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An Interregional SAM Construction focused on Institutional Sectors and Structural Path Analysis in Japan

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Abstract:

The aim of this research is to build a multiregional social accounting matrix in Japan to evaluate the regional spillover effects of economic impacts. While research on national and regional SAM has become common, examples of interregional SAM are rare currently. This study points out that there is a substantial need to build a small regional SAM because of economic sensitivity. Our work evaluates the economic effects of national and regional government behavior, such as changes of the local tax system and decentralization of power, on the regional economy by structural path analysis.

Keywords: input–output table, interregional social accounting matrix, structural path analysis, Japan

1. Introduction

Input–Output (I–O) analysis (Miller and Blair, 1995), developed by the Russian economist Wassily W. Leontief (1906–1999), is an effective tool to evaluate the mutual spatial effects of regional economies. I–O analysis is a systematic tool to analyze the relationship between industries through the production activities of each industry in a nation and region. To this day, the tool is used for empirical and advanced research. In Japan, the I–O table is compiled by prefectures, government-designated cities, and the national government, and analysis based on the I–O table is used widely. Because the main purpose of I–O analysis is to discuss the money flows or exchanges between industries, this analysis does not consider all money flows, such as money exchanges with institutional sectors (household, company, and central and local governments) and fund flows with capital accounts (savings/investments)¹.

To meet this challenge, the social accounting matrix (SAM), developed by Sir J. Richard N. Stone (1913–1991)², uses the I–O table as a basis to indicate all money exchanges at the

¹ See Itoh (2005) and Itoh and Doi (2008) for the endogenizing consumption model in the I–O analysis.

² See Stone and Croft-Murray (1959) for early research by Stone on SAM.

same point in time with all economic agents: industry, household, company, government, and the rest of the world (ROW). Therefore, the SAM at the level of a country or region shows the economic size and money exchanges in that country or region.

The aim of this study is to propose an analytical framework of interregional SAM (ISAM) focusing on institutional sectors based on data availability in Japan. In addition, the study aims to evaluate SAM multipliers and the regional spillover effects of economic impacts by using (spatial) structural path analysis (SPA) for an ISAM construction.

The following two points summarize the contribution of this study. First, the construction of ISAM focuses on detailed institutional sectors. SAM constructed in early research essentially has three main categories as institutional sectors: household, company, and government. On the other hand, the SAM proposed in this study has much more detailed categories, especially for companies and governments. For example, by applying this SAM for empirical analysis, we can analyze the interdependent relationships between, for example, social security funds, taxes, and subsidies in governments. In addition, because the SAM constructed in this empirical analysis is based on the lists of income/expenditure following the system of national accounts (SNA) in Japan, balanced adjustments of the data gaps of sectors are quite easy using ISAM. The second contribution is that this study applies SPA for ISAM in the analysis of spillover effects for regional incomes. This study undertakes a comparative analysis of regional economic spillover mechanisms for household incomes in regions by using the ISAM database with Hokkaido prefecture and other regions in Japan.

The remainder of this paper is organized as follows. Section 2 explains the purpose and orientation of this research. Section 3 shows the frameworks of *intra*regional and *inter*regional SAMs, and proposes an ISAM with detailed institutional sectors by discussing the data possibilities of SNA in Japan. Moreover, this section provides an ISAM with two regions, focusing on Hokkaido prefecture. Next, Section 4 explains the method of (spatial) SPA, discusses the detailed regional economic spillover effects, and analyzes the results of the numerical example of the Hokkaido ISAM. Lastly, Section 5 concludes the research and gives direction for further research.

2. Research Motivation

SAM is a comprehensive, disaggregated, consistent, and complete data system that captures the interdependent relationships within a social economic system. The sectoral classifications in most research using SAM are very rough because of data limitations. For example, a typical SAM has only household, company, and government as institutional sectors. However, detailed

classification would be needed for analysis on issues that involve decentralization of power, like taxes, subsidies, and social security funds.

In this research, we attempt to construct an ISAM with detailed institutional sectors—including local governments, or local agencies of central government, prefectures, and municipalities—social security funds, direct and indirect taxes, and subsidies in each region. Moreover, we evaluate the regional economic spillover effects for household income and discuss the differences of economic spillover mechanisms by applying spatial SPA for an ISAM construction. This study presents an analytical framework of ISAM with detailed classification for Japan.

2.1 Research purpose

At the project level, like public investment, specific sectoral costs are changed. Thus, the traditional partial equilibrium model, for example, cost–benefit analysis (CBA), which is applied for policy evaluation, has some implications for the local evaluation of financial and economic efficiency of the relevant sectors. However, these methods cannot provide policy evaluation for the important structural changes to various other sectors; the methods can evaluate only the relevant sectors, and cannot evaluate the interdependent relationships between production, price, consumption, and the money flows of income/expenditure. Therefore, computable general equilibrium (CGE)³ models based on the SAM database are applied as a useful tool for the evaluation of all sectors of the regional economy by economic policy above the project level, like regulation and interposition, relaxation of regulations, liberalization of trade, labor market, public finance, banking, transportation, and environment. Over the past few decades, CGE models have been adapted in many research fields other than economics, such as civil engineering, and research output has accumulated⁴.

Moreover, interregional models are needed for the analysis to consider temporal and spatial factors, like trade and transportation, because of the limitations with the model analysis using SAM and CGE with a single country and a single region. That is, although goods and services represent primary demand, in general, transportation demand is derivative demand. Therefore, the networks of freight movements at home and abroad change drastically according to transport infrastructure investment and efforts toward transport efficiencies and CO₂ emissions reduction by companies. For example, the interregional models for economic impact analysis are needed for policy discussion. This is because their economic impacts shift policy to

³ SAM is a very useful analytical tool. However, similar to I–O analysis, SAM assumes that the prices of goods and production factors, production technology (input efficient), and allocation of production factors are stable. Thus, SAM analyzes only the regional economic spillover effects by an increase in final demand under a constant (stable) production structure in the short term.

⁴ See Donaghy (2009) for a recent survey of CGE models and Doi (2006) for recent empirical analyses using CGE models.

freight rail and domestic sea transport in order to reduce greenhouse gas emissions and relocates logistics facilities to reduce logistics costs. These are important recent challenges as cargo movement networks are vast.

