 1.0248                               |
| Fisheries                                            | 1.8017                               |
| Metal product industry                               | 1.7163                               |
### Table 7 Forward linkage measurement of China’s urban rail transit (2012)

| Industry sector | Forward linkage measurement |
|-----------------|----------------------------|
| Agriculture     | 6.9279                     |
| Electronic component manufacturing industry | 5.3441 |
| Steel rolling industry | 4.0220 |
| Basic chemical raw material manufacturing industry | 3.4636 |
| Road transport  | 3.2882                     |
| Metal product industry | 3.1940 |
| Cotton, chemical fiber textile and printing & dyeing industry | 3.0698 |
| Animal husbandry | 2.8799                     |
| Plastic product industry | 2.7821 |
| Commercial service industry | 2.6904 |
| Special chemical product manufacturing industry | 2.5584 |
| Other flexible unit manufacturing industry | 2.4605 |
| Non-ferrous metal rolling industry | 2.3865 |
| Synthetic material manufacturing industry | 2.2614 |
| Papermaking and paper product manufacturing industry | 2.2274 |
| Petroleum and natural gas exploration industries | 2.0203 |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.7422 |
| Automobile and parts and components manufacturing industry | 1.5866 |
| Grain grinding industry | 1.4183 |
| Chemical fiber manufacturing industry | 1.3841 |
| Mining and Dressing of Ferrous Metals | 1.3230 |
| Vegetable oil processing industry | 1.2227 |
| Fisheries       | 1.2036                     |
| Catering industry | 1.0951                     |
| Professional Technical Services | 1.0728 |
| Telecommunications and other information transmission services industry | 1.0644 |
| Rubber product industry | 1.0061 |

### Table 8 Complete forward linkage measurement of China’s urban rail transit (2012)

| Industry sector | Complete forward linkage measurement |
|-----------------|---------------------------------------|
| Agriculture     | 4.3573                                |
| Electronic component manufacturing industry | 3.7752 |
| Basic chemical raw material manufacturing industry | 3.7398 |
| Petroleum and natural gas exploration industries | 3.6126 |
| Steel rolling industry | 2.8963 |
| Special chemical product manufacturing industry | 2.3203 |
| Road transport  | 2.2511                                 |
| Metal product industry | 2.2140 |
| Synthetic material manufacturing industry | 2.1962 |
| Plastic product industry | 2.1044 |
| Agriculture     | 4.3573                                |
| Electronic component manufacturing industry | 3.7752 |
| Non-ferrous metal rolling industry | 1.9435 |
| Commercial service industry | 1.8068 |
| Other flexible unit manufacturing industry | 1.7706 |
| Mining and Dressing of Ferrous Metals | 1.6649 |
| Papermaking and paper product manufacturing industry | 1.6564 |
| Animal husbandry | 1.6026                     |
| Automobile and parts and components manufacturing industry | 1.4930 |
| Wood processing and wooden, bamboo, rattan, palm and straw-made article industry | 1.3105 |
| Nonferrous Metals Mining and Dressing | 1.2499 |
| Chemical fiber manufacturing industry | 1.1678 |
| Fertilizer manufacturing industry | 1.0386 |
| Non-ferrous metal rolling industry | 1.9435 |
| Commercial service industry | 1.8068 |

### References
Bao, Y. P. (2005). Analysis on Technical Economic Ties among China’s Industries. *Co-operative Economy & Science*. 7, pp. 56-57.

Li, N. (2007). Analysis of economic benefit of urban rail transit. Beijing Jiaotong University, China.

Li, X. M. (2007). Industrial relevance theory and Application Research of urban rail transit in Beijing. Beijing Jiaotong University, China.

Seung, C. K., Waters, E. C. (2006). The role of the Alaska seafood industry: a social accounting matrix (SAM) model approach to economic base analysis. *The Annals of Regional Science*. 40(2), pp. 335-350. [https://doi.org/10.1007/s00168-005-0048-0](https://doi.org/10.1007/s00168-005-0048-0)

Thorbecke, E., Jung, H-S. (1996). A multiplier decomposition method to analyze poverty alleviation. *Journal of Development Economics*. 48(2), pp. 279-300. [https://doi.org/10.1016/0304-3878(95)00037-2](https://doi.org/10.1016/0304-3878(95)00037-2)

Wei, Y., Feng, A. J., Ding, D. Y., Wang, Y. H. (2013). Study on the urban rail transit industry chain and its development direction in China. *Urban Rail Transit*, 26. pp. 58-61.

Yang, C. (2005). A Study on Industry Association Measure Method and Relevant Problems. *Statistical Research*. 9, pp. 72-75.