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PIH and ROT alternative in view of the intertemporal non-separability of preferences: empirical findings from a Japanese panel data

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Abstract

This paper describes an empirical investigation into the permanent income hypothesis (PIH) and the rule-of-thumb (ROT) alternative hypothesis, both of which allow for the intertemporal non-separability of preferences in the sense that past consumption of the PIH consumers has influence on their current utility. The data used in this study is a Japanese aggregate panel data processed with the Family Income and Expenditure Survey (FIES) for the period 1981-2002, and the GMM estimations for the panel data are carried out for spans within the period. The results demonstrate that the PIH holds for the bubble span 1988-1993 and the serious deflation span 1997-2002, while the ROT alternative holds for the post-bubble depression span 1993-1998.

JEL code: E21, C23.

Keywords: Permanent income hypothesis; Rule-of-thumb alternative hypothesis; Intertemporal non-separability of preferences; Panel data; Generalized method of moments

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1. Introduction

The permanent income hypothesis (PIH) based on the rational expectation indicates that the consumption of the rational consumer follows a random walk pattern. This proposal dates back to Hall (1978), and has been tested in many empirical literatures using aggregate time series data and household-based panel data. In the empirical literatures, it is often found that consumption is not independent of disposable income, leading to the rejection of the PIH.[1] In particular, the excess sensitivity of consumption change to income change is often estimated significantly in the latter literatures.

To explain why the excess sensitivity is estimated using aggregate time series data, a theoretical model is proposed by Campbell and Mankiw (1989, 1991) as an alternative hypothesis to the PIH. They call their hypothesis the rule-of-thumb alternative (ROT alternative). According to their model, some of the consumers in the economy are the PIH consumers (i.e. consumers consuming in the PIH mode), while the residuals are the rule-of-thumb (hereafter ROT) consumers (i.e. consumers consuming their current income on the spot due to their liquidity constraints). As a consequence, the excess sensitivity to be estimated is interpreted as the share of disposable income earned by the ROT consumers in the economy.

On the contrary to the propulsion of the rejection of the PIH, some works cast doubt on the specification of the PIH model often used in the empirical studies, which assumes the intertemporal separability of preferences in the sense that past consumption of the PIH consumers does not influence their current utility. Instead of this specification, Guariglia and Rossi (2002) and Weber (2002) test the PIH in their empirical studies, based on the specification assuming the intertemporal non-separability of preferences in the sense that past consumption of the PIH consumers has an influence on their current utility. In accordance with their results, it is reasonable to consider that the PIH holds, and therefore their results appeal to us that the rejection of the PIH in empirical studies might result from the inappropriate specification without allowing for the intertemporal non-separability.

Using one type of Japanese aggregate data, this paper describes an empirical investigation into a simple PIH model in view of the intertemporal non-separability, which is proposed by Alessie and Lusardi (1997), and a ROT alternative model in view

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[1] For example, Campbell and Mankiw (1989, 1991) and Chyi and Huang (1997) using the time series data, and Zeldes (1989) using the panel data reject the PIH. On the other hand, Runkle (1991) using the panel data support the PIH.

of the intertemporal non-separability, which is devised by Cushing (1992). The data used is made up of aggregate panel data obtained from the Family Income and Expenditure Survey (FIES) for the period 1981-2002, and the estimations based on the models above are carried out for spans within this period. The estimators used are the generalized method of moments (GMM) estimators taking into consideration the structure of panel data, which are mainly proposed in Arellano and Bond (1991) and Arellano and Bover (1995) and in recent years field-proven in panel data econometrics.

The layout of this paper is as follows. In section 2, the theoretical models are described incorporating the intertemporal non-separability. Section 3 presents the data used, and explains the econometric specifications and methods. Section 4 shows the estimation results and discussion for the results. Finally, section 5 concludes the paper.

2. Model

In this section, firstly, a model of the permanent income hypothesis (PIH) is introduced, allowing for the intertemporal non-separability of preferences in the sense that past consumption of the PIH consumers influences their current utility. Secondly, a model assuming the presence of the rule of thumb (ROT) consumers in addition to the PIH consumers in an economy is introduced, allowing for the intertemporal non-separability of preferences. Both models generate the equations underlying the empirical analysis of the PIH and the ROT alternative, which include not only the current consumption change but also the lagged consumption change. In addition, the latter model is interpreted as a theoretical grounding for the excess sensitivity of consumption change to income change, which has been estimated significantly in aggregate data.

The consumption used in this paper is the refined non-durable and service (RNDS) consumption, which is obtained by completely deleting expenditure items including the durable goods from living expenditure.

<u>PIH allowing for the intertemporal non-separability of preferences</u>

A simple model of the PIH is proposed by Alessie and Lusardi (1997), which allows for the intertemporal non-separability of preferences (that is, the habit formation or the durability). According to their model, a PIH model on the RNDS consumption is constructed, where the PIH consumer spends the ϕ share of his disposable income for the RNDS consumption and the $1-\phi$ share for the consumption of the durable goods and other goods. Thus, in the model, the PIH consumer decides his RNDS consumption at each time period so as to maximize

$$E_t\left[\sum_{s=t}^{\infty}(1+\rho)^{t-s}U(c_s-\alpha c_{s-1})\right], \tag{1}$$

subject to the evolution process of his assets

$$A_t=(1+r)A_{t-1}+\phi y_t-c_t, \tag{2}$$

and his transversality condition

$$\lim_{s\to\infty}(1+r)^{t-s}A_s=0, \tag{3}$$

where c_{t-1} and A_{t-1} are given, and $E_t[\bullet]$ is the expectation conditional on the information set up to time t. In this formulation, c_s is the RNDS consumption at time

s, $U(\bullet)$ is the utility function, ρ is the time preference rate, y_s is the labour income at time s, A_s is the non-human assets at time s (with respect to the RNDS consumption), and r is the interest rate. The absolute value of the parameter α measures the strength of the influence from the consumption dated $t-1$ to the utility of the PIH consumer dated t, and hereafter the parameter α is called the intertemporal non-separability parameter. The larger absolute value of positive α implies the larger strength of the habit formation (that is, addiction) from the consumption dated $t-1$, which generates the less utility level of the PIH consumer dated t, while the larger absolute value of negative α implies the larger strength of the durability from the consumption dated $t-1$, which generates the larger utility level of the PIH consumer dated t.

