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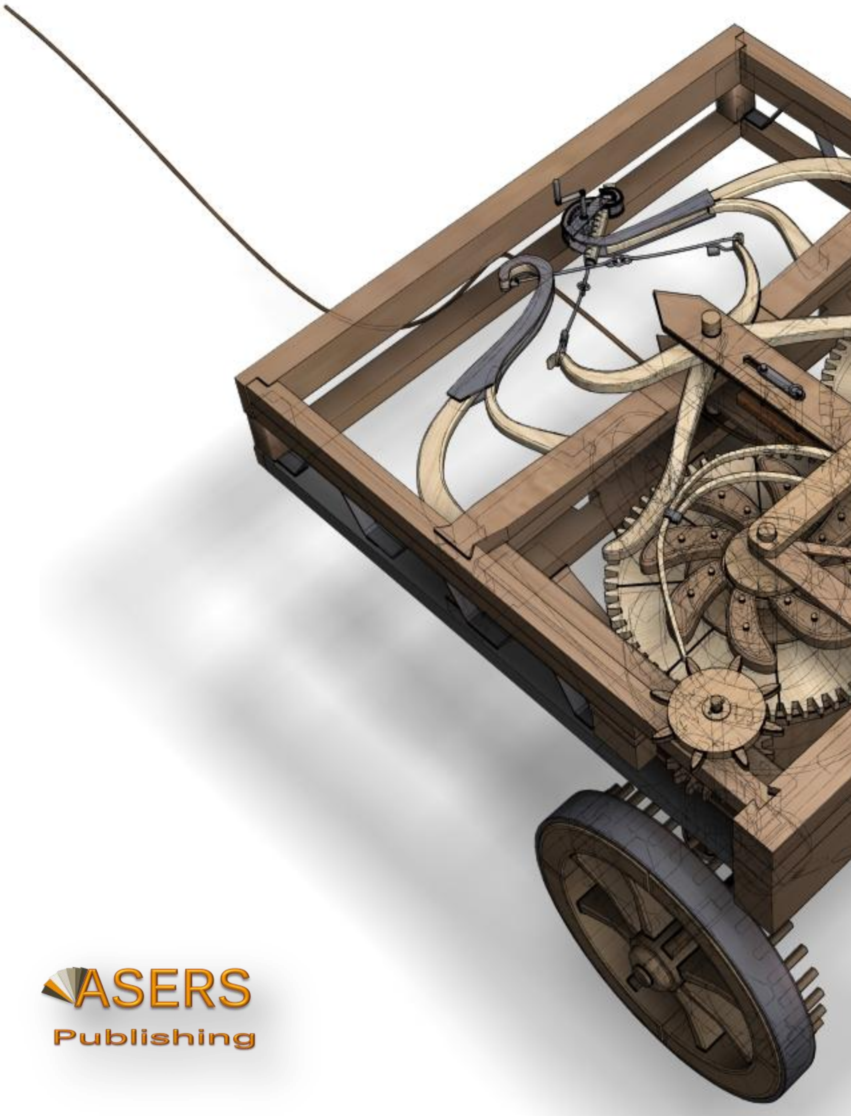

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SPATIAL ANALYSIS OF INCOME GROWTH IN THE PHILIPPINES. EVIDENCE FROM INTRA-COUNTRY DATA

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Abstract:

This paper looks at the spatial relationship of the average per capita income growth using provincial data from 1988 to 2009. The results from the study provide insights on the geographical dimensions of provincial income growth and showed evidence on the role of spatial effects in the formal econometric analysis of intra-country income growth models. Despite data limitations, the study provides a strong empirical evidence of the presence of positive spatial dependence or degree of similarity in the average per capita income growth of the provinces, albeit the degree of positive spatial dependence weakens in the latter periods. This positive spatial correlation suggests the provinces may be converging in terms of their income growth and they do so in movements similar to their neighbors. Moreover, the study shows that spatial dependence weakened in the latter periods (1994-2000 and 2000-2009). The weakening of spatial dependence may provide insights on the uneven provincial/regional income growth experienced in the country. One possible explanation of the weak spatial dependence is that two or more groups of neighboring provinces are growing at similar rates within the group, but at different rates across groups. This opens the possibility of having different convergence clubs (of provinces) within the country.

Keywords: spatial dependence, Moran's index, intra-country growth mode.

1. Introduction

The growth rates of provincial per capita income in the Philippines in the last 25 years have been generallydiverse: there are provinces withaverage annual per capita income growths that can be considered as moderately high (more than 5%), while majority of the provinces have income growth that is comparable to the poorest countries in the world (around 1%). There are several reasons why the economic performance of the Philippines, in general, had been disappointing relative to its more successful East Asian neighbors. As noted by Balisacan and Hill (2003), "the Philippines economic performance looks deficient partly because it is most often compared with its neighbors … the world's fastest growing".[1] Several papers have come out in recent years, specifically explaining what went wrong in the case of the Philippines.[2]

The relatively moderate and inconsistent (compared to the country's East Asian neighbors) income growth over a longer period is one of the major reasons of the high povertyincidence in the country. The official statistics on headcount poverty compiled by the National Statistical Coordination Board (NSCB) showed that while the percentage of poor Filipinos increased to 26.5% in 2009 (the latest poverty data) from 24.9 in 2003. Moreover, the percentage of subsistence poor (or food poor)[3] did not change much during the same period, only slightly decreasing from 11.1% in 2003 to 10.8% in 2009. However, the number of food poor in the population has increased to about 9.44 million in 2009 from 8.8 million in 2003.

Empirical analysis using cross-country data during the period 1975 to 2000 (Mapa and Balisacan, 2004) points to the country's rapid population growth as one of the reasons why the country is not one of the high-performing Asian economies. The Philippines has the second largest population in Southeast Asia (about 92 million in 2010), next only to Indonesia, and ranks among the countries with the highest population growth rates in Asia.[4]The authors' econometric models showed that demographic factors have strong and significant effects on economic growth. Using simulation analysis to compare the income growth paths of the Philippines and Thailand, the authors showed that differences in the population growth rates between the two countries account for about 0.768 % point of forgone growth for the Philippines. It implies that had the Philippines followed Thailand population growth path during the period 1975 to 2000 the country's growth in the average income per person would have been 0.768 percentage point higher every year. Using the country's provincial data,

Using intra-country (provincial) data, Mapa, Balisacan and Briones (2006) identified the factors constraining the income growth in the Philippines provinces during the period 1985 to 2003. Using robustness procedures, the authors found that the high level of inequality and high percentage of young dependents (percentage of those aged 0 to 14 relative to the total population) are contributing negatively to the average provincial per capita income growth. The authors also showed the two variables to be robust determinants of provincial income growth. Moreover, the models also showed that the long running conflict in the provinces of the Autonomous Region of Muslim Mindanao (ARMM)[5]

[1] During the period 1976-2000, for example, the average growth rates (in US$ Purchasing Power Parity or PPP) for the Philippines, Thailand and Korea are 4.1%, 7.98%, and 9.90%, respectively.

[2] Balisacan and Hill (2003) and Balisacan and Hill (2007) provide a collection of such good papers.

[3] The prevalence of subsistence poor refers to the proportion of families or individuals with per capita income less than the per capita food threshold. The food threshold is determined using regional one-day menus priced at the provincial level. These menus are determined using low-cost nutritionally adequate food items satisfying basic food requirements of 2,000 calories which are 100% adequate for the recommended energy and nutrient intake (RENI) for energy and protein and 80% adequate for the RENI for vitamins, minerals and other nutrients (NSCB 2010).

[4] The country's annual population growth rate from 1975 to 2000 is 2.36%, although this has gone down to 1.90% for 2000-2010 based on the results of the 2010 Census of Population. In May 1, 2010 the population of the Philippines is at 92.34 million. Moreover, data shows that the total fertility rate (TFR) is highest among the poorest households, where the TFR is 5.20 for the poorest 20% of households against the national average of 3.30 (as of 2008).

[5] The Autonomous Region in Muslim Mindanao is the region of the Philippines that is composed of all the Philippines' predominantly Muslim provinces, namely: Basilan (except Isabela City), Lanao del Sur, Maguindanao, Sulu and Tawi-Tawi, and the Philippines' only predominantly Muslim city, the Islamic City of Marawi. The regional capital is at Cotabato City, although this city is outside of its jurisdiction. The poverty incidence (percent of population) in the region is 45.9% in 2009 and three of its provinces are among the poorest provinces in the Philippines in 2009, namely: Sulu (poverty incidence: 44.1%), Maguindanao (53.7%) and Lanaodel Sur (44.8%).

results to a lower average per capita income growth in these provinces relative to the other provinces in the Philippines.

Other studies notably, Balisacan (2005, 2007) and Balisacan and Fuwa (2002), showed the level of human stock capital (using child mortality rate as the proxy variable in the studies) asa statistically significant determinant of provincial income growth rate. In addition, these studies also showed the literacy rate and access to infrastructure as positive and significant determinants of provincial income growth rate. The authors also find that increment in land reform implementation (CARP) have a positive and significant effect on the average provincial income growth rate. To capture the effects ofpolitics on provincial income growth, the Balisacan papers utilized the initial political conditions defined as the extent of dynasty within a province – empirically measured as the proportion of provincial officials related by blood or affinity. Using different econometric model specifications, Balisacan and Fuwa (2002) showed that the extent of dynasty has a negative and significant effect on income growth, while Balisacan (2007) showed the same dynasty variable, while negatively affecting income growth, is statistically insignificant.

The motivation of this paper is to investigate the reasons for having unequal growth rates in per capita income in the provinces in the Philippines. This research question will be answered by looking at the effect of spatial dependence (or location dependence) in the empirical growth models. The paper aims to contribute empirical evidence explaining why growth rates in the provinces are uneven and provide policy handles to mitigate this problem.

The rest of the paper is presented as follows. Section II gives an overview of the spatial dependence, particularly in the context of the econometric growth models. This section also explains the process of computing the Spatial Weight Matrix and the concepts of the Moran's Index, the Moran's Scatterplot. Section III provides the empirical analysis of the spatial dependence of the provincial income growth of the provinces while section IV discusses the results of the econometric models. Lastly, section V concludes.

2. Spatial autocorrelation in the econometric growth model

Spatial autocorrelation is defined as the coincidence of value similarity with location similarity (Anselin and Bera; 1998). Spatial dependence occurs when the observations of one location depends on the values of the other locations. The presence of spatial structure in the quantitative data provides the information about the similarity of the characteristics (e.g. income growth of neighboring provinces) vis-à-vis the distance between the locations (provinces) and the spatial autocorrelation of the variable (e.g. income growth) explains how this variation is affected by the distance (Fortin and Dale; 2009). Positive spatial autocorrelation happens when similar values of the variable of interest (e.g. income growth) cluster together, while negative spatial autocorrelation appears when dissimilar values are clustered in space. In the economic growth literature, the possibility that space is a determinant of income growth has been studied widely in the context of geographical variables such as climate and location (Gallup, Sachs, Mellinger; 1999). The area of spatial-econometrics, a sub-field of econometrics, looks at the possibility of spatial interaction and spatial structure and has recently been incorporated into the study of empirical growth (Durlauf and Quah; 1999). The applications of spatial econometric has been traditionally carried out in the regional science applications (Abreu, De Groot and Florax; 2004), where politically unstable regions/countries may have negative externalities or spillover effects on the other regions/countries. Since the publication of the book on Spatial Econometrics: Methods and Models by Luc Anselin (Anselin; 1988), numerous studies on spatial econometric analysis of geographical spillovers and growth have been made. The basic premise of spatial econometrics in regional/provincial economic growth studies is that regional/provincial data can be spatially ordered since similar regions tend to cluster and that econometric models must take into account the fact that economic phenomenon may not be randomly distributed on an economically integrated regional space (Baumont, Ertur, Le Gallo; 2001).

To capture potential spatial/spillover effects which indicates how the average growth rate of per capita income in the Philippine provinces is affected by its neighboring provinces, after controlling for other factors affecting income growth, Mapa, Balisacan and Briones (2006) introduced a measure of neighborhood effect in their intra-country growth regression models. This variable is computed as the average growth rate of the neighboring provinces, where the neighbors (of a specific home province) are identified using a contiguity-nearest distance based measure.[6] The inclusion of this spatial variable, the neighborhood effect, into the growth regression model, conforms to the spatial auto-regressive model discussed by Anselin (1988, 2009). By introducing a spatial variable, the dynamics of how the provinces' economic performance interacts with each other can be better understood. The empirical analysis of the authors showed a negative and significant influence of the neighborhood effect in the growth regression model. The results showed a negative spatial correlation among the neighboring provinces, as the average growth rate of per capita income of the home province increases, the average growth rate of per capita income of the neighboring provinces decrease, showing some sort of negative growth externalities.[7]

This paper incorporates the provincial spatial dependence in the intra-country growth regression model (Barro-type) by utilizing the commonly used spatial lag model to capture this location dependency.[8] Substantive spatial dependence is incorporated into the unconditional growth regression specification through a spatially lagged dependent variable,

$$g_{y^0} = \mathbf{X\beta} - \alpha \log\left(y^0_{T_1}\right) + \theta\left(\frac{YD}{P}\right) + \rho\mathbf{W}g_{y^0} + \epsilon \qquad (1)$$

where $g_{y^0}$is the growth rate of per capita income, $y^0_{T1}$is the initial per capita income, YD/P is the proportion of young dependents (aged 0 to 14) in the population and X is the vector of economic and political variables (or the Barro's core) that may have impact on the steady state growth.

The matrix W is the spatial weights matrix with elements w_{ij} corresponding to the province (i,j). The spatial weight matrix is an (n x n) positive matrix (W) that provides "neighborhood sets" for each observation (Anselin, 2002). Its elements are non-stochastic, non-negative, finite, and exogenous to the model. An observation is not a neighbor to itself; hence the diagonal elements, denoted by $\boldsymbol{w_{ii}}$, are set to zero. The element $\boldsymbol{w_{ij}}\ (\boldsymbol{i \neq j})$, indicates the spatial connection between region i to region j(Baumont, Ertur, & Le Gallo, 2001). To facilitate comparison among different models, the weight matrix shall be standardized so that the sum of the elements in a row equals unity. The choice on the kind of matrix to be used depends on the researcher. An example is the simple binary contiguity matrix, which is a matrix with values of elements equal to 1, when regions *i* and *j* share a border; and 0, otherwise. The use of the contiguity measure is not appropriate if there is a relatively high degree of heterogeneity in the spatial distribution of points or in the areas of regions (Anselin, 2002). For locations with high degree of heterogeneity, a spatial weight matrix with a distance-based critical cut-off is preferred. This paper employs the distance-based spatial weight, using the inverse of the distance, defined as:

$$w_{ij} = \begin{cases} 0 & if\ i = j \\ 1/d_{ij} & if\ d_{ij} < D \\ 0 & if\ d_{ij} \geq D \end{cases} \qquad (2)$$

[6] Using the contiguity measure, two provinces are neighbors if they share a common border. To mitigate the problem associated with some island provinces (e.g. Province of Cebu) in the country, the authors used the nearest neighbor method for this group of provinces.

[7] Similar studies using European regions (Baumont, Ertur and Le Gallo (2001)) and US States/Counties show that the neighborhood effect is positive.

[8] The two other methods of capturing spatial dependence are the spatial error model and the spatial cross-regressive model.

where d_{ij} is the distance between provinces i and j, using the provincial capital city/municipality as the point of reference and D is the cut-off distance, usually equal but not restricted to the first quartile of the distances (Baumont, Ertur, & Le Gallo, 2001). For the purposes of this study, the 35th percentile, a distance of about 655 kilometers, was used to ensure the existence of at least one neighbor for each province. Our interest is the parameter ρ in the econometric model in (1), which provides information on the spatial relationship of the per capita income growth of the home provinces and their neighbors, controlling for other factors.

2.1 Moran's Index

Existence of spatial autocorrelation indicates that the values of variables in one location are affected by values of the variables in neighboring locations. This is one of the problems faced by researchers in executing regression analysis on spatial relationships. Several measures of spatial autocorrelation, like the Geary's C (Geary, 1954), have already been proposed. The most popular of which is the Moran's Index (Moran, 1950), which will be the focal measure of spatial dependence that will be used in this paper. The Moran's Ihave shown to be consistently more powerful than Geary's C (Cliff and Ord, 1975; 1981), tests for global spatial autocorrelation for continuous data. The statistic is expressed as,

$$I = \left[\frac{n}{S_o}\right] \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}x_i x_j}{\sum_{j=1}^{n} x_i^2} \tag{3}$$

where n is the number of observations, w_{ij} is the element of the spatial weight matrix W corresponding to the ith row and the jth column, $x_i$and x_j are deviations from the mean of a variable for regions i and j, respectively, and S_o is a normalizing factor equal to the sum of the elements of the weights matrix W, that is, $S_o = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}$. If the rows of the weight matrix are standardized, the Moran's Index reduces to,

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}x_i x_j}{\sum_{j=1}^{n} x_i^2} \tag{4}$$

In matrix notation, this is,

$$I = \frac{x'Wx}{x'x} \tag{5}$$

where W is a spatial weights matrix and x is a vector of observed values x_i, in deviations from the mean (Lim, 2003). Based on the cross-products of the deviations from the mean, the Moran's Index is similar but not equivalent to a correlation coefficientbetween x at one location and the weighted average of the values of x of its neighbors. Its range of possible values is from -1 to 1, where a positive value indicates that across all geographic units, similar values are more likely than dissimilar values between neighbors, and vice versa. Under the assumption of no autocorrelation, the expected value of the Moran's Index is $-\frac{1}{n-1}$, regardless of the specified weight matrix. The expected value approaches to zero as n approaches infinity. In addition, the Moran's Index is equivalent to the slope coefficient in the linear regression of the spatial W_x on x.

2.2 Moran's Scatterplot

The Moran's I statistic gives us a single global result for the whole data set. However, it does not provide information on the characteristics of spatial clustering. To provide graphical analysis of local spatial dependence, one may use the Moran's scatterplot. The scatterplot is helpful in identifying outlying provinces. The Moran's scatterplot has four main parts and providing four different kinds of spatial association between the home province and its neighboring provinces. For this paper, the four parts correspond the following classifications: (a) high per capita income growth rate for the home province with high per capita income growth rate for neighboring provinces (HH - Quadrant I), (b) low per capita income growth rate for the home province with high per capita income growth rate for neighboring provinces (LH - Quadrant II), (c) low per capita income growth rate for the home province with low per capita income growth rate for neighboring provinces (LL - Quadrant III), (d) high per capita income growth rate for the home province with low per capita income growth rate for neighboring provinces (HL - Quadrant IV). One can think of it as "the spatial lag of the variable on the vertical axis and the original variable on the horizontal axis (Anselin, 2002)." A more comprehensive presentation of the spatial dependence of the average per capita income growth rate can be done using scatter plot maps.

3. Empirical analysis of the provincial data (1988-2009)

The dataset used in this study consist of information collected from the 74 provinces in the Philippines. The provinces are those defined in 1985 for data consistency. Currently, there are 80 existing provinces. The provinces are listed in Table 1 below. Data on average per capita income were sourced from the Family Income and Expenditure Surveys (FIES), data on road density were sourced from the Department of Public Works and Highways (DPWH). Information on the proportion of governors and mayors affiliated to the President comes from the Commission on Elections (COMELEC). The Philippine Statistical Yearbook (PSY) provides the data on the land type of all the provinces in the Philippines. The data on the percentage of municipalities classified according to the degree of slope is taken from GIS maps. The data on the annual amount of rainfall (in millimeter) for each province was taken from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The variables and the data sources used in the econometric models are provided in Table 2.

Table 1. List of 74 Philippine provinces included in the study

Region I	**Region IV**[9]	**Region VI**	**Region X**	**Region XIII**
Ilocos Norte	Aurora	Aklan	Bukidnon	Metro Manila
Ilocos Sur	Batangas	Antique	Camiguin	XIV
La Union	Cavite	Capiz	Misamis Occidental	Abra
Pangasinan	Laguna	Iloilo[10]	Misamis Oriental	Benguet
Region II	Marinduque	Negros Occidental	**Region XI**	Ifugao
Batanes	Mindoro Oriental	**Region VII**	Davao[11]	KalingaApayao[12]
Cagayan	Quezon	Bohol	Davao del Sur	Mt. Province
Isabela	Rizal	Cebu	Davao Oriental	**Region XV**
Nueva Vizcaya	Romblon	Negros Oriental	South Cotabato[13]	Lanao del Sur
Quirino	Mindoro Occidental	Siquijor	**Region XII**	Maguindanao[14]
Region III	Palawan	**Region VIII**	Cotabato	Sulu
Bataan	**Region V**	Eastern Samar	Lanao del Norte	Tawi-Tawi
Bulacan	Albay	Leyte[15]	Sultan Kudarat	**Region XVI**

[9] Region IV is now divided into CALABARZON or Region IV-A and MIMAROPA or Region IV-B.
[10] Guimaras is now separated from Iloilo.
[11] Compostela Valley is now separated from Davao. The name of Davao changed back to Davao del Norte.
[12] KalingaApayao is now two different provinces: Kalinga and Apayao.
[13] Sarangani is now separated from South Cotabato.
[14] ShariffKabunsuan is now separated from Maguindanao.
[15] Biliran is now separated from Leyte.

Nueva Ecija	Camarines Norte	Northern Samar		Agusan del Norte
Pampanga	Camarines Sur	Samar		Agusan del Sur
Tarlac	Catanduanes	Southern Leyte		Surigao del Norte[16]
Zambales	Masbate	**Region IX**		Surigao del Sur
	Sorsogon	Baslian[17]		
		Zamboanga del Sur[18]		
		Zamboanga del Norte		

Table 2. Variables and data sources in the econometric models

Variables	Description	Data Source
GROWTH	Average Annual Growth Rate of Nominal Per Capita Income	Authors Computation from FIES data of NSO
LOGINIINC	Initial per capita income (in natural logarithm); for 1988, 1994 and 2000	FIES, NSO
POP014_INIT	percentage of young dependents	Authors Computation from FIES, NSO
AVERAIN	Average Rainfall	PAGASA
AVEGOVMAY	Percentage of Mayor and Gov with the President's Party	COMELEC
AVEEGINI	Gini Coefficient (income)	Authors Computation from FIES, NSO
AVEEGINI_SQ	Square of Gini (income)	Authors Computation from FIES, NSO
GRELECTSH	Growth Rate - HHs with Electricity	Authors Computation from FIES, NSO
GRROADNAT	Growth Rate - National Road	Department of Public Works and Highways
GEOGRAPHY	Dummy Variable for Geography (Landlock)	Philippine Statistical Yearbook
SLOPE	Slope of the Land	Geographical Information System
MINERAL	Province with Mineral	DENR, Mines and Geosciences Bureau

Using the data set, the authors created three (3) pseudo-panel data, for years: (a) 1988-1994, (b) 1994-2000 and (c) 2000-2009. One of the objectives of the paper is to look the changes (if there any) of spatial correlation or spatial dependence of the growth rates of income in the Philippine provinces through the years. Another reason for the creation of the pseudo-panel data is to increase the sample size to minimize the error in the estimation of the econometric models.

The average per capita income growth for the provinces during the three (3) pseudo-panel periods are provided in table 3. The figures show that the average income growth per person has been erratic and inconsistent, growing at just about 0.51 percent during the period 1988 to 1994, increasing at a relatively impressive rate of 3.45% in 1994 to 2000, but dropped again to 0.36 for 2000 to 2009. The overall per capita income growth during the period 1988 to 2009, a period of 21 years, is just about 1.24%.

Table 3. Average per capita income growth of the Philippine provinces

Variable	Mean	Std. Dev.	Min	Max
Annual Growth Per Capita Income (1988-1994)	0.47	3.41	-8.96	10.63
Annual Growth Per Capita Income (1994-2000)	3.45	3.28	-3.19	13.05
Annual Growth Per Capita Income (2000-2009)	0.36	1.73	-4.20	5.26
Annual Growth Per Capita Income (1988-2009)	1.24	1.35	-2.49	4.25

The existence of spatial autocorrelation in income growth is examined using the Moran's index and the results are given in table 4. The estimated Moran's indices are all positive for the three panels and for the overall period 1988 to 2009, implying positive spatial correlation on the provincial per capita

[16] Dinagat Islands was separated from SurigaodelNorte in 2006.
[17] Basilan now belongs to Region XV (ARMM), and Aurora in Region III.
[18] ZamboangaSibugay is now separated from Zamboangadel Sur.

income growth. This means that the average income growth of the home and neighboring provinces are more likely to be similar (increasing together or decreasing together), rather than being dissimilar (one is increasing while the other is decreasing). All these values, although small, mean that a positive autocorrelation is present in the data indicating the clustering of provinces with similar average per capita income growth rates.

Testing the significance of the Moran's indices, however, shows that only the values for 1988 to 1994 and the overall period 1988 to 2009are significantly different from zero. The indices for the periods 1994 to 2000 and 2000 to 2009 are not significantly different from zero.

Table 4. Moran's Indices for the Average per Capita Income Growth

Year	Moran's Index	SD	z-stat	p-value*
1988-1994	0.194	0.052	4.037	0.0000
1994-2000	0.036	0.052	0.963	0.1680
2000-2009	0.030	0.050	0.891	0.1860
1988-2009	0.120	0.049	2.725	0.0030

Note: * one-sided p-value

The figures below present the Moran's scatter plots and the corresponding Philippine maps that will be used to describe the movement of the average income growth rate of the provinces through time. The Moran's scatterplots in figures 1 to 4 display the distribution of all the 74 provinceson the four quadrants, based on the home provinces'relation to the average income growth rate of the neighboring provinces. The provinces in quadrants 1 (High-High or HH) and 3 (low-Low or LL) represent the home provinces that experienced similar income growth rates to the neighboring provinces, whereas those included in quadrants 2 (Low-High or LH) and 4 (High-Low or HL) represent the home provinces with contrasting income growth rates to the neighboring provinces.

The provinces included in quadrant 1 (HH) are the provinces where the both the home province and the neighboring provinces (using the distance measure) had average per capita growth rates higher than the national average, while the provinces in quadrant 3 (LL) are the are the provinces where the both the home province and the neighboring provinces had average per capita growth rates lower than the national average. The provinces in quadrant 2 (LH) are the provinces where the home province had lower average income growth compared to the national average, while the neighboring provinces experienced higher income growth compared to the national average. The provinces in quadrant 4 (LH) are the provinces where the home province had higher average income growth rate than the national average whereas the neighboring provinces had lower average income growth compared to the national average.

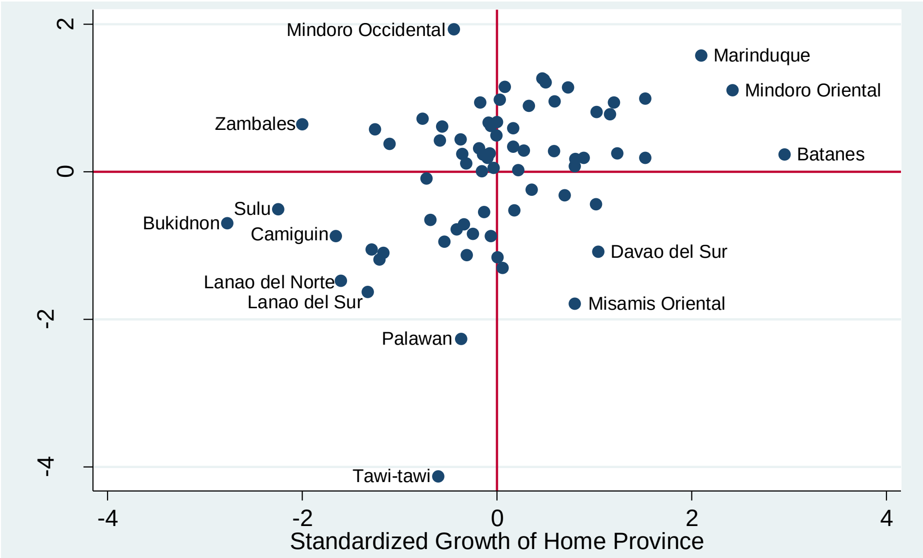


Figure 1. Moran's Scatter Plot (1988-1994)

The scatter plot corresponding to the period 1988 to 1994 indicates that about 60% of all the home provinces have similar income growth rates (higher or lower than the national average) with the neighboring provinces. About 34% of the provinces are in the High-High quadrant (quadrant 1), while 26% of the provinces are in the Low-Low quadrant (quadrant 1).

