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Abstract

This study investigates state transitions of the comparative advantage structures by use of a Balassa index and one of the applicative methods of the stochastic process. The analytical framework consists of estimating non-parametrically the initial distribution of the transition probability matrix (TPM) that is well known as Markov matrix, evaluating the mobility, which means the degree of structural change in the analysis, of the initial distributions, and computing numerically the limit distributions of the TPM. The analysis also attempts to improve methods of the existing studies, and proposes a new evaluation index. Results of a series of analyses based on empirical data provide the following facts: firstly, the comparative advantage mobility differs between trade in goods and in services. Secondly, the state persistency of the comparative advantage indicates the higher probabilities in both strong and weak edge regions and the lower probabilities in intermediate regions, relatively. Thirdly, a convergence speed of the stochastic process depends on conditions of the initial distributions of the TPM. The convergence speed is related to the mobility, and differs between the goods and the services. Finally, external shocks stimulate the mobility. This study consequently brings out features of the comparative advantage structure dynamics.

JEL CLASSIFICATION: C14, F01

KEYWORDS: Balassa Index, Structural Change, Comparative Advantage Dynamics, Stochastic Process, Mobility/Persistency

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1. Introduction

Comparative advantage is one of the core concepts of international trade, and researchers of economics share importance of comparative advantage, theoretically and empirically. This paper purposes to investigate the mobility differences of the comparative advantage dynamics between trade in goods and in services. The comparative advantage dynamics, namely specialization dynamics (e.g., Redding (2002)), represents technical progress in one economy. The successive existing studies in economics theory supposed source of technical progress as learning-by-doing (e.g., Krugman (1987) and Lucas (1993)), and technology transfer or knowledge spillover (e.g., Bernard-Jones (1996)). In order to achieve the purpose, the author sets up an analytical framework that rests with existing studies (e.g., Proudman-Redding (2000), and Hinloopen-Van Marrewijk (2001)). The author additionally makes the following improvements to the analytical framework.

Main findings of this study are as follows. First, the comparative advantage mobility differs between trade in goods and in services. Second, the state persistency of the comparative advantage indicates the higher probabilities in both strong and weak edge regions and the lower probabilities in intermediate regions, relatively. Third, a convergence speed of the stochastic process depends on conditions of the initial distributions of the TPM. The convergence speed is related to the mobility, and differs between the goods and the services. Finally, external shocks stimulate the mobility. This study consequently brings out features of the comparative advantage structure dynamics.

The existing literatures that the author should be basement of this study are as follows. Proudman and Redding (2000), which is one of the key studies in setting up the analytical framework, found that patterns of international specialization of G-5 countries (the United Kingdom, the United States, France, Germany, and Japan) on trade in goods were different from each other, by application of an analytical framework for the income distributions (e.g., Quah (1996, 1997) and Shorrocks (1978)). Based on the specialization pattern differences, they also found that the mobility was

highest in France and the United Kingdom and lowest in Japan. While they analyzed the mobility of trade in goods only, it was important consequences to propose a new analytical framework and to show the relevancy of the comparative advantage dynamics. By use of a similar method, Hinloopen and Van Marrewijk (2001) investigated the empirical distributions of the Balassa index in the European Union and Japan.

This study focuses on international trade in goods and in services. Breinlich and Criscuolo (2011) highlighted the importance of the trade in services, and found that firm-level heterogeneity is a key feature of trade in services. They also results, in theoretically, that heterogeneous firm models for trade in goods would be first step for giving an explanation of trade in services. Empirical studies also address to econometrically analyze properties of trade in services (e.g., Mann (2004), Kimura-Lee (2006), and Hisanaga (2008)). In analyzing the comparative advantage of trade in services, we must consider applicability of it to trade in services. Deardorff (1980) investigated the validity of comparative advantage in general, and supports our consideration. The validity is statistically tested by the following researchers, who almost supported the validity (e.g., Bernhofen and Brown (2004) and Kiyota (2011)). On measurement of comparative advantage, this study uses a Revealed Comparative Advantage (RCA) index that is well known as Balassa index and well-established in the empirical trade studies (e.g., Proudman-Redding (2000), Hinloopen-Van Marrewijk (2001), Brakman *et al*., (2011)).

The following sections are included the analytical framework and its results, issues of the comparative advantage dynamics in the world and several countries, and concluding remarks. In Section 2 the author makes a preparation of the analytical framework in order to measure the comparative advantage and its dynamics, and to evaluate situation of the comparative advantage dynamics. The analytical framework mainly consists of the measurement of comparative advantage, the estimation of transition probabilities, and the evaluation of dynamics. Section 3 indicates analytical results that are gained from the preparations in the preceding section. The author

explains the analytical results and related discussions. Finally, the author wraps up a series of the analytical results and discussions, and the concluding remarks are indicated in Section 4.

2. Analytical Framework

A series of analysis in order to capture the comparative advantage dynamics bases on the following methodology in this section. The analytical framework is consisted of two poles, which are the Markov process as one of the types of the stochastic process and the concept of the revealed comparative advantage. This section mainly explains analytical tools, and proposes some improvements for advanced analysis.

2.1 Application of the Stochastic Process

The analytical view throughout this study identifies the fluctuation of the comparative advantage structure in the world as the dynamic system in which the states transition over time. In order to mathematically describe the fluctuations, this study applies Markov stochastic process to analysis. The comparative advantage dynamics, in this context, means that the comparative advantage fluctuates from one state to another during two periods (**Figure 1**). Definitions of states and periods are closely explained in the just after section, because those have some types or ranges depending on analytical objectives.

First of applying the Markov probability process is to introduce basic concept of it. Time points are presented as t. The state on the system changes at $t = 0,1, \dots, k, \dots, n$. The analysis assumes the following conditions: 1) Numbers of states that the system could be are N; 2) The system is in one state of the N states; and 3) Probability p_{ij} that one system transits from state i at $t = k$ to state j at $k + 1$ are determined only by the states i and j, and have no relation to the value of t and to the changes of the system before k.

The probability p_{ij}, which is called a transition probability, is generally defined as follows:

$$p_{ij} \equiv P(X_{k+1} = j | X_k = i), \tag{1}$$

where $P(\cdot)$ is probability, X_t means the states of the system at t. The above definition thus means that the transition probability is a conditional probability of $X_{k+1} = j$, given $X_k = i$.

The transition probability has the following properties: 1) $0 \leq p_{ij} \leq 1$; and 2) $\sum_{j=1}^{N} p_{ij} = 1$. The first property is clear because of the axiom of probability. The second property is also clear because of the above assumptions. Based on Equation 1 and its properties, the transition probability for the numerical estimation is specifically redefined as follows:

$$p_{ij} \equiv \frac{s_{ij}}{\sum_{j=1}^{N} s_{ij}}, \tag{2}$$

where s_{ij} is the numbers of the state changes from the state i at k to the state j at $k+1$, and N is the numbers of the states.

Based on Equation 2, a transition probability matrix, which is well-known as Markov matrix, is as follows:

$$\boldsymbol{P}_{k,k+1} \equiv \begin{pmatrix} p_{11} & \cdots & p_{1N} \\ \vdots & \ddots & \vdots \\ p_{N1} & \cdots & p_{NN} \end{pmatrix}. \tag{3}$$

Each row of Equation 3 is a group of the transition probabilities based on the state at k. The each row holds the second property of the transition probability, because the system in the state i at one time point is sure to transit any one of the states $1, 2, \ldots, N$ according to the above second assumption.

The numerical estimation will firstly generate the transition probability matrix from a pair of data tables at the discretely continuing two time points during the observation periods (**Figure 2**). This matrix generated from the primary data tables both k and $k+1$ is called as an initial distribution of the transition probability matrix in the $(k, k+1)$ period. In the following numerical estimations the initial distributions are generated from the RCA data tables that the estimation types require.

The Markov probability process formed from the initial distribution requires the following assumptions: 1) an aperiodicity, and 2) an irreducibility. The aperiodicity

means that any states is not recursive in the next period. The irreducibility means that any states at one period can transit any states including itself at the next period. These assumptions assure the convergence of the Markov process from the initial distribution to the limit distribution.

2.2 The Limit Distribution and Convergence

The analysis also focuses on a convergence speed of the system in each period. In order to measure the convergence speed, this section explains an n-step (a higher order) transition probability matrix and related well-known theorems on the limit.

The higher order transition probability matrix is yield by power of the initial distribution. The transition probability matrix holds the basic property of the linear algebra as follows: $\boldsymbol{P}^n = \boldsymbol{P}^{n-1}\boldsymbol{P}$. On the higher order transition probability matrix $\boldsymbol{P}^n$, the limit of it has following property:

$$\lim_{n\to\infty} \boldsymbol{P}^n = \lim_{n\to\infty} \begin{pmatrix} p_{11}^{(n)} & \cdots & p_{1N}^{(n)} \\ \vdots & \ddots & \vdots \\ p_{N1}^{(n)} & \cdots & p_{NN}^{(n)} \end{pmatrix} \Leftrightarrow \boldsymbol{\Pi} = \begin{pmatrix} \pi_1 & \cdots & \pi_N \\ \vdots & \ddots & \vdots \\ \pi_1 & \cdots & \pi_N \end{pmatrix} \tag{4}$$

where $\boldsymbol{\Pi}$ is the limit distribution of the transition probability matrix, and $\pi_1 \dots \pi_N$ are limit probabilities. The limit distribution has the following properties: $\pi_k \geq 0\ (k = 1 \dots N)$ and $\sum_{k=1}^{N} \pi_k = 1$. These properties are as well as the initial distribution. In addition to the above properties, each row vector $\boldsymbol{\pi}_i = (\pi_1 \dots \pi_N)$ is equal to each other. The numerical estimation uses the last property ($\boldsymbol{\pi}_1 = \cdots = \boldsymbol{\pi}_N$) in order to determine the convergence of the stochastic process. In determining the convergence the estimation also uses the following relational expression:

$$\boldsymbol{\Pi} = \boldsymbol{\Pi}\boldsymbol{P} \tag{5}$$

The relationship is easy to be derived. On the trivial expression $\boldsymbol{P}^n = \boldsymbol{P}^{n-1}\boldsymbol{P}$, it takes the limit $n \to \infty$ in both sides. Based on the Equation 4, $\boldsymbol{P}^n$ and $\boldsymbol{P}^{n-1}$ converge on $\boldsymbol{\Pi}$. The limit distribution, therefore, satisfies the above relational expression.

The reminder of this subsection collaterally explains a convergence criterion in the numerical estimation and a meaning of the convergence speed. According to the

Equation 4 and related explanations, the initial distribution converges on the limit distribution in raising the transition probability matrix by the extent of iterations. Based on the Equation 5, the multiplication of the transition probability matrixes remains constant. When the multiplication of the matrixes has the constant, the numerical estimation determines that the initial distribution reaches the limit distribution. In that time, the number of iterations of the multiplications is the time that it takes the limit distribution by appearing, namely the convergence time. The analytical framework calls the convergence time on the numerical estimation as a Limit Appearance Time (LAT). The convergence criterion, therefore, is that the transition probability matrix becomes the constant after iterations of the multiplication.

The convergence time or speed means a certain temporal distance between an actual condition and an ideal condition that would be the steady state in economics. If the convergence time is long/short, the distance would be far/close. When the temporal distance is far, a convergence process would be exposed to additional or cumulative external shocks. The farer the temporal distance is, the higher the exposure risks become. The convergence speed, thus, has important implications.

