Extended Input-Output Model for Demographic Change

– Preliminary Application to the Chinese Urbanisation*

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Abstract

China carries out "Urbanisation" as an economic policy which intends to concentrate people in the urban area and boost the whole economic growth on the basis of "Economy of Agglomeration" struggling with the pressure of "middle-income trap" or "new normal." The research question here is about how the labour migration from rural areas to urban areas has an economic and industrial impact on the Chinese economy, and whether or not the geographical change between space is truly beneficial for Chinese economic growth in the near future. To answer these question, this research develops the extend input-output model based on the previous research such as Batey (2018) and their other research, which focus on incorporating labour account with Input-Output model. In this original model, the Input-Output model has been developed into the economic model with a household which takes account of immigrants from other regions, people who are out of work, and ordinary labour force. This study develops this extended Input-Output model for demographic change, in particular, change of population movements from villages to cities in China since the urbanisation process is seen as the continuous concentration of people in the certain areas, especially, cities. The study will illustrate the preliminary results in the case of China by using this model. Furthermore, the paper will discuss the possibilities of a wide range of application of the Input-Output table in terms of demography.

JEL Classification: C67, J11, O18, R58

Keywords: demography, urbanisation, migration, input-output analysis

1. Introduction

For the sustainable economic development of any region, its demography is important. China, which is large populous country, has recently proceeded the urbanisation

* This work was supported by JSPS KAKENHI Grant Number JP15K06261 and JP16K02002. This is the preliminary version of the paper which will be presented in IIOA conference in June 2019.
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and townisation [1] as an economic policy since in order to overcome the so-called 'middle-income gap', increasing the productivity of cities, which is considered the decisive engine of the economic growth, by concentrating the people in cities. The swelling population in urban areas might have an important effect on the regional economy. However, the previous researches have not clarified the interrelational process between migration and economy such as how the migrants in cities affect the economy.

This study aims to make clear the above-mentioned interrelation by using the input-output model, which focus on the interdependency of economic factors. The conventional input-output analysis has focused on the changes in output brought about by industrial activities; households have been incorporated into the model wherein they are treated as an industry within the framework. Batey and his co-researchers, mainly Madden, have positively contributed to the field of the extended input-output model involving population, especially labour accounts (Batey and Madden 1981; Batey 1985; Batey and Weeks 1987; Batey, Madden, and Weeks 1987; Batey and Madden 1988; Batey and Weeks 1989; Batey and Madden 1999a, 1999b). The development and potential of this model was discussed by Batey and Rose (1990); more recently, the model has been reviewed in the context of declining regional economies (Batey 2018).

The paper consists of the following parts. First, it starts with a description of extended models of households to its derivative model of demography—which Batey and others focused on in their literature. Second, we developed the input-output model for urbanisation, applying the 'Batey–Madden model', and further discussion on its multipliers. Then, the empirical analysis of the Chinese urbanisation process is conducted. Finally, it reflects on the results and conclusions.

2. Extended Model for Households and Demography

2.1 The basic model for household

Based on a simple and very typical input-output model, the important final demand promotes an increase in the output of each sector via input-output relations among sectors. Thus, the final demand sectors such as household consumption, government investment, and shipment in foreign trade are considered as an exogenous sector. However, households, governments, and foreign economic entities are composed of important elements of domestic economic activity within the real world. In particular, categorising households as the exogenous sector places a strain on the basic economic theory.

Households can earn income from the payment for their labour input to production processes; moreover, as consumers, they spend their income in well-patterned ways. In particular, a change in the amount of labour requirement for production in one or more

[1] In China, the term of 'urbanisation' includes the concentration of people in cities in urban area and towns in rural area. The latter is usually refered as 'townisation'.

sectors can lead to changes in the amount of spending by households as a group for consumption.

For input-output analysis, we have attempted to incorporate households in the model. The basic model is shown as follows:

$$x = Zi + f$$
$$x = Ax + f$$
$$(I - A)x = f$$

This model indicates that interindustrial production activities lead to an unknown valuable of total output due to constraints on the final demand amount.

To move the household sector from the final demand items and value-added items to the above model as an endogenous sector and making it one of the endogenous sectors leads to the closure of the model for households (Miller and Blair 2009, pp.34-41). The same model in the form of a matrix is as follows,

$$\begin{bmatrix} x \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} A & h_C \\ h_r & h \end{bmatrix} \begin{bmatrix} x \\ x_{n+1} \end{bmatrix} + \begin{bmatrix} f^* \\ f^*_{n+1} \end{bmatrix}$$

Then,

$$\begin{bmatrix} I - A & -h_C \\ -h_r & 1 - h \end{bmatrix} \begin{bmatrix} x \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} f^* \\ f^*_{n+1} \end{bmatrix} \quad (1)$$

Here,

x_{n+1}: the total income of the labour sector or the total value of its sale of labour services to the various sectors

h_C: the consumption coefficients of households

h_r: the row vector of labour input coefficients is obtained from the division of labour income by gross input

h: the coefficient of labour input coefficient for household is usually zero for the ordinary input-output table

f^*: the final demand for industrial sectors after excluding consumption by households

f^*_{n+1}: the exogenous income such as payments to government employees (Miller and Blair 2009, p.36) or income received by inhabitants from outside region; however, it is usually zero for ordinary input-output tables

Using these variables, we can derive two equations from the matrix formulae of the closing model in Equation (1).

$$(I - A)x - h_c x_{n+1} = f^* \quad (2)$$
$$-h_r x + (1 - h)x_{n+1} = f^*_{n+1} \quad (3)$$

Equation (2) shows the ordinary input-output model for households. For simplicity, we set $h = 0$, $f^*_{n+1} = 0$; then, Equation (3) could be written as follows:

$$x_{n+1} = h_r x \quad (4)$$

This indicates that total income for the household sector, n+1, is generated from wages

earned from industrial activities. We then substitute (4) for (2) as follows:

$$(I - A)x - h_c h_r x = f^* \tag{5}$$

Then

$$x = (I - A - h_c h_r)^{-1} f^* \tag{6}$$

Miyazawa (1976) studied endogenising households in an input-output model, which were generated using various important multiplier matrixes. Based on Miyazawa, assuming $h = 0,$ the two system equations in (1) are as follows:

$$\begin{bmatrix} x \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} I - A & -h_C \\ -h_r & 1 \end{bmatrix}^{-1} \begin{bmatrix} f^* \\ 0 \end{bmatrix} \tag{7}$$