The purpose of this research is to construct an analytical framework of ISAM and to undertake numerical analysis based on the SAM database to discuss economic spillover mechanisms. This study confirms the importance and challenges of ISAM. The analysis based on the SAM database can deal with income transfers in detail by considering not only the money flows between industries but also the money flows between institutional sectors, namely, household, company, and government, and production factors, namely, capital and labor. However, most of the early research using SAM, including CGE models, is for single international countries because of data limitations and the difficulty of analytical tools. This research discusses an evaluation method for regional economic policy, whose importance is increasing for the progress of local governments, by providing the analytical frameworks of intraregional and interregional SAM below the national level. Moreover, the characteristics of a (relatively small) regional economy are affected more than the national economy by price changes, including transportation costs, offshore leakages, transfer of production factors, and interregional spillovers. Therefore, there is an increasing need for an analytical tool evaluating regional economic policy with consideration for various economic characteristics of regions. In this study, we discuss the analytical framework of ISAM for prefectures and government-designated cities as well as the method for constructing the SAM database. In addition, we discuss the analytical availability or effectiveness of ISAM using SAM multiplier analysis and SPA for the ISAM with two regions as a numerical example.

2.2 Research orientation

There is much early research for economy-wide model analysis (EMA), like SAM analysis and CGE models based on a SAM database, which analyzes the interdependent effects between industries and institutional sectors at the national level. However, although the need for intraregional and interregional models is quite high, the research excluding theoretical and virtual numerical analyses is limited, except for a few foreign studies. Although the need for empirical analysis in Japan is also high, the empirical research on prefectures and cities is limited, particularly for comparatively closed regional economies, like Okinawa and Hokkaido prefectures⁵. The reason is the lack of data. SNA, or national economic accounting, is used for making a national-level SAM the main information source in Japan. Similarly, regional (or prefectural) economic accounting is used for making regional SAMs. However, the data from this economic accounting is not sufficient for constructing a detailed regional SAM database.

⁵ For example, Doi et al. (2006) constructed a CGE model for Hokkaido prefecture.

Therefore, there is limited empirical research on detailed regional (or interregional) SAM below the national level. In this research, we discuss the data availability of regional economic accounting in Japan, and propose an empirical framework of ISAM that records the institutional sectors of household, company, and government in detail.

Reviews of earlier studies show the following two challenges. First, EMA at the national level in Japan and elsewhere cannot provide effective policy implications for a specific regional economy. Second, I–O analysis that cannot model important factors endogenously—like price changes and the movements of production factors between industries on regions, which have big impacts for national and regional economies, including small regions—is insufficient. However, in addition, as stated in Subsection 2.1, earlier studies could not construct ISAM with detailed sectors, except for production activities from the I–O table, because of insufficient regional economic accounts; this is the challenge for EMA on prefectures and government-designated cities in Japan. There is some early research (Miyagi, 1998; Takeda and Ban, 2008) that applies Japanese ISAMs constructed for CGE analysis. However, because their main focus is CGE modeling, they do not provide detailed information sources for their ISAM database construction. Therefore, the discussion on data availability is one of this study’s contributions.

3. Construction of ISAM and empirical analysis in Japan

In this section, first, we explain the general SAM structure for a single country or region. Then, we broaden the normal *intra*regional SAM to *inter*regional SAM, and discuss the characteristics and analytical possibilities of ISAM. The ISAM proposed in this research is constructed using an *Isard*-type I–O table. The *Isard*-type I–O table, that is, the interregional I–O table with noncompetitive domestic imports, considers intermediate goods from other regions and foreign countries as different goods to those from the relevant (own) region. Second, this section introduces the structure of the interregional I–O table and the characteristics of available regional economic accounting, or regional SNA, in Japan as the main databases for the construction of ISAM. Finally, this section proposes a structural framework of ISAM in Japan considering data availability, and produces an ISAM with two regions, Hokkaido and another region, based on the year 2000, which is discussed in the next section as a numerical example. The original interregional I–O table for ISAM is based on year 1995, which has 9 regions and 46 sectors. The input coefficients of ISAM are updated by the RAS method (Bacharach, 1970; Lynch, 1986) to 2000. The case study aggregates 10 industrial sectors for SAM multiplier and SPA estimation.

3. 1 Structure of SAM

(1) Intraregional SAM

SAM provides rich information on not only the economic situation of each sector but also comprehensive (or global) economic circulation. The matrix is constructed by economic sectors, like production activities, value added (or production factors), and institutional sectors as the rows and columns of the matrix, following three rules (Pyatt and Thorbecke, 1976):

- A) A row and column with the same number (of matrix) is the same economic sector.
- B) The sum of a row and column with the same number is the same.
- C) Expenditure of a sector is a row and income of a sector is a column, with the value reported at their intersection.

SAM simultaneously provides information on sectoral balance of payments and sectoral income/expenditure on transactions. Therefore, SAM clarifies actual economic circulation, including the distribution structure of value added, by constructing SAM with the abovementioned three conditions. Moreover, because the production activities of SAM are the same as the structure of the I–O table, SAM clarifies not only the entire economic circulation but also the detailed structure of production activities by incorporating the I–O table’s ratio(s) or the structure of supply and demand by goods and services for each sector (or industry). The construction of SAM with detailed economic circulation provides the relationship between supply and demand of goods and services, and the principle of three equivalence of (national) income of value added (with final demand).

Figure 1 shows the structure of simplified *intraregional* SAM, including the ROW for a single county or region. The lengthwise direction is income and the crosswise direction is expenditure. Here, we show the economic spillover mechanisms (by arrows) from the demand increase of exports by the “ROW.” “Industry” produces value added by producing goods or services for export demand. The purchase of goods and services for production and consumption from the “ROW” is treated as imports, without distinguishing between intermediate goods and final goods. Some of the value added of “Capital” is redistributed to households of “Institute” as income from the reward for the labor of “Capital.” Moreover, there is a transfer of money through taxes and subsidies within “Institute,” after which households of “Capital” consume goods and services from posttax income, and the production of “Industry” is reinduced by the consumption demand of households. The SAM analysis can provide the paths of the economic spillover mechanism. Here, because the shaded areas in Figure 1 are considered in the analysis of the I–O table, such analysis cannot discuss the economic spillover mechanisms through income redistribution by institutes (or governments).

