Asymmetric Shocks and Regional Risk Sharing: Evidence from Japan

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We use the methodology of Kalemli-Ozcan, Sørensen, and Yosha (2003) to calculate the degree of insurance among the Japanese prefectures. Prefectural-level data for fiscal years 1975 to 1999 are used to analyze the impact of idiosyncratic shocks to regional income. The results indicate that about 20 percent of idiosyncratic shocks to regional income are absorbed by inter-regional income insurance through the capital market, about 10 percent is absorbed by the national government through the inter-regional tax transfer system, and about 60 percent is absorbed as a result of changes in saving and dissaving.

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I. Introduction

Even after the successful launch of the euro on January 1, 1999 and the circulation of euro-denominated banknotes and coins in January 2002, many economists and policymakers are still concerned with a difficult question: exactly how should a central bank react to region-specific shocks within a monetary union? In response, economists have conducted numerous empirical analyses regarding the necessity of central fiscal policy to guard against asymmetric shocks, particularly using state-level data in the United States (see Kletzer and von Hagen [2000] and Mélitz [2004, section 1] for a recent review). These studies have generally indicated that fiscal transfers may be significant in some existing monetary unions, but it is nevertheless difficult to conclude how important it is in practice for the stabilization of the regional economies.

As part of this body of work, Asdrubali, Sørensen, and Yosha (1996) (hereafter, ASY [1996]) propose a straightforward method for estimating the degree of regional income and consumption smoothing via insurance and credit. Their method essentially comprises the decomposition of cross-sectional variance in gross U.S. state product into four parts: fractions of shocks to gross state product smoothed via capital markets, fractions of shocks to gross state product smoothed by the federal fiscal system, fractions of shocks to gross state product smoothed by credit markets, and an unsmoothed residual fraction. According to ASY (1996), over the period 1963–90, 39 percent of shocks to gross state products are smoothed via capital markets, 13 percent are smoothed by the federal government, and 23 percent are smoothed by credit markets. The remaining 25 percent are unsmoothed.

Mélitz and Zumer (1999) propose some modifications to the methods by ASY (1996), but U.S. data from 1964 to 1990 yield results similar to ASY (1996). Likewise, pooling estimates based on Canadian data from 1962 to 1994 also support the findings of ASY (1996): 30 percent of shocks to gross provincial products are smoothed via capital markets, 8 percent are smoothed by the federal government, and 25 percent are smoothed by credit markets. However, the pooling estimates using U.K. data from 1972 to 1996 and Italian data from 1984 to 1992 do not yield statistically significant estimates of shocks smoothed either by the federal government or by credit markets.

Kalemli-Ozcan, Sørensen, and Yosha (2003) (hereafter KSY [2003]) go one step further to investigate the empirical relation between risk sharing and specialization in production (i.e., the supply side of the economy). KSY (2003) consider various groups of regions and countries (U.S. states, the Japanese prefectures, European Community countries) and (1) calculate the degree of insurance among members of the group, (2) compute an index of industrial specialization for each region within the group, and (3) check whether a high degree of insurance within a group is associated with high specialization of regions. They find that there is more risk sharing among regions within countries than among countries, and that regions within countries are more specialized than countries as a whole. Regarding Japan, KSY (2003) use Japanese data from 1975 to 1993 and find that 21.6 percent of shocks to gross prefectural product are smoothed via capital markets and only 2.7 percent are unsmoothed. KSY (2004) provide a summary of the literature and report updates based on the data up until 1999.

Mélitz (2004) also includes a useful survey of the literature, especially regarding evidence from the European economies.

In this paper, we employ the methodology of KSY (2003) to calculate the degree of insurance among the Japanese prefectures.[1] Our contribution is novel because we (1) use the more recent data up to 2001 to update their results, (2) try to use various combinations of macroeconomic variables employed for estimation, (3) examine the subsample properties of estimates of the shocks smoothed via capital markets and by the national government and credit markets, and (4) employ more detailed data to provide new estimates of fractions of shocks to gross prefectural product smoothed by the national government in Japan, which KSY (2003) do not provide.

In addition, we believe our study is important for at least three reasons. First, as suggested by Mélitz and Zumer (1999, 2002) and Mélitz (2004), the analysis in this framework might not be robust to the choice of monetary union and macroeconomic variables. It is then useful to examine their methods based on more detailed Japanese data sets. Second, Japanese macroeconomic data show the slowdown of the growth rate after the collapse of the bubble economy in the early 1990s. It is then necessary to investigate to what extent the analysis of KSY (2003) is robust to the choice of sample period. Finally, recent political debate in Japan stresses the need for more independent regional governments in terms of both regional fiscal policy and the tax base. This debate requires a reasonable understanding of the current situation of risk sharing across the prefectures, especially by means of nationwide fiscal policy. For example, is the fraction of shocks to Japanese gross prefectural product smoothed via capital markets and credit markets higher or lower than those smoothed by the national government? Unfortunately, KSY (2003) do not examine this owing to data limitations. In the following discussion, we address this important point.

Importantly, we do not claim that our study is the first to examine Japanese cross-regional risk sharing, consumption smoothing, or even the correlation between saving and investment, since there are many studies that deal with these questions. For example, van Wincoop (1995) examines the cross-correlation of consumption and output across the Japanese prefectures in the period between 1970 and 1989. Iwamoto and van Wincoop (2000) analyze saving and investment relationships within the Japanese regions from 1975 to 1990, by employing the framework of Feldstein and Horioka (1980), and find that the correlation is significantly lower than that for Organisation for Economic Co-operation and Development (OECD) countries.[2] Doi (2000) first applies the methodology of KSY (2003) to Japanese data from 1956 to 1996. We use more recent data up to 2001.

The paper itself is structured as follows. Section II explains the model first proposed by ASY (1996) and the recent KSY (2003) model. Section III discusses the data sets used in our study. Section IV reports the results of the analysis based on our

1. See Asdrubali and Kim (2004) for further improvement on methodology using a structural vector autoregression model.
2. Yamori (1995) and Dekle (1996) also apply the methods proposed by Feldstein and Horioka (1980) to Japanese regional data.

main data set. Section V reports the results of sensitivity testing of the choice of macroeconomic variables. Section VI summarizes our findings and discusses some policy implications. Section VII concludes.

II. Model

KSY (2003) use two measures of regional risk sharing. Their method follows pioneering work by ASY (1996), which proposes a measure to decompose the cross-sectional variance into the variations smoothed by the capital market, by the federal tax system, and by credit markets. The decomposition of period-by-period, cross-sectional variance in regional income is as below. We define Y_1 as regional income without any smoothing, such as regional GDP. We assume that Y_1 is homogenous nondurable goods, and that there is no capital gain and capital loss. We define Y_2 as regional income smoothed only through capital markets, such as regional GNP that includes dividend, interest, and rental income from other regions. We define Y_3 as regional income smoothed through the national government as well as capital markets, such as disposable income (i.e., regional income net of tax and transfer across regions). Finally, let C be regional consumption.

Consider the identity,

$$Y_{1it} = \frac{Y_{1it}}{Y_{2it}} \frac{Y_{2it}}{Y_{3it}} \frac{Y_{3it}}{C_{it}} C_{it}, \tag{1}$$

where subscript t denotes time, and subscript i denotes the region. Taking logs and differences, multiplying both sides by $\Delta \ln Y_{1it}$ and taking expectations, we obtain the following decomposition of cross-sectional variance in $\Delta \ln Y_{1it}$ for fixed t.

$$\begin{aligned} Var(\Delta \ln Y_{1it}) &= Cov(\Delta \ln Y_{1it}, \Delta \ln Y_{1it} - \Delta \ln Y_{2it}) + Cov(\Delta \ln Y_{1it}, \Delta \ln Y_{2it} - \Delta \ln Y_{3it}) \\ &\quad + Cov(\Delta \ln Y_{1it}, \Delta \ln Y_{3it} - \Delta \ln C_{it}) + Cov(\Delta \ln Y_{1it}, \Delta \ln C_{it}). \end{aligned} \tag{2}$$

Dividing both sides of the equation by the variance of $\Delta \ln Y_{1it}$, we obtain an identity:

$$1 = \beta_K + \beta_T + \beta_C + \beta_U, \tag{3}$$

where β_K is the ordinary least square (OLS) estimate of the slope in the regression of $\Delta \ln Y_{1it} - \Delta \ln Y_{2it}$ on $\Delta \ln Y_{1it}$, β_T is the OLS estimate of the slope in the regression of $\Delta \ln Y_{2it} - \Delta \ln Y_{3it}$ on $\Delta \ln Y_{1it}$, β_C is the OLS estimate of the slope in the regression of $\Delta \ln Y_{3it} - \Delta \ln C_{it}$ on $\Delta \ln Y_{1it}$, and β_U is the OLS estimate of the slope in the regression of $\Delta \ln C_{it}$ on $\Delta \ln Y_{1it}$.

To measure these four fractions, ASY (1996) suggest the following panel regression:

$$\Delta \ln Y_{1it} - \Delta \ln Y_{2it} = v_{Kt} + \beta_K \Delta \ln Y_{1it} + \epsilon_{Kit}, \tag{4}$$

$$\Delta\ln Y_{2it} - \Delta\ln Y_{3it} = v_{Tt} + \beta_T \Delta\ln Y_{1it} + \epsilon_{Tit}, \tag{5}$$

$$\Delta\ln Y_{3it} - \Delta\ln C_{it} = v_{Ct} + \beta_C \Delta\ln Y_{1it} + \epsilon_{Cit}, \tag{6}$$

$$\Delta\ln C_{it} = v_{Ut} + \beta_U \Delta\ln Y_{1it} + \epsilon_{Uit}, \tag{7}$$

where v_{jt} is a time-fixed effect that captures the within-group undiversifiable fluctuations ($j = K$, T, C, and U). To estimate equations (4)–(7), ASY (1996) employ regional GDP per capita for Y_1 and market-price regional income per capita for Y_2, market-price regional disposal income per capita for Y_3, and regional retail sales per capita for C (hereafter we use all the variables on a constant price basis deflated by the regional consumer price index [CPI], and a per capita basis without any special notation).