Assuming that $U(\bullet)$ is quadratic and $\rho = r$, one can derive the closed-form solution of the constrained dynamic optimization problem composed of (1), (2), and (3) for the consumption, according to Alessie and Lusardi (1997). From the closed-form solution, the following random walk process described on the basis of the consumption change at time t is explicitly derived, which allows for the intertemporal non-separability of preferences:

$$\Delta c_t = \alpha \, \Delta c_{t-1} + e_t, \qquad (4)$$

where e_t is the random error with $E_{t-1}[e_t] = 0$.[2]

<u>ROT alternative allowing for the intertemporal non-separability of preferences</u>

A ROT alternative hypothesis model allowing for the intertemporal non-separability of preferences is presented, referring to Cushing (1992). The ROT alternative hypothesis model is designed by incorporating the ROT consumers into the PIH model described above.

Consider that there are two groups of consumers in the economy: the group of the ROT consumers and the group of the PIH consumers.

The ROT consumer consumes his current labour income on the spot. The RNDS consumption of the ROT consumers in the economy at time t is formulated as follows:

$$c_t^{ROT} = \varphi \, y_t^{ROT}, \qquad (5)$$

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[2] Noting that relationship (4) is written as $c_t^* = c_{t-1}^* + \varepsilon_t$ where $c_t^* = c_t - \alpha \, c_{t-1}$, it is clear that (4) is the random walk process.

where c_t^{ROT} and y_t^{ROT} are the RNDS consumption and the labour income of the ROT consumers at time t respectively, and φ is the proportion at which the ROT consumers distribute y_t^{ROT} to their RNDS consumption.

On the other hand, according to relationship (4), the RNDS consumption of the PIH consumers subject to the intertemporal non-separability of preferences in the economy at time t is formulated as follows:

$$\Delta c_t^{PIH} = \alpha \Delta c_{t-1}^{PIH} + \varepsilon_t , \qquad (6)$$

where ε_t is the random error with $E_{t-1}[\varepsilon_t] = 0$, and c_t^{PIH} is the RNDS consumption by the group of the PIH consumers.

In this model, it is assumed that the share λ of the income in the economy is earned by the group of the ROT consumers, so that $y_t^{ROT} = \lambda y_t$, where y_t are total labour income in the economy at time t. Further, the total RNDS consumption in the economy at time t is described as $c_t = c_t^{ROT} + c_t^{PIH}$. Using these relationships and equations (5) and (6), it follows that

$$\Delta c_t = \alpha \Delta c_{t-1} + \beta \Delta y_t + \gamma \Delta y_{t-1} + \xi_t , \qquad (7)$$

where $\gamma = -\alpha \beta$ and $E_{t-1}[\xi_t] = 0$. Equation (7) is the equation underlying the empirical analysis for the ROT alternative. The derivation of equation (7), referring to Cushing (1992), is described in Appendix. In equation (7), β is the share of the income earned by the ROT consumers (which is said conservatively), and hereafter called the crude ROT ratio, since $\beta = \lambda\varphi$.

Keeping in mind the relationship $\gamma = -\alpha \beta$, the following three special cases for equation (7) will be considered. The first is the case that $\gamma = 0$ with $\alpha \neq 0$ and $\beta \neq 0$ (that is, the case that the absolute value of γ is very small and assumed to be zero), where equation (7) can simply test the excess sensitivity assuming the intertemporal non-separability of preferences. The second is the case that $\beta = 0$ (that is, assuming there are no ROT consumers in the economy), where equation (7) can directly test the PIH assuming the intertemporal non-separability of preferences. The third is the case that $\alpha = 0$, where equation (7) can test the excess sensitivity assuming the intertemporal separability of preferences.

3. Data and estimation issues

This section describes the data and the estimation issues for the empirical analysis on the PIH model and ROT alternative hypothesis model allowing for the intertemporal non-separability of preferences. The Japanese panel data to be used is explained, and its fragmentation is conducted for the purpose of the analysis for each span in the period composing the panel data. Then, the empirical specification of equation (7) is presented, and the estimation techniques for the specification are illustrated.

Data used

The data set of the RNDS consumption and the disposable income is constructed from annual magazines that run one type of processed FIES data. The title of the magazines is Annual Report on the Family Income and Expenditure Survey (Kakei Chosa Nenpo, in Japanese).[3] For each of years ranging from 1981 to 2002, the magazine presents tables of yearly average of monthly receipts and disbursements per household for 47 cities with prefectural governments on workers' households. The monthly receipt and disbursement per household for each of the cities are sample averages of the monthly receipts and disbursements of the households randomly sampled in the city, respectively.[4]

The RNDS consumption data is extracted by drastically ruling out items including the durable goods from Living Expenditure (LE). Accordingly, using items of Materials for Repairs & Maintenance (MRM), Furniture & Household Utensils (FHU), Domestic Non-Durable Goods ($DNDG$), Domestic Services (DS), Clothes and Footwear (CF), Services Related to Clothing (SRC), Medical Supplies & Appliances (MSA), Private Transportation (PT), Communication (Cmm), Recreational Durable Goods (RDG), Recreational Goods (RG), Books & Other Reading Materials ($BORM$), Toilet Articles (TA), Personal Effects (PE), Other Miscellaneous (OM), Pocket Money (PM), Social Expenses (SE), and Remittance (Rmt), the RNDS consumption is constructed as follows:

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[3] The magazines are published by Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Government of Japan (Somusho Tokeikyoku, in Japanese). The former name of this organization is Statistics Bureau, Management and Coordination Agency, Government of Japan (Somucho Tokeikyoku, in Japanese).

[4] The method of random sampling used in FIES is described in the magazines.

$$RNDS = LE - MRM - (FHU - DNDG - DS) - (CF - SRC) - MSA \\ - (PT + Cmm) - (RDG + RG + BORM) - (TA + PE + OM) \\ - (PM + SE + Rmt).$$

Disposable income (DI) is given as an item in the tables above.

The RNDS consumption and the disposable income per household are deflated by using the general consumer price indexes (excluding imputed rent) and further deflated by using the indexes of the total price difference (among the cities). The former data source is Annual Report on the Consumer Price Index (Shohisha Bukka Shisu Nenpo, in Japanese), and the latter data source is Local Town Business and Social Statistics (Chiiki Keizai Soran, in Japanese).[5]

As is seen from descriptions above, the RNDS consumption and the disposable income per household for each of the cities are sample averages of the RNDS consumption and the disposable income of households randomly sampled in the city. That is, the sample averages approximate the per capita RNDS consumption and disposable income for each of the cities, which are scaled in monthly term. Assuming that all the workers' households in the sample are composed of the ROT households and the PIH households, some percentages of the RNDS consumption and the disposable income are for the ROT consumers, while the remaining percentages are for the PIH households. These percentages reflect the percentages of the RNDS consumption and the disposable income of the ROT consumers and the PIH consumers in the city.

