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COVID-19 impacts of tourism on Chinese economy

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ABSTRACT

To comprehensively assess the economic impacts from China's tourism industry caused by COVID-19 in 2020, this article develops a new multiplier calculation and decomposition method based on the social accounting matrix (SAM). This method is suitable for situations in which multiple industries are simultaneously exposed to external shocks, especially comprehensive industries like tourism. By categorizing all industries as being in either the tourism sector or the nontourism sector, we calculate the output, value-added and employment impacts of COVID-19, then decompose them into four levels: direct, indirect, spillover and reverberation effects. There are some subindustries of both the tourism and nontourism sectors that were severely affected. Compared with the calculation results from the traditional SAM method, the method developed in this paper identifies quite different industrial structures, although there is almost no difference in the total impacts.

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1. Introduction

Since its outbreak, COVID-19 has devastated the global tourism industry. To block or slow the spread of the epidemic, countries have adopted regional blockades or economic restrictions, requiring people to strictly maintain a social distance, and the international tourism industry has been severely impacted. In 2020, the number of global international tourists dropped by 73%, and the number of tourists in the Asia-Pacific region dropped by 80% (UNWTO, 2021). China's tourism industry has also been severely affected by COVID-19. In 2020, domestic tourism revenue decreased by CNY 3.50 trillion compared with 2019, a year-on-year decrease of 61.10% (Ministry of Culture and Tourism, PRC, 2021), and inbound tourism revenue decreased by US$114.3 billion compared with 2019, a year-on-year decrease of 87.1% (Source: Data Center of the Ministry of Culture and Tourism, PRC).

Impact monitoring, valuation, and forecasting is one of the key themes in the early literature on COVID-19 and tourism (Yang et al., 2021b). Research into the impacts

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of COVID-19 on the tourism industry has advanced somewhat. Henseler et al. (2022) found using a computable general equilibrium (CGE) model that the shocks transmitted via international and domestic channels had negative impacts in all Tanzanian sectors. Wu et al. (2022) adopted tourism satellite account (TSA) method to calculate the direct contribution of domestic tourism to Guangdong's economy and found that it declined from 2.53% to 1.20%. Škare et al. (2021) adopted panel structural vector auto-regression (PSVAR) to measure the potential effects of COVID-19 on the tourism industry worldwide; they found that COVID-19 outbreaks have had a much larger destructive impact on the travel and tourism industry than previous studies had indicate. Pham et al. (2021) adopted a CGE model to analyse the short-term impact of inbound tourism on the Australian economy during the epidemic. Their results illustrate that the pandemic directly affected tourism through a decline in output and employment not only in characteristic tourism industries such as accommodations, restaurants, and transportation, but also in a range of other industries. Tsui et al. (2021) adopted a dynamic GMM model and found that the COVID-19 pandemic has had significant negative impacts on the tourism and aviation sectors in Hong Kong. Uğur and Akbıyık (2020) used text mining technology to study the response of travellers during the epidemic and found that tourism was one of the industries most affected by the COVID-19 pandemic. Yang et al. (2021a) compiled a COVID-19 tourism index to monitor the impact of the pandemic on the tourism industry, and their results showed that the global average for the COVID19 tourism index based on a sample of 100 countries was 27.483 as of October 24, 2020, compared to a benchmark of 'normal' levels (100). Among the above studies, the compilation of various indexes and the use of econometric research methods tend to aim to focus on analysing the direct impact of the tourism industry, and subsequent indirect and induced impacts are rarely involved. The CGE model is prone to controversy due to the selection of the functional form of economic behaviour modelling and the calibration of important parameters, so it is difficult to use this tool for practical policy guidance (Akkemik, 2012).

In terms of calculating the indirect and induced impacts after the tourism industry is subjected to exogenous shocks, compared with CGE model analysis, input-output (IO) analysis (Archer & Fletcher, 1996; Frechtling & Horváth, 1999) and social accounting matrix (SAM) multiplier analysis (Wagner, 1997) are two classic methods (Song et al., 2012). Of these two methods, IO analysis has been more widely adopted. IO tables concisely describe the IO relationships among industries. Therefore, only from the perspective of interindustry relations can the indirect and induced impacts on the tourism industry affected by exogenous shocks be measured or the position of the tourism industry within an economy be assessed (Archer, 1995; Archer & Fletcher, 1996; Baster, 1980; Frechtling & Horváth, 1999; Henry & Deane, 1997; Oosterhaven & Fan, 2006; Prasad & Kulshrestha, 2015; Ruíz, 1985; West & Gamage, 2001), the IO analysis method is very applicable (Fletcher, 1989).

However, the IO open model (type I model) involves only the IO relationships among industries, and the IO partial closed model (type II model) usually adds only two sectors – labour compensation and household consumption – as the endogenous accounts on the basis of the open model to participate in the multiplier calculation.

The economic information contained in the IO model is relatively limited. The SAM method comprehensively describes the income-payment relationships among industries, factors, and major institutional sectors, contains more economic information, and solves the problem of expenditure leakage well. Therefore, the SAM method is closer to actual economic operations. However, the compilation of the SAM requires much more economic data. Because these data often come from different departments, their statistical calibres are not uniform, and errors and omissions are thus unavoidable. It is almost impossible to directly determine that each row sum equals the corresponding column sum in the matrix. Appropriate methods have to be used to balance the preliminarily compiled unbalanced matrix. Therefore, since the tourism industry has been subjected to exogenous shocks, there have been some attempts at multiplier operations based on the SAM (Akkemik, 2012; Incera & Fernández, 2015; Jones et al., 2010), but compared with IO analysis, the frequency of SAM adoption is lower.

This article compiles an SAM based on Chinese IO tables (2017), which were most recently updated in 2019; develops a new SAM multiplier decomposition method that distinguishes industry categories; and adopts this method to measure the COVID-19 tourism impacts on China's output, value-added, and employment. The marginal contributions of this work are as follows. First, in terms of methodology, an SAM multiplier decomposition method is developed that is capable of assessing the economic impacts of joint shocks in multiple industries. This method is expected to be widely used in other similar shock scenarios. Simultaneously, this method can be used to test whether the traditional SAM multiplier calculation method overestimates the economic impact when multiple industries are jointly affected. Second, a reasonable estimation of the output, value-added, and employment impacts of COVID-19 on China's tourism industry is conducive to responding to similar exogenous shocks currently and in the future.

2. Methodology

2.1. Traditional SAM multiplier decomposition

Pyatt and Round (1979) derived a SAM multiplier, which is a widely used method of SAM multiplier decomposition. Assuming that the SAM of an economy includes three types of endogenous accounts – industries, factors and institutions – the average expenditure propensity matrix is as follows:

$$A_n = \begin{bmatrix} A_{11} & 0 & A_{13} \\ A_{21} & 0 & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix} \tag{1}$$

where A_{11} denotes the income-payment relationships among industrial accounts, A_{13} denotes the expenditures (consumption and investment) of the institutional accounts (residents and enterprises) for the industrial accounts, A_{21} denotes the income obtained by the factor accounts (labour and capital) from the industrial accounts, A_{32}

denotes the income obtained by the institutional accounts from the factor accounts, and A_{33} denotes the transfer payment within the institutional accounts.

X_1, X_2 and X_3 are denoted as the total income of industrial accounts, factor accounts and institutional accounts, respectively; $X = \begin{bmatrix} X_1 & X_2 & X_3 \end{bmatrix}^T$. Y_1, Y_2 and Y_3 are denoted as exogenous injections (such as final consumption and export) into the industrial accounts, factor accounts, and institutional accounts, respectively; $Y = \begin{bmatrix} Y_1 & Y_2 & Y_3 \end{bmatrix}^T$. Based on the definition of average expenditure propensity, the following must hold:

$$A_n \times X + Y = X \tag{2}$$

Then, formula (2) can be rewritten as follows:

$$X = (I - A_n)^{-1} Y = M_a Y \tag{3}$$

where M_a is the SAM multiplier matrix. Taking the diagonal matrix of A_n and marking it as $\tilde{A}_n$, $A^* = (I - \tilde{A}_n)(A_n - \tilde{A}_n)$. After a complete economic cycle, M_a can be decomposed as follows:

$$M_a = (I - A^{*3})^{-1}(I + A^* + A^{*2})(I - \tilde{A}_n)^{-1} = M_{a3} M_{a2} M_{a1} \tag{4}$$

Stone (1978) wrote formula (4) in the following additive form:

$$\begin{aligned} M_a &= I + (M_{a1} - I) + (M_{a2} - I) M_{a1} + (M_{a3} - I) M_{a2} M_{a1} \\ &= I + T + O + C \end{aligned} \tag{5}$$

where I is the direct multiplier matrix, T is the net effect matrix of the transfer multiplier, O is the net effect matrix of the open-loop multiplier, and C is the net effect matrix of the closed-loop multiplier.