The rest of the provinces, about 40%, showed contrasting (or dissimilar) income growth rates with the neighboring provinces, with 29% in the Low-High quadrant (quadrant 2) and the remaining 11% in the High-Low quadrant (quadrant 4).

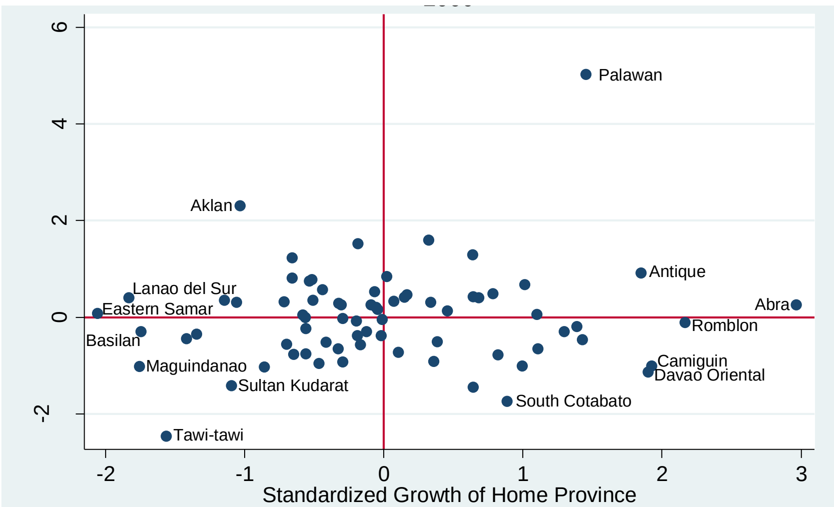


Figure 2. Moran's Scatter Plot (1994-2000)

For the period 1994 to 2000, the percentage of provinces having similar growth rates in per capita income with the neighboring provinces (higher or lower than the national average) dropped to about 54% (from 60% for the period 1988 to 1994). Moreover, only 22% of the provinces are in the High-High quadrant (quadrant 1), while a higher 32% are in the Low-Low quadrant (quadrant 1). The percentage of the provinces showing dissimilar income growth rates with the neighboring provinces increase to 46% (from 40% for the period 1988 to 1994), with 27% in the Low-High quadrant (quadrant 2) and 19% in the High-Low quadrant (quadrant 4). The results suggest that the degree of similarity in the average per capita income growth of the home provinces with their neighbors weakened during the second period, as shown by the Moran's Index (in Table 4), where the value decreased to 0.036 (for 1994 to 2000) from 0.196 (for 1988 to 1994).

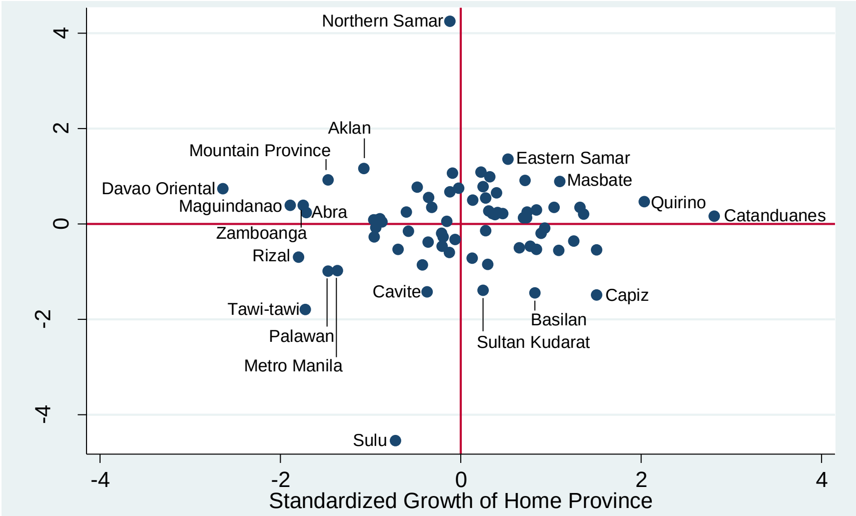


Figure 3. Moran's Scatter Plot (2000-2009)

For the period 2000 to 2009, the percentage of provinces having similar growth rates in per capita income with the neighboring provinces is about 55% (with 32% in the High-High quadrant (quadrant 1) and 23% in the Low-Low quadrant (quadrant 1)). The percentage of the provinces showing dissimilar income growth rates with the neighboring provinces increase is about 45% (with 26% in the Low-High quadrant (quadrant 2) and 19% in the High-Low quadrant (quadrant 4). Similar to the period 1994 to 2000, the degree of similarity of the income growth rate between the home provinces and the neighbors is very weak as shown by the Moran's Index for this period which is about 0.030.

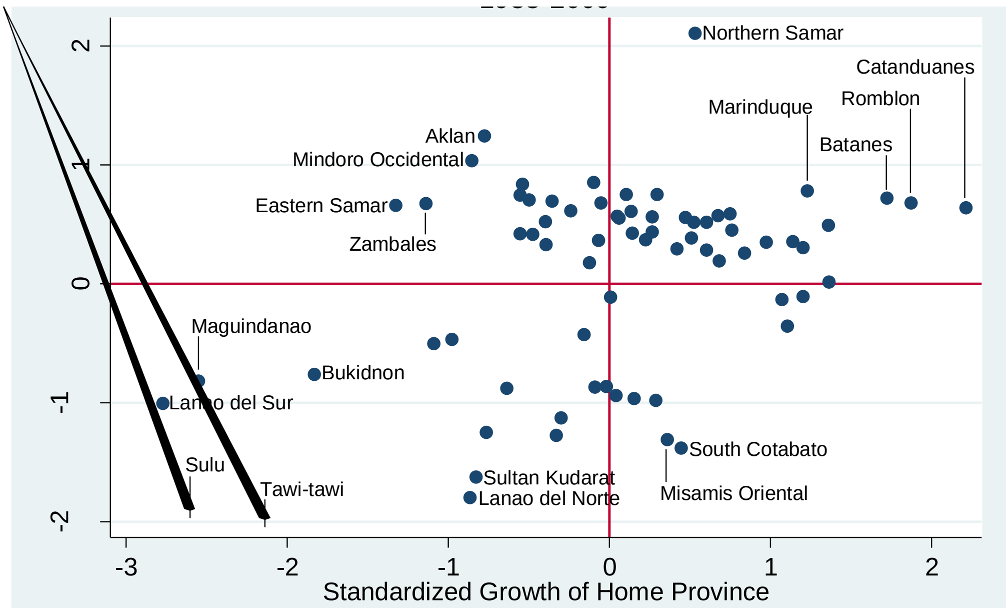
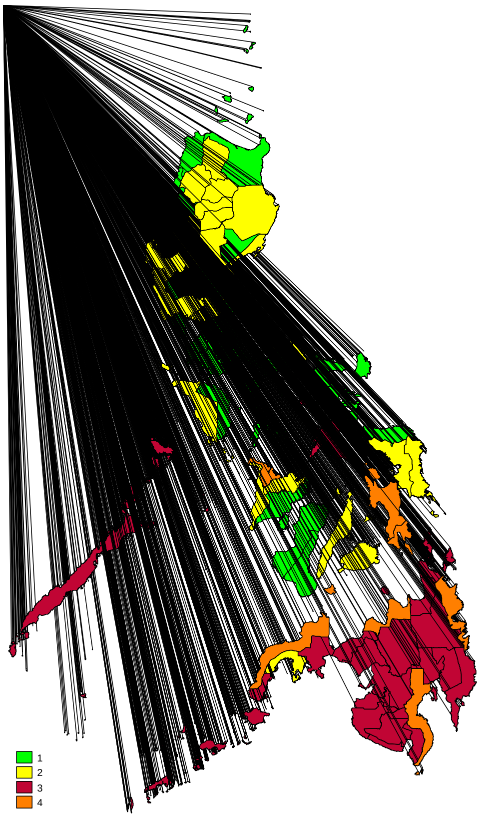


Figure 4. Moran's Scatter Plot (1988-2009)

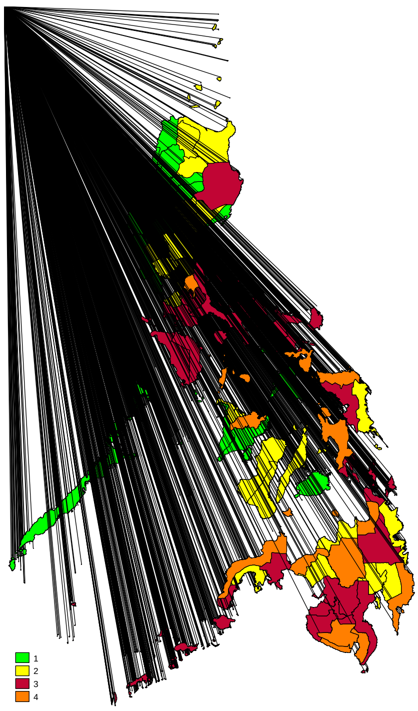
For the overall period 1988 to 2009, the percentage of provinces having similar growth rates in per capita income with the neighboring provinces is about 64% (with 42% in the High-High quadrant (quadrant 1) and 22% in the Low-Low quadrant (quadrant 1)). The percentage of the provinces showing dissimilar income growth rates with the neighboring provinces increase is about 36% (with 24% in the

Low-High quadrant (quadrant 2) and 12% in the High-Low quadrant (quadrant 4). The degree of similarity of the income growth rate between the home provinces and the neighbors is positive and significant, with a Moran's Index of about 0.12.



Note: Quadrant 1 is High-High; Quadrant 2 is Low-High; Quadrant 3 is Low-Low and Quadrant 4 is High-Low

Figure 5. Mapping of the Philippine Provinces Income Growth (1988-1994) using the Moran's Quadrant



Note: Quadrant 1 is High-High; Quadrant 2 is Low-High; Quadrant 3 is Low-Low and Quadrant 4 is High-Low

Figure 6. Mapping of the Philippine Provinces Income Growth (1994-2000) using the Moran's Quadrant

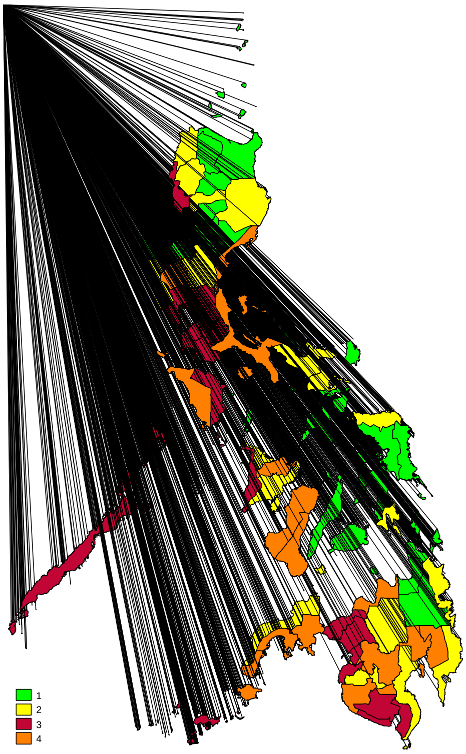
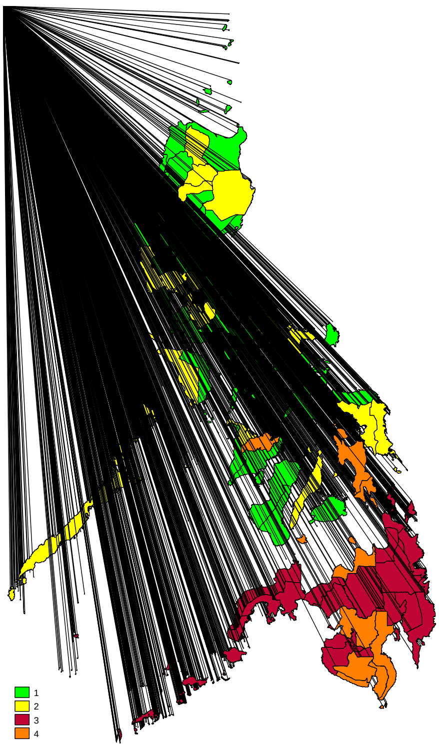


Figure 7. Mapping of the Philippine Provinces Income Growth (2000-2009) using the Moran's Quadrant

Note: (Quadrant 1 is High-High; Quadrant 2 is Low-High; Quadrant 3 is Low-Low and Quadrant 4 is High-Low)



Note: (Quadrant 1 is High-High; Quadrant 2 is Low-High; Quadrant 3 is Low-Low and Quadrant 4 is High-Low)

Figure 8. Mapping of the Philippine Provinces Income Growth (1988-2009) using the Moran's Quadrant

4. Econometric models

This section discusses the empirical results of the econometric model using country's intra-country data for the period 1988 to 2009. The econometric model for the average per capita income growth (the dependent variable) is a Barro-type (Barro and Xala-i-Martin, 2004) growth regression model, augmenting it to incorporate the provincial spatial dependence using the distance measure of identifying the neighboring provinces of a particular home province (using the maximum distance of 655 kilometers to identify the neighbor). The weight used is the inverse of the distance implying that the correlation between income growth of the two provinces decreases with distance. The spatial dependence is referred to as the neighborhood effect. The explanatory variables include the initial per capita income of the province (to capture the conditional convergence or catching-up effect), the proportion of young dependents (aged 0 to 14) in the population (demographic factor), measure of inequality (using the expenditure Gini and its square), geographical variables such as average amount of rainfall, average slope of the land and an indicator variables if the province is landlocked or not. An indicator variable if the province has mineral resources is also included in the model. Measures of infrastructure are also included in the model using the proxy variables growth rates of households with electricity and the national road. A political indicator variable is incorporated in the model using the percentage of mayors and governors in the provinces who are affiliated with the same political party as the incumbent president of the country. The vector of economic and political variables (known as the Barro's Core) is included in the econometric since these usually affect the steady state growth of income.

The empirical results are shown in Tables 5 and 6 below. The results in Table 5 show the full model, while Table 6 shows the results of the reduced model after eliminating the statistically insignificant coefficients.In Tables 5 and 6, the coefficient of the neighborhood effect (or the spatial effect) is positive and significantly affecting the average income growth of the home province, controlling for other factors. In particular, if the average per capita income growth of the neighboring provinces increase by 1 percentage point, the average per capita income growth of the home province will increase by about 0.5 percentage points, all things being the same. This value shows a strong and positive spatial dependence between the home province and its neighbors. The positive sign of the spatial effect is also consistent with the values of the Moran's indices. The other variables that are significantly affecting the average growth of provincial per capita income are the initial income, percentage of young dependents and the political variable.

The magnitude of the coefficient of the natural logarithm of initial income (at -8.054 for the final model) implies that (conditional) convergence of provincial income occurs at the rate of about 8 percent per year.[19] This result is congruent with the expectation of conditional convergence, that is, the economy grows faster the further it is from its own steady state level of income. Thus, on the average, provinces with higher per capita income at the start of the sample period experienced lower average growth rate relative to provinces with lower initial income per capita, all other things being the same. In other words, poorer provinces have the opportunity to catch up (in terms of income growth) with the richer provinces in the long run. Note, however, that this convergence is conditional in that it predicts a higher growth in response to a lower starting provincial income per person if the other explanatory variables are held constant.

The demographic variable, proportion of young dependents, has a negative and significant effect on the average per capita income growth of the provinces. The estimated coefficient of -7.342 (in the final model) implies that a one-percentage point reduction in the percentage of young dependents

[19] This estimate of the rate of conditional convergence of the model is higher than that previously estimated by Balisacan (2005) at 4% per year and closer to the estimate of Balisacan and Fuwa (2002) which was 9% per year for the Philippines provincial data.

at the start of the period will results in an estimated 7.3 basis points increase on the average growth rate of income per person, all things being the same. The absolute figure of 7.3 basis points may seem small but it should be considered that the estimated increase in income growth, as provided by the model, is accumulated over the period 1988 to 2009 (over 21 years), which is substantially large at the end of the period 2009. This result supports the earlier studies, notably Mapa and Balisacan (2004) and Bloom and Williamson (1997), using cross-country data, that a country with a large proportion of young dependents will experience constricting effects on its economic growth during the first phase of the demographic transition.

The political variable, percentage of mayors and governors that are affiliated with the same party as the country's president, is also a significant determinant of per capita income growth. However, the sign of the estimated coefficient for this variable is negative, somewhat inconsistent with the expectation that being affiliated with the same party as the country's president may result higher, rather than lower income growth. Being affiliated with the seating president's political party may bring in more infrastructure projects that will likely increase income growth. A study on the impact of political variable on infrastructure development by Balisacan, Mapa, Fuwa, Abad-Santos and Piza (2011) showed that growth rate in the percentage of household with electricity (the authors' proxy for infrastructure) is targeted to provinces with higher proportion of mayors and governor affiliated with the President's party.

Table 5. Results of the Spatial Lag Econometric Model for Average Provincial Growth Rate (Full Model)

Variable	Estimated Coefficient	SE	p-value
Neighborhood Effect (Spatial Effect)	0.522	0.226	0.021
Initial Income (in natural logarithm)	-9.515	1.701	0.000
Percentage of young dependents	-5.808	4.495	0.196
Average Rainfall	0.000	0.000	0.239
Percentage of Mayor and Gov with the President's Party	-3.239	1.454	0.026
Gini Coefficient	22.688	36.155	0.530
Square of Gini	-31.165	51.383	0.544
Growth Rate - HHs with Electricity	-0.018	0.042	0.668
Growth Rate - National Road	-0.028	0.025	0.268
Dummy Variable for Geography (Landlock)	-0.428	0.323	0.186
Slope of the Land	0.297	0.221	0.180
Province with Mineral Resources	0.186	0.485	0.701
Year Indicator (for 1994-2000)	2.724	0.489	0.000
Year Indicator (for 2000-2009)	0.492	0.525	0.348
Constant Term	41.648	9.861	0.000

Note: Wald's Test for Spatial Coefficient (Rho) = 0 (Test Stat = 5.335; p-value = 0.021)

Table 6. Results of the Spatial Lag Econometric Model for Average Provincial Growth Rate (Final Model)

Variable	Estimated Coefficient	SE	p-value
Neighborhood Effect (Spatial Effect)	0.548	0.216	0.011
Initial Income (in natural logarithm)	-8.054	1.497	0.000
Percentage of young dependents	-7.342	4.218	0.082
Percentage of Mayor and Gov with the President's Party	-2.895	1.441	0.045
Year Indicator (for 1994-2000)	2.465	0.406	0.000
Constant Term	39.416	7.114	0.000

Note: Wald's Test for Spatial Coefficient (Rho) = 0 (Test Stat = 6.459; p-value = 0.011)

Conclusion

This study looks at the spatial relationship of the average per capita income growth using intra-country or provincial data from 1988 to 2009. The results from the study provide insights on the geographical dimensions of provincial income growth and showed evidence on the role of spatial effects in the formal econometric analysis of intra-country income growth models. Despite the data limitations, the study provides a strong empirical evidence of the presence of positive spatial dependence or degree of similarity in the average per capita income growth of the provinces, albeit the degree of positive spatial dependence weakens in the latter periods. This positive spatial correlation suggests the provinces may be converging in terms of their income growth and they do so in movements similar to their neighbors.The finding of the study that spatial dependence weakened in the latter periods (1994-2000 and 2000-2009) needs to be analyzed further. The weakening of spatial dependence may provide insights on the uneven provincial/regional income growth experienced in the country. One possible explanation of the weak spatial dependence is that two or more groups of neighboring provinces are growing at similar rates within the group, but at different rates across groups. This opens the possibility of having different convergence clubs (of provinces) within the country. We hope this paper can stimulate others to investigate further the spatial dimensions of income growth in the country.

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Bubbles, Bluffs and Greed

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Abstract:

A rational bubble cannot theoretically exist if people have infinite horizons. This paper shows that a bubble-like phenomenon can be generated by a "bluff" even if people are rational and have infinite horizons. A bluff is defined as the behavior of an agent who pretends to possess private information to gain profits, particularly (false or misleading) information that the representative household's rate of time preference (RTP RH) has changed. An alternative definition of the representative household indicates that households must ex ante generate an expected RTP RH to behave optimally, but the expected RTP RH has to be generated based on beliefs about the RTP RH. Bluffers exploit the opportunities derived from the fragile nature of the expected RTP RH. The driving force behind bluffs is greed because bluffers do not work hard to gain profits by producing and selling better goods and services more cheaply, but by disseminating contaminated information, or acting in such a way to mislead people into believing the expected RTP RH has changed.

Keywords: bubble, bluff, greed, time preference, representative household, financial supervision.

JEL Classification: E32, E44, G14

1. Introduction

The Great Recession that occurred in the latter half of the 2000s forced us to once again realize the importance of the economic phenomenon known as a "bubble". In this case, it was not only a single commodity's bubble that burst but a global bubble-led economic boom. Theoretically, a rational bubble cannot exist if agents have infinite horizons (Blanchard and Watson, 1982; Santos and Woodford, 1997). Hence, an economic boom led by a rational bubble is also impossible if agents have infinite horizons. An assumption of some kind of irrationality may therefore be necessary to explain the existence of bubble-like phenomena. However, merely making *ad hoc* assumptions of irrational agents does not appear to be a compelling argument. It is too easy to *ad hoc* assume irrationality because, if we assume irrationality in human behaviors, we can explain any otherwise unexplainable human phenomena. However, there is another possible source of this bubble-like phenomenon. If some factor or factors obstruct agents' rational decision making, a bubble may be generated. In this paper, I show that a mechanism which I call a "bluff" is such a factor, and it generates a bubble-like phenomenon even if people are rational and have infinite horizons. In this context, I consider a bluff to be a strategy or trick in which an agent pretends to possess private information that is actually untrue to gain profit. To the best of my knowledge, this type of strategy has not been studied as a source of bubble-like phenomena, but it can potentially obstruct agents' decision making and force them to make non-optimal decisions *ex post*; in other words, people can potentially be fooled or cheated by an agent who bluffs.

I show that, by utilizing private information about the rate of time preference of the representative household (RTP RH), a bluffer can generate a bubble-like phenomenon. Becker (1980) and Harashima (2014a, b) indicate that it is not possible to assume the representative household as the average household in dynamic models. An alternative definition of the representative household is shown in Harashima (2014a, b); it entails the collective behavior of households under sustainable heterogeneity. This alternative definition of the representative household requires that each household must generate an expectedRTPRH*exante* for it to behave optimally. However, although a household knows its own rate of time preference (RTP), it cannot directly observe the RTP RH. Therefore, the expected RTP RH has to be generated based on each household's beliefs about the RTP RH. The expected RTP RH is therefore fragile. If bluffers can exploit opportunities provided by this fragility and manipulate the expected RTP RH, the use of bluffs can cause a bubble-like phenomenon.

Greed is the driving force behind bluffs. Financial crises and the ensuing economic crises (e.g., the Great Depression or the Great Recession) are often seen as the consequences of greed. However, some people have argued that greed is an indispensable driving force of capitalism and therefore should not be blamed. Bluffers' greed, however, should clearly be blamed for negative economic outcomes because bluffers do not work harder to obtain profits by producing and selling better goods and services more cheaply; rather, they gain profit by acting in such a way to mislead people into believing the expected RTP RH has changed.

2. The expected rate of time preference of representative household (RTP RH)

2.1. An alternative definition of the representative household

2.1.1. The definition

As Becker (1980) and Harashima (2014a, b) indicate, it is not possible to assume the representative household as the average household in dynamic models. Harashima (2014a, b) shows an alternative definition of the representative household such that the behavior of the representative household is defined as the collective behavior of all households under sustainable heterogeneity. The reason why this alternative definition is needed and the nature of sustainable heterogeneity are described in detail in the Appendix. Unlike the case in which the representative household is assumed to be the average household, this alternatively defined representative household reaches a steady state in which all households satisfy all of their optimality conditions in dynamic models, even if households are heterogeneous. In addition, the alternatively defined representative household has an RTP that is equal to the average RTP as shown in Eqs. (A7) and (A8) in the Appendix.[20] Hence, we can assume not only a representative household but also that its RTP is the average rate of all households.

2.1.2 Necessity of expecting RTP RH

This alternatively defined representative household requires that each household must generate an expected RTP RH *ex ante* for it to behave optimally as shown in the Appendix (see also Harashima, 2014a, b). However, a problem remains. Although a household knows its own RTP, it cannot directly observe the RTP RH, and therefore, the expected RTP RH has to be generated based

[20] If sustainable heterogeneity is achieved with the help of government intervention, the time preference rate of the representative household will not be exactly equal to the average rate of time preference.

on its beliefs about RTP RH. Beliefs will be formed by using heuristics (a detailed explanation of the expected RTP RH and the heuristics used to estimate it are shown in the Appendix).

2.2 The path when the expected and intrinsic RTP RHs are different

The alternative definition of the representative household requires sustainable heterogeneity. Achieving sustainable heterogeneity affects the behavior of individual households because sustainable heterogeneity requires that each household must consider other households' optimality (as well as the behavior of the government, if necessary). This feature does not, however, mean that households behave cooperatively. Each household behaves autonomously based on its own RTP, but at the same time, its behavior is influenced by whether or not the other households' optimality conditions are achieved. This consideration affects the actions a household takes in that it affects the choice of a household's initial consumption.

Sustainable heterogeneity indicates that a household's future path of consumption has to be consistent with the future path of sustainable heterogeneity. Therefore, each heterogeneous household sets its initial consumption such that it proceeds on the path that is consistent with the path of sustainable heterogeneity and eventually reaches a steady state. That is, each heterogeneous household sets its initial consumption counting backward from its expected consumption in the steady state, which is calculated based on the expected RTP RH, to its present consumption supposing that all the other households also set their initial consumptions in a similar manner. All households thereby behave autonomously in the same manner. Even if the expected RTP RH is not equal to the intrinsic RTP RH, all households set their initial consumption consistent with the steady state derived from the expected RTP RH. After setting the initial consumption, each heterogeneous household proceeds according to its own optimality conditions and eventually reaches a steady state. In the steady state, households' capital accumulation stops, and production, consumption, and capital no longer change. Therefore, even if the expected RTP RH is not equal to the intrinsic RTP RH, the steady state is stable and can be kept for a long period as long as households believe that the expected RTP RH is the correct one.

This nature is important because it indicates that the economy is subject not to the intrinsic RTP RH but to the expected RTP RH. Even if the expected RTP RH is actually very different from the intrinsic RTP RH, the economy will appear to proceed quite "normally" for an indefinite period of time without any inconsistencies among observed economic indicators. Therefore, the observed economic indicators alone cannot tell us whether the expected RTP RH is truly identical to the intrinsic RTP RH or whether or not the current economy is in a bubble-like state.