(Figure 1, insert here)

(2) Interregional SAM

Here, we provide a possible framework of ISAM for a number of regions. This discussion supposes an ISAM in Japan, as we see later in this section. Table 1 presents the structure of *interregional* SAM simplified for two regions, including the ROW. Based on Figure 2, there are two differences between the models for a single region (Figure 1) and two regions (Figure 2). One difference is the interregional distribution of value added of industry, or the rewards of labor and the operational surpluses of capital. For example, the value added by production of industry in Region 1 is distributed to Regions 1 and 2 based on the locations of suppliers of labor and capital for production. The second difference is the treatment of exports and imports. Goods or services purchased from Region 1 by Region 2 as intermediate goods (or final consumption goods) are considered as inputs for production (or imports for consumption). On the other hand, purchases of goods and services (intermediate goods and final goods) from the ROW are reported as imports. As discussed, one of the characteristics of interregional SAM is the detailed reports of money flows between industries and institutes in Regions 1 and 2. Similar to Figure 1, Figure 2 shows the economic spillover mechanisms (by arrows) for Region 1 of an export demand increase from the ROW. Again, similar to Figure 1, the shaded areas in Figure 2 are considered only for the analysis of the interregional I–O table.

(Figure 2, insert here)

3. 2 Utilization data for interregional SAM construction

This subsection explains the main data sources needed for constructing an intraregional (interregional) SAM. We show (1) the interregional I–O table providing information about input structure (technical coefficient) of each industrial sector and (2) the regional economic accounting (or regional SNA) providing information about income/expenditure of institutions, for example, household, company, and government.

(1) Interregional input–output table in Japan

The interregional I–O table, which is the basic data for constructing ISAM for many regions at the same time, is constructed for interregional economic spillover analysis through interdependent interregional relationships. In Japan, the *intraregional* I–O tables are a joint project by the Ministry of Economy, Trade and Industry (METI), Cabinet Office, governments of Japan, Okinawa General Bureau, and Okinawa prefecture. The *intraregional* I–O tables, divided by nine Japanese regions⁶, has been constructed at 5-year intervals after 1960. In addition, METI's research and statistics department has connected the *interregional* I–O table to

⁶ Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, and Okinawa (nine regions).

the abovementioned regional I–O tables.

The *intraregional* I–O table shows the trade (money) flows of goods and services for a specific region within a certain period, similar to the I–O table for a single country or prefecture. The analysis based on the table is limited to the trade flows in the relevant region. On the other hand, the *interregional* I–O table includes the economic activities of some regions on a single table and shows the trade flows of goods and services not only in the relevant region but also between regions. In particular, in the *intraregional* I–O table, the goods and services provided to other domestic regions from the relevant domestic region are accounted for as “exports,” and the sum of exported goods and services is noted only on each sector. However, the goods and services produced in each sector of regions are accounted as the volume inputted or consumed by each sector in regions on the *interregional* I–O table⁷; alternatively, these goods and services show the quantity of goods and services consumed by industries of each region. Thus, the *interregional* I–O table enables us to discuss not only the industrial trade flow structures between sectors of regions but also some interregional spillover effects, which are never discussed in the *intraregional* I–O table.

(2) National (or regional) economic accounting

The SNA (national economic accounting) is an international standard that systematically records both the flows of production, consumption, and investment, and the stocks of assets and debt for the national (or prefectural) economy.

For constructing the regional (or interregional) SAM at the level of prefectures, the economic accounting at the level of prefecture (or regional SNA) is needed as the main data and includes the regional I–O table of the relevant prefecture. Moreover, each dataset is required for the construction of *intraregional* SAM at the level of the municipality, which is lower than the prefecture. In addition to the regional I–O table, because regional economic accounting is undertaken in all Japanese prefectures, the basic data source for constructing regional SAMs is available. In particular, we are able to use the following table that is included in prefectural economic accounting: “income–expenditure transactions of general governments (*IET* table).” Here, for example, the *IET* table is needed to construct the detailed regional (or interregional) SAMs. The table reflects the distinctive characteristics of this SAM analysis and has rich information on income–expenditure transactions in four institutional sectors; 1) local agencies of central government, 2) prefectural governments, 3) municipal governments, and 4) social security funds⁸.

The general basic rule for constructing regional economic accounting at the level of

⁷ This interregional I–O table is known as the *Isard*-type I–O table. For detailed interregional I–O analysis, see Chapter 3 of Isard et al. (1998). In addition, the interregional I–O table is officially made up only in Japan; therefore, the discussion in this research provides useful information.

⁸ See Table 1 in Itoh (2008b) for an actual table for Hokkaido prefecture.

prefectures is standardized by the Economic and Social Research Institute (ESRI) in Japan. However, there is no confirmed rule for constructing an *IET* table. Therefore, this table comprises only 13 of 47 prefectures in Japan⁹ for regional economic accounting. In addition, for government-designated cities, whose level is lower than that of prefectures, only Osaka city comprises a part of this kind of table. Many government-designated cities make neither the *IET* table nor their regional economic accounting per se, including the regional I–O table. If such a table is available, we can construct regional SAMs that indicate the money flows between central and regional governments or more detailed institutional sectors, and the economic impacts can be analyzed by the transfer of tax revenue sources from central to regional governments on the regional or interregional SAM.

(3) Challenges for regional (interregional) SAM construction

In general, this study constructs ISAM shown basically in Figure 2 by using the interregional I–O table and regional and national economic accounting in Japan. Because the total income and expenditure of each sector must be the same under a characteristic of SAM conditions, as discussed in Subsection 3.1, the sums of each sectoral row and column in ISAM must also be the same. However, owing to differences of data estimation methods in various yearbooks of Japan, the total expenditure does not match the total income in some sectors. For example, although the I–O table is based on the calendar year, national economic accounting (i.e., SNA) is based on the fiscal year in Japan. Therefore, there is a natural gap of a quarter of a year. In addition, the data estimation methods of indirect taxes differ from Japanese yearbooks. In this research, we apply the RAS method, which is a sequential matrix modification method, for adjusting these gaps of values at each sector on ISAM for empirical analysis.

The challenges in the application of economic accounting data for SAM construction are the gaps of data estimation methods used to construct statistical yearbooks, and the differences between data listings in national and regional statistical yearbooks. For example, some Japanese prefectural governments do not compile and provide *IET* tables publicly.