2.2. Another SAM multiplier decomposition method

The tourism sector is a comprehensive industry involving diverse products and services such as accommodations, food and beverage services, transportation, communications, culture, sports and entertainment, wholesale and retail trade, and business services. Once exogenous shocks occur, these industries are directly affected, and then, indirect and induced impacts are brought about by the intricate income-payment relationships among endogenous accounts. Therefore, there are certain difficulties inherent in summarizing the economic impact when various industries are jointly affected.

From the existing literature, three ways to deal with this problem are identified. The first is sector integration; that is, tourism-related output (income) and input (expenses) are separated from original industries and then merged again into the tourism industry. Then, IO or SAM multipliers are calculated with the tourism industry as an endogenous account (Akkemik, 2012; Jones et al., 2010). The problem with this approach is that it requires the integration of multiple products and services that

are very different into one industry, violating the product or service homogeneity principle of the industry category (West & Gamage, 2001). The second way to deal with this problem is decomposition and weighting, that is, to decompose tourism expenditure into various related industries, use these percentages of corresponding industries as weights, and then calculate the corresponding weighted average multiplier based on the IO or SAM multiplier of each industry (Bryden, 1973). This is currently the most widely used approach. The third way is through pure tourism derivation, which means choosing an industry that simply provides tourism services, such as the travel agency industry, as the starting point for exogenous shocks and then calculating the subsequent indirect and induced effects based on the IO or income-payment relationship (Li et al., 2001; Liu et al., 2011). The implicit premise of this approach is that the exogenous shocks to all subindustries of the tourism sector are sequential rather than joint. In other words, the tourism agency industry is first affected, and then followed by other industries through the IO or income-payment relationship; however, this assumption is unreasonable.

Even the widely used decomposition and weighting approach may have some problems, as it does not regard the tourism sector as a whole. The multipliers of each subindustry are calculated independently, and then, the weighted average is calculated. This approach may ignore or distort the influence mechanisms among subindustries of the tourism sector, among different nontourism industries, and between the tourism industry and nontourism industries as a whole.

To solve the reliability problem of the calculation and decomposition of the SAM multiplier when multiple industries are simultaneously subjected to the initial exogenous impact, it is necessary to develop another multiplier decomposition method. We try to divide industrial accounts into two categories: industries that are simultaneously affected by exogenous shocks are categorized as type i industries, while other industries are categorized as type j industries. The average expenditure propensity matrix for formula (1) can be rewritten as follows:

$$A_n = \begin{bmatrix} A_{ii} & A_{ij} & 0 & A_{i3} \\ A_{ji} & A_{jj} & 0 & A_{j3} \\ A_{2i} & A_{2j} & 0 & 0 \\ 0 & 0 & A_{32} & A_{33} \end{bmatrix} \tag{6}$$

Similarly, X_i, X_j, X_2 and X_3 denote the total income of the type i industries, type j industries, factor accounts and institutional accounts, respectively; $X = \begin{bmatrix} X_i & X_j & X_2 & X_3 \end{bmatrix}^T$. Y_i, Y_j, Y_2 and Y_3 denote the injections of type i industries, type j industries, factor accounts and institutional accounts, respectively; $Y = \begin{bmatrix} Y_i & Y_j & Y_2 & Y_3 \end{bmatrix}^T$. Then,

$$A_n \times X + Y = X \tag{7}$$

For brevity, we set the following:

$$\begin{aligned}
\alpha &= (I-A_{ii}) \\
\beta &= A_{i3}(I-A_{33})^{-1}A_{32}A_{2i} \\
\gamma &= A_{ij} + A_{i3}(I-A_{33})^{-1}A_{32}A_{2j} \\
\varepsilon &= (I-A_{jj}) \\
\eta &= A_{j3}(I-A_{33})^{-1}A_{32}A_{2j} \\
\delta &= A_{ji} + A_{j3}(I-A_{33})^{-1}A_{32}A_{2i} \\
\theta &= A_{j3}(I-A_{33})^{-1} \\
\varphi &= A_{i3}(I-A_{33})^{-1}
\end{aligned} \tag{8}$$

Solving the equations involved in formula (7) obtains

$$\begin{aligned}
X_i = &\left[\alpha - \beta - \gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} \\
&\times \left\{\gamma(\varepsilon-\eta)^{-1} \times \left[\theta(A_{32}Y_2 + Y_3) + Y_j\right] + \varphi(A_{32}Y_2 + Y_3) + Y_i\right\}
\end{aligned} \tag{9}$$

Based on formula (9), the exogenous impact of Y_i, Y_j, Y_2 and Y_3 on type i industries can be calculated.

Referring to the decomposition concept presented by Muradov (2016), the matrix written as B = LH can be decomposed as follows:

$$B = LH = I + (L-I) + (H-I) + (L-I)(H-I) \tag{10}$$

Then, the first factor of formula (9) can be decomposed as follows:

$$\begin{aligned}
&\left[\alpha - \beta - \gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} \\
&\quad = \left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} \times \alpha^{-1} \\
&\quad = I + (\alpha^{-1}-I) + \left\{\left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} - I\right\} \\
&\qquad + (\alpha^{-1}-I) \times \left\{\left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} - I\right\}
\end{aligned} \tag{11}$$

The following can be observed regarding the decomposition result of formula (11):

1. The first item is an identity matrix, which reflects the direct output impact of the initial shocks on type i industries;
2. The second item $(\alpha^{-1}-I)$ reflects the indirect output impact of the initial shocks within type i industries;
3. The third term $\left\{\left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} - I\right\}$ represents the spillover output effect on all industries of the initial shocks; and
4. The fourth item $(\alpha^{-1}-I) \times \left\{\left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta\right]^{-1} - I\right\}$ reflects the reverberation output effect produced by the spillover effect among type i industries.

The second factor of formula (9) can be decomposed as follows:

$$\begin{aligned}
&\gamma(\varepsilon-\eta)^{-1}\times\left[\theta(A_{32}Y_2+Y_3)+Y_j\right]+\varphi(A_{32}Y_2+Y_3(+Y_i\\
&\quad=\left[\gamma(\varepsilon-\eta)^{-1}\theta+\varphi\right]A_{32}Y_2+\left[\gamma(\varepsilon-\eta)^{-1}\theta+\varphi\right]Y_3+\gamma(\varepsilon-\eta)^{-1}Y_j+Y_i\\
&\quad=\begin{bmatrix}T_i & T_j & T_2 & T_3\end{bmatrix}\times\begin{bmatrix}Y_i\\ Y_j\\ Y_2\\ Y_3\end{bmatrix}
\end{aligned}\tag{12}$$

Observing formula (12), the four exogenous shocks of Y_i, Y_j, Y_2 and Y_3 all affect X_i, but only Y_i is directly influenced by the multiplier (T_i is 1), which is shown in formula (11).