This study simply defines the Convergence Speed Index (CSI) as the following equation: $CSI_{t,t+1} \equiv 1/LAT_{t,t+1}$, where CSI has the domain as $0 \leq CSI \leq 1$. The convergence speed would vary depending on the conditions of the initial distributions. Since the CSIs are computed on the process of estimating the limit distribution, the analysis compares each CSI corresponding to the periods of the initial and the limit distributions in order to investigate differences between the actual conditions and the ideals.

2.3 Evaluation of Dynamics

The analysis evaluates dynamics by use of an index based on the trace (Tr) of the matrix. Each diagonal probability (p_{kk}) of the transition probability matrix (Equation 3) indicate the probability that one sample remains the same state during t and $t+1$. That is a persistence probability (persistency). In which case the persistency is an event

on probability space, complementary events are what one sample does not remain the same state. One sample, in other words, transits another state during the two periods. The non-persisting probability means what one sample is mobile to transit from states to states during the two periods. The non-persisting probability is recognized as the mobile probability (mobility). The mobility, thus, is the complementary events of the persistency, and it described as $1 - p_{kk}$.

In accord with the above explanation, this study proposes to introduce an evaluation index, which is named as a Discrete-time Mobility Index (DMI), of the whole dynamic system (transition probability matrix). The DMI is defined as the following equation:

$$DMI_{t,t+1} \equiv 1 - \left(Tr\, \boldsymbol{P}_{k,k+1}\right)/N \tag{6}$$

where N is the number of states, which is same as Equation 2 and 3. The DMI indicates the complementary event of the average persistency, namely the average mobility. The deriving process of the DMI is described in Appendix.

The DMI mainly measures the degree of the mobility in the initial distributions. In measuring the mobility by sectors and in time periods, the analysis clarifies differences between sectors and trends in time series. Additionally, the DMI would indicate different features by the numerical estimation type, which is to be described in Section 2.6.1.

2.4 Definitions of Periods and States

The analytical framework sets up two types of the periods: the two-term periods and the sequential periods. The estimation plan to be described is consisted of the combination of both types, in consideration of their utility and/or constraints.

The first of types, which Proudman and Redding (2000) employs, divides the observation periods into the first and the second half. Each half has the pooled data corresponding to them, and requires the same sample size between the first and the second half in order to assure the symmetric property on dataset during the periods. The two-term periods type is suited for measuring the long-term and large shits. For

instance, if the observers would like to measure in a few decades or farther, this period type would provide meaningful results. In the other viewpoints, if they would like to investigate differences or structural changes between prior states and post ones when some incidents occur, this period type would also useful outcomes.

The second of types, which Hinloopen and Van Marrewijk (2001) employs, is the time series periods such as the annually, quarterly, or monthly periods. In comparison to the former type, the sequential period type is suited for determining the tendency of the state changes in the short-term. For instance, in the forecited article[1)] its authors analyze the similarity of the comparative advantage changes between monthly and annual. This analytical framework, thus, employs the annual data, which is classified in the sequential period type, in analyzing the mobility changes in the short term.

The transition probability analysis requires the definition of the states. Since this study focuses on how the comparative advantage transits from the past to the present, the definition of the states is an important to make analytical outcomes. The analytical framework defines two types of states. One is based on the exiting studies, another is a proposal approach by this study.

The standard type classifies the conditions of the comparative advantage into four states. For instance, Proudman and Redding (2000) employ the variable threshold method that simply sorts the comparative advantage data in descending and divides them equally, and Hinloopen and Van Marrewijk (2001) employ the fixed threshold method that classifies the comparative advantage data in each class that one sample satisfies the threshold conditions. The method of these studies follows the influential study by Quah (1996, 1997).

The proposal type has more elaborate states than the standard type. The number of states is equal to that of the observation countries. Each state, in other words, means the order of several sectors. The transition probabilities are consisted that how many sectors move from one state in t to other states in $t+1$. Since this type observes all patterns of the state transitions by sectors, it can analyze more elaborate state

[1)] Hinloopen-Van Marrewijk (2001).

transitions and the degree of them (the mobility or the persistency).

2.5 Measurements of Comparative Advantage

The analytical framework employs the Balassa type RCA index in order to measure the degree of the comparative advantage or the specialization, after Hinloopen and Van Marrewijk (2001). The definitional equation of the index is as follows:

$$RCA_{ij} \equiv \frac{X_{ij}/\sum_{j=1}^{m} X_{ij}}{\sum_{i=1}^{n} X_{ij}/\sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij}}$$

where X_{ij} is the export value of sector j in country i. The numerator means the ratio of sector within the country. The denominator means the ratio of the world amount of sectors to that of sectors and countries. Although the RCA index has a lot of derivations, this study follows the Balassa type that Hinloopen and Van Marrewijk (2001) give an instance that the index indicates similar transitions between annual and monthly. Since this study focuses on dynamics by use of annual data, the Balassa type is adequate for the purpose of analysis.

2.6 Plan of Numerical Estimations and Dataset

The analysis makes numerical estimations, based on the framework presented in the foregoing parts of this section, in line with the following plan, and by use of the dataset to be described in the last paragraphs of this section.

2.6.1 Plan of Numerical Estimations

A plan of the numerical estimations are consisted of combinations of the states and periods that are described above. The numerical estimations are examined by the following three types: a Proudman-Redding (PR) type, an improved Proudman-Redding (iPR) type, and a proposal type. These types have a different composition of the states and the periods. These types and settings are summarized in **Table 1**.

Firstly, the PR type is an estimation method based on Proudman-Redding (2000), which employs the four states and the two-period pooled dataset. This type is the

benchmark estimation and an analytical result for the following two type estimations. Secondly, the iPR type adopts the annual period dataset as substituted for the two-period pooled dataset. This modification provides elaborate results on the time series fluctuation in comparison to the PR type. Finally, the proposal type adopts both the number of countries and the annual period dataset. Since both settings of the proposal type are different from the PR type, this type captures more elaborate than the first type.

The analytical framework executes these estimations on the trade in goods, in services, and in goods and services. Analytical results would indicate differences of the mobility between the goods and the services, features of the transitions in the observation periods, and relationship between the initial distribution of transition probability matrix and the convergence speed.

2.6.2 Dataset

The analytical framework sets up dataset including the trade in goods and services in OECD countries from 2002 to 2011. The dataset of the trade in goods and in services refers to *International Trade Statistics Yearbook* (ITSY)[2)] published by United Nations (UN) and *Balance of Payments Statistics* (BPS)[3)] published by International Monetary Fund (IMF), respectively.

Firstly, ITSY classifies trade in goods into 10 sectors, which is based on Standard International Trade Classification (SITC). The sectors and their compositions are listed in **Table 2**. Since open information of the ITSY is listed in 8 sectors that are combined the digit 0 with 1st and done the digit 2nd and 4th, the analytical framework uses 8 sectors due to statistical constraint. While SITC, prudent readers know, has more particular items (4 digits or more), the analytical framework uses a large category in order to coordinate with the category of trade in services to be described.

Secondly, BPS classifies trade in services into 11 sectors, which is based on

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[2)] UN (2014). See also UN Comtrade Yearbook, http://comtrade.un.org/pb/.
[3)] IMF (2014). See also IMF eLibrary, http://elibrary-data.imf.org/.

Balance of Payments Manual (BPM)[4]. The sectors and their compositions are listed in **Table 2**. The analytical framework gets rid of a few sectors that are not suited to the research purpose. The categories excluded from analysis are both the Insurance Services sector and the Government Services n.i.e.[5] sector. The former sector contains not only agent commissions related to insurance transactions but also direct insurance and reinsurance[6]. Whereas the agent commissions seem to satisfy property of the trade in services, the direct insurance and reinsurance would be capital transaction rather than trade in services. The direct insurance and reinsurance also cause a problem for computing the RCA index. While the domain of the RCA index is $0 \leq RCA$ as the definitional equation suggests, net base transactions of the direct insurance and reinsurance can result in negative values of the RCA index. It is inexpedience for the analysis to leave the problem. The analytical framework, thus, excludes the Insurance Services sector. The latter sector contains all transactions by embassies, consulates, military units, and defense agencies[7]. In economics, the comparative advantage fundamentally would not relate to the government services. Because the analytical purpose also examines private transactions, the analytical framework excludes the Government Services n.i.e. sector.

The analytical framework observes OECD countries (**Table 3**). These countries are easily accessible to trade statistics both goods and services in a relatively long-term. The newly acceding countries, which Chile, Slovenia, Israel, and Estonia acceded in 2010, are excluded in the observation countries, because these countries have more missing values in the trade statistics.

The analytical framework sets the observation periods for 13 years (2001 to 2013) in goods and 10 years (2002 to 2011) in services, due to statistical constraints. Because data on the goods and services are 10 years (2002 to 2011) that both the goods and the services are overlap, the observation periods of the transition probability matrix

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4) IMF (1993).
5) Note: "n.i.e." stands for "not included elsewhere."
6) IMF (1993), p.66.
7) IMF (1993), p.69.

analysis are 9 periods that are differences of the full observation periods (**Table 3**). In the observation periods, the world economy has passed through a lot of the economic incidents such as the September 11 attacks in 2001, the Bankruptcy of Lehman Brothers in 2008, the European debt crisis in 2010, and the Japan earthquake in 2011. These incidents as external shocks would affect the situation of the comparative advantage structure.

3. Analytical Results and Discussion

In this section the author presents results gained from the analysis explained in the preceding section. The first part section indicates descriptive statistics of the RCA index. The second part lists the comparative advantage dynamics data in order of the analysis types: the PR type, the iPR type, and the proposal type. We would know that these types have their distinctive features by contrast with several methods. The last part observes the difference of the convergence speed from the initial distribution to the limit distribution in each period.

3.1 Descriptive Statistics of the RCA Index

First of all, this section shows descriptive statistics of the RCA index by sectors during 2002 and 2011 (**Table 4**). In comparison between the goods and the services trade, the mean of the RCA in the goods is excess to that in the services in the middle of the periods (2005 to 2007), while the RCA on the services is excess to that on the goods in other periods. This fact seems to makes us occur structural change on the comparative advantage in 2004-2005 and 2007-2008 periods. Additionally, a characteristic change also occurs in closing years of periods. While the mean of the RCA of the services temporarily rises up, that of the goods contrastively falls down in 2010.

The goods sectors that the mean of the RCA widely fluctuates are SITC 2+4, which contains crude materials (excluding fuels), oils, and fats, and SITC 9, which contains commodities and transactions not classified elsewhere in SITC, throughout the period. The former temporarily falls down in 2010. The latter gradually increase until 2006,

and after that decreases. In the other hand the services sectors are wholly stable fluctuation except the category of Personal, cultural, and recreational services. In the first half of the period the category fluctuate around 1.07, and in the second half it stably increases except for a temporary rising in 2010.

Standard deviation (SD) tends that the services are excess to the goods throughout the period. The SD expresses the scattering condition of the comparative advantage, that is, the distribution of the specialization in each sector. While the goods transit around 1.0, the services do around 1.8. These facts mean that the services show a wider distribution than the goods. In the goods categories the SD of SITC 0+1, 2+4, and 3 tends to indicate higher values than others, although there are exceptional years. These categories are related to agricultural products and natural resources. Since observation countries are the OECD countries that are mainly consisted of industrial countries, this result would reflect real economic circumstances. In the services categories, in contrast, the SD differs between categories. While the SD of the Royalties and License Fees category, the Other Business Services category, and the Construction Services category transits lower values across the broad, the SD of the Financial Services category transits foremost higher values. We will discuss on differences of distributions in the services for details in Section 4.