Taking the first differences of the RNDS consumption and the disposable income per household generates the panel data set of the RNDS consumption change and the disposable income change with $N = 47$ and $T = 21$ (where N is the number of cities with prefectural governments and T is the number of years ranging from 1982 to 2002), and therefore enables an empirical analysis to be performed using appropriate transformations of equation (7).

Data fragmentation

The original panel data set above is fragmented into the fractional panel data sets, which are composed of the sequential k years in order that they have the sample sizes $N = 47$ and $T = k$, where k is the one-digit number which is not large. Accordingly, the number of the fractional panel data sets to be quarried from the original panel data

[5] The former magazine is published by Statistics Bureau, and the latter is published by Toyo Keizai Inc. (Toyo Keizai Shinposha, in Japanese).

set is $21-k+1$. The aim of the fragmentation is to conduct the analysis on the PIH model and the ROT alternative model for each of the spans in the period 1982-2002.

Panel data specification

The fractional panel datasets quarried from the original panel data set satisfy the property that the cross-sectional size N is large and the time dimension T is small. For these panel data sets, equation (7) is converted into the following dynamic panel data specification by defining Δc_{it} and Δy_{it} as the RNDS consumption change and the disposable income change for individual (city) i at time (year) t:

$$\Delta c_{it} = \alpha\,\Delta c_{i,t-1} + \beta\,\Delta y_{it} + \gamma\,\Delta y_{i,t-1} + TD_t + \eta_i + v_{it}\,, \tag{8}$$

with $\gamma = -\alpha\beta$ and where $i = 1,\ldots,N$ and $t = 2,\ldots,T$. In this specification, the parameters of interest α, β, and γ to be estimated are common among individuals and over time, TD_t is the time-specific effect at time t (which is the parameter of interest to be estimated), η_i is the individual specific fixed effect for the cross-sectional unit i (which controls for the individual heterogeneity, is unobservable, and is the nuisance parameter for large N and small T) with mean zero, and v_{it} is the disturbance term with mean zero.[6] It is assumed that η_i is not correlated with v_{it}, and further taking over the relationship $E_{t-1}[\xi_t] = 0$ in equation (7), the disturbance v_{it} is established so as to satisfy the conditional moment restriction $E[v_{it} \mid I_{i,t-1}] = 0$ where $I_{i,t-1}$ is the information set up to $t-1$ for the individual i.

However, the time aggregation structures for c_{it} and the measurement errors for c_{it} and y_{it} might generate a more complex structure of the disturbance v_{it} (see Working (1960), Cushing (1992), and Dynan (2000), etc.), as well as the approximation errors caused by the use of the sample averages mentioned above for c_{it} and y_{it} might do. For the time aggregation issue, it is assumed in this paper that the decision intervals of the worker's households are yearly, allowing for the fact that the households generally receive not only the monthly salaries from their company but also the bonus twice a

6 The time specific effect TD_t could also capture the income risk for the PIH consumers when the PIH or ROT alternative models allowing for the intertemporal non-separability of preferences incorporate the presence of uncertainty as is formulated in section 3 of Alessie and Lusardi (1997) and Guariglia and Rossi (2002).

year. In addition, the position taken in this paper is that the measurement errors and the approximation errors are captured by the fixed effect η_i. Accordingly, the estimations of equation (8) based on the conditional moment restriction $E[v_{it} \mid I_{i,t-1}] = 0$ are conducted, and then the structures of the disturbance v_{it} are checked using the estimated form on v_{it}.

Estimation techniques

Note that the consistent estimation of the parameters of interest (i.e., α, β, γ, and time dummies) in equation (8) is implemented not only based on the conditional moment restriction $E[v_{it} \mid I_{i,t-1}] = 0$ but also by controlling for the fixed effect η_i.

The consistent estimation of the parameters of interest cannot be conducted with the GMM using the instruments Δc_{is} and Δy_{is} for $s = 1,\ldots,t-1$ (which are included in $I_{i,t-1}$) to the level equation of (8). This is because Δc_{it} for all t is correlated with the fixed effect η_i due to the driving process of equation (8), and further it is legitimate that Δy_{it} for all t is regarded as being correlated with η_i. That is, $E[\Delta c_{is}(\eta_i + v_{it})] \neq 0$ and $E[\Delta y_{is}(\eta_i + v_{it})] \neq 0$ for $s = 1,\ldots,t-1$ and $t = 2,\ldots,T$.

To overcome this problem, the relationship is used where Δc_{is} and Δy_{is} for $s = 1,\ldots,t-2$ (which are included in the information set $I_{i,t-2}$ contained in $I_{i,t-1}$) are not correlated with the disturbance Δv_{it}. Then, the following unconditional moment restrictions hold:

$$E[\Delta c_{is} \Delta v_{it}] = 0, \qquad \text{for } s = 1,\ldots,t-2 \text{ and } t = 3,\ldots,T, \qquad (9)$$

$$E[\Delta y_{is} \Delta v_{it}] = 0, \qquad \text{for } s = 1,\ldots,t-2 \text{ and } t = 3,\ldots,T. \qquad (10)$$

The GMM utilizing the unconditional moment restrictions (9) and (10) carries out the consistent estimation of the parameters of interest, which is in other words the GMM using the instruments Δc_{is} and Δy_{is} for $s = 1,\ldots,t-2$ to the first-differenced equation of (8) at time t (with the fixed effect η_i eliminated). This usage of the moment restrictions is from Holtz-Eakin et al. (1988) and Arellano and Bond (1991). These moment restrictions are called the standard moment restrictions, and the GMM estimator using the standard moment restrictions is henceforth denoted GMM (DIF).

Further, considered is the case where Δc_{it} and Δy_{it} are mean-stationary in the sense that $\Delta^2 c_{it}$ and $\Delta^2 y_{it}$ are not correlated with the fixed effect η_i, where Δ^2 is the second-differencing operator. In this case, the variables $\Delta^2 c_{is}$ and $\Delta^2 y_{is}$ for $s = 2,\ldots,t-1$ are not correlated with the disturbance v_{it}, since they are included in the information set $I_{i,t-1}$. Accordingly, the following unconditional moment restrictions hold:

$$E[\Delta^2 c_{i,t-1}(\eta_i + v_{it})] = 0, \quad \text{for } t = 3,\ldots,T, \tag{11}$$

$$E[\Delta^2 y_{i,t-1}(\eta_i + v_{it})] = 0, \quad \text{for } t = 3,\ldots,T. \tag{12}$$

These moment restrictions are called the stationarity moment restrictions, and use the instruments $\Delta^2 c_{i,t-1}$ and $\Delta^2 y_{i,t-1}$ to the level equation of (8) at time t. The GMM using the standard moment restrictions (9) and (10) together with the stationarity moment restrictions (11) and (12) carries out the consistent estimation of the parameters of interest, whose estimator is henceforth denoted the GMM (SYS) estimator. The stationarity moment restrictions and the GMM (SYS) estimator are proposed by Arellano and Bover (1995) and discussed by Ahn and Schmidt (1995), and in particular it is demonstrated by theoretical illustrations and Monte Carlo experiments in Blundell and Bond (1998) that the GMM (SYS) estimator improves the small sample biases arising when the GMM (DIF) estimator is used for the persistent series of Δc_{it} and Δy_{it}.