3. Bluff

The important role of the expected RTP RH as discussed in Section 2 indicates that, if the expected RTP RH can be manipulated, the economy can also be manipulated. The fragility of the expected RTP RH (i.e., it is formed based on beliefs) indicates that there is room for an agent (probably a malicious agent) to manipulate the expected RTP RH, for example, by intentionally disseminating misleading information.

3.1 Bubble

In bubble theory, a bubble is defined as an excess of asset prices over their fundamental values or intrinsically useless assets that are traded at positive prices. The theory concludes that if all agents are rational and has infinite horizons, bubbles cannot be generated. Therefore, no bubble-led economic boom can exist theoretically. Hereafter, I use the term "bubble" not only to indicate an excess of asset prices but more broadly to include a bubble-led economic boom. An excess of asset prices may not always accompany an economic boom, but I focus on the cases where an excess of asset prices does accompany the boom.

Despite their theoretical impossibility, many bubble-like phenomena have been observed across economies and time periods. According to bubble theory, if intrinsically useless assets are really being traded at positive prices, the condition of rational decision makes must be violated to some extent somewhere along the line; for example, many agents behaving as if they have finite horizons. However, the *ad hoc* assumption that agents are intrinsically irrational is not compelling. There is, however, another possible source of interference with rational decision making. If some factor or factors disturb the decision-making process, the decisions made will not be optimal *ex post*. If expectations of the future economic path are skewed or somehow flawed, for example, because information is incomplete and asymmetric among agents, intrinsically useless assets may be traded at positive prices and then a bubble-like phenomenon may be generated. The existence of bluffs may therefore allow the generation of bubble-like phenomena if the bluffers can successfully manipulate information.

Even if information manipulation can cause small-scale episodes of trading in intrinsically useless assets, can it generate economy-wide large-scale bubble-like phenomena? Although excesses in some asset prices may be caused through information manipulation, it does not necessarily follow that these excess prices will lead to an economy-wide boom. To generate an economy-wide boom, the manipulated information not only needs to have a very large impact on the economy as a whole, but it must also not be easily detected by people. If the manipulation is easily detected, the effects of the manipulation will soon vanish.

3.2 Bluff

Although it may seem that there is no type of manipulation that would satisfy the conditions for generating the bubble-like phenomenon discussed in Section 3.1, manipulating information with regard to the expected RTP RH could satisfy the conditions and cause bubble-like phenomena. The expected RTP RH has a huge impact on the economy because it is the discount factor of future utilities in the expected future economy, and it is not easy for households to detect information manipulation merely by observing economic indicators as discussed in Section 2. Bluffs can be used to intentionally manipulate the expected RTP RH. In a poker game, a bluff is generally a bet made by a player with an inferior hand. By analogy, a bluff herein is defined as the behavior of an agent who pretends to possess the (false) information that the intrinsic RTP RH has changed. The bluffer hopes that his actions will lead people believe the false information and take actions that will ultimately benefit him. The misleading actions of the bluffer may affect the heuristics used by people in forming their beliefs and expectations of RTP RH. Households may become confused by the information the bluffer has disseminated, and in some cases, they may believe that this false information is actually true.

One way of bluffing is to inject huge amounts of money into financial markets to make loans or buy assets that are usually regarded to be too risky to own. Episodes when such large amounts of money have been injected for loans or risky stocks are not rare. Examples include the subprime mortgage loans in the United States in the first decade of the 21st century, the dot-com bubble in the United States in the late 1990s, or the real estate loans by banks in Japan in the later 1980s. Although it remains uncertain whether these episodes were generated intentionally by bluffers, we can agree that during these periods financial institutions injected huge amounts of money into projects that have historically been viewed as quite risky.

As households observe such huge injections of money into highly risky projects, they may ask themselves why some agents are taking these actions. There are several possibilities - the agents may be irrational or foolish, they may be bluffing, or the expected RTP RH of many households has changed and therefore projects that previously were deemed to be too risky are no longer viewed in that way. House holds judge which of these possibilities is true by using heuristics. However, there is no guarantee that households will always reach the correct conclusion. There is the possibility that at least some households will come to believe that the expected RTP RH of other households has really changed even though, in actuality, the information has been contaminated by the bluffers, whose aim is to exploit these misconceptions.

As stated previously, if the expected RTP RH is successfully manipulated in this manner, its impact on the economy is huge because the RTP RH is the discount factor in expectations of future utilities. Even a small downward shift of the discount factor will largely increase the expected steady-state production and generate a bubble-like economic boom. The more the bluff changes people's expected RTP RH, the larger the bubble and the expected payoffs to the bluffers who initiated this movement will be. No household can know the bluffer's initial state of mind, and as shown in Section 2, it is not easy for households to detect contaminated information by observing economic indicators. As a result, the economy may appear to be "normal" and steady as shown in the Appendix. Hence, the bubble-like economic boom can continue for a long period.

If bluffers can successfully change households' expected RTP RH, their "investments" (i.e., money used for the bluff) can yield a huge amount of profits by successfully influencing the sale of stocks or other financial instruments before households detect the bluff.

3.3 Return on assets or RTP RH?

Information can also be distorted by altering information about the expected future dividend. The present value of an asset (the non-bubble part of the price) is most simply expressed as:

$$E\int_0^\infty \exp(-\theta t) D_t \, dt$$

where: θ is RTP, D_t is the return on asset in period t and E is the expectation operator. Hence, in addition to the expected RTP RH, contaminated information can also be used to skew future dividends to generate a bubble-like phenomenon.

However, on average, the returns D_t are proportionate to the marginal returns on capital $\frac{df(k_t)}{dk_t}$ and at the steady state, $\frac{df(k_t)}{dk_t} = \theta$.

That is, the expected future stream of average returns is determined depending on the expected RTP RH. Bluffers may disseminate false information about expected future dividends by, for example pretending to possess knowledge on future technologies, but at the steady state, the equation $\frac{df(k_t)}{dk_t} = \theta$ still holds.

Therefore, given the expected RTP RH, there will be little room for bluffers to exploit opportunities for payoffs by contaminating information about the average returns on assets in the economy. Hence, the bluffer's target manipulations will be limited to the expected RTP RH.

3.4 Bluff conditions

3.4.1 Conditions

Suppose for simplicity that all bluffers are identical. Therefore, bluffers' actions (bluffs) are represented by a representative bluffer (hereafter, "the bluffer"). Let $\overline{\pi}$ be the subjective payoffs of a bluff to the bluffer if the expected RTP RH is successfully manipulated. Let *p* $(0 \le p \le 1)$ be the probability that, after observing the information the bluffer disseminated, households decide that the expected RTP RH has changed. If households do not believe the information and do not change the expected RTP RH, the bluff fails and the bluffer suffers the loss $-\underline{\pi}$ where $0 < \underline{\pi} < \overline{\pi}$. It is assumed for simplicity that $\overline{\pi}$, $-\underline{\pi}$, and *p* are identical for any bluff.

The expected payoffs to the bluffer (*Π*) for a bluff is therefore

$$\Pi = p\overline{\pi} + (1-p)(-\underline{\pi}) = p(\overline{\pi} + \underline{\pi}) - \underline{\pi} \quad (1)$$

Eq. (1) indicates that, even if p is small, $\Pi > 0$ if $\overline{\pi}$ is sufficiently large. The variance of Π, σ^2, is

$$\sigma^2 = (p - p^2)(\overline{\pi} + \underline{\pi})^2 .$$

Because $0 \le p \le 1$, then $p - p^2 \ge 0$, $\sigma^2 \ge 0$,

$$\frac{d\sigma^2}{d\overline{\pi}} = (p - p^2)2(\overline{\pi} + \underline{\pi}) > 0 \quad \text{and} \quad \frac{d^2\sigma^2}{d\overline{\pi}^2} = 2(p - p^2) > 0 .$$

In addition, because $0 \le p \le 1$,

$$\frac{d\sigma^2}{d\Pi} = 2(1-p)(\overline{\pi} + \underline{\pi}) > 0 \quad \text{and} \quad \frac{d^2\sigma^2}{d\Pi^2} = 2(p^{-1} - 1) > 0 .$$

Hence, a payoff curve can be drawn as the bold line on the Π–σ^2 plane in Figure 1. The thin solid line in Figure 1 indicates the indifference curve of the bluffer that has a point of contact at A with the payoff curve. At point A, the bluffer undertakes a bluff.

For simplicity, additional assumptions are introduced. In every period, the bluffer can undertake one bluff because of financial constraints, and the chances of a bluff being made at any point on the curve in the Π–σ^2 plane occur randomly. That is, in a given period, a bluff succeeds with the probability p if a bluff that corresponds to point A on the curve in the Π–σ^2 plane occurs. If the chances of a bluff corresponding to point A do not occur frequently and p is small, then a bubble-like phenomenon caused by a bluff will not necessarily be frequently observed.

In the case of a more risk adverse bluffer, the shape of indifference curve will be something like the thin dotted line shown in Figure 1. A bluff will not be undertaken in this case because the bluffer's indifference curve has a point of contact at B with the payoff curve, but at point B, payoffs are negative and thus the bluff is not profitable. Nevertheless, bluffers are likely to be less risk averse than ordinary people. Hence, the shape of the bluffer's indifference curve will usually resemble the thin solid line in Figure 1 where the payoff (Π) at point A is positive.

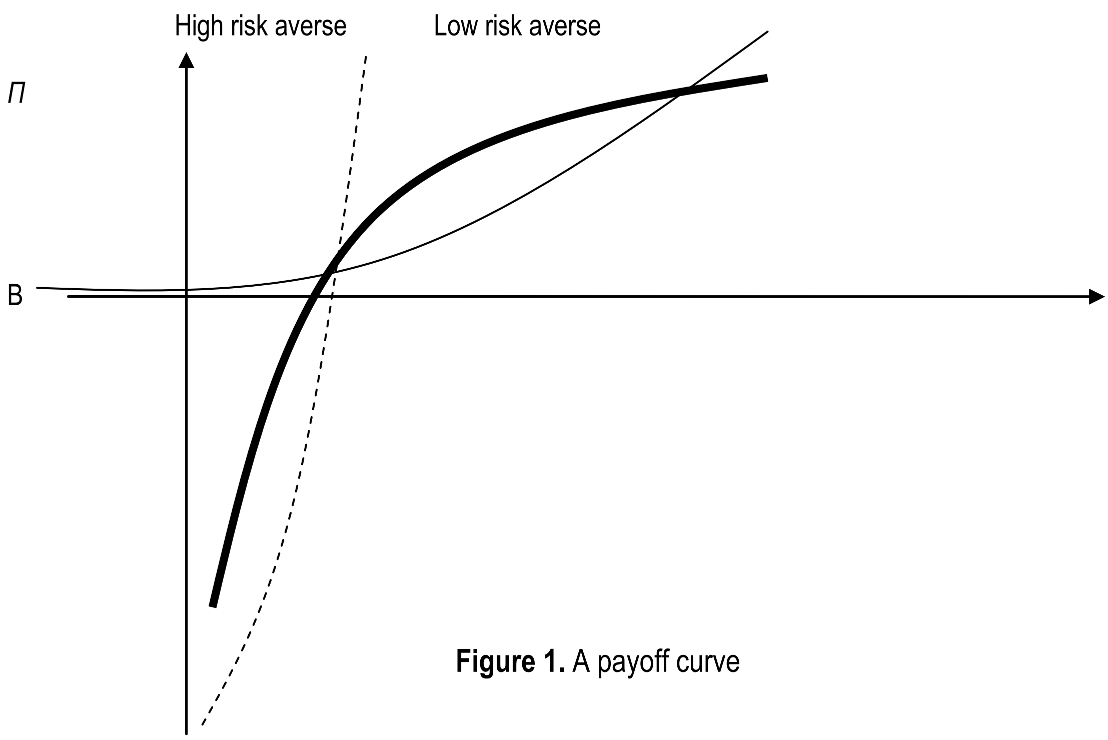

Figure 1. A payoff curve

3.4.2 Initial costs

The occurrence probability of a bubble-like phenomenon caused by a bluff will be different depending on the value of $\underline{\pi}$ because point A varies depending on $\underline{\pi}$. Suppose that *p* is identical for any $\underline{\pi}$.

Because $\frac{d^2\sigma^2}{d\overline{\pi}^2}=2\left(p-p^2\right)$, as: $\underline{\pi}$ increases, *Π* decreases and $\sigma^2=\left(p-p^2\right)\left(\overline{\pi}+\underline{\pi}\right)^2$, $\frac{d\sigma^2}{d\overline{\pi}}=\left(p-p^2\right)2\left(\overline{\pi}+\underline{\pi}\right)$, and $\frac{d^2\sigma^2}{d\overline{\pi}^2}=2\left(p-p^2\right)$ increase.

There fore, when $\underline{\pi}$ increases, the bold solid line shifts to the bold dashed line in Figure 2, and point A moves to the point A'. *Π* for A' is smaller than *Π* for A. As $\underline{\pi}$ increases, *Π* decreases and eventually becomes negative. Hence, if $\underline{\pi}$ is sufficiently large, even if the bluffer's degree of risk averseness is very low, the bluffer will not undertake a bluff because the expected payoffs for a bluff are negative. Conversely, if $\underline{\pi}$ is sufficiently small, the bluffer will undertake a bluff even if the bluffer's degree of risk averseness is relatively high.

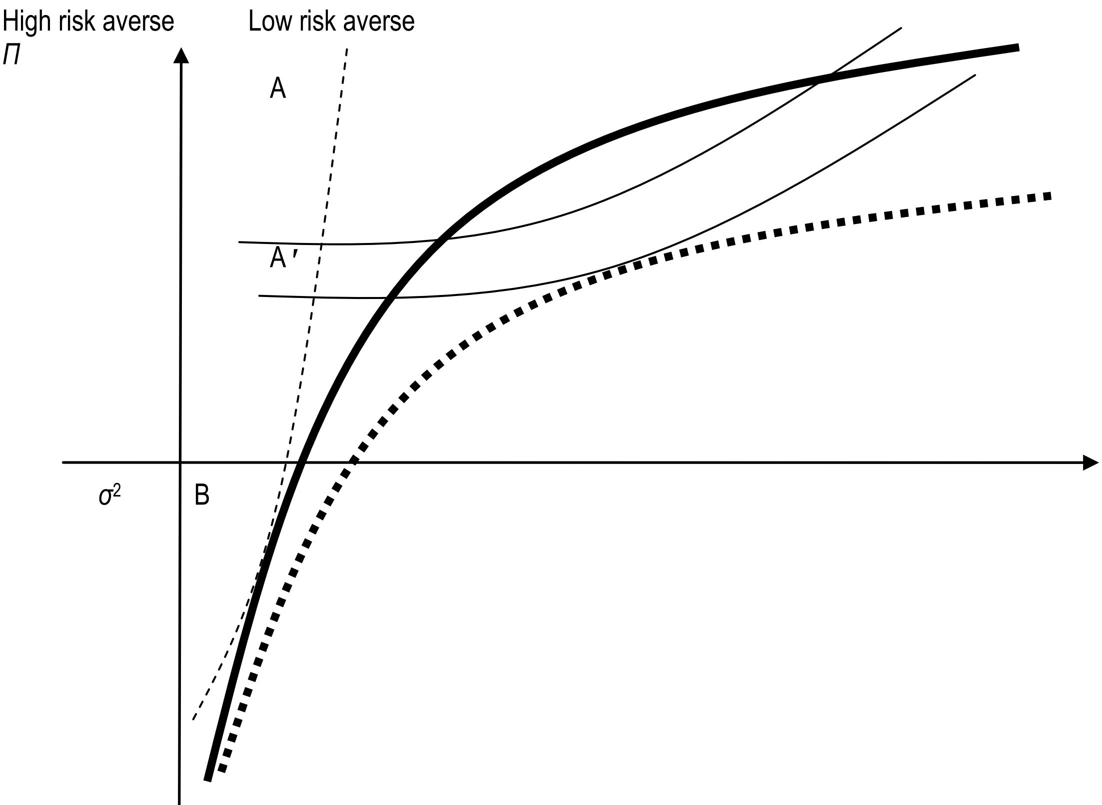

Figure 2. Payoff curves for different initial costs

3.5 The end of a bluff

As shown in Section 2, once a bluff succeeds the economy proceeds "normally" and steadily on the path calculated based on the manipulated expected RTP RH until households detect that a bluff have occurred. If the bluffer can successfully continue to hide their intentions, households do not doubt that they are behaving optimally. Nevertheless if households detect the bluff, the bubble-like phenomenon will end. However, how do households detect a bluff? As Section 2 demonstrated, the economy looks to be proceeding "normally" on a path that was expected to be optimal. In addition, most observed economic data are consistent with this expected optimal path and can be interpreted as indicating that the economy is quite normal.

There are two ways of detecting a bluff. First, authorized information suggesting the existence of the bluffmay be provided by the government. Here, the supervising financial authority plays an important role. Unlike households, the financial authority has special powers of investigation. If its supervision is sufficiently prudent and extensive, it is likely that the authority will eventually uncover the bluff. When the financial authority perceives the existence of a bluff, it has the power to force the bluffer to stop bluffing and provide this information to households. In this sense, prudential supervision is crucially important to help households avoid the damages inflicted on them by bluffers. The importance of the financial authority's supervision conversely indicates that, if households begin to doubt whether the authority's supervision is sufficiently prudent, they may adjust the expected RTP RH largely supposing that the current economic boom is caused by a bluff because the supervision has failed. The bluff and bubble-like phenomenon will end when households begin to doubt either the supervising authority.

A second possible way of detecting a bluff is if the bluffer pushes too far because of greed. The bluffer may have to take on a high level of risk of being detected to obtain greater payoffs. The probability that the hidden intention of the bluffer will be detected by households will increase as the bluffer pursues greater amounts money. A bluffer who has become complacent or conceited because of the success of the bluff may indeed engage in such high-risk behavior. This possibility appears to be likely because bluffers are quite likely to be greedy by nature. The bluffer does not work hard to gain profits by producing and selling better goods and services more cheaply, but by disseminating contaminated information. This behavior clearly indicates that they are intrinsically greedy.

When a bluff is detected, households will not only return the expected RTP RH to the former value, but they may go further. That is, they may generate a much higher expected RTP RH than the original one (before the bluff) because the credibility of the financial authority has been undermined and therefore future uncertainty about the economy increases. The structural model of RTP indicates that an increase in future uncertainty increases RTP (see the Appendix and Harashima, 2014a, b), so the expected RTP RH will be changed to a higher value than that before the bluff. The subsequent economic stagnation will worsen as compared with the case where the expected RTP RH simply returns to the pre-bluff value.

3.6 The bluffer is not a noise trader or criminal

Although a bubble-like phenomenon generated by a bluff is not a rational bubble as defined in bubble theory, it can be observed even if all agents behave rationally and have infinite horizons. A bubble-like phenomenon is generated not because of irrationality, but rather because of fragility in the belief and expectation of the RTP RH as shown in Section 2. This fragility provides the opportunity for bluffers. Hence, the bluffer is not a noise trader because noise traders are irrational and bluffers behave completely rationally. In fact, both households and bluffers behave quite rationally.

Furthermore, a bluff is not a crime in most, if not all, countries. "Pump and dump" stock sales are a crime in most countries because false news is intentionally disseminated to gain profits. Although the bluffer contaminates information similar to a pump and dump strategy, false news is not actually disseminated. Instead, the bluffer engages in equivocal behavior and confuses households, but the bluffer's behavior itself is not false news. The interpretation of the bluffer's actions is completely up to households. Even if households wrongly interpret them, the bluffer is not responsible for their wrong interpretation. In theory, confusing households could be ruled out by law, but there are many kinds of economic activities that have the potential to confuse households to a greater or lesser extent. It would be very difficult to enact a law that strictly defines a bluff, while also distinguishing it from other confusing activities. Bluffs therefore should not be controlled by law enforcement agencies, but they should be strictly and prudently supervised by the financial authority.

Conclusion

Rational bubbles and economic booms led by them are not theoretically possible if agents have infinite horizons. However, assuming irrationality *ad hoc* does not appear to be a compelling argument. Even if people are rational and have infinite horizons, a bubble-like phenomenon can be generated if the expectation of the future economic path is hindered by some factors. In this paper, I show that bluffs are such a factor. The bluffer manipulates the household's expected RTP RH by acting in such a way as to lead people to believe incorrect information. A bluffer can thereby generate a bubble-like phenomenon even if people are rational and have infinite horizons because the expected RTP RH is the discount factor that is used to determine the expected future economic path.

An example of bluff is the injection of a huge amount of money into financial markets to give loans or buy assets that would usually be regarded too risky. Bluffs are effective because each household must generate an expected RTP RH *ex ante* for it to behave optimally and the expected RTP RH has to be formed based on beliefs about RTP RH. The bluffer exploits the opportunity provided by the fragility of the expectation.

The driving force behind bluffs is greed because bluffers do not work hard to get profits by producing and selling better goods and services more cheaply, but by disseminating contaminated information or acting in such a way to mislead people.

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APPENDIX

A1. The representative household in dynamic models

A1.1 The assumption of the representative household

The concept of the representative household is a necessity in macroeconomic studies. It is used as a matter of course, but its theoretical foundation is fragile. The representative household has been used given the assumption that all households are identical or that there exists one specific individual household, the actions of which are always average among households (I call such a household "the average household" in this paper). The assumption that all households are identical seems to be too strict; therefore, it is usually assumed explicitly or implicitly that the representative household is the average household. However, the average household can exist only under very strict conditions. Antonelli (1886) showed that the existence of an average household requires that all households have homothetic and homogeneous utility functions. This type of utility function is not usually assumed in macroeconomic studies because it is very restrictive and unrealistic. If more general utility functions are assumed, however, the assumption of the representative household as the average household is inconsistent with the assumptions underlying the utility functions.

Nevertheless, the assumption of the representative household has been widely used, probably because it has been believed that the representative household can be interpreted as an approximation of the average household. Particularly in static models, the representative household can be seen to approximate the average household. However, in dynamic models, it is hard to accept the representative household as an approximation of the average household because, if RTPs of households are heterogeneous, there is no steady state where all of the optimality conditions of the heterogeneous households are satisfied (Becker, 1980). Therefore, macroeconomic studies using dynamic models are fallacious if the representative household is assumed to approximate the average household.

A1.2 The representative household in static models

Static models are usually used to analyze comparative statics. If the average household is represented by one specific unique household for any static state, there will be no problem in assuming the representative household as an approximation of the average household. Even though the average household is not always represented by one specific unique household in some states, if the average household is always represented by a household in a set of households that are very similar in preferences and other features, then the representative household assumption can be used to approximate the average household.

Suppose, for simplicity, that households are heterogeneous such that they are identical except for a particular preference. Because of the heterogeneous preference, household consumption varies. However, levels of consumption will not be distributed randomly because the distribution of consumption will correspond to the distribution of the preference. The consumption of a household that has a very different preference from the average will be very different from the average household consumption. Conversely, it is likely that the consumption of a household that has the average preference will nearly have the average consumption. In addition, the order of the degree of consumption will be almost unchanged for any static state because the order of the degree of the preference does not change for the given state.

If the order of consumption is unchanged for any given static state, it is likely that the household with consumption that is closest to the average consumption will also always be a household belonging to a group of households that have very similar preferences. Hence, it is possible to argue that, approximately, one specific unique household's consumption is always average for any static state. Of course, it is possible to show evidence that is counter to this argument, particularly in some special situations, but it is likely that this conjecture is usually true in normal situations, and the assumption that the representative household approximates the average household is acceptable in static models.

A1.3 The representative household in dynamic models

In dynamic models, however, the story is more complicated. In particular, heterogeneous RTPs pose a serious problem. This problem is easily understood in a dynamic model with exogenous technology (i.e., a Ramsey growth model). Suppose that households are heterogeneous in RTP, degree of risk aversion (ε), and productivity of the labor they provide. Suppose also for simplicity that there are many "economies" in a country, and an economy consists of a household and a firm. The household provides labor to the firm in the particular economy, and the firm's level of technology (A) varies depending on the productivity of labor that the household in its economy provides. Economies trade with each other: that is, the entire economy of a country consists of many individual small economies that trade with each other.

A household maximizes its expected utility, $E\int_0^\infty u(c_t)\exp(-\theta t)dt$, subject to $\dot{k}_t = f(k_t) - c_t$, where $u(\bullet)$ is the utility function; $f(\bullet)$ is the production function; θ is RTP; E is the expectation operator; $y_t = \frac{Y_t}{L_t}$, $k_t = \frac{K_t}{L_t}$, and $c_t = \frac{C_t}{L_t}$; Y_t (≥ 0) is output, K_t (≥ 0) is capital input, L_t (≥ 0) is labor input, and C_t (≥ 0) is consumption in period t. The optimal consumption path of this Ramsey-type growth model is

$$\frac{\dot{c}_t}{c_t} = \varepsilon^{-1}\left(\frac{\partial y_t}{\partial k_t} - \theta\right) ,$$

and at steady state,

$$\frac{\partial y_t}{\partial k_t} = \theta \ . \qquad \text{(A1)}$$

Therefore, at steady state, the heterogeneity in the degree of risk aversion (ε) is irrelevant, and the heterogeneity in productivity does not result in permanent trade imbalances among economies because $\frac{\partial y_t}{\partial k_t}$ in all economies is kept equal by market arbitrage. Hence, heterogeneity in the degree of risk aversion and productivity does not matter at steady state. Therefore, the same logic as that used for static models can be applied. Approximately, one specific unique household's consumption is always average for any time in dynamic models, even if the degree of risk aversion and the productivity are heterogeneous. Thus, the assumption of the representative household is also acceptable in dynamic models even if the degree of risk aversion and the productivity are heterogeneous.

However, Eq. (A1) clearly indicates that heterogeneity in RTP is problematic. As Becker (1980) shows, if RTP is heterogeneous, the household that has the lowest RTP will eventually possess all capital. With heterogeneous RTPs, there is no steady state where all households achieve all of their optimality conditions. In addition, the household with consumption that is average at present has a very different RTP from the household with consumption that is average in the distant future. The consumption of a household that has the average RTP will initially be almost average, but in the future the household with the lowest RTP will be the one with consumption that is almost average. That is, the consumption path of the household that presently has average consumption is notably different from that of the household with average consumption in the future. Therefore, any individual household cannot be almost average in any period and thus cannot even approximate the average household. As a result, even if the representative household is assumed in a dynamic model, its discounted expected utility

$E\int_0^\infty u(c_t)\exp(-\theta t)dt$ is meaningless, and analyses based on it are fallacious.

If we assume that RTP is identical for all households, the above problem is solved. However, this solution is still problematic because that assumption is not merely expedient for the sake of simplicity; rather, it is a critical requirement to allow for an assumed representative household. Therefore, the rationale for identical RTPs should be validated; that is, it should be demonstrated that identical RTPs are actually and universally observed. RTP is, however, unquestionably not identical among households. Hence, it is difficult to accept the representative household assumption in dynamic models based on the assumption of identical RTP.

The conclusion that the representative household assumption in dynamic models is meaningless and leads to fallacious results is very important, because a huge number of studies have used the representative household assumption in dynamic models. To solve this severe problem, an alternative interpretation or definition of the representative household is needed.

Note that in an endogenous growth model the situation is even more complicated. Because a heterogeneous degree of risk aversion also matters, the assumption of the representative household is more difficult to accept, so an alternative interpretation or definition is even more important when endogenous growth models are used.