3.2 Dynamics of the Comparative Advantage Structure

The result of the comparative advantage dynamics shows a characteristic tendency by each type. The following subsections are consisted of different types: PR type as the benchmark, the iPR type, and the Proposal type.

3.2.1 Proudman-Redding Type

The initial distribution of the transition probability matrix in the goods and services during 2002-2006 and 2007-2011 shows the following characteristic facts: 1) the either end of the diagonal elements indicate higher probabilities, and 2) the distribution of the transition probabilities in each row places a disproportionate emphasis on the

diagonal elements (**Figure 3a**). The either end of the diagonal elements means a higher comparative advantage class and a lower comparative advantage class, respectively. The diagonal elements indicate higher probability than the off-diagonal elements in every row. The characteristic values, which are Trace, Determinant, and DMI, indicate 2.9896, 0.2713, and 0.2526, respectively (**Table 5**). LAT and the convergence speed are 9 steps and 0.1111, respectively.

The initial distribution of the goods shows similarity to the goods and services. The transition probability matrix indicates higher probabilities in the either end of the diagonal elements (**Figure 3b**). These probabilities are just a hair over those of the goods and services. The characteristic values indicate 3.0267, 0.2843, and 0.2433. DMI, namely the average mobility, is lower than the goods and services. Since the convergence speed is 0.125, it is faster than the goods and services (**Table 5**).

The initial distribution of the services also shows higher probabilities in the diagonal elements. In comparison to the noted above two segments, the lower end indicates low probability (**Figure 3c**). The characteristic values also indicate similar values. These are 3.001, 0.2823, and 0.2497. Since DMI of the services is higher than that of the goods, the fluctuation of the comparative advantage in the services is relatively active against the goods. The fact that the goods and services indicates the highest DMI in these segments and the remained segments indicate similarly and relatively low values implies that the fluctuation of the comparative advantage also occurs between the goods and the services. LAT and the convergence speed are as same as the goods and services (**Table 5**).

3.2.2 Improved Proudman-Redding Type

The improved Proudman-Redding type captures the fluctuation of the comparative advantage between two points of time. In this analysis the fluctuation between the two points means annual fluctuations during the observation period. The following initial distributions and the characteristic values provide features of annual fluctuations by the goods and services, the goods, and the services.

The initial distributions of the goods and services show that the either end of the diagonal elements is higher than the intermediate of them every period (**Figure 4**). This trend is as well as the standard Proudman-Redding type above. Distinctive trends, however, are found in off-diagonal elements. First, the transition probabilities include 0.0 that means no transitions between states from 2002-2003 to 2008-2009, while they does not from 2009-2010 to 2010-2011. This fact means that the transition probabilities diffuse to the closing periods of the observation periods. Second, the wide transitions ($d = |i - j| \geq 2$) increase after 2007-2008 period in comparison to before it. This diffusion of transition probabilities, or increasing the breadth of the distribution, implies an activation of the comparative advantage fluctuations.

The characteristic values of the initial distributions of the goods and services also provide evidence on the active extents of the comparative advantage fluctuations in the observation periods (**Table 6**). Trace, degree of persistency, has decreased after 2005-2006. At same time DMI has increased. The convergence speed becomes to be fast from 0.1 in 2002-2003 to 0.125 in 2010-2011.

The initial distributions of the goods have the non-transition elements every period at variance with those of the goods and services (**Figure 5**). The non-transition elements in the goods are more than that in the goods and services (the goods: 31, the goods and services: 20). The wide transitions are less than the goods and services (the goods: 23, the goods and services: 34). These data thus suggest that profound fluctuations unlikely to occur in the goods during the observation periods.

The characteristic values of the initial distributions of the goods are listed in **Table 7**. It is distinctive that the DMI has gradually increased since 2006-2007 periods. While the DMI of the goods and services is relatively flat, that of the goods precisely shows upturn mobility. Throughout the observation periods DMI of the goods exceeds that of the goods and services.

The initial distributions of the services show that the non-transition elements are approximately 1.85 times of the goods and services (the services: 37, the goods: 31, and the goods and services: 20) and the wide transitions are the half of the goods and

services (the services: 17, the goods: 23, and the goods and services: 34) throughout the periods (**Figure 6**). The number of the non-transition elements means the concentration of the distribution. In the distributions of the services most of the non-transition elements are found in the edges of the matrix except the either edge of the diagonal elements. The reduction of the wide transitions, therefore, is indeed a case in point.

In the latest periods (2009-2010 and 2010-2011), the middle and lower elements of the diagonals indicates lower probabilities in comparison to other periods. The similar trend is observed in the goods and the goods and services. The observation countries had seemed to sustain aftermath of Lehman's fall in 2008 or European debt crisis in 2010.

The characteristic values, especially the DMI, indicate a more distinctive fact (**Table 8**). Although the DMI indicates lower value from 2002-2003 to 2007-2008, the values of it has rapidly increased since 2008-2009. This increasing is more obvious than the goods. The convergence speed is slow in the middle of the periods (2005-2006 to 2007-2008).

3.2.3 Proposal Type

The proposal type captures the elaborate state transitions of the comparative advantage with the annual fluctuations. The following results supplement the foregoing results, which are the Proudman-Redding type and the improved Proudman-Redding type. Improvements, which the type sets states up elaboration, provide to make us to see that the mobility difference between an inter-state transition and an intra-state transitions and the distribution difference between domains of the initial distributions.

In the proposal type, the goods and services describes the distinctive initial distributions (**Figure 7**), which have higher transition probabilities in both edges of the diagonal elements, as well as the improved Proudman-Redding type. Throughout the observations periods both edges of the diagonals maintain high probabilities. Additionally, the proposal type, in comparison to the former types, definitely indicates

a gradation of the transition probabilities of the diagonal elements. The middle range of the initial distributions is lower probabilities than the both edge ranges of those.

The elaborate states setting makes us to see a new feature of the initial distributions. In classifying states to three layers: a high layer includes the state 1 to 10, a middle layer includes the state 11 to 20, and a low layer includes the other states (21 to 30), the middle layer of the initial distributions tends to indicate that the transition probabilities except some outliers distribute in wide ranges in comparison to the other layers. This feature is not captured in the former types.

In a time series variation, the initial distribution spreads in the closing periods (2008-2009 to 2010-2011) in comparison to the opening periods (2002-2003 to 2004-2005). Especially, most of the wide range transitions distributes in the closing periods. This fact implies that the comparative advantage structure has changed since 2008.

The characteristic values of the initial distributions of the goods and services are listed in **Table 9**. The DMI has increased since the 2006-2007 period, and has maintained high level of the comparative advantage mobility. The Trace, which is symmetrical relation to the DMI, has decreased since that period. The Determinant indicates significantly small values, because the initial distributions have much zero elements. The fastest LAT and CSI are indicated in the 2009-2010 period. In the 2007-2008 period, the initial distribution does not converge to the limiting distribution, because an absorbing state occurs in the distribution.

The initial distributions of the goods also indicate the high probabilities in both edges and the low probabilities in middle of the diagonal elements (**Figure 8**). In the first half of the periods, the initial distribution, at variance with the goods and services, ranges the narrow scope centering on diagonals. In the last three periods (2008-2009 to 2010-2011), the initial distribution spreads as well as the goods and services. It is a distinctive point that the initial distributions place a disproportionate emphasis on the upper or lower triangular matrix with low probabilities in these periods. The initial distribution in the 2009-2010 period places a disproportionate spread on the upper, and that in the 2010-2011 period places the disproportionate spread on the lower. The

distribution placed on the disproportionate emphasis on the upper/lower means that one state transits to one of the superior/inferior states. The opposite triangular matrix, in the nature of the case, places a disproportionate emphasis narrow scope centering on diagonals with high probabilities.

The characteristic values of the goods are listed in **Table 10**. Mobility, the value of DMI, is more stable in comparison to the goods and services, while it has twice downward phases in the 2003-2004 and 2006-2007 periods. The Determinant indicates significantly small values as well as the goods and services. In the 2003-2004 and 2007-2008 periods, the initial distribution does not converge to the limiting distribution.

A distinctive point in the initial distributions of the services is that the lower edge probabilities of the diagonals are higher than that of the goods (**Figure 9**). In the first half of the periods the distinction is especially found in the initial distributions. In the last three periods the initial distributions also place a disproportionate emphasis on the upper or lower triangular matrix with low probabilities as well as the goods. The disproportionation trends, however, are opposite to the goods. Comparing the initial distributions of the services with those of the goods in the 2009-2010 and 2010-2011 periods, we can observe the symmetrical trend.

In the characteristic values of the services (**Table 11**), the DMI indicates a distinctive trajectory. Although an overall trend of the DMI plots an upward-sloping curve, the curve locally marks a sizable drop from the 2005-2006 to the 2006-2007 periods. The mobility has rapidly increased since the 2006-2007 period, and has maintained in higher level since the 2008-2009 period. In comparison to the DMI of the goods, that of the services would have a sufficient impact on the entire mobility, namely the goods and services mobility.

Another distinctive data is that the initial distributions of the services do not converge to the limiting distribution. Because those of the services have the absorbing state every period, those do not reach the convergence. This fact would imply rigidity of the comparative advantage dynamics in the services. The Trace decreases with the increase of the DMI during periods. The Determinant, as well as the goods and the

goods and services, indicates the extremely small values.

3.3 Discussion

Analytical results not only show new findings but also raise issues related to empirical and theoretical studies. We discuss the findings and issues on the comparative advantage dynamics. First of all, we discuss the differences of the degree of the mobility between trade in goods and in services, examine sector specific property, and discuss influences of external shocks to the mobility. Second, we examine the consistency of the result against the international trade theory. Finally, we discuss other issues and remarks.

3.3.1 Differences of the Dynamics between the Goods and the Services

Analytical results show the obvious differences of the comparative advantage mobility between the goods and the services. We can observe the difference, and its expansion and conversion of the mobility between the goods and the services in the observation periods from 2002-2003 to 2010-2011. **Figure 10** is illustrated by gathered data based on analytical results by the sectors and the estimation types. In both iPR and proposal type, we can observe the mobility differences between the goods and the services, which show distinctive transitions after the 2004-2005 periods. Although both estimation types indicate the mobility differences, the proposal type presents more obviously than the iPR type. Since the proposal type excludes the intra-state transitions that the iPR type includes, the differences of the mobility obviously and sensitively appear in the analytical results.

The most distinctive feature would be trends of the proposal type after the 2007-2008 periods. A rapid rise of the mobility in the period would certainly be influence of the Bankruptcy of Lehman Brothers in September 2008. In the rapid rise of the mobility, the services are more sensitive than the goods. The range of the mobility in the services indicates 0.367 (max.: 0.852, min.: 0.485), and that in the goods indicates 0.159 (max.: 0.717, min.: 0.558) during the observation periods. A band of fluctuation in the services

is broader than that in the goods.

Trends between the 2004-2005 periods and the 2007-2008 periods are also one of the distinctive features. In the periods both sectors show the opposite trends after the 2007-2008 periods, and that is the mobility in the goods is higher than that in the services. Before the 2004-2005 period, the differences of the mobility between the goods and the services are not at all. Factors that stimulates changes of the comparative advantage would have gradually booted since the 2004-2005 period. In comparison to the post 2007-2008 periods, the mobility in goods maybe naturally higher than that in services. Although the discussion so far based on data of the proposal type, another data series, which is the iPR type, shows the trend that the mobility in the goods wholly surpasses that in the services during the observation periods.