Following ASY (1996), KSY (2003) estimate equation (4) using regional GDP for Y_1 and regional personal income for Y_2. Suppose that Y_1 is an exogenous variable, and that it is composed of homogenous nondurable goods. If the idiosyncratic part of fluctuations in Y_2 is *ex ante* perfectly insured within the group, say, by the cross-holding of assets among regions through the capital market, each region's Y_2 should not be affected by the idiosyncratic fluctuations of Y_1, and Y_2 should be equal to some constant value captured by v_{Kt}. Thus, β_K in equation (4) must equal unity. Suppose then that Y_2 is not perfectly insured within the group. If there is no insurance in Y_2, then Y_2 and Y_1 must co-move perfectly, and thus β_K will be zero. In this way, the fraction of idiosyncratic shocks to Y_1 that is absorbed by inter-regional income insurance through capital markets is measured by β_K.

KSY (2000) consider the second panel regression, which is not analyzed in KSY (2003), across the regions that constitute a risk-sharing group:

$$\Delta\ln Y_{1it} - \Delta\ln Y_{3it} = v_{K+Tt} + \beta_{K+T} \Delta\ln Y_{1it} + \epsilon_{K+Tit}, \tag{8}$$

where Y_3 indicates income smoothed through the national (federal) government as well as capital markets, and v_{K+Tt} is a time-fixed effect. In practice, KSY (2000) use personal disposable income for Y_3. The coefficient β_{K+T} in equation (8) measures the fraction of idiosyncratic shocks to Y_1 absorbed not only by capital markets but also by the national government; that is, the inter-regional tax transfer system. Since equation (8) is obtained by summing equation (4) and (5), $\beta_T = \beta_{K+T} - \beta_K$ measures the insurance through the national government. KSY (2000) do not estimate equation (8) for Japan because of the lack of a suitable data series, but we will attempt the estimation of this equation armed with detailed data sets of prefectural System of National Accounts (SNA) statistics and our own estimates of personal disposable income and personal income.

KSY (2003) consider another measure of regional risk sharing. Suppose that the representative consumer in each region is risk averse and maximizes his/her lifetime expected utility from consumption. If the utility function is constant relative risk aversion, and all regions have the same discount factor, perfect *ex ante* risk sharing of income (namely, consumption equals to income) implies that regional consumption and income are proportional to aggregate consumption and aggregate income. If full risk sharing is achieved *only after* income insurance and consumption smoothing, then regional consumption is proportional to aggregate consumption. Reason further that income insurance through capital markets and the national government and consumption smoothing are perfect. Then, regional consumption must co-move with group-wide Y_1 as well as group-wide Y_2, each region's consumption should not be affected by the idiosyncratic fluctuations of Y_1, and each region's consumption should be equal to v_{K+T+Ct}, a time-fixed effect that captures the nondiversifiable fluctuations of within-group Y_1. Thus, β_{K+T+C} must be unity in the following regression equation (9), if there is perfect inter-regional overall income and consumption smoothing:

$$\Delta \ln Y_{1it} - \Delta \ln C_{it} = v_{K+T+Ct} + \beta_{K+T+C} \Delta \ln Y_{1it} + \epsilon_{K+T+Cit}, \tag{9}$$

where C is consumption and v_{K+T+Ct} is a time-fixed effect that captures the undiversifiable fluctuations of within-group Y_1. On the other hand, β_{K+T+C} will be zero with no income and consumption smoothing. Since equation (9) is the sum of equations (4), (5), and (6), it is easy to compute the fraction of the idiosyncratic shock smoothed by the changes in saving and dissaving typically instigated by the credit markets after the realization of the idiosyncratic shock once we recognize the role of the national government by $\beta_C = \beta_{K+T+C} - \beta_T - \beta_K$.

Let us summarize the relationship with other studies on consumption before moving on to the details of the data (see KSY [2004, section 2] for an extensive literature review). First, we rearrange equation (9) and obtain the following:

$$-\Delta \ln C_{it} = v_{K+T+Ct} + (\beta_{K+T+C} - 1)\Delta \ln Y_{1it} + \epsilon_{K+T+Cit}. \tag{10}$$

Note that equation (10) is almost the same as Cochrane's (1991) empirical model, which assumes full risk sharing, such that $(\beta_{K+T+C} - 1)$ is zero.[3] Cochrane (1991) measures whether the consumption of economies responds only to aggregate shocks or not. The focus here is the measurement of the fraction of region-specific Y_1 shocks absorbed through the various channels of inter-regional insurance. Second, if we add the real interest rate to the right-hand side of equation (10) instead of time-fixed effects, the empirical model is the same as that found in Campbell and Mankiw (1989) with the "rule-of-thumb" consumers subject to a liquidity constraint. However, Campbell and Mankiw's (1989) main motivation is to verify the permanent income hypothesis, and accordingly they emphasize the time-series direction of the regression, while our analysis places more emphasis on its cross-sectional direction. Moreover, the coefficient β_{K+T+C} measures all inter-regional income insurance through capital markets and the national government as well as the credit market. In this way, we interpret the degree of overall income and consumption smoothing against the idiosyncratic regional shock to Y_1 as measured by three sources: first, the fraction of the idiosyncratic shock smoothed by cross-holding of financial assets (*ex ante* insurance) measured by β_K; second, the fraction of the idiosyncratic shock smoothed by net inter-regional

3. To be precise, Cochrane (1991) used various data series other than income data for the right-hand-side variable, primarily because he regarded income as endogenous.

transfer made by the national government (instigated after the realization of the idiosyncratic shock) measured by β_T; and third, the fraction of the idiosyncratic shock smoothed by the changes in savings and dissavings typically instigated by the credit markets after the realization of the idiosyncratic shock once we recognize the role of the national government, measured by β_C. We believe that the estimates of the degree of overall income and consumption smoothing against the idiosyncratic regional shock will help us to measure the effectiveness of inter-regional consumption and income smoothing in Japan as a currency area. We hope that these results will then assist the quantitative evaluation of the status quo prior to the debate on the need for more independent fiscal policies by Japanese regional governments.

III. Data

In this section, we explain the details of the data series used in our study. We require data on income without any smoothing (Y_1), income smoothed only through capital markets (Y_2), income smoothed through capital markets and the national government (Y_3), and consumption (C). We use four sets of proxy variables for Y_1, Y_2, and Y_3. Our preferred statistic to obtain the effects of income smoothing is net market-price base variables. Market-price base data are measured by the market price, while factor cost base data are market-price base data minus net indirect tax (indirect tax on products minus subsidies). Net base data and gross base data differ in their valuations of depreciation cost.[4]

We prefer net market-price basis data because the proxy variables for Y_1, Y_2, and Y_3 exclude depreciation cost in a consistent manner for our analytical requirements. Our preference is not based on any economic model, but solely on the consistency between statistical definitions of Japanese prefectural SNA statistics, which might affect the estimates of β_K, β_T, and β_C.

The remaining three data sets include the variables suggested by ASY (1996) and KSY (2000, 2003). These data sets have some shortcomings in light of the consistency of construction of statistics, and we use them in sensitivity checks. More specifically, the second data set includes regional GDP and market-price regional income as suggested by ASY (1996). The third data set collects gross market-price base variables proposed in KSY (2003). The fourth data set is for the replication of the results reported by KSY (2003).

A. Benchmark Data: Data Based on Net Market-Price Basis Data

We first construct benchmark data: net market-price data. We begin by defining C and Y_3. Then we subtract accounting items that reflect income transfer by the national government and capital markets to construct Y_2 and Y_1. We use two consistent annual data series on prefectural SNA statistics compiled by the Economic and Social Research Institute, Cabinet Office of Japan. These data series are the prefectural-level

4. The accounting item that makes the difference between the gross base data and net base data is “consumption of fixed capital.” In practice, valuation with depreciation (including consumption of fixed capital) is gross base data, and valuation net of depreciation (excluding consumption of fixed capital) is net base data.

counterpart of the national income account. The first series is available from fiscal 1990 (hereafter all years refer to the Japanese fiscal year, which runs from April to March of the following year) to 2001, and is based on the 1993 SNA methodology. The second series is from 1975 to 1999, and is based on the 1968 SNA methodology.

Regarding consumption data, we use total final consumption expenditure (the sum of private final consumption expenditure and government final consumption expenditure) for C, because we make the assumption that each prefecture is an economic agent. The data series on total final consumption expenditure is available in the prefectural SNA statistics.

As for data on Y_3, we use prefectural disposable income data for Y_3, because prefectural disposable income is income data smoothed through the capital markets as well as the federal tax and transfer. In practice, we use disposable income in the prefectural SNA statistics for prefectural disposable income data.

Y_2 is prefectural disposable income, Y_3, less the national government's income transfers, which are specifically referred to as "other net transfers" in the SNA statistics. Because, as the first and second rows in the upper panel of the Figure 1 show, prefectural disposable income is the sum of "other net transfers" and market-price prefectural income, market-price prefectural income is Y_2, income smoothed through the capital markets.

Y_1 is Y_2 minus income transfer through the capital markets, which is referred to as "net factor income transfer from outside the prefecture" in the SNA statistics.[5] Because, as the second and third rows in the upper panel of Figure 1 show, the sum of market-price prefectural income Y_2 and "net factor income transfer from outside the prefecture" is prefectural net domestic product (NDP), Y_1. In practice, we estimate prefectural NDP by subtracting consumption of fixed capital from prefectural GDP, as the third and fourth rows of the upper panel of the Figure 1 show. The upper panel of Figure 1 shows that the three data series in our benchmark data set consistently include net indirect tax and consistently exclude consumption of fixed capital. Based on this consistency, we consider that these market-price basis data give us reasonable estimates of β_K, β_T, and β_C.