A2 Sustainable heterogeneity

A2.1 The model

Suppose that two heterogeneous economies—economy 1 and economy 2—are identical except for their RTPs. Households within each economy are assumed to be identical for simplicity. The population growth rate is zero. The economies are fully open to each other, and goods, services, and capital are freely transacted between them, but labor is immobilized in each economy.

Each economy can be interpreted as representing either a country (the international interpretation) or a group of identical households in a country (the national interpretation). Because the economies are fully open, they are integrated through trade and form a combined economy. The combined economy is the world economy in the international interpretation and the national economy in the national interpretation. In the following discussion, a model based on the international interpretation is called an international model and that based on the national interpretation is called a national model. Usually, the concept of the balance of payments is used only for the international transactions. However, because both national and international interpretations are possible, this concept and terminology are also used for the national models in this paper.

RTP of household in economy 1 is θ_1 and that in economy 2 is θ_2, and $\theta_1<\theta_2$. The production function in economy 1 is $y_{1,t} = A^\alpha f(k_{1,t})$ and that in economy 2 is $y_{2,t} = A^\alpha f(k_{2,t})$, where $y_{i,t}$ and $k_{i,t}$ are, respectively, output and capital per capita in economy i in period t for i = 1, 2; A is technology; and $\alpha(0<\alpha<1)$ is a constant. The population of each economy is $\frac{L}{2}$; thus, the total for both is L, which is sufficiently large. Firms operate in both economies. The current account balance in economy 1 is τ_t and that in economy 2 is $-\tau_t$. The production functions are specified as:

$$y_{i,t} = A^\alpha k_{i,t}^{1-\alpha} \ ;$$

thus, $Y_{i,t} = K_{i,t}^{1-\alpha}(AL)^\alpha \ (i=1,2)$. Because A is given exogenously, this model is an exogenous technology model (Ramsey growth model). The examination of sustainable heterogeneity based on an endogenous growth model is shown in Harashima (2014a).

Because both economies are fully open, returns on investments in each economy are kept equal through arbitration, such that

$$\frac{\partial y_{1,t}}{\partial k_{1,t}} = \frac{\partial y_{2,t}}{\partial k_{2,t}} \ . \tag{A2}$$

Because Eq. (A2) always holds through arbitration, equations $k_{1,t} = k_{2,t}$, $\dot{k}_{1,t} = \dot{k}_{2,t}$, $y_{1,t} = y_{2,t}$, and $\dot{y}_{1,t} = \dot{y}_{2,t}$ also hold.

The accumulated current account balance $\int_0^t \tau_s ds$ mirrors capital flows between the two economies. The economy with current account surpluses invests them in the other economy. Because $\frac{\partial y_{1,t}}{\partial k_{1,t}}\left(= \frac{\partial y_{2,t}}{\partial k_{2,t}}\right)$ are returns on investments, $\frac{\partial y_{1,t}}{\partial k_{1,t}} \int_0^t \tau_s ds$ and $\frac{\partial y_{2,t}}{\partial k_{2,t}} \int_0^t \tau_s ds$ represent income receipts or payments on the assets that an economy owns in the other economy. Hence, $\tau_t - \frac{\partial y_{2,t}}{\partial k_{2,t}} \int_0^t \tau_s ds$ is the balance on goods and services of economy 1, and $\frac{\partial y_{1,t}}{\partial k_{1,t}} \int_0^t \tau_s ds - \tau_t$ is that of economy 2. Because the current account balance mirrors capital flows between the economies, the balance is a function of capital in both economies, such that:

$\tau_t = \kappa\left(k_{1,t}, k_{2,t}\right)$.

The government (or an international supranational organization) intervenes in the activities of economies 1 and 2 by transferring money from economy 1 to economy 2. The amount of transfer in period *t* is g_t, and it is assumed that g_t depends on capital inputs, such that:

$g_t = \bar{g} k_{1,t}$, *where* $\bar{g}$ is a constant.

Because $k_{1,t} = k_{2,t}$ and $\dot{k}_{1,t} = \dot{k}_{2,t}$, $g_t = \bar{g} k_{1,t} = \bar{g} k_{2,t}$ .Each household in economy 1 therefore maximizes its expected utility:

$E\int_0^\infty u_1\left(c_{1,t}\right)\exp\left(-\theta_1 t\right)dt$,subject to

$$\dot{k}_{1,t} = A^\alpha k_{1,t}^{1-\alpha} - c_{1,t} + (1-\alpha) A^\alpha k_{1,t}^{-\alpha} \int_0^t \tau_s ds - \tau_t - \bar{g} k_{1,t} \ , \tag{A3}$$

and each household in economy 2 maximizes its expected utility:

$E\int_0^\infty u_2\left(c_{2,t}\right)\exp\left(-\theta_2 t\right)dt$,

subject to:

$$\dot{k}_{2,t} = A^\alpha k_{2,t}^{1-\alpha} - c_{2,t} - (1-\alpha) A^\alpha k_{2,t}^{-\alpha} \int_0^t \tau_s ds + \tau_t + \bar{g} k_{2,t} \ , \tag{A4}$$

where$u_{i,t}$ and $c_{i,t}$, respectively, are the utility function and per capita consumption in economy *i* in period *t* for *i* = 1, 2; and *E* is the expectation operator. Eqs.(A3) and (A4) implicitly assume that each economy does not have foreign assets or debt in period *t* = 0.

A2.2 Sustainable heterogeneitywithout government intervention

Heterogeneity is defined as being sustainable if all of the optimality conditions of all heterogeneous households are satisfied indefinitely. First, the natures of the model when the government does not intervene (i.e., $\bar{g} = 0$) are examined. The growth rate of consumption in economy 1 is:

$$\frac{\dot{c}_{1,t}}{c_{1,t}} = \varepsilon^{-1}\left\{(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha} + (1-\alpha)A^{\alpha}k_{1,t}^{-\alpha}\frac{\partial\int_0^t \tau_s ds}{\partial k_{1,t}} - \alpha(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha-1}\int_0^t \tau_s ds - \frac{\partial \tau_t}{\partial k_{1,t}} - \theta_1\right\} .$$

Hence,

$$\lim_{t\to\infty}\frac{\dot{c}_{1,t}}{c_{1,t}} = \varepsilon^{-1}\lim_{t\to\infty}\left\{(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha} + (1-\alpha)A^{\alpha}k_{1,t}^{-\alpha}\frac{\partial\int_0^t \tau_s ds}{\partial k_{1,t}} - \alpha(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha-1}\int_0^t \tau_s ds - \frac{\partial \tau_t}{\partial k_{1,t}} - \theta_1\right\} = 0$$

and thereby

$$\lim_{t\to\infty}(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha}\left[1+(1-\alpha)\varPsi\right] - \varXi - \theta_1 = 0 \ ,$$

where $\varXi = \lim_{t\to\infty}\frac{\tau_t}{k_{1,t}} = \lim_{t\to\infty}\frac{\tau_t}{k_{2,t}}$ and $\varPsi = \lim_{t\to\infty}\frac{\int_0^t \tau_s ds}{k_{1,t}} = \lim_{t\to\infty}\frac{\int_0^t \tau_s ds}{k_{2,t}}$. $\lim_{t\to\infty}\frac{\dot{y}_{1,t}}{y_{1,t}} = \lim_{t\to\infty}\frac{\dot{c}_{1,t}}{c_{1,t}} = \lim_{t\to\infty}\frac{\dot{k}_{1,t}}{k_{1,t}} = \lim_{t\to\infty}\frac{\dot{\tau}_t}{\tau_t} = 0$, and $\varPsi$ is constant at steady state because $k_{1,t}$ and τ_t are constant; thus, $\varXi = \lim_{t\to\infty}\frac{\tau_t}{k_{1,t}}$ is constant at steady state. For $\varPsi$ to be constant at steady state, it is necessary that $\lim_{t\to\infty}\tau_t = 0$ and thus $\varXi = 0$. Therefore,

$$\lim_{t\to\infty}(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha}\left[1+(1-\alpha)\varPsi\right] - \theta_1 = 0 \ , \qquad \text{(A5)}$$

and

$$\lim_{t\to\infty}(1-\alpha)A^{\alpha}k_{2,t}^{-\alpha}\left[1-(1-\alpha)\varPsi\right] - \theta_2 = 0$$

because

$$\lim_{t\to\infty}\frac{\dot{c}_{2,t}}{c_{2,t}} = \varepsilon^{-1}\lim_{t\to\infty}\left\{(1-\alpha)A^{\alpha}k_{2,t}^{-\alpha} - (1-\alpha)A^{\alpha}k_{2,t}^{-\alpha}\frac{\partial\int_0^t \tau_s ds}{\partial k_{2,t}} + \alpha(1-\alpha)A^{\alpha}k_{2,t}^{-\alpha-1}\int_0^t \tau_s ds + \frac{\partial \tau_t}{\partial k_{2,t}} - \theta_2\right\} = 0 \ .$$

Because $\lim_{t\to\infty}(1-\alpha)A^{\alpha}k_{1,t}^{-\alpha}\left[1+(1-\alpha)\varPsi\right] = \theta_1$, $\lim_{t\to\infty}(1-\alpha)A^{\alpha}k_{2,t}^{-\alpha}\left[1-(1-\alpha)\varPsi\right] = \theta_2$, and $\frac{\partial y_{1,t}}{\partial k_{1.t}} = \frac{\partial y_{2,t}}{\partial k_{2.t}} = A^{\alpha}k_{1,t}^{-\alpha} = A^{\alpha}k_{2,t}^{-\alpha}$, then

$$\varPsi = \frac{\theta_1 - \theta_2}{2(1-\alpha)\lim_{t\to\infty}\frac{\partial y_{1,t}}{\partial k_{1.t}}} \ . \qquad \text{(A6)}$$

By Eqs. (A5) and (A6),

$$\lim_{t\to\infty}\frac{\partial y_{1,t}}{\partial k_{1.t}}+\lim_{t\to\infty}\frac{\partial y_{1,t}}{\partial k_{1.t}}(1-\alpha)\Psi=\theta_1\ ;$$

thus,

$$\lim_{t\to\infty}\frac{\partial y_{1,t}}{\partial k_{1.t}}=\frac{\theta_1+\theta_2}{2}=\lim_{t\to\infty}\frac{\partial y_{2,t}}{\partial k_{2.t}} \tag{A7}$$

If Eq. (A7) holds, all of the optimality conditions of both economies are indefinitely satisfied. The state indicated by Eq. (A7) is called the "multilateral steady state" or "multilateral state" in the following discussion. By procedures similar to those used for the endogenous growth model in Harashima (2014a), the condition of the multilateral steady state for *H* economies that are identical except for their RTPs is shown as

$$\lim_{t\to\infty}\frac{\partial y_{i,t}}{\partial k_{i.t}}=\frac{\sum_{q=1}^{H}\theta_q}{H} \tag{A8}$$

for any *i*, where *i* = 1, 2, … , *H*.Because $\Psi=\frac{\theta_1-\theta_2}{2(1-\alpha)\lim_{t\to\infty}\frac{\partial y_{1,t}}{\partial k_{1.t}}}=\frac{\theta_1-\theta_2}{(1-\alpha)(\theta_1+\theta_2)}<0$ by Eq. (A7), then by $\lim_{t\to\infty}\frac{\int_0^t\tau_s ds}{k_{1,t}}=\Psi<0$, $\lim_{t\to\infty}\int_0^t\tau_s ds<0$ that is, economy 1 possesses accumulated debts owed to economy 2 at steady state, and economy 1 has to export goods and services to economy 2 by: $\left|(1-\alpha)A^\alpha k_{1,t}^{-\alpha}\int_0^t\tau_s ds\right|$ in every period to pay the debts. Nevertheless, because $\lim_{t\to\infty}\tau_t=0$ and $\Xi=0$, the debts do notexplode but stabilize at steady state. Because of the debts, the consumption of economy 1 is smaller than that of economy 2 at steady state under the condition of sustainable heterogeneity.

Note that many empirical studies conclude that RTP is negatively correlated with income (e.g., Lawrance, 1991; Samwick, 1998; Ventura, 2003). Suppose that, in addition to the heterogeneity in RTP ($\theta_1<\theta_2$), the productivity of economy 1 is higher than that of economy 2. At steady state, the consumption of economy 1 would be larger than that of economy 2 as a result of the heterogeneity in productivity. However, as a result of the heterogeneity in RTP, the consumption of economy 1 is smaller than that of economy 2 at steady state under sustainable heterogeneity. Which effect prevails will depend on differences in the degrees of heterogeneity. For example, if the difference in productivity is relatively large whereas that in RTP is relatively small, the effect of the productivity difference will prevail and the consumption of economy 1 will be larger than that of economy 2 at steady state under sustainable heterogeneity.

A3. An alternative definition of the representative household

A3.1 The definition

Section A2 indicates that, when sustainable heterogeneity is achieved, all heterogeneous households are connected (in the sense that all households behave by considering other households' optimality) and appear to be behaving collectively as a combined supra-household that unites all households, as Eqs. (A7) and (A8) indicate. The supra-household is unique and its behavior is time-consistent. Its actions always and consistently represent those of all households. Considering these natures of households under sustainable heterogeneity, I present the following alternative definition of the representative household: "the behavior of the representative household is defined as the collective behavior of all households under sustainable heterogeneity."

Even if households are heterogeneous, they can be represented by a representative household as defined above. Unlike the representative household defined as the average household, the collective representative household reaches a steady state where all households satisfy all of their optimality conditions in dynamic models. In addition, this representative household has a RTP that is equal to the average RTP as shown in Eqs. (A7) and (A8).[21] Hence, we can assume not only a representative household but also that its RTP is the average rate of all households.

A3.2 Universality of sustainable heterogeneity

An important point, however, is that this alternatively defined representative household can be used in dynamic models only if sustainable heterogeneity is achieved, but this condition is not necessarily always naturally satisfied. Sustainable heterogeneity is achieved only if households with lower RTPs behave multilaterally or the government appropriately intervenes. Therefore, the representative household assumption is not necessarily naturally acceptable in dynamic models unless it is confirmed that sustainable heterogeneity is usually achieved in an economy.

Notwithstanding this flaw, the representative household assumption has been widely used in many macroeconomic studies that use dynamic models. Furthermore, these studies have been little criticized for using the inappropriate representative household assumption. In addition, in most economies, the dire state that Becker (1980) predicts has not been observed even though RTPs of households are unquestionably heterogeneous. These facts conversely indicate that sustainable heterogeneity—probably with government interventions—has been usually and universally achieved across economies and time periods. In a sense, these facts are indirect evidence that sustainable heterogeneity usually prevails in economies.

Note that because the representative household's behavior in dynamic models is represented by the collective behavior of all households under sustainable heterogeneity, RH's RTP is not intrinsically known to households, but they do need to have an expected rate. Each household intrinsically knows its own preferences, but it does not intrinsically know the collective preference of all households. Therefore, in dynamic models, it must be assumed that all households do not *ex ante* know RH's RTP, but households estimate it from information on the behaviors of other households and the government.

A4 Need for an expected RTP RH

A4.1 The behavior of household

Achieving sustainable heterogeneity affects the behavior of the individual household because sustainable heterogeneity indicates that each household must consider the other households' optimality (as well as the behavior of the government, if necessary). This feature does not mean that households behave cooperatively with other households. Each household behaves non-cooperatively based on its own RTP, but at the same time, it behaves considering whether the other households' optimality conditions are achieved or not. This consideration affects the actions a household takes in that it affects the choice of a household's initial consumption.

Sustainable heterogeneity indicates that a household's future path of consumption has to be consistent with the future path of sustainable heterogeneity. Thereby, a household sets its initial consumption such that it will proceed on the path that is consistent with the path of sustainable heterogeneity and eventually reach a steady state.

[21] If sustainable heterogeneity is achieved with the help of the government's intervention, the time preference rate of the representative household will not be exactly equal to the average rate of time preference.

A4.2 Deviation from sustainable heterogeneity

A4.2.1 Political elements

What happens if a household deviates from sustainable heterogeneity? A deviation means that a household sets its initial consumption at a level that is not consistent with sustainable heterogeneity. For less advantaged households (i.e., households with higher RTPs), the only way to satisfy all of their optimality conditions is to set their initial consumption consistent with sustainable heterogeneity.

Therefore, they will not take the initiative to deviate. In contrast, the most advantaged households (i.e., those with the lowest RTP) can satisfy all of their optimality conditions even if they set initial consumption independent of sustainable heterogeneity. The incentive for the most advantaged household to select a multilateral path will be weak because the growth rate of the most advantaged household on the multilateral path is lower than that on the unilateral path.

When economy 1 selects the unilateral path, does economy 2 quietly accept the unfavorable consequences shown in Becker (1980)? From an economic perspective, the optimal response of economy 2 is the one shown in Harashima (2010): economy 2 should behave as a follower and accept the unfavorable consequences. However, if other factors—particularly political ones—are taken into account, the response of economy 2 will be different. Faced with a situation in which all the optimality conditions cannot be satisfied, it is highly likely that economy 2 would politically protest and resist economy 1. It should be emphasized economy 2 is not responsible for its own non-optimality, which is a result of economy 1's unilateral behavior in a heterogeneous population. Economy 2 may overlook the non-optimality if it is temporary, but it will not if it is permanent. As shown in Harashima (2010), the non-optimality is permanent, it is quite likely that economy 2 will seriously resist economy 1 politically.

If economy 1 could achieve its optimality only on the unilateral path, economy 1 would counter the resistance of economy 2, but this is not the case. Because of this, economy 2's demand does not necessarily appear to be unreasonable or selfish. Faced with the protest and resistance by economy 2, economy 1 may compromise or cooperate with economy 2 and select the multilateral path.

A4.2.2 Resistance

The main objective of economy 2 is to force economy 1 to select the multilateral path and to establish sustainable heterogeneity. This objective may be achieved through cooperative measures, non-violent civil disobedience (e.g., trade restrictions), or other more violent means.

Restricting or abolishing trade between the two economies will cost economy 1 because it necessitates a restructuring of the division of labor, and the restructuring will not be confined to a small scale. Large-scale adjustments will develop that involve all levels of divided labor, because they are all correlated with each other. For example, if an important industry had previously existed only in one economy, owing to a division of labor, and trade between the two economies was no longer permitted, the other economy would have to establish this industry while also maintaining other industries. As a result, economy 1 would incur non-negligible costs. More developed economies have more complicated and sophisticated divisions of labor, and restructuring costs from the disruption of trade will be much higher in developed economies. In addition, more resources will need to be allocated to the generation of technology because technology will also no longer be traded. Finally, all of the conventional benefits of trade will be lost. Trade is beneficial because of the heterogeneous endowment of resources, as the Heckscher-Ohlin theorem shows. Because goods and services are assumed to be uniform in the models presented in this paper, the benefits of trade are implicit in the models. However, in the real word, resources such as oil and other raw materials are unevenly distributed, so a disruption or restriction of trade will substantially damage economic activities on both national and international levels.

The damage done by trade restrictions has an upper limit, however, because the restructuring of the division of labor, additional resource allocation to innovation, and loss of trade benefits are all finite. Therefore, in some cases, particularly if economies are not sufficiently developed and division of labor is not complex, the damage caused will be relatively small. Hence, a disruption of trade (non-violent civil disobedience in the national models) may not be sufficiently effective as a means of resistance under some these conditions.

In some cases, harassment, sabotage, intimidation, and violence may be used, whether legal or illegal. In extreme cases, war or revolution could ensue. In such cases, economy 1 will be substantially damaged in many ways and be unable to achieve optimality. The resistance and resulting damages will continue until sustainability is established.

In any case, the objective of economy 2's resistance conversely implies that establishing sustainability eliminates the risk and cost of political and social instability. The resistance of economy 2 will lower the desire of economy 1 to select the unilateral path.

A4.2.3 United economies

An important countermeasure to the fragility of sustainable heterogeneity for less advantaged economies is the formation of a union of economies. If economies other than economy 1 are united by commonly selecting the multilateral path within them, their power to resist economy 1 will be substantially enhanced. Consider the multi-economy model shown in Harashima (2010). If the economies do not form a union, the power to resist the unilateral actions of economy 1 is divided and limited to the power of each individual economy. However, if the economies are united, the power to resist economy 1 increases. If a sufficient number of economies unite, the multilateral path will almost certainly be selected by economy 1.

To maintain the union, any economy in the union should have the explicit and resolved intention of selecting the multilateral path within the union, even if it is relatively more advantaged within the union. To demand that relatively more advantaged economies select the multilateral path, less advantaged economies themselves must also select the multilateral path in any case. Otherwise, less advantaged economies will be divided and ruled by more advantaged economies. For all heterogeneous people to happily coexist, all of them should behave multilaterally. At the same time, Harashima (2010) indicates that the more advantaged an economy is, the more modestly it should behave, i.e., the more it should restrain itself from accumulating extra capitals.

In general, therefore, the most advantaged (the lowest RTP) household will be forced to set its initial consumption consistent with sustainable heterogeneity.

A4.3 Need for an expected RTP RH

Because all households need to set their initial consumption consistent with sustainable heterogeneity to achieve it, households must calculate the path of sustainable heterogeneity before setting their initial consumption levels. To calculate this level, each household first must know the value of RTP RH. However, although a household naturally knows the value of its own RTP, it does not intrinsically know the value of RTP RH. To know this, a household would have to know the values of all of the other households' RTPs. Hence, the expected value of RTP RHmust somehow be generated utilizing all other relevant available information. The necessity of an expected RTP RHis critically important because RTP plays a crucial role as the discount factor in dynamic models.

Note that, if we assume that RTP is identical for all households, an expected RTP RHis no longer needed because any household's own RTP is equal to the RTP RH. This solution is still problematic, however, because the assumption is not merely expedient for the sake of simplicity; rather, it is a critical requirement to eliminate the need for an expected RTP RH. Therefore, any rationale for assuming identical RTPs should be validated; that is, it should be demonstrated that identical RTPs do exist and are universally observed. However, RTP is unquestionably not identical among households. Therefore, households must use expected values of RTP RH.

A5. The RTP model

A5.1 Need to know the structural model

If RTP RHis a constant parameter, as has been long and widely assumed, the need for an expected RTP RH would not be a serious problem. The historical mean of an unchanging RTP RH could be estimated relatively precisely based on long-term data of various economic indicators even if the structural model remained unknown. The RTP RH could be specified as the RTP that is most consistent with long-term trends of the indicators.

Although RTP has been treated as a constant parameter in many studies, this feature has not been demonstrated either empirically or theoretically. Rather, the assumption is merely expedient for the sake of simplicity. There is another practical reason for this treatment: models with a permanently constant RTP exhibit excellent tractability (see Samuelson, 1937). However, some have argued that it is natural to view RTP as temporally variable, and the concept of a temporally varying RTP has a long history (e.g., Böhm-Bawerk, 1889; Fisher, 1930). More recently, Lawrance (1991) and Becker and Mulligan (1997) showed that people do not inherit permanently constant RTPs by nature and that economic and social factors affect the formation of RTPs. Their arguments indicate that many incidents can affect and change RTP. Models of endogenous RTP have been presented, the most familiar of which is Uzawa's (1968) model.

If the RTP RH is temporally variable, its future stream must be expected by households, and a rational expectation is a model-consistent expectation. To generate rational expectations of RTP RH, therefore, the structural model of the RTP RH (i.e., equations that fundamentally describe how it is endogenously formed) needs to be known.

A5.2 Endogenous RTP models

A5.2.1 Uzawa's (1968) model

The most well-known endogenous RTP model is that of Uzawa (1968). It has been applied in many analyses (e.g., Epstein and Hynes, 1983; Lucas and Stokey, 1984; Epstein, 1987; Obstfeld, 1990). However, Uzawa's model has not necessarily been regarded as a realistic expression of the endogeneity of RTP because it has a serious drawback in that impatience increases as income, consumption, and utility increase.

The basic structure of Uzawa's model is $\theta_t = \theta^*[u(c_t)]$, $0 < \frac{d\theta_t}{du(c_t)}$,in which RTP in period $t(\theta_t)$ is temporally variable and an increasing function of present utility $u(c_t)$ where c_t is consumption in period t. The condition $0 < \frac{d\theta_t}{du(c_t)}$ is necessary for the model to be stable.

This property is quite controversial and difficult to accept *a priori* because many empirical studies have indicated that RTP is negatively correlated with permanent income (e.g., Lawrance, 1991); thus, many economists are critical of Uzawa's model. Epstein (1987), however, discussed the plausibility of increasing impatience and offered some counter-arguments. However, his view is in the minority, and most economists support arguments in favor of a decreasing RTP, such that $\frac{d\theta_t}{du(c_t)} < 0$.

Hence, although Uzawa's model attracted some attention, the analysis of the endogeneity of RTP has progressed very little. Although Uzawa's model may be flawed, it does not mean that the conjecture that RTP is influenced by future income, consumption, and utility is fallacious. Rather, it means that an appropriate model in which RTP is negatively correlated with income, consumption, and utility has not been presented.

A5.2.2 Size effect on impatience

The problem of $0 < \frac{d\theta_t}{du(c_t)}$ in Uzawa's model arises because distant future levels of consumption have little influence on factors that form RTP; that is, RTP is formed only with the information on present consumption, and it must be revised every period in accordance with consumption growth. However, there is no *a priori* reason why information on distant future activities should be far less important than the information on the present and near future activities. Fisher (1930) argued that our first step, then, is to show how a person's impatience depends on the *size* of his income, assuming the other three conditions to remain constant; for, evidently, it is possible that two incomes may have the same time shape, composition and risk, and yet differ in size, one being, say, twice the other in every period of time.

In general, it may be said that, other things being equal, the smaller the income, the higher the preference for the present over the future income. It is true of course that a permanently small income implies a keen appreciation of wants as well as of immediate wants. But it increases the want for immediate income *even more* than it increases the want for future income. (p. 72)

According to Fisher's (1930) view, a force that influences RTP is a psychological response derived from the perception of the "size of the entire income or utility stream." This view indicates that it is necessary to probe how people perceive the size of the entire income or utility stream.

Little effort has been directed toward probing the nature of the size of the utility or income stream on RTP, although numerous psychological experiments have been performed with regard to the anomalies of the expected utility model with a constant RTP (e.g., Frederick *et al.*, 2002). Analyses using endogenous RTP models so far have merely introduced the *a priori* assumption of endogeneity of RTP without explaining the reasoning for doing so in detail. Hence, even now, Fisher's (1930) insights are very useful for the examination of the size effect. An important point in Fisher's quote is that the size of the infinite utility stream is perceived as "permanently" high or low. The size difference among the utility streams may be perceived as a permanently continuing difference of utilities among different utility streams. Anticipation of a permanently higher utility may enhance an emotional sense of well-being because people feel they are in a long-lasting secure situation, which will generate a positive psychological response and make people more patient. If that is true, distant future utilities should be taken into account equally with present utility. Otherwise, it is impossible to distinguish whether the difference of utilities will continue permanently.

From this point of view, the specification that only the present utility influences the formation of RTP, as is the case of Uzawa's model, is inadequate. Instead, a simple measure of the size where present and future utilities are summed with equal weight will be a more appropriate measure of the size of a utility stream.[22]

A5.3 Model of RTP23

A5.3.1 The model

The representative household solves the maximization problem as shown in Section A1.3. Taking the arguments in Section A5.2 into account, the "size" of the infinite utility stream can be defined as follows.

Definition 1: The size of the utility stream W for a given technology A is:

$$W = \lim_{T \to \infty} E \int_0^T \rho(t) u(c_t) dt \ ,$$

[22] Das (2003) showed another stable endogenous time preference model with decreasing impatience. Her model is stable, although the rate of time preference is decreasing because endogenous impatience is almost constant. In this sense, the situation her model describes is very special.