3.3 Analytical framework of ISAM construction and empirical example in Japan

(1) Analytical framework of ISAM construction

In this research, we propose a detailed analytical framework, or structure, of ISAM focusing on income/expenditure, or money flows, of institutional sectors in (two) endogenous regions and “other part” (see Table 1), and the ROW (exogenous). The basic steps for the ISAM construction with more than two regions are the same as this one; however, the volumes of data required for them make it difficult to construct ISAM.

⁹ The 13 prefectures in Japan are Hokkaido, Aomori, Iwate, Akita, Miyagi, Ibaraki, Niigata, Nagano, Aichi, Hyogo, Okayama, Saga, and Okinawa.

Table 1 shows the (simplified) framework of ISAM with two regions (Hokkaido and another region in Japan), for the empirical example in Section 4. Each region has “production activities (industry, goods, and services),” “production factors (labor and capital),” and “institutional sectors.” Moreover, this ISMA has “other part (endogenous sectors at the national level, see Table 1),” including direct tax, indirect tax, property income, other sectors (other current transfers), central government, which does not form part of each region, and lastly, foreign accounts (exogenous sectors, export and import of goods and services)¹⁰.

(Table 1, insert here)

A rather important characteristic of ISAM proposed in this research is the creation of the trade flows of institutional sectors in precise detail following the SNA in Japan. The institutional sectors are divided into “current accounts (in general, household, company, and local government)” and “capital accounts (savings/investments).” Moreover, the current accounts are classified into five sectors (see Table 1).

We can consider the detailed money flows of social costs and benefits by specifying four categories (see Table 1) of local government (prefectures) based on an *IET* table.” In addition, we can discuss the distributional structure of taxes in detail using indirect taxes (taxes for production and imported goods) and direct taxes (ordinary taxes for incomes and wealth) as independent terms on “other part.”

(2) Empirical analysis of Hokkaido ISAM

For empirical analysis, we construct the ISAM database with two regions by using the interregional I–O table and national and prefectural economic accounting in Japan. In particular, the two regions on ISAM are Hokkaido prefecture and another region of 46 prefectures. This is because Hokkaido prefecture is an independent region on the interregional I–O table in Japan and its *IET* table is publicly available. Therefore, Hokkaido prefecture would be a better region for construction of the ISAM proposed in this research. The ISAM for empirical analysis is based on the year 2000. Moreover, the case study of Hokkaido would be a very good example to understand the characteristics of this SAM framework because transportation and commerce systems are very important in this isolated region. In addition, the Hokkaido economy suffers from a very difficult economic situation. Meanwhile, the interregional I–O table for 2000 is not publicly available¹¹. Therefore, we apply technology coefficients between industries on regions (or input coefficients in the interregional I–O table) from the database in 1995, and other

¹⁰ See Appendix 1 in Itoh (2008b) for the value elicitation of each cell in the ISAM database.

¹¹ However, currently, the interregional I–O table in 2005 is available publicly.
<http://www.meti.go.jp/statistics/tyo/tiikiio/>.

information in 2000¹².

The difference between the proposed ISAM (Table 1) and Hokkaido ISAM for this empirical analysis is the treatment of local government (prefectural level). Because the *IET* table of Hokkaido is publicly available (see footnote 9), detailed information is available about the four sectors in local and central government. However, the breakdown of classified information for local government is not available for the other region(s) because we have to apply essentially the information on SNA (or national economic accounting), which includes only the central government, regional government, and social security funds, and this is a different classification to the prefectural information on regional economic accounting. Therefore, the Hokkaido ISAM for this empirical analysis has an aggregated “local government” of three sectors (local agency of central government, prefecture, and municipality) and social security funds for both regions in our comparative analysis in the next section.

4. Analysis of economic spillover mechanism on Hokkaido ISAM

In this section, we analyze the economic spillover impacts by applying SAM multipliers for the Hokkaido ISAM developed in Section 3 as an empirical example. Next, we show the analytical challenges of SAM multipliers and introduce the SPA, which is an advanced analytical tool for studying economic structures, by using the ISMA. As a numerical example, this section discusses the differences of economic spillover mechanisms of Hokkaido and the other Japanese region by comparing in detail the economic impacts on their household incomes.

4.1 SAM multiplier analysis

This subsection shows the possibility of ISAM analysis by undertaking empirical analysis of the economic interdependence of both regions for the Hokkaido ISAM constructed in this study. For the classification of industrial sectors representing the input structure of the interregional I–O table of ISAM, this research uses the 10 aggregated industrial sectors based on the 46 interregional I–O tables in Japan that are publically available (see Table 1). In this numerical example, we apply the decomposition method of the degrees of interregional economic interdependence by Round (1985) and Pyatt and Round (1979)¹³.

Here, y is the column vector of total expenditure (= total income) of each sector, x is the column vector of (total) exogenous sector(s), and B is the component matrix of SAM,

¹² Because of space constraints, this paper omits an actual Hokkaido ISAM database: there are, in total, 45 rows and 45 columns.

¹³ See Roberts (1998) for a recent empirical analysis discussing the decomposition method for the degree of interregional interdependences. The case study of this paper is for the northeast region in Scotland.

which is similar to the input coefficient matrix of the I–O table. In addition, to match the empirical analysis of this study, we decompose each vector, y and x , and matrix B into two regions (parts), which, finally, allows us to construct the three required parts, including “other part” (see Table 1). By solving Equation (1) for y , we take Equation (2). M shows the interregional “*Global Multiplier Effects (GME)*,” or SAM multiplier(s). That is, the components of this matrix (M) indicate the increase of income of each sector for a unit increase of exogenous demand (i.e., exports).

$$y = By + x \quad (1)$$

$$y = (I - B)^{-1}x = Mx \quad (2)$$

Moreover, considering B_{ii} , which indicates a submatrix with expenditure from region i to each sector of region i , and \hat{b}_{ij} , which indicates a submatrix with expenditure from region i to each sector of region j , Equation (1) is converted to Equation (3).

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} B_{11} & \hat{b}_{12} & \hat{b}_{13} \\ \hat{b}_{21} & B_{22} & \hat{b}_{23} \\ \hat{b}_{31} & \hat{b}_{32} & B_{33} \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} + \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \quad (3)$$

Moreover, by zoning a) the part of income/expenditure within the own region, b) the part of income/expenditure with the other region, and c) the part of income/expenditure with “other part (or taxes and money transfers of governments in this framework),” and solving Equation (3) to y , we can obtain Equations (4) and (5). In this empirical analysis, subscript 1 is Hokkaido prefecture, 2 is the other region, and 3 is “other part¹⁴.”

