Input-output System Dynamics Model of Regional Tourism

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Abstract:.
The importance of tourism to the economy is widely recognized. Tourism multiplier models and input-output analysis techniques are commonly used to measure the economic impact of changes in tourism spending. However, because the relationship between tourism and economic activity is more complex than these analytical methods assume, they all have technical limitations. This paper explores how a system dynamics perspective can be used to analyze the economic impact of tourism, taking into account the challenges for domestic tourism highlighted by COVID-19. Specifically, we will develop the standard input-output model in tourism analysis into a system dynamics model and attempt to incorporate region-specific issues into the computational process.

Keywords: tourism, input-output analysis, economic ripple effects, rural development

1. Introduction

Tourism is one of the fastest growing industries. According to the United Nations World Tourism Organization (UNWTO), tourism is an important part of international trade, a major source of income for many developing countries, and provides economic and employment benefits in a wide range of related economic sectors even in developed countries.

After World War II, inbound tourism was also emphasized in Japan to earn foreign currency for economic rebuilding. However, the rapid economic recovery from the mid-1950s increased the number of Japanese traveling abroad. By 1971, the number of outbound tourists exceeded the number of inbound tourists, and the gap between the two widened against the background of the strong yen. In 1994, the Ministry of Transport (now the Ministry of Land, Infrastructure, Transport and Tourism) formulated the "Welcome Plan 21 (Plan to double the number of outbound tourists to Japan)" to change the imbalance in the balance of payments for travel, and in 2002, the then Koizumi Cabinet approved the "Basic Policy for Economic and Fiscal Management and Structural Reform 2002", which positioned tourism as a "new growth area". The plan was approved in 2002.

The "Tourism Nation Promotion Basic Law", which came into effect in January 2007, aims to capture overseas travel demand as before, but it has been re-explained that tourism contributes to stimulating the local economy and increasing employment opportunities. It is now redefined. The "Tourism Nation Promotion Basic Plan", approved by the Cabinet in March 2017, states that tourism is a key element of the Basic Plan for the Promotion of a Tourism Nation, which aims to attract overseas travel demand to Japan's rural areas. in March 2017, calls for tourism to grow into a key industry in the face of a declining population.

In this context, tourism policies are currently being promoted in many parts of the country. But is tourism promotion an essential policy for the growth of all local economies? The new coronavirus disease (COVID-19), which began in late 2019, has caused significant damage not only to international tourism, but also to domestic tourism. At the time, city officials and tourism association officials in Atami Onsen (Atami City, Shizuoka Prefecture), one of the three major hot springs in Japan, called for voluntary refraining from visiting by people from outside the prefecture.[1] This news made the author aware of the vulnerability of the tourism industry. Therefore, in order to accurately and quickly estimate the economic losses from the Coronavirus pandemic, the author decided to consider a method to estimate the economic spillover effects on a monthly basis. Input-output analysis is commonly used to estimate economic impacts in regional economies, including tourism. This method provides predicted values one or more years in the future. But is a forecast

1 https://www.chunichi.co.jp/article/22535 (accessed 30 November 2023). The city of Atami is also known as the gateway to the Izu Peninsula.

more than a year ahead useful for businesses and residents in the middle of a pandemic? I decided to develop a tourism analysis model because I believe that system dynamics, which reveals the behavior of socio-economic phenomena over time, must be able to provide rapid predictions for the near future. Section 2 below provides an overview of traditional analysis methods in tourism research, while Section 3 discusses the questions that require system dynamics. Sections 4 and 5 take the Izu Peninsula region of Shizuoka Prefecture as a specific example of a tourism destination and proceed with the analysis.

2. Tourism and the local economy

Local economies are struggling with a declining population due to natural decline caused by declining birth rates, an ageing population, and migration to urban areas. The basis of economic activity is consumption, and the circular structure of the regional economy can be represented by a causal loop diagram, as shown in Figure 1

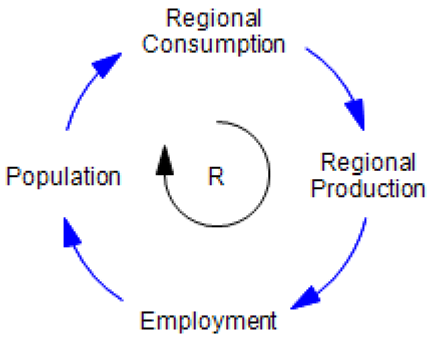

Figure 1: Basic regional economic circulation

From the economic theory perspective, local residents' consumption activities stimulate production activities through a multiplier effect, which supports the regional economy by expanding incomes. Economic expansion creates new jobs, attracts workers from outside the region, and increases the local population. Population decline due to ageing and the out-migration of young residents will turn this positive cycle into a negative one.

To reverse the decline of regional economies, governments have tried to attract businesses and universities, but in recent years, the role of tourism has been reassessed. This is because it can capitalize on the region's unique resources. Policies and commentators promoting tourism emphasize its significant role in stimulating the regional economy. For example, Aso (2015) points out that "by attracting overnight guests from outside the region through tourism promotion and drawing tourism consumption from them, a circulation of money is created within the region, which induces investment within the region, resulting in increased income, employment and tax revenues under the economic ripple effect, and stimulating the regional economy" (p. 119). The economic effects of tourism promotion are expected to ripple through a wide range of related industries, including agriculture, forestry, fisheries, manufacturing, and retail trade, with the accommodation, transportation, and food and beverage industries at the core. The breadth of the so-called "range" is a characteristic of tourism and is the reason why tourism promotion is attracting attention as a means of regional development.

Regional multiplier or input-output analysis is used to measure the ripple effects of tourism on the local economy. Regional multiplier analysis is highly consistent with economic theory as it was developed from J.M. Keynes' (1883-1946) theory of the national economy. However, research is required on the income cycle structure of the target region. On the other hand, input-output analysis can use input-output tables that reflect the characteristics of the target region; as pointed out by Fletcher (1989), input-output analysis using input-output tables can be useful to determine the economic effects of tourism, and analyses using this method are flourishing[2].

Input-output tables are basic statistics that show, in matrix form, the flow of goods and services (economic circulation) over a given period (usually one year) in the target economy, as the relationship between industrial sectors, between

[2] According to the 'Survey of input-output table production in the world' (https://www.sanken.keio.ac.jp/user/kiji/iohiroba/worldio/Report-J.htm, accessed 30 November 2023), as of 1999, input-output tables had been produced in more than 83 countries worldwide. In Japan, input-output relations tables are called inter-industry relations tables, and input-output analysis is called inter-industry analysis.

industry and households and capital, and between industry and the outside world (overseas). In Japan, national input-output tables have been compiled every five years since the first tables were compiled in 1951. In conjunction with the national tables, 47 prefectures and government-designated large cities have also compiled input-output tables.

Table 1: Structure of an input-output table comprising two sectors

Input \ Output		Intermediate Demand: Industry 1	Intermediate Demand: Industry 2	Final Demand	Imports	Total Output
Intermediate Input	Industry 1	X_{11}	X_{12}	F_1	$-M_1$	X_1
	Industry 2	X_{21}	X_{22}	F_2	$-M_2$	X_2
Value added		V_1	V_2			
Total Output		X_1	X_2			

The matrix expression for the row direction of the input-output table is

$$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{F} - \boldsymbol{M} \tag{1}$$

where $\boldsymbol{A}$ is known as the technical coefficient matrix. The technical coefficient $a_{ij} = \frac{x_{ij}}{x_j}$ represents of requirements of input *i* needed in the production of one unit of output *j*, reading *i* as a row and *j* as a column. The technical coefficients for industries 1, 2, 3…*n* can be arranged into a matrix form.

$$\boldsymbol{A} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$$

$\boldsymbol{X}$ is the total production column vector, and $\boldsymbol{F}$ is the final demand column vector; and $\boldsymbol{M}$ is the transfer column vector. The regional economy also purchases goods from outside the region that are necessary for economic activities within the region. These imports are considered to depend on the sum of intermediate and final demand within the region. The ratio between total intra-regional demand and imports can be calculated for each industry as follows:

$$m_i = \frac{M_i}{\sum_{j=1}^{n} a_{ij}X_j + F_j}, j = 1, \cdots, n$$

The import coefficients for industries 1, 2, 3…*n* can be arranged into a matrix $\widehat{\boldsymbol{M}}$.