In the same way, solving the equations involved in formula (7) obtains

$$\begin{aligned}
X_j=&\left[\varepsilon-\eta-\delta(\alpha-\beta)^{-1}\gamma\right]^{-1}\\
&\times\left\{\delta(\alpha-\beta)^{-1}\times\left[\varphi(A_{32}Y_2+Y_3)+Y_i\right]+\theta(A_{32}Y_2+Y_3)+Y_j\right\}
\end{aligned}\tag{13}$$

The second factor of formula (13) can be rewritten as follows:

$$\begin{aligned}
&\delta(\alpha-\beta)^{-1}\times\left[\varphi(A_{32}Y_2+Y_3)+Y_i\right]+\theta(A_{32}Y_2+Y_3)+Y_j\\
&\quad=\left[\delta(\alpha-\beta)^{-1}\varphi+\theta\right]A_{32}Y_2+\left[\delta(\alpha-\beta)^{-1}\varphi+\theta\right]Y_3+\delta(\alpha-\beta)^{-1}Y_i+Y_j
\end{aligned}\tag{14}$$

Then, the output impact of injections of type i industries (Y_i) on type j industries is as follows:

$$X_j=\left[\varepsilon-\eta-\delta(\alpha-\beta)^{-1}\gamma\right]^{-1}\times\delta(\alpha-\beta)^{-1}\times Y_i\tag{15}$$

Formula (15) shows that injections of type i industries (Y_i) produce output impacts within type i industries first (i.e., $(\alpha-\beta)^{-1}$) and then affect X_j through two components: the intermediate input of type j industries to type i industries (A_{ji}) and the induced impact of type i industries on type j industries (i.e., $A_{j3}(I-A_{33})^{-1}A_{32}A_{2i}$). The first factor of formula (15) can also be decomposed as follows:

$$\begin{aligned}
\left[\varepsilon-\eta-\delta(\alpha-\beta)^{-1}\gamma\right]^{-1}=&I+(\varepsilon^{-1}-I)+\left\{\left[I-\varepsilon^{-1}\eta-\varepsilon^{-1}\delta(\alpha-\beta)^{-1}\gamma\right]^{-1}-I\right\}\\
&+(\varepsilon^{-1}-I)\times\left\{\left[I-\varepsilon^{-1}\eta-\varepsilon^{-1}\delta(\alpha-\beta)^{-1}\gamma\right]^{-1}-I\right\}
\end{aligned}\tag{16}$$

The four terms in formula (16) represent the direct, indirect, spillover, and reverberation output effects of injections of type i industries on type j industries.

Thus far, after type i industries are subjected to exogenous shocks, the output impacts of all levels on all industries are as follows:

1. Direct effect

$$\Delta X_{direct} = \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_{direct} = \begin{bmatrix} \Delta Y_i \\ \delta(\alpha-\beta)^{-1} \times \Delta Y_i \end{bmatrix} \tag{17}$$

2. Indirect effect

$$\Delta X_{indirect} = \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_{indirect} = \begin{bmatrix} (\alpha^{-1}-I) \times \Delta Y_i \\ (\varepsilon^{-1}-I) \times \delta(\alpha-\beta)^{-1} \times \Delta Y_i \end{bmatrix} \tag{18}$$

3. Spillover effect

$$\begin{aligned} \Delta X_{spillover} &= \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_{spillover} \\ &= \begin{bmatrix} \left\{ \left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta \right]^{-1} - I \right\} \times \Delta Y_i \\ \left\{ \left[I - \varepsilon^{-1}\eta - \varepsilon^{-1}\delta(\alpha-\beta)^{-1}\gamma \right]^{-1} - I \right\} \times \delta(\alpha-\beta)^{-1} \times \Delta Y_i \end{bmatrix} \end{aligned} \tag{19}$$

4. Reverberation effect

$$\begin{aligned} \Delta X_{reverberate} &= \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_{reverberate} \\ &= \begin{bmatrix} (\alpha^{-1}-I) \times \left\{ \left[I - \alpha^{-1}\beta - \alpha^{-1}\gamma(\varepsilon-\eta)^{-1}\delta \right]^{-1} - I \right\} \times \Delta Y_i \\ (\varepsilon^{-1}-I) \times \left\{ \left[I - \varepsilon^{-1}\eta - \varepsilon^{-1}\delta(\alpha-\beta)^{-1}\gamma \right]^{-1} - I \right\} \times \delta(\alpha-\beta)^{-1} \times \Delta Y_i \end{bmatrix} \end{aligned} \tag{20}$$

The specific meanings and influencing factors of direct, indirect, spillover and reverberation effects are shown in Table 1, and the specific impact mechanism is illustrated in Figure 1.

2.3. Decomposition of value-added and employment multipliers

Let $diag(C_{VA})$ denote the diagonal matrix of the value-added coefficient of each industry, obtained by dividing the value added of each industry by its total output in the IO table. Then, the value-added impact at all levels of exogenous shocks of type i industries on all industries can be calculated as follows:

$$\Delta VA_k = diag(\Delta VA)_k = \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_k^T \times diag(C_{VA}) \tag{21}$$

where k represents 'direct', 'indirect', 'spillover' or 'reverberation', denoting direct, indirect, spillover or reverberation effects, respectively.

Table 1. The specific meaning and influencing factors of four effects.

	Type *i* industries (industries affected directly)	Influencing factors	Type *j* industries (other industries)	Influencing factors
Direct effect	Direct impact of injections on type *i* industries	Industrial distribution of exogenous shocks	The total impact on type *i* industries directly impacts the output of type *j* industries	The IO relationship between type *i* and type *j* industries, distribution of factor compensation, institutional income and expenditure structure
Indirect effect	Indirect impact caused by injections within type *i* industries	IO relationship among subindustries within type *i* industries	The indirect impact within type *j* industries	IO relationship among subindustries within type *j* industries
Spillover effect	Reduced effect of injections into type *i* industries on all industries	IO relationships among all industries, distribution of factor compensation, institutional income and expenditure structure	Reduced effect of the direct effects on type *j* industries on all industries	IO relationships among all industries, distribution of factor compensation, institutional income and expenditure structure
Reverberation effect	Further impact of spillover effect within type *i* industries	IO relationship among subindustries within type *i* industries	Further impact of spillover effects within type *j* industries	IO relationship among subindustries within type *j* industries

Source: Authors' estimation.

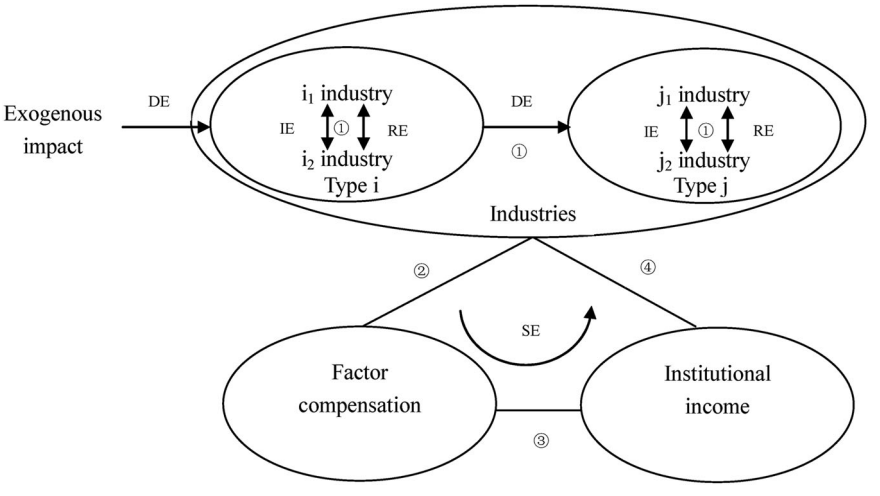

Figure 1. Mechanism underlying the four effects.
DE: Direct effect, IE: Indirect effect, SE: Spillover effect, RE: reverberation effect.
①IO relationship ②Primary distribution ③Secondary distribution
④Institutional expenditure (consumption and investment)
Source: Authors' estimation.

Similarly, let $diag(C_E)$ denote the diagonal matrix of the employment coefficient in each industry, obtained by dividing the number of employees in each industry by its total output. Then, the employment impact at all levels of exogenous shocks of type i industries on all industries can be calculated as follows:

$$\Delta E_k = diag(\Delta E)_k = \begin{bmatrix} \Delta X_i \\ \Delta X_j \end{bmatrix}_k^T \times diag(C_E) \tag{22}$$

The meaning of k is the same as in formula (21).