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} I & -D_{12} & -D_{13} \\ -D_{21} & I & -D_{23} \\ -D_{31} & -D_{32} & I \end{bmatrix}^{-1} \begin{bmatrix} (I - B_{11})^{-1} & 0 & 0 \\ 0 & (I - B_{22})^{-1} & 0 \\ 0 & 0 & (I - B_{33})^{-1} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \quad (4)$$

Here, $D_{ij} = (I - B_{ii})^{-1} \hat{b}_{ij}$. Or,

$$y = M_{r2} M_{r1} x \quad (5)$$

In Equation (5), M_{r2} is constructed by “*Interregional Multiplier Effects (IEME)*” between Regions 1 and 2, and the *multiplier (spillover) effects* between each region (1 and 2) and “other part,” and M_{r1} is constructed by “*Intraregional Multiplier Effects (IAME)*” within each region (1 and 2) and the *multiplier (spillover) effects* within “other part.”

¹⁴ See Appendix 3 in Itoh (2008b) for a detailed mathematical explanation about the decomposition method of the degree of interregional interdependence.

For example, although the “household (H)” in Hokkaido has a 1.314 (income) increase by a unit (expenditure) increase by the “regional government (H)” in Hokkaido prefecture, the spillover effects from Hokkaido (own) region within the 1.314 (income) increase is just 0.940, based on the results of the matrix calculation for Hokkaido ISAM¹⁵.

Based on this, we can understand the income expanding mechanism (M_{r2}) of households in Hokkaido through economic linkages with the other region and “other part” with taxes and subsidies (or the “household” row for Hokkaido in M_{r2}) after the (income) increase in each sector (or the “regional government” column for Hokkaido in M_{r1}) by the unit (expenditure) increase of “regional government (H)” in Hokkaido prefecture¹⁶. In particular, the income via households, furthermore other services, and local government, are comparatively large. Similarly, “household (O)” in the other region has a 8.698 (income) increase by a unit (expenditure) increase by the “regional government (O)” of the other region. In this income increase (8.698), because the economic impacts of the economic linkages inside the (own) region is just 1.600, the impacts on another region, Hokkaido, and “other part” is bigger than the case in Hokkaido¹⁷. In particular, the income via household, nonfinance company, and local government are comparatively large.

As previously discussed, the advantage of SAM analysis is that it can evaluate in detail the transfers of income (distribution) in institutional sectors, including households. Table 2 summarizes the sectors that have economic impacts on the households of Hokkaido (H) and the other region (O) based on the size of the SAM multipliers (or *GME*) in decreasing order. The economic impacts from service sectors, including “commerce (H)” and “transportation (H),” for “household (H)” are comparatively large in Hokkaido prefecture. In addition, the capital sectors (“labor (H)” and “capital (H)”) directly have economic impacts on “household (H).” On the other hand, the economic impacts on “household (O)” from “property income,” “other sectors,” and “central government” are large in the other region. Moreover, “household (O)” in the other region is affected economically by not only “finance company (O)” in other regions but also “finance company (H)” in Hokkaido prefecture focusing on finance companies in “current accounts.”

(Table 2, insert here)

¹⁵ Because of the huge matrix with 43 rows and 43 columns, this paper does not insert the table of matrix.

¹⁶ In particular, this is the sum of products of the row vector (1-by-43) of “household (H)” for Hokkaido with the column vector (43-by-1) of “local government (H)” for Hokkaido.

¹⁷ The SMA multipliers of other regions are much bigger than those of Hokkaido because these multipliers depend on the SAM structure (economic size). The difference in economic size of both regions (the gross regional product of Hokkaido is just 3.9% of the national total, based on the I-O table in 2000) produces the differences of components in the SAM structure (economic size).

4.2 Structural Path Analysis of ISAM

(1) Tool of Structural Path Analysis¹⁸

We evaluated the economic spillover effects by SAM multipliers in Subsection 4.1. SAM multipliers indicate the (total) economic impacts through the direct and indirect spillover impacts on some economic agent (or household) by a unit (expenditure) increase on some sector (or agent). For example, an income increase of “household (H)” in Hokkaido is 1.314 for a unit (expenditure) increase of “local government (H)” in Hokkaido prefecture. Similarly, an income increase of “household (O)” in the other region is 8.698 for a unit (expenditure) increase of “local government (O)” in the other region. Even though it would be possible to decompose the SAM multiplier into intraregional (*IAME*) and interregional (*IEME*) spillover effects separately, we cannot distinguish the paths of these effects. If we can determine the paths of economic impacts, or spillover effects, we can discuss and understand which economic policy is effective, or identify sectors that are bottlenecks for regional economic development.

SPA is the analytical tool for this challenge. It can decompose the SAM multiplier(s) from some sector i (origin) to some sector j (destination) into each sectoral connection (paths or economic links). For example, we can know the path from the expenditure of the Hokkaido local government (origin) to the increasing household income (destination) in Hokkaido prefecture and which sector contributes to the income increase. In other words, SAM multiplier(s) do not clarify the “black box,” that is, the economic structure and behavioral mechanism that is responsible for the effects (or, *GME*). SPA provides a detailed method of decomposing multipliers and of identifying the whole network of paths whose influence is transmitted from one sector of origin to the ultimate destination, thereby opening the “black box.”

Here, this part explains the analytical tool of SPA by using the empirical results for Hokkaido ISAM. Once again, the economic impacts on “household (H)” in Hokkaido of a unit (expenditure) increase of “local government (H)” in Hokkaido prefecture, or the SAM multiplier (*GME*), is 1.314. For example, we pick up the spillover effects, as an example, via “other services (H)” and “labor (H)” within this (total) multiplier, and define the effects as “*Direct Effects*” (*DE*). Figure 3 shows this structural relationship. c is “*Marginal Expenditure Propensity*,” which is a concept of input coefficients. In particular, c_{xi} , or the expenditure on “other services (H)” within the unit expenditure of “local government (H),” is 0.526, which is from the results of the Hokkaido ISAM. Similarly, c_{yx} , the expenditure on “labor (H)” within the unit expenditure of “other services (H),” is 0.342, and c_{jy} , the expenditure on “household (H)” within the unit expenditure of “labor (H),” is 1.000. Finally, the spillover effect on “household

¹⁸ See Defourmy and Thorbecke (1984) for initial research about SPA. Moreover, see Sonis and Hewings (1998) for recent research discussing SPA for interregional I–O tables.