Following KSY (2003), we use prefectural CPI as the deflator to obtain constant values. In addition, all of these data series are adjusted to a per capita basis, using population data provided in the prefectural SNA statistics.

B. Data Based on GDP and Market-Price Prefectural Income

ASY (1996) suggest the use of prefectural GDP and market-price regional income to estimate β_K. To follow this suggestion, we make one change in our choice of variable compared with our baseline data set. Regarding Y_1, we use prefectural GDP, rather

5. Net factor income transfer from outside the prefecture includes not only capital income but also labor income transfer. Around a large city area, it is quite plausible that a worker might earn earnings from a business in the neighboring prefecture. Therefore, estimates of β_K based on this data may not reflect just the smoothing of income through capital markets.

We aggregate the prefectures around the large economic centers to cope with this problem. We regard the greater Tokyo region (Tokyo, Kanagawa, Chiba, and Saitama), the Tokai region (Aichi, Gifu, and Mie) and the Kansai region (Osaka, Kyoto, Hyogo, Shiga, Wakayama, and Nara) as three large prefectures. However, estimation results do not differ much from the ones obtained from our original data set. Therefore, the commuter effect seems to be negligible.

Figure 1 Comparison of Income Data

[1] Benchmark Data

Prefectural disposable income (Y_3)

NFITOP	*PFI*	*NIT*	*ONT*

Market-price prefectural income (Y_2)

NFITOP	*PFI*	*NIT*

Prefectural NDP (Y_1)

	PFI	*NIT*

Prefectural GDP [Reference]

	PFI	*NIT*	*CFC*

[2] Data Based on Prefectural GDP and Market-Price Prefectural Income (Following ASY [1996])

Prefectural disposable income (Y_3)

NFITOP	*PFI*	*NIT*	*ONT*

Market-price prefectural income (Y_2)

NFITOP	*PFI*	*NIT*

Prefectural GDP (Y_1)

	PFI	*NIT*	*CFC*

[3] Data Based on Gross Market-Price Data (Following KSY [2003])

Prefectural disposable income (Y_3)

NFITOP	*PFI*	*NIT*	*ONT*

Prefectural GNP (Y_2)

NFITOP	*PFI*	*NIT*	*CFC*

Prefectural GDP (Y_1)

	PFI	*NIT*	*CFC*

Notes: *NFITOP*: Net factor income transfer from outside the prefecture.
PFI: Prefectural factor income.
NIT: Net indirect tax.
ONT: Other net transfers.
CFC: Consumption of fixed capital.

than prefectural NDP. We use market-price prefectural income for Y_2, prefectural disposable income for Y_3, and consumption data as our benchmark data set does.

We point out one shortcoming in this data set. As the middle panel of Figure 1 shows, the estimates of β_K based on this data set include not only the effect of net factor income transfer from outside the prefecture, but also the effect of consumption of fixed capital. This is because prefectural GDP contains consumption of fixed capital, while market-price prefectural income does not. This point is clearly demonstrated in the middle panel of Figure 1.

C. Data Based on Gross Market-Price Basis Data

We consider another set of income data to follow the suggestion of KSY (2003). We make two changes in our choice of variables compared with our baseline data set. Regarding Y_1, we use prefectural GDP, rather than prefectural NDP. As regards Y_2, we use prefectural GNP for Y_2, rather than market-price prefectural income.[6]

This data set has a similar shortcoming to that of the previous subsection. As the bottom panel of Figure 1 shows, both prefectural GDP and prefectural GNP include consumption of fixed capital, while prefectural disposable income does not. Thus, β_{K+T} measures the effect of consumption of fixed capital in addition to other net transfers and net factor income transfer from outside the prefecture.

D. Data to Replicate Kalemli-Ozcan, Sørensen, and Yosha (2003)

To replicate KSY (2003), we use prefectural GDP for Y_1, prefectural personal income for Y_2, and prefectural personal disposable income for Y_3. Note that KSY (2003) suggest using alternative macroeconomic variables, given their limitation of data as we have seen in the previous subsections. Thus, the replication is for the sake of comparison only.

On the subject of Y_2, prefectural personal income roughly corresponds to market-price prefectural income distributed to households and private nonprofit institutions serving households.[7] In practice, we estimate the data series on prefectural personal income because prefectural personal income is not reported in the prefectural SNA statistics. The appendix explains the estimation method in detail. With Y_3, prefectural personal disposable income corresponds to prefectural disposable income distributed to households and private nonprofit institutions serving households minus employer contributions for social insurance. In practice, as prefectural personal disposable income is not reported in the prefectural SNA statistics, we must estimate this data series. The appendix also explains the estimation method in detail.[8]

6. In practice, we use gross national expenditure data series in the prefectural SNA statistics for prefectural GNP data.

7. Prefectural personal income differs from prefectural income in three respects. First, prefectural personal income covers only households and private nonprofit institutions serving households, while prefectural income covers all the economic agents consisting of nonfinancial corporations, financial corporations, and the government in addition to households and private nonprofit institutions serving households. Second, prefectural personal income does not include employer contributions for social insurance, which is included in prefectural income. Third, prefectural personal income includes transfer payments to persons minus personal contributions for social insurance, which can be considered as "other net transfers" other than payment of direct tax.

8. KSY (2003) use prefectural GDP for Y_1, prefectural personal income for Y_2, and prefectural total consumption for C, obtained from National Accounts Japanese Prefectural Data (Sinfonica) in estimating equations (4) and (9) using the sample from 1975 to 1993. However, as mentioned above, KSY (2003) do not estimate equation (8) for Japan because they do not have personal disposable income, which could be used for Y_3.

E. Summary Statistics

The discussion above shows that our statistically consistent and preferred data set is net market-price basis data. The other two data sets are quite likely to yield biased estimates. Before moving on to the regression analyses, Tables 1 and 2 provide summary statistics for the data. All data series are on a per capita constant price basis, with annual changes in percentage points. Table 1 shows the summary statistics of changes in these variables based on the 1968 SNA. Table 2 shows the summary statistics based on the 1993 SNA. Tables 3 and 4 report the correlation matrix based on the 1968 SNA and 1993 SNA. Data series within the groups of Y_1, Y_2, Y_3, and C are positively correlated. However, the sizes of correlation coefficients are not uniformly high even within the group, depending on the choice of accounting methods, such as net or gross, or focusing on the entire prefecture or a subset of economic agents in a prefecture, and so forth. These results casually suggest that the choice of macroeconomic variables affects the results of the following econometric exercise. We will see the details in the following sections.

Table 1 Data Description: 1968 SNA

		Number of observations	Mean	Standard deviation	Min.	Max.
Y_1	Prefectural NDP	898	1.78	3.00	–10.18	14.82
	Prefectural GDP	1,128	2.07	2.80	–9.32	14.17
Y_2	Market-price prefectural income	913	1.95	3.01	–9.76	13.13
	Prefectural GNP	1,128	2.17	2.83	–8.96	16.59
	Prefectural personal income	1,126	1.42	3.72	–16.36	16.43
Y_3	Prefectural disposable income	788	2.01	2.97	–9.53	17.29
	Prefectural personal disposable income	1,126	1.35	3.84	–16.00	15.48
C	Total consumption	1,128	2.03	1.93	–5.77	13.80

Note: All the figures are computed based on the change rate of real and per capita data series, and all the figures except for the number of observations are on a percentage basis.

Table 2 Data Description: 1993 SNA

		Number of observations	Mean	Standard deviation	Min.	Max.
Y_1	Prefectural NDP	506	–0.15	2.38	–8.02	6.54
	Prefectural GDP	517	0.32	2.19	–6.46	6.64
Y_2	Market-price prefectural income	506	0.02	2.54	–6.80	6.83
	Prefectural GNP	517	0.46	2.34	–5.87	6.02
	Prefectural personal income	517	0.18	3.21	–9.97	19.26
Y_3	Prefectural disposable income	495	0.50	2.51	–8.26	10.78
	Prefectural personal disposable income	517	0.50	3.57	–10.51	9.93
C	Total consumption	517	1.50	1.80	–6.45	7.56

Note: All the figures are computed based on the change rate of real and per capita data series, and all the figures except for the number of observations are on a percentage basis.

Table 3 Correlation Matrix: 1968 SNA

			Y_1		Y_2			Y_3		C
			(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Y_1	Prefectural NDP	(a)	1.000							
	Prefectural GDP	(b)	0.986	1.000						
Y_2	Market-price prefectural income	(c)	0.888	0.881	1.000					
	Prefectural GNP	(d)	0.877	0.892	0.986	1.000				
	Prefectural personal income	(e)	0.570	0.586	0.679	0.696	1.000			
Y_3	Prefectural disposable income	(f)	0.798	0.795	0.905	0.891	0.603	1.000		
	Prefectural personal disposable income	(g)	0.504	0.520	0.611	0.624	0.937	0.557	1.000	
C	Total consumption	(h)	0.429	0.461	0.448	0.467	0.351	0.412	0.291	1.000

Note: Correlation coefficients are based on the change rate of real and per capita data series.

Table 4 Correlation Matrix: 1993 SNA

			Y_1		Y_2			Y_3		C
			(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Y_1	Prefectural NDP	(a)	1.000							
	Prefectural GDP	(b)	0.983	1.000						
Y_2	Market-price prefectural income	(c)	0.891	0.891	1.000					
	Prefectural GNP	(d)	0.882	0.910	0.986	1.000				
	Prefectural personal income	(e)	0.520	0.533	0.651	0.648	1.000			
Y_3	Prefectural disposable income	(f)	0.797	0.797	0.859	0.850	0.576	1.000		
	Prefectural personal disposable income	(g)	0.481	0.500	0.575	0.580	0.892	0.551	1.000	
C	Total consumption	(h)	0.404	0.445	0.416	0.452	0.334	0.411	0.274	1.000

Note: Correlation coefficients are based on the change rate of real and per capita data series.