3. Data

3.1. Tourism and nontourism sector division

As mentioned above, the tourism industry is a comprehensive industry that provides a variety of products and services; there has been ongoing debate regarding how to properly count the output, value added and employment of this industry in the national income accounting system. To solve this practical problem, the United Nations (UN), the World Tourism Organization (UNWTO), the Statistical Office of the European Communities (Eurostat), and the Organization for Economic Cooperation and Development (OECD) jointly compiled the 'Tourism Satellite Account: Recommended Methodological Framework 2008' (TSA: RMF2008) in 2010, and this document clearly states:

> *A tourism industry represents the grouping of those establishments whose main activity is the same tourism characteristic activity.* (TSA: RMF2008, p.25)

The specific tourism activities include 12 types, as shown in the second column of Table 2, and we map these 12 types of tourism-specific activities to the industries in China's Input-Output Tables (2017). We merge some of these activities because the current available statistical data in China do not allow the proportion of tourism expenditure in each establishment to be obtained. For example, we can obtain the transportation expenditure of domestic or inbound tourism, but we cannot identify the proportion of transportation expenses in the subdivided form.

Therefore, when studying the economic impacts of COVID-19 through its impacts on domestic tourism, this article sets 5 industries – wholesale and retail trade; transportation, storage and post; accommodation; food and beverage services; and culture, sports and entertainment – as being within the tourism sector and the remaining 38 industries as being in the nontourism sector. When studying the impacts of COVID-19 from inbound tourism, the telecommunication, software and information technology service industry is considered a supplement to the tourism sector. The reason for this differentiated treatment is the difference in the availability of data on the expenditure distribution of domestic and inbound tourism in statistical data. Since the proportion of travel agencies and other reservation services expenditure is not available, we have to classify leasing and business services activities within the nontourism industry. From this perspective, the results in this article will be underestimated to a certain extent. Expenditure on travel agencies and other reservation services is

Table 2. List of categories of characteristic tourism activities and their corresponding industries in China.

No.	Activities	Corresponding industries
1.	Accommodation for visitors	Accommodation
2.	Food- and beverage-serving activities	Food and Beverage Services
3.	Railway passenger transport	Transportation, storage and post
4.	Road passenger transport	
5.	Water passenger transport	
6.	Air passenger transport	
7.	Transport equipment rental	
8.	Travel agencies and other reservation services activities	Leasing and business services
9.	Cultural activities	Culture, sports, and entertainment
10.	Sports and recreational activities	
11.	Retail trade of country-specific tourism characteristic goods	Wholesale and retail trade
12.	Other country-specific tourism characteristic activities	NA

NA = not applicable. Sources: TSA – RMF2008, 2017 Input – Output Tables of China.
Source: Authors' estimation.

classified as 'other expenditure', which accounts for a relatively small proportion of domestic and inbound tourism expenditure over the years, and so the underestimation will not be significant.

3.2. Compilation of the 2017 Chinese SAM

Based on China's 2017 IO tables, combined with the corresponding year's China Statistical Yearbook, Finance Yearbook of China, China's Balance of Payments and Date of Flow of Funds of China and other statistical data, we first compiled the Macro-SAM 2017 (shown in Appendix A.1). The matrix includes 10 accounts: Commodities, Activities, Labor, Capital, Households, Enterprises, Government, Savings-Investment, Inventory, and Rest of the World. Then, the Commodities and Activities accounts are further divided to obtain the subdivided SAM 2017 as follows. Based on the Chinese IO tables (2017) with 149 and 42 accounts, we compiled IO tables with 43 accounts. In this table, the 'Accommodation and Catering' account is split into two accounts: accommodation and food and beverage services. The reason for this treatment is that the two accounts are both important subindustries of the tourism sector, as each accounts for a large proportion of tourism expenditure. Therefore, the Commodities and Activities accounts are both 43×43, and the subdivided SAM is 94×94.

In China's SAM 2017, we set 6 accounts – Commodities, Activities, Labor, Capital, Households, and Enterprises – as endogenous accounts and the other 4 accounts as exogenous accounts.

3.3. Direct impact of COVID-19 on the tourism industry and its distribution

As shown in Table 3, affected by the epidemic, China's domestic and inbound tourism revenue dropped sharply in 2020, especially that of inbound tourism, which dropped by as much as 87.1%. To determine the specific industrial distribution of the decline in domestic tourism revenue, we obtained the composition of each trip of domestic casual tourists of urban and rural residents from the 'Tourism Sample

Table 3. China's decline in tourism revenue in 2020.

	Revenue in 2020	Revenue in 2019	Decline in 2020
Domestic tourism	2.23 (CNY $\times$ 10^{13})	5.73(CNY $\times$ 10^{13})	61.1%
Urban residents	1.80 (CNY $\times$ 10^{13})	4.75(CNY $\times$ 10^{13})	62.2%
Rural residents	0.43 (CNY $\times$ 10^{13})	0.97(CNY $\times$ 10^{13})	55.7%
Inbound tourism	170 (USD $\times$ 10^{9})	1,313(USD $\times$ 10^{9})	87.1%

Source: The data for 2019 come from the 'China Statistical Yearbook of Culture, Relics and Tourism 2020'; the domestic tourism revenue data for 2020 come from the Ministry of Culture and Tourism, PRC, 'Domestic Tourism Data in 2020' (http://zwgk.mct.gov.cn)/zfxxgkml/tjxx/202102/t20210218_921658.html), February 18, 2021; and the 2020 inbound tourism revenue data come from the Data Center of the Ministry of Culture and Tourism, PRC, 'China Tourism Economic Blue Book (No. 13)'.

Table 4. Per capita expenditure of domestic residents per trip (%).

	Transportation	Accommodation	Food and beverage	Shopping	Scenic tour	Other
Urban resident	36.3	17.5	22.9	12.7	5.4	5.2
Rural resident	34.9	12.6	25.2	14.8	4.8	7.7

Source: 'Tourism Sample Survey Data 2018' by Ministry of Culture and Tourism, PRC.

Survey Data 2018' of the Ministry of Culture and Tourism, PRC, as shown in Table 4.

From the website of the National Bureau of Statistics of China, we can obtain inbound tourism revenue for each category in 2019 and then divide it by the total revenue of inbound tourism to obtain the composition of the inbound tourism revenue for the year. Inbound tourism revenue is derived from expenditures on long-distance transportation, accommodation, food and beverage services, sightseeing, entertainment, commodity purchases, intracity transportation, post and telecommunications and other services, and the percentages of the revenue from these categories are 30.62%, 15.27%, 12.22%, 4.47%, 3.37%, 23.08%, 2.63%, 0.57% and 7.76%, respectively. Decomposing the decline in domestic and inbound tourism revenue in 2020 according to the tourism revenue structure of each type, we can obtain the industrial distribution of tourism revenue decline in 2020, as shown in Table 5.

3.4. Value-added and employment coefficients

The industrial value-added coefficient can be directly calculated by dividing the value added of each industry by its total output in the IO table (2017). The employment coefficient is calculated as follows. First, the labour compensation data of each industry are obtained from the IO tables (2017). Second, the per capita annual salary of urban enterprises in each industry in 2017 is obtained from the 'China Labor Statistical Yearbook 2018', where some industries need to merge to be consistent with the industry division of the IO table (2017). Third, the labour compensation of each industry obtained in the first step is divided by the per capita annual salary in the corresponding industry obtained in the second step to obtain a preliminary estimation of the number of employees in each industry. Fourth, we sum the estimated industrial employment data according to the three industries. The number of employees in the primary industry is directly replaced by the corresponding number in the 'China Labor Statistical Yearbook 2018', and the numbers of employees in the secondary and tertiary industries reported in the 'China Labor Statistical Yearbook 2018'

Table 5. Industrial distribution of tourism revenue decline in 2020.

	Domestic tourism (CNY × 10^9)			Inbound tourism	
	Urban resident	Rural resident	Total	USD × 10^9	CNY × 10^9
Transport, storage and post	10,708.5	1,884.6	12,593.1	380.06	2,621.43
Accommodation	5,162.5	680.4	5,842.9	174.59	1,204.24
Food and beverage services	6,755.5	1,360.8	8,116.3	139.69	963.50
Wholesale and retail trade	3,746.5	799.2	4,545.7	263.84	1,819.81
Culture, sports and entertainment	1,593	259.2	1,852.2	89.58	617.87
Telecommunication, software and information Technology service	NA	NA	NA	6.51	44.90

Notes:
① The decline in inbound tourism revenue denominated in CNY is obtained by multiplying the decrease in USD by the 2020 annual average exchange rate of USD/RMB, which is 6.8974 and comes from the National Bureau of Statistics, PRC.
② Regardless of the composition of revenue from domestic tourism or inbound tourism, since it is not clear which industries are involved in 'other revenue', this part of revenue is ignored here.
Source: Authors' estimation.

are divided by the respective estimated values of the two industries in the third step. Thus, we can obtain the conversion coefficients of employment in the secondary and tertiary industries. Finally, the conversion coefficients calculated in the fourth step are multiplied by the estimated value of each industry (calculated in the third step). The final estimated number of employees in each industry is then obtained.