Eventually, since equation (8) includes time dummies, the consistent GMM (DIF) estimator uses the standard moment restrictions (9) and (10) together with the following auxiliary moment restrictions

$$E[\Delta v_{it}] = 0, \qquad \text{for } t = 3,\ldots,T, \tag{13}$$

where the parameters of interest corresponding to the time dummies are the first-differenced time dummies ΔTD_t for $t = 3,\ldots,T$, while the consistent GMM (SYS) estimator uses the standard moment restrictions (9) and (10) and the stationarity moment restrictions (11) and (12) together with the following auxiliary moment restrictions

$$E[\eta_i + v_{it}] = 0, \qquad \text{for } t = 2,\ldots,T, \tag{14}$$

where the parameters of interest corresponding to the time dummies are the level time dummies TD_t for $t = 2,\ldots,T$.[7]

After estimating the parameters of interest, Sargan and three serial correlation tests are implemented. Sargan test is a test of the validity of the model specification and the moment restrictions used, which is χ^2-distributed with degree of freedom being the number of moment restrictions minus the number of parameters of interest under the null hypothesis that the moment restrictions are over-identified. The three serial correlation tests AR(1), AR(2), and AR(3) are the first-order, second-order, and third-order serial correlation tests on the first-differenced disturbance Δv_{it} using the estimated Δv_{it}, respectively (see Arellano and Bond (1991)). These serial correlation tests are standard-normally distributed under the null hypothesis that there are no such serial correlations in Δv_{it}. If v_{it} is serially uncorrelated, the presence of the first-order serial correlation in Δv_{it} and the absence of the second-order and third-order serial correlation in Δv_{it} should be recognized. Accordingly, if v_{it} is serially uncorrelated, AR(1) test rejects the null that there is no first-order serial correlation in Δv_{it} but AR(2) and AR(3) tests fail to reject the null that there is no second-order and third-order serial correlations in Δv_{it} respectively. These tests are important to investigate the validity of the model specification and the instruments used and the structure of the disturbance v_{it}.

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[7] When assuming $\alpha = 0$ in equation (8), the moment restrictions used are the same as those for the original form, except for the use of the auxiliary moment restrictions. In this case, the auxiliary moment restrictions $E[\Delta v_{it}] = 0$ for $t = 2,\ldots,T$ are used for the GMM (DIF) instead of (13), while $E[\eta_i + v_{it}] = 0$ for $t = 1,\ldots,T$ are used for the GMM (SYS) instead of (14). When assuming $\beta = 0$ in equation (8), the GMM (DIF) uses the standard moment restriction (9) and the moment restriction (13) to estimate the parameters of interest α and the first-differenced time dummies ΔTD_t for $t = 3,\ldots,T$, while the GMM (SYS) uses the standard moment restriction (9), the stationary moment restriction (11), and the moment restriction (14) to estimate the parameters of interest α and the level time dummies TD_t for $t = 2,\ldots,T$. When assuming $\gamma = 0$ in equation (8), the moment restrictions used are the same as those for the original form.

4. Results and discussion

Estimation results of equations (8) for $k = 6$ are presented in Table 1-5 for the different specifications. Table 1 presents the estimation results for equation (8) in the original form, which assumes the presence of the ROT consumers. Table 2 presents the results for equation (8) with $\gamma = 0$, for which the simple test of the excess sensitivity is conducted. Table 3 presents the results for equation (8) with $\beta = 0$, which assumes the absence of the ROT consumers and therefore tests the PIH directly. Table 4 presents the results for equation (8) with $\alpha = 0$, which assumes the intertemporal separability of preference for the PIH consumers, and in which therefore the ordinary equation to estimate the excess sensitivity is used. Finally, in Table 5, equation (8) with $\alpha = 0$ is estimated under the assumption that the disturbance v_{it} has the first-order serial correlation.[8]

Through the three models corresponding to Table 1-3, the GMM (DIF) and GMM (SYS) estimates of α (the intertemporal non-separability parameter) are negative and significant at conventional level in all spans.[9] If the model is correctly specified and the moment restrictions used are valid, the durability of the RNDS consumption of the PIH consumers is not negligible. Taking this into account, the results are first presented on the spans where it is positively considered that the PIH holds (that is, there are no ROT consumers), and the results are secondly presented on the spans where it is positively considered that the ROT alternative holds (that is, there are quite a few ROT consumers). Then, the estimation results are discussed why the PIH or the ROT alternative holds for each of the spans.

[8] In this situation, the standard moment restrictions utilized in the consistent GMM (DIF) and GMM (SYS) estimators are $E[\Delta c_{is}\Delta v_{it}] = 0$ and $E[\Delta y_{is}\Delta v_{it}] = 0$ for $s = 1,\ldots,t-3$ and $t = 4,\ldots,T$, which use the instruments Δc_{is} and Δy_{is} for $s = 1,\ldots,t-3$ to the first-differenced equation of (8) at time t, and the stationarity moment restrictions utilized in the consistent GMM (SYS) estimators are $E[\Delta^2 c_{i,t-2}(\eta_i + v_{it})] = 0$ and $E[\Delta^2 y_{i,t-2}(\eta_i + v_{it})] = 0$ for $t = 4,\ldots,T$, which use the instruments $\Delta^2 c_{i,t-2}$ and $\Delta^2 y_{i,t-2}$ to the level equation of (8) at time t. In addition, the auxiliary moment restrictions $E[\Delta v_{it}] = 0$ for $t = 2,\ldots,T$ are used for the GMM (DIF), while $E[\eta_i + v_{it}] = 0$ for $t = 1,\ldots,T$ are used for the GMM (SYS).

[9] Hayashi (1985) revealed from the data of Japanese households that the expenditure changes are negatively correlated over time. The negative estimates of α are consistent with the evidence that he found.