$$\widehat{M} = \begin{pmatrix} m_1 & 0 & \cdots & 0 \\ 0 & m_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & m_n \end{pmatrix}$$

Using this diagonal matrix, equation (1) becomes

$$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{F} - \widehat{\boldsymbol{M}}(\boldsymbol{AX} + \boldsymbol{F}) \tag{2}$$

This can be transformed to determine how much final demand ($\boldsymbol{F}$) will generate how much output ($\boldsymbol{X}$) that would generate ().

$$\boldsymbol{X} = \left[\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right]^{-1}\left[\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{F}\right] \tag{3}$$

where $\boldsymbol{I}$ is the unit matrix, and $\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)$ is the self-sufficiency matrix of the region in question. In the context of tourism, the amount consumed by tourists for goods and services in the region is the final demand.$\boldsymbol{F}$ The amount of goods and services that can be supplied within a region is determined by multiplying the amount of tourism consumption by the self-sufficiency ratio (direct effect). In addition, most of the goods consumed in the tourism sector of the region and its raw materials are purchased from other industrial sectors.$\left[\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right]^{-1}$ is a matrix showing the magnitude of production spillovers induced directly and indirectly in each industry through the demand for intermediate goods necessary for the production of one unit of final demand in an industrial sector, and is called *Leontief inverse* matrix, after W. W. Leontief (1906-99), who devised the input-output table. An input-output analysis is depicted in a causal loop diagram in Figure 2.

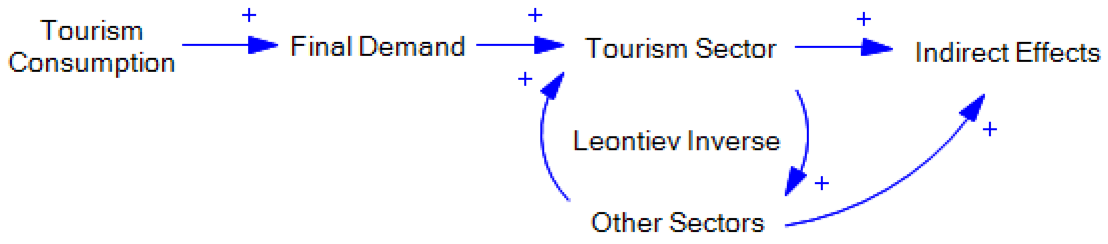

Figure 2: Input-output analysis

The resulting production spillovers are the sum of direct and indirect effects.

Public authorities produce input-output tables in many countries worldwide, and they are reliable. However, this analytical approach remains problematic.

(1) Only one-way causality is shown.

In input-output analysis, the increase in final demand due to tourism spending increases total economic activity by adding up production activity in other industries. It always generates more income than the initial increase in demand. Therefore, increasing the number of tourists is desirable in an assessment based on input-output analysis (Dwyer *et al*., 2003). However, Fujimoto (1993) points out that the input-output model "does not include a feedback loop and is designed as a system of unilateral causality without interdependent mechanisms."

(2) It ignores the existence of supply constraints.

In local economies, resources such as labor, land, and capital are finite. If supply constraints exist, expanding production in the short run is impossible to meet a sudden increase in final demand. There would also be upward pressure on factor prices. However, resource scarcity and price fluctuations are rarely considered in input-output analysis. In addition, feedback effects that work in the opposite direction of such changes in final demand are not taken into account, such as additional inputs of production factors to the tourism industry that reduce inputs to other industries and thus work to reduce production activity in the industry with reduced inputs.

(3) The technical relationship between industries is fixed.

Input-output tables provide information on the economy's structure for a given period, usually one year. Transaction tables, which record the production flow, explain where each industry's output goes and from where the inputs come. Although input-output tables can provide helpful information about the economic structure of an area, production technology, and factor inputs will change over time. In contrast, the production technology assumed by the transaction tables sees the ratio of inputs to output as a fixed proportional relationship (Leontief-type production function). It is assumed to remain invariant concerning the period over which the forecast is made.

While the input-output analysts are considering improving problem (3), other analytical methods will be necessary to overcome the problems in (1) and (2). System dynamics is one useful method.

3. Tourism dynamics

Except for some studies on environmental issues, support for input-output analysis has yet to be found in system dynamics. In addition, only some industries are dealt with when they are covered. The reasons are that the fixed ratio production in input-output analysis eliminates non-linearity (Andria and Provenzano, 2006), and the solutions obtained dynamically may not match the static solutions of input-output analysis (Braden, 1981).

According to Gazoni and Silva (2021), who researched tourism papers from a system dynamics perspective, tourism has a negative side. For example, while region-specific resources such as natural landscapes and historical culture increase tourism attractiveness, an increase in tourism damages these resources, thus drawing a negative feedback loop (Figure 2). In recent years, a phenomenon known as "overtourism" or "tourism pollution" has become a non-negligible issue in Japan, in Mt. Fuji and Kyoto City.

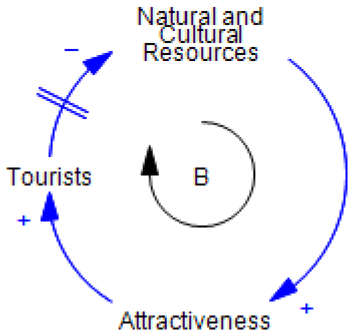

Figure 3: Sustainable tourism.

System dynamics is needed to handle negative loops. To address these points, let us consider tourism's specific economic benefits using an Izu Peninsula model that incorporates the input-output table into a system dynamics model.

4. The Izu Peninsula model

The Izu Peninsula region[3] of Shizuoka Prefecture, where hot springs were formed in the Edo period (1603-1868), became a tourist destination in the Meiji period (1868-1912) when the railway was built. The rugged coastline and steep terrain were not conducive to the development of manufacturing industries, but they were excellent resources for tourism. After WWII, the area quickly became a tourist destination and vacation home resort, which continues to be so.

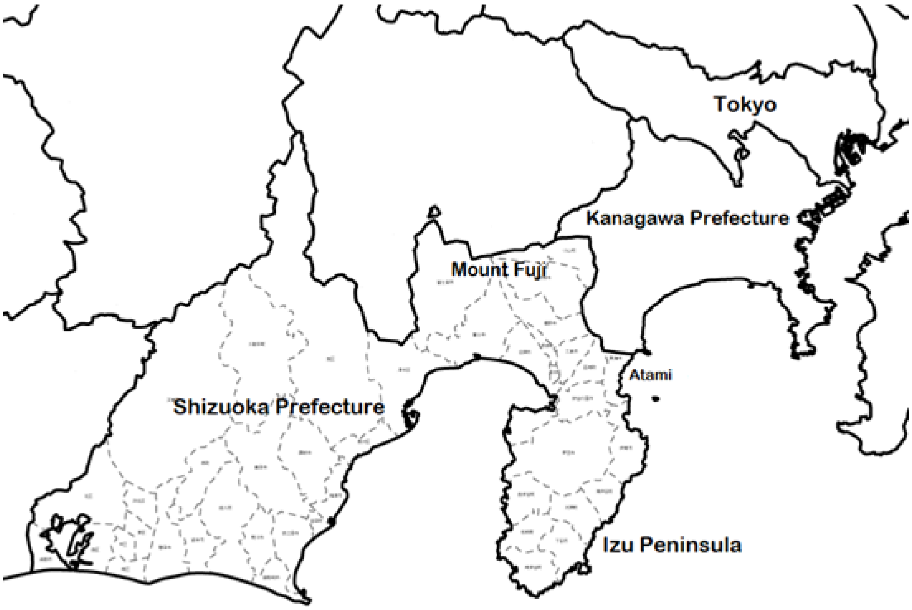

Figure 4: Izu Peninsula in Shizuoka Prefecture

The primary data used to calculate the economic impact of tourism is the amount of tourism consumption. We obtain tourism consumption by multiplying the number of tourists and consumption per capita.

$$\text{Tourism Cosumption} = \text{Number of tourists} \times \text{Tourism Consumption per capita}$$

Data on the number of visitors and consumption per tourism unit are available from the government and tourism associations. However, the measurement methods and accuracy need to be more reliable. We can obtain the monthly number of overnight and day visitors by region in Shizuoka Prefecture from the Shizuoka Prefectural Sports, Culture and Tourism Bureau's "Trends in Shizuoka Prefecture Tourism Exchange". Trends in the number of overnight visitors are

[3] The Izu Peninsula region consists of seven cities and six towns: Numazu, Atami, Mishima, Ito, Shimoda, Izu, Izu-no-kuni, Higashi Izu, Kawazu, Minami Izu, Matsuzaki, Nishi-Izu and Kannami.

essential regarding the size of unit tourism consumption. For this reason, we focus on the number of overnight visitors[4].