4. Results

4.1. Output impact of COVID-19 from China's tourism sector

4.1.1. Output impact of COVID-19 from domestic tourism

The output impacts of COVID-19 from domestic and inbound tourism in 2020 are shown in Appendix A.2. The total output impact from domestic tourism on (the first 5 industries of) the tourism sector is approximately CNY 4.79 trillion, of which the direct, indirect, spillover and reverberation effects are CNY 3.3 trillion, CNY 429.4 billion, CNY 947.4 billion, and CNY 120.7 billion, respectively, which shows that the output impacts from domestic tourism on the tourism sector mainly take the form of direct and spillover effects. From the perspective of the total output impact, the transportation industry has suffered the most compared to other industries, approximately CNY 1.95 trillion, followed by the food and beverage services industry and wholesale and retail trade industry, each approaching CNY 1 trillion.

The total output impact on the nontourism sector (the last 38 industries) of COVID-19 from domestic tourism is approximately CNY 8.13 trillion, of which the direct, indirect, spillover and reverberation effects are approximately CNY 2.21 trillion, CNY 2.69 trillion, CNY 1.4 trillion, and CNY 1.82 trillion, respectively, which shows that the direct and indirect effects on the nontourism sector are greater than those on the tourism sector. From the perspective of total effects, the food and tobacco, agriculture, chemical, finance, leasing and business services, and real estate

industries are the most affected. The total output impact of these six industries is approximately CNY 4.38 trillion, which is more than 50% of the total output impact on the nontourism sector.

4.1.2. Output impact of COVID-19 from inbound tourism

Since inbound tourism has been affected by COVID-19 in 2020, the total output impact on the tourism sector (the first 6 industries) is approximately CNY 1.09 trillion, of which the direct, indirect, spillover and reverberation effects are approximately CNY 727.2 billion, CNY 106.7 billion, CNY 225 billion, and CNY 34.9 billion, respectively. The impacts mainly take the form of direct and spillover effects. From the perspective of the total effects, the transportation industry has suffered the most output impact, with approximately CNY 410.1 billion, followed by wholesale and retail trade, with approximately CNY 284.9 billion. This finding shows that since the IO relationships among subindustries in the tourism sector, the distribution of factor compensation and the income and expenditure structures of the institutional sectors all remain unchanged, the relative positions of the indirect effects, spillover effects and reverberation effects in the tourism industry remain basically unchanged. However, due to the different expenditure structures between inbound and domestic tourism, the output impact of COVID-19 from inbound tourism on the wholesale and retail trade industry is ranked higher.

The total output impact of inbound tourism brought about by COVID-19 on nontourism industries (the last 37 industries) is approximately CNY 1.69 trillion, of which the direct, indirect, spillover and reverberation effects are approximately CNY 462.7 billion, CNY 549 billion, CNY 295.4 billion and CNY 378.6 billion, respectively. Similarly, this shows that the direct and indirect effects on nontourism industries are relatively greater than the other effects. From the perspective of the total effects, the food and tobacco, agriculture, chemical, finance, leasing and business services, and real estate industries are the most affected. The total output impact on these six industries due to COVID-19 inbound tourism is approximately CNY 904.9 billion, which is more than 50% of the that on nontourism industries.

4.2. Value-added impact of COVID-19 from China's tourism sector

4.2.1. Value-added impact of COVID-19 from domestic tourism

As shown in Appendix A.3, since the domestic tourism industry has been affected in 2020, the total value-added impact of the tourism sector (the first 5 industries) is approximately CNY 2.26 trillion, of which the direct, indirect, spillover and reverberation effects are approximately CNY 1.49 trillion, CNY 217.3 billion, CNY 492.6 billion and CNY 59.2 billion, respectively. From the perspective of the total effects, transportation (approximately CNY 881.5 billion) and wholesale and retail trade (CNY 638.9 billion) have been the industries most severely affected. The total value-added impact of these two industries is approximately CNY 1.52 trillion, accounting for 67% of the total value-added impact on the tourism sector.

The total value-added impact of domestic tourism on the nontourism sector is approximately CNY 3.02 trillion, of which the direct, indirect, spillover and

reverberation effects are approximately CNY 861.6 billion, CNY 989.4 billion, CNY 542.4 billion and CNY 625.9 billion, respectively, which shows that the four levels of value-added impacts on the nontourism sector are relatively evenly distributed. From the perspective of the total effects, the agriculture, finance, real estate, food and tobacco, chemical, and leasing and business services industries are those that are most affected. The total value-added impact of these six industries is approximately CNY 1.837 trillion, accounting for 57.53% of the value-added impact on the nontourism sector.

4.2.2. Value-added impact of COVID-19 from inbound tourism

Since inbound tourism has been affected in 2020, its value-added impact on the tourism or nontourism sectors at each level is not much different from the impact of domestic tourism in terms of structure and ranking. The significant difference is that in the value-added impact of inbound tourism on the tourism industry, food and beverage services suffer fewer impacts at all levels, mainly due to differences in expenditure structure between domestic and inbound tourism. From the perspective of the total value-added impact, in the tourism sector, the wholesale and retail trade and the transportation industries have been harder hit. These two industries account for 68.8% of the total value-added impact of the tourism industry, while in the nontourism sector, the agriculture, finance, real estate, food and tobacco, chemical, and leasing and business services industries are the most severely affected. The total impact of these six industries is approximately CNY 383.881 billion, accounting for 61.74% of the value-added impact of the nontourism sector.

Regardless of whether domestic or inbound tourism is impacted, the ranking of the value-added impacts on all industries at various levels is different from that of the output impacts at the corresponding levels. The reason for this is that when we calculate the value-added impact at all levels, in addition to the factors listed in Table 1, the results are also affected by the value-added coefficients of all industries.

4.3. Employment impact of COVID-19 from China's tourism sector

4.3.1. Employment impact of COVID-19 from domestic tourism

As shown in Appendix A.4, since the domestic tourism industry was impacted in 2020, the total employment impact on the tourism sector (the first 5 industries) is approximately 23.02 million employees, of which the direct, indirect, spillover and reverberation effects are approximately 16.24 million, 1.82 million, 4.46 million and 0.5 million, respectively. This finding shows that the direct and spillover effects are relatively greater than the other effects. In terms of the total employment impact, the transportation, food and beverage services, wholesale and retail trade, and accommodation industries have been severely yet uniformly affected. The total employment impact of these four industries is approximately 21.8 million employees, accounting for 94.69% of the total employment impact on the tourism sector.

Since the domestic tourism industry has been impacted, the total employment loss of the nontourism sector (the last 38 industries) is approximately 32.73 million, of which the number of direct, indirect, spillover and reverberation effects are

approximately 7.89 million, 11.93 million, 5.997 million and 6.915 million, respectively, which shows that among the four levels of employment impacts suffered by nontourism industries, the indirect effect is more significant, while the other three effects are relatively close. Compared with the output and value-added impacts on the real estate and chemical industries at all levels, the employment impacts on these two industries are lower. The reason for this is that the employment coefficient of these two industries is relatively small (see appendix A.5 for specific values and rankings). In terms of total employment impact, the agriculture, leasing and business services, finance, food and tobacco, and services to households, repair and other services have suffered the most. The total employment impact of these five industries is approximately 24.82 million employees, accounting for 75.83% of the employment impact suffered by the nontourism sector.