3.3.2 Consistency of Theory

The provided results of the initial distributions of the transition probabilities in the series of analyses partially support consequences of the previous theoretical studies. For instance, a Ricardian model with a continuum of goods, which is developed by Dornbusch et al. (1977), implies that the comparative advantage of the both edges (higher and lower regions) is persistent and that of the middle region where product conditions are fluid through changes of external environment is mobile. While the above model is two countries, a Ricardian comparative advantage with multi countries and sectors developed by Eaton and Kortum (2002) also implies similar consequences. The consistency of theory is also mentioned in Proudman and Redding (2000), although that study treats only the goods. It is the concerned case that not only the goods but also the services (and additionally the goods and services) indicate similar tendency.

The case that the higher extent of both edges of the initial distribution implies that the comparative advantage structure has possibilities to polarize. In the macroeconomics field, the polarization means that income distribution towards the rich and the poor (e.g., Quah, 1996, 1997). If it interpreted in the context of international economics, the polarization of the comparative advantage would mean that the

comparative advantage towards the strength and the weakness in several sectors. Proudman and Redding (2000), on this point, describes that "we would expect to observe a polarization of the RCA distribution towards extreme values[8)]." While their study mainly focuses on the comparative advantage structure of the goods within countries, the analytical results of this study provides new consequences with the services. The polarization of the comparative advantage, thus, would have the general validity on the international trade.

3.3.3 Implication of convergence speed

This analysis also focuses on convergence speed of the transition probability matrix from the initial distribution to the limit distribution in each period. **Figure 11** shows changes of the convergence speed during the observation periods. The convergence speed is different from period to period. The difference of the convergence speed would be that of theoretical distance between the initial distribution and the limit distribution in each period. These differences, in the context of economic theory, would have a critical implication. In case that the convergence speed is faster, the possibility that the convergence process is exposed to external shocks would be lower. The distance between both distributions also implies whether the real situation of the comparative advantage dynamics is far from the ideal situation or not. If the convergence speed is significantly-fast in a period, the real and the ideal situation would be similar in that time.

Table 12 provides additional information of correlation between the convergence speed and the mobility with respect to each sector. In the Proudman-Redding type estimation indicates high correlation, and the proposal type does middle correlation. While the situations of the initial distribution of each sector and each estimation are visually confirmed in the above section, sectors that relatively-uniform distribute in the initial distribution indicate high correlation. Namely, the initial distributions estimated by the Proudman-Redding type have more uniform than the proposal type.

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8) Proudman-Redding (2000), p.392.

3.3.4 Intra-State Mobility

Comparison of DMI estimated by the Proudman-Redding type with that estimated by the proposal type presents a suggestion. In **Figure 10**, the DMI of the Proudman-Redding type and that of the proposal type indicates lower and higher values respectively. Since the Proudman-Redding type potentially covers over the state variations within each state, the Proudman-Redding type's DMI that captures the state variations between states indicates lower values. The DMI of the proposal type, meanwhile, indicates higher values. Since the definition of the state in the proposal type means that the number of the state is equal to that of the countries, the state variations in the proposal type captures the full state variations. Thus, the relational equation of the DMI of intra-, inter-, and full-state is expressed as follows:

$$DMI_{intra} = DMI_{full} - DMI_{inter}.$$

Figure 12 demonstrates the intra-state DMI of the goods, the services, and the goods and services. Although the intra-state DMI is average values of the Proudman-Redding type, the Figure makes us see that the comparative advantage has the intra-state fluctuations in each states.

4. Concluding Remarks

The mobility of the comparative advantage structure obviously differs between the goods and the services. The results from the series of analyses provide the impressive cases. The analytical results have shown that the mobility of the services is more sensitive to external shocks such as the Lehman's fall than that of the goods. The empirical findings of estimating the initial distributions and their time series analysis supports theoretical implications and fit almost together the related existing studies. The series of the analytical results rest on bases of the consequence of existing studies and the some improvements in this study. Focusing on the relationship between the extent of the comparative advantage dynamics and the convergence speed, the differences of the initial distribution yield those of the convergence speed, in other

words, the theoretical distance between the real and the ideal situations.

The empirical findings of the initial distributions show that the comparative advantage dynamics rarely appear the wide range transitions from the higher to the lower states, vice versa. Thus, the comparative advantage structure gradually changes over time. The empirical findings also show that the both edges of the diagonal of the transition probabilities are higher than the middle of the diagonal. This fact implies that the polarization, which predicted in the income distributions, is likely to occur in the comparative advantage structure.

Appendix: Discrete Mobility Index

In this appendix the author shows the process of deriving the DMI (Equation 6). The Trace (Tr) of the matrix P_n is defined as the following equation:

$$Tr \equiv \sum_{k=1}^{n} p_{kk},$$

where p_{kk} is the diagonal elements of the transition probabilities (p_{ij}) in the transition probability matrix (P_n). Because p_{kk} is satisfied with the axiom of the probabilities, its domain is $0 \leq p_{kk} \leq 1 \Leftrightarrow 0 \leq \sum p_{kk} \leq n$. In a row of the matrix, the relationship between the diagonal element and the off-diagonal elements is expressed as the following equation:

$$p_{kk} = 1 - \sum_{l=1, l \neq k}^{n} p_{kl}.$$

We can rewrite Tr as the following equation:

$$Tr = \sum_{k=1}^{n} \left(1 - \sum_{l=1, l \neq k}^{n} p_{kl}\right) = n - \sum_{k=1}^{n} \sum_{l=1, l \neq k}^{n} p_{kl}.$$

Here, the analytical framework assumes that observations are both the population and the sample. Associated with the above equation, it divides both members by n.

$$\frac{Tr}{n} = 1 - \frac{1}{n} \sum_{k=1}^{n} \sum_{l=1, l \neq k}^{n} p_{kl} \quad \Leftrightarrow \quad \frac{1}{n} \sum_{k=1}^{n} \sum_{l=1, l \neq k}^{n} p_{kl} = 1 - \frac{Tr}{n} \ (= DMI).$$

In the above equation, the left hand is the mean of the off-diagonal elements of the transition probability matrix. The mean of the off-diagonal elements means the average mobility of the system. In the right hand, Tr/n is the mean of the diagonal elements and it namely means the average persistency of the system. According to the domain of the Trace, a domain of Tr/n is $0 \leq Tr/n \leq 1$. The right hand, thereby, means the complementary event of the average persistency.

The above equation, therefore, indicates that the relationship between the average mobility and the average persistency is that between the event and the complementary event. In putting the average persistency as the event, the average mobility (DMI) is expressed by the complementary event of that.

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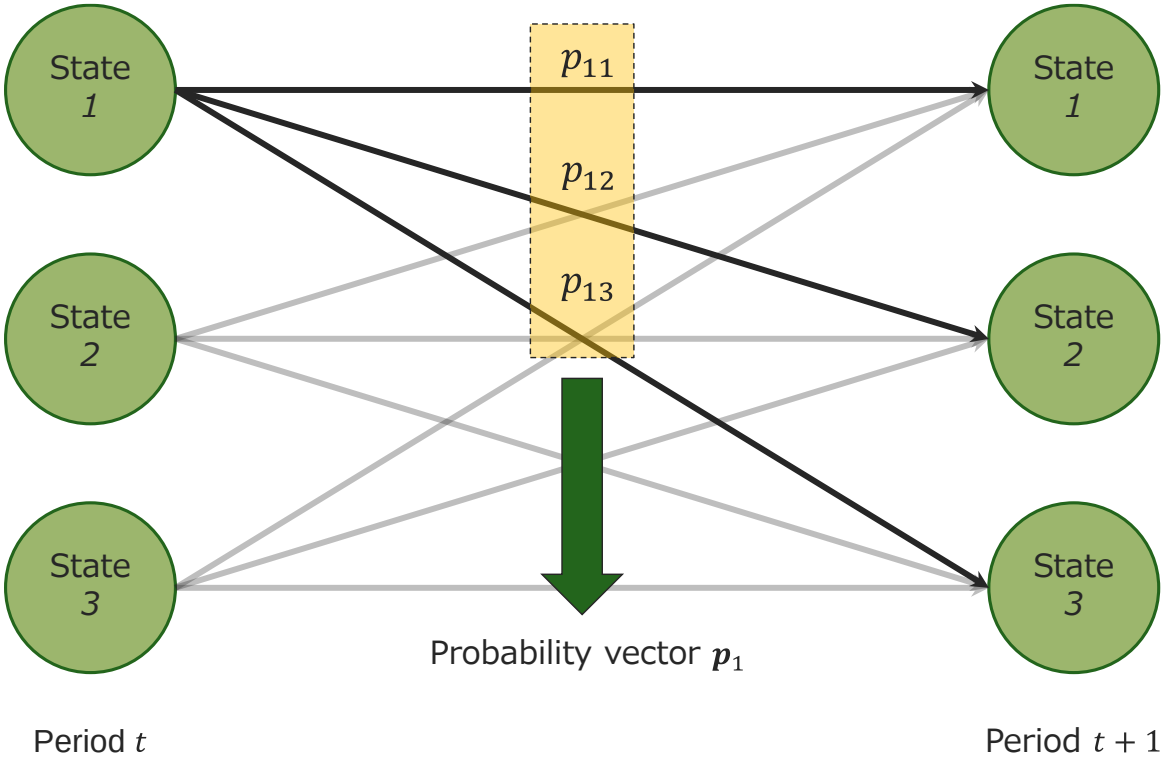
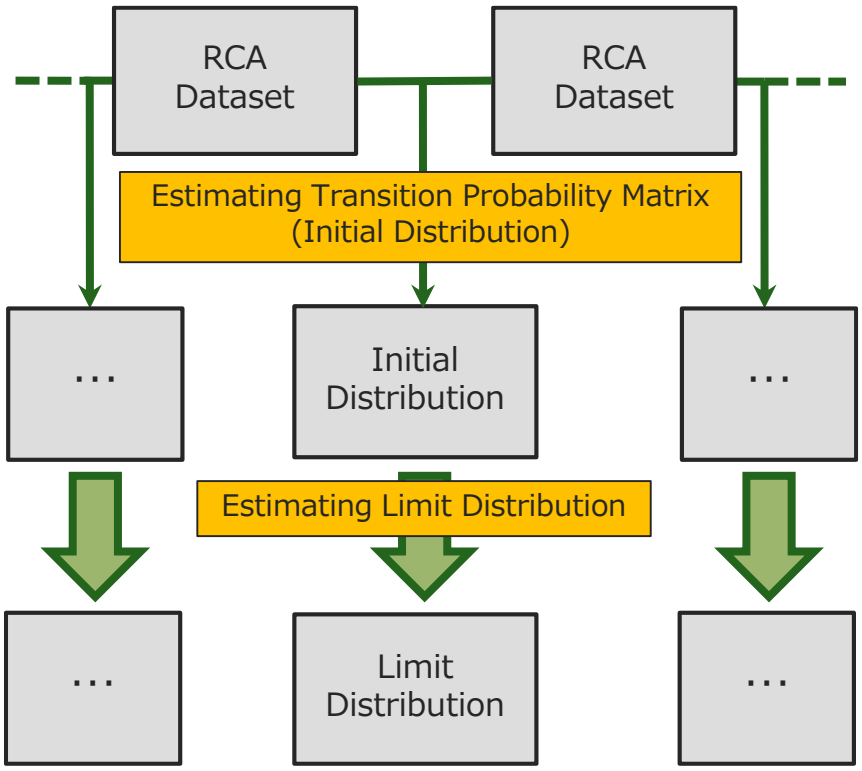


Source: Illustrated by the author

Figure 1

State Transitions and Transition Probabilities



Source: Illustrated by the author

Figure 2

Estimation of Transition Probability Matrix

0.8166	0.1332	0.0157	0.0345
0.1554	0.6641	0.1366	0.0440
0.0047	0.1790	0.7017	0.1146
0.0235	0.0235	0.1458	0.8072

Figure 3a (Goods and Services)

0.8367	0.1367	0.0200	0.0067
0.1400	0.6667	0.1533	0.0400
0.0067	0.1700	0.6967	0.1267
0.0167	0.0267	0.1300	0.8267

Figure 3b (Goods)

0.8077	0.1302	0.0030	0.0592
0.1632	0.6647	0.1098	0.0623
0.0000	0.1602	0.7448	0.0950
0.0296	0.0444	0.1420	0.7840

Figure 3c (Services)

Note:

$p = 0.0$	$0.0 \leq p < 0.25$	$0.25 \leq p < 0.5$	$0.5 \leq p < 0.75$	$0.75 \leq p < 1.0$	$p = 1.0$

Source: Compiled by the author.