The coronavirus pandemic has significantly affected the number of overnight visitors crossing the prefectural border to the Izu Peninsula. Shizuoka Prefecture, known for its natural beauty, is the fifth most visited prefecture in the country, with over 50% of all overnight stays in the Izu Peninsula area. However, the "Shizuoka Prefecture Tourism Exchange Trends" data does not distinguish between in-prefecture and out-of-prefecture visitors. To address this, we turned to the Japan Tourism Agency's Lodging Travel Statistics Survey, which provides information on the number of overnight visitors by prefecture and place of residence, to estimate the number of overnight visitors.

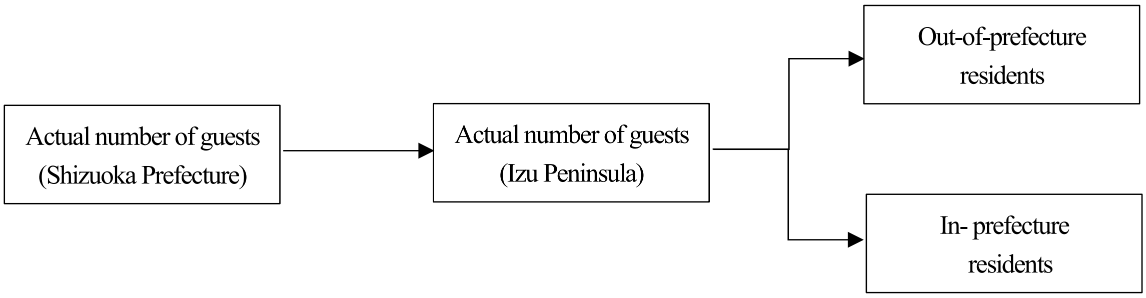

Figure 5: Procedure for estimating the number of overnight guests

The number of overnight guests in the Izu Peninsula region was obtained by starting with the number of actual overnight guests at the prefectural level in the Japan Tourism Agency's "Lodging Travel Statistics Survey" (Table 5) and multiplying by the share of overnight guests by region within the prefecture from the "Trends in Shizuoka Prefecture Tourism Exchange." Furthermore, using the share of residential areas from the Japan Tourism Agency's "Lodging Travel Statistics Survey" the number of overnight guests in the Izu region was divided into those from outside the prefecture or those from within the prefecture (Fig. 5). Fig.6 shows the number of actual overnight guests. The number in 2019, before the arrival of the new coronavirus, indicates that the Izu Peninsula is a busy tourist destination in summer.

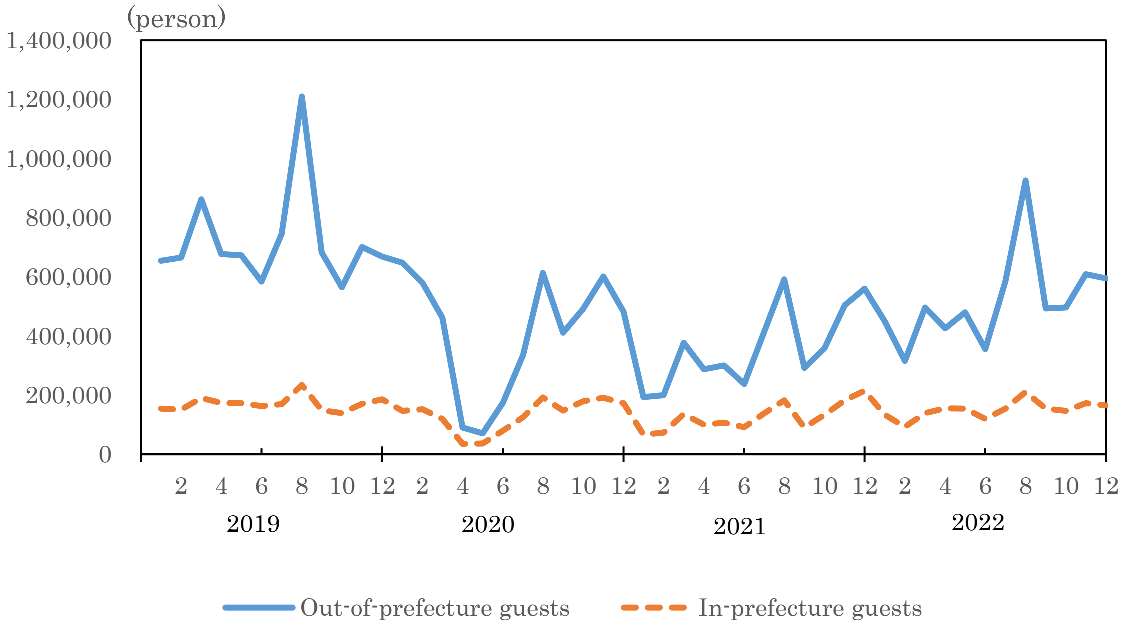

Figure 6: Number of overnight guests in the Izu Peninsula

For the unit cost of tourism consumption, we used "Total Travel Expenditure per Person" from the "Survey of Tourism Flow and Satisfaction in Shizuoka Prefecture" conducted by the Shizuoka Prefectural Sports, Culture and Tourism

4 It is important to note while lodging facilities are required to prepare and keep a guest list, accurately accounting for the number of day-trippers is impossible.

Bureau. Travelers in Shizuoka Prefecture answered the survey about their consumption expenditures in Shizuoka Prefecture during their trip, with overnight visitors divided into in-prefecture and out-of-prefecture groups. However, since the annual expenditures are aggregated into six categories - "transportation," "accommodation," "food and drink," "souvenirs and shopping," and "other" - it is not possible to directly allocate them to the refined sectoral categories in the input-output table. Therefore, I needed to allocate the expenditure proportionally to the 42 inputs-output table sectors based on the unit expenditure per item from the 2015 survey, which published the most detailed breakdown of expenditure items. It should be noted that some of the items used in the "Survey" were produced outside of Shizuoka Prefecture. For this reason, it was necessary to separate expenditure on goods produced in the prefecture from goods of unknown origin (i.e., goods produced outside the prefecture), even within the same industrial sector. In all expenditure categories, per capita consumption expenditure was higher for out-of-prefecture guests than in-prefecture guests.

For some products produced in the prefecture, intermediate products and raw materials are transferred from outside the prefecture, which can be included in the self-sufficiency ratio. Most local tourism resources, such as accommodation, food, and drink, are services with a self-sufficiency ratio of 1.

With the above preparations in place, the effect ΔX of a change in final demand ΔF on the economy as a whole is calculated. Namely,

$$\Delta\boldsymbol{X} = \left[\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right]^{-1}\left[\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\Delta\boldsymbol{F_1} + \Delta\boldsymbol{F_2}\right]$$

$$= \left[\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right]^{-1}\left\{n \times \left[\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\Delta\boldsymbol{f_1} + \Delta\boldsymbol{f_2}\right]\right\} \quad (4)$$

where, $\boldsymbol{F_1}$ is the value of tourism consumption of products produced in the prefecture, $\boldsymbol{F_2}$ is the value of tourism consumption of products from outside the prefecture, and $\boldsymbol{f_1}$ and $\boldsymbol{f_2}$ are per capita tourism consumption, respectively. n is the number of overnight stays. *Leontchev's inverse* matrix$\left(\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right)^{-1}$ and the self-sufficiency matrix $\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)$ are obtained from the "2015 Shizuoka Prefecture Input-Output Table."