4.3.2. Employment impact of COVID-19 from inbound tourism

Since inbound tourism has been affected by COVID-19 in 2020, by comparing the employment impact on the tourism sector and nontourism sector at all levels with that caused by the domestic tourism industry, the following significant differences are found. First, among the subindustries of the tourism sector, the wholesale and retail trade industry endures the most direct effects, while the employment impact on the food and beverage services industry is weaker. The reason for this is that inbound tourists spend a larger proportion of their total expenditure on shopping while spending a smaller proportion on food and beverage services. Second, from the perspective of the total employment impact, within the tourism sector, the wholesale and retail trade, transportation and accommodation industries are the most affected. Compared with the total employment impact from domestic tourism, the industrial structure is different. For the nontourism sector, the industrial distribution of employment impacts from inbound tourism at all levels is approximately the same as that from domestic tourism. The agriculture, leasing and business services, finance, services to households, repair and other services, and food and tobacco industries are the most severely affected. The total employment impact of these five industries is approximately 4.9 million employees, accounting for 74.67% of the employment impact on nontourism industries from inbound tourism.

4.4. Comparison with traditional SAM calculation results

Table 6 lists the output, value-added, and employment impacts of domestic and inbound tourism on the tourism and nontourism sectors at various levels, calculated based on the new method, where we find that due to the impacts of COVID-19 in 2020, domestic and inbound tourism have been affected directly by approximately CNY 3.3 trillion and CNY 727.2 billion, respectively; the total output, value-added and employment impacts of COVID-19 from domestic tourism are CNY 12.92 trillion, CNY 5.28 trillion, and 55.75 million employees, respectively; and those from inbound tourism are CNY 2.78 trillion, CNY 1.17 trillion, and 11.7 million employees, respectively. Therefore, domestic tourism is the main type of tourism that has been impacted. For the tourism sector, the direct and spillover effects of domestic

Table 6. Summary of various impacts calculated based on a new method.

		Domestic tourism impacts					Inbound tourism impacts				
	Impacts	Direct effect	Indirect effect	Spillover effect	Reverberation effect	Total	Direct effect	Indirect effect	Spillover effect	Reverberation effect	Total
Tourism sector	Output	32,950.20	4,293.64	9,474.11	1,206.74	47,924.69	7,271.74	1,066.66	2,249.92	349.37	10,937.70
	Value added	14,931.57	2,172.53	4,926.41	592.20	22,622.71	3,577.11	533.89	1,167.80	174.56	5,453.37
	Employment	1,624.41	182.01	445.82	49.64	2,301.88	357.91	41.82	98.41	12.64	510.77
Nontourism sector	Output	22,124.16	26,912.91	14,028.48	18,212.80	81,278.34	4,626.73	5,489.85	2,953.85	3,785.69	16,856.12
	Value added	8,615.56	9,894.27	5,423.94	6,259.21	30,192.98	1,819.30	1,979.57	1,129.97	1,289.12	6,217.97
	Employment	789.34	1,192.67	599.71	691.53	3,273.25	158.52	227.58	127.62	145.70	659.43
Total	Output	55,074.36	31,206.54	23,502.59	19,419.54	129,203.03	11,898.47	6,556.51	5,203.78	4,135.06	27,793.82
	Value added	23,547.13	12,066.80	10,350.35	6,851.41	52,815.69	5,396.41	2,513.46	2,297.77	1,463.69	11,671.34
	Employment	2,413.75	1,374.68	1,045.53	741.17	5,575.13	516.43	269.40	226.03	158.34	1,170.19

Source: Authors' estimation.

Table 7. The total impacts calculated by the traditional SAM multiplier calculation method.

	Total impact of domestic tourism expenditure decline			Total impact of inbound tourism expenditure decline		
	Output (CNY × 10^9)	Value added (CNY × 10^9)	Employment (10^4 person)	Output (CNY × 10^9)	Value added (CNY × 10^9)	Employment (10^4 person)
Transportation	47,826.39	19,764.76	1,687.11	9,955.72	4,114.31	351.20
Accommodation	23,652.75	9,631.31	1,153.19	4,874.89	1,985.04	237.68
Food and beverage services	34,808.14	13,556.75	1,825.83	4,321.12	1,609.34	216.75
Wholesale and retail trade	14,535.51	7,124.56	643.12	5,819.10	2,852.22	257.46
Culture, sports and entertainment	7,196.81	3,086.35	308.65	2,400.76	1,029.57	102.96
Telecommunication, software and information technology service	NA	NA	NA	160.31	447.79	4.98
Total	128,019.59	53,163.73	5,617.89	27,342.89	12,038.26	1,171.02

Source: Authors' estimation.

and inbound tourism are relatively higher. For nontourism industries, in addition to the direct impact from the tourism sector, the indirect impact is also relatively great.

Additionally, based on the industry distribution data of tourism revenue decline in Table 5, we adopted the traditional SAM multiplier decomposition method shown in formula (5) to calculate the total output, value-added and employment impacts on the tourism sector, the results of which are shown in Table 7.

Comparing the results in Table 7 with those in Table 6, it is not difficult to note a certain contradiction: the total output result of the traditional calculation is slightly less than that calculated by the new method, while its total value-added and employment results are slightly higher. This seemingly contradictory result can be explained by observing Appendix A.5.

In Appendix A.5, the total output impact calculated by the traditional method for industries No. 1–10 is higher than that calculated by the new method, industries No. 11–27 show the opposite results, and the results calculated by the two methods for industries No. 28–43 show little difference. It can be observed that the value-added and employment coefficients of the top 10 industries are relatively high, while those of the middle 17 industries are relatively low. Therefore, although the total output impact calculated by the traditional method is approximately 1% lower than that of the new method, because the value-added and the employment coefficients of various industries play important roles, it is reasonable that the value-added and employment impacts calculated by the traditional method are higher than those of the new method.

5. Conclusions

This paper develops a new SAM-based multiplier calculation and decomposition method, divides all industries into two major industrial sectors – the tourism sector and the nontourism sector – and calculates the output, value-added and employment impacts of COVID-19 from domestic and inbound tourism in China in 2020. We

decompose all types of impacts into direct, indirect, spillover, and reverberation effects, the main conclusions of which are as follows.

5.1. Overall conclusions of the impacts

In 2020, due to the impacts of COVID-19, the direct impacts that domestic and inbound tourism endured are approximately CNY 3.3 trillion and CNY 727.2 billion, respectively. The total output, value-added, and employment impacts from domestic tourism are CNY 12.92 trillion, CNY 5.28 trillion and 55.75 million employees, respectively. The output, value-added and employment impacts caused by inbound tourism are CNY 2.78 trillion, CNY 1.17 trillion and 11.7 million employees, respectively. Domestic tourism is mainly affected.

Affected by COVID-19, in terms of the output, valued-added, and employment impacts from domestic and inbound tourism on the tourism sector, direct and spillover effects are more significant compared to the other types of effects. Regarding the corresponding impacts on the nontourism sector, the direct and indirect effects are greater. According to the meaning of the different levels of effects in Table 1, this implies that COVID-19 will have a significant impact on the tourism sector in both the short term and long term, while its impact on the nontourism sector will be mainly limited to the short term.

Regardless of whether they come from domestic or inbound tourism, in terms of the output, value-added and employment impacts on the tourism and nontourism sectors, some industries that have been severely affected can always be found. These industries should be the focus of our response to these impacts on tourism. Due to its different tourism expenditure structure compared to that of domestic tourism, inbound tourism has a relatively low impact on the food and beverage services industry, while its impact on the wholesale and retail trade industry is more significant.

5.2. Policy implications

There are at least two policy implications that arise from the identification of the key industries at four levels: First, when we respond to the effects on China's economy from COVID-19's impact on tourism during different stages of the epidemic, the key industries should also be determined differently. Specifically, when the epidemic is still spreading, the tourism sector is still being severely affected. The focus should be on the industries most affected, both directly and indirectly. This is because the direct and indirect impacts are mainly short-term. As the epidemic is gradually brought under control and the tourism sector is gradually recovering, the focus of the response should be shifted to those industries with more serious spillover and reverberation effects. The reason is that the economy needs to go through a complete cycle before these two types of effects begin to emerge.