Figure 3

Initial Distributions of the Proudman-Redding Type

2002-2003:

0.9219	0.0781	0.0000	0.0000
0.0787	0.8346	0.0866	0.0000
0.0000	0.0630	0.8740	0.0630
0.0000	0.0234	0.0391	0.9375

2003-2004:

0.9219	0.0703	0.0000	0.0078
0.0787	0.8819	0.0236	0.0157
0.0000	0.0472	0.9134	0.0394
0.0000	0.0000	0.0625	0.9375

2004-2005:

0.8984	0.0859	0.0000	0.0156
0.0945	0.7953	0.1024	0.0079
0.0000	0.1024	0.8189	0.0787
0.0078	0.0156	0.0781	0.8984

2005-2006:

0.8984	0.0859	0.0156	0.0000
0.0945	0.8268	0.0709	0.0079
0.0079	0.0787	0.8504	0.0630
0.0000	0.0078	0.0625	0.9297

2006-2007:

0.9141	0.0859	0.0000	0.0000
0.0787	0.8189	0.1024	0.0000
0.0000	0.0866	0.8346	0.0787
0.0078	0.0078	0.0625	0.9219

2007-2008:

0.8906	0.0938	0.0078	0.0078
0.1024	0.7795	0.1024	0.0157
0.0079	0.1181	0.8189	0.0551
0.0000	0.0078	0.0703	0.9219

2008-2009:

0.8594	0.1250	0.0000	0.0156
0.1260	0.7244	0.1260	0.0236
0.0079	0.1496	0.7717	0.0709
0.0078	0.0000	0.1016	0.8906

2009-2010:

0.7969	0.1328	0.0625	0.0078
0.1260	0.6929	0.1417	0.0394
0.0079	0.1181	0.6772	0.1969
0.0703	0.0547	0.1172	0.7578

2010-2011:

0.8125	0.0781	0.0078	0.1016
0.1181	0.7323	0.0630	0.0866
0.0630	0.1575	0.6299	0.1496
0.0078	0.0313	0.2969	0.6641

Source: Compiled by the author.

Figure 4

The Initial Distributions of the Improved Proudman-Redding Type

(Goods and Services)

2002-2003:

0.9167	0.0833	0.0000	0.0000
0.0667	0.8500	0.0833	0.0000
0.0167	0.0500	0.9000	0.0333
0.0000	0.0167	0.0167	0.9667

2003-2004:

0.9500	0.0500	0.0000	0.0000
0.0500	0.9000	0.0500	0.0000
0.0000	0.0500	0.9000	0.0500
0.0000	0.0000	0.0500	0.9500

2004-2005:

0.8667	0.1333	0.0000	0.0000
0.1000	0.7667	0.1333	0.0000
0.0167	0.0833	0.8167	0.0833
0.0167	0.0167	0.0500	0.9167

2005-2006:

0.8500	0.1333	0.0000	0.0167
0.1333	0.7667	0.1000	0.0000
0.0000	0.1000	0.8000	0.1000
0.0167	0.0000	0.1000	0.8833

2006-2007:

0.9000	0.1000	0.0000	0.0000
0.0833	0.8000	0.1167	0.0000
0.0000	0.0833	0.8167	0.1000
0.0167	0.0167	0.0667	0.9000

2007-2008:

0.8667	0.1000	0.0167	0.0167
0.1333	0.7833	0.0833	0.0000
0.0000	0.1167	0.7833	0.1000
0.0000	0.0000	0.1167	0.8833

2008-2009:

0.8667	0.1167	0.0167	0.0000
0.1000	0.7000	0.1667	0.0333
0.0167	0.1833	0.6833	0.1167
0.0167	0.0000	0.1333	0.8500

2009-2010:

0.7667	0.1000	0.1167	0.0167
0.2000	0.5833	0.1167	0.1000
0.0000	0.3167	0.5167	0.1667
0.0333	0.0000	0.2500	0.7167

2010-2011:

0.7667	0.2167	0.0000	0.0167
0.1000	0.6667	0.2333	0.0000
0.1167	0.0667	0.5500	0.2667
0.0167	0.0500	0.2167	0.7167

Source: Compiled by the author.

Figure 5

The Initial Distributions of the Improved Proudman-Redding Type (Goods)

2002-2003:

0.9265	0.0735	0.0000	0.0000
0.0746	0.8657	0.0597	0.0000
0.0000	0.0149	0.9104	0.0746
0.0000	0.0441	0.0294	0.9265

2003-2004:

0.8971	0.0882	0.0000	0.0147
0.1045	0.8358	0.0299	0.0299
0.0000	0.0746	0.8955	0.0299
0.0000	0.0000	0.0735	0.9265

2004-2005:

0.8824	0.0882	0.0000	0.0294
0.1194	0.8060	0.0597	0.0149
0.0000	0.0896	0.8955	0.0149
0.0000	0.0147	0.0441	0.9412

2005-2006:

0.9412	0.0588	0.0000	0.0000
0.0597	0.8507	0.0746	0.0149
0.0000	0.0746	0.8806	0.0448
0.0000	0.0147	0.0441	0.9412

2006-2007:

0.9118	0.0882	0.0000	0.0000
0.0896	0.8209	0.0896	0.0000
0.0000	0.0896	0.8657	0.0448
0.0000	0.0000	0.0441	0.9559

2007-2008:

0.9118	0.0882	0.0000	0.0000
0.0896	0.8209	0.0896	0.0000
0.0000	0.0896	0.8657	0.0448
0.0000	0.0000	0.0441	0.9559

2008-2009:

0.8382	0.1324	0.0000	0.0294
0.1642	0.7164	0.0597	0.0597
0.0000	0.1493	0.7612	0.0896
0.0000	0.0000	0.1765	0.8235

2009-2010:

0.8235	0.1471	0.0294	0.0000
0.0597	0.6716	0.2687	0.0000
0.0149	0.0299	0.5672	0.3881
0.1029	0.1471	0.1324	0.6176

2010-2011:

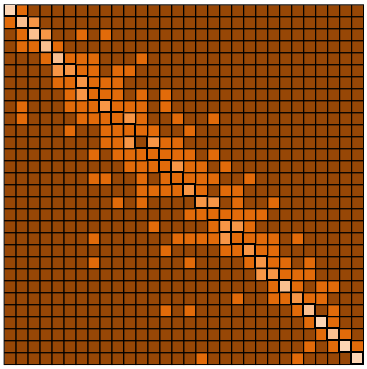
0.8088	0.0000	0.0588	0.1324
0.1642	0.6269	0.0299	0.1791
0.0299	0.3731	0.4179	0.1791
0.0000	0.0000	0.4853	0.5147

Source: Compiled by the author.

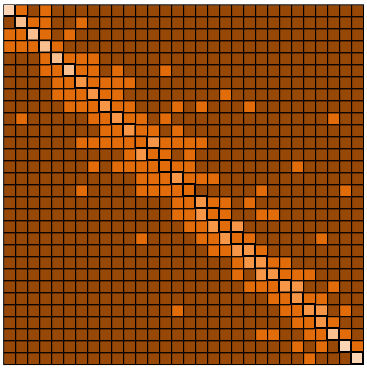
Figure 6

The Initial Distributions of the Improved Proudman-Redding Type (Services)

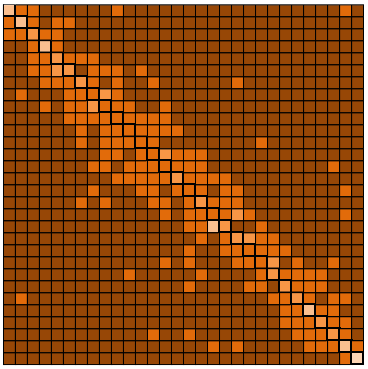
2002-2003:



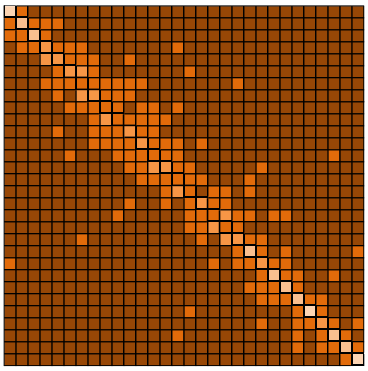
2003-2004:



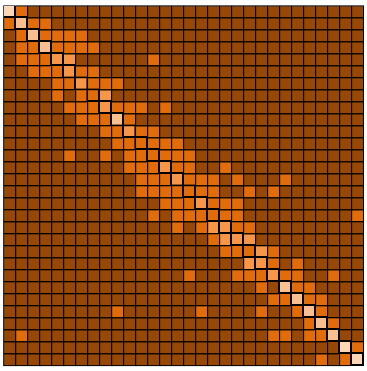
2004-2005:



2005-2006:



2006-2007:



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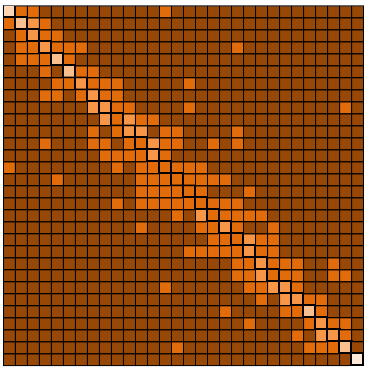

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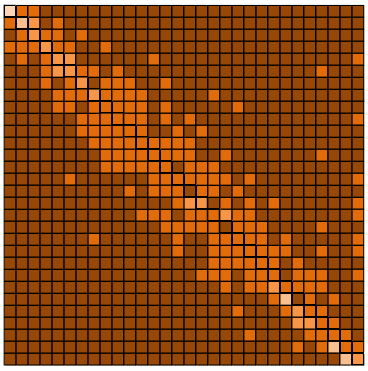

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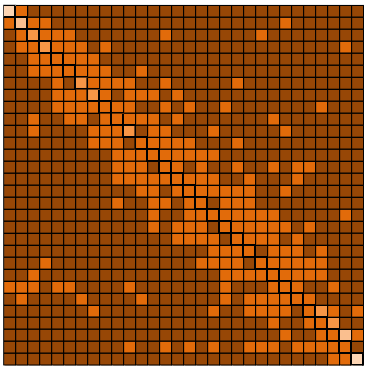

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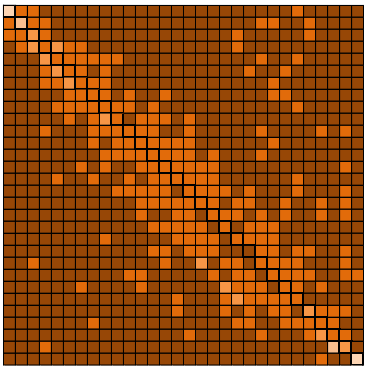
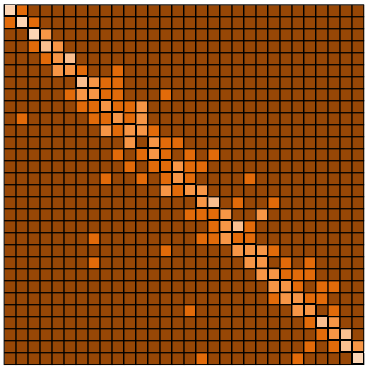


Source: Compiled by the author.