Since system dynamics focuses on the behavior of the system over time (*t*), equation (3) becomes

$$\boldsymbol{X_{t+1}} = \left[\boldsymbol{I} - \left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{A}\right]^{-1}\left[\left(\boldsymbol{I} - \widehat{\boldsymbol{M}}\right)\boldsymbol{F_{1t}} + \boldsymbol{F_{2t}}\right] \quad (5)$$

In this study's model, the number of overnight visitors is set as the flow variable, and the production ripple effects are set as the stock variable, so the dynamic behavior is consistent with the results of the static analysis. A causal structure is assumed, as shown in Figure 2.

4.1 Production ripple effect

The input-output table used in this paper compiles the basic transactions in Shizuoka Prefecture during the year 2015, and is the most recent table published in December 2020. There are three transaction tables: 37-sector table, 108-sector table, and 187-sector table. In this study, the 108-sector table was used, and the "commerce" in the 108-sector table was further divided into "wholesale" and "retail," resulting in 108 sectors. Typically, in an inter-industry analysis, a year is used as the unit of analysis. However, since monthly data on the number of tourists is available for the Izu Peninsula, we decided to use one month as the time step unit of analysis.

By way of illustration, the value of tourism consumption is indicated by purchaser prices. The price of goods purchased by tourism entities is the producer's shipping price plus margins and freight charges. As the input-output table is prepared in producer prices, it was necessary to convert purchaser prices to producer prices. The commercial margin rate as a percentage of the purchaser price (w) and the transport cost ratio (tc) were calculated and these were redistributed between the commercial and transport sectors to convert tourism consumption to producer prices.

$$\text{Tourism Consumption (Producer price)} = \text{Tourism Consumption (Purchaser price)} \times (1 - w - tc) \quad (6)$$

The direct effect $(\boldsymbol{I}-\widehat{\boldsymbol{M}})\boldsymbol{F}$, the amount of money that tourism consumption directly brings to the tourism industry, should be calculated separately for out-of-prefecture and in-prefecture guests. Furthermore, $[(\boldsymbol{I}-\widehat{\boldsymbol{M}})\boldsymbol{F}_{1t}+\boldsymbol{F}_{2t}]$ is calculated outside the model because it requires sorting the goods and services. Figure 7 shows the process of calculating the direct effects of out-of-prefecture guests, where Guests_1 is the number of out-of-prefecture guests (scalar), Consumption_1 is the per capita tourism consumption vector (108 rows × 1 column) for out-of-prefecture guests. Direct_effects_1 returns the direct effects as an array of 108. It is a stock variable because it is consistent with the usual calculation of an input-output analysis when accumulated over 12 periods (12 months). However, the direct effects are cleared to keep track of movement each month using Previous_D1. The initial value of Direct_effects_1 is 0. Similarly, the direct effects of in-prefecture guests (Guests_2) are calculated.

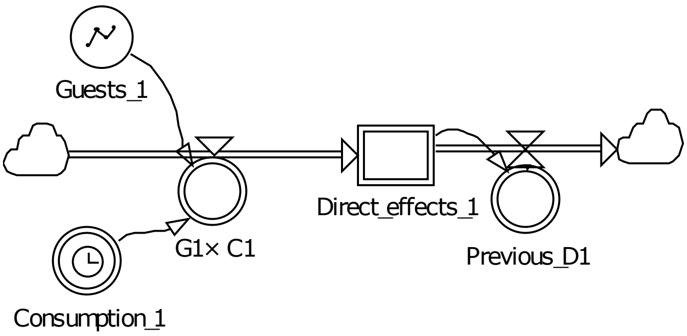

Figure 7: Direct effects of out-of-prefecture visitors

The inner product of the *Leonchev inverse* matrix (108 rows × 108 columns) and the direct effects (108 rows × 1 column) return the total effects: the sum of the direct effects on the tourism industry and the indirect effects (indirect first-order effects) on other industries that supply raw materials and intermediate goods to the tourism industry. Total_effects_1 is a stock variable with an array of 108 for the out-of-prefecture guests (Fig. 8); the initial value of Total_effects_1 is 0. The previous period's value (Previous_D1) is liquidated. In the same way, the production ripple effects from in-prefecture guests are calculated (Total_effects_2). Total_effects_1 and Total_effects_2 are summed in the auxiliary variable Sum_of_total_effects. The programming environment for System Dynamics does not have a complete set of functions for matrix calculations, so care had to be taken in the order of the calculations. [5]

[5] This study used Powersim Studio, which makes creating matrices easier than other software. Symbols surrounded by double lines represent arrayed variables calculated for each of the 108 sectors. The thick arrows on the right shoulder of Total_effects, etc., indicate that the calculated values are output to an external Excel file. The model in this study was also presented in Japanese. doi:10.24803/sdjapan.21.0_1.

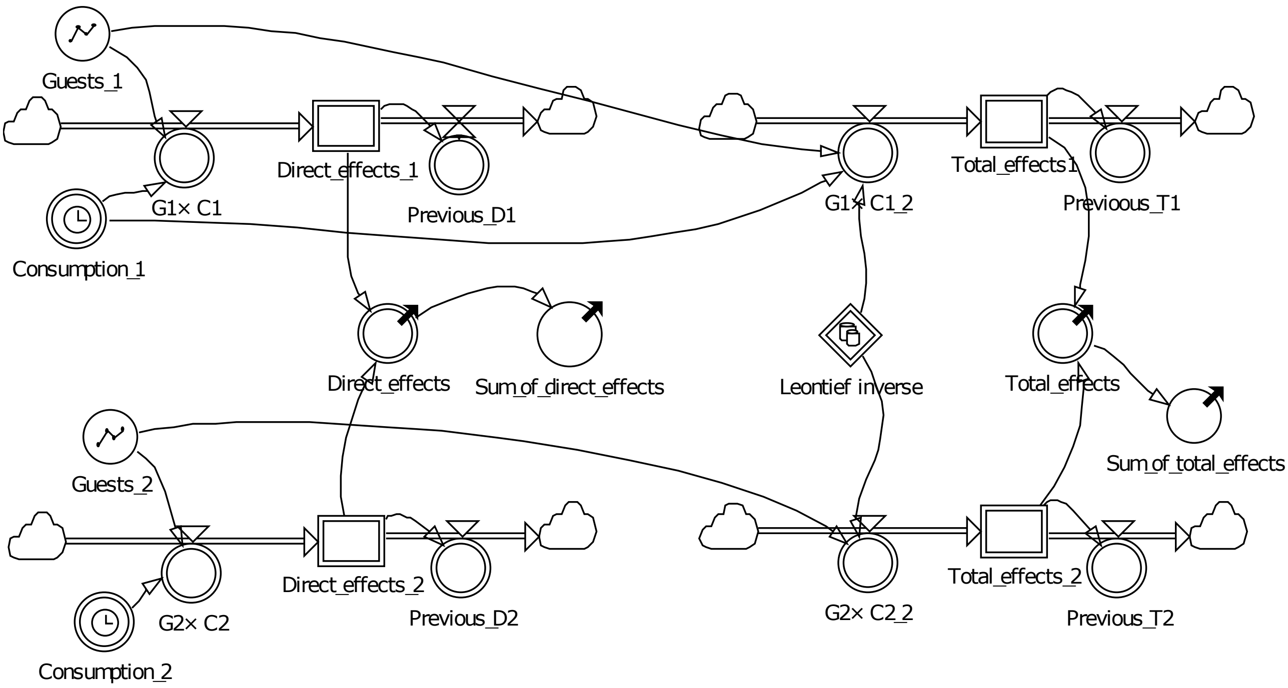

Figure 8: Calculation of production ripple effects

Figure 9 shows the production ripple effects (induced production) of Izu tourism from 2019 to the end of 2022. By incorporating a time component into the input-output model and running monthly estimates, the situation on the Izu Peninsula in the coronavirus pandemic was reproduced. The estimation results show that the Izu Peninsula experienced severe economic conditions during the busy summer.