IV. Main Results

This section first discusses the details of the empirical estimation. Then it presents the main results based on net market-price basis data: prefectural NDP for Y_1, market-price prefectural income for Y_2, and prefectural disposable income for Y_3. Finally, this section reports the subsample properties of our estimates.

A. Methods of Estimations

Our estimations are constructed as below. First, based on the entire sample, we estimate equation (4),

$$\Delta \ln Y_{1it} - \Delta \ln Y_{2it} = \nu_{Kt} + \beta_K \Delta \ln Y_{1it} + \epsilon_{Kit},$$

and obtain the estimates of $(100 \cdot \beta_K)$. Second, we estimate equation (9),

$$\Delta \ln Y_{1it} - \Delta \ln C_{it} = \nu_{K+T+Ct} + \beta_{K+T+C} \Delta \ln Y_{1it} + \epsilon_{K+T+Cit},$$

and obtain the estimates of $(100 \cdot \beta_{K+T+C})$.

Since the data limitation on prefectural disposable income forces us to reduce the number of observations available for the analysis, we repeat the analysis using the observations with prefectural disposable income. For those prefectures, we begin by estimating equation (4),

$$\Delta \ln Y_{1it} - \Delta \ln Y_{2it} = v_{Kt} + \beta_K \Delta \ln Y_{1it} + \epsilon_{Kit},$$

and obtain the estimates of $(100 \cdot \beta_K)$. Second, we estimate equation (8),

$$\Delta \ln Y_{1it} - \Delta \ln Y_{3it} = v_{K+Tt} + \beta_{K+T} \Delta \ln Y_{1it} + \epsilon_{K+Tit},$$

and obtain the estimates of $(100 \cdot \beta_{K+T})$. Finally, we estimate equation (9),

$$\Delta \ln Y_{1it} - \Delta \ln C_{it} = v_{K+T+Ct} + \beta_{K+T+C} \Delta \ln Y_{1it} + \epsilon_{K+T+Cit},$$

and obtain the estimates of $(100 \cdot \beta_{K+T+C})$. Using the relationship that $(100 \cdot \beta_{K+T+C}) - (100 \cdot \beta_{K+T}) = (100 \cdot \beta_C)$ and $(100 \cdot \beta_{K+T}) - (100 \cdot \beta_K) = (100 \cdot \beta_T)$, we compute the individual components of risk sharing.

We estimate equations (4), (8), and (9) in two steps to take the heteroskedasticity in the error terms into consideration. In the first step, we begin by estimating each equation separately by OLS, including fixed time effects into the regressor. We then estimate the variance of the error term in each prefecture from the residuals obtained from each equation. Armed with those estimates of variance, in the second step we correct the heteroskedasticity in the error term in each prefecture. Specifically, we estimate each equation by weighted least square (WLS) with fixed time effects. We call this method "WLS1."

Note that the regressors in the three equations are not common in WLS1, because the regressors are scaled by the size of variance obtained in each equation. Thus, the identity of variance decomposition expressed in equation (2) does not hold for WLS1.[9] To solve this problem, we also estimate the three equations based on a common variance estimate for each prefecture obtained from the OLS residuals of the three equations (4), (8), and (9). In this method, the identity of variance decomposition holds. We call this "WLS2."

9. To cope with this problem, we try to correct correlations in the error terms among the prefectures and equations, and autocorrelations in the error terms as suggested by ASY (1996) as follows. First, we estimate the matrix Ω of correlation between equations, covariance matrix of prefectures Γ, and the matrix of time-series autocorrelation R (assuming autoregressive order of one process) using OLS residuals. Second, we estimate the covariance matrix of error terms assuming that its structure is expressed by $\sum = \Omega \otimes \Gamma \otimes R$, and adjusting the size to meet our unbalanced observations to conduct the generalized least square estimation. However, our estimate of $\sum$ turns out to be non-positive-definite, and our estimate of $\sum$ does not satisfy the necessary condition for a valid estimate for a variance-covariance matrix. This problem may occur because the size of sample in each prefecture is too small to estimate precise Γ, as pointed out by ASY (1996).

B. Results Based on a Full Sample

We present the results based on net market-price basis data: prefectural NDP for Y_1, market-price prefectural income for Y_2, and prefectural disposable income for Y_3. The fourth and fifth rows of Table 5 show the results based on the 1968 SNA estimated by WSL1. We find the estimate of $(100 \cdot \beta_K)$ to be 23.9 percent, or 22.0 percent based on the sample from 1975 to 1999, which is close to the result reported by KSY (2003) (21.6 percent, 1975–93 data). The estimates of $(100 \cdot \beta_{K+T+C}$, 91.3 percent or 92.4 percent) are also similar to that of KSY (2003) (97.3 percent, 1975–93 data) based on the 1968 SNA data. As shown in the ninth and tenth rows of Table 5, WLS2 provides almost the same estimates.

Table 5 Estimation Based on Net Market-Price Basis Data

	Number of regions	Capital markets $100 \cdot \beta_K$ (percent)	Capital markets and national government $100 \cdot \beta_{K+T}$ (percent)	Overall income and consumption smoothing $100 \cdot \beta_{K+T+C}$ (percent)	Consumption smoothing $100 \cdot \beta_C$ (percent)
		Y_1 Prefectural NDP	Y_2 Market-price prefectural income	Y_3 Prefectural disposable income	C Total consumption
WLS1					
1968 SNA (1) (1975–99)	44	23.9 (1.5)	—	91.3 (1.7)	
1968 SNA (2) (1975–99)	41	22.0 (1.6)	30.6 (2.0)	92.4 (1.8)	61.8
1993 SNA (1) (1990–2001)	46	19.8 (1.9)	—	87.3 (2.4)	
1993 SNA (2) (1990–2001)	45	19.4 (1.9)	33.0 (2.5)	87.5 (2.5)	54.5
WLS2					
1968 SNA (1) (1975–99)	44	23.5 (1.7)	—	91.0 (1.7)	
1968 SNA (2) (1975–99)	41	22.4 (2.0)	30.5 (2.0)	92.3 (2.0)	61.8
1993 SNA (1) (1990–2001)	46	20.1 (2.4)	—	86.6 (2.4)	
1993 SNA (2) (1990–2001)	45	19.1 (2.6)	31.9 (2.6)	87.3 (2.6)	55.4

Note: Numbers in parentheses show the standard errors for the parameters. Estimates for 1968 SNA (1) are based on 898 unbalanced observations, while estimates for 1968 SNA (2) are based on 788 unbalanced observations, reduced owing to the lack of prefectural disposable income data. Correspondingly, estimates for 1993 SNA (1) are based on 506 balanced observations, while estimates for 1993 SNA (2) are based on 495 balanced observations. The balanced observations indicate that all the regions have the same number of observations, while the unbalanced observations indicate that at least one region does not have the same number of observations.

To assess the effects of choice of definition of the SNA statistics and sample period, we compare the estimates based on the 1968 SNA and 1993 SNA, focusing on the individual magnitude of $(100 \cdot \beta_K)$, $(100 \cdot \beta_T)$, and $(100 \cdot \beta_C)$ estimated based on WLS2. In the 11th and 12th rows of Table 5, $(100 \cdot \beta_K)$ takes only smaller values based on the 1993 SNA data compared with the 1968 SNA. However, the estimate of $(100 \cdot \beta_C)$ based on the 1993 SNA data takes a smaller value (55.4 percent) than that based on the 1968 SNA data (61.8 percent).

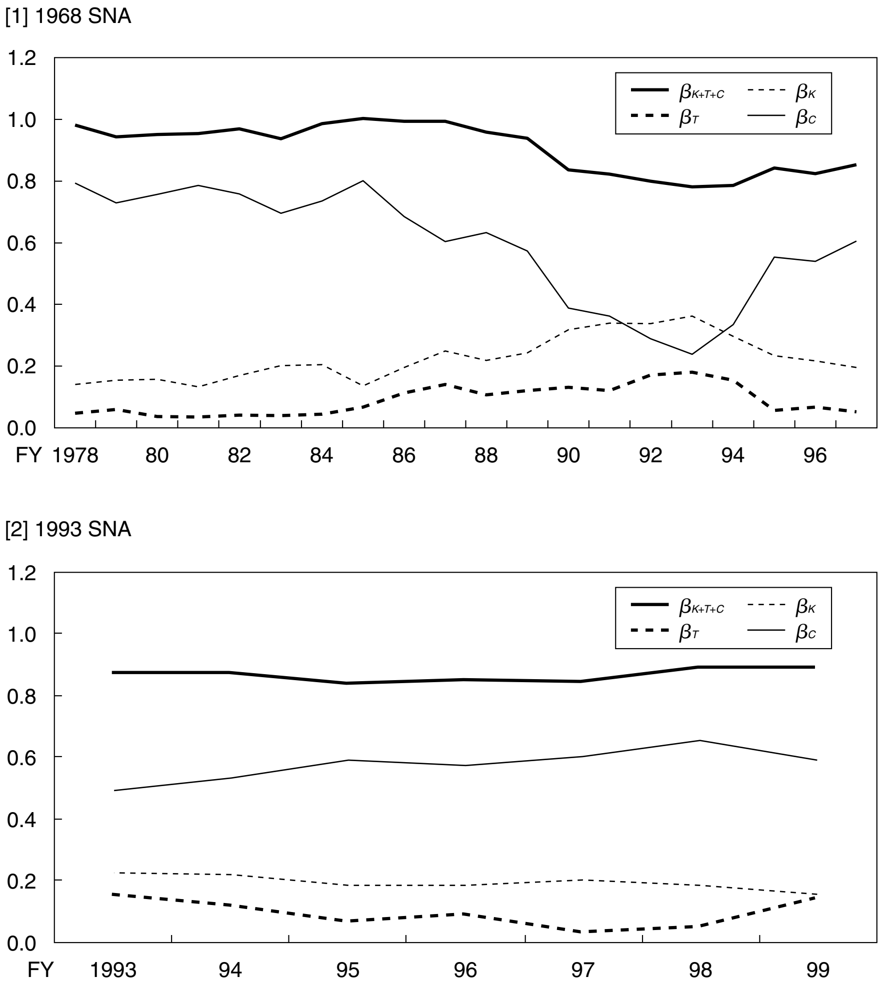
Did $(100 \cdot \beta_C)$ really fall in the 1990s, or did $(100 \cdot \beta_C)$ fall in the 1990s because of the changes in statistical measures between the 1968 SNA and the 1993 SNA? We will examine the robustness of our findings using subsample periods, rather than the entire sample periods for estimation for both the 1968 SNA data and 1993 SNA data.