Based on the results of inverses of partitioned matrixes, we can derive elements of the partitioned inverse as follows:

$$\begin{bmatrix} x \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} B[I + h_c(I - h_r B h_c)^{-1} h_r B] & B h_c (I - h_r B h_c)^{-1} \\ (I - h_r B h_c)^{-1} h_r B & (I - h_r B h_c)^{-1} \end{bmatrix} \begin{bmatrix} f^* \\ 0 \end{bmatrix} \tag{8}$$

where $B = (I - A)^{-1}$ and $K = (I - h_r B h_c)^{-1}$

Then, this equation can be simplified as follows:

$$\begin{bmatrix} x \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} B[I + h_c K h_r B] & B h_c K \\ K h_r B & K \end{bmatrix} \begin{bmatrix} f^* \\ 0 \end{bmatrix} \tag{9}$$

Miyazawa defined $h_r B h_c$ as an 'inter-income-group coefficient' (here we assume only one income category) and K as the 'inter-relational income multiplier' matrix.

From the above equation,

$$x = B(I + h_c K h_r B) f^* \tag{10}$$

$$x_{n+1} = K h_r B f^* \tag{11}$$

Note that Equation (10) seems to be different from Equation (6). However, they are equal to each other; thus,

$$B(I + h_c K h_r B) = (I - A - h_c h_r)^{-1}$$

Equation エラー! 参照元が見つかりません。 is easier for interpreting the function of the multiplier, indicating that interindustrial activities stimulate consumption via increased wages, leading to increase in industrial output.

2.2 Model for demography

Batey et al. developed their model into the one measured as a number of people rather than for a monetary unit were able to capture changes in economic activities induced by changes in the number of labour or demographic changes.

Based on the above discussion, all variables in the models are measured using monetary units. Batey et al. proposed that the household activity variables should be converted to units of the population so that the model can be used to analyse demographic changes. By making a number of simple modifications to the above equations, we can

construct an extended input-output model for demography.

Using Equation (12), we can describe the model in its most rudimentary form (Batey and Weeks 1987; Batey 2018), which is the so-called Batey–Madden Model (Batey 2018).

$$\begin{bmatrix} I-A & -\dot{h}_c^e & -\dot{h}_c^u \\ -l & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_I \\ e \\ u \end{bmatrix} = \begin{bmatrix} d_I \\ 0 \\ p \end{bmatrix} \tag{12}$$

where

$\dot{h}_c^e$: a column vector of consumption coefficients, expressed as consumption per household, for employed workers

$\dot{h}_c^u$: a column vector of consumption coefficients, expressed as consumption per household, for unemployed workers

l: a row vector of employment-production (employment/gross output ratios) functions by industrial sector

e: a scalar, the number of employed workers

u: a scalar, the number of unemployed workers

p: a scalar, the level of labour supply

The model consists of three blocks of simultaneous equations. The first block of equations establishes that the gross output is equal to the sum of intermediate and final demand:

$$(I-A)x_I - \dot{h}_c^e e - \dot{h}_c^u u = d_I \tag{13}$$

It is worth mentioning that the rest of the equation expresses the demographic change. The second block of equations indicates that the number representing employment is equal to the induced labour demand by total production:

$$-lx_I + e = 0 \tag{14}$$

Then;

$$e = lx_I \tag{15}$$

The third block of equations shows that the labour supply consists of the number of employed and unemployed:

$$e + u = p \tag{16}$$

Looking at the block equation structure of this model, it can be concluded that it is possible to partition the matrix coefficients, and the vectors of activity level and inputs, in order to separate the economic and demographic characteristics of the system, as shown in Table 1.

Table 1 System of an input-output model for demography

	Economic activities	Demographic activities
Economic inputs	$[I-A]$ Interindustry transaction	$\left[-\dot{h}_c^e - \dot{h}_c^u\right]$ Household consumption
Demographic inputs	$\begin{bmatrix} -l \\ 0 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$

	Household income	Household formation, generation of labour supply

3. Input-Output Model for Urbanisation

3.1 Model elaboration with urbanisation

The urbanisation is defined as the process of the movement from people in rural areas to urban areas. Farmers are mainly devoting themselves to agriculture production, migrate to cities to find better jobs and seek for their better life. City dwellers transformed from farmers become an important labour force in factories and offices, at the same time, they enjoy the modern consumption life.

Dividing households into one in cities and the other in villages, the input-output model for urbanisation is constructed as the application of rudimentary Batey-Madden Model in the equation (12).

$$\begin{bmatrix} I-A & -\dot{h}_c^u & -\dot{h}_c^r \\ -l & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_I \\ u \\ r \end{bmatrix} = \begin{bmatrix} d_I \\ 0 \\ p \end{bmatrix} \tag{17}$$

where

$\dot{h}_c^u$: a column vector of consumption coefficients, expressed as consumption per household, for urban residence

$\dot{h}_c^r$: a column vector of consumption coefficients, expressed as consumption per household, for rural residence

l: a row vector of urban employment-production (urban employment/gross output ratios) functions by industrial sector

u a scalar, the number of urban workers

r: a scalar, the number of rural workers

p: a scalar, the level of labour supply

The first equation of (17) is derived as follows:

$$(I-A)x_I - \dot{h}_c^u u - \dot{h}_c^r r = d_I \tag{18}$$

The equation (18) shows that the final demand consists of household consumption of both urban residence and rural residence and other final demand such as capital formation and net-export. The rest of the equation (17) indicate the demographic changes occurred in the process of urbanisation:

$$-lx_I + u = 0 \tag{19}$$

And also:

$$u + r = p \tag{20}$$

The equation (20) shows that the national labour supply is composed of urban workers and rural workers, and urban workers are induced by the urban employment opportunities defined as the following equation transformed from the equation (19):

$$u = lx_I \tag{21}$$

Thus, the demografic change can be expressed by substituting (21) into the equation (20). Then:

$$lx_I + r = p \tag{22}$$

As we can see, the equation (22) shows that the total labour supply in the country consists of the labour migration to cities from villages and the rest of the people left behind in rural areas.