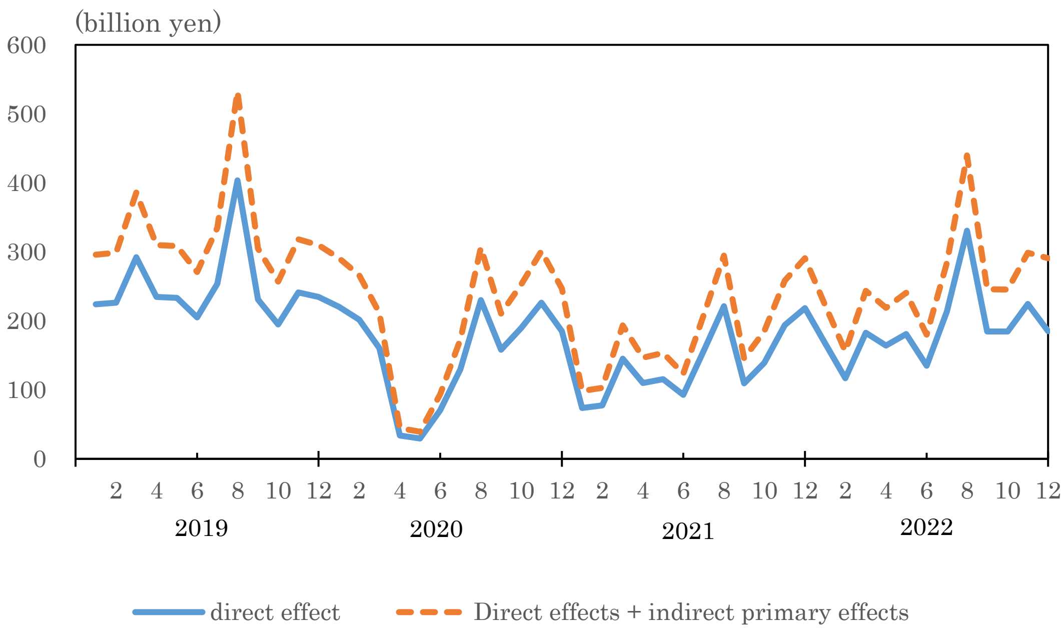

Figure 9: Production ripple effects of tourism (direct and indirect primary effects)

This study provides information on economic ripple effects by 108 sectors. Figure 10 shows the economic spillover effects (direct + indirect) for the three core tourism service industries. The first emergency declaration (7 April-25 May 2020), followed by the second emergency declaration (8 January-21 March 2021) and the third emergency declaration (25

April-20 June 2021), had a significant impact on movement restrictions.

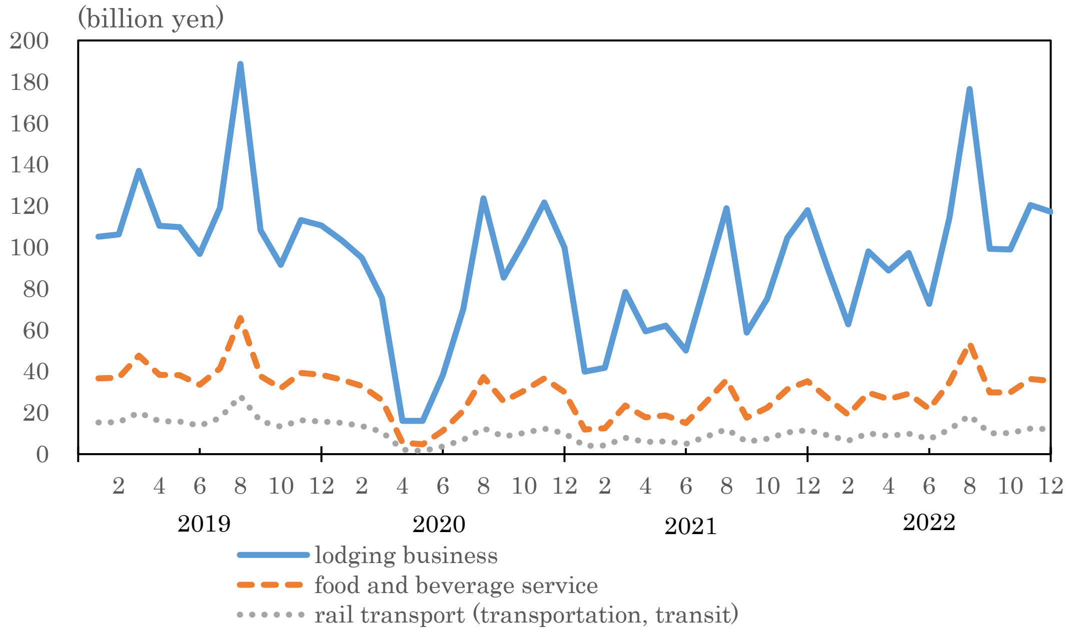

Figure 10: Economic spillovers in the tourism industry

4.2 Other effects.

Direct and indirect effects have been analyzed by focusing only on production activities and how much production increases. However, if production increases, income increases and consumption expenditure increases accordingly, the economic ripple effect should be calculated based on this increase in demand. These are called induced effects or indirect secondary effects. This additional ripple effect can be examined quantitatively by multiplying the production spillovers by the employment income rate. In addition, the number of induced jobs can also be measured by multiplying the employment coefficients by the production ripple effects (Figure 11).

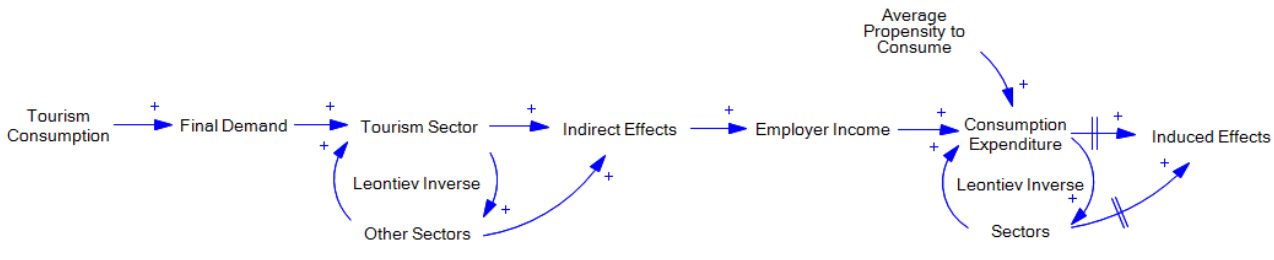

Figure 11: Induced and employment effects

The induced effect (indirect second-order effect) is derived from the following equation.

$$\Delta \boldsymbol{X2} = \left[\boldsymbol{I} - (\boldsymbol{I} - \widehat{\boldsymbol{M}})\boldsymbol{A}\right]^{-1}(\boldsymbol{I} - \widehat{\boldsymbol{M}})\boldsymbol{ckw}\Delta\boldsymbol{X} \tag{7}$$

where, $\boldsymbol{w}$ is the employment income rate, and $\boldsymbol{w}$ and $\Delta\boldsymbol{X}$ is the total employment income. $\boldsymbol{c}$ is the consumption coefficient and k is the household's average propensity to consume.

Another significant effect that can be derived from an input-output analysis is the employment-inducing effect, L_i If the employment coefficient for one unit of output in a sector is given by, with the amount of employment as

$$l_i = \frac{L_i}{X_i} \tag{8}$$

By multiplying the output of each sector by the employment coefficient, the amount of new employment needed can be projected.

$$\Delta \boldsymbol{E} = \boldsymbol{L} \times \Delta \boldsymbol{X} + \boldsymbol{L} \times \Delta \boldsymbol{X2} \tag{9}$$

where, $\boldsymbol{L}$ is the row vector of employment coefficients. In the system dynamics model, which examines the time-series behavior of each variable, $\Delta \boldsymbol{E}$ refers to the increase or decrease in the number of new jobs during each period.