C. Subsample

To examine whether the decrease in the value of $(100 \cdot \beta_C)$ in the 1990s is a statistical artifact due to the change from the 1968 SNA data to the 1993 SNA data, we compute the values of $(100 \cdot \beta_K)$, $(100 \cdot \beta_T)$, and $(100 \cdot \beta_C)$ in equations (4) to (7) using the five-year sample periods by WLS2. Regarding the 1968 SNA data, our sample periods are 1976–80, 1977–81, . . . , and 1995–99. Regarding the 1993 SNA data, our sample periods are 1991–95, 1992–96, . . . , and 1997–2001.

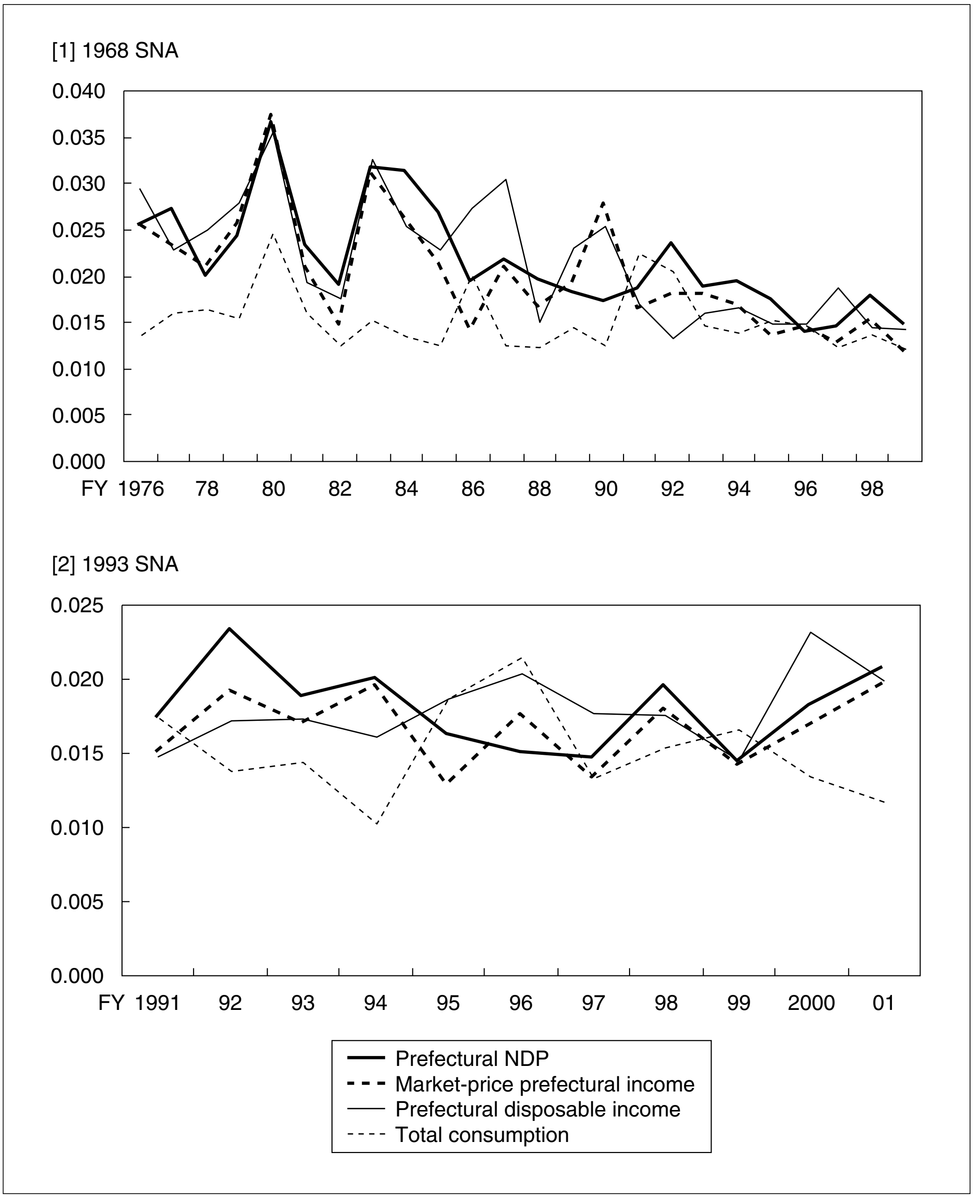
Figure 2 summarizes the results. The upper figure uses 1968 SNA data, and the lower figure uses 1993 SNA data. The numbers on the horizontal axis represent the middle year of the sample periods. For example, "1996" means the results based on the sample from 1994 to 1998. The upper figure shows that, in the early 1990s, there seems to be a substantial decrease in the size of $(100 \cdot \beta_C)$, and overall effects of income insurance and smoothing. The lower figure confirms that the size of $(100 \cdot \beta_C)$ is relatively small in the early sample, and increases somewhat as we move the sample close to 2001. The upper figure also suggests that the size of $(100 \cdot \beta_T)$ and $(100 \cdot \beta_K)$ increases somewhat during the period in which we observe the decrease in $(100 \cdot \beta_C)$. Figure 3 plots the cross-sectional standard deviation of each variable. Cross-sectional standard deviations of consumption seem to be of the same order as those of prefectural NDP in the early 1990s. That is why, we expect, the degree of overall risk sharing measured by $(100 \cdot \beta_{K+T+C})$ decreases. Given the small increase in $(100 \cdot \beta_{K+T})$ in those periods, we find lower values of $(100 \cdot \beta_C)$.

Figure 2 Estimations with Net Market-Price Basis Data



Note: We use prefectural NDP data for Y_1, market-price prefectural income data for Y_2, and prefectural disposable income for Y_3.

Figure 3 Standard Deviations of Net Market-Price Basis Data



V. Sensitivity on the Choice of Macroeconomic Variables

This section presents our results based on GDP and market-price prefectural income data, gross market-price data, and replication of KSY (2003). Since the estimation methods are essentially the same as those in the previous sections, we merely present the results. We only mention the results based on WLS2, because the results are similar whether based on WLS1 or WLS2.

A. Results Based on GDP and Market-Price Prefectural Income

The ninth and tenth rows of Table 6 show that based on the 1968 SNA we get estimates of ($100 \cdot \beta_K$) of 17.6 percent or 16.6 percent, which are smaller than that of KSY (2003) (21.6 percent). The estimates of ($100 \cdot \beta_{K+T+C}$, 88.9 percent or 90.1 percent) are also close to that of KSY (2003) (97.3 percent) based on the 1968 SNA data. However, our finding is not robust to the choice of definition of SNA

Table 6 Estimation with Prefectural GDP and Market-Price Prefectural Income Data

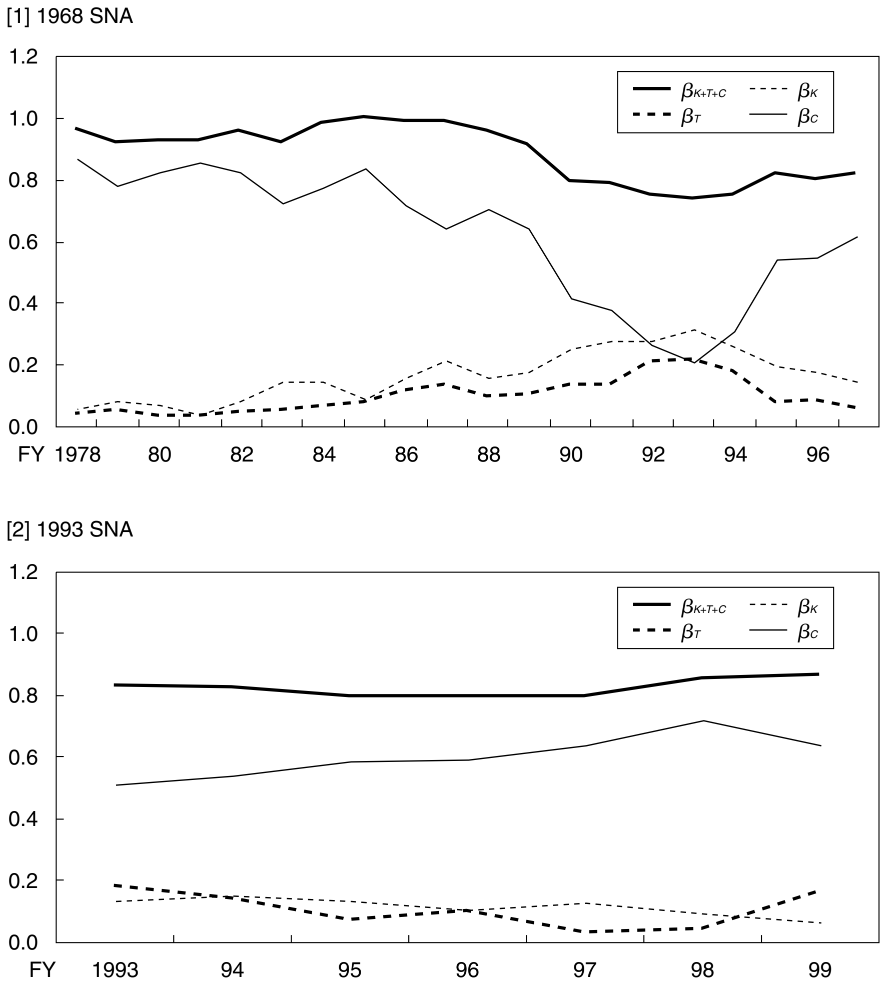
	Number of regions	Capital markets $100 \cdot \beta_K$ (percent)	Capital markets and national government $100 \cdot \beta_{K+T}$ (percent)	Overall income and consumption smoothing $100 \cdot \beta_{K+T+C}$ (percent)
	Y_1 Prefectural GDP	Y_2 Market-price prefectural income	Y_3 Prefectural disposable income	C Total consumption
WLS1				
1968 SNA (1) (1975–99)	44	18.0 (1.8)	—	90.3 (1.9)
1968 SNA (2) (1975–99)	41	15.5 (1.8)	24.6 (2.3)	91.9 (1.9)
1993 SNA (1) (1990–2001)	46	12.4 (2.1)	—	83.2 (2.7)
1993 SNA (2) (1990–2001)	45	12.1 (2.1)	25.3 (2.8)	83.4 (2.8)
WLS2				
1968 SNA (1) (1975–99)	44	17.6 (2.0)	—	88.9 (2.0)
1968 SNA (2) (1975–99)	41	16.6 (2.2)	25.5 (2.2)	90.1 (2.2)
1993 SNA (1) (1990–2001)	46	11.8 (2.7)	—	82.2 (2.7)
1993 SNA (2) (1990–2001)	45	10.4 (2.9)	24.6 (2.9)	83.3 (2.9)