3.2 Multiplier of the model

Let us again analyse equation (17), the so-called rudimentary form of the Batey-Madden model. If the matrix is partitioned with the economic and demographic activity, then it can be converted to a simple form of equation as follows:

$$\begin{bmatrix} I - A & -\dot{h}_c^u & -\dot{h}_c^r \\ -l & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} = \begin{bmatrix} I - A & -H_c \\ -H_l & D \end{bmatrix} \tag{23}$$

where $H_c = \begin{bmatrix} \dot{h}_c^u & \dot{h}_c^r \end{bmatrix}$, $H_l = \begin{bmatrix} l \\ 0 \end{bmatrix}$, $D = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$. In addition, $x_d = \begin{bmatrix} u \\ r \end{bmatrix}$ is defined as the number of urban and rural workers, $d_d = \begin{bmatrix} 0 \\ p \end{bmatrix}$ is the number of commuting workers from rural areas[2], which is assumed to be an imbalance and therefore set at zero, and the number of active economic population or labour supply of the country. The equation (27) can then be rewritten as:

$$\begin{bmatrix} I - A & -H_c \\ -H_l & D \end{bmatrix} \begin{bmatrix} x_I \\ x_d \end{bmatrix} = \begin{bmatrix} d_I \\ d_d \end{bmatrix} \tag{24}$$

Its inverse matrix, $\begin{bmatrix} I - A & -H_c \\ -H_l & D \end{bmatrix}^{-1}$, is defined as $\begin{bmatrix} L^{11} & L^{12} \\ L^{21} & L^{22} \end{bmatrix}$, and equation (24) is solved for the unknown variables, the total output of industry, and the number of urban and rural workers by using the above inverse matrix:

$$\begin{bmatrix} x_I \\ x_d \end{bmatrix} = \begin{bmatrix} L^{11} & L^{12} \\ L^{21} & L^{22} \end{bmatrix} \begin{bmatrix} d_I \\ d_d \end{bmatrix} \tag{25}$$

This impact model can be interpreted in the same way as the conventional household endogenous model in relation to the total output impacts on the whole economy. The first row of equation (25) is expressed as:

$$x_I = L^{11} d_I + L^{12} d_d \tag{26}$$

This equation represents that the total output is the sum of the output induced by the final demand $(L^{11} d_I)$ and the output generated or intensified by labour supply. This implies that

[2] The model assumes that there is no commuting workers from rural areas to urban areas for their job. It means that rural workers work only at villages as long as they live in the countrysides.

the output is impacted due to a rise in consumption as well as a growth in labour population.

The second row of equation (25) that is derived as follows requires to be explained more in detail:

$$x_d = L^{21}d_I + L^{22}d_d \tag{27}$$

The number that signifies urban and rural workers, x_d, can be obtained by summing the numbers induced by economic final demand, $L^{21}d_I$, and by demographic change, $L^{22}d_d$.

The analytical relationship embodied in equation (25) is explored by analysing each quadrant in detail. From equation (24), the following two equations can be obtained:

$$(I - A)x_I - H_c x_d = d_I \tag{28}$$

$$-H_l x_i + D x_d = d_d \tag{29}$$

From equation (28),

$$x_I = (I - A)^{-1}d_I + (I - A)^{-1}H_c x_d \tag{30}$$

Substituting (30) for (29),

$$x_d = [D - H_l(I - A)^{-1}H_c]^{-1}H_l(I - A)^{-1}d_I + [D - H_l(I - A)^{-1}H_c]^{-1}d_d \tag{31}$$

Substituting (31) for (28),

$$\begin{aligned} x_I = (I - A)^{-1}\{I + H_c[D - H_l(I - A)^{-1}H_c]^{-1}H_l(I - A)^{-1}\}d_I \\ +(I - A)^{-1}H_c[D - H_l(I - A)^{-1}H_c]^{-1}d_d \end{aligned} \tag{32}$$

This can be further simplified, where it was defined that $B = (I - A)^{-1}$, $L^{22} = [D - H_l B H_c]^{-1}$, so that:

$$\begin{bmatrix} x_I \\ x_d \end{bmatrix} = \begin{bmatrix} B(I + H_c L^{22} H_l B) & B H_c L^{22} \\ L^{22} H_l B & L^{22} \end{bmatrix} \begin{bmatrix} d_I \\ d_d \end{bmatrix} \tag{33}$$

Based on the comparison carried out using equation (8) and (9), a slight difference is observed between $K = (I - h_r B h_c)^{-1}$ in the model for households and $L^{22} = [D - H_l B H_c]^{-1}$ in the model for urabanisation. This implies that the situation of the labour market D determines the so-called 'interrelational income multiplier', K, matrix (by Miyazawa) [3]. However, $L^{22} = [D - H_l B H_c]^{-1}$ which plays important role in implementation of this model should be defined as 'urban and rural labour allocation multiplier', or more simply, 'urbanisation multiplier' as examined later on.

As presented in the above matrix algebra:

$$L^{22} = [D - H_l B H_c]^{-1} = \left\{ \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} - \begin{bmatrix} l \\ 0 \end{bmatrix} B [\dot{h}_c^u \quad \dot{h}_c^r] \right\}^{-1} \tag{34}$$

This expression can be further simplified as

$$L^{22} = \begin{bmatrix} 1 - lB\dot{h}_c^u & -lB\dot{h}_c^r \\ 1 & 1 \end{bmatrix}^{-1} \tag{35}$$

This yields

$$L^{22} = \begin{bmatrix} L_{11}^{22} & L_{12}^{22} \\ L_{21}^{22} & L_{22}^{22} \end{bmatrix} = k \begin{bmatrix} 1 & lB\dot{h}_c^r \\ -1 & 1 - lB\dot{h}_c^u \end{bmatrix} \tag{36}$$

[3] See the relation with Miyazawa's multiplier for Batey and Madden (1999a)

where $k = 1/\left(1 - lB\dot{h}_c^u + lB\dot{h}_c^r\right)$ and $lB\dot{h}_c^u$ and $lB\dot{h}_c^r$ are the direct and indirect effects on the consumption of an urban or rural worker, respectively. Each element of the submatrix L^{22} is expressed as follows:

$$L_{11}^{22} = \frac{1}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{37}$$

$$L_{12}^{22} = \frac{lB\dot{h}_c^r}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{38}$$

$$L_{21}^{22} = \frac{-1}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{39}$$

$$L_{22}^{22} = \frac{1 - lB\dot{h}_c^u}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{40}$$

The element L_{11}^{22} or equation (37) can be interpreted as a multisector urban employment multiplier, which is analogous to the Keynesian multiplier as mentioned in Batey (2018). This may indicate the effect on the urban's employment level of an exogenous unit with increase in urban employment, which denotes the unit increase in the number of workers outside the country (it is set to zero in this model). The equation (39) represents the mirror image of this effect on rural employment in the region. On the contrary, the two remaining elements L_{12}^{22} and L_{22}^{22} represent the effects on urban and rural workers, respectively, with respect to an increase in the size of labour supply or economic active population. Since an increase in the labour supply must either get converted to urban or rural population, they can be interpreted as probabilities because the sum of L_{12}^{22} and L_{22}^{22} is unity according to equations (38) and (40) based on Batey's interpretation. The probabilities include, in the former case, the probability of moving to cities for employment and, in the latter case, the probability of workers remained in rural areas, while considering that the other factors, particularly final demand, remain constant.