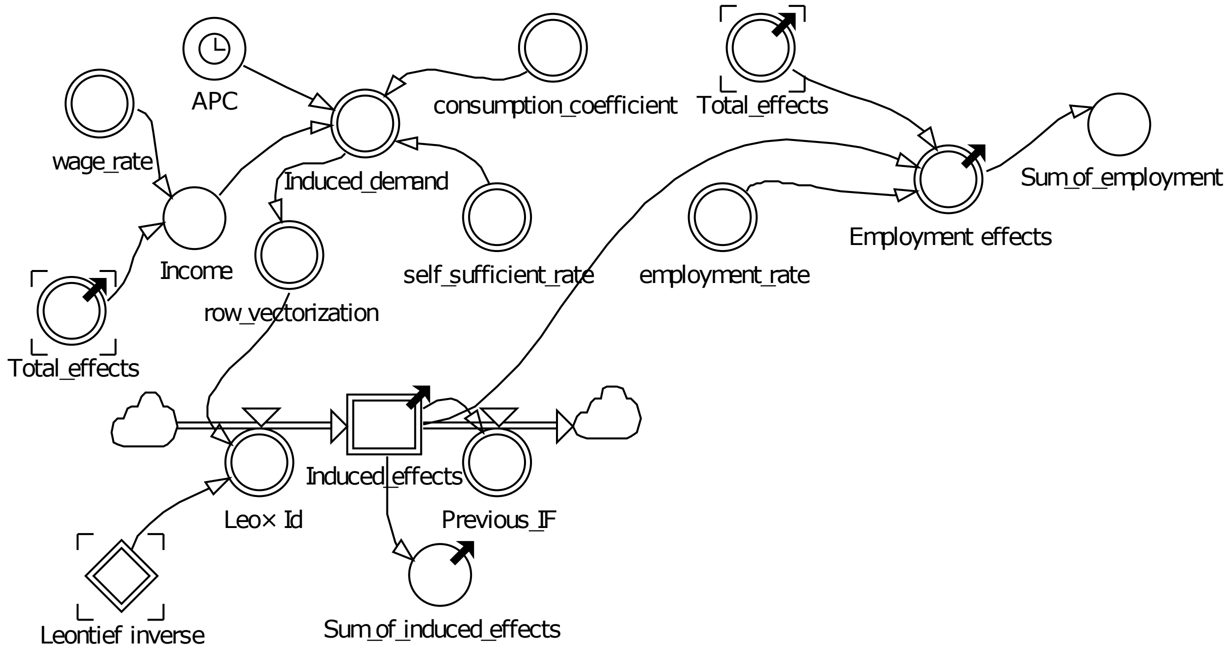

Figure 12: Calculation of induced and employment effects

In Figure 12, wage_rate is the wage income rate, income is the total wage income, APC is the average propensity to consume, consumption_efficient is the consumption coefficient, and self-sufficient_rate is the self-sufficiency rate. They are multiplied by the production spillovers $\Delta \boldsymbol{X}$ multiplied by.

$(\boldsymbol{I} - \widehat{\boldsymbol{M}})\boldsymbol{ckw}\Delta \boldsymbol{X}$i is the induced demand, an array with 108 elements. As it is not possible to take the inner product with the matrix as it is, it is necessary to use the auxiliary variable row_vectorization through

"FOR(i=1..108|{{'Induced_demand'[i]}})"

to create a column vector with 108 rows × 1 column. The inner product with the *Leontchev inverse* matrix was calculated to obtain the induced effects (second-order indirect effects) in equation (7) (Induced_effects). The labor income ratio was obtained from the ratio of labor income to output in each industry in the Shizuoka Prefectural Input-Output Table, the consumption coefficient was obtained from the ratio of private consumption expenditure to gross value added in the same data, and the average consumption propensity was obtained from the respective annual editions of the Annual Report on Household Budget Survey (Working Households, Tokai Region) of the General Affairs Agency.

The average consumption propensity was 0.6679 in 2019, 0.5950 in 2020, 0.6477 in 2021, and 0.6461 in 2022, indicating that consumption activity was sluggish due to requests to refrain from going out and the closure of offices due to emergency declarations. The calculation results also reflect changes in the average propensity to consume by changing the value of APC as the year progresses (Figure 13). Note that the indirect secondary effects are calculated one period (one month) later than the production spillover effects. However, this is a natural time lag because consumption spending is an economic activity after receiving monthly income. This reproduces a point that is overlooked in regular input-output analysis.

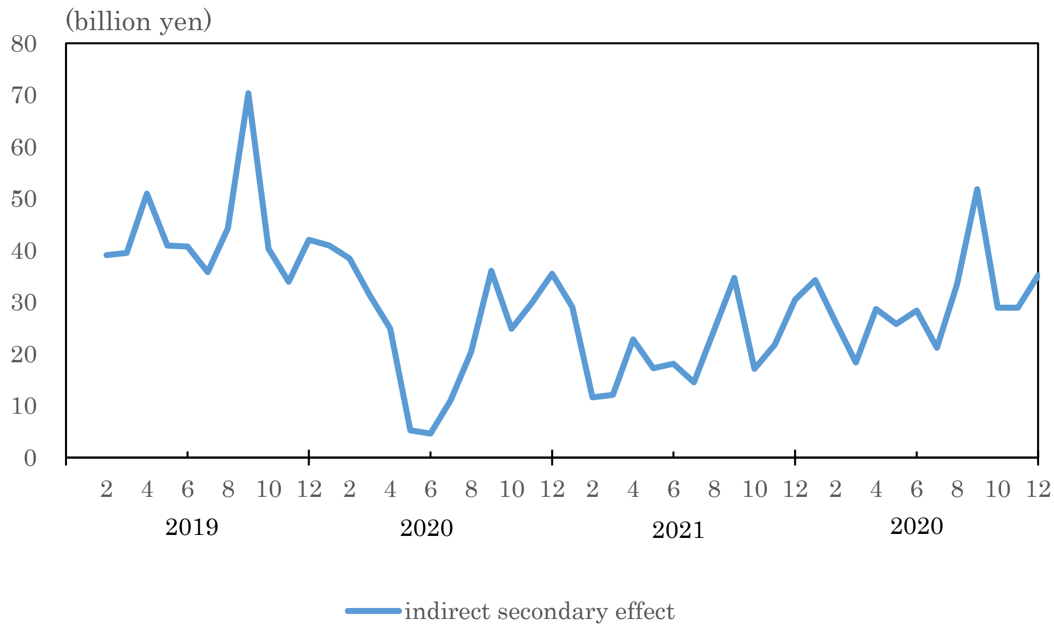

Figure 13: Indirect secondary effects

Returning to Figure 12, employment_coefficient is the employment coefficient for each industry. According to equation (9), this coefficient is multiplied by the output of each sector to determine the induced number of employees, which is the auxiliary variable Employment_effects. Since Employment_effects is divided by 108 sectors, it is summed by Sum_of_employment. The obtained economic spillovers are summarized in the usual form of an input-output analysis in Table 2.

Table 2: Summary of economic ripple effects

	Direct effect (billion yen)	Indirect effect (billion yen)	Induced effect (billion yen)	Total effect (billion yen)	Employment effect (person)
2019	2,975.0	951.6	478.0	4,404.6	34,623
2020	1,835.7	601.0	303.2	2,739.9	21,765
2021	1,653.5	547.4	254.2	2,455.1	19,601
2022	2,303.9	761.6	361.3	3,426.8	27,322

The total impact in 2020 was 40% lower than in 2019, before the arrival of the new coronavirus. In the second year of the coronavirus disaster, the overall impact in 2021 was 45% lower than in 2019, indicating that the economic situation was even more severe.