Note: Numbers in parentheses show the standard errors for parameters. Estimates for 1968 SNA (1) are based on 913 unbalanced observations, while estimates for 1968 SNA (2) are based on 788 unbalanced observations, reduced owing to the lack of prefectural disposable income data. Correspondingly, estimates for 1993 SNA (1) are based on 506 balanced observations, while estimates for 1993 SNA (2) are based on 495 balanced observations. The balanced observations indicate that all the regions have the same number of observations, while the unbalanced observations indicate that at least one region does not have the same number of observations.

statistics and/or sample period. As the 11th and 12th rows of Table 6 suggest, $(100 \cdot \beta_K)$ and $(100 \cdot \beta_C)$ take even smaller values based on the 1993 SNA data.

Figure 4 summarizes the results using the subsample period. The upper figure shows that in the early 1990s there seems to be a substantial decrease in the size of $(100 \cdot \beta_C)$, and overall effects of income insurance and smoothing. The lower figure also confirms that the size of $(100 \cdot \beta_C)$ is relatively small in the early sample, and increases somewhat as we move the sample close to 2001. The upper figure also suggests that the size of $(100 \cdot \beta_T)$ and $(100 \cdot \beta_K)$ increases somewhat during the period in which we observe the decrease in $(100 \cdot \beta_C)$.

Figure 4 Estimations with Prefectural GDP and Market-Price Prefectural Income Data



Note: We use prefectural GDP data for Y_1, market-price prefectural income data for Y_2, and prefectural disposable income for Y_3.

There is a statistical inconsistency in this data set, because it includes both gross and net base data; Y_1 is gross, while Y_2 and Y_3 are net. The statistical inconsistency seems to explain the relatively smaller values of $(100 \cdot \beta_K)$ for this data set than those of our benchmark data set. Nonetheless, estimates obtained from this data set do not vary much from those obtained from our baseline data set.

B. Results Based on Gross Market-Price Basis Data

Following KSY's (2003) argument that the best estimate of Y_2 is regional-level GNP, we present the results based on gross market-price basis data: prefectural GDP for Y_1, prefectural GNP for Y_2, and prefectural disposable income for Y_3.

From the ninth and tenth rows of Table 7 based on the 1968 SNA, we obtain larger values of $(100 \cdot \beta_K)$, 23.1 percent or 21.3 percent based on the sample from 1975 to 1999, than those reported in Table 6, and close to the result reported by KSY (2003) (21.6 percent). The estimates of $(100 \cdot \beta_{K+T+C}$, 90.1 percent or 90.3 percent) are similar to that of KSY (2003) (97.3 percent) based on the 1968 SNA data. Our findings again

Table 7 Estimation Based on Gross Market-Price Basis Data

	Number of regions	Capital markets $100 \cdot \beta_K$ (percent)	Capital markets and national government $100 \cdot \beta_{K+T}$ (percent)	Overall income and consumption smoothing $100 \cdot \beta_{K+T+C}$ (percent)
	Y_1 Prefectural GDP	Y_2 Prefectural GNP	Y_3 Prefectural disposable income	C Total consumption
WLS1				
1968 SNA (1) (1975–99)	47	22.3 (1.4)	—	90.4 (1.7)
1968 SNA (2) (1975–99)	41	19.8 (1.5)	26.1 (2.4)	90.8 (2.0)
1993 SNA (1) (1990–2001)	47	16.3 (1.7)	—	83.6 (2.7)
1993 SNA (2) (1990–2001)	45	16.3 (1.2)	25.3 (2.8)	83.4 (2.8)
WLS2				
1968 SNA (1) (1975–99)	47	23.1 (1.7)	—	90.1 (1.7)
1968 SNA (2) (1975–99)	41	21.3 (2.1)	25.0 (2.1)	90.3 (2.1)
1993 SNA (1) (1990–2001)	47	16.5 (2.5)	—	83.2 (2.5)
1993 SNA (2) (1990–2001)	45	16.3 (2.8)	24.5 (2.8)	83.6 (2.8)

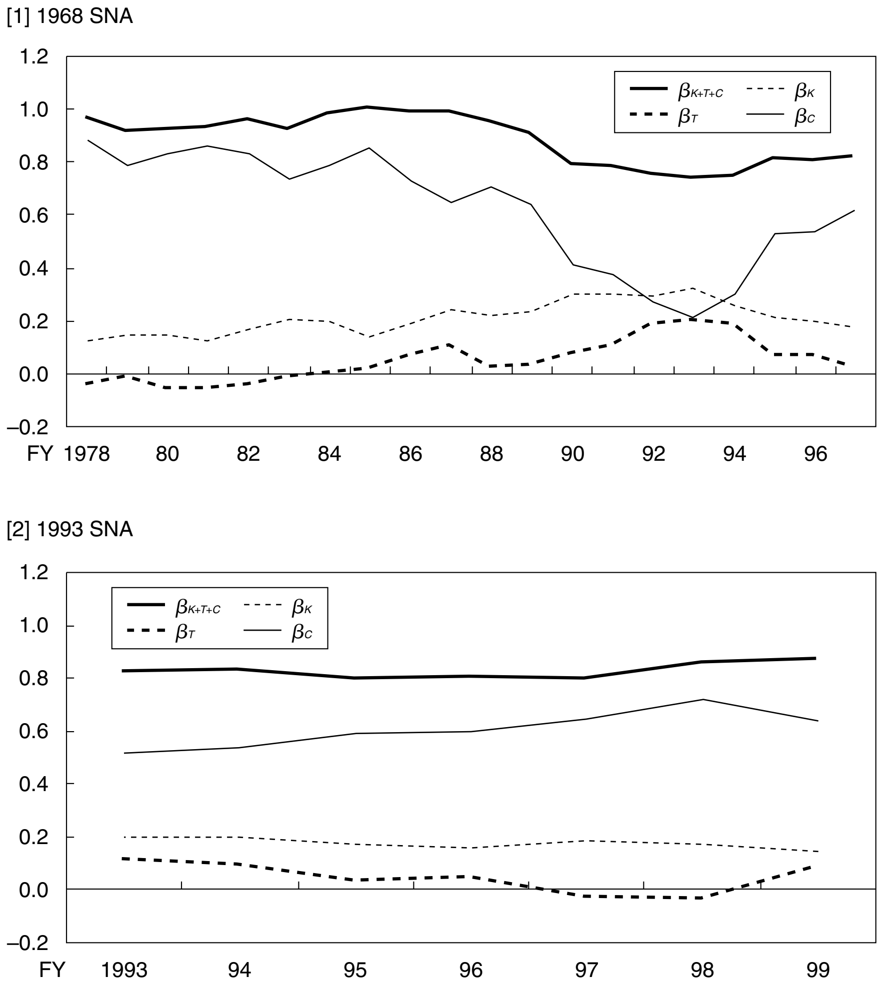
Note: Numbers in parentheses show the standard errors for parameters. Estimates for 1968 SNA (1) are based on 1,128 balanced observations, while estimates for 1968 SNA (2) are based on 788 unbalanced observations, reduced owing to the lack of prefectural disposable income data. Correspondingly, estimates for 1993 SNA (1) are based on 517 balanced observations, while estimates for 1993 SNA (2) are based on 495 balanced observations. The balanced observations indicate that all the regions have the same number of observations, while the unbalanced observations indicate that at least one region does not have the same number of observations.

are not robust to the choice of sample period. As the 11th and 12th rows of Table 7 suggest, $(100 \cdot \beta_K)$ and $(100 \cdot \beta_C)$ take only smaller values based on the 1993 SNA data.

Figure 5 summarizes the results using the subsamples. We confirm that the size of $(100 \cdot \beta_K)$ is not robust to the choice of subsample periods in both the 1968 SNA and 1993 SNA. We also find the same decline in the size of $(100 \cdot \beta_C)$ around the late 1980s and early 1990s.

There is a statistical inconsistency in this data set, because it includes both gross and net base data; Y_1 and Y_2 are gross data, while Y_3 is net. Nonetheless, sizes and trends of estimates obtained from this data set do not vary much from those obtained from our baseline data set.

Figure 5 Estimations Based on Gross Market-Price Basis Data



Note: We use prefectural GDP data for Y_1, prefectural GNP data for Y_2, and prefectural disposable income for Y_3.

C. Replication of Kalemli-Ozcan, Sørensen, and Yosha (2003)

Table 8 shows the results and our replication of KSY (2003) based on the 1968 SNA (ninth row), and sensitivity tests using a new data series from 1990 to 2001 (10th row). We point out an important feature.