[23] The idea of this type of endogenous time preference model was originally presented in Harashima (2004).

whereE is the expectation operator, and

$\rho(t) = \dfrac{1}{T}$ if $0 \le t \le T$

$\rho(t) = 0$ otherwise $\rho(t)$ indicates weights and has the same value in any period. Thus, the weights for the evaluation of future utilities are distributed evenly over time, as discussed in Section A5.2.

To this point, technology *A* has been assumed to be constant. If *A* is temporally variable (A_t) and grows at a constant rate and the economy is on a balanced growth path such that A_t, y_t, k_t, and c_t grow at the same rate, then the definition of *W* needs to be modified because any stream of c_t and $u(c_t)$ grows to infinity. It is then impossible to distinguish the sizes of the utility stream by simply summing up c_t as $T \to \infty$ as shown in Definition 1. Because balanced growth is possible only when technological progress is Harrod neutral, I assume a Harrod neutral production function such that:

$$y_t = \omega A_t^{\varpi} k_t^{1-\varpi} \ ,$$

where $\varpi\,(0 < \varpi < 1)$ and $\omega\,(0 < \omega)$ are constants. To distinguish the sizes of utility stream, the following value is set as the standard stream of utility,

$$u\left(\tilde{c}\, e^{\psi t}\right) ,$$

where $\tilde{c}\,(0 < \tilde{c})$ is a constant and $\psi\,(0 < \psi)$ is a constant rate of growth. Streams of utility can be compared with this standard stream. If a constant relative risk aversion utility function is assumed, a stream of utility can be compared with the standard stream of utility as follows:

$$\frac{u(c_t)}{u\left(\tilde{c} e^{\psi t}\right)} = \frac{c_t^{1-\gamma}}{\left(\tilde{c} e^{\psi t}\right)^{1-\gamma}} = \frac{1-\gamma}{\tilde{c}^{1-\gamma}} u\left(\frac{c_t}{e^{\psi t}}\right) .$$

By using this ratio, a given stream of utility can be distinguished from the standard stream of utility. That is, the size of a utility stream *W* for a given stream of technology A_t that grows at the same rate *ψ*asy_t, k_t, and c_t can be alternatively defined as:

$$W = \lim_{T \to \infty} E \int_0^T \rho(t) u\left(\frac{c_t}{e^{\psi t}}\right) dt \ .$$

Clearly, if *ψ* = 0, then the size (*W*) degenerates into the one shown in Definition 1.If there is a steady state such that:

$\lim_{t \to \infty} E[u(c_t)] = E[u(c^*)]$,or for the case of expected balanced growth $\lim_{t \to \infty} E\left[u\left(\frac{c_t}{e^{\psi t}}\right)\right] = E[u(c^*)]$,

where c^* is a constant and indicates steady-state consumption, then $W = E[u(c^*)]$ for the following reason.

Because $\lim_{t \to \infty} E[u(c_t)] = E[u(c^*)]$ or $\lim_{t \to \infty} E\left[u\left(\frac{c_t}{e^{\psi t}}\right)\right] = E[u(c^*)]$),

then

$$\lim_{T \to \infty} \int_0^T \rho(t) \{E[u(c^*)] - E[u(c_t)]\} dt = E[u(c^*)] - W \qquad \text{or}$$

$$\lim_{T \to \infty} \int_0^T \rho(t) \left\{E[u(c^*)] - E\left[u\left(\frac{c_t}{e^{\psi t}}\right)\right]\right\} dt = E[u(c^*)] - W\ ) .$$

In addition,

$$\lim_{T \to \infty} \int_0^T \rho(t) \{E[u(c^*)] - E[u(c_t)]\} dt = 0 \qquad \text{or}$$

$\lim_{T \to \infty} \int_0^T \rho(t) \left\{ E\left[u\left(c^*\right)\right] - E\left[u\left(\frac{c_t}{e^{\psi t}}\right)\right] \right\} dt = 0$).

Hence, $W = E\left[u\left(c^*\right)\right]$; that is, RTP is determined by steady-state consumption (c*).The RTP model presented in this paper is constructed on the basis of this measure of W. An essential property that must be incorporated into the model is that RTP is sensitive to, and a function of, W such that

$$\theta = \theta^{**}(W) ,$$

where $\theta^{**}(W)$ is monotonically continuous and continuously differentiable. Because W is a sum of utilities, this property simply reflects the core idea of an endogenous RTP. However, this property is new in the sense that RTP is sensitive not only to the present utility but also to the entire stream of utility, that is, the size of the utility stream represented by the utility of steady-state consumption. This property is intuitively acceptable because it is likely that people set their principles or parameters for their behaviors considering the final consequences of their behavior (i.e., the steady state; see, e.g., Barsky and Sims, 2012).

Another essential property that must be incorporated into the model is:

$$\frac{d\theta}{dW} < 0 .$$

Because $W = E\left[u\left(c^*\right)\right]$ and $0 < \frac{du(c_t)}{dc_t}$, RTP is inversely proportionate to c*. This property is consistent with the findings in many empirical studies, which have shown that RTP is negatively correlated with permanent income (e.g., Lawrance, 1991).

In summary, the basic structure of the model is:

$$\theta = \theta^{**}(W) = \theta^{**}\left\{E\left[u\left(c^*\right)\right]\right\} ,$$

$$\frac{d\theta}{dW} = \frac{d\theta}{dE\left[u\left(c^*\right)\right]} < 0 \qquad \text{(A9)}$$

This model is deceptively similar to Uzawa's endogenous RTP model and simply replaces c_t with c* and $0 < \frac{d\theta_t}{du(c_t)}$ with $\frac{d\theta}{dE\left[u\left(c^*\right)\right]} < 0$. However, the two models are completely different because of the opposite characteristics of:

$$0 < \frac{d\theta_t}{du(c_t)} \text{ and } \frac{d\theta}{dE\left[u\left(c^*\right)\right]} < 0 .$$

A5.3.2 Nature of the model

The model can be regarded as successful only if it exhibits stability. In Uzawa's model, the economy becomes unstable if:

$$0 < \frac{d\theta_t}{du(c_t)} \text{ is replaced with } \frac{d\theta_t}{du(c_t)} < 0 .$$

In this section, I examine the stability of the model.

A5.3.2.1 Equilibrium RTP

In Ramsey-type models, such as shown in Section A1.3, if a constant RTP is given, the value of the marginal product of capital (i.e., the value of the real interest rate) converges to that of the given RTP as the economy approaches the steady state. Hence, when a RTP is specified at a certain value, the corresponding expected steady-state consumption is uniquely determined. Given fixed values of other exogenous parameters, any predetermined RTP has unique values of expected consumption and utility at steady state. There is a one-to-one correspondence between the expected utilities at steady state and the RTPs; therefore, the expected utility at steady state can be expressed as a function of RTP. Let c_x^* be a set of steady-state consumption levels, given a set of RTPs (θ_X) and other fixed exogenous parameters. The concept of $\theta \rightarrow W$ discussed above can be described as

$$g(\theta) = E[u(c^*)](=W), \tag{A10}$$

where $c^* \in c_x^*$ and $\theta \in \theta_x$. On the other hand, RTP is a continuous function of steady-state consumption as shown in Eq. (A9) such that $\theta = \theta^{**}(W) = \theta^{**}\{E[u(c^*)]\}$. The reverse function is

$$h(\theta) = E[u(c^*)](=W) \tag{A11}$$

The equilibrium RTP is determined by the point of intersection of the two functions, $g(\theta)$ and $h(\theta)$, as shown in Figure A1. Figure A2 shows the special but conventionally assumed case for $h(\theta)$ in which θ is not sensitive to *W*, and RTP is constant. There exists a point of intersection because both $g(\theta)$ and $h(\theta)$ are monotonically continuous for $\theta > 0$. $h(\theta)$ is monotonically continuous because $\theta^{**}(W)$ is monotonically continuous. $g(\theta)$ is monotonically continuous because, as a result of utility maximization, $c^* = f(k^*)$ and $\theta = \frac{df(k^*)}{dk^*}$, where k^* is capital input per capita at steady state such that $k^* = \lim_{t\to\infty}(k_t)$. Because $f(k^*)$ and $\frac{df(k^*)}{dk^*}$ are monotonically continuous for $k^* > 0$, *c** is a monotonically continuous function of θ for $\theta > 0$. Here, because *u* is monotonically continuous, then $E[u(c^*)] = g(\theta)$ is also monotonically continuous for $\theta > 0$.

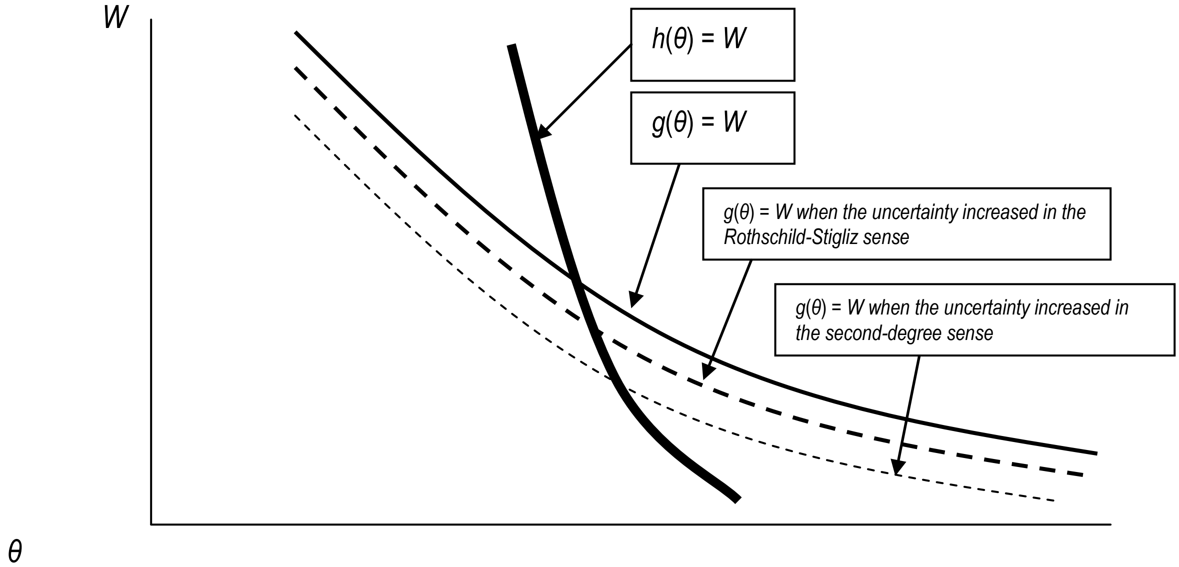

Figure A1. Endogenous time preference

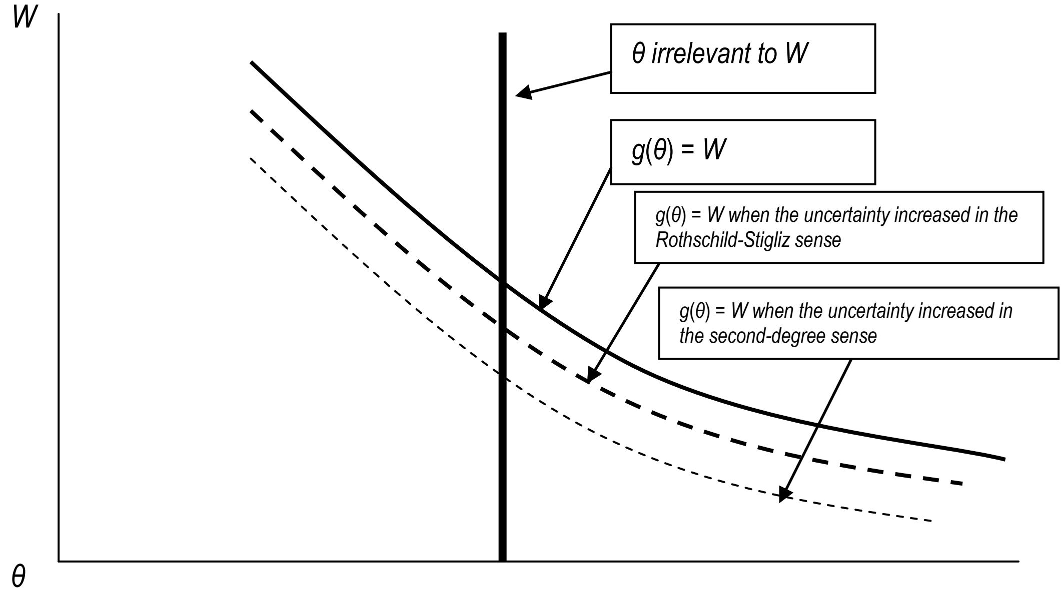

Figure A2. Permanently constant time preference

The function $g(\theta) = E[u(c^*)] = W$ is a decreasing function of *θ* because higher RTP results in lower steady state consumption. The function $h(\theta) = E[u(c^*)] = W$ is also a decreasing function of *θ* because $\frac{d\theta}{dW} < 0$. Thus, both $g(\theta)$ and $h(\theta)$ are decreasing, but the slope of $h(\theta)$ is steeper than that of $g(\theta)$ as shown in Figure A1. This is true because $g(\theta) = W$ is the consequence of a Ramsey-type model as shown in Section A1.3; thus, if $\theta \to \infty$, then $g(\theta) = W \to 0$ because $\theta = i_t \to \infty$ and $k_t \to 0$, and if $\theta \to 0$, then $g(\theta) = W \to \infty$ because $\theta = i_t \to 0$ and $k_t \to \infty$. The function $h(\theta) = W$ indicates the endogeneity of RTP, and because RTP is usually neither zero nor infinity, then even if $h(\theta) = W \to 0$, $\theta < \infty$, and $h(\theta) = W \to \infty$, $0 < \theta$. Hence, the locus $h(\theta) = W$ cuts the locus $g(\theta) = W$ downward from the top, as shown in Figure A1. Hence, the locus $h(\theta) = W$ is more vertical than $g(\theta) = W$, and thereby a permanently constant RTP, as shown in Figure 2, has probably been used as an approximation of the locus $h(\theta) = W$ for simplicity.

A5.3.2.2 Stability of the model

RTP is constant unless a shock that changes the expected *c** occurs because *W* does not depend on *t* but on the expected *c**. Thus, the same RTP and steady state continue until such a shock hits the economy. Therefore, the endogeneity of RTP only matters when a shock occurs. This constancy is the key for the stability of the model. Once the RTP corresponding to the intersection (Figure 1) is determined, it is constant and the economy converges at a unique steady state unless a shock that changes the expected *c** occurs. The shock is exogenous to the model, and the economy does not explode endogenously but stabilizes at the steady state. Hence, the property $\frac{d\theta}{dW} < 0$ in the model, which is consistent with empirical findings, does not causes instability.The model is therefore acceptable as a model of endogenous RTP. Furthermore, because RTP is endogenously determined, the assumption of irrationality is not necessary for the determination of RTP. Nevertheless, a shock on RTP can be initiated by a shock on the expected *c**; thus, even if the so-called animal spirits are directly irrelevant to determination of RTP, they may be relevant in the generation of shocks on the expected c^*.

A6 Frequent RTP shocks

A6.1 Difficulty in knowing RTP RH

To estimate the parameter values of Eq. (A11) in the structural model of RTP RH, it is necessary to obtain a sufficiently large amount of data on the value of RTP RH. To obtain these data, a household must know the RTPs of all the other households. Although a household knows its own RTP, it has almost no information about the RTPs of all the other households much less time-series data on each household's RTP. Because of the lack of available data, a household cannot estimate the parameter values in Eq. (A11) in the structural model of RTP RHeven if it knows the functional forms of equations in the structural model. We can easily generate data on aggregate consumption, investment, production, inflation, trade, and other factors at a relatively low cost, but we cannot directly observe the value of RTP RH. Nonetheless, many estimates of RTP have been reported, but they are not based on a structural model of RTP. Most are the results of experimental studies or indirect estimates based on other models (e.g., Ramsey growth models) on the assumption that RTP is constant. Experiments can give us some information on the RTPs of test subjects, but we should not naively use these estimates as the RTP RHin the calculation of the future path of economy because they vary widely according to the experimental environments. Furthermore, most of the indirect estimates were calculated on the assumption that RTP is constant, which as discussed previously, is most likely not the case. The basic problem is that no credible estimation method of RTP RHhas been established.

A6.2 Expectations based on beliefs

The lack of observable data on RTP RH will significantly hinder households from generating rational expectations of the future path of economy. How do households rationally expect their future streams of consumption and production and calculate their optimal paths without information on RTP RH, which is indispensable as the discount factor? The historical mean of RTP RHestimated by long-term data is not consistent with a rational expectation of the future stream because RTP is not constant. Without a reliable method for estimating the parameters of the structural model, it is impossible for households to generate rational expectations of the future path of the economy.

An alternative way of estimating expected values of RTP RH is needed, but even if an alternative method is utilized, households still have to behave as rationally as possible even in an environment of significantly incomplete information. In this situation, household may have to use the concept of bounded rationality to make decisions. It is possible that the only alternative for a household is to use its "belief" about the RTP RH. The use of a belief does not mean that households deviate from rationality; rather, it is the most rational behavior they can use in an environment where insufficient information is available.

Such a belief is defined in this paper as the range of values of RTP RH within which a household believes that the true RTP RH exists. Households utilize the belief in place of Eq. (A11). More specifically, suppose that household i ($i \in N$) believes that the RTP RH in the future is situated in the range λ_i, where the subjective probability density at any point on λ_i is identical (i.e., its distribution shape is uniform). Because households have no information about the shape of the distribution, they assume that it is uniform. This supposition means that household $i$believes that $\lambda_i$is stationary. Let $\overline{\lambda}_i$ be the mean of λ_i. Suppose that household i calculate its optimal future path on the belief that the mean of future values of RTP RH is $\overline{\lambda}_i$. By Eq. (A10), W can be calculated based on $\overline{\lambda}_i$, and the expected future path of economy can be calculated.

Households can equally access all relevant information. Therefore, if the belief of a household is very different from those of the majority, the household will soon perceive that its belief is different, through observing the behavior of majority. The household will change its belief to the almost same as those of the majority because otherwise it cannot achieve optimality as expected on the assumption that sustainable heterogeneity is achieved. Hence, it is likely that households' beliefs become similar, and thereby, it is assumed for simplicity that households' beliefs are identical.

Note that households do not cooperatively and collectively expect the future path of economy (i.e., the representative household's future path), but each household independently and individually generates its own expectations based on its belief in RTP RH. The household thereby creates its own expected future path considering the expected representative household's future path. The aggregates are the sum of all household's independent and individual activities, but if sustainable heterogeneity is achieved, the aggregates appear to be the same as the results of the representative household's activities.

A6.3 Refining beliefs

A household knows that its expectation is based on its beliefs and not the structural model. Therefore, it will always want to refine the belief, that is, raise the probability that the belief is the correct value, by exploiting all currently available relevant information. Let a set of currently available economic indicators be $\boldsymbol{I}_t$ (e.g., the observed data on consumption, production, inventory, etc.). These data may provide some useful information on the past RTP RH, and a household may refine its belief based on this information. These data and Eq. (A10) can be used to generate estimates of past values of RTP RH. However, $\boldsymbol{I}_t$ includes noise, and data in $\boldsymbol{I}_t$ will usually be somewhat inconsistent between the elements of $\boldsymbol{I}_t$. In addition, because Eq. (A10) indicates the steady state values that are achieved after a long-period transition, the short-term past data included in $\boldsymbol{I}_t$ are basically insufficient to obtain a credible estimate. Therefore, the estimate of the past values of RTP RH based on $\boldsymbol{I}_t$ and Eq. (A10) will usually have a large confidence interval. Let $\bar{\mu}_I$ be the estimated past RTP RH and μ_I be its confidence interval of, for example, 95%. Because households can equally access all relevant information, assume for simplicity that μ_I and $\bar{\mu}_I$ are identical for all households.

Although a household knows that $\bar{\mu}_I$ is not a credible estimate, has a large confidence interval, and is merely an estimate (usually a point estimate) of a past value, it will strive to utilize the information derived from $\bar{\mu}_I$ to refine its beliefs in the future value of RTP RH. Usually $\bar{\mu}_I$ will not be equal to $\bar{\lambda}_i$, but the ranges of λ_i and μ_I may partly overlap. Household $i$may utilize the information from this partial overlap to refine its belief (i.e., information of how λ_i is different from μ_I). $\bar{\mu}_I \neq \bar{\lambda}_i$ indicates that the belief $\bar{\lambda}_i$ is wrong, $\bar{\mu}_I$ is wrong, both are wrong, or both are right if the true past RTP RH is $\bar{\mu}_I$ but the true future RTP RH is $\bar{\lambda}_i$. The belief $\bar{\lambda}_i$ may be wrong because the RTP RH will change in the near future, and $\bar{\mu}_I$ may be wrong because the RTP RH changed during the period in which the data were obtained. In addition, a household knows that μ_I is the result of all households' activities based on their beliefs, not on the true value of RTP RH. These uncertainties arise because households cannot know the parameters of the structural model. Without using the structural model, household $i$cannot judge whether $\bar{\lambda}_i$ is wrong, $\bar{\mu}_I$ is wrong, both are wrong, or both are right. As a result, household i will not easily adjust its belief from $\bar{\lambda}_i$ to $\bar{\mu}_I$.

However, it is still likely that information about the difference between λ_i and μ_I can be used to refine the belief. To extract the useful information, the following rules may be used:

Rule 1: if $\bar{\mu}_I$ is included in λ_i, the belief is not adjusted; otherwise, the belief is adjusted from $\bar{\lambda}_i$ to $\bar{\mu}_I$.

Rule 2: if $\bar{\lambda}_i$ is included in μ_I, the belief is not adjusted; otherwise, the belief is adjusted from $\bar{\lambda}_i$ to $\bar{\mu}_I$.

Rule 3: if λ_i and μ_I overlap at or above a specified ratio, the belief is not adjusted; otherwise, the belief is adjusted from $\overline{\lambda}_i$ to $\overline{\mu}_I$.

The above rules may be seen as a type of adaptive expectation because μ_I indicates the past RTP RH. However, in the situation where the parameters of the structural model of the RTP RH are unknown, it may be seen as rational to utilize the information contained in μ_I by adopting one of these rules.

A6.4 Changing beliefs

However, it does not seem likely that a household will refine its belief following one of the rules shown above because the rules are basically backward looking and will not be adopted as a tool for refining the belief if a household is convinced that the RTP RH is temporally variable. The belief will only be changed if forward-looking information is available, that is, when a household becomes aware of information about the future RTP RH in μ_I. For example, the difference between λ_i and μ_I may reflect an unexpected and large positive technology shock that occurred after the formation of belief λ_i. Because the effects of the technology shock will persist for long periods in the future, household *i* will most likely change its belief. In this case, a household will not simply refine its belief from $\overline{\lambda}_i$ to $\overline{\mu}_I$; it will change to another value that is formed as an entirely new belief.Whether a household changes its belief or not, therefore, will depend not simply on μ_I but on the information the household can extract from μ_I about the future path of the economy. Hence, in some cases, a household will change its belief when new values of μ_I are obtained, but in other cases, it will not, depending on how the household interprets the information contained in μ_I.

A6.5 Heuristics

When a household interprets μ_I, it may also use heuristic methods, for example, a simplified linear reduced form model of RTP RH. Studies of the use of heuristics and bounded rationality in this context would be useful for better understanding the interpretation mechanism of μ_I. There are many possible simplified linear reduced form models of RH's RTP that could be used as heuristic methods although most of them may be ad hoc. Even though such reduced form models are far less credible than a structural model, they may be utilized as a heuristic method of interpreting μ_I by households. Although these types of models may often result in misleading conclusions, they may sometimes provide useful information. For example, if a linear correlation between RTP RH and a financial indicator exists, even if it is weak or temporary, changes in the financial indicator may contain useful information about changes in the RTP RH. Therefore, if a household believes that this correlation exists, it will use this information to interpret μ_I.

A6.6 Frequent RTP shocks

Households must have expected values of RTP RH for sustainable heterogeneity, but as previously discussed, the expectations are not based on the structural model but rather on a belief that is not guaranteed to generate the correct value. In addition, the belief can be influenced by heuristic considerations. These features indicate that the expected values of RTP RH will fluctuate more frequently than the intrinsic RTP RH.

Households' expectations of RTP RH will change when the intrinsic RTP RH shifts, for example, when new information about shocks on the factors that determine Eq. (A10) becomes available. For a given θ, $E\left[u\left(c^*\right)\right]$ changes if the expectation of future productivity changes. Productivity at the macro level will be influenced by scientific technology, financial technology, social infrastructure, and other factors. If expectations about these factors in the future changes, the expected future productivity and $E\left[u\left(c^*\right)\right]$ will also change. In addition, even if intrinsic RTP RH does not change, the expected RTP RH will change if a household's belief is altered because of new information contained in μ_I. Hence, the expected RTP RH can change independently of intrinsic changes in RTP RH. Therefore, even if intrinsic changes in RTP RH occur infrequently, changes in the expected RTP RH may occur more frequently.

A household's expected RTP RH can potentially changeevery time new information on μ_I becomes available if it contains the information that makes beliefs change. Information concerning factors that affect the expected RTP RH will become available frequently, and at least some of the information may be both very important and unexpected. In addition, there will be many disturbances in the fundamental factors that affect Eq. (A10), and many of these disturbances will also cause $\mu_I$to change. As discussed previously, a household may interpret these changes in μ_I as a change in the true RTP RH. Therefore, it is likely that households' expected RTP RH change more frequently than the intrinsic RTP RH, and thereby, that time preference shocks also occur more frequently than previously thought.

Even a small piece of additional information about the belief can significantly change the path of the economy. For example, if many households believe a rumor (whether it is true or not) related to information about the interpretation of μ_I and respond similarly to it, their expectations will be changed in the same direction by the rumor. If all households respond similarly to an untrue rumor and change their expectations equally to an untrue value, the economy will proceed based on the incorrect expectation of RTP RH. The $\overline{\mu}_I$ that is observed a few periods later will follow these wrongly expected values of RTP RH. Upon obtaining new data of $\overline{\mu}_I$ that are consistent with these wrongly expected values, households will judge that their (incorrect) changes were in fact correct. As a result, the incorrect expectations become self-fulfilling. This spurious situation may reach an impasse at some point in the future because the expectations are based not on a structural model but on the (incorrect) beliefs. Households will not anticipate the impasse until the economy reaches it because they believe that the wrongly expected RTP RH (i.e., the currently held belief) is true.

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The Whole Economy Approach of the Input-Output Model

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Abstract:

In macroeconomy research that uses technological table, most studies have only considered a special aspect. This paper develops an input-output model that extends to the whole economy by adding finance into transaction table. This forms an integrated capital flow cycling system for whole economy. Economic growth is used to reflect economic dynamic characteristics. Whole economy is divided into five subsystems. On the basis of subsystem's balance sheet, we set up the simultaneous equation of whole economy. As part of the disposal income, the new loan of the subsystems is affected by money supply badly and the income ratio is not stable. In this paper, expenditure ratio of subsystems is used to solve the simultaneous equation. The subsystem's balance sheets and the simultaneous equation can be applied to study fundamental economic issues effectively.

Keywords: macroeconomy, input-output model, balance sheet, economic mechanism, fundamental economic issues, economic simulation experiment.

JEL Classification: C00,C30.