A series of the estimations have been carried out with DPD for Ox.[10]

Spans where the PIH holds: 1988-1993 and 1997-2002

Looking at Table 1 (depicting the results for equation (8) in the original form), the GMM (DIF) estimates of α, β, and γ (and their t-values) are -0.302 (-4.33), 0.089 (1.28), and 0.059 (1.85) in span 1988-1993 respectively, and -0.523 (-5.26), 0.057 (0.63), and 0.037 (0.93) in span 1997-2002 respectively, and further the GMM (SYS) estimates of α, β, and γ (and their t-values) are -0.278 (-3.99), 0.096 (1.73), and 0.065 (2.58) in span 1988-1993 respectively, and -0.467 (-4.94), 0.046 (0.47), and 0.025 (0.62) in span 1997-2002 respectively. In both spans, the GMM (DIF) and GMM (SYS) estimates of α are negative and significant at conventional level, the absolute values of the GMM (DIF) and GMM (SYS) estimates of β are small (near to zero) comparing with the estimates of β in other spans and not significant at conventional level, and the absolute values of the GMM (DIF) and GMM (SYS) estimates of γ are small (near to zero) and especially in span 1997-2002 not significant at conventional level. In addition, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics, it is said that the model is correctly specified and the moment restrictions used for the GMM (DIF) and GMM (SYS) estimators are valid in both spans.

Next, looking toward Table 2 (depicting the results for equation (8) with $\gamma = 0$), the GMM (DIF) estimates of α and β (and their t-values) are -0.261 (-3.09) and 0.022 (0.52) in span 1988-1993 respectively, and -0.538 (-6.04) and 0.000 (0.01) in span 1997-2002 respectively, and further the GMM (SYS) estimates of α and β (and their t-values) are -0.254 (-3.32) and 0.019 (0.41) in span 1988-1993 respectively, and -0.494 (-7.03) and -0.009 (-0.20) in span 1997-2002 respectively. As well as in Table 1, in both spans, the GMM (DIF) and GMM (SYS) estimates of α are negative and significant at conventional level, the absolute values of the GMM (DIF) and GMM (SYS) estimates of β are small (near to zero) and not significant at conventional level, and it seems that the model is correctly specified and the moment restrictions used for the GMM (DIF) and GMM (SYS) estimators are valid, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics.

Accordingly, the results in spans 1988-1993 and 1997-2002 from Table 1 and Table 2 indicates that the durability of the RNDS consumption is not negligible on the grounds

[10] A manual of DPD for Ox is written by Doornik et al. (2002).

that the values of estimated α are negative and significant, and there seems to be no ROT consumers in these spans where all consumers behave in the PIH mode on the grounds that the absolute values of estimated β are small and the null hypothesis of zero β (the crude ROT ratio) is not rejected at conventional level.

To obtain further corroboration of this finding, the estimation results using equation (8) with $\beta = 0$ are presented in Table 3. In this table, the GMM (DIF) and GMM (SYS) estimates of α are -0.284 (-4.52) and -0.274 (-4.15) in span 1988-1993, and -0.529 (-8.83) and -0.496 (-7.33) in span 1997-2002. These are also negative and significant at conventional level in both spans, and it is recognized that in both spans, the model is correctly specified and the moment restrictions used for the GMM (DIF) and GMM (SYS) estimators are valid, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics.[11]

However, looking at Table 4 (depicting the results for equation (8) with $\alpha = 0$), in span 1997-2002, the GMM (DIF) and GMM (SYS) estimates of β are 0.217 (3.61) and 0.214 (3.52), which are positive, far from zero, and significant at conventional level, and then it can be said that the model is correctly specified and the moment restrictions used are valid, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics. This estimation results say that there are quite a few ROT consumers in the economy in span 1997-2002, which are different from the results from the equations incorporating the lagged RNDS consumption shown in Table 1-2. It is considered that this is the empirical failure that the results without supporting the PIH model might be generated from the estimation equations without lagged consumption change, based on the erroneous assumption that the lagged consumption does not influence on the current utility of the consumers, as is pointed out by Guariglia and Rossi (2002) and Weber (2002).

The essence of the empirical failure mentioned above seems to be as follows. If the specification of equation (8) omits the lagged consumption change, the first-order serial correlation of v_{it} could be induced and the estimators ignoring the serial correlation are inconsistent. Accordingly, it is possible that the estimates of β for 1997-2002 in Table 4 are inconsistent estimates, although test statistics say that the model is correctly specified and the moment restrictions used are valid. Therefore the empirical

[11] In many other spans, it is doubtful that the correct model specification and the valid moment restrictions used are conducted in this specification, judging from the statistics.

failure that the positive β far from zero is estimated significantly seems to occur. To conduct further investigation on the possibility of the empirical failure, the results are presented applying the consistent estimators to the equation with $\alpha = 0$ under the assumption that v_{it} has the first-order serial correlation, which are shown in Table 5. In this table, in span 1997-2002, the GMM (DIF) and GMM (SYS) estimates of β is 0.090 (1.14) and 0.134 (1.35), which are smaller than the estimates shown in Table 4, and insignificant at conventional level, and it can be almost said that the model is correctly specified and the moment restrictions used are valid, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics.[12] From these facts, it is considered that the PIH is not rejected in span 1997-2002.

Span where the ROT alternative holds: 1993-1998

In Table 1 (depicting the results for equation (8) in the original form), in span 1993-1998, the GMM (DIF) estimates of α, β, and γ (and their t-values) are -0.398 (-4.66), 0.263 (5.24), and 0.081 (3.57) respectively, and the GMM (SYS) estimates of α, β, and γ (and their t-values) are -0.360 (-4.03), 0.221 (3.28), and 0.077 (2.61) respectively. The GMM (DIF) and GMM (SYS) estimates of α are negative and significant at conventional level, the GMM (DIF) and GMM (SYS) estimates of β are positive, far from zero, and significant at conventional level, and the GMM (DIF) and GMM (SYS) estimates of γ are positive and significant at conventional level. The positive sign of the values of estimated γ is tantamount to that predicted in the original equation, since $\gamma = -\alpha\beta$ where the signs of the values of estimated α and β are negative and positive respectively. Further, it is recognized that the model specification is correct and the moment restrictions used are valid, judging from Sargan test statistic and AR(1), AR(2), and AR(3) test statistics.

From this evidence, it is considered that the presence of the ROT consumers cannot be neglected in span 1993-1998, and the share of the income earned by ROT consumers is to say the least about 20 percent, based on the GMM (DIF) and GMM (SYS) estimates of the crude ROT ratio β, which are 0.263 and 0.221 respectively.