To summarise, the quadrant L^{22} of the complete multiplier denotes the impact on urban and rural employment based on the changes in labour supply or demographic factors. Hence, these multipliers called 'urban and rural employment multipliers'. This quadrant provides a basis for weighing the impacts due to changes in the elements of the spatial labour market between urban areas and rural areas. Therefore, our 'urbanisation multiplier' can be interpreted as in Table 2.

Table 2 Interpretation of urbanisation multiplier (L^{22})

	Urban household	Rural household
Urban employment	Urban employment multiplier	The probability of urban employment
Rural employment	Rural employment multiplier	The probability of rural employment

Let us move on to the first item of the equation (27). It is apparent that if the focus is on the impact caused by changes in the economic activity, represented by d_d, and the labour supply remains unchanged and is represented as zero, then the impact on urban employment can be estimated by economic final demand as follows:

$$x_d = L^{21} d_I \tag{41}$$

The L^{21} quadrant of the inverse matrix in equation (41) contains information about the direct, indirect, and induced effects, when a unit change is employed in final demand. This quadrant is expressed in a manner similar to L^{22};

$$L^{21} = \begin{bmatrix} L_{11}^{21} & L_{12}^{21} \\ L_{21}^{21} & L_{22}^{21} \end{bmatrix} = L^{22} H_l B = k \begin{bmatrix} 1 & lB\dot{h}_c^r \\ -1 & 1 - lB\dot{h}_c^u \end{bmatrix} \begin{bmatrix} l \\ 0 \end{bmatrix} B \tag{42}$$

Each element of the submatrix L^{21} is expressed as follows:

$$L_{11}^{21} = \frac{lB}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{43}$$

$$L_{21}^{21} = \frac{-lB}{1 - lB\dot{h}_c^u + lB\dot{h}_c^r} \tag{44}$$

Here, the other elements of the submatrix are zero; that is, $L_{12}^{21} = L_{22}^{21} = 0$. It is worth reporting that L_{11}^{21} and L_{21}^{21} are presented in vector form, unlike the elements of L^{22} that are presented in scalar form. In the most straightforward case, where only one type of urban worker is identified, the row vector L_{11}^{21} denotes urban employment effects, while the second element L_{21}^{21} indicates the rural employment effects. As highlighted in the case of employment and unemployment by Batey (2018), since an increase in urban employment is matched by a corresponding decrease in rural employment, the equation (44) merely repeats the elements of equation (43) with signs reversed. Therefore, equation (44) is a mirror image of equation (43), and equation (43) can be interpreted as the number of urban employment that has an impact effect on employment induced by a unit increase in final demand of the economy.

Finally, we go on to the second item of the equation (26) since the analogous interpretation in the equation (11?) can be applied to the first term of that equation (26). The equation (26) can be written as follows assuming that the industrial final demand equal to zero:

$$x_I = L^{12} d_d = B H_c L^{22} d_d$$

This implies that demographic change, d_d, has an impact on the increase of per capita consumption H_c through the reallocation of the urban and rural labour force in the country, L^{22}, then stimulating industrial output, x_I, by intermediate transaction activity, B.

In short, the inverse matrix of the extended model for urbanisation shown in the equation (33) can be summarised in table 3.

Table 3 Image of the inverse matrix of the extended input-output model for urbanisation

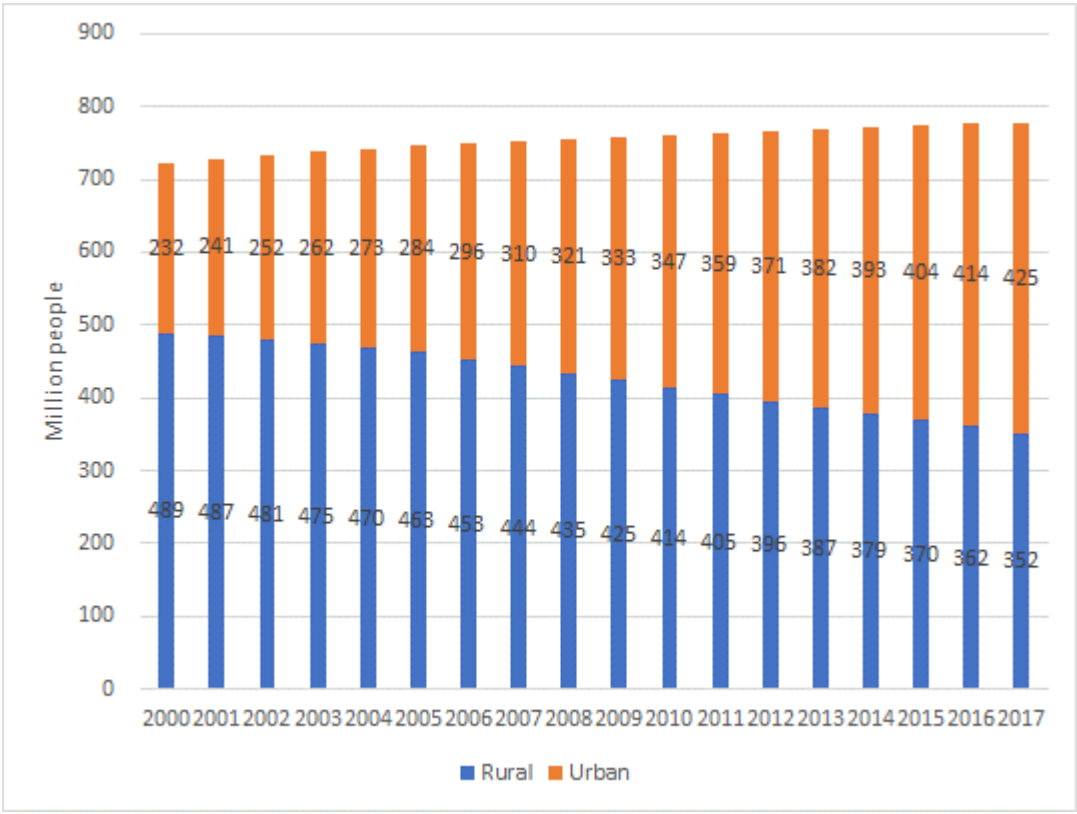
	Industry	Urban and rural household
Industry	$B(I + H_c L^{22} H_l B)$ Leontief inverse	$BH_c L^{22}$ Induced per capita consumption
Urban and rural employment	$L^{22} H_l B$ Induced urban employment and reduced rural employment	L^{22} urban and rural labour allocation multiplier, urbanisation multiplier