5. The future of the Izu Peninsula

What factors negatively affect tourism in the Izu Peninsula region? The constraints to economic ripple effects are the declining population and shrinking accommodation facilities. The size of the population or population agglomeration is one of the attractions of a tourist destination (Yamada and Kakishima, 2016), and the number of rooms in accommodation facilities, which supports the supply side of tourism, is also an attraction of a tourist destination. The recent emphasis on tourism promotion is because the relationship between tourism and economic growth has become more apparent. This hypothesis, known as the tourism-led growth hypothesis, has empirical support in international tourism. In domestic tourism, Soukiazis and Proença (2008) found that tourism positively impacts regional growth in Portugal through accommodation capacity.

However, the number of lodging rooms on the Izu Peninsula is declining. According to the Census conducted every five years, the number of people working in the "accommodation and food services industry" on the Izu Peninsula will decline at an average annual rate of 2.1% between 2010 and 2020. According to the census conducted every five years, the number of people employed in the "accommodation and food services" sector in the Izu Peninsula will decline at an average annual rate of 2.1% between 2010 and 2020. According to "Number of hotels, inns, and simple accommodation facilities and rooms" in the Shizuoka Prefectural Statistical Yearbook, the number of rooms in hotels and inns has declined at an average annual rate of -1.24% over the same period, suggesting a specific relationship between the number of workers and the number of rooms. Let us examine the question of the decline in the number of employees behind the number of rooms.

Add labor market dynamics to the model in Figure 3 (Figure 14). In the labor market, the employment-inducing effect that the employment coefficient tells us corresponds to an increase in the demand for labor. On the other side of the market is the labor supply, which corresponds to the lower demand or supply, so the market is in equilibrium. The equilibrium value is the number of people employed.

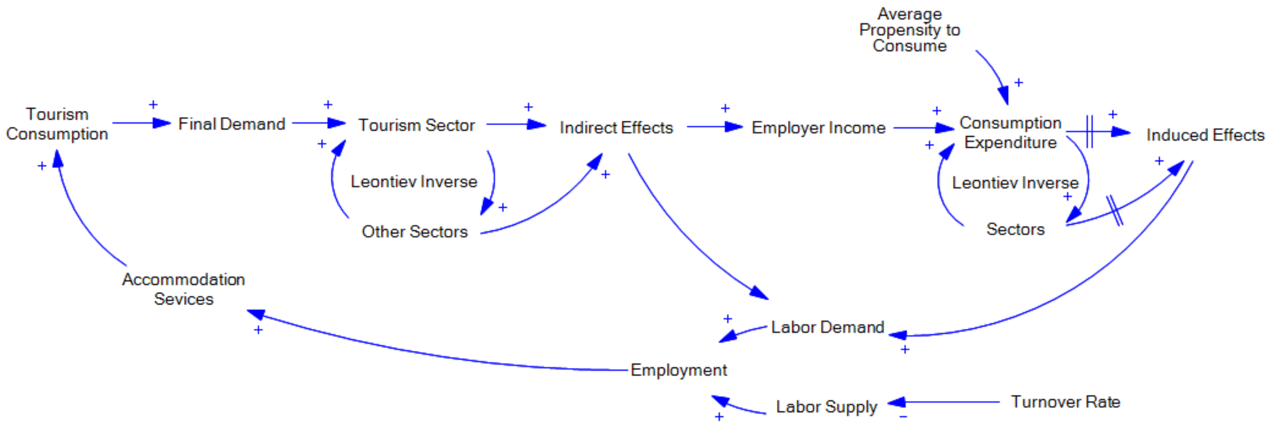

Figure 14: Supply constraints in the Izu Peninsula

The first step was forecasting the number of overnight stays (calendar year total) between 2023 and 2030. The number of out-of-prefecture overnight stays was forecast using an autoregressive integrated moving average (ARIMA) model based on figures from January 2015 to January 2020 before the coronavirus pandemic. ARIMA(0,2,2) was selected using the AIC (Akaike's Information Criterion) as the indicator. Since large seasonal fluctuations characterize the number of out-of-prefecture overnight guests, we prorated the average value from 2008 to 2018 by month. On the other hand, while the number of out-of-prefecture guests crossing the border in coronavirus pandemic declined sharply, there was almost no decline in the number of in-prefecture guests. There were also a few seasonal fluctuations. Therefore, we chose an ARIMA (3,0,3) model with AIC as the indicator based on the actual results from January 2015 to January 2020 (Figure 15).

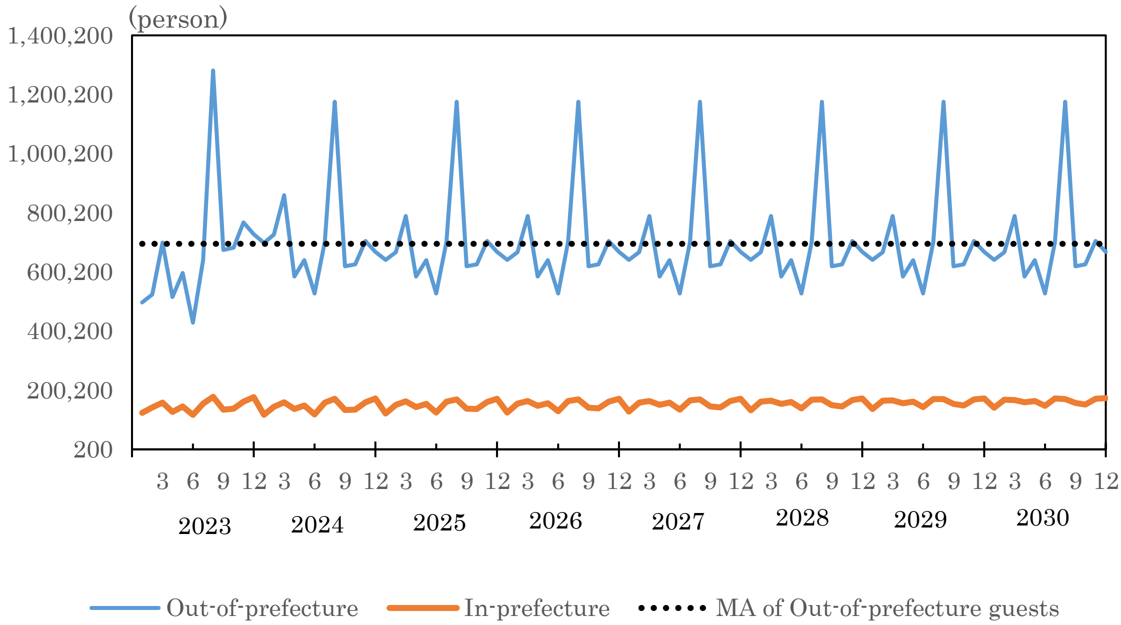

Figure 15: Number of overnight guests and the supply constraints in the Izu Peninsula

Next, the number of workers in the accommodation industry is considered. The census is an accurate indicator of the number of workers by industry. However, the statistical tables that cover all cities and towns in the county use broad industry categories, which means that the accommodation and food services industries are combined. According to the latest 2020 Census, the number of workers in the Izu Peninsula region's accommodation and food services industry in 2020 was 27,559. It is expected to continue to decline at the above-average annual rate of 2.1% (0.177% per month) through 2030. Few lodging bankruptcies have been reported in the coronavirus pandemic, partly due to government support for businesses. However, there may have been high job turnover and layoffs in the sector. This is because the accommodation industry has long experienced difficulties in recruiting workers. The labor shortage may become even more acute, as rehiring workers who have left or been laid off is generally tricky. To consider this, a scenario of an average annual decline of 4.2% (an average of 0.355% per month) was also prepared.

In the model, only employment in accommodation and food services was taken as labor demand (Demand_of_labor) from the employment effects (Employment_effects, Figure 16). The model's labor demand was set to 2,6423 + ΔL_102 + ΔL_103 = 27,559 in October 2020. In the sequential numbers in the input-output table, 102 refers to the accommodation and food services sector and 103 to the food and beverage services sector. For the labor supply (supply_of_labor), the initial value was set to 27,995 in October 2020, with the number of workers decreasing according to turnover_rate.