Secondly, when we respond to the effect on China's economy from COVID-19's impacts on tourism, employment goals should be given higher priority. In terms of the impacts on output, value added and employment, the ranking of different industries differs across the four levels. After aggregating the total effect on all industries

from domestic and inbound tourism, we find that the total effects on output, value-added and employment are CNY15.70 trillion, CNY 6.45 trillion and 67.45 million employees, respectively. In 2017, China's total output, value-added and employment were CNY 225.77 trillion (Source: China's 2017 IO tables), CNY 83.09 trillion (Source: National Bureau of Statistics of China) and 760.58 million employees (Source: National Bureau of Statistics of China). Thus, the total output, value-added and employment effects across all industries are equivalent to 6.95%, 7.76% and 8.87% of the corresponding total value in China in 2017. It is obvious that employment has been affected the worst due to the labour-intensive nature of the tourism industry. Therefore, during all stages of the epidemic, the response should prioritize the employment goals, which would facilitate the sustainable recovery of the tourism sector and the entire economy.

5.3. Conclusion-related calculation method

Based on the same data, the output, value-added and employment impacts calculated by the traditional SAM method and the new method developed in this paper show very few differences in terms of the total amounts, which can be mutually confirmed and tested. The implication here is that when multiple industries are subject to exogenous shocks simultaneously, as long as the quantitative shocks can be decomposed into these industries, according to the traditional SAM calculation method, by calculating the economic impact of each industry directly affected one by one first and then adding them up, there is no double counting problem.

From this finding, an inference can be drawn: if only one subindustry (such as the travel agency industry) of the tourism sector is chosen as the initial impact point to estimate the economic impact rather than multiple industries that are simultaneously impacted, then the impacts of all aspects are significantly underestimated. Therefore, this approach should not be adopted in future research.

Compared with the calculation results of the traditional SAM method based on the same data, we estimate a significantly different industrial structure. From the perspective of total impacts, the output result of the traditional calculation is slightly less than that calculated by the new method, while its value-added and employment results are slightly higher. The implication of this seemingly contradictory result is that when we estimate the economic impact of multiple industries simultaneously affected by exogenous shocks, these industries should be treated as a whole to participate in calculation jointly; otherwise, we obtain the incorrect industrial structure of the associated impacts.

This paper only develops a new SAM-based multiplier calculation and decomposition method for the case in which multiple industries are affected by the same shock simultaneously. The SAM-based multiplier calculation assumes that prices and all income and expenditure coefficients are constant, and the same is true of the method in this article. Therefore, the method needs to evolve in terms of flexibility and dynamism to improve its predictive capabilities, although this method is still applicable when studying the effects of an exogenous impact on the characteristics of the industrial structure.

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Appendix A.1

Macro-SAM for China, 2017

2017 (CNY × 10^9)		01	02	03	04	05	06	07	08	09	10	Total
01	Commodities		1434518			320427		123750	359151	8307	163847	2410000
02	Activities	2257734										2257734
03	Labor		423268								1468	424735.6
04	Capital		304969								17896	322864.7
05	Households			424279.4	30627.82		52836.89	5385.742			472	513601.5
06	Enterprises				265191							265191
07	Government	2997.85	94979		7454.6	11966.37	38717.47		26245.61		1430.722	183791.2
08	Saving-Investment					180564.1	173636.6	52593.53			−13090	393704
09	Inventory								8307			8307
10	Rest of the world	149268		456.2393	19591.34	644.3358		2061.644				172021.9
Total		2410000	2257734	424735.6	322864.7	513601.5	265191	183791.2	393704	8307	172021.9	

Source: Authors' estimation.

Appendix A.2

Output Impact of Domestic and Inbound Tourism (partial, CNY × 10^9)

	Domestic Tourism Impact					Inbound Tourism Impact				
Industry	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total
Wholesale and retail Trade	4545.70	1184.41	3628.44	250.19	9608.74	1819.81	219.96	750.62	58.18	2848.58
Transport, Storage and Post	12593.10	2548.55	3520.65	796.71	19459.01	2621.43	572.09	734.93	172.84	4101.29
Accommodation	5842.90	89.45	396.20	28.71	6357.26	1204.24	24.69	85.58	7.08	1321.59
Food and Beverage Services	8116.30	295.13	1422.67	86.76	9920.86	963.50	68.66	305.44	19.52	1357.11
Culture, Sports and Entertainment	1852.20	176.10	506.15	44.37	2578.82	617.87	51.66	108.25	10.63	788.41
Telecommunication, Software and Information Technology Service	649.65	494.33	352.94	295.34	1792.26	44.90	129.59	265.10	81.12	520.72
Farming, Forestry, Animal Production and Fishery	1692.72	4091.77	1687.72	2149.94	9622.15	281.61	741.12	362.22	460.26	1845.22
Mining and Washing of Coal	8.40	622.86	152.71	484.81	1268.78	1.89	134.30	33.03	103.79	273.01
Extraction of Crude Petroleum and Natural Gas	0.03	1195.38	220.77	515.48	1931.67	0.01	255.43	47.50	110.42	413.36
Food, Beverages and Tobacco products	5499.96	2541.73	2119.65	1311.41	11472.76	950.83	461.87	455.24	279.83	2147.77
Manufacture of Chemicals and Chemical products	612.90	3209.55	1231.76	2802.10	7856.30	137.08	675.62	265.14	598.94	1676.78
Manufacture and Processing of Metals	7.64	1242.99	336.06	1103.20	2689.89	1.64	276.40	73.08	235.84	586.96
Fabricated Metal Products	59.46	455.50	136.78	340.61	992.36	13.07	101.05	29.69	72.53	216.34

(*continued*)

Continued.

Industry	Domestic Tourism Impact					Inbound Tourism Impact				
	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total
General-Purpose Machinery	129.92	466.69	134.09	352.34	1083.03	27.59	100.95	28.99	75.32	232.85
Transport Equipment	1468.02	1016.83	602.90	482.88	3570.63	317.28	224.30	129.12	102.91	773.61
Electrical Machinery and Apparatus	205.01	592.01	251.94	458.19	1507.15	54.83	129.57	55.17	95.61	335.18
Computer, Communication Equipment and Other Electronic Equipment	294.44	1194.81	521.09	1152.24	3162.57	83.55	256.99	117.67	235.25	693.47
Production and Supply of Electricity and Steam	574.49	1186.16	420.09	940.10	3120.84	132.03	252.35	91.16	199.56	675.10
Finance	2636.59	1475.40	1050.21	894.57	6056.76	610.26	327.82	226.36	187.15	1351.60
Real Estate	2088.36	746.93	1027.16	381.14	4243.60	518.62	160.37	222.03	73.60	974.61
Renting and Leasing, Business Services	1485.79	1491.49	700.76	856.08	4534.11	410.78	315.98	153.62	172.72	1053.09
Services to Households, Repair and Other Services	737.73	198.11	359.71	125.43	1420.98	170.44	43.18	77.03	26.31	316.95

Source: Authors' estimation.

Appendix A.3

Value Added Impact of Domestic and Inbound Tourism (partial, CNY × 10^9)

	Domestic Tourism Impact					Inbound Tourism Impact				
Industry	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total
Wholesale and retail Trade	3022.65	787.57	2412.72	166.36	6389.30	1210.08	146.26	499.12	38.69	1894.15
Transport, Storage and Post	5704.79	1154.52	1594.89	360.92	8815.11	1187.53	259.16	332.93	78.30	1857.92
Accommodation	2443.57	37.41	165.70	12.01	2658.68	503.63	10.33	35.79	2.96	552.70
Food and Beverage Services	2801.85	101.88	491.13	29.95	3424.81	332.61	23.70	105.44	6.74	468.49
Culture, Sports and Entertainment	958.70	91.15	261.98	22.97	1334.80	319.81	26.74	56.03	5.50	408.08
Telecommunication, Software and Information Technology Service	339.36	258.23	184.37	154.28	936.24	23.46	67.70	138.48	42.38	272.01
Farming, Forestry, Animal Production and Fishery	1006.07	2431.95	1003.10	1277.82	5718.94	167.38	440.48	215.29	273.56	1096.71
Mining and Washing of Coal	4.30	319.01	78.21	248.30	649.83	0.97	68.78	16.92	53.16	139.83
Extraction of Crude Petroleum and Natural Gas	0.02	795.62	146.94	343.09	1285.68	0.01	170.01	31.62	73.49	275.13
Food, Beverages and Tobacco products	1300.37	600.95	501.15	310.06	2712.53	224.81	109.20	107.63	66.16	507.80
Refined Petroleum, Coke Products, Processing of Other Fuel	340.37	155.00	86.81	119.98	702.16	73.09	33.57	18.68	25.62	150.96
Manufacture of Chemicals and Chemical products	142.06	743.91	285.50	649.47	1820.93	31.77	156.59	61.45	138.82	388.65
Manufacture and Processing of Metals	1.72	279.71	75.63	248.26	605.32	0.37	62.20	16.45	53.07	132.09
Transport Equipment	324.16	224.53	133.13	106.63	788.44	70.06	49.53	28.51	22.72	170.82
Production and Supply of Electricity and Steam	184.31	380.54	134.77	301.60	1001.22	42.36	80.96	29.24	64.02	216.58
Finance	1510.10	845.03	601.50	512.36	3468.99	349.53	187.76	129.65	107.19	774.12
Real Estate	1556.97	556.88	765.80	284.16	3163.80	386.65	119.56	165.53	54.87	726.62
Renting and Leasing, Business Services	486.64	488.50	229.52	280.39	1485.05	134.54	103.49	50.32	56.57	344.92
Services to Households, Repair and Other Services	385.56	103.54	187.99	65.55	742.64	89.08	22.56	40.26	13.75	165.65