Figure 7

The Initial Distributions of the Proposal Type (Goods and Services)

2002-2003:



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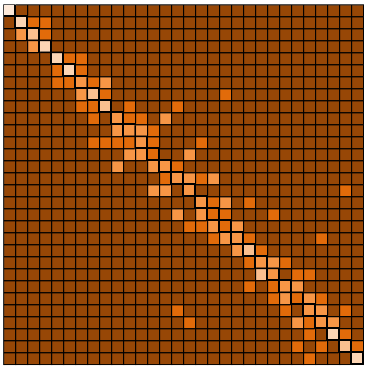
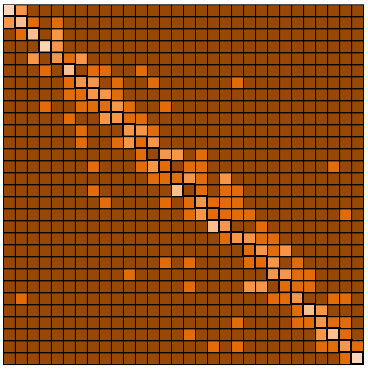
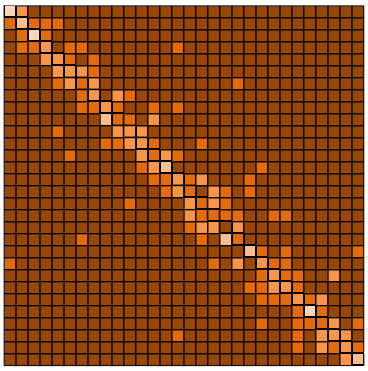


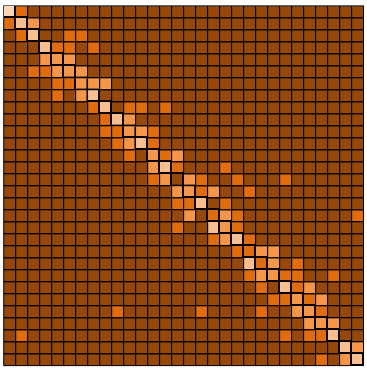
2004-2005:



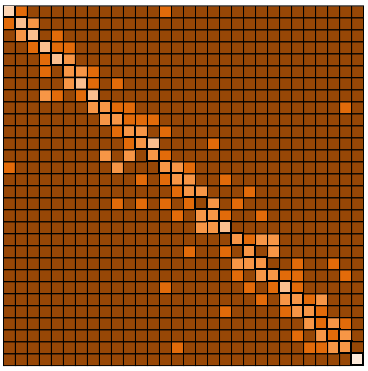
2005-2006:



2006-2007:



2007-2008:



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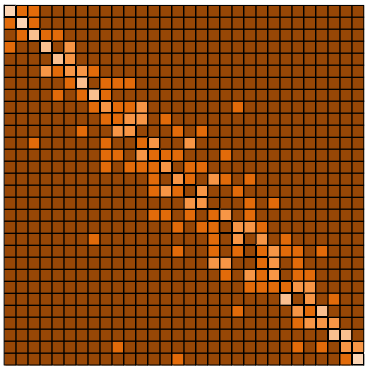
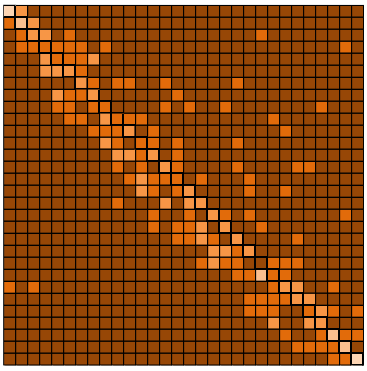
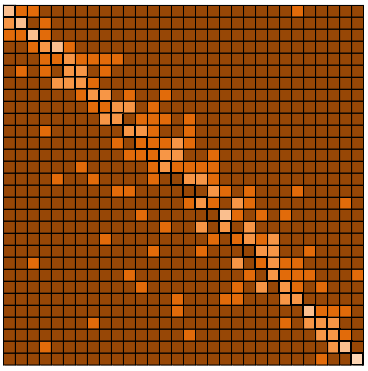


2009-2010:



2010-2011:

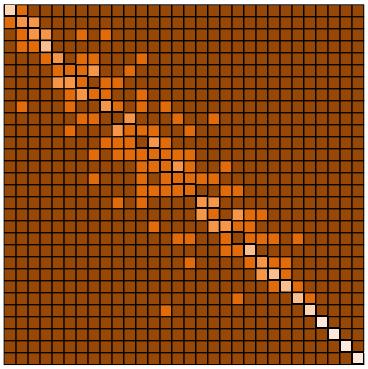


Source: Compiled by the author.

Figure 8

The Initial Distributions of the Proposal Type (Goods)

2002-2003:



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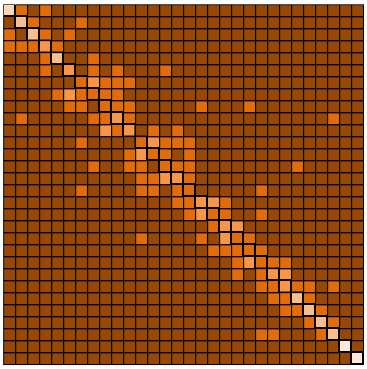
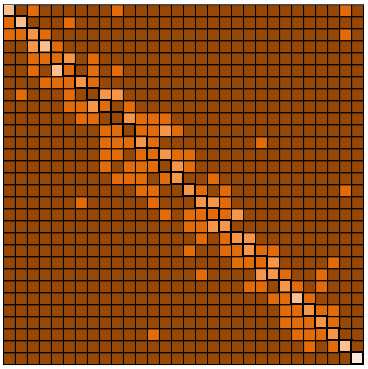


2004-2005:



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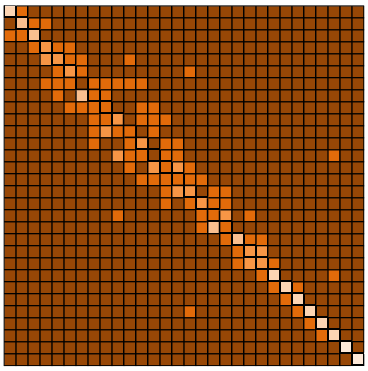
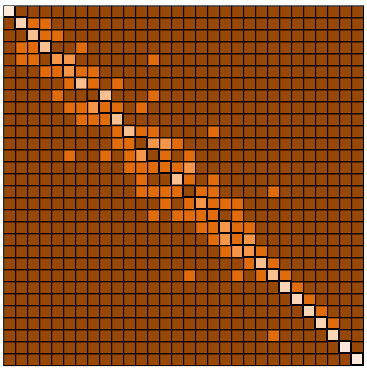
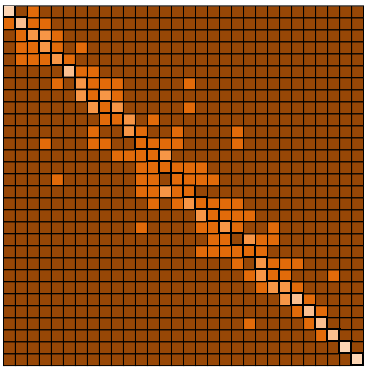


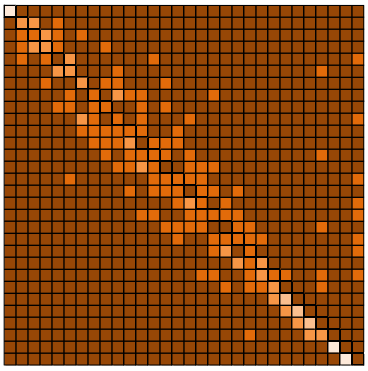
2006-2007:



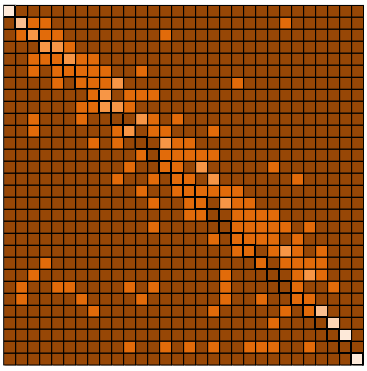
2007-2008:



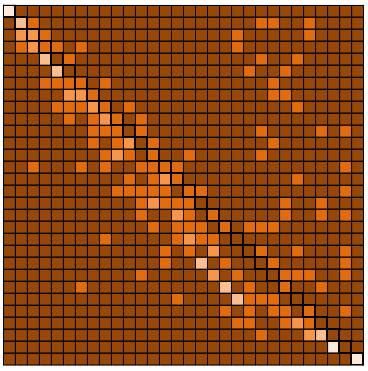
2008-2009:



2009-2010:



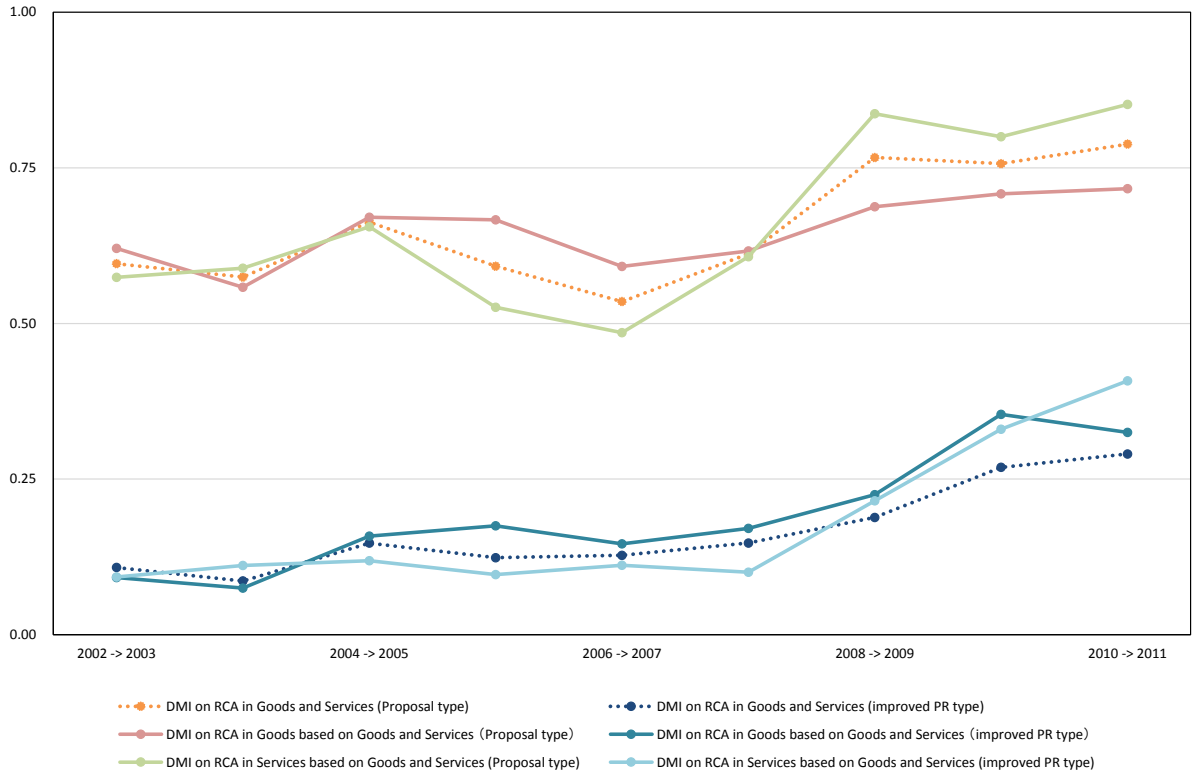
2010-2011:



Source: Compiled by the author.