Our estimates of $(100 \cdot \beta_K)$ are very different from those obtained by KSY (2003). The 12th row of Table 8 shows that the estimate of $(100 \cdot \beta_K)$ takes a quite high value (55.4 percent) compared with the Japanese estimate of KSY (2003) (21.6 percent, the fourth row), rather close to the U.S. estimate (63.5 percent) reported by KSY (2003). The estimate of $(100 \cdot \beta_{K+T+C}$, 88.2 percent) is similar to that of KSY (2003) (97.3 percent) based on the 1968 SNA data.

Since our estimate of $(100 \cdot \beta_{K+T})$ is 58.9 percent, we infer that $(100 \cdot \beta_T)$ is 3.5 percent and $(100 \cdot \beta_C)$ is 29.3 percent. The role played by $(100 \cdot \beta_T)$ of our estimate in Japan is a little smaller in magnitude than that estimated in the United States by KSY

Table 8 Replication of KSY (2003)

	Number of regions	Capital markets $100 \cdot \beta_K$ (percent)	Capital markets and national government $100 \cdot \beta_{K+T}$ (percent)	Overall income and consumption smoothing $100 \cdot \beta_{K+T+C}$ (percent)
KSY (2003)	Y_1 GDP	Y_2 Personal income	Y_3	C Retail sales and total consumption
U.S. data (1977–94)	50	63.5 (1.8)	—	77.6 (4.5)
Japanese data (1975–93)	47	21.6 (2.2)	—	97.3 (3.0)
KSY (2000)	Y_1 GDP	Y_2 Personal income	Y_3 Personal disposable income	C Retail sales
U.S. data (1977–94)	—	59.2 (1.5)	64.8 (1.6)	67.5 (4.6)
Japanese estimates	Y_1 Prefectural GDP	Y_2 Prefectural personal income	Y_3 Prefectural personal disposable income	C Total consumption
WLS1				
1968 SNA (1975–99)	47	56.0 (2.8)	58.2 (3.2)	90.5 (1.7)
1993 SNA (1990–2001)	47	58.6 (5.9)	63.2 (6.4)	83.7 (2.7)
WLS2				
1968 SNA (1975–99)	47	55.4 (2.8)	58.9 (2.8)	88.2 (2.8)
1993 SNA (1990–2001)	47	60.6 (5.6)	62.8 (5.6)	76.5 (5.6)

Note: Numbers in parentheses show the standard errors for parameters. Estimates for 1968 SNA are based on 1,126 unbalanced observations, while estimates for 1993 SNA are based on 517 balanced observations. The balanced observations indicate that all the regions have the same number of observations, while the unbalanced observations indicate that at least one region does not have the same number of observations.

(2000), 5.6 percent. The 13th row of Table 8 shows the estimates of $(100 \cdot \beta_K)$, $(100 \cdot \beta_{K+T})$ and $(100 \cdot \beta_{K+T+C})$ based on the 1993 SNA data from 1990 to 2001. Compared with the estimate based on the 1968 SNA data, $(100 \cdot \beta_K)$ takes a slightly higher value. One can easily verify that $(100 \cdot \beta_T)$ is only 2.2 percent and $(100 \cdot \beta_C)$ is 13.7 percent.

The difference between our estimate of $(100 \cdot \beta_K)$ and KSY (2003) comes from the data employed in each study. KSY (2003) collect their data from Sinfonica, while we estimate our own data. Since a large part of income transfer is already reflected in personal income, the size of the estimates of $(100 \cdot \beta_K)$ based on prefectural personal income for Y_2 shown in Table 8 must be greater than those based on prefectural GNP for Y_2 by construction. However, the fourth row of Table 8 shows the estimate of $(100 \cdot \beta_K)$ using prefectural personal income from Sinfonica by KSY (2003) to be 21.6 percent, which is not much different from that based on prefectural GNP for Y_2. This seems implausible, considering the definition of statistical series.[10] We, therefore, prefer our estimate.

VI. Discussion

A. Summary of Results

Overall, our results show that the findings reported by KSY (2003) are not very sensitive to the choice of macroeconomic variables, as long as we use the three data sets described in Figure 1. However, the choice of prefectural GDP and prefectural personal income provides a much higher estimate of $(100 \cdot \beta_K)$, which could misrepresent the magnitude of risk sharing. We summarize our estimates of $(100 \cdot \beta_K)$, $(100 \cdot \beta_T)$, and $(100 \cdot \beta_C)$ in Table 9.

In addition, individual insurance and smoothing effects of income vary significantly depending on the sample period. Regarding the estimates of $(100 \cdot \beta_K)$, results reported in Figure 2 suggest that the plausible range is 14–36 percent in the 1968 SNA and 15–23 percent in the 1993 SNA and that this is sensitive to the choice of sample period. Concerning $(100 \cdot \beta_T)$, the results in Figure 2 show that the plausible size of $(100 \cdot \beta_T)$ is 3–18 percent in the 1968 SNA and 3–15 percent in the 1993 SNA. As for the estimates of $(100 \cdot \beta_C)$, the plausible range is 23–80 percent in the 1968 SNA and 49–66 percent in the 1993 SNA. Moreover, the degree of income smoothing instigated by the changes in savings and dissavings, $(100 \cdot \beta_C)$, seems to have fallen dramatically in the 1990s. The results of subsample estimation show that the reduction in $(100 \cdot \beta_C)$ measured by the 1993 SNA data is not the result of statistical discrepancy.

10. Note that the difference of economic agents as well as transferred items could affect the estimates. Regarding the estimates of $(100 \cdot \beta_T)$, Mélitz and Zumer (2002) examine the effects of choice of economic agents between the personal economic agents (households and private nonprofit institutions serving households) and all the economic agents (nonfinancial corporations, financial corporations, and the government in addition to households and private nonprofit institutions serving households) using Canadian data and the U.S. data. As for the personal economic agents, given Y_3 as personal disposable income and Y_2 as personal income, $(100 \cdot \beta_T)$ based on the U.S. data is 20.0 percent (Mélitz and Zumer [2002, p. 280, table 3, row 4]) and $(100 \cdot \beta_T)$ based on the Canadian data is 20.9 percent (p. 280, table 3, row 9). Regarding all the economic agents, given Y_3 as disposable regional income and Y_2 as regional GNP, $(100 \cdot \beta_T)$ based on the U.S. data is 11.8 percent (p. 282, table 4, row 4) and $(100 \cdot \beta_T)$ based on the Canadian data is 12.6 percent (p. 282, table 4, row 9).

Table 9 Comparisons of Individual Insurance and Smoothing Effects in Tables 5–8

	Number of regions	Capital markets $100 \cdot \beta_K$ (percent)	National government $100 \cdot \beta_T$ (percent)	Credit markets $100 \cdot \beta_C$ (percent)
Table 5	Y_1 Prefectural NDP	Y_2 Prefectural income (market-price)	Y_3 Prefectural disposable income	C Total consumption
1968 SNA (1975–99)	41	22.4	8.1	61.8
1993 SNA (1990–2001)	45	19.1	12.8	55.4
Table 6	Y_1 Prefectural GDP	Y_2 Prefectural income (market-price)	Y_3 Prefectural disposable income	C Total consumption
1968 SNA (1975–99)	41	16.6	8.9	64.6
1993 SNA (1990–2001)	45	10.4	14.2	58.9
Table 7	Y_1 Prefectural GDP	Y_2 Prefectural GNP	Y_3 Prefectural disposable income	C Total consumption
1968 SNA (1975–99)	41	21.3	3.7	65.3
1993 SNA (1990–2001)	45	16.3	8.2	59.1
Table 8	Y_1 Prefectural GDP	Y_2 Prefectural personal income	Y_3 Personal disposable income	C Total consumption
1968 SNA (1975–99)	47	55.4	3.5	29.3
1993 SNA (1990–2001)	47	60.6	2.2	13.7

Note: Individual insurance and smoothing effects are estimated from the WLS2 in Tables 5–8 by the subsequent equations; $\beta_T = \beta_{K+T} - \beta_K$, $\beta_C = \beta_{K+T+C} - \beta_{K+T}$.

In the full sample period estimation, our estimates suggest that, in Japan, plausible estimates are 22.4 percent for $(100 \cdot \beta_K)$, 8.1 percent for $(100 \cdot \beta_T)$, and 61.8 percent for $(100 \cdot \beta_C)$, based on the 1968 SNA data from 1975 to 1999. Our plausible estimates are 19.1 percent for $(100 \cdot \beta_K)$, 12.8 percent for $(100 \cdot \beta_T)$, and 55.4 percent $(100 \cdot \beta_C)$, based on the 1993 SNA data.

B. Interpretations

We offer three interpretations based on the above results. First, regarding the magnitude of $(100 \cdot \beta_K)$, our estimates based on prefectural GDP and market-price prefectural income are consistently smaller than those in ASY (1996) (39 percent), which is based on the same U.S. state data set. Although our analysis is not based on any structural models, one piece of evidence supporting our results is the fact that Japanese households allocate only 7 percent of their financial assets to stocks and investment trusts according to the 2001 flow of funds statistics, while U.S. households allocate 46 percent of their financial assets to stocks and investment trusts.

One may hypothesize that the dominance of bank deposits and cash in Japanese household assets (54 percent in Japan, 11 percent in the United States) explains the relatively weak effects of $(100 \cdot \beta_K)$ across regions in Japan. The small value of $(100 \cdot \beta_K)$ seems to counter the argument that a household chooses to hold stocks whose returns are negatively correlated with the region in which the household is located. One might cast doubt on such a nice risk hedge by a household. Nonetheless, one may still conjecture that bank lending to firms outside the prefecture hedges risk for the household; thus, the household may not need to rely on capital markets.

One problem for this hypothesis is that, according to KSY (2003), the estimates of $(100 \cdot \beta_K)$ based on 20 Italian regions from 1983 to 1992 is 76.4 percent, and 11 British regions is 41.6 percent based on data from 1978 to 1993. The ratio of bank deposits and cash in Italian households in 2001 is 17 percent, and that of British households is 23 percent. These data do not support the hypothesis above.