(H)” from a unit expenditure increase of “local government (H)” via “other services (H)” and “labor (H)” is $c_{xi} \times c_{yx} \times c_{jy} = 0.526 \times 0.342 \times 1.000 = 0.179$; this is equal to DE .

(Figure 3, insert here)

However, the effects on “household (H)” from “other services (H)” and “labor (H)” are not only this DE but also the other paths. For example, it is possible that effects are brought indirectly to “household (H)” via other sectors during the path from “other services (H)” to “labor (H).” Therefore, we define this effect as “*Path Effects*” (PE). In Figure 3, these PE are c_{xy} and $c_{zy} \cdot c_{xz}$. The aggregated path effects with direct and indirect effects are defined as “*Total Effects*” (TE). In this empirical analysis, the TE from “local government (H)” to “household (H)” is 0.456; then the PE is 2.591, which is 0.465 divided by 0.179¹⁹. In general, the PE is proportionate to the number of sectors going through origin (i) to destination (j). This is understood economically as the duration time of economic impacts.

Moreover, the economic impacts (or spillover effects) from “local government (H)” to “household (H)” are not only via “other services (H)” and “labor (H)” but also other sectors. For example, the spillover effects on “household (H)” via “social security funds (H)” from “local government (H)” has a TE of 0.027. In this way, there are various paths for economic effects from “local government (H)” as the origin i to “household (H)” as the destination j . The sum of all $TE(s)$ is GME , which is the same for the SAM multiplier discussed in Subsection 4.1.

Table 3 shows the spillover effects from “local government (H)” to “household (H)” in decreasing order of $TE(s)$. The TE via “other services (H)” and “labor (H)” is 0.465, which is 35.4% for the SAM multiplier. In addition, the TE from “local government” directly (or no other connection with this sector) to “household (H)” is 0.344, which is 26.1% for the SAM multiplier. The sum of the top six paths occupies about 80% of the SAM multiplier. We can observe the economic spillover mechanism by applying SPA in detail.

(Table 3, insert here)

(2) Results of empirical analysis

This subsection compares and discusses the differences of economic spillover mechanisms on Hokkaido (H) and the other region (O) based on the SPA results. We decompose the SAM multipliers for “household(s)” of Hokkaido (H) and the other region (O) as the final destination. Figure 4 summarizes the economic spillover mechanisms, or structural paths, for household

¹⁹ The “*Total Effects (TE)*” is defined as $c_{xi} c_{yx} c_{jy} [1 - c_{yx} (c_{xy} + c_{zy} c_{xz})]^{-1}$ on Figure 3, and $[*]^{-1}$ is the “*Path Effects (PE)*.” See Defourny and Thorbecke (1984) for details.

(HH) in each region in decreasing order of $TE(s)$ until the top 30 paths. To understand them easily, Figure 4 is simplified by grouping some sectors with similar paths. Moreover, the <number> with a sector in the figure shows the order of TE of the sector as the origin for “household (H)” in Hokkaido. Similarly, the [number] with a sector in the figure shows the order of TE of the sector as the origin for “household (O)” in another region. For example, we can find a spillover path (the order of TE is 19th) to “household (H)” via “savings/investments (H)” and “construction (H)” from “nonfinance company (H)” as the origin. On the other hand, we can find a direct path (the order of TE is 26th) to “household (H)” from “nonfinance company (H). Moreover, “nonfinance company (H)” affects not only “household (H)” but also “household (O)” in the other region via “property income” (the order of TE is 24th).

(Figure 4, insert here)

In this result, the comparison of spillover mechanisms for household incomes between Hokkaido and another region provide similar paths. Distinctively, there are significant spillover effects via “other services (H) and (O)” from “local government (H) and (O),” “social security funds (H) and (O),” and “private nonprofit organization (NPO) for household (H) and (O)” as the origins²⁰. Because “other services” include other public services and medical, healthcare, and social security services in the detailed 46 industrial sectors, these paths are quite reasonable. Moreover, there is a significant path via “savings/investments (H) and (O)” and “construction (H) and (O)” from “nonfinance company (H) and (O)” as the origins to household income. This result shows that much of company savings flow to construction investments in both regions.

However, for the different spillover mechanisms, the economic impacts via industrial sectors on Hokkaido are relatively higher than those in the other region. For example, service industries, like “commerce (H)” and “transportation (H),” affect household income not only directly via “labor (H)” and “capital (H)” but also via “other services (H).” However, although “commerce (H)” has high $TE(s)$ via both “labor (H)” and “capital (H),” “transport (H)” has high TE only via “labor (H).” The order of the TE via “capital (H)” from “transport (H)” is lower than 30th because the transportation industry is typified by labor-intensive truck carriers. In addition, although the economic impact is not so high (30th), the spillover effect from “capital (H)” as the origin going through “nonfinance company (H),” “savings/investments (H),” “construction (H),” and “labor (H)” to household income in Hokkaido is distinguishable and different from the case in other regions. Hokkaido’s regional economy, or economic spillover mechanism, depends much more on construction investments.

²⁰ The spillover paths via industrial sectors go through the capital sector (capital and labor) just after the industry because of the structure of ISAM.

On the other hand, the economic impacts from “other part” as the origin to household income in the other region are higher than those in Hokkaido. For example, the “indirect tax” and “central government” as the origins affect household income via “local government (O)” and “social security funds (O),” respectively. Moreover, the function of “property income” for the economy in the other region differs from the case of Hokkaido. Although this sector directly affects “household (O)” (the order of TE is 8th), the sector is a hub of the economic impacts from not only “nonfinance company (O)” (29th) and “finance company (O)” (11th) in the other region but also from “nonfinance company (H)” (24th) and “finance company (H)” (13th) in Hokkaido as the origins indirectly affect household (O) to some extent. That is, the money from Hokkaido companies flows out of the intraregional economy (Hokkaido) to the external economy, or to the other region. Therefore, the size of income transfers (or subsidies) to households from not only central government and the other region’s sectors but also intraregional companies in Hokkaido is relatively small compared to the case in the other region. Conversely, the size of economic impacts via service sectors, including commerce, transportation, and construction, on households in Hokkaido is relatively larger than the case in the other region or sectors, including updates on logistics infrastructure and the introduction of modern distribution systems, which have more potent multiplier effects for Hokkaido’s economy.