Figure 9

The Initial Distributions of the Proposal Type (Services)



Source: Illustrated by the author.

Figure 10

Differences of Mobility between the Goods and the Services

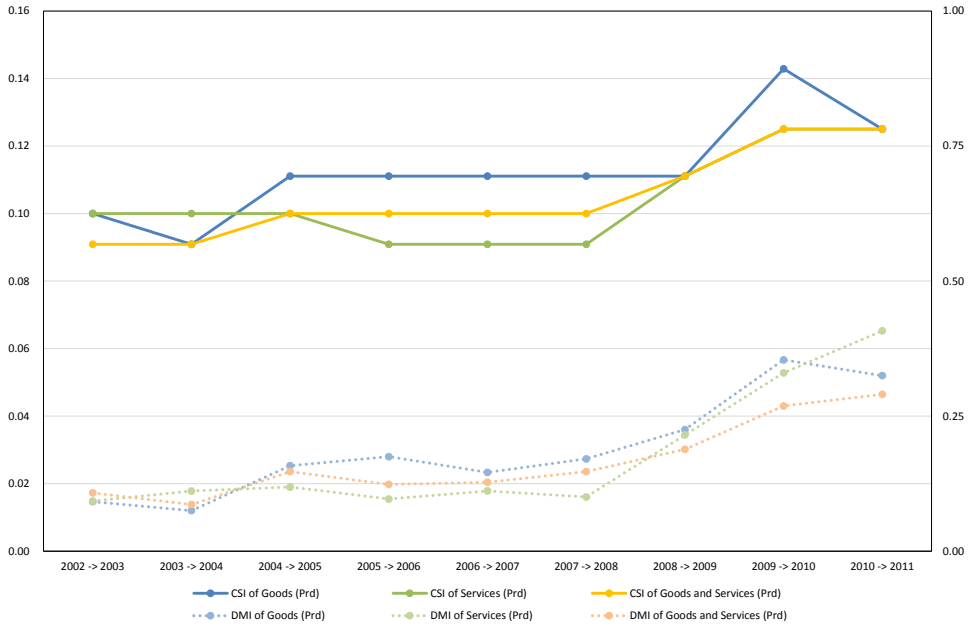


Figure 11a Improved Proudman-Redding Type

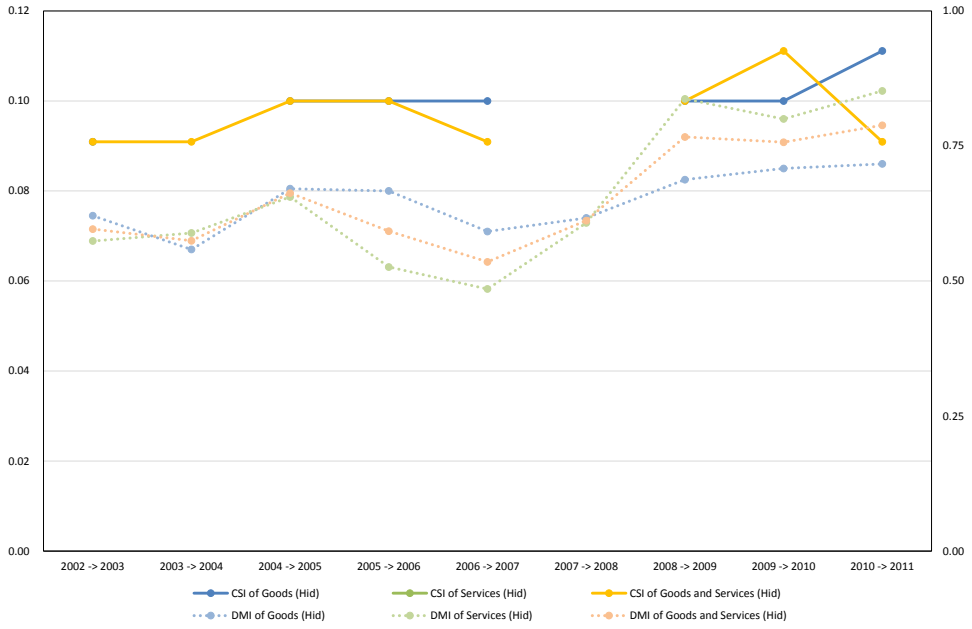
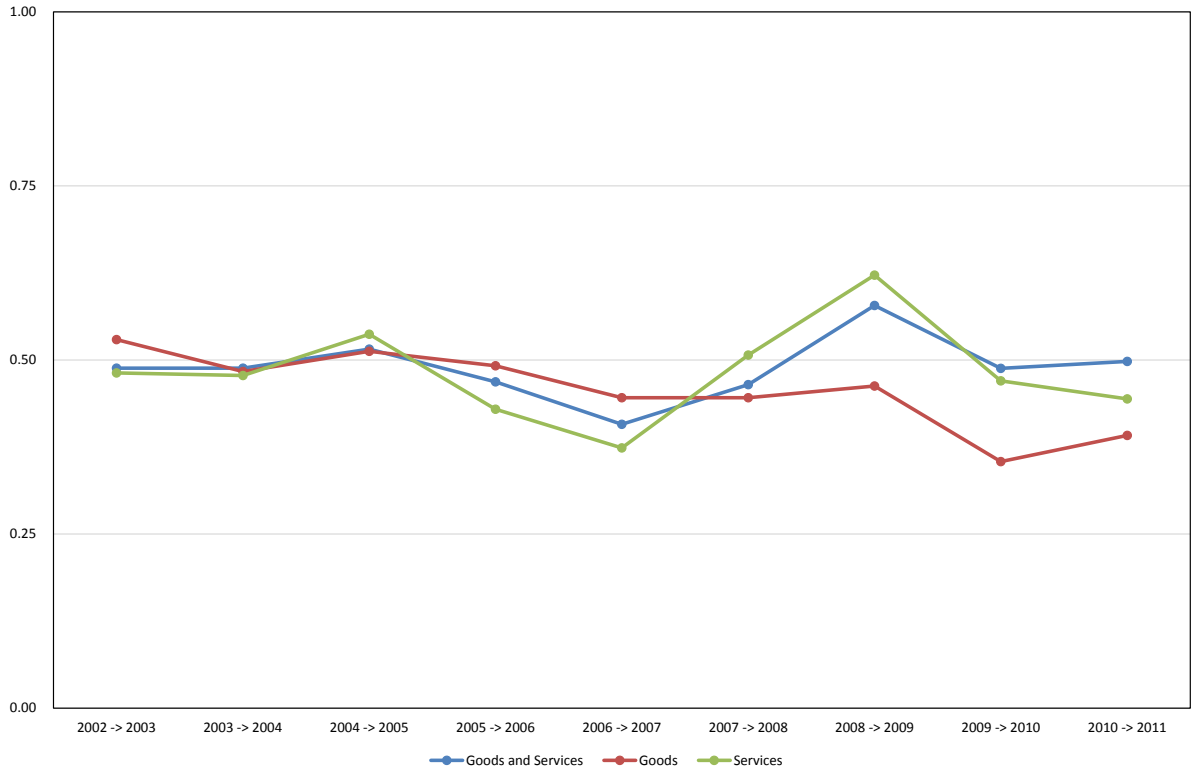


Figure 11b Proposal Type

Source: Illustrated by the author.

Figure 11

Comparison of the Convergence Speed



Source: Illustrated by the author.

Figure 12

Intra-State Mobility

Table 1

Estimation Settings

Estimation Types	State	Period
Proudman-Redding type	4 states	Two Period
Improved Proudman-Redding type	4 states	Annual
Proposal type	30 states*)	Annual

*) the number of observation countries.

Source: Listed by the author.

Table 2

Sectors of Trade in goods and in services

Goods	Services
SITC 0: Food and live animals	Transportation
SITC 1: Beverages and tobacco	Travel
SITC 2: Crude materials, inedible, except fuels	Communications services
SITC 3: Mineral fuels, lubricants and related materials	Construction services
SITC 4: Animal and vegetable oils, fats and waxes	Insurance services
SITC 5: Chemicals and related products, n.e.s.	Financial services
SITC 6: Manufactured goods classified chiefly by material	Computer and information services
SITC 7: Machinery and transport equipment	Royalties and license fees
SITC 8: Miscellaneous manufactured articles	Other business services
SITC 9: Commodities and transactions not classified elsewhere in the SITC	Personal, cultural, and recreational services
	Government services n.i.e.

Source: IMF (1993) and UN (2014).

Table 3

Observation Countries and Periods

Countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.
Periods: Goods 2001 to 2013 (13 years), Services 2002 to 2011 (10 years), and Goods and Services 2002 to 2011 (10 years)

Source: Listed by the author.