Another hypothesis that explains the cross-country difference of $(100 \cdot \beta_K)$ is that one country has a stream of regional incomes whose cross-correlations are strong and thus the role of capital markets in smoothing cross-regional income variations is weak (as in Japan), while the other country has a stream of regional incomes whose cross-correlations are weak and the role of capital markets in smoothing cross-regional income variations is strong.

Concerning the estimates based on euro area data, KSY (2004) report that their estimates of $(100 \cdot \beta_K)$ using GDP and GNP in eight European Union (EU) economies is 11 percent and their estimates of $(100 \cdot \beta_K)$ in euro area economies is 9 percent based on the data for 1993–2000, while the estimates of $(100 \cdot \beta_K)$ based on the data for 1972–92 are small and even negative. The integration of European financial markets appears to have increased the level of $(100 \cdot \beta_K)$, but not close to the Japanese estimates of 21.3 percent, using GDP and GNP.

Second, regarding the size of $(100 \cdot \beta_T)$, the sizes are consistent with the results based on U.S. data (10–13 percent) such as ASY (1996), KSY (2003), and Mélitz and Zumer (2002). Although Kletzer and von Hagen (2000) argue that the evidence regarding the stabilization effects based on fiscal transfers is mixed, it is noteworthy that within the framework following ASY (1996) and KSY (2003), U.S. and Japanese idiosyncratic shocks to regional GDP absorbed by the national government (the inter-regional tax transfer system) are of the same magnitude. Other studies argue that Japanese fiscal policy has strong distributional effects across regions (see Higo and Nakagawa [2001]), and that the sustainability of such a distribution from richer to poorer prefectures is dubious. Note that we simply measure the fraction of idiosyncratic shocks to regional GDP absorbed by the national government, and do not conclude anything about the distributional effects of regional fiscal policy or the welfare consequences of these policies.

Regarding the distributional effects of regional fiscal policy based on income transfer, the statistical methods employed in this paper include public investment allocated by the national government in the raw data, Y_1, and thus do not measure the distributional effects of fiscal policy through national government public investment.

Regarding welfare consequences of the policy, the national government may not regard average prefectural income as a policy target variable to be smoothed. Therefore, the evidence in this paper should not be taken as policy advice based on welfare evaluations.

Third, regarding the decline of $(100 \cdot \beta_C)$ around the late 1980s followed by the shift downward in the 1990s, one may conjecture that something happened to the pattern of household saving and dissaving by credit markets. This might be related to the asset price bubbles during that period, which widened the dispersion of income across the prefectures. For example, a shock during the bubble period might have increased income and consumption simultaneously, motivated by the consumption of luxury goods. Another interpretation is that there were strong regional shocks asymmetric to the regions in the 1990s, and thus the overall degree of risk sharing across regions decreased.

VII. Summary

We used the methodology of KSY (2003) to calculate the degree of insurance among the Japanese prefectures. Our plausible estimate of the fraction of idiosyncratic shocks to prefectural NDP absorbed by inter-regional income insurance through capital markets, $(100 \cdot \beta_K)$, is 22.4 percent, based on the 1968 SNA data from 1975 to 1999. The fraction of idiosyncratic shocks to market-price regional prefectural income absorbed by the national government via the inter-regional tax transfer system, $(100 \cdot \beta_T)$, is 8.1 percent, based on the 1968 SNA data from 1975 to 1999. The fraction of idiosyncratic shocks to market-price regional prefectural income absorbed by the changes in savings and dissavings typically instigated by the credit markets after the realization of the idiosyncratic shock, $(100 \cdot \beta_C)$, is 61.8 percent, based on the 1968 SNA data from 1975 to 1999. Our plausible estimates are in the range of 19.1 percent for $(100 \cdot \beta_K)$, 12.8 percent for $(100 \cdot \beta_T)$, and 55.4 percent for $(100 \cdot \beta_C)$, based on the 1993 SNA data.

APPENDIX: CONSTRUCTION OF DATA SERIES ON PREFECTURAL PERSONAL DISPOSABLE INCOME AND PREFECTURAL PERSONAL INCOME

The prefectural SNA statistics in Japan do not report prefectural personal income and prefectural disposable income. We utilize some data series in the *Family Income and Expenditure Survey* (FIES) compiled by the Statistics Bureau of the Ministry of Internal Affairs and Communications to estimate prefectural personal income and prefectural personal disposable income. One may wonder if we can conduct the entire study using the data on consumption from the FIES, rather than the prefectural SNA statistics. We choose not to do that because prefectural SNA statistics are more complete and are well-accepted data for most studies. Indeed, the consumption data in the FIES are supplemented by the other regional statistics and yield the estimates of the consumption data series in the prefectural SNA statistics.

We assume that the following three data series in the prefectural SNA statistics and the FIES are equal throughout our estimation: (1) prefectural income distributed to households and private nonprofit institutions serving households (hereafter personal economic agents) minus employer contributions for social insurance in prefectural SNA statistics; (2) income minus social security benefits in the FIES; and (3) prefectural income minus "other net transfers" to personal economic agents other than payment of direct taxes. We begin by estimating prefectural personal disposable income, and then proceed to the estimation of prefectural personal income.

A. Prefectural Personal Disposable Income

By definition, prefectural personal disposable income is equivalent to prefectural disposable income distributed to personal economic agents minus employer contributions for social insurance. We should be able to obtain a consistent data series on prefectural personal disposable income with the following equation:

(Prefectural personal disposable income) = (prefectural disposable income [households]) + (prefectural disposable income [private nonprofit institutions serving households]) − (employer contributions for social insurance).

However, the prefectural SNA statistics have many missing observations in the data series of employer contributions for social insurance. We cannot estimate the data on prefectural personal disposable income using the definition explained above.

To cope with this problem, we estimate prefectural personal disposable income utilizing some data series in the FIES. First, we estimate prefectural personal disposable income under an additional assumption that the definition of disposable income in both the prefectural SNA statistics and the FIES are roughly consistent. Under this additional assumption, we estimate the ratio of (prefectural income distributed to personal economic agents minus employer contributions for social insurance; Y^{spa}) to (prefectural disposable income distributed to personal economic agents minus employer contributions for social insurance; D^{spa}) in prefectural SNA statistics by the ratio of (income minus social security benefits; Y^{H}) to (disposable income; D^{H}) in the FIES. Since the latter ratio is easily available from the FIES, we estimate D^{spa} in terms of prefectural SNA statistics by the following formula:

$$D^{spa}{}_{it} = Y^{spa}{}_{it}\left(\frac{D^{H}{}_{it}}{Y^{H}{}_{it}}\right),$$

where subscript t and i denote time and region, respectively.

Second, we make an additional adjustment to our D^{spa} series following Ito and Watanabe (2004). As the FIES covers workers' households only, the ratio of Y^H to D^H might be biased from the ratio of all households in each prefecture. Therefore, D^{spa} estimated above might also be biased. To cope with this bias, we utilize data from the national SNA statistics to adjust the average bias based on the following formula:

$$Adjusted\ D^{spa}{}_{it} = D^{spa}{}_{it}\left(\frac{D^{sna}{}_{t}/Y^{sna}{}_{t}}{\sum_i D^{spa}{}_{it}\Big/\sum_i Y^{spa}{}_{it}}\right),$$

where Y^{sna} and D^{sna} denote the national counterparts of Y^{spa} and D^{spa} in the national SNA statistics, respectively. In this adjustment, the average bias in D^{spa}/Y^{spa} derived from the bias in D^H/Y^H is corrected by the national counterpart. We use the data series on *adjusted* D^{spa} for our estimate of prefectural personal disposable income.

B. Prefectural Personal Income

By definition, prefectural personal income is equivalent to prefectural income distributed to personal economic agents minus employer contributions for social insurance plus "other net transfers" to personal economic agents other than payment of taxes. We should be able to obtain a consistent data series on prefectural personal income based on the following formula:

(Prefectural personal income) = (prefectural income [households]) + (prefectural income [private nonprofit institutions serving households]) − (employer contributions for social insurance) + ("other net transfers" to personal economic agents other than payment of taxes).

However, since the prefectural SNA statistics do not report the data series on "other net transfers" and "payment of taxes" for personal economic agents, we cannot use the above formula to estimate prefectural personal income. To cope with this problem, we estimate prefectural personal income based on the following relationship:

(Prefectural personal income) = (prefectural personal disposable income) + (payment of direct taxes by personal economic agents).

Specifically, we first estimate the payment of direct taxes by personal economic agents using the data series in the FIES. We add that series to our own estimates of prefectural personal disposable income to obtain prefectural personal income.

Specifically, we first estimate payment of direct taxes by personal economic agents under the assumption that the payment of direct taxes in both the prefectural SNA statistics and the FIES are consistent. Under this additional assumption, we estimate the ratio of Y^{spa} to (payment of direct taxes by households; T^{spa}) in the prefectural SNA statistics, and the ratio of Y^{H} to (direct taxes; T^{H}) by the ratio reported in the FIES. We estimate T^{spa} by the following equation:

$$T^{spa}{}_{it} = Y^{spa}{}_{it}\left(\frac{T^{H}{}_{it}}{Y^{H}{}_{it}}\right).$$

We also make an adjustment proposed by Ito and Watanabe (2004):

$$Adjusted\ T^{spa}{}_{it} = T^{spa}{}_{it}\left(\frac{T^{sna}{}_{t}/Y^{sna}{}_{t}}{\sum_{i} T^{spa}{}_{it} \Big/ \sum_{i} Y^{spa}{}_{it}}\right),$$

where T^{sna} denotes payment of direct taxes by households in the national SNA statistics.

Second, we add our estimates of payment of direct taxes by personal economic agents to the estimated prefectural personal disposable income to obtain our own estimates of personal income (PI):

$$PI_{it} = adjusted\ D^{spa}{}_{it} + adjusted\ T^{spa}{}_{it}.$$

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