The finding that the share of consumption by the ROT consumers is substantial in

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[12] Note that if v_{it} has the first-order serial correlation, Δv_{it} could have the second-order serial correlation.

span 1993-1998 is made doubly sure by looking at the estimation results on this span in Table 3, in which equation (8) with $\beta = 0$ (that is, assuming no ROT consumers) is estimated. In Table 3, the GMM (DIF) and GMM (SYS) estimation results for span 1993-1998 indicate that the specification is incorrect, judging from Sargan test statistic, whose p-values are 0.005 and 0.021 for the GMM (DIF) and GMM (SYS) estimators respectively.[13] Accordingly, in span 1993-1998, the PIH is not supported.[14]

Discussion

A simple discussion is conducted on the reason why the PIH holds in span 1988-1993 and 1997-2002, while the ROT alternative holds in span 1993-1998. The former spans 1988-1993 and 1997-2002 correspond to the bubble regime and the serious deflation regime in Japan respectively, while the latter span 1993-1998 corresponds to the post-bubble depression regime. It is considered that in the bubble regime, most households could rationally behave as the PIH consumers since the economic condition was prosperous and the lifetime employment system with the seniority-based pay was alive and well. However, in the post-bubble depression regime, some households seem to change into the ROT consumers, confronting the liquidity constraint without being oblivious of the luxurious life experienced in the bubble regime. In the serious deflation regime after the post-bubble depression regime, the situation surrounding the households changes drastically. The increasing number of the firms adopting the job-evaluation-based pay and giving the early retirement advice to their workers, in addition to the gloomy perspective of the economic recovery, would make the households feel uneasy. It is considered that in this regime, the uncertainty to the future obliges the households to behave as the PIH consumers.

13 In addition, the less clear-cut values of AR(2) test statistics for the GMM (DIF) and GMM (SYS) estimators (i.e. –1.532 and –1.026) do not wipe away the possibility of the second-order serial correlation on Δv_{it}.

14 Looking at Table 2, the GMM (DIF) estimation result for span 1993-1998 indicates that the specification assuming that $\gamma = 0$ is not correct, judging from Sargan test statistic. In addition, the GMM (DIF) and GMM (SYS) estimation result for span 1993-1998 in Table 4 show that the specification assuming that $\alpha = 0$ is dubious, judging from Sargan test and AR(2) test. It is recognized that the specification in the original form is valid.

5. Conclusion

This paper described an empirical investigation into the PIH and the ROT alternative, allowing for the intertemporal non-separability of preferences. The data of RNDS consumption and disposable income to be used is a Japanese aggregate panel data composed of yearly data per household for 47 cities with prefecturel government (on workers' households), whose period is 1981-2002. For each of the selected spans in the period, the GMM estimations appropriate for the panel data were carried out. The two main findings were obtained from the estimations. The first finding is that the parameter estimates on the intertemporal non-separability are negative and significant at conventional level. This implies that the durability of the past RNDS consumption of the PIH consumers is considerable. The second finding is that the parameter estimates on the crude ROT ratio are near to zero and not significant at conventional level for the bubble regime 1988-1993 and the serious deflation regime 1997-2002, while they are positive and significant at conventional level for the post-bubble depression regime 1992-1997. This implies that the PIH holds for the bubble regime and the serious deflation regime, while the ROT alternative assuming the presence of the ROT consumers holds for the post-bubble depression regime. However, without allowing for the intertemporal non-separability, the estimates of the crude ROT ratio are positive and significant at conventional level for the serious deflation regime, implying that the PIH is rejected. This is thought to be the empirical failure pointed out by Guarglia and Rossi (2002) and Weber (2002), of which indication is that the PIH model without allowing for the intertemporal non-separability leads to the rejection of the PIH in the empirical studies.

Appendix

From the relationship $c_t = c_t^{ROT} + c_t^{PIH}$, the relationship $\Delta c_t = \Delta c_t^{ROT} + \Delta c_t^{PIH}$ is obtained. Solving this equation for Δc_t^{PIH}, and using the relationship $y_t^{ROT} = \lambda y_t$ and (5), the following relationship is obtained:

$$\Delta c_t^{PIH} = \Delta c_t - \Delta c_t^{ROT} = \Delta c_t - \beta \Delta y_t , \qquad \text{(A1)}$$

where $\beta = \lambda\varphi$. Substituting (A1) into (6), equation (7) is obtained.

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Table 1. Equation (8) in the original form

Estimation equation: $\Delta c_{it} = \alpha \Delta c_{i,t-1} + \beta \Delta y_{it} + \gamma \Delta y_{i,t-1} + TD_t + \eta_i + v_{it}$

(a) Estimator: GMM (DIF)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.433	-5.27	0.318	4.56	0.135	5.32	19.28	(17)	[0.313]	-3.304	-1.803	0.886	47	6
1983-1988	-0.447	-7.17	0.203	3.02	0.128	3.00	23.53	(17)	[0.133]	-3.458	-1.999	1.068	47	6
1984-1989	-0.416	-6.08	0.254	4.03	0.123	2.78	16.92	(17)	[0.460]	-3.097	-0.225	-0.241	47	6
1985-1990	-0.457	-4.43	0.393	3.61	0.164	2.55	16.14	(17)	[0.514]	-2.736	0.330	-0.556	47	6
1986-1991	-0.417	-6.75	0.219	4.72	0.121	3.99	15.23	(17)	[0.579]	-3.449	-1.104	0.784	47	6
1987-1992	-0.365	-7.31	0.158	2.54	0.078	2.55	18.57	(17)	[0.354]	-3.557	-1.094	0.278	47	6
1988-1993	-0.302	-4.33	0.089	1.28	0.059	1.85	17.46	(17)	[0.424]	-3.755	-0.387	0.389	47	6
1989-1994	-0.323	-4.11	0.123	1.42	0.074	1.82	14.04	(17)	[0.665]	-3.753	-1.107	-0.396	47	6
1990-1995	-0.322	-5.42	0.158	1.98	0.062	1.90	12.87	(17)	[0.745]	-4.101	-0.573	-0.008	47	6
1991-1996	-0.354	-4.40	0.178	2.59	0.082	2.45	17.01	(17)	[0.454]	-3.818	-0.899	0.201	47	6
1992-1997	-0.307	-4.64	0.290	5.11	0.080	3.22	12.03	(17)	[0.799]	-3.717	-1.173	1.520	47	6
1993-1998	-0.398	-4.66	0.263	5.24	0.081	3.57	20.98	(17)	[0.227]	-2.893	-0.442	-0.542	47	6
1994-1999	-0.418	-3.93	0.170	2.61	0.050	1.41	26.50	(17)	[0.066]	-2.715	-0.544	-0.576	47	6
1995-2000	-0.387	-3.35	0.211	3.92	0.070	2.83	17.13	(17)	[0.446]	-2.974	-1.066	0.813	47	6
1996-2001	-0.458	-4.56	0.121	1.28	0.063	2.08	16.28	(17)	[0.504]	-3.816	-1.575	1.883	47	6
1997-2002	-0.523	-5.26	0.057	0.63	0.037	0.93	23.37	(17)	[0.138]	-3.165	-0.422	-0.075	47	6