Source: Authors' estimation.

Appendix A.4

Employment Impact of Domestic and Inbound Tourism (partial, 10^4 person)

	Domestic Tourism Impact					Inbound Tourism Impact				
Industry	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total	Direct Effect	Indirect Effect	Spillover Effect	Reverberation Effect	Total
Wholesale and retail Trade	246.52	64.23	196.77	13.57	521.09	98.69	11.93	40.71	3.16	154.48
Transport, Storage and Post	430.87	87.20	120.46	27.26	665.78	89.69	19.57	25.15	5.91	140.32
Accommodation	428.09	6.55	29.03	2.10	465.78	88.23	1.81	6.27	0.52	96.83
Food and Beverage Services	431.18	15.68	75.58	4.61	527.04	51.19	3.65	16.23	1.04	72.10
Culture, Sports and Entertainment	87.76	8.34	23.98	2.10	122.18	29.27	2.45	5.13	0.50	37.35
Telecommunication, Software and Information Technology Service	12.08	9.19	6.56	5.49	33.32	0.83	2.41	4.93	1.51	9.68
Farming, Forestry, Animal Production and Fishery	321.93	778.20	320.98	408.89	1829.99	53.56	140.95	68.89	87.54	350.93
Mining and Washing of Coal	0.27	20.02	4.91	15.59	40.79	0.06	4.32	1.06	3.34	8.78
Food, Beverages and Tobacco products	76.17	35.20	29.36	18.16	158.90	13.17	6.40	6.31	3.88	29.75
Papermaking, Printing, Stationeries, Musical Instruments, Arts and Crafts, Sports Goods, Games and Toys	6.52	17.07	6.21	10.39	40.19	1.83	3.77	1.37	2.13	9.10
Manufacture of Chemicals and Chemical products	6.92	36.21	13.90	31.62	88.64	1.55	7.62	2.99	6.76	18.92
Finance	70.38	39.39	28.04	23.88	161.68	16.29	8.75	6.04	5.00	36.08
Real Estate	43.68	15.62	21.48	7.97	88.75	10.85	3.35	4.64	1.54	20.38
Renting and Leasing, Business Services	60.25	60.48	28.42	34.71	183.86	16.66	12.81	6.23	7.00	42.70

Source: Authors' estimation.

Appendix A.5

Comparison of Output Impacts Computed by Two Methods

No.	Industry	Output Impact Calculated by Traditional Method (CNY × 10^9)	Output Impact Calculated by New Method (CNY × 10^9)	Value Added Coefficients	Employment Coefficients (Person/10^4CNY)
1	Real Estate	5116.8865	4243.5976	0.7455	0.0209
2	Telecommunication, Software and Information Technology Service	1928.5640	1792.2601	0.5224	0.0186
3	Food, Beverages and Tobacco products	12735.2561	11472.7606	0.2364	0.0139
4	Textile Wearing Apparel, Leather, Fur, Feather and Its Products and Footwear	1596.3700	1342.3613	0.1926	0.0245
5	Transport Equipment	3827.5790	3570.6294	0.2208	0.0080
6	Services to Households, Repair and Other Services	1736.2161	1420.9759	0.5226	0.1039
7	Education	1093.0940	731.2656	0.7127	0.0809
8	Health Care and Social Work Activities	956.5182	624.3778	0.4078	0.0474
9	Production and Distribution of Gas	601.3920	542.9407	0.2567	0.0133
10	Finance	6445.7129	6056.7649	0.5727	0.0267
11	Manufacture of Chemicals and Chemical products	6558.3952	7856.2992	0.2318	0.0113
12	Mining and Washing of Coal	970.1213	1268.7844	0.5122	0.0321
13	Extraction of Crude Petroleum and Natural Gas	1685.8913	1931.6675	0.6656	0.0121
14	Mining of Metal Ores	430.2894	655.9769	0.4582	0.0233
15	Mining and Quarrying of Non-metallic Mineral and Other Mineral, and Mining Support Activities	337.8496	440.4191	0.4443	0.0309
16	Textiles	1495.7471	1730.7999	0.1756	0.0190
17	Papermaking, Printing, Stationeries, Musical Instruments, Arts and Crafts, Sports Goods, Games and Toys	1956.5837	2106.5760	0.2322	0.0191
18	Manufacture of Non-metallic Mineral	525.1466	645.1546	0.2866	0.0193
19	Manufacture and Processing of Metals	1997.3792	2689.8911	0.2250	0.0103
20	Fabricated Metal Products	818.6298	992.3608	0.2428	0.0196
21	General-Purpose Machinery	894.5953	1083.0312	0.2292	0.0141
22	Special-Purpose Machinery	531.5479	658.7951	0.2344	0.0160
23	Electrical Machinery and Apparatus	1357.0394	1507.1483	0.1916	0.0119
24	Computer, Communication Equipment and Other Electronic Equipment	2648.0030	3162.5731	0.1635	0.0125
25	Other Manufacture, Utilization of Waste Resources	357.2815	448.4742	0.6188	0.0227
26	Production and Supply of Electricity and Steam	2691.9467	3120.8398	0.3208	0.0100

(*continued*)

Continued.

No.	Industry	Output Impact Calculated by Traditional Method (CNY × 10^9)	Output Impact Calculated by New Method (CNY × 10^9)	Value Added Coefficients	Employment Coefficients (Person/10^4CNY)
27	Technical Services	542.5701	610.2508	0.3898	0.0294
28	Wholesale and Retail Trade	9778.9477	9608.7381	0.6649	0.0542
29	Transport, Storage and Post	19076.1190	19459.0126	0.4530	0.0342
30	Accommodation	6378.6903	6357.2616	0.4182	0.0733
31	Food and Beverage Services	10008.9231	9920.8637	0.3452	0.0531
32	Culture, Sports and Entertainment	2597.3174	2578.8155	0.5176	0.0474
33	Farming, Forestry, Animal Production and Fishery	9525.7683	9622.1496	0.5944	0.1902
34	Wood and Furniture	466.2327	494.6496	0.2134	0.0200
35	Refined Petroleum, Coke Products, Processing of Other Fuel	2722.9579	2777.8722	0.2528	0.0035
36	Measuring Instruments	288.3351	352.5814	0.2533	0.0138
37	Fabricated Metal Products, Machinery and Equipment Repair	62.8463	69.4174	0.2240	0.0146
38	Production and Distribution of Water	197.2610	178.1826	0.4675	0.0313
39	Construction	223.2623	227.8077	0.2417	0.0258
40	Renting and Leasing, Business Services	4528.1404	4534.1079	0.3275	0.0406
41	Research and Development	0.0000	0.0000	0.4281	0.0281
42	Management of Water Conservancy, Environment and Public Facilities	229.7139	225.1057	0.4257	0.0488
43	Public Management, Social Security and Social Organization	98.4695	89.4914	0.6054	0.0800

Source: Authors' estimation.