4. Empirical Result

4.1 Spatial labour account

We are going to test the model of how it works using the relevant data. First, the data used in our analysis is the 2015 input-output table for China, which is the latest but the updated table from the 2012 benchmark table, and data related to the labour account for the latest ten years, namely from 2008 through 2017. First, the overall labour accounts are shown in figure 1.

Figure 1 Economically Active Population in Rural and Urban areas



Source: China Statistical Yearbook

Figure 1 shows the labour force allocation of where they work (without the unemployment population). Total population is slightly on the increase, and the number of urban workers has been increasing significantly. The rural workers were smaller than the urban workers in 2015, meaning that the majority of the labour force exists in cities after that.

Figure 2 indicates the number of the employee by sector in cities; it also describes which sector has absorbed the population from rural areas. It clearly reveals that the tertiary sector plays an important role in employment in urban areas. On the contrary, the primary sector in the rural area is the main source of labour supply to urban industries in Figure 3.

Figure 2 Number of employment in urban areas

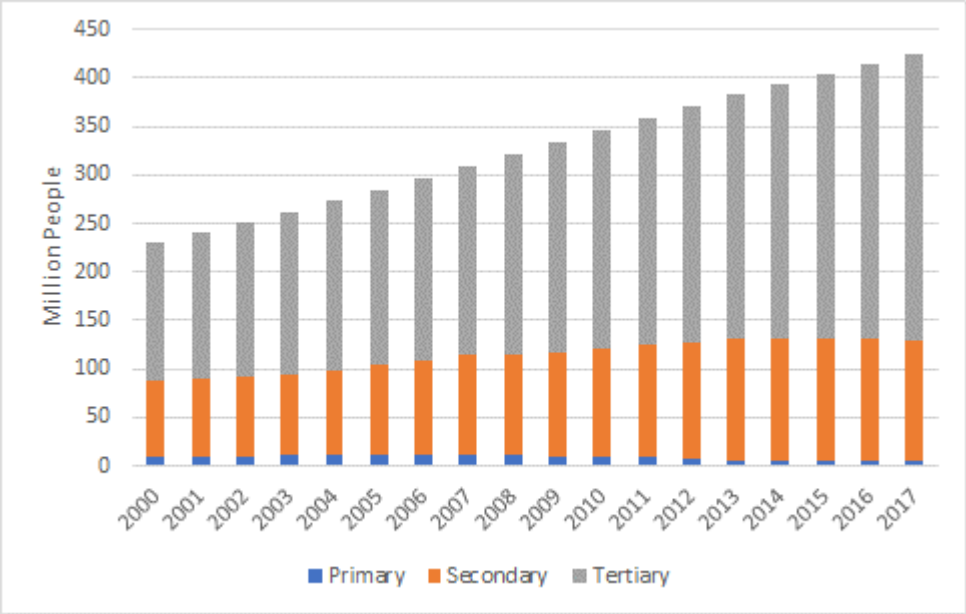
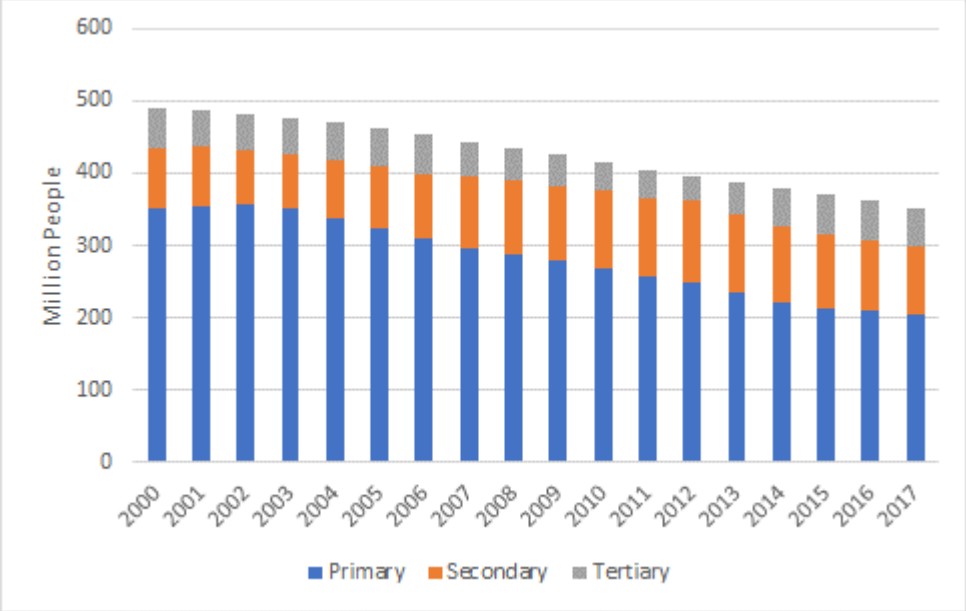


Figure 3 Number of employment in rural areas



Source: Estimated from China Statistical Yearbook

4.2 Urbanisation process in China

Now we investigate the result of the model implementation by using 2015 China input-output table[4] and labour account for 2015. Table 3 shows the outcome implemented by the model for urbanisation. Each part of the table corresponds with the inverse matrix shown in Table 3.

Table 4 Result of the model execution for 2015

	Primary	Secondary	Tertiary	Urban Houshold	Rural Household
Primary	1.215	0.208	0.106	6429	4275
Secondary	0.939	3.088	1.200	67089	31359
Tertiary	0.406	0.959	2.000	54662	22237
Total	2.560	4.255	3.307	128180	57871
Urban employment	3.18	6.87	8.94	1.280	0.119
Rural employment	-3.18	-6.87	-8.94	-1.280	0.881

Note: A unit of household consumption is yuan and employment in person.