5. Conclusion

This study proposed an ISAM framework with detailed institutional sectors by discussing the structure and availability of data in Japan. In particular, we constructed an ISAM with Hokkaido prefecture and another region based on the interregional I–O table for 2000 and national and prefectural economic accounting. This ISAM was built based on an *Isard*-type I–O table and considered in detail monetary exchanges of institutional sectors, especially local and central governments, social security funds, and some taxes. Moreover, this study conducted a comparative analysis of the economic spillover mechanisms for household income of each region by applying an analytical tool of SPA for the ISAM database as a case study, which enabled a discussion on the differences of economic multiplier mechanisms in both regions.

For further research, we propose the following two directions. The first direction involves construction of a multiregional SAM based on the analytical framework of this research. Because the original interregional I–O table is for nine regions (there are two regions in the database for this study), construction of a multiregional SAM with regional characteristics of each region is needed. The second proposed research direction involves modeling multiregional (or spatial) CGE by applying the database of ISAM. An EMA that endogenizes

price (or cost) mechanisms is available by incorporating the functions of income transfers between institutional sectors, especially central and regional governments, and the decision making of shippers and transport companies who use transportation and commercial services in SCGE. For example, the result of model shift analysis (see Itoh, 2008a, for Japanese shippers), or the elasticity of transport models by discrete choice analysis would be incorporated in the functions of shippers (or manufacturers, wholesalers, and retailers) in the SCGE model. Because the regional economy has quite different characteristics compared with the national economy, differences of transportation and distribution systems would affect much more than the regional economy. However, because of data limitations, most ISAM analyses, including CGE analyses, are for international and national levels.

Acknowledgements

The original research appears in Itoh (2008b) in Japanese. Because of space constraints, the current paper essentially focuses on SPA for the conference. Refer to the original paper for the construction of the Japanese ISAM.

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Tables and Figures

Table 1: Classification of accounts on ISAM

(a) Endogenous Sectors, Each Region (Hokkaido pref. and other region)

		Normal SAM	SAM in this research
Production Activities		Industry	Industry (see, table below in details)
		Goods and services	Goods and services
Production Factors		Labor	Labor
		Capital	Capital
Institution Sectors	Current Accounts	Household	Household (single category)
		Company	Private NPO for household
			Non-finance company
			Finance company
		Local Government (Prefecture)	Local agency of central Gov.
			Prefecture
			City, town and village
	Social security funds		
Capital Accounts	Saving/Investment	Saving/Investment	

(b) Endogenous Sectors, "other part" (not included in each region)

Direct tax
Indirect tax
Property income
Other sectors
Central Gov.

(c) Exogenous Sectors

Export / Import

(d) 10 Industrial Sectors

Sector 1	Agriculture, forestry and fisheries industry
Sector 2	Mining
Sector 3	Non-durable goods manufacturing
Sector 4	Infrastructure equipment manufacturing
Sector 5	Durable goods manufacturing
Sector 6	Construction
Sector 7	Electric, gas, heat and water supply, and waste
Sector 8	Commerce
Sector 9	Transportation
Sector 10	Other services

Source: Author's construction.

Note: In this analysis, 10 industrial classifications are obtained by aggregating the publicly available interregional I-O table with 46 industrial sectors. One of the advantages of economy-wide model analysis is its ability to evaluate the economic impacts on the regional economy by the difference between trade patterns. For discussing the impacts on regional economies of their differences of distribution systems, this SAM uses the commercial sector (commerce margin) and transportation sector (transport margin) as sectors that are independent from other service sectors. See Itoh (2008b) for details.

Table 2: SAM Multipliers focused on household (HH) incomes by Hokkaido ISAM

	Hokkaido (H)		Other regions(O)	
	Sectors	SAM Multiplier	Sectors	SAM Multiplier
1	Labor (H)	1.997	Labor (O)	9.561
2	Commerce (H)	1.502	Social security funds (O)	9.134
3	Transportation (H)	1.434	Commerce (O)	9.095
4	Other services (H)	1.374	Property Income	8.991
5	Capital (H)	1.320	Other sector	8.989
6	Local government (H)	1.314	Finance company (O)	8.867
7	Construction (H)	1.267	Capital (O)	8.858
8	Utilities (H)	1.261	Central government	8.790
9	Social security funds (H)	1.234	Other services (O)	8.774
10	Agriculture etc (H)	1.128	Direct tax	8.758
11	Private NPO for HH (H)	1.111	Indirect tax	8.733
12	Infrastructure Manu. (H)	1.084	Local government (O)	8.698
13	Saving/Investment (H)	1.037	Finance company (H)	8.665
14	Non-durable Manu. (H)	0.925	Construction (O)	8.658
15	Non-finance company (H)	0.899	Private NPO for HH (O)	8.499

Source: Author's construction.

Table 3: Economic Spillover Mechanism

Local Gov. (H) $i \rightarrow$ HH (H) j via sectors	Direct Effects	Path effects	Total effects	% (Accu. %)
Other services (H) \rightarrow Labor (H)	0.179	2.591	0.465	35.4 (35.4)
(none)	0.159	2.162	0.344	26.1 (61.5)
Other services (H) \rightarrow Capital (H)	0.054	2.714	0.146	11.1 (72.6)
S/I (H) \rightarrow Construction (H) \rightarrow Labor (H)	0.020	2.316	0.045	3.5 (76.1)
Social security funds (H)	0.012	2.260	0.027	2.1 (78.2)
Other services (H) \rightarrow Capital (H) \rightarrow Non-finance company (H)	0.005	2.725	0.013	1.0 (79.2)
...
Sum (Global effects = SAM multiplier)	-	-	1.314	- (100.0)

Source: Author's construction.

Figure 1: The structure of Intra-regional SAM

	Industry	Capital	Institute	ROW
Industry	Production		Consumption	Export
Capital	Value-added			
Institute		Income	Transfer	
ROW	Import			

Source: Author's construction.

Note: This model does not consider a "savings/investments" function as a subsidiary unit for the institutional sector. Therefore, this model assumes that the sector, including households, must consume all disposable income, in other words, there are no savings.