Table 4 Descriptive Statistics of the RCA index (2002-2011)

		Goods								Services								
		SITC 0+1	SITC 2+4	SITC 3	SITC 5	SITC 6	SITC 7	SITC 8	SITC 9	Trans.	Travel	Commu.	Const.	Fin.	Comp.	Royalties	Other Biz	Personal
2002	mean	1.479	1.239	1.296	0.875	1.197	0.816	1.028	0.777	1.252	1.254	1.097	0.880	1.559	1.046	0.394	0.895	1.559
	s.d.	1.726	1.254	2.352	0.778	0.554	0.422	0.567	0.861	1.265	1.214	1.089	0.913	6.037	2.288	0.675	0.666	2.479
	min	0.000	0.200	0.000	0.205	0.143	0.082	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	8.068	6.081	12.691	3.366	2.443	1.606	2.488	3.680	5.935	5.753	5.627	3.473	33.200	12.738	3.409	2.634	12.719
2003	mean	1.436	1.227	1.267	0.858	1.174	0.831	1.021	0.730	1.297	1.278	1.066	0.879	1.531	1.152	0.416	0.893	1.434
	s.d.	1.588	1.198	2.226	0.747	0.532	0.442	0.552	0.748	1.412	1.226	1.026	0.764	5.775	2.535	0.716	0.645	1.793
	min	0.000	0.218	0.036	0.210	0.148	0.073	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.307	5.995	11.954	3.237	2.368	1.634	2.480	3.229	6.697	5.268	5.378	2.372	31.712	13.734	3.590	2.554	7.610
2004	mean	1.477	1.183	1.242	0.849	1.165	0.836	0.998	0.772	1.313	1.256	1.042	0.832	1.462	1.238	0.441	0.892	1.599
	s.d.	1.718	1.128	2.085	0.745	0.541	0.451	0.541	0.984	1.570	1.186	0.967	0.773	5.441	2.790	0.739	0.660	2.468
	min	0.000	0.222	0.039	0.190	0.135	0.088	0.185	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.736	5.609	11.288	3.210	2.406	1.616	2.552	5.185	7.692	5.015	4.779	2.260	29.835	14.724	3.650	2.468	9.168
2005	mean	1.469	1.147	1.157	0.852	1.107	0.882	0.968	0.917	1.220	1.193	1.027	0.759	1.411	1.217	0.439	0.832	1.317
	s.d.	1.635	1.206	1.768	0.725	0.486	0.462	0.530	0.747	1.512	1.187	0.948	0.740	5.292	2.599	0.695	0.647	1.705
	min	0.000	0.184	0.021	0.146	0.118	0.136	0.176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.018	6.396	9.363	3.145	2.138	1.699	2.523	3.227	7.554	4.972	4.554	2.599	29.040	13.780	3.424	2.004	7.912
2006	mean	1.519	1.176	1.176	0.866	1.124	0.835	0.974	1.163	1.220	1.235	0.986	0.739	1.375	1.243	0.441	0.878	1.369
	s.d.	1.747	1.316	1.750	0.750	0.481	0.463	0.538	2.174	1.457	1.240	0.924	0.779	5.161	2.764	0.728	0.693	1.624
	min	0.000	0.165	0.020	0.123	0.114	0.137	0.208	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.615	7.038	9.282	3.334	2.277	1.590	2.676	12.164	7.667	5.400	4.543	3.259	28.302	15.126	3.604	2.302	6.848
2007	mean	1.454	1.137	1.181	0.858	1.121	0.857	0.974	1.011	1.221	1.224	1.016	0.756	1.304	1.190	0.446	0.915	1.446
	s.d.	1.618	1.297	1.759	0.732	0.469	0.477	0.564	1.676	1.516	1.198	1.085	0.858	4.727	2.770	0.745	0.766	1.791
	min	0.000	0.156	0.030	0.119	0.108	0.147	0.157	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.705	7.011	9.271	3.232	2.170	1.658	2.786	9.268	8.206	5.083	5.623	3.819	25.816	15.363	3.672	2.799	7.377
2008	mean	1.441	1.051	1.124	0.841	1.139	0.885	0.975	0.807	1.207	1.201	1.048	0.792	1.336	1.302	0.452	0.940	1.539
	s.d.	1.637	1.260	1.585	0.722	0.518	0.479	0.574	0.647	1.554	1.150	1.265	1.007	4.827	2.923	0.712	0.735	1.913
	min	0.084	0.140	0.023	0.111	0.103	0.138	0.162	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.733	6.939	8.027	3.130	2.207	1.728	2.872	2.758	8.513	5.084	6.844	4.632	26.369	15.410	3.443	2.679	6.918
2009	mean	1.394	1.181	1.210	0.874	1.177	0.871	0.967	0.729	1.205	1.175	1.069	0.744	1.306	1.285	0.460	0.944	1.644
	s.d.	1.389	1.629	1.686	0.764	0.588	0.507	0.539	0.659	1.437	1.253	1.613	0.927	4.694	2.911	0.689	0.796	2.519
	min	0.075	0.100	0.040	0.125	0.084	0.158	0.156	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	6.946	9.136	8.348	3.446	2.876	1.767	2.670	2.826	7.538	5.186	8.794	4.223	25.626	14.874	3.400	2.695	11.467
2010	mean	1.495	0.593	1.246	0.883	1.171	0.901	0.984	0.783	1.371	1.257	1.041	0.941	1.462	1.405	0.510	1.026	1.692
	s.d.	1.580	1.202	1.796	0.719	0.681	0.584	0.504	0.718	1.551	1.104	1.132	1.006	5.038	3.046	0.736	0.746	2.682
	min	0.099	0.061	0.031	0.132	0.100	0.116	0.190	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.986	6.130	8.860	3.249	3.202	2.156	2.155	2.990	8.424	4.615	6.247	4.598	27.649	16.035	3.401	2.586	13.211
2011	mean	1.416	1.145	1.200	0.871	1.160	0.853	0.968	0.749	1.241	1.153	0.913	0.858	1.333	1.274	0.472	0.951	1.613
	s.d.	1.450	1.762	1.695	0.718	0.569	0.531	0.576	0.640	1.575	1.262	1.139	1.163	5.068	3.251	0.775	0.899	3.306
	min	0.096	0.226	0.022	0.118	0.096	0.098	0.170	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	max	7.392	9.984	8.934	3.134	2.667	1.918	2.905	2.630	7.812	5.045	5.531	4.798	27.740	17.356	3.681	2.820	17.146

Source: Compiled by the author.

Table 5

Characteristic Values of the Initial Distribution of the Proudman- Redding type

(2002-2006 -> 2007-2011)	DMI	Trace	Det	LAT	CVI
Goods and Services	0.2526	2.9896	0.2713	9	0.1111
Goods	0.2433	3.0267	0.2843	8	0.1250
Services	0.2497	3.0012	0.2823	9	0.1111

Source: Compiled by the author.

Table 6

Characteristic Values of the Initial Distribution of the Improved Proudman-Redding type (Goods and Services)

Periods	DMI	Trace	Det	LAT	CVI
2002 -> 2003	0.1080	3.5680	0.6190	11	0.0909
2003 -> 2004	0.0863	3.6547	0.6885	11	0.0909
2004 -> 2005	0.1472	3.4110	0.5069	10	0.1000
2005 -> 2006	0.1237	3.5053	0.5734	10	0.1000
2006 -> 2007	0.1276	3.4895	0.5597	10	0.1000
2007 -> 2008	0.1473	3.4109	0.5045	10	0.1000
2008 -> 2009	0.1885	3.2461	0.3986	9	0.1111
2009 -> 2010	0.2688	2.9248	0.2536	8	0.1250
2010 -> 2011	0.2903	2.8388	0.2165	8	0.1250

Source: Compiled by the author.

Table 7

Characteristic Values of the Initial Distribution of the Improved Proudman-Redding type (Goods)

Periods	DMI	Trace	Det	LAT	CVI
2002 -> 2003	0.0917	3.6333	0.6691	10	0.1000
2003 -> 2004	0.0750	3.7000	0.7245	11	0.0909
2004 -> 2005	0.1583	3.3667	0.4763	9	0.1111
2005 -> 2006	0.1750	3.3000	0.4339	9	0.1111
2006 -> 2007	0.1458	3.4167	0.5106	9	0.1111
2007 -> 2008	0.1708	3.3167	0.4455	9	0.1111
2008 -> 2009	0.2250	3.1000	0.3149	9	0.1111
2009 -> 2010	0.3542	2.5833	0.1314	7	0.1429
2010 -> 2011	0.3250	2.7000	0.1627	8	0.1250

Source: Compiled by the author.

Table 8

Characteristic Values of the Initial Distribution of the Improved Proudman-Redding type (Services)

Periods	DMI	Trace	Det	LAT	CVI
2002 -> 2003	0.0927	3.6291	0.6695	10	0.1000
2003 -> 2004	0.1113	3.5549	0.6111	10	0.1000
2004 -> 2005	0.1187	3.5250	0.5855	10	0.1000
2005 -> 2006	0.0966	3.6137	0.6541	11	0.0909
2006 -> 2007	0.1114	3.5542	0.6043	11	0.0909
2007 -> 2008	0.1003	3.5988	0.6375	11	0.0909
2008 -> 2009	0.2152	3.1394	0.3487	9	0.1111
2009 -> 2010	0.3300	2.6800	0.1706	8	0.1250
2010 -> 2011	0.4079	2.3683	0.0851	8	0.1250

Source: Compiled by the author.

Table 9

Characteristic Values of the Initial Distribution of the Proposal type (Goods and Services)

Periods	DMI	Trace	Det	LAT	CVI
2002 -> 2003	0.5961	12.1176	0.0000	11	0.09091
2003 -> 2004	0.5745	12.7647	0.0000	11	0.09091
2004 -> 2005	0.6627	10.1176	0.0000	10	0.10000
2005 -> 2006	0.5922	12.2353	0.0000	10	0.10000
2006 -> 2007	0.5353	13.9412	0.0000	11	0.09091
2007 -> 2008	0.6118	11.6471	0.0000	n.a.	n.a.
2008 -> 2009	0.7667	7.0000	0.0000	10	0.10000
2009 -> 2010	0.7569	7.2941	0.0000	9	0.11111
2010 -> 2011	0.7882	6.3529	0.0000	11	0.09091

Source: Compiled by the author.

Table 10

Characteristic Values of the Initial Distribution of the Proposal type (Goods)

Periods	DMI	Trace	Det	LAT	CVI
2002 -> 2003	0.6208	11.3750	0.0000	11	0.0909
2003 -> 2004	0.5583	13.2500	0.0000	n.a.	n.a.
2004 -> 2005	0.6708	9.8750	0.0000	10	0.1000
2005 -> 2006	0.6667	10.0000	0.0000	10	0.1000
2006 -> 2007	0.5917	12.2500	0.0000	10	0.1000
2007 -> 2008	0.6167	11.5000	0.0000	n.a.	n.a.
2008 -> 2009	0.6875	9.3750	0.0000	10	0.1000
2009 -> 2010	0.7083	8.7500	0.0000	10	0.1000
2010 -> 2011	0.7167	8.5000	0.0000	9	0.1111

Source: Compiled by the author.

Table 11

Characteristic Values of the Initial Distribution of the Proposal type (Services)

Periods	Trace	DMI	Det	LAT	CVI
2002 -> 2003	12.7778	0.5741	0.0000	n.a.	n.a.
2003 -> 2004	12.3333	0.5889	0.0000	n.a.	n.a.
2004 -> 2005	10.3333	0.6556	0.0000	n.a.	n.a.
2005 -> 2006	14.2222	0.5259	0.0000	n.a.	n.a.
2006 -> 2007	15.4444	0.4852	0.0000	n.a.	n.a.
2007 -> 2008	11.7778	0.6074	0.0000	n.a.	n.a.
2008 -> 2009	4.8889	0.8370	0.0000	n.a.	n.a.
2009 -> 2010	6.0000	0.8000	0.0000	n.a.	n.a.
2010 -> 2011	4.4444	0.8519	0.0000	n.a.	n.a.

Source: Compiled by the author.

Table 12

Correlations between the Mobility and the Convergence Speed

	CVI (IPR)			CVI (Prop.)		
	Goods	Services	Goods and Services	Goods	Services	Goods and Services
DMI of Goods (Improved Prodman-Redding Type: IPR)	0.9397	0.8186	0.9898	0.6918	n.a.	0.5827
DMI of Services (IPR)	0.7554	0.9438	0.9449	0.7380	n.a.	0.2855
DMI of Goods and Services (IPR)	0.8750	0.8845	0.9844	0.7305	n.a.	0.4278
DMI of Goods (Proposal: Prop.)	0.7811	0.7174	0.8356	0.6095	n.a.	0.5975
DMI of Services (Prop.)	0.5917	0.9041	0.8271	0.5334	n.a.	0.3956
DMI of Goods and Services (Prop.)	0.6713	0.8959	0.8685	0.5621	n.a.	0.4689

Source: Compiled by the author.