First, since the households are incorporated into the model, each cell of the multiplier is larger than the conventional Leontief inverse, and the total of the column which is seen as the total backward linkage effect indicates 2.560 for primary, 4.255 for secondary, and 3.307 for tertiary industry respectively.

Next, the upper-right part of the table shows the output generated by a unit increase in consumption induced by demographic change. The increase in economically active population will induce the total output in the industry to meet their increased consumption. We can see the total induced effects which are the sum of the column, 128,180 yuan for urban areas and 57,871 yuan for rural areas. This shows that urban areas consumption raised by the increase in the number of the population play a crucial factor in the growth of industrial production.

Third, we find the employment induced by final demand in the lower-left of the table. This model considers only employment in urban areas assumed to be induced by the final demand of sectors. The number of employment in urban areas is increased, 3.18 people in primary, 6.87 people for secondary, and 8.94 people for the tertiary sector respectively. And also, the same number of people are decreased in rural areas. Thus, approximately 19 people are migrated from villages to cities by a unit increase in final demand.

[4] The data is provided as the format of so called import-competitive type. Each transaction includes imported goods and services. This elimination work will be done in future research.

Finally, the lower-right of the table illustrates the information about the demographic change, in particular, the process of urbanisation in China. That is defined here as 'urban and rural labour allocation multiplier', simply, 'urbanization multiplier.' Urban employment multiplier is 1.280 whereas the same amount of negative figure is the rural employment multiplier. From the viewpoint of rural households, their probability of taking a job in urban areas is 0.119 (11.9%), and the probability of remaining in rural areas is 0.881 (88.1%).

4.3 Effects by changes in labour account

In order to understand how the model works deeply, the changes in each element of the multiplier are investigated by the changes of labour accounts from 2008 to 2017 with remaining constant of input-output data for 2015. That is, we can see the changes in impacts on the whole economy and demography induced by the changes in labour allocation between urban and rural areas, assuming that the economic structure is unchanged.

Figure 4 Leontief multiplier (Backward linkage)

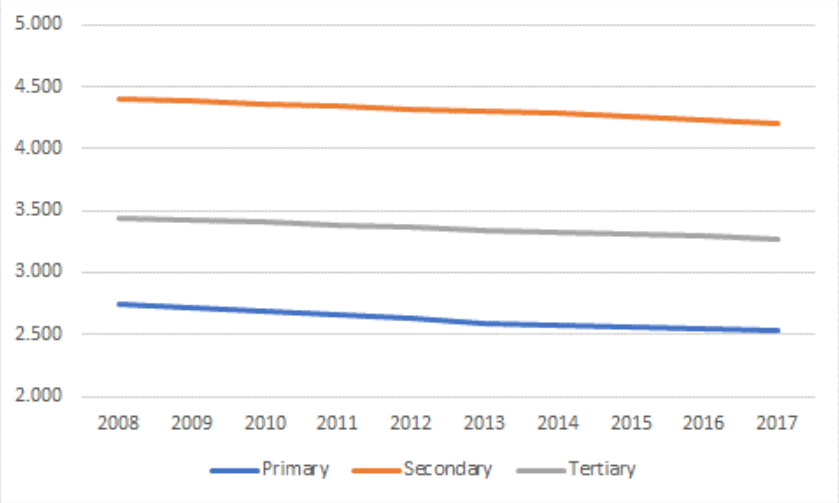
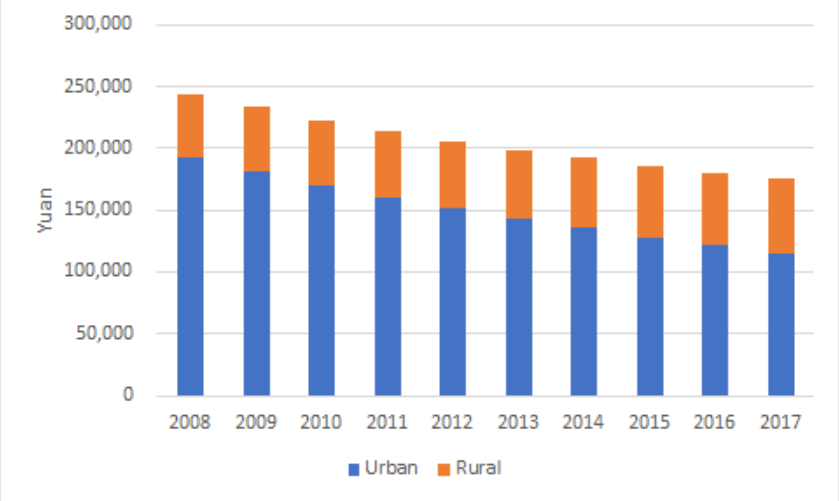


Figure 5 Output induced by consumption



The results are shown in Figure 4 and 7. As seen in Figure 1, 2 and 3, there was a tendency of labour migration from rural areas to urban areas with a slight increase in total labour supply in China from 2008 to 2017. Figure 4 indicates that with the constant of input-output structure, the Leontief multiplier or total sum of it called backward linkages is marginally decreasing even though the secondary sector has the strongest backward linkage among sectors. The movement of labour from the urban sector to rural sector might have a force to reduce the backward linkages in the whole country. Reflecting this change in backward linkages, the output induced by total household consumption is also decreasing, in particular, urban household, but the consumption of rural areas remain relatively stable (Figure 5). We still need further analysis of the reason why they are decreasing as the urban population increases. The result seems to be opposite to our intuition.