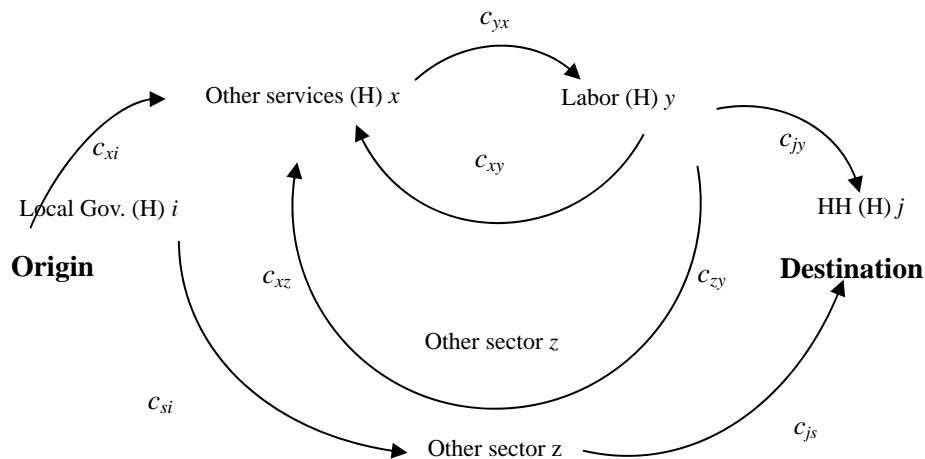
Figure 2: The structure of Interregional SAM

		Region 1			Region 2			ROW
		Industry	Capital	Institute	Industry	Capital	Institute	
Region 1	Industry	Production		Consumption	Input		Import	Export
	Capital	VA			VA			
	Institute		Income	Transfer				
Region 2	Industry	Input		Import	Production		Consumption	Export
	Capital	VA			VA			
	Institute			Income		Transfer		
ROW		Import			Import			

Source: Author's construction.

Notes: ROW is "rest of the world" and VA is "value added." As in Figure 1, this model does not consider a "savings/investments" function as a subsidiary unit of the institutional sector. Therefore, this model assumes that the sector, including households, must consume all disposable income in a year, in other words, there are no savings.

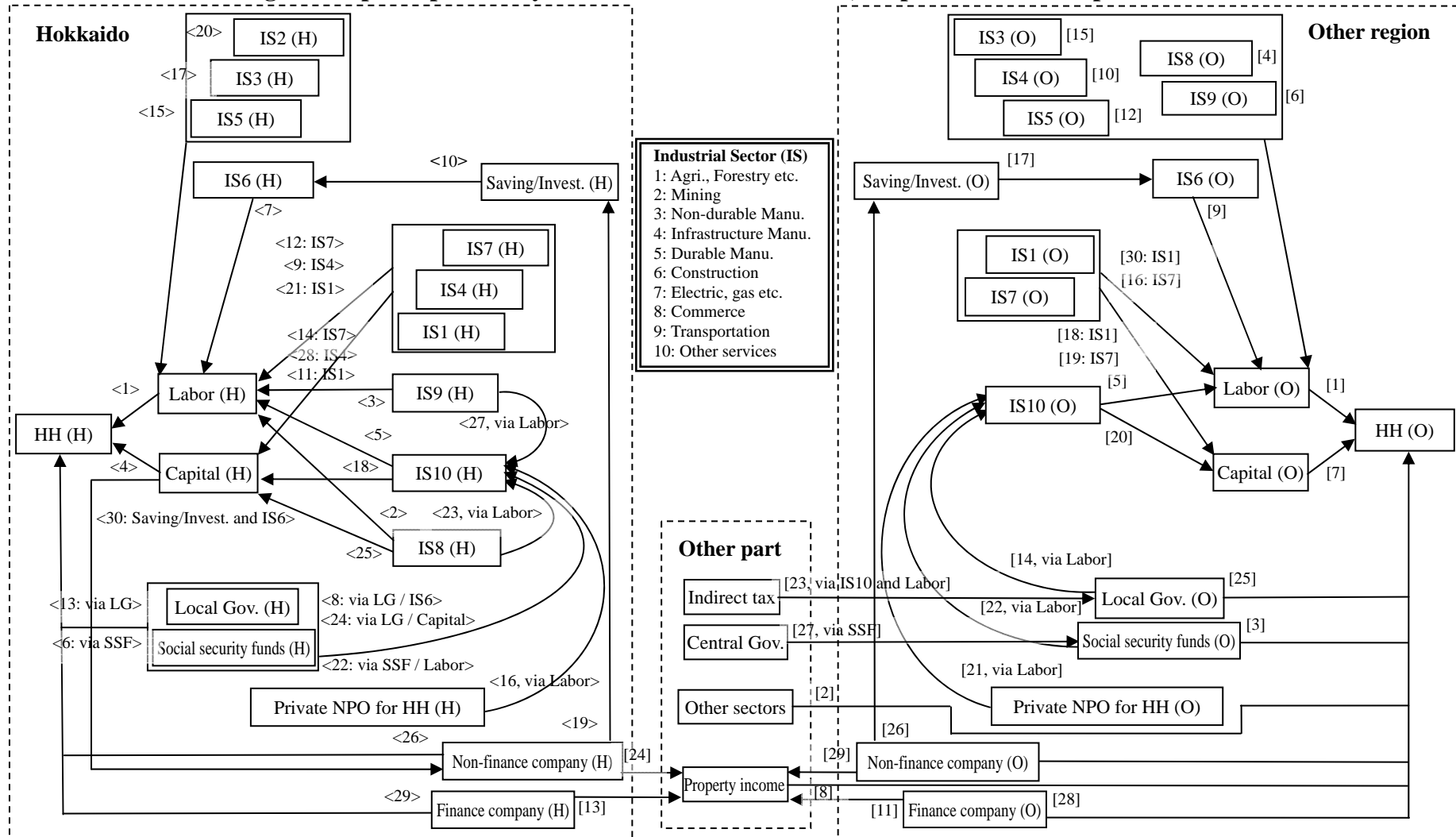
Figure 3: Direct Effect, Path Effect and Total Effect



Source: Author's construction, using Defourny and Thorbecke (1984, p. 121, Figure 3) as a reference.

Note: C is the marginal expenditure propensity of each sector.

Figure 4: Spatial path analysis for ISAM with Hokkaido, Map of Economic Impacts to HHs



Note: This figure shows the economic multiplier structure based on "Total Effects (TE)" by SPA.