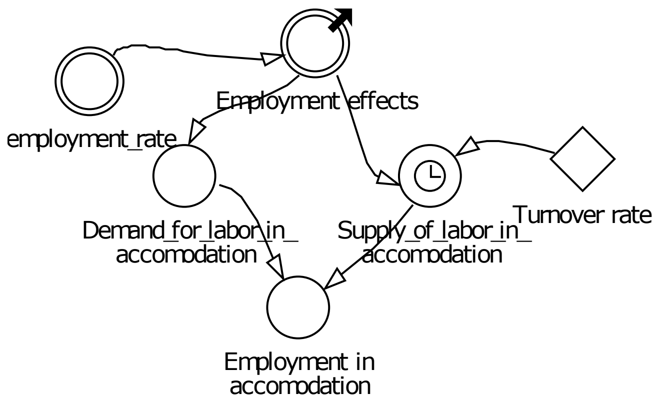

Figure 16: Labor market in the Izu Peninsula

A decrease in the number of workers is accompanied by a decrease in the number of rooms and food and beverage services, which undermines the capacity of accommodation service (capacity) for out-of-prefecture guests. As an indicator of this, "number of workers÷27995" was used and added as number of overnight guests x capacity beginning in December 2023 (Figure 17). [6] Capacity affects in-prefecture guests in the same way.

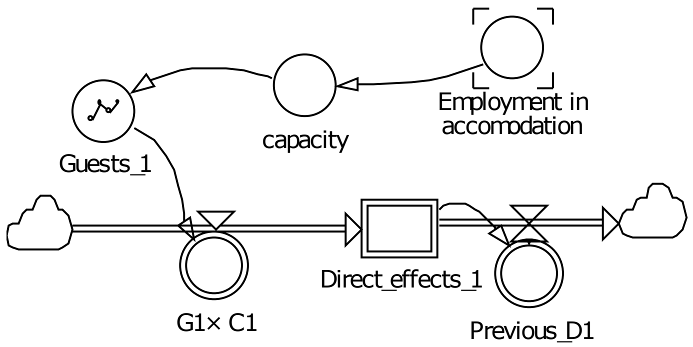

Figure 17: Change in capacity of accommodation service

Table 3 shows the simulation results assuming 0%, 2.1%, and 4.2% for the average annual decline in the number of employees.

Table 3: Future estimates of production ripple effects

	Production ripple effects (billion yen)		
Year	- 0%	- 2.1%	- 4.2%
2023	3,518.3	3,518.3	3518.3
2024	4,073.8	4,042.5	4,011.4
2025	3,931.0	3,892.3	3,853.9
2026	3,939.0	3,891.8	3,845.0
2027	3,947.3	3,891.5	3,836.3
2028	3,955.7	3,891.4	3,827.8
2029	3,964.1	3,891.2	3,819.3
2030	3972.6	3,891.0	38108

A standard input-output analysis does not consider the labor supply and demand mechanism, which is equivalent to assuming that the rate of decrease in the number of workers is 0%. For this reason, tourism research using input-output analysis invariably concludes that tourism promotion is desirable for the local economy. However, a system dynamics model that incorporates the supply and demand mechanisms of the labour market shows that the shortage of workers will gradually but surely reduce the economic benefits of tourism.

6. Conclusion

In this paper, input-output analysis has been developed as a system dynamics model, allowing us to identify economic conditions that ordinary input-output analysis cannot reveal. Inbound tourism has fully recovered in Japan, but tourism in rural areas is taking longer. We explored the reasons for this using the Izu region as an example. The specific results are as follows.

1) The SD input-output model estimates economic ripple effects every month. This approach precisely grasped tourism revenue, subject to significant seasonal fluctuations. As a case study, we were able to learn in detail about the difficulties

[6] At the time of modeling for this paper, it was possible to estimate the number of overnight guests through July 2023 from publicly available data, so capacity was included as a future estimate.

faced by the Izu Peninsula region during the coronavirus pandemic. In the Izu Peninsula region, which uses a rich natural environment, including hot springs, the sea and highlands, as tourist resources, the summer (August) is the busy season. However, the number of guests decreased during the busy and profitable season due to the fear of the coronavirus. This economic loss may delay the recovery of the local economy.

2) By developing an input-output model incorporating a table of 108 sectors, we find that the economic spillover effect from the accommodation, food and drink, and railway transport industries, which form the core of tourism services, is negligible. This finding differs from conventional tourism analyses that use a rough industrial classification. In recent years, there has been a growing interest in a circular economy, such as local production for local consumption, and we can say that the extent to which the relevant region can incorporate as many industries as possible will determine the outcome of tourism projects.

3) Another strength of the system dynamics model is that it can make future predictions. In the case of the Izu Peninsula region, we learned about the economic impact of a decline in accommodation services. Although this is rarely mentioned in tourism promotion discussions, residents' income in local tourist areas is low. The Izu Peninsula region is no exception, and this is the reason for the turnover in the accommodation industry. The workforce shortage in the tourism industry is not a problem that can be seen only in the Izu Peninsula region. It is necessary to consider the sustainability of tourist destinations as a human resources issue.

4) As a problem unique to the Izu Peninsula region, the number of overnight guests in 2021 was lower than in 2020. The fact that the number of guests has not recovered may delay the area's economic recovery.

The Club of Rome's *The Limits to Growth* (1972) sparked public interest in the sustainability of economic growth and introduced the analytical method of system dynamics to society. However, criticism of the analysis has also been voiced. For example, economist W. Nordhouse strongly criticised the World Dynamics model (Forrester, 1973), on which the report is based, for not referring to empirical data (Nordhouse, 1973). In contrast, the inclusion of input-output tables in the model, which are relied upon by governments and local authorities, makes system dynamics research more resistant to such criticism.

Acknowledgements

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References

Andria, F. and Provenzano, D. 2006. Tourism and equilibrium quantities: a dynamic perspective, *Proceedings of the 24th International Conference of the System Dynamics Society*, 1-18.

Aso, K. 2015. Kanko-Keizaigaku No Shiten (Perspectives on tourism economics), *Kanko Hyoron* (*Tourism Review*) vol. 3, no. 2, 115-124.

Braden, C. H. 1981. System dynamics and input-output analysis, *Proceedings of the 1981 System Dynamics Research Conference*, 1-12.

Dwyer, L., Forsythb, P., Spurr, R. 2003. Evaluating tourism's economic effects: new and old approaches, *Tourism Management,* 25, 307-317.

Fletcher, J. E. 1989. Input-output Fletcheranalysis and tourism impact studies, *Annals of Tourism Research*, 16, 514-529.

Forrester, J. W. 1973. *World dynamics*, Cambridge, Mass.: Wright-Allen Press.

Fujimoto, T. 1993. Kanko Shouhi NO Sangyo Renkan Bunseki Ni Tsuite (On the regional input-output analysis of tourism consumption), *Okayama Daigaku Keizai Gakkai Zasshi* (*Journal of Okayama University Economics Association*), Vol. 24, No. 4, 25-48.

Gazoni, J. L. and Silva, E. A. M. D. 2021. System dynamics framework for tourism development management, *Current Issues in Tourism*, vol. 25 no. 15, 2457-2478.

Nordhouse W. D. 1973. World Dynamics: Measurement Without Data, *Economic Journal*, Vol. 83, No. 332, 1156-1183.

Soukiazis, E. and Proença, S. 2008. Tourism as an alternative source of regional growth in Portugal: a panel data analysis at NUTS II and III levels. *Portuguese Economic Journal*, vol. 7, 43-61.

Yamada, Y. and A. Kakishima, A. 2016. Kanko Kyaku-su To Jinko-Kibo NO Kankei (The relationship between the number of tourists and the population size - for the number of overnight guests), *Nihon Kokusai Kanko Gakkai Ronbun-shu* (*Collected papers of the Japan Society for International Tourism*), Vol. 23, 155-160.