Figure 6 Induced urban employment

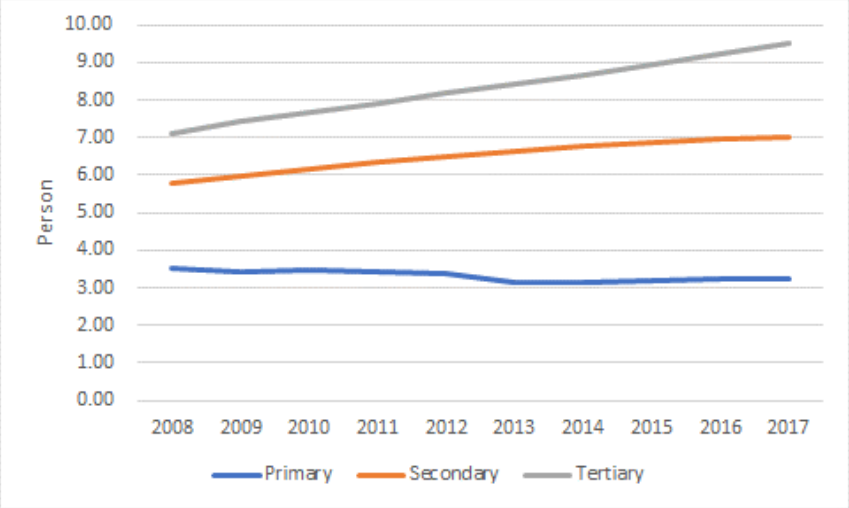


Figure 7 Urbanisation multiplier (urban and rural labour allocation multiplier)

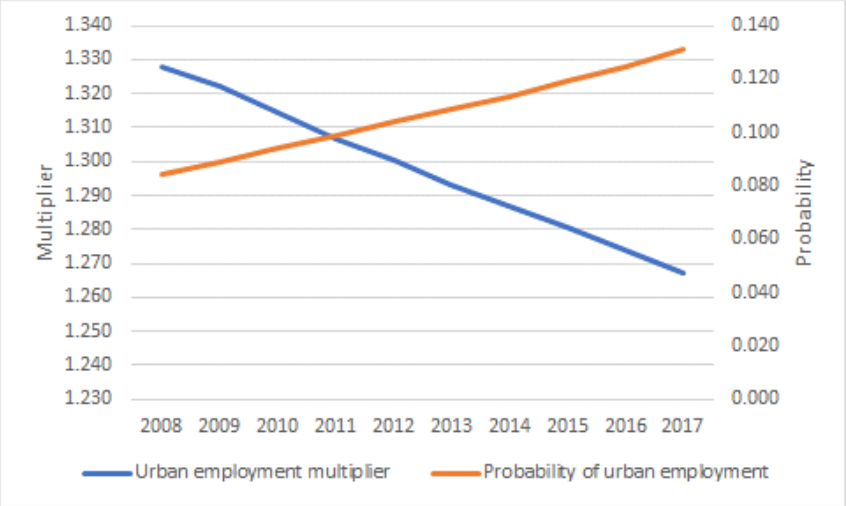


Figure 6 and 7 shows the changes in the lower side of the model inverse matrix,

specifically, urban employment (or movement to urban sectors) in Figure 6, and urbanisation multiplier in Figure 7. There is a constant increase in the number of people absorbed in the urban tertiary sector, whilst employment in primary sectors remain constant. Nevertheless, urban employment multiplier is declining whereas we can see an upward movement in the probability of urban employment.

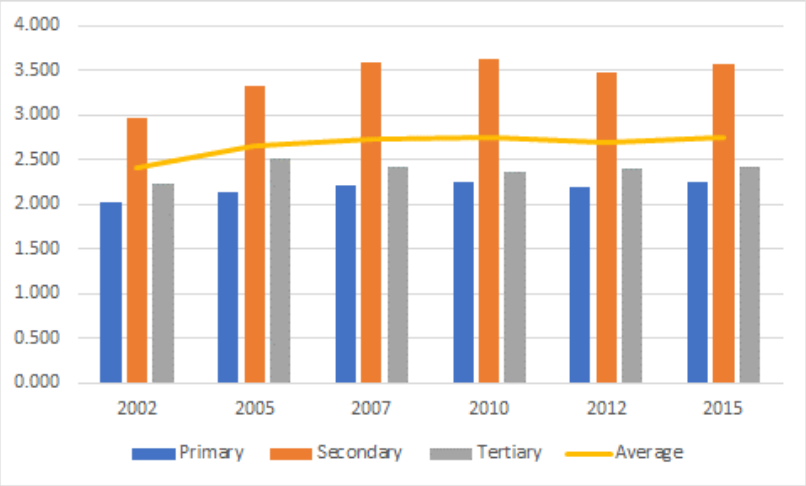
4.4 Effects by changes in economic structure

By contrast of above section, this section will offer another insight of our model with the labour account remained unchanged, but by changing the input-output tables. It reflects how the economic structure has an effect on changes in the parameter of our model.

China Input-Output tables are compiled by the survey based data every five years in year of 2 and 7, and updated tables are released in the year of 0 and 5. For example, 2002, 2007, 2012 data are survey based benchmark tables and 2005, 2010, and 2015 tables are updated from the relevant macro data.

First of all, conventional Leontief multipliers from the input-output data of 2002 to 2015, in consecutive six points of time are calculated in Figure 8. It shows an increase trend in the average of backward linkages by sector, except in 2012, and the manufacturing industry has the biggest multiplier throughout the observed period. The multiplier of service industry rises from 2002 to 2005, but it decreased under 2.0 and remained almost unchanged.

Figure 8 Conventional Leontief multiplier



Based on this fundamental change in input-output multiplier, we move on to the analysis of inverse matrix of our extended input-output model for urbanisation. Figure 9 and 10 indicate the Leontief multiplier including demographic change and induced output by consumption of urban and rural household. The multipliers of primary and secondary sector are rising from 2002 to 2010, dropping slightly in 2012, then went up to the highest level in 2015. On the contrary, tertiary sector shows the same trend as the conventional one which

remains almost the same level from 2005 to 2015 after increasing from 2002 to 2005. When it comes to the output induced by consumption brought about by the unit increase in labour supply, total output of both households is dramatically increasing from 26,474 yuan in 2003 to 186,051 in 2015.