(b) Estimator: GMM (SYS)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.385	-4.92	0.267	4.15	0.131	4.40	29.70	(25)	[0.236]	-3.257	-1.616	0.621	47	6
1983-1988	-0.400	-5.62	0.190	3.03	0.131	3.68	30.44	(25)	[0.208]	-3.129	-1.730	1.166	47	6
1984-1989	-0.404	-5.43	0.237	3.33	0.129	3.83	26.68	(25)	[0.372]	-2.883	-0.463	-0.202	47	6
1985-1990	-0.363	-3.29	0.314	3.06	0.145	2.91	29.40	(25)	[0.248]	-2.336	0.049	-0.344	47	6
1986-1991	-0.382	-6.85	0.191	3.92	0.107	3.59	20.81	(25)	[0.703]	-3.332	-0.660	0.651	47	6
1987-1992	-0.341	-7.43	0.127	2.20	0.065	3.38	21.06	(25)	[0.689]	-3.347	-0.548	-0.100	47	6
1988-1993	-0.278	-3.99	0.096	1.73	0.065	2.58	19.76	(25)	[0.759]	-3.787	-0.164	0.322	47	6
1989-1994	-0.306	-5.05	0.108	1.70	0.054	1.34	22.81	(25)	[0.589]	-3.890	-1.142	-0.496	47	6
1990-1995	-0.310	-4.86	0.153	2.72	0.067	2.02	21.18	(25)	[0.683]	-3.840	-0.562	0.064	47	6
1991-1996	-0.303	-3.18	0.192	3.88	0.074	2.81	26.71	(25)	[0.371]	-3.549	-0.357	0.103	47	6
1992-1997	-0.354	-5.76	0.292	6.31	0.103	4.88	18.74	(25)	[0.809]	-3.398	-1.745	1.588	47	6
1993-1998	-0.360	-4.03	0.221	3.28	0.077	2.61	30.75	(25)	[0.197]	-2.715	-0.421	-0.586	47	6
1994-1999	-0.366	-3.27	0.195	3.76	0.055	1.81	29.43	(25)	[0.246]	-2.576	-0.123	-0.885	47	6
1995-2000	-0.309	-2.52	0.199	3.71	0.050	1.72	29.48	(25)	[0.245]	-2.975	-0.394	0.603	47	6
1996-2001	-0.424	-5.13	0.106	1.34	0.063	2.07	25.75	(25)	[0.421]	-3.730	-1.003	1.877	47	6
1997-2002	-0.467	-4.94	0.046	0.47	0.025	0.62	32.76	(25)	[0.137]	-3.169	-0.006	-0.176	47	6

Notes: [1] The estimates of time dummies are abbreviated. [2] $t(\alpha)$, $t(\beta)$ and $t(\gamma)$ are t-values for the estimates of the parameters α, β, and γ, which are calculated with the Windmeijer's (2005) correction of the standard errors. [3] Sargan is a test of the over-identifying restrictions for the GMM estimator, which is asymptotically distributed as chi-square with the degree of freedom being S-df and whose p-value is S-pval. [4] AR(1), AR(2), and AR(3) are the first-order, second-order, and third-order serial correlation tests, which are asymptotically N(0,1)-distributed under the null of no such serial correlations. [5] For the GMM (DIF) estimator, the moment restrictions (9), (10), and (13) are used, and for the GMM (SYS) estimator, the moment restrictions (9), (10), (11), (12), and (14) are used.

Table 2. Equation (8) with $\gamma = 0$

Estimation equation: $\Delta c_{it} = \alpha \Delta c_{i,t-1} + \beta \Delta y_{it} + TD_t + \eta_i + v_{it}$

(a) Estimator: GMM (DIF)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.268	-3.14	0.203	2.95	-	-	24.36	(18)	[0.144]	-3.729	-0.753	0.146	47	6
1983-1988	-0.329	-4.98	0.146	2.40	-	-	24.28	(18)	[0.146]	-3.890	-1.556	1.768	47	6
1984-1989	-0.293	-4.53	0.124	1.34	-	-	26.24	(18)	[0.094]	-3.744	-0.247	-0.041	47	6
1985-1990	-0.360	-5.23	0.085	1.23	-	-	28.34	(18)	[0.057]	-3.844	-0.452	-0.078	47	6
1986-1991	-0.299	-3.82	0.051	1.01	-	-	23.00	(18)	[0.190]	-3.326	0.074	-0.571	47	6
1987-1992	-0.297	-5.02	0.016	0.34	-	-	18.60	(18)	[0.417]	-3.413	-0.073	-0.578	47	6
1988-1993	-0.261	-3.09	0.022	0.52	-	-	17.58	(18)	[0.483]	-3.551	-0.382	0.259	47	6
1989-1994	-0.324	-3.87	0.011	0.24	-	-	14.34	(18)	[0.707]	-3.623	-1.775	-0.094	47	6
1990-1995	-0.253	-3.81	0.073	1.38	-	-	13.77	(18)	[0.744]	-3.846	-1.020	0.237	47	6
1991-1996	-0.277	-3.02	0.093	1.34	-	-	21.51	(18)	[0.255]	-4.134	-1.218	0.730	47	6
1992-1997	-0.244	-3.14	0.208	4.41	-	-	20.45	(18)	[0.308]	-4.056	-0.602	1.687	47	6
1993-1998	-0.310	-3.70	0.151	2.60	-	-	31.18	(18)	[0.027]	-3.394	-0.475	0.218	47	6
1994-1999	-0.374	-4.09	0.117	2.46	-	-	28.21	(18)	[0.059]	-3.048	-0.491	-0.373	47	6
1995-2000	-0.351	-3.32	0.115	2.57	-	-	23.99	(18)	[0.155]	-3.481	-0.665	1.160	47	6
1996-2001	-0.450	-4.23	0.029	0.47	-	-	21.92	(18)	[0.236]	-3.705	-0.694	2.299	47	6
1997-2002	-0.538	-6.04	0.000	0.01	-	-	23.92	(18)	[0.158]	-3.288	-0.293	-0.128	47	6