1. Introduction

In mathematical logic, Leontief built up the legitimate relationship among macroeconomic variables. It is a system of simultaneous equation of economic variables expressed with technological matrix (Leontief 1970) Input-output model (I-O in short) is very well known among economists and policy analysts, and it is widely used to study economic impacts of one sector on an economy in the national and the regional level.

Leontief set up the relationship of environment pollution with consumption and production (Leontief 1986). M. Peneder illustrated the effect of industrial structure on aggregate income and growth (Peneder 2002). Swenson and Moore presented a method to determine full economic impacts of tax law (Swenson, Moore, 1987). Santos identified regional perturbations pursuant to disaster scenarios (Fisher 1916)

The application of technological table is too long to list. They have a common feature that every application is specialized in a particular aspect due to short of finance system. With finance in transaction table, it forms an integrated capital flow cycling system for the whole economy. Together with production, consumption and investment, taking finance into consideration is essential to build technological matrix, with which we can depict macroeconomy phenomena and explain its mechanism reasonably as a whole.

This paper attempts to fill the gap. On the closed economy, we divided whole economy into five subsystems: household, government, enterprise, investment and finance. As a result, the technological matrix is simplified to each subsystem's receipts and expenditure table. For every sector on the technological table, input equals output and for every subsystem's on transaction table, disposal income equals payment. Both of them are in accordance with Walras general equilibrium theory (Walras 1957)

To illustrate economic dynamic characteristic, economic growth is introduced into transaction table. Then we get simultaneous equation of whole economy on the basis of transaction table and balance sheets. To solve the equation, we use output (expenditure) ratio instead of input (income) ratio. As part of disposal income, new loan amount is affected by money supply very badly, and as part of expenditure, the amount of loan to be repaid is decided by total loan of previous period. This suggests that expenditure ratio is more stable than income ratio. With the help of expenditure ratio, independent variables replace the dependent ones. After plugging replaced variables into these equations, they become solvable. They can be used to illustrate economic mechanism, to perform economic simulating experiments, and to explain economic phenomena and fundamental issues such as money supply, calculation of inflation rate and economy growth, reasonable interest rate and exchange rate, and the cause of stagnation.

2. Transaction table

To analyse macroeconomic situation as a whole, we divide closed economy system into 5 subsystems: household, government, enterprise, investment and finance. By tracing capital flows among subsystems, we get closed macroeconomy's technological table similar to Leontief's I-O table. Because subsystem's receipt is its input and payment is the output, the macroeconomy's technological table is also transaction table. We use $x_{ij}$to represent the capital flows among subsystems. x_{ij} indicates subsystem i paid $x$amount of money to subsystem j. The row sum $\sum_{j=1}^{n} x_{ij}$represents subsystem's total payments and column sum $\sum_{i=1}^{n} x_{ij}$total receipts.

Table 1. Transaction table

	H	G	E	I	F
H	\	x_{12}	x_{13}	x_{14}	x_{15}
G	x_{21}	\	x_{23}	x_{24}	x_{25}
E	x_{31}	x_{32}	\	x_{34}	x_{35}
I	x_{41}	x_{42}	x_{43}	\	x_{45}
F	x_{51}	x_{52}	x_{53}	x_{54}	\

Note: *H: Household; G: Government; E: Enterprise; I: Investment; F: Finance.

For Leontief's I-O table, it is evident that every sector's total input equals total output and for the transaction table above, receipts equal payments. Both of them are in accordance with the general equilibrium presented by Walras. The equilibrium of subsystems capital flows are exactly the balance sheets used in accounting. For the purpose of easy to understand and convenient to discuss in depth, the components of income and payment of every subsystem will be listed and their relationship will be studied.

3. Balance sheets

The balance sheet discussed here is in a broad sense. The income is all the money a subsystem can get (including new loan), and payment consists of all the money a subsystem can use. To complete balance sheets, the variables and their meanings are given in Table2.

Table 2. List of variables and their meanings.

VARIABLE	MEANING
A_i	*Asset* bought from government for investment (mainly land).
AR	Available money to be loaned and deposit reserve.
B	*Bond* - B_e, B_{en}, B_g and B_{gn} are the bonds becoming due and newly issued by enterprise and government respectively.
C	*Consumption*: C_g– Government consumption; C_h – Household consumption; C_i– Investment consumption; C_{ig} – Capital Construction consumption; C_{ih} – Housed investing consumption
C_r	Unit material cost rate:
D	*Deposit*: D_e, D_g, D_h and D_i – Enterprise, government, household and investment deposits respectively
D_i	*Depositinterest*: D_{ie}, D_{ig}, D_{ih} and D_{ii} – Interest income from enterprise, government household and investment deposits respectively
I	*Investment*: $I_{gi}$is government investment to state owned companies.
L	*Loan*: L_e, L_g, L_h, L_i - Enterprise, government, household and investment loans respectively
L_a	The amount of the *loan to be repaid:* L_{ae}, L_{ag}, L_{ah} andL_{ai} – the loan amount needed to be paid to finance by enterprise, government, household and investment respectively
L_c	*Laborcost*: L_{ce}, L_{cg}, L_{ci} – Enterprise, government capital construction, and investment labor costs
L_i	*Loaninterest*: L_{ie}, L_{ig}, $L_{ih}$and L_{ii} - the loan interest paid to finance by enterprise, government, household and investment respectively
M	*Money*. Newly issued money.
P	*Price*
P_r	*Profit:* *P_{rg}, P_{rh} – profits paid to government and household by enterprise.* *P_{ri} – profit used for new investment by enterprise.*
Q	Quantity. The amount of goods and service.
S	*Stock*.
SL	*Salary*. Government employee salary.
T	*Tax*.

Take householding as an example to demonstrate the establishment of subsystem's balance sheets. Household incomes and payments are listed in Table 3.

Table 3. Household incomes and payments.

INCOME	COMES FROM	PAYMENT	GOES TO
Labour cost L_{ce}	E	Consumption C_h	E
Matured Bond B_e	E	Investment consumption C_{ih}	E
Profit P_{rh}	E		
Salary SL	G	New bond B_{gn}	G
Matured bond B_g	G		
Labour cost L_{cg}	G		
Labour cost L_{ci}	I	New bond B_{en}, new stock S	I
New loan L_h	F	Due loan L_{ah}	F
Deposit interest D_i	F	Loan interest L_{ih}	F
		Deposit D_h	F

Note: *Pensions are included in salary.

Writing in symbols, household balance sheet becomes:

$$L_{ce} + B_e + P_{rh} + S_L + B_g + L_{cg} + L_{ci} + L_h + D_{ih} = C_h + C_ih + S + B_{en} + B_{gn} + L_{ah} + D_h + L_{ih}$$

Inspecting the balance sheet, we find that the loan is still part of disposal income. Actually in the whole inspecting period, the loan was gradually used and used up at the end of period. The new loan added to entire economy caused the price goes up and quantity rises. In turn, comparing with last period, it enhanced every sub-system's actual income. In short, every sub-system's loan melts down in the entire economy by the work of economical mechanism and increased sub-systems' actual incomes by feedback. The problem appeared above is caused by analyzing dynamic economic issues with static analysis method. Therefore the balance sheet has to be reformatted to approach actual economic condition.

For simplicity, we assume constant increment to scale. That is if nominal growth increase by 5 percent, all the transaction variables in inspecting period will also increase by 5 percent, except for the variables related to finance $x_{5j}$and $x_{i5}(i,j = 1, \dots ,5)$. The reason that finance related variables do not move together with growth is that new loan is decided by new issued money and repaid loan is affected by total loan.

Take actual income from last period plus new loan and interest of deposit from this period as this period's disposal income, and take the sum of actual payment of last period and its nominal increment from this period, plus payback to finance from this period as this period's payments, the reformatted household balance sheet is shown below:

$$L_{ce}^o + B_e^o + P_{rh}^o + S_L^o + B_g^o + L_{cg}^o + L_{ci}^o + L'_h + D'_{ih} = (1 + Q')\left(C_h^o + C_{ih}^o + S^o + B_{en}^o + B_{gn}^o\right) + L'_{ah} + D'_h + L'_{ih}$$

where superscripts $.^o$ indicates Last period (year), and $.'$ indicates the inspecting period (this year).

Likewise Government balance sheet:

$$T^o + P_{rg}^o + B_{gn}^o + A_i^o + L'_g + D'_{ig} = (1 + Q')\left(C_g^o + C_{ig}^o + I_{gi}^o + SL^o + B_g^o + L_{cg}^o\right) + L'_{ag} + D'_g + L'_{ig}$$

andEnterprise balance sheet:

$$P^oQ^o + L'_e + D'_{ie} = (1+Q)\left(C_r^oQ^o + L_{ce}^o + B_e^o + P_{rh}^o + P_{ri}^o + P_{rg}^o + T^o\right) + L'_{ae} + D'_e + L'_{ie}$$

Note that total sales PQ, intermediate goods C_rQ and final goods satisfy:

$$PQ - C_rQ = C_h + C_{ih} + C_g + C_{ig} + C_i$$

If the ratio of intermediate goods to total sales λ is a constant. The intermediate goods could be replaced by $\lambda$and the final goods:

$$PQ = \frac{1}{1-\lambda}\left(C_h + C_{ih} + C_g + C_{ig} + C_i\right),\ \ PQ = \frac{C_rQ}{\lambda}$$

This gives:

$$C_rQ = \frac{\lambda}{1-\lambda}\left(C_h + C_{ih} + C_g + C_{ig} + C_i\right),\ \ Q'C_rQ = \frac{\lambda Q'}{1-\lambda}\left(C_h + C_{ih} + C_{ig} + C_i\right)$$

Hence the transformed enterprise balance sheet will be:

$$\left(1-\frac{\lambda Q'}{1-\lambda}\right)\left(C_h^o + C_{ih}^o + C_g^o + C_{ig}^o + C_i^o\right) + L'_e + D'_{ie} = (1+Q')\left(L_{ce}^o + B_e^o + P_{rh}^o + P_{ri}^o + \right.$$
$Prgo+To+Lae'+De'+Lie'.$

Investment balance sheet and the Finance balance sheet will respectively be:

$$P_{ri}^o + S^o + B_{en}^o + I_{gi}^o + L'_i + D'_{ii} = (1+Q')(C_i^o + A_i^o + L_{ci}^o) + L'_{ai} + D'_i + L'_{ii};$$

$$M' + L'_{ah} + D'_h + L'_{ih} + L'_{ag} + D'_g + L'_{ig} + L'_{ae} + D'_e + L'_{ie} + L'_{ai} + D'_i + L'_{ii}$$
$$= \Delta AR' + L'_h + D'_{ih} + L'_g + D'_{ig} + L'_e + D'_{ie} + L'_i + D'_{ii}.$$

4. Macro economy mechanism

Summing up all the money one subsystem can get from others forms capital flow variables x_{ij} used in transaction table. See Table 4.

Table 4. Components of x_{ij}.

x_{21}	x_{12}	x_{31}	x_{13}	x_{41}
$S_L + B_g + L_{cg}$	B_{gn}	$L_{ce} + P_{rh} + B_e$	$C_h + C_{ih}$	L_{ci}
x_{14}	x_{24}	x_{42}	x_{23}	x_{32}
$B_{en} + S$	I_{gi}	A_i	$C_g + C_{ig}$	$P_{rg} + T$
x_{34}	x_{43}	x_{51}	x_{15}	x_{52}
P_{ri}	C_i	$L_h + D_{ih}$	$L_{ah} + L_{ih} + D_h$	$L_g + D_{ig}$
x_{25}	x_{54}	x_{45}	x_{53}	x_{35}
$L_{ag} + L_{ig} + D_g$	$L_i + D_{ii}$	$L_{ai} + L_{ii} + D_i$	$L_e + D_{ie}$	$L_{ae} + L_{ie} + D_e$
$M_1 = M - \Delta AR$				

On the basis of sub-system's balance sheets and summed up capital flow variables, the working mechanism chart of entire-dynamic macro economy can be drawn as Figure 1.

Figure 1 depicts the working mechanism of entire dynamic macro economy and how it is running orderly and effectively. On the market, profits drive economic units, resource provides basic needs and monetary policy ensures the market moving smoothly. The capital flows formed in market transaction makes all the economic activities a whole macro economy. The changes of amount and direction of capital flows determine the state of macro economy.

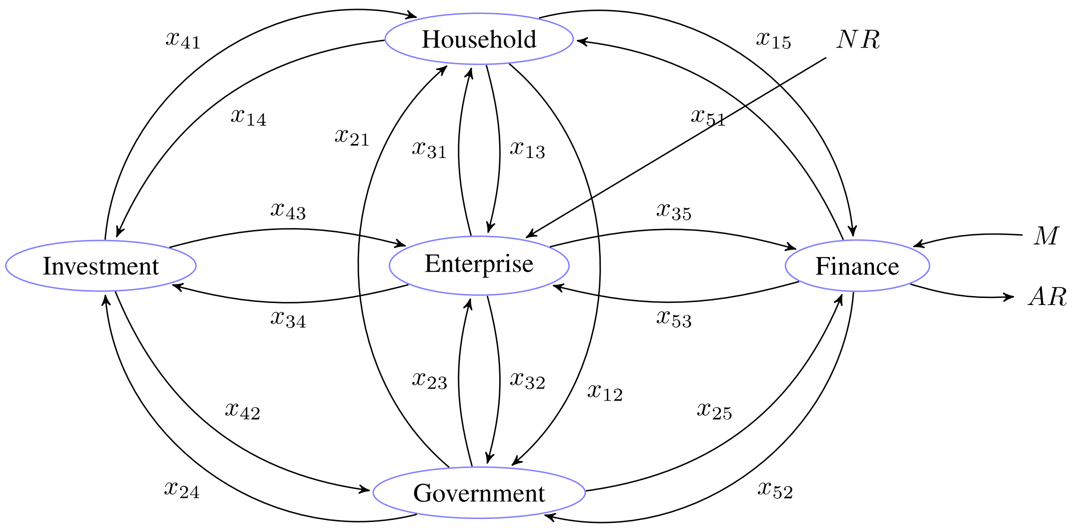

Figure 1.Illustration of the entire dynamic macro economy. NR: Natural Resource; M: Money Supply; AR:Available money to be loaned and deposit reserve.

5. Dynamic transaction table

Among sub-systems of macro economy, there are capital inter-flows. It is the capital inter-flows of sub-systems, which connect one sub-system to another inseparably, forming a whole organic macro economy. In the following discussion, the simultaneous equations will be set-up according to the quantities of capital flow among sub-systems, which contains the logical relationship of all the macro-economic variables.

Putting summed up variable x_{ij} into balance sheets; we get simultaneous equations composed of 5 subsystem balance sheets:

$$x_{21}^o + x_{31}^o + x_{41}^o + x_{51}^{'} = \left(1 + Q^{'}\right)(x_{12}^o + x_{13}^o + x_{14}^o) + x_{15}^{'};$$

$$x_{12}^o + x_{42}^o + x_{32}^o + x_{52}^{'} = \left(1 + Q^{'}\right)(x_{21}^o + x_{24}^o + x_{23}^o) + x_{25}^{'};$$

$$\left(1 - \frac{\lambda Q^{'}}{1-\lambda}\right)(x_{13}^o + x_{23}^o + x_{43}^o) + x_{53}^{'} = \left(1 + Q^{'}\right)(x_{31}^o + x_{32}^o + x_{34}^o) + x_{35}^{'};$$

$$x_{14}^o + x_{24}^o + x_{34}^o + x_{54}^{'} = \left(1 + Q^{'}\right)(x_{41}^o + x_{42}^o + x_{43}^o) + x_{45}^{'};$$

$$x_{15}^{'} + x_{25}^{'} + x_{45}^{'} + x_{35}^{'} + M_1^{'} = x_{51}^{'} + x_{52}^{'} + x_{54}^{'} + x_{53}^{'}.$$

Table 1 is a static and settled accounts transaction matrix. We can establish a dynamic one according to the equations above. See Table 5.

Table 5. Dynamic transaction table.

<table>
<tr><th></th><th>H</th><th>G</th><th>E</th><th>I</th><th>F</th></tr>
<tr><td rowspan="2">H</td><td rowspan="2"></td><td>$(1+\theta')x_{12}^o$</td><td>$(1+\theta')x_{13}^o$</td><td>$(1+\theta')x_{14}^o$</td><td rowspan="2">x_{15}'</td></tr>
<tr><td>x_{12}^o</td><td>$\left(1-\frac{\lambda\theta'}{1-\lambda}\right)x_{13}^o$</td><td>$x_{14}^o$</td></tr>
<tr><td rowspan="2">G</td><td>$(1+\theta')x_{21}^o$</td><td rowspan="2"></td><td>$(1+\theta')x_{23}^o$</td><td>$(1+\theta')x_{24}^o$</td><td rowspan="2">x_{25}'</td></tr>
<tr><td>x_{21}^o</td><td>$\left(1-\frac{\lambda\theta'}{1-\lambda}\right)x_{23}^o$</td><td>$x_{24}^o$</td></tr>
<tr><td>E</td><td>$(1+\theta')x_{31}^o$</td><td>$(1+\theta')x_{32}^o$</td><td></td><td>$(1+\theta')x_{34}^o$</td><td>x_{35}'</td></tr>
</table>

	x_{31}^{o}	x_{32}^{o}		x_{34}^{o}	
I	$(1+\theta')x_{41}^{o}$	$(1+\theta')x_{42}^{o}$	$(1+\theta')x_{43}^{o}$		x'_{45}
	x_{41}^{o}	x_{42}^{o}	$\left(1-\frac{\lambda\theta'}{1-\lambda}\right)x_{43}^{o}$		
F	x'_{51}	x'_{52}	x'_{53}	x'_{54}	M'_{1}

The variables on the top of each cell are used to calculate payments and those on the bottom are used to calculate receipts.

6. Simultaneous equation

Even taking M'_1 as known, the simultaneous equation has 20 unknowns and only 5 linear equations. To solve it, we need the second assumption. Similar to single process production function assumption used in I-O model (Mouhammed 2000), we assume that there is a fixed expenditure pattern for every subsystem. The constant payment to scale is that subsystems single payment will increase with its total income by the same percent. The payment proportion to total income of subsystems is subject to economic structure. They are relatively stable, so we take it as constant. For example, during the 11 years from 2001 to 2012 in United Kingdom, the living cost and food expenditure remains steady, 489 pound per week (inflation adjusted). It is almost a level line (Office for National Statistics, 2013). The statistical analysis of Americans household expenditure proportion got similar conclusion (The Wall Street Journal, 2012).

Emphasizing the stability of expenditure ratio does not deny its little change. The payment ratio is only an instrument used to solve the equation here. In the process of applying them, we need to adjust them according to actual statistic results. The payment ratio can be used to reform the simultaneous equations. Payment ratio of sub-systems is in Table 6.

Table 6 . Payment ratio of subsystems.

Household	Ratio	x_{12}	x_{13}	x_{14}	x_{15}	
		α_1	α_2	α_3	α_4	$\sum\alpha_i=1$
Government	Variable	x_{21}	x_{24}	x_{23}	x_{25}	
	Ratio	β_1	β_2	β_3	β_4	$\sum\beta_i=1$
Enterprise	Variable	x_{31}	x_{32}	x_{34}	x_{35}	
	Variable	γ_1	γ_2	γ_3	γ_4	$\sum\gamma_i=1$
Investment	Variable	x_{41}	x_{42}	x_{43}	x_{45}	
	Ratio	ζ_1	ζ_2	ζ_3	ζ_4	$\sum\zeta_i=1$
Finance	Variable	x_{51}	x_{52}	x_{54}	x_{53}	
	Ratio	ϵ_1	ϵ_2	ϵ_3	ϵ_4	$\sum\epsilon_i=1$

Note: The calculation of payment ratio is shown in Table 7.

Table 7. Payment ratio calculation.

$\boldsymbol{\alpha_1}$	$\boldsymbol{\frac{(1+Q')x_{12}^{o}}{x_{21}^{o}+x_{31}^{o}+x_{41}^{o}+x'_{51}}}$	$\boldsymbol{\beta_1}$	$\boldsymbol{\frac{(1+Q')x_{21}^{o}}{x_{12}^{o}+x_{42}^{o}+x_{32}^{o}+x'_{52}}}$
$\boldsymbol{\alpha_2}$	$\frac{(1+Q')x_{13}^{o}}{x_{21}^{o}+x_{31}^{o}+x_{41}^{o}+x'_{51}}$	β_2	$\frac{(1+Q')x_{24}^{o}}{x_{12}^{o}+x_{42}^{o}+x_{32}^{o}+x'_{52}}$
$\boldsymbol{\alpha_3}$	$\frac{(1+Q')x_{14}^{o}}{x_{21}^{o}+x_{31}^{o}+x_{41}^{o}+x'_{51}}$	β_3	$\frac{(1+Q')x_{23}^{o}}{x_{12}^{o}+x_{42}^{o}+x_{32}^{o}+x'_{52}}$
$\boldsymbol{\alpha_4}$	$\frac{x'_{15}}{x_{21}^{o}+x_{31}^{o}+x_{41}^{o}+x'_{51}}$	β_4	$\frac{x'_{25}}{x_{12}^{o}+x_{42}^{o}+x_{32}^{o}+x_{52}{}'}$

ζ_1	$\frac{(1+Q')x_{41}^o}{x_{14}^o+x_{24}^o+x_{34}^o+x_{54}'}$	γ_1	$\frac{(1+Q')x_{31}^o}{\left(1-\frac{\lambda Q'}{1-\lambda}\right)(x_{13}^o+x_{23}^o+x_{43}^o)+x_{53}'}$
ζ_2	$\frac{(1+Q')x_{42}^o}{x_{14}^o+x_{24}^o+x_{34}^o+x_{54}'}$	γ_2	$\frac{(1+Q')x_{32}^o}{\left(1-\frac{\lambda Q'}{1-\lambda}\right)(x_{13}^o+x_{23}^o+x_{43}^o)+x_{53}'}$
ζ_3	$\frac{(1+Q')x_{43}^o}{x_{14}^o+x_{24}^o+x_{34}^o+x_{54}'}$	γ_3	$\frac{(1+Q')x_{34}^o}{\left(1-\frac{\lambda Q'}{1-\lambda}\right)(x_{13}^o+x_{23}^o+x_{43}^o)+x_{53}'}$
ζ_4	$\frac{x_{45}'}{x_{14}^o+x_{24}^o+x_{34}^o+x_{54}'}$	γ_3	$\frac{(1+Q')x_{35}^o}{\left(1-\frac{\lambda Q'}{1-\lambda}\right)(x_{13}^o+x_{23}^o+x_{43}^o)+x_{53}'}$

ϵ_1	$\frac{x_{51}{}'}{x_{15}'+x_{25}'+x_{45}'+x_{35}'+M_1'}$
ϵ_2	$\frac{x_{52}{}'}{x_{15}'+x_{25}'+x_{45}'+x_{35}'+M_1'}$
ϵ_3	$\frac{x_{54}{}'}{x_{15}'+x_{25}'+x_{45}'+x_{35}'+M_1'}$
ϵ_4	$\frac{x_{53}'}{x_{15}'+x_{25}'+x_{45}'+x_{35}'+M_1'}$

On the basis of the second assumption, every subsystem's expenditure variables are all interrelated and dependent variables. There is only one independent expenditure variable in each subsystem. They can be replaced one by the other. Therefore, the simultaneous equation has 5 independent variables with 5 linear equations. It can be solved uniquely. Choosing one payment variable such as $x_{21}^o$and 4 income variables $x_{12}^o, x_{42}^o, x_{32}^o, x_{52}'$ in one subsystem's balance sheet as basic variables, we build new simultaneous equations, shown below.

$$x_{21}^o = \frac{\beta_1}{1+Q'}(x_{12}^o + x_{42}^o + x_{32}^o + x_{52}');$$

$$x_{12}^o = \frac{\alpha_1}{1+Q'}(x_{21}^o + x_{31}^o + x_{41}^o + x_{51}');$$

$$x_{42}^o = \frac{\zeta_2}{1+Q'}(x_{14}^o + x_{24}^o + x_{34}^o + x_{54}');$$

$$x_{32}^o = \frac{\gamma_2}{1+Q'}\left[\left(1-\frac{\lambda Q'}{1-\lambda}\right)(x_{13}^o + x_{23}^o + x_{43}^o) + x_{53}'\right];$$

$$x_{52}' = \epsilon_2(x_{15}' + x_{25}' + x_{45}' + x_{35}' + M_1').$$

To get solvable equations, we need to replace all other variables by basic ones with the aid of variable replacement table. See Table 8.

Table 8. Variable replacement table.