Figure 9 Leontief multiplier (Backward linkage)

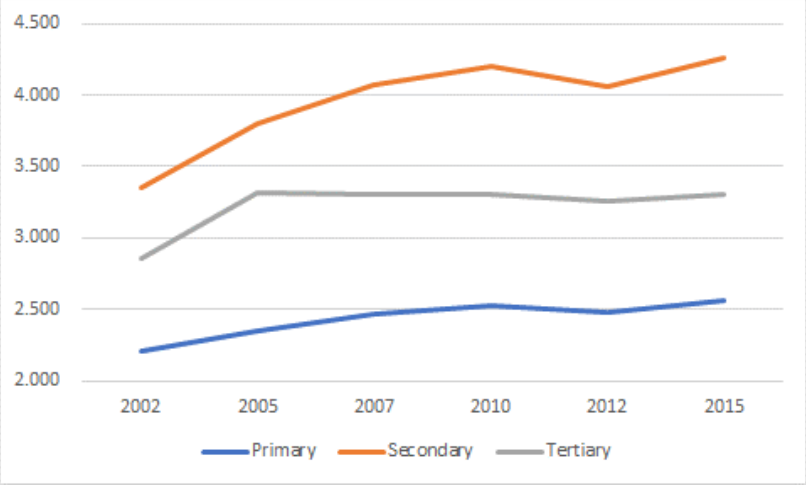
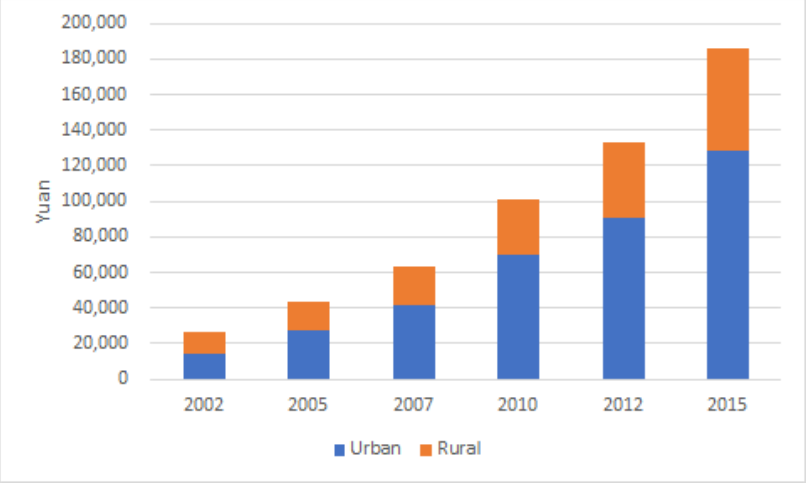


Figure 10 Output induced by consumption



With the increase of total labour supply and migration from villages to cities and through the period, job opportunities in urban areas are on declining as shown in Figure 11. That seems to be against our intuition, but the employment coefficient are obtained by the number of employment divided by total input in monetary unit, which are getting smaller in the earlier period, resulting in the relative larger figures in employment. As a result, fewer and fewer people are hired in each sector in cities.

Figure 12 illustrate the process of urbanisation in China, which shows urban employment multiplier and allocation of labour source to both urban and rural areas. There is a rise in the urban employment multiplier except 2012 as the conventional multiplier

experienced the same changes. On the contrary, the probability of urban labour allocation decreased from 2002 to 2010, and went up until 2015.

Figure 11 Induced urban employment

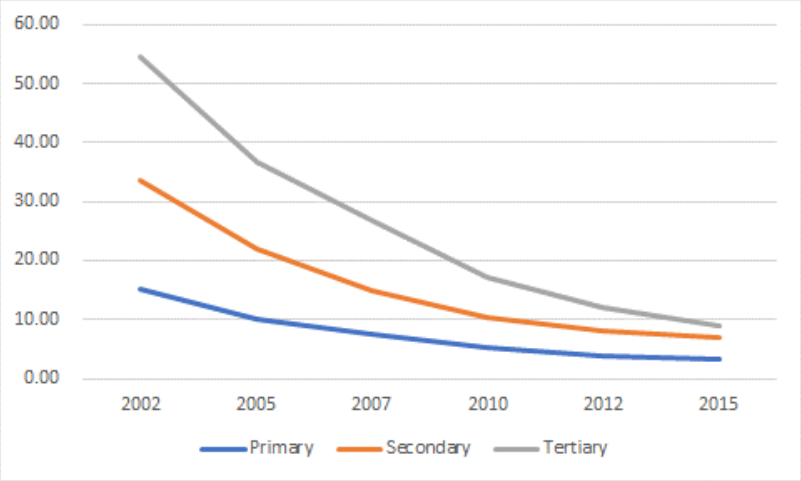
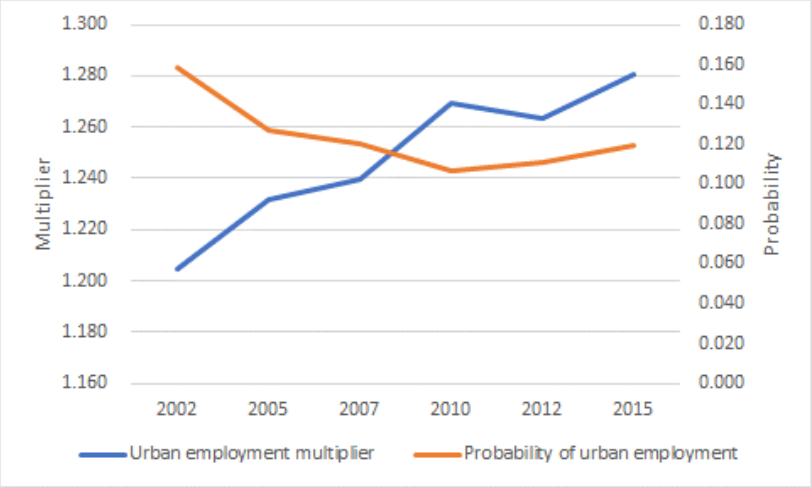


Figure 12 Urbanisation multiplier (urban and rural labour allocation multiplier)



5. Conclusion

This paper has proposed the extended input-output model with regard to the urbanisation, which is considered as the demographic change, i.e., the population movement from the countryside to the cities, by applying the Batey-Madden model. It has also analysed the model structure and the new multiplier called 'urbanisation multiplier' has been provided after its multiplier have been thoroughly studied.

The framework of our extend input-output model for urbanisation provides a useful basis for studying the relationship between urbanisation and economic change. An important aspect of this change is the increase or decrease in the number associated with urban workers and rural workers, together with national labour supply. In fact, the model has been used to

analyse the urbanisation process of China. The results provide us with an insightful and new aspect of understanding the urbanisation, which has been carried out as economic policy in China.

This model has a strong potential for further revelations and hence is apt for more in-depth analysis. We could elaborate the valuables in the model by reflecting the current situations in China, for instance, the existence of rural migrant workers in cities who are not treated as inhabitants in cities, as well as accumulating the empirical studies in wider aspects.

In future research, the objective is to conduct an empirical study by obtaining more detail data with regards to labour account by sector.

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