Government	**Variable**	x_{21}^o	x_{24}^o	x_{23}^o	x_{25}'
	Replacement	$\frac{\beta_1}{\beta_1}x_{21}^o$	$\frac{\beta_2}{\beta_1}x_{21}^o$	$\frac{\beta_3}{\beta_1}x_{21}^o$	$\frac{\beta_4(1+Q')}{\beta_1}x_{21}^o$
Household	Variable	x_{12}^o	x_{13}^o	x_{14}^o	x_{15}'
	Replacement	$\frac{\alpha_1}{\alpha_1}x_{12}^o$	$\frac{\alpha_2}{\alpha_1}x_{12}^o$	$\frac{\alpha_3}{\alpha_1}x_{12}^o$	$\frac{\alpha_4(1+Q')}{\alpha_1}x_{12}^o$

Investment	Variable	x_{42}^{o}	x_{41}^{o}	x_{43}^{o}	$x_{45}^{'}$
	Replacement	$\frac{\zeta_2}{\zeta_2}x_{42}^{o}$	$\frac{\zeta_1}{\zeta_2}x_{42}^{o}$	$\frac{\zeta_3}{\zeta_2}x_{42}^{o}$	$\frac{\zeta_4(1+Q^{'})}{\zeta_1}x_{42}^{o}$
Enterprise	Variable	x_{32}^{o}	x_{31}^{o}	x_{34}^{o}	$x_{35}^{'}$
	Replacement	$\frac{\gamma_2}{\gamma_2}x_{32}^{o}$	$\frac{\gamma_1}{\gamma_2}x_{32}^{o}$	$\frac{\gamma_3}{\gamma_2}x_{32}^{o}$	$\frac{\gamma_4(1+Q^{'})}{\gamma_2}x_{32}^{o}$
Finance	Variable	$x_{52}^{'}$	$x_{51}^{'}$	$x_{54}^{'}$	$x_{53}^{'}$
	Replacement	$\frac{\epsilon_2}{\epsilon_2}x_{52}^{'}$	$\frac{\epsilon_1}{\epsilon_2}x_{52}^{'}$	$\frac{\epsilon_3}{\epsilon_2}x_{52}^{'}$	$\frac{\epsilon_4}{\epsilon_2}x_{52}^{'}$

Putting replaced variables into new simultaneous equations, we have re-organized 5 elements linear function simultaneous equations. See below.

$$x_{21}^{o}=\frac{\beta_1}{1+Q'}(x_{12}^{o}+x_{42}^{o}+x_{32}^{o}+x_{52}^{\prime});$$

$$x_{12}^{o}=\frac{\alpha_1}{1+Q'}\left(x_{21}^{o}+\frac{\zeta_1}{\zeta_2}x_{42}^{o}+\frac{\gamma_1}{\gamma_2}x_{32}^{o}+\frac{\epsilon_1}{\epsilon_2}x_{52}^{\prime}\right);$$

$$x_{42}^{o}=\frac{\zeta_1}{1+Q'}\left(\frac{\beta_2}{\beta_1}x_{21}^{o}+\frac{\alpha_3}{\alpha_1}x_{12}^{o}+\frac{\gamma_3}{\gamma_2}x_{32}^{o}+\frac{\epsilon_3}{\epsilon_2}x_{52}^{\prime}\right);$$

$$x_{32}^{o}=\frac{\gamma_2}{1+Q'}\left[\left(1-\frac{\lambda Q'}{1-\lambda}\right)\left(\frac{\beta_3}{\beta_1}x_{21}^{o}+\frac{\alpha_2}{\alpha_1}x_{12}^{o}+\frac{\zeta_3}{\zeta_2}x_{42}^{o}\right)+\frac{\epsilon_4}{\epsilon_2}x_{52}^{\prime}\right];$$

$$x_{52}^{\prime}=\epsilon_2(1+Q')\left(\frac{\beta_4}{\beta_1}x_{21}^{o}+\frac{\alpha_4}{\alpha_1}x_{12}^{o}+\frac{\zeta_4}{\zeta_2}x_{42}^{o}+\frac{\gamma_4}{\gamma_2}x_{32}^{o}\right)+\epsilon_2 M_1^{\prime}.$$

Taking economic structure ratio $\alpha_i,\beta_i,\zeta_i,\epsilon_i$and nominal growth rate $Q^{'}$ as known.x_{ij}can be solved, which are expressed by $M_1^{'}$. The determinant solution of the simultaneous equation is given below:

$$\begin{pmatrix} 1 & -\frac{\beta_1}{1+Q'} & -\frac{\beta_1}{1+Q'} & -\frac{\beta_1}{1+Q'} & -\frac{\beta_1}{1+Q'} \\ -\frac{\alpha_1}{1+Q'} & 1 & -\frac{\zeta_1\alpha_1}{\zeta_2(1+Q')} & -\frac{\gamma_1\alpha_1}{\gamma_2(1+Q')} & -\frac{\epsilon_1\alpha_1}{\epsilon_2(1+Q')} \\ -\frac{\beta_2\zeta_2}{\beta_1(1+Q')} & -\frac{\alpha_3\zeta_2}{\alpha_1(1+Q')} & 1 & -\frac{\gamma_3\zeta_2}{\gamma_2(1+Q')} & -\frac{\epsilon_3\zeta_2}{\epsilon_2(1+Q')} \\ -\frac{\beta_3\gamma_2\left(1-\frac{\lambda Q'}{1-\lambda}\right)}{\beta_1(1+Q')} & -\frac{\alpha_2\gamma_2\left(1-\frac{\lambda Q'}{1-\lambda}\right)}{\alpha_1(1+Q')} & -\frac{\zeta_3\gamma_2\left(1-\frac{\lambda Q'}{1-\lambda}\right)}{\zeta_2(1+Q')} & 1 & -\frac{\epsilon_4\gamma_2}{\epsilon_2(1+Q')} \\ -\frac{\beta_4\epsilon_2(1+Q')}{\beta_1} & -\frac{\alpha_4\epsilon_2(1+Q')}{\alpha_1} & -\frac{\zeta_4\epsilon_2(1+Q')}{\zeta_2} & -\frac{\gamma_4\epsilon_2(1+Q')}{\gamma_2} & 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \epsilon_2 M_1' \end{pmatrix}$$

7. The usage of simultaneous equation

To demonstrate the usage of simultaneous equation, a hypothetical payment ratio table is given in Table 9.

Table 9. Hypothetical payment ratio.

Series / Ratio	1	2	3	4
α	.05	.4	.1	.45
β	.15	.1	.55	.2

γ	.35	.3	.2	.15
ζ	.2	.1	.55	.15
ϵ	.12	.3	.4	.18

If the hypothetical nominal growth θ' and intermediate goods ratio λ are $.25$ and $.4$ respectively. The calculated determinant solution of the simultaneous equation is:

$$\begin{pmatrix} 1 & -.12 & -.12 & -.12 & -.12 \\ -.04 & 1 & -.08 & -.0466 & -.016 \\ -.0533 & -.16 & 1 & -.0533 & -.1067 \\ -.7333 & -1.6 & -1.1 & 1 & -.144 \\ -.5 & -3.375 & -.5625 & -.1875 & 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ .3M_1' \end{pmatrix}$$

After solving the equation, we get x_{ij}^{o} and x_{ij}' in Table 10.

Table 10. x_{ij} solutions.

	x_{12}^{o}	x_{13}^{o}	x_{14}^{o}	$x_{15}^{'}$
	.04077	.32616	.08154	.45866
x_{21}^{0}		x_{23}^{o}	x_{24}^{o}	$x_{25}^{'}$
.13687		.50816	.09125	.22812
x_{31}^{o}	x_{32}^{o}		x_{34}^{o}	$x_{35}^{'}$
.42864	.36741		.24494	.22963
x_{41}^{o}	x_{42}^{o}	x_{43}^{o}		$x_{45}^{'}$
.20158	.10079	.55435		.18898
$x_{51}^{'}$	$x_{52}^{'}$	$x_{53}^{'}$	$x_{54}^{'}$	
.25264	.63160	.37896	.84213	

Note: We omit M_1' factor in all entries.

Now the dynamic transaction table becomes:

Table 11. Hypothetical dynamic transaction table.

	H	G	E	I	F
H		.05096 .04077	.40770 .27180	.10193 .08154	.45866
G	.17109 .13687		.62733 .41821	.11406 .09125	.22812
E	.53580 .42864	.45926 .36741		.30618 .24494	.22963
I	.25198 .20158	.12600 .10079	.69294 .46196		.18898
F	.25264	.63160	.37896	.84213	1

8. Applications

The result discussed above can be used widely in macroeconomy. We give a few examples demonstrating applications of balance sheets and the simultaneous equation.

8.1. Applications of Balance Sheets

Monetary equation

The money supply can be captured by summing up sub-system's 5 balance sheets. After added up and reorganized, we have the money supply:

$M^{'} = \Delta AR$

Available loan and reserve increment:

$+ \Delta C_h^o + \Delta C_{ih}^o + \Delta C_g^o + \Delta C_{ig}^o + \Delta C_i^o + \Delta C_r^o \cdot Q^o$

Total sales increment $\Delta(\mathrm{PQ})$:

$+\Delta L_{ce}^o + \Delta L_{ci}^o + \Delta L_{cg}^o + \Delta SL^o$

Labor cost increment ΔL_c

$+\Delta P_{rh}^o + \Delta P_{rg}^o + \Delta P_{ri}^o$

Profit increment ΔP_r

$+\Delta B_{en}^o + \Delta B_{gn}^o + \Delta B_e^o + \Delta B_g^o + \Delta S^o$ security market volume increment $\Delta \mathrm{B}$

$+\Delta T^o$ Tax increment

$+\Delta A_i^o$ Asset increment

$+\Delta I_{gn}^o$ State owned co investment increment by government

Let $\mathrm{Y} = \mathrm{LC} + P_r + B + T + A_i + I_{gi}$ denote the yield. The money supply is equal to total sales increment and total yield increment plus available loan and reserve increment. Equation can be written in short:

$$M' = \Delta(PQ)^o + \Delta Y^o + \Delta AR' \text{ or } M_1' = \Delta(PQ)^o + \Delta Y^o$$

Compared with monetary exchange equation $\mathrm{MV} = \mathrm{PQ}$ by Irving Fisher in 1911(Office for National Statistics, 2013) it is evident that its foundation is not enough. Except for total sales increment and total yield incrementof the year, last year's total sales and total yield is supported by existing money in the system. Furthermore, the velocity of money has no direct connection with money supply, because money owner can only use their money once.

Inflation rate and economy growth calculation

By changing monetary equation into another form, the relationship among money supply, all sales, inflation rate and economic growth will surface. Dividing both sides of monetary equation with total sales $P^o Q^o$ and reorganizing it we get inflation rate and the economy growth formula:

$$\frac{\Delta P}{P} + \frac{\Delta Q}{Q} = \frac{M' - \Delta AR' - \Delta Y^o}{P^o Q^o} \quad \text{or} \quad \frac{\Delta P}{P} + \frac{\Delta Q}{Q} = \frac{M_1' - \Delta Y^o}{P^o Q^o}$$

The formula above tells that inflation rate plus growth equals new issued money minus available loan and reserve increment and yield increment divided by total sales of last year.

Actually the article *Relationship between the Money Supply and Inflation*(F.M.I. Strategy, 2012) already got close conclusion with the formula above: The perception relationship between money supply and inflation should take economic growth into consideration.

Interest rate calculation in closed economy

By summing up the balance sheets of four sub-systems $(\mathrm{H}, \mathrm{G}, \mathrm{E}, \mathrm{I})$, the relationship among economy growth, total loan and deposit of the term, accumulative total loan and deposit of last term, difference value between loan and deposit interest rate, time limit of loan and loan interest rate is uncovered. The reasonable loan interest rate in a closed enonomy setting can be calculated with the formula below:

$$i_l = \frac{TL' - TD'}{ATL^o - ATD^o} - \frac{TL^o/K + wTD^o}{ATL^o - ATD^o} - \frac{Q'((PQ)^o + Y^o)}{ATL^o - ATD^o}$$

Here TLand TD are the total loan and deposit of this term respectively, ATL andATD are accumulate total loan and deposit of last term resp., K is the time limit of the loan and$w$represents the difference value of loan and deposit interest rate.

In Taylor's monetary and policy rule, interest rate responses to changes in inflation and output (Taylor, 1993).The formula above provides a more close approach by taking new issued money into consideration.

Exchange rate calculation in open economy

Adding merchandise trading amount of export and import and capital flows in and out of the country to subsystem's balance sheet of closed economy, we get subsystems' balance sheets of open economy. By summing up five subsystems' balance sheets in an open economy setting, the relationship among supply, economy growth, export of last term, import of this term, surplus of capital flow and exchange rate will appear. We can calculate the exchange rate from the formula below.

$$\mathrm{Re} = \frac{M_1' - Q'(P^oQ^o + Y^o)}{(1+Q')IM^o - EX^o - S_e'}$$

where: Re means exchange rate, IM represents import, EX denotes export and S_e means capital flow surplus. OANDA only listed top 5 factors affecting exchange rate: interest rate, employment outlook, economic growth expectation, trade balance and central bank action (OANDA). The formula also expounded the mathematical relationship among these factors.

8.2. Applications of simultaneous equation

The impacts of one variable to others

As the I-O model, simultaneous equation can be used to study the economic impacts of one variable change on others (Mouhammed, 2002). Actually, if we takeM_1' as a variable, the equation is a homogeneous system. Its solutions can be expressed with any one of six variables. So we can study the economic impacts on the other five variables caused by one variable change.

Economic simulating experiment

The simultaneous equation can be used to do economic simulating experiment. Input different set of macroeconomic control instruments like $M_1', \beta_i$and t(tax rate) with controlled level of inflation$\frac{\Delta p}{p}$ and expected target of growth $\frac{\Delta Q}{Q}$ together into simultaneous equation, we can get different set of x_{ij}.According to the desired economic state (x_{ij}),economy reality and feasibility of the instruments, policy maker can opt one set of macroeconomic control instrument $(M_1', \beta_i, \mathrm{t})$and put them into practice.

Reasons for stagnation

After the stagnation happened, the transaction variablesx_{ij}^o in the period of economy crisis and x_{ij}' in the period of stagnation are all known. Rewrite simultaneous equation, the inflation rate $\Delta P/P$, subsystems's actual growth ($\frac{\Delta Q_h}{Q_h}, \frac{\Delta Q_g}{Q_g}, \frac{\Delta Q_e}{Q_e}, \frac{\Delta Q_i}{Q_i}$) can be solved.

$$x_{21}^{o} + x_{31}^{o} + x_{41}^{o} + x_{51}' = \left(1 + \frac{\Delta P}{P} + \frac{\Delta Q_h}{Q_h}\right)(x_{12}^{o} + x_{13}^{o} + x_{14}^{o}) + x_{15}'$$

$$x_{12}^{o} + x_{32}^{o} + x_{42}^{o} + x_{52}' = \left(1 + \frac{\Delta P}{P} + \frac{\Delta Q_g}{Q_g}\right)(x_{21}^{o} + x_{23}^{o} + x_{24}^{o}) + x_{25}'$$

$$\left[1 - \frac{\lambda}{1-\lambda}\left(\frac{\Delta P}{P} + \frac{\Delta Q_e}{Q_e}\right)\right](x_{13}^{o} + x_{23}^{o} + x_{43}^{o}) + x_{53}' = \left(1 + \frac{\Delta P}{P} + \frac{\Delta Q_e}{Q_e}\right)(x_{31}^{o} + x_{32}^{o} + x_{34}^{o}) + x_{35}'$$

$$x_{14}^{o} + x_{24}^{o} + x_{34}^{o} + x_{54}' = \left(1 + \frac{\Delta P}{P} + \frac{\Delta Q_i}{Q_i}\right)(x_{41}^{o} + x_{42}^{o} + x_{43}^{o}) + x_{45}'$$

To show how to use the equation above, we use the hypothetical $x_{ij}^{o}$and x_{i5}', $\mathrm{i} = 1, \dots, 4$. Reallocate total loan with $\varepsilon_1(.1), \varepsilon_2(.4), \varepsilon_3(.35), \varepsilon_4(.15)$, and

$$x_{51}' = .21584 \quad M_1', x_{52}' = .86336 \quad M_1', x_{53}' = .75544 \quad M_1', x_{54}' = .32376 M_1'$$

Plug those known values (x_{ij}^{o},x_{ij}') into the equation we get:

$\frac{\Delta P}{P} + \frac{\Delta Q_h}{Q_h} \approx .17, \frac{\Delta P}{P} + \frac{\Delta Q_g}{Q_g} \approx .57, \frac{\Delta P}{P} + \frac{\Delta Q_e}{Q_e} \approx .22, \frac{\Delta P}{P} + \frac{\Delta Q_i}{Q_i} \approx .15.$

By the try and error method, we will obtain:

Inflation rate:	$\frac{\Delta P}{P} = 28\%$
Household real consumption growth:	$\frac{\Delta Q_h}{Q_h} = -11\%$
Government consumption growth:	$\frac{\Delta Q_g}{Q_g} = 29\%$
Enterprise real production growth:	$\frac{\Delta Q_e}{Q_e} = -6\%$
Invest real growth:	$\frac{\Delta Q_i}{Q_i} = -13\%$

Therefore on the basis of economic crisis, government's stimulating measures are the reason for stagnation. This conclusion provides a theoretical support to some existing deduction (The Christian Science Monitor, 2011).

Conclusion

We summarize below the main results and observations in this paper. Making use of balance sheets, we solve fundamental macro-economic issue.

- *Monetary equation:*

  $M' = \Delta(PQ)^{o} + \Delta Y^{o} + \Delta AR'.$

- *Inflation rate and economy growth formula:*

$$\frac{\Delta P}{P} + \frac{\Delta Q}{Q} = \frac{M' - \Delta AR' - \Delta Y^{o}}{P^{o} Q^{o}}$$

- *Interest rate formula:*

$$i_l = \frac{TL' - TD'}{ATL^o - ATD^o} - \frac{\frac{TL^o}{K} + wTD^o}{ATL^o - ATD^o} - \frac{Q'((PQ)^o + Y^o)}{ATL^o - ATD^o}$$

- Exchange rate formula:

$$\text{Re} = \frac{M_1' - Q'(P^oQ^o + Y^o)}{(1+Q')IM^o - EX^o - S_e'}$$

Applying simultaneous equation, we can do economic simulating experiment on computer, to provide scientific basic for macro economy management. We also see that government's stimulating measures in economic crisis are the reason for stagnation.

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Networks in context: the concept of network in Manuel Castells' theory of the network society

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Abstract:

This article discusses the conceptualization of network in Manuel Castells' theory of network society. Networks appeared in Castells' works in the late 1980s, when he became interested in the configuration of the relationships between technology, economy, and society. The culmination of this phase was his opus magnum, The Information Age trilogy, which introduced network as a key concept of his macro theory, even though he remained laconic about the concept itself. This is paradoxical, for Castells became possibly the most prominent figure globally in adopting network terminology in macro sociological theory, but at the same time made hardly any empirical, theoretical or methodological contribution to social network analysis or network theory in general. This implies that 'network' in Castells' social theory is based on institutional network analysis. Moreover, it is not an analytical concept but rather a powerful metaphor that served to capture his idea of the new social morphology of informational capitalism.

Keywords: Manuel Castells, network, network society, informationalism, The Information Age, political economy

JEL Classification: A13, A14, B31, B52, F60, F68, O2, P16

1. Introduction

The Spanish sociologist Manuel Castells created one of the most ambitious macro theories of our time, which endeavors to explain and interpret power, economy, and social life in a world transformed by globalization and informatization. Castells already rose to fame as a radical urban sociologist in the 1970s, but his international reputation is largely due to *The Information Age* trilogy published in three volumes in the latter half of the 1990s. This is a political economy-oriented macro-analysis of the tensional relationship between the instrumental networks of informational economy and historically-rooted identities and the world-wide developments conditioned by it. The concept of network entered his thinking in the late 1980s, culminating in the first volume of the trilogy, *The Rise of the Network Society* (Castells 1996).

In this article I discuss the nature and role of the concept of network in Castells' theory of network society. The research question is: how does Castells operationalize and utilize the concept of network in his analysis of the network society? I first contextualize the discussion by briefly shedding light on the most significant events of Castells' academic career. The discussion then turns to introducing the concept of network and its role in his macro sociological theorization. Lastly, I position Castells in the field of social network analysis and assess his contribution to network theory.

2. Turning points of Castells' academic career

Manuel Castells Oliván was born in 1942 to a conservative family in the small town of Hellín in the autonomous region of Castilla-La Mancha, Spain. He spent most of his childhood in Barcelona, where he also started his university studies in the late 1950s. The life of Spanish people was shadowed at that time by Franco's military regime. The young Castells like many others participated in the opposition movement. When the grasp of the military government tightened, many of Castells' friends were captured and tortured; he himself was able to escape to France. (Castells and Ince 2003, 5-9; Fischer 1999; see also Castells 2009).

Castells settled in France and graduated from the University of Paris (la Sorbonne) in 1964. He was interested at that time in conducting sociological analysis of the working class, an interest shared by the famous French sociologist, Professor Alain Touraine, who eventually became Castells' academic mentor (Castells and Ince 2003, 10-12; see also Stalder 2006). In 1967 Castells took his doctoral degree and was soon nominated as an associate professor in sociology at the University of Paris (Castells and Ince 2003, 12-13). Due to his involvement in the 'May 68' movement he was deported from France. After being granted an amnesty by the French government, he was able to return in 1970, this time at the invitation of Touraine to hold an associate professorship at EHESS in Paris (*L'École des hautesétudes en sciences sociales*). This was the beginning of the gradual consolidation of his position in French and slowly also in international circles of urban sociology (Castells and Ince 2003, 15-16; Stalder 2006).

Academically, Castells' main objective became to combine Marxist theory, urban sociology and social movement research, the focus being on empirical research. The most important outcome of that period was *La question urbaine*, which was published in 1972 and translated into English five years later under the title *The Urban Question* (Castells 1977). The book was a great success both in France and internationally, providing considerable input to Marxist urban sociology (Castells and Ince 2003, 15-16; Castells 1977; 1978; see also Pickvance 1975; Rex 1977; Dunleavy 1977; 1980; Elliott 1980, 152; Whiteley 1980; Lowe 1986; Gurr and King 1987; Katznelson 1992; Walton 1993; Merrifield 2002, 114). Probably the most widely discussed issue around this work was the conceptualization of the city as the arena of collective consumption. The message of Castells' structural analysis was that political contradictions escalate unless they are eased by publicly organized and funded collective consumption that meets people's basic needs (Castells 1977; Lowe 1986, 2; see also Dunleavy 1980; Lojkine 1976; de Moura Costa 2007, 23; Cochrane 2003, 531).

The American universities had impressed Castells since the early years of his career. He even said that his own research orientation was more American than French, even though he clearly combined the empirical analysis typical of the American tradition with the theorization associated with the French tradition and the political activism that reflects his Spanish background (Castells and Ince 2003, 16-17; Institute of International Studies 2001). Castells' reputation as a radical reformer of urban political analysis became widely known among urban researchers. Yet his reliance on Marxism began to decline in the late 1970s and by the end of the decade had vanished (Rantanen 2005, 137). That was the time when Castells' academic career took a new turn as he was invited to take up a professorship of urban sociology at UC Berkeley, USA. He took up his post in 1979, at the age of 37. He started to pursue his intellectual passion, research on social movements, but this time in the socially diverse San Francisco (see for example, Castells and Murphy 1982). The culmination of this period was

The City and the Grassroots, published in 1983, which Castells himself regarded as his best work in urban studies (Castells 1983, 291-301; Castells and Ince 2003, 16-17; Fuchs 2008; Mayer 2006).

Around the year 1983 Castells decided to start investigating the connection between technology, economy, and society and how these were reflected in urban structure (e.g. Castells 1985; 1989; Portes*et al.* 1989; Mollenkopf and Castells 1991). He later stated that at that time he felt that in Europe the magnitude of the information technology revolution had not yet been understood as it was on the other side of the Atlantic (Institute of International Studies 2001; Stalder 2006; cf. Hydén 2001). The first major outcome of this new turn was *The Informational City*, a book that opened up a new contextual view of urban reality by paying attention to the geographical impacts of informational economy (Castells 1989). Castells had earlier emphasized in his urban analyses both productive relations (Castells and Godard 1974) and consumption processes (Castells 1977), but now broader exchange, interaction, and communication processes and spaces were taken into the spotlight (Castells 1989; 2002; Stalder 2006; 1998; cf. Hassan 2004, 59). Later the project expanded into an encyclopedic endeavor resulting in the trilogy entitled *The Information Age*, its three volumes being *The Rise of the Network Society* (1996), *The Power of Identity* (1997a), and *End of Millennium* (1998). The trilogy was essentially a crystallization of Castells' ideas developed throughout the previous decades, augmented by the ample evidence he needed to be able to present a grand narrative of the structural contradiction between the Net and the Self that characterizes the world we live in. The trilogy became a huge success and confirmed Castells' position as one of the most cited social theorists worldwide (Institute of International Studies 2001; Castells and Ince 2003, 18-20).

After retiring from his professorship in UC Berkeley in 2003, Castells accepted a professorship of communication in the prestigious Annenberg School for Communication and Journalism at the University of Southern California, Los Angeles. Castells approached communication in the context of societal changes and power structures, which reveals an unbroken connection with his earlier works (cf. Waterman 1999; see also Kling 2002; Howard 2011; Allan 2007). A cornerstone of this turn was *Communication Power*, which the media analyst Jan van Dijk (2010) has described as the extension of the discussion presented in the second volume of the trilogy, *The Power of Identity* (Castells 2009; on other contributions of Castells' late career, see Carnoy and Castells 2001; Castells 2001; Castells et al. 2004; Castells 2007; Arsenault and Castells 2008a; 2008b). We may add to this one of his more recent works, *Networks of Outrage and Hope: Social Movements in the Internet Age*, which illuminates how he fuses his earlier works (e.g. Castells 1983; 1998; 2001) into an insightful analysis of recent social conflicts from the Arab Spring to the Occupy Wall Street movement that are in the spotlight of global news (Castells 2012).

Next I will take a closer look at Castells' concept of network and after that assess its use in his analysis of the network society.

3. The concept of network in Castells' theorization

3.1. Introduction of networks in the informational city

In the light of the Marxist influence it is understandable that the concept of network did not notably figure in Castells' works of the 1970s. His approach changed in the 1980s, and more so in the following decade, however, as he started to renew his conceptual arsenal. The first significant attempt to clarify the network logic within a wider theoretical framework was *The Informational City*, which can actually be seen as the first sketch of *The Information Age* trilogy. Even if it included only a few direct references to networks, the concept itself aptly described something fundamental in the emerging social morphology and related changes in the techno-economic system. Castells (1989, 32) writes,

> *"These networks, which could not exist on such a large scale without the medium provided by new information technologies, are the emerging organizational form of our world, and have played a fundamental role in ensuring the restructuring process: ---. Networks, on the basis of*

new information technologies, provide the organizational basis for the transformation of socially and spatially based relationships of production into flows of information and power that articulate the new flexible system of production and management."

In the analysis presented in *The Informational City* 'network' remained an auxiliary concept subject to the structural framework, having only a modest role in the account of informational capitalism, at least if measured by explicit references to the concept. On the other hand, the few references made by Castells showed the tremendous explanatory power of the concept of network: it depicted the organizational basis for the transformation of production system; it provided a means for corporate system to control its inputs and expand its outputs, thus creating a new global socio-spatial division of labor; its adaptive potential became conducive to the restructuring of the capitalist economy; and it empowered the libertarian spirit of capitalism through organizational networks and information flows which were able to dissolve locales and supersede societies (Castells 1989, 32, 125). The concept of network sketched in *The Informational City* started to resonate later in *The Information Age* as a depiction of the fundamental transformative organizational logic, which relates dialectically to the informational mode of development as an enabler and globalization of the economy as the indication of the transformation of the material base of social life (Castells 1996; 1997a; 1998).

3.2. Networks as sets of interconnected nodes

In *The Information Age* and many subsequent works Castells defines 'network' explicitly as a set of interconnected nodesof which he mentions such examples as stock exchange markets and their ancillary centers of advanced financial services in the network of global financial flows; political elites in political networks, such as national councils of ministers and EU commissioners in the governance network of the European Union; broadcasting systems, studios, computer-aided communications, social network service providers in the global network of media, and so forth (Castells 1996, 470). By definition, networks do not have one center but are characterized by binary logic (inclusion/exclusion) and decentralized structures and decision-making patterns. The existence of networks is determined by the utility of the nodes of the network. If some node ceases to serve the network, it will be phased out or replaced and the network rearranges itself in the manner of cells in biological processes. The importance of each node is determined by its ability to gain trust within the network by sharing information and to program and connect networks by mastering protocols, which enable the operation of the critical switches of the network (Castells 1996, 470-471; 2000a; 2000b; 2009; Stalder 2006, 135-136).

Such a formal view derives its rationality from the fact that the network concept was adjusted to a broader structural framework. The introduction of this concept was not motivated by its distinctiveness or content as such, nor did it include any particular methodological contribution, but rather served as a kind of historically grounded epochal "axiom" in a social theoretical deduction from general theoretical principles to the explanation of empirical phenomena, such as new business models, urban conflicts, or state restructuring (Castells 1996; 1997a; 1998). In this sense we may say that the concept of 'network' was subordinate to structural framework and its deductive logic. Castells' insightful idea was to use the global networks of instrumental exchanges as a point of reference to the notion of network. He does not seem to be puzzled by how networks come into being, how they evolve, the nature of given network ties, or even how the information networks really function, but provides only a formal definition and a few sketchy examples, which keeps the discussion at a high level of abstraction (Castells 2000a; 2004a).

Castells assumes that technological development is the most important individual precondition for the resurge of networks (Castells 1996; 2004b; Fuchs 2009). He supports his view with a claim that the emergence of networks as an efficient form of social organization is the result of three features that have proved their usefulness in the emerging techno-economic environment, namely flexibility, scalability and survivability (Castells 2004a, 5-6; cf. Castells 2009, 23),

> *"Flexibility: they can reconfigurate according to changing environments, keeping their goals while changing their components. They go around blocking points of communication channels to find new connections. Scalability: they can expand or shrink in size with little disruption. Survivability: because they have no center, and can operate in a wide range of configurations, they can resist attacks to their nodes and codes, because the codes of the network are contained in multiple nodes that can reproduce the instructions and find new ways to perform."*

To summarize, Castells (2004a; 2009) defines networks as sets of interconnected nodes, which process financial and other value flows with the help of new technologies. The concept of network provided not only opposing model to hierarchy (Eriksson 2005) but also a view to the novel aspects of social organization that emanates from the crumbling foundations of modernity (Giddens 1992), which served perfectly the building of his grand narrative. In Castells' theorization networks are self-configurable, complex structures of communication and power, which cooperate and compete internally and externally according to interests expressed within the nodes using ultimately a binary logic of inclusion/exclusion. They have the capability of self-renewal in the sense that they may introduce new actors and content as conditions change. Their dynamic nature makes them flexible, scalable and survivable, which are indispensable for the survival of organizations in continuously changing techno-economic environment (Castells 1996; cf. Tampere 2011).

3.3. Binary logic of informational capitalism

Castells' theory of network society takes the concept of network to a high level of abstraction, utilizing it as a concept that depicts macro level tendencies associated with the social organization in informational capitalism. He expressed the role of networks in his social theory as follows (Castells 1996, 469):

> *"… dominant functions and processes in the information age are increasingly organized around networks. Networks constitute the new social morphology of our societies, and the diffusion of networking logic substantially modifies the operation and outcomes in processes of production, experience, power, and culture. While the networking form of social organization has existed in other times and spaces, the new information technology paradigm provides the material basis for its pervasive expansion throughout the entire social structure."*

Understanding the societal context of such networks entails returning to the political economy of the social transformation of capitalist society. Initially, as an evocation of his Marxist roots, Castells repeatedly emphasized that the network society is a capitalist society. In fact, for the first time almost the entire globe can be said to function under the conditions of the capitalist system (Castells 2000a). The most central tension of such a societal formation is that between capital and labor, as depicted in Karl Marx's thesis of the in-built contradiction of capitalism. According to Castells, a key contradiction critical to understanding informational capitalism is the historical asymmetrization of the capital-labor relationship: while capital creates networks, labor becomes individualized (Castells 1996, 471; 1997b).

Informational capitalism is based on the informational mode of development, in which information becomes both key input and outcome of production processes and a source of productivity and growth. It makes informationalism in essential sense different from agrarian and industrial modes of development. Historically, such a new focus on information processing was accompanied by three key processes of the restructuring of capitalism that emerged in the 1980s and the following decades, those of increased capital intensity, changes in the pattern of state intervention, and accelerated globalization of all economic activities (Castells 1989; see also Schmiede 2006).

Informational economy works through global networks of instrumental exchanges. As they process flows within the fluid "space of flows," relationships surpass places in importance in the functioning of the system. The other side of the equation, waged labor, became historically united against capital in the form of the labor movement from the late 19th century onwards. Disillusionment with socialism, the anomalies of Marxist doctrine and real-life developments in advanced democracies caused the inevitable evanescence of the subject of revolution. Castells, like many of his post-Marxist contemporaries, called for a more subtle and nuanced interpretation of the conditions and agenda of social change. The most serious attempts to restore the actorship behind radical social change have rested on social and ecological movements and more broadly on civil society (Kling and Posner 1991, 30; see e.g. Wright 1997; 2005; Katznelson 1981; Marcuse 1964). Castells sought individual and community-level awareness, adaptability and innovativeness in a pluralist society without committing to any ideologically fixed manifesto or political program (Institute of International Studies 2001; cf. Waterman 1999; Boyraz 2008; Rantanen 2005). Thus the analysis of the network society did not aim at providing a formula for the working class to solve the contradiction between capital and labor, but rather at opening up new horizons to understand our social conditions and to challenge global instrumentality through bottom-up strategies developed by people who ultimately rely on the power of their locally-rooted socio-historical identities.

Macro level network logic comes into this picture in Castells' dramatic claim that individuals, groups, communities, and even nations are included or excluded from the networks of economic power depending on their usefulness to such networks. The processes of human life are increasingly conditioned by global economic networks that position people according to their "use value" and create sophisticated means of controlling everyday life. This creates tension, which Castells (1996, 3) expressed in one of the most widely quoted crystallizations of his theory: "Our societies are increasingly structured around a bipolar opposition between the Net and the Self." Hence the emancipatory message built into Castells' theory and the related special nature of "power of identity" as counterforce to instrumental networks.

3.4. From neuropolitics to general network theory

The most recent phase of Castells' academic career has been devoted to the analysis of communication, power, and networks. Even if he adheres to topics elaborated in his earlier works, his interest in micro sociology gained ascendancy. According to van Dick (2009), Castells' main work in this area, *Communication Power*, illustrates the change of his thinking in two respects. First, tying the analysis to self and identity is not as superficial as it was in *The Information Age,* but developed a firmer psychological foundation for understanding social action. In this he relies on neuroscience, as exemplified the works of Professor Antonio Damasio (1994) of the University of Southern California, who has contributed to shifting the center of gravity in the analysis of human behavior from cognition and rationality to biology and emotions (cf. Kelly 1994). We may identify similar aspirations in Castells' attempt to apply Robert Entman's (1993) frame theory in analyzing power in communication. Another important departure from Castells' earlier approach was to take the internal power struggles of networks onto the agenda, which in his earlier works were only mentioned in passing (van Dijk 2001; 2010). Fascination with micro sociological explanatory schemes began to profoundly affect Castells' thinking (see Castells 2009).

In Castells' analysis network appears as a central structural element in the new forms of communication and in a mediatized society in general, which is manifest in the "mass self-communication" associated with social media, in the environmental movement's contribution to mitigate climate change, and in neuropolitics, which analyzes power through cognitive processes (Castells 2009; cf. Castells 2012). He became interested in biological analogies and neuroscience, which tries to explain how political affiliation and action relate to the human brain (e.g. Lakoff 2008). Castells ended up with a notion that as conscious actors we resemble organic networks with a connection to the external world of networks (Delfanti 2009). From that assumption it is only a short step to a general network theory, which makes sense of the material, psychological, and social aspects of our world, serving as a unifying framework for the natural sciences, humanities and social sciences in the same way as general systems theory or complexity theory were assumed to do (Castells 2009; 2010).

Castells' micro-sociological excursions have been criticized for making an excessively simplistic use of the results of brain research to explain complex phenomena, such as power and politics. It is also worth asking how useful the network metaphor actually is when taken to its extreme, i.e. to explain practically everything, as Castells eventually seems to do (see Delfanti 2009; Stalder 2006; Thompson 2003, 192). This raises an interesting question of the relation between macro and micro in Castells' theorization. The concept of network has allowed Castells to maintain his macro sociological framework while deepening his analysis along micro sociological lines.

Castells placed great faith in the network theory, proposing that it may even offer a unifying language and framework to understand nature and human society through the networks of biological, neurological, digital, and human communication (Castells 2010). While for understandable reasons he maintained his belief in his theory of network society, his recent views of the role of networks in social research would require the refinement of the fundamentals of his theory if applied to his analysis. Such an endeavor is akin not only to the previously mentioned micro sociological endeavors (Damasio 1994; Kelly 1994; Entman 1993; Lakoff 2008) but also to complexity theory and the related new network conceptions, as represented by Capra (2003) and Barabási (2002). This is a methodological project which Castells touched upon in *Communication Power* and referred to in some of his speeches (e.g. Castells 2010) but which he obviously did not set himself to complete.

4. Castells in the field of network research

Castells is a renowned social theorist, whose influence is perceptible in various ways in various academic and social discourses of our time (McCarthy *et al.* 2004; May 2006; Barney 2004, 181). His trilogy in particular introduced a long awaited social theoretical perpective on the understanding of the trends and challenges of global transformation (Fuller 2004; Giddens 1996; Cabot 2003; Heiskala 2003). If we take the concept of network to be the core of his analysis, however, the picture changes in some respects. Namely, paradoxically Castells' influence is minimal in network research even though his network society theory is one of the most widely discussed social theoretical contributions of the 1990s.

4.1. Social network analysis

Castells' theorization is not imbued by references to social anthropologists who have studied social ties (e.g. Alfred Radcliffe-Brown and E.E. Evans-Pritchard), sociological classics that contributed to the network-oriented analysis of social structures and interaction (Georg Simmel, Leopold von Wiese, Norbert Elias, Herbert Blumer) or later generations of scholars who have developed social network analysis, including J. Clyde Mitchell, Harrison White, Michael Schwartz, Barry Wellman, and Mark Granovetter (on the sociology of social networks, see Freeman 2004; Pescosolido 2006; Borgatti*et al.* 2009). In its basic form social network analysis focuses on the interaction of small groups and dyadic relationships (Granovetter 1973; 1983), which are not addressed in Castells' analysis. He conceptualized "social ties" as imprecise impersonal exchange relations at a theoretically constructed whole-network level, relying on benefit-based antecedents or the utility maximization view of network formation as a reflection of instrumentality built into the logic of the capitalist system. While directing attention one-dimensionally to the formal features of network-based organization, he eventually totally excluded 'social interaction' from his network analysis.

Another noteworthy point is that in his analysis the economic sphere had a critical role as the primary locus of the network society, which is a fairly narrow slice of network theory as a whole. In this sense similarities with Castells' network conception could be sought from economic network analysis – the representatives of this approach being Christopher Freeman and Walter W. Powell – and within it especially from an approach in which the proliferation of networks is associated with technological and economic development. More precisely, Castells' 'network' can be seen as institutionally defined concept embedded in the macro-theoretically oriented economic network analysis (Castells 1996; 2000a; 2000b; 2010). In short, for Castells its role in defining social morphology and related institutional effects (Owen-Smith and Powell 2008) are more important than the factual social relations within each network.

If Castells overhauled the traditions of the social network analysis lightly, it is not surprising that his network concept remained too sketchy for the network analysts. Castells' contribution to social research is not based on the sophistication of the network concept *per se*. Network society theory attracted attention because it afforded a rich perspective on societal change in which network was a social theoretical axiom or metaphor rather than an analytical concept. Be that as it may, social scientists who analyze network society at the macro-theoretical level have inevitably benefited from Castells' seminal work, which paves the way for a better understanding of the emerging forms of the social organization of society and their structural conditions (e.g. Barry 2001; Thompson 2003; Barney 2004; Lehmann *et al.* 2007).

4.2. Remarks on network society theorizations

If we discuss the concept of 'network' at a higher level of abstraction, within macro sociology or political economy, Castells' contribution gains currency. In the 1970s the center of gravity of network research in general shifted to sociology (Borgatti*et al.* 2009). Along with this shift network society theorizations emerged as a reflection of the increased complexity and interactivity occasioned by the digitalization, informatization, and mediatization of society (Craven and Wellman 1973; Wellman 1979; Hiltz and Turoff 1978; Martin 1977; see also van Dijk 1999). Other contributions to this field came from discussions about post-industrial society (Bell 1973; Kumar 2005), various strands of information and knowledge society discourses (see Webster 1995; Stehr 1994), theorizations of reflexive or late modernity in sociology (Giddens 1992; Beck *et al.* 1994; Lash and Urry 1994), and insightful views in futures research (Toffler 1970; 1980; 1990; Naisbitt 1984) to mention just a few prominent discourses that relate to network society theorizations. In this field Castells' work stands out as an unparalleled encyclopedic, critical social-theoretical endeavor that links structural analysis of global and societal transformations with various aspects of economy, power, and everyday life.

Castells did not strongly relate his discussion to any theoretically-oriented sociological tradition but set his own agenda (see Iyer 1999; cf. Collins 1999; Smart 2000; Holton 2005). Most notably, he rejected the concepts of information and knowledge as primary explanatory categories and assigned such a role to networks. He made network a basic unit of analysis, which integrated social structures, social action, social organization, space of flows, and new technologies into a macro theoretical framework that utilizes quasi-Marxist ideas, such as the informational mode of development. With this solution he contributed to the wider acceptance of the concept of network as an interpretative norm in social sciences (Kasvio 2005; May 2006; Stalder 1998; on the network society analyses published after Castells' trilogy, see Schiller 2000; Thompson 2003; Barney 2004; Hassan 2004; McCarthy *et al.* 2004; Castells and Cardoso 2005; Lehmann *et al.* 2007; Cardoso 2007). Networks have undoubtedly been emphasized in economy and society long before Castells (Bridge and Watson 2003, 107), but none of the earlier works used network as the basic category of the analysis of capitalist system as Castells did in his theory.

5. Discussion

In numerous evaluations of his trilogy, Castells is usually unquestioningly applauded for identifying the profound social trends and their inter-relationships and for describing them with illustrative concepts that are incorporated into his social theoretical framework (Giddens 1996; Wilenius1998; Fischer 1999; Heiskala 2003). On the other hand, *The Information Age* does not critically analyze the themes it covers, why references to alternative approaches, theories and concepts remain superficial or mostly non-existent (Iyer 1999). The thematically broad agenda of the trilogy actually includes quite a lot of conclusions, which cannot be derived from the given premises, and generalizations that are too bold. Moreover, Castells' affinity with novel, emerging forms of social life increases the sketchiness and the imprecision of his generalizations (Barney 2004). These points are good to keep in mind when assessing his way of understanding and using the concept of network.

To begin with, Castells uses network as a theoretical concept that refers to the general form of social organization and development, which can be best referred to as a network metaphor as it lacks explanatory accuracy and analytical depth concerning the dynamics of networks. As an analytical concept network is abstract, and thus unable to frame the interpretation of real-life networks, whereas as a theoretical concept network is actually an excellent crystallization of the social morphology of informational capitalism. As an upshot of the latter, the concept of network society has a certain intellectual appeal, even if it looks almost as if the formal description of the concept of network was needed only to legitimate its use as a metaphor. Concerning the hard core of the metaphor, we come to the true message of Castellsian political economy: the network in its paradigmatic form is about the nodes and connections of multinational corporations and powerful economic institutions that process flows of values in pursuit of the accumulation of capital. Such networks of instrumental exchanges are challenged by social movements and people with their historical and locally-rooted identities, which are a source of genuine human meaning as opposed to global instrumentality. Hence the fundamental tension between the Net and the Self. Such a view echoes Castells' early adherence to Marxist analysis, even if purged of ideological fixities.

Castells built an insightful analysis, which was seemingly affected by a soft version of technological determinism. It was, however, surpassed by structurally oriented social determinism as evidenced by the "axiomatic" use of network. Concerning the interplay of these two forms of determinism, it is worth noting that in the 1990s, when new technologies penetrated developed countries and appeared to shape all aspects of capital accumulation and professional and everyday life, the use of informationalism and network logic to explain novel phenomena started to produce diminishing returns. The explanatory scheme that appeared to work well with the macro theoretical analysis in *The Informational City* and *The Information Age* trilogy at a later stage became disruptive when more nuanced analyses of social reality were clearly needed. As aptly pointed out by Harris (2010, 409) in his review of Castells' book *The Internet Galaxy*, the book in question offers a distinctive antidote to the teleology and hype on Internet and ICTs but,

> *"... stops short of explaining the consequences of these technologies in purely 'political' terms, relying instead on the network metaphor to unravel the complexities and contradictions of the digital age."*

In the same vain, to explain what Castells wanted to explain in *Networks of Outrage and Hope* would have required a more nuanced understanding of the Internet and social media in everyday life, as pointed out by Barassi (2013) and Fuchs (2012). Castells perceives protest movements essentially as autonomous communication networks supported by the Internet and wireless communication irrespective of the actual penetration, use, and significance of ICTs in the given real-life setting. Likewise, if everything from Facebook to protests in the streets of Seattle or New York to an interconnected stock market system is explained in terms of network logic, the ability to accurately account for their emergence, forms, and operations becomes difficult. In such analyses the metaphorical use of the concept of network appears to be a social counterpart of technological determinism with less and less relevance as a formal conceptual tool.

Conclusion

The point of departure of Castells' intellectual conviction was Marxist urban sociology, which over the years developed into a social critique of the network society. Networks came into the picture as late as in the latter half of the 1980s, when Castells devoted himself to the macro-theoretical analysis of the relationship between technology, economy, and society, which culminated in the breakthrough trilogy, *The Information Age* (Castells 1996; 1997a; 1998). At this point the critical role of networks for social theory became apparent. Castells came to the conclusion that the concept of information society should be replaced by the notion of network society. This solution did not necessarily go from bad to any better, as pointed out by Kasvio (2005), but showed in any case how Castells distanced himself from conventional information society theories and the sociology of knowledge.

The reviewers of Castells' trilogy and of a series of books that followed it (Castells 2001; 2009; 2012) have repeatedly pointed out the deficiencies of his conceptualization of network and the obvious lack of related empirical evidence. Indeed, the institutional or metaphorical use of the network concept in theory building has a tendency to reify networks and limit our understanding of their inner logic. In spite of leaving social relations within networks only implicit, Castells was nevertheless able to demonstrate the power of institutional concept of network as a constitutive element of his grand theory. Retrospectively, Castells' theory of network society served as a long awaited structural framework for understanding contemporary societies and the human condition in a globalized world. It is a source of inspiration for those wishing to develop ideas for institutional renewal and contextualize the aspects of living in the global. It paints a rich picture of contemporary society, which in the spirit of C. Wright Mills' (1959) idea of sociological imagination helps us to conceive of ourselves as humans in a rapidly changing world capable of resisting the pervasive instrumentality exuded from the pores of global informational capitalism.

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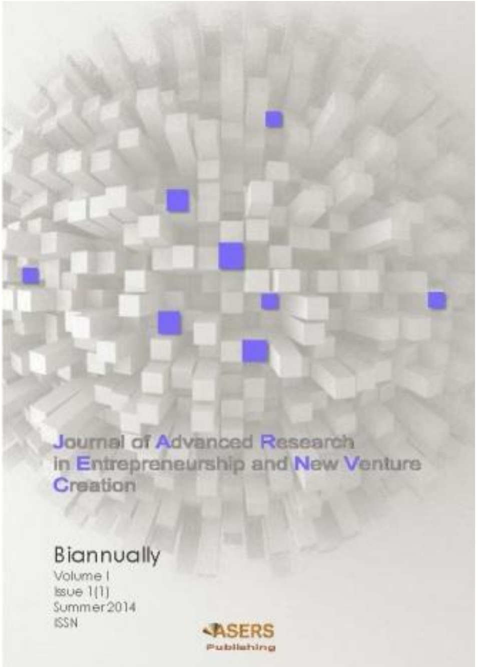

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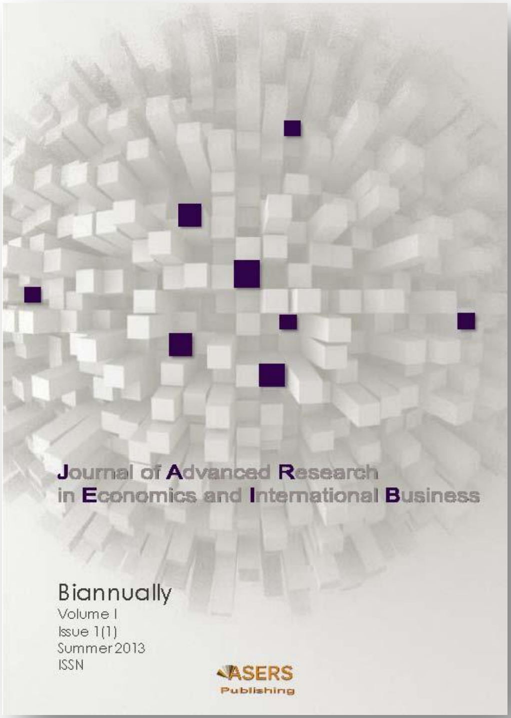

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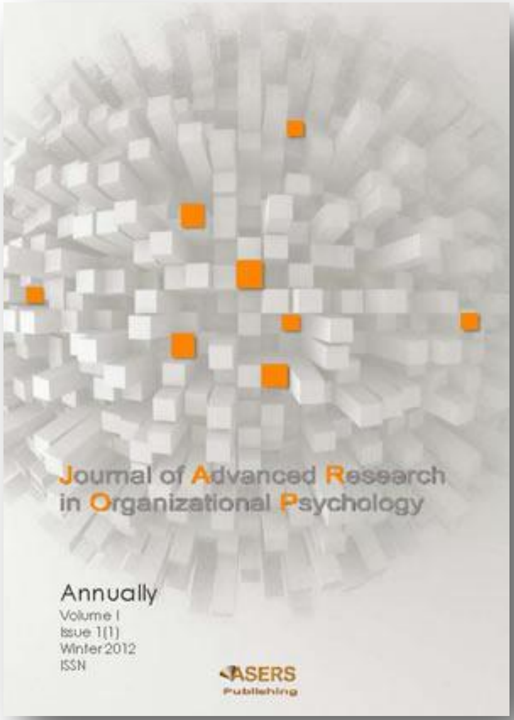

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Journal of Advanced Research in Organizational Psychology, starting with its first issue, will be indexed in RePEC, and CEEOLdatabases.

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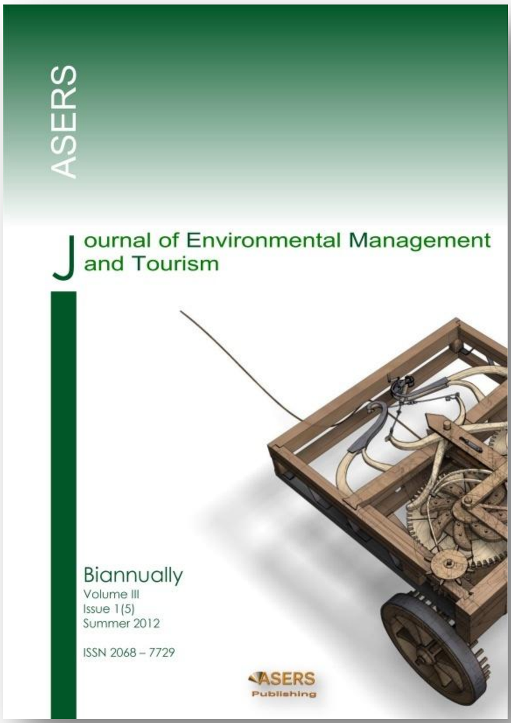

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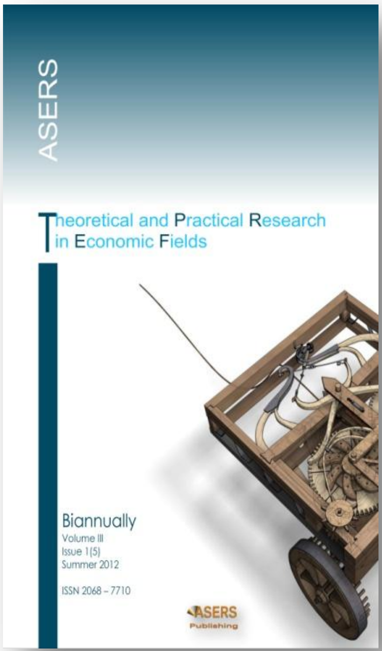

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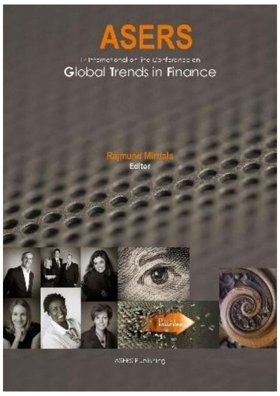

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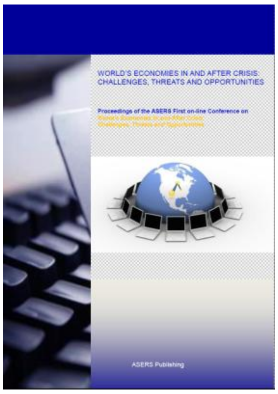

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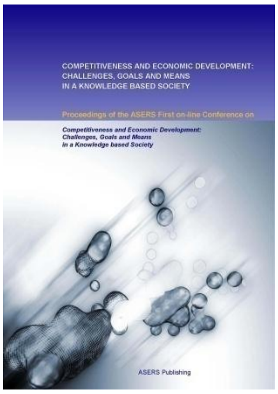

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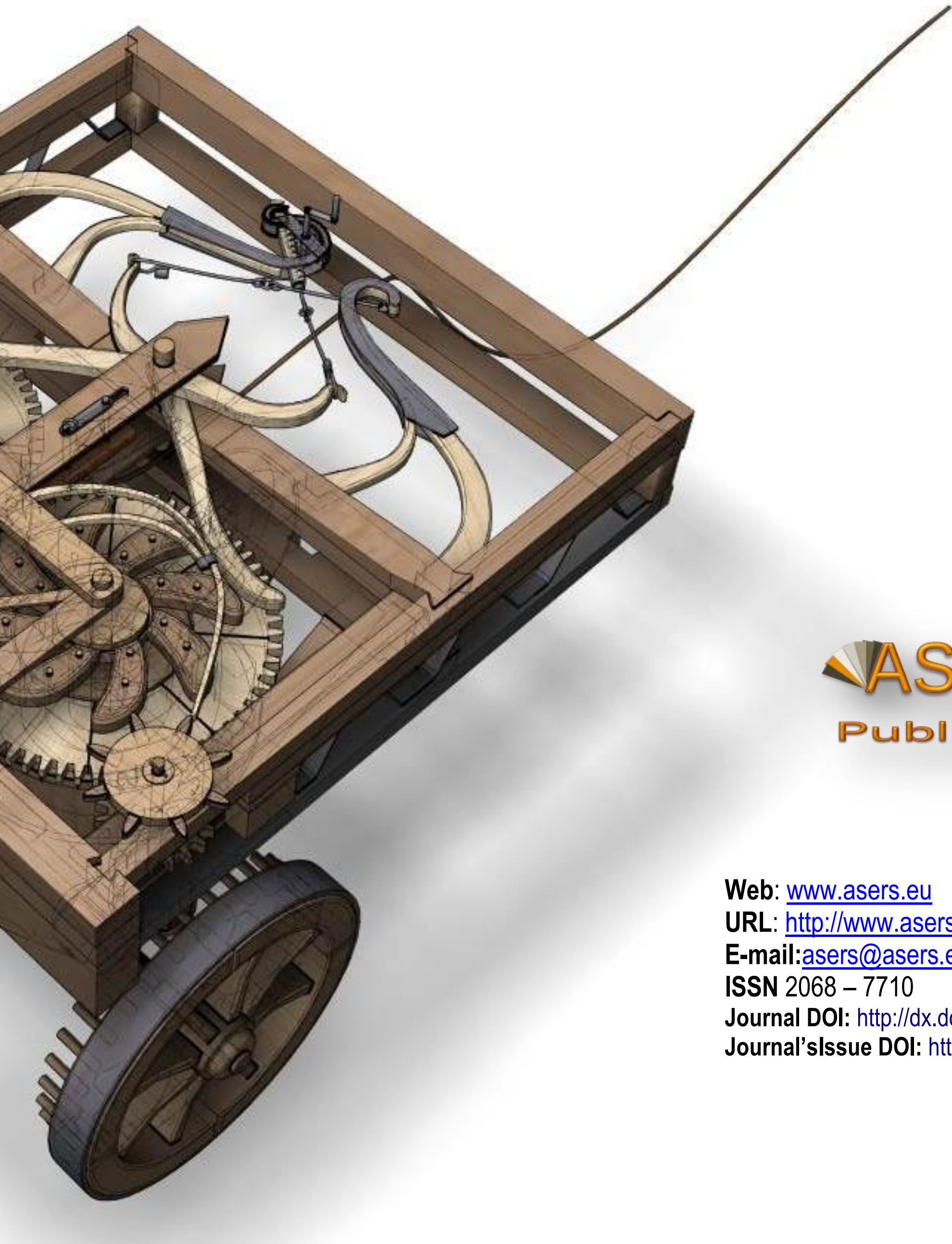

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