(b) Estimator: GMM (SYS)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.208	-2.81	0.167	2.43	-	-	29.48	(26)	[0.290]	-3.727	-0.567	0.039	47	6
1983-1988	-0.259	-3.38	0.110	1.56	-	-	31.48	(26)	[0.211]	-3.506	-1.515	1.880	47	6
1984-1989	-0.251	-3.14	0.038	0.95	-	-	32.20	(26)	[0.187]	-3.192	-1.265	0.486	47	6
1985-1990	-0.287	-3.58	0.016	0.29	-	-	36.02	(26)	[0.091]	-3.696	-0.308	-0.055	47	6
1986-1991	-0.297	-4.37	0.023	0.34	-	-	29.50	(26)	[0.289]	-3.107	0.150	-0.818	47	6
1987-1992	-0.303	-5.23	0.013	0.21	-	-	25.31	(26)	[0.502]	-3.282	-0.112	-0.564	47	6
1988-1993	-0.254	-3.32	0.019	0.41	-	-	25.81	(26)	[0.474]	-3.326	-0.339	0.241	47	6
1989-1994	-0.274	-4.20	0.039	0.92	-	-	21.32	(26)	[0.725]	-3.722	-1.376	-0.310	47	6
1990-1995	-0.220	-2.98	0.083	1.69	-	-	23.81	(26)	[0.587]	-3.642	-0.650	0.164	47	6
1991-1996	-0.232	-2.32	0.129	2.30	-	-	30.40	(26)	[0.251]	-3.873	-0.301	0.440	47	6
1992-1997	-0.245	-4.01	0.168	4.85	-	-	28.47	(26)	[0.336]	-3.982	-0.932	1.800	47	6
1993-1998	-0.299	-3.94	0.128	2.95	-	-	35.42	(26)	[0.103]	-3.264	-0.544	0.360	47	6
1994-1999	-0.328	-3.56	0.132	2.93	-	-	31.74	(26)	[0.202]	-3.019	-0.080	-0.705	47	6
1995-2000	-0.321	-2.76	0.127	2.17	-	-	29.49	(26)	[0.289]	-3.431	-0.412	0.960	47	6
1996-2001	-0.406	-3.92	0.017	0.28	-	-	31.77	(26)	[0.201]	-3.692	-0.235	2.258	47	6
1997-2002	-0.494	-7.03	-0.009	-0.20	-	-	28.99	(26)	[0.312]	-3.332	0.139	-0.298	47	6

Notes: The descriptions are the same as in Table 1.

Table 3. Equation (8) with $\beta = 0$

Estimation equation: $\Delta c_{it} = \alpha \Delta c_{i,t-1} + TD_t + \eta_i + v_{it}$

(a) Estimator: GMM (DIF)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.313	-4.35	-	-	-	-	20.60	(9)	[0.015]	-3.178	-2.175	-0.093	47	6
1983-1988	-0.342	-6.12	-	-	-	-	14.31	(9)	[0.112]	-3.889	-2.847	2.428	47	6
1984-1989	-0.297	-4.77	-	-	-	-	14.79	(9)	[0.097]	-3.860	-2.179	0.693	47	6
1985-1990	-0.357	-4.88	-	-	-	-	19.92	(9)	[0.018]	-4.187	-0.794	0.061	47	6
1986-1991	-0.272	-3.78	-	-	-	-	9.67	(9)	[0.378]	-3.897	0.499	-1.053	47	6
1987-1992	-0.314	-5.82	-	-	-	-	8.37	(9)	[0.497]	-3.968	-0.153	-0.621	47	6
1988-1993	-0.284	-4.52	-	-	-	-	6.66	(9)	[0.673]	-4.281	-0.613	0.241	47	6
1989-1994	-0.343	-4.98	-	-	-	-	10.19	(9)	[0.336]	-3.966	-1.972	-0.022	47	6
1990-1995	-0.276	-4.01	-	-	-	-	6.32	(9)	[0.708]	-4.359	-1.940	0.871	47	6
1991-1996	-0.302	-3.93	-	-	-	-	11.12	(9)	[0.268]	-4.015	-2.451	1.090	47	6
1992-1997	-0.331	-4.60	-	-	-	-	24.09	(9)	[0.004]	-3.487	-2.266	1.826	47	6
1993-1998	-0.383	-4.83	-	-	-	-	23.62	(9)	[0.005]	-3.416	-1.532	1.459	47	6
1994-1999	-0.424	-4.75	-	-	-	-	21.13	(9)	[0.012]	-3.513	-1.594	0.677	47	6
1995-2000	-0.477	-6.51	-	-	-	-	17.55	(9)	[0.041]	-3.948	-1.528	1.954	47	6
1996-2001	-0.482	-8.01	-	-	-	-	13.61	(9)	[0.137]	-3.885	-0.589	2.373	47	6
1997-2002	-0.529	-8.83	-	-	-	-	13.43	(9)	[0.144]	-3.459	-0.254	-0.172	47	6

(b) Estimator: GMM (SYS)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-0.245	-3.41	-	-	-	-	25.15	(13)	[0.022]	-3.212	-1.546	-0.062	47	6
1983-1988	-0.318	-4.88	-	-	-	-	16.43	(13)	[0.226]	-3.671	-2.715	2.350	47	6
1984-1989	-0.303	-4.59	-	-	-	-	17.52	(13)	[0.177]	-3.708	-2.236	0.701	47	6
1985-1990	-0.323	-4.20	-	-	-	-	19.47	(13)	[0.109]	-4.055	-0.573	0.011	47	6
1986-1991	-0.280	-4.16	-	-	-	-	12.76	(13)	[0.466]	-3.908	0.429	-1.032	47	6
1987-1992	-0.320	-5.53	-	-	-	-	11.79	(13)	[0.545]	-3.655	-0.204	-0.593	47	6
1988-1993	-0.274	-4.15	-	-	-	-	10.42	(13)	[0.659]	-3.963	-0.517	0.228	47	6
1989-1994	-0.344	-5.23	-	-	-	-	11.57	(13)	[0.563]	-4.101	-1.992	-0.053	47	6
1990-1995	-0.297	-3.70	-	-	-	-	14.29	(13)	[0.354]	-4.016	-2.045	0.862	47	6
1991-1996	-0.292	-3.35	-	-	-	-	22.82	(13)	[0.044]	-3.699	-2.255	1.091	47	6
1992-1997	-0.277	-3.62	-	-	-	-	27.33	(13)	[0.011]	-3.306	-1.916	1.892	47	6
1993-1998	-0.303	-4.14	-	-	-	-	25.25	(13)	[0.021]	-3.377	-1.026	1.248	47	6
1994-1999	-0.386	-4.09	-	-	-	-	22.28	(13)	[0.051]	-3.388	-1.193	0.508	47	6
1995-2000	-0.443	-5.73	-	-	-	-	22.55	(13)	[0.047]	-3.998	-1.192	1.800	47	6
1996-2001	-0.433	-6.53	-	-	-	-	19.19	(13)	[0.117]	-3.750	-0.227	2.353	47	6
1997-2002	-0.496	-7.33	-	-	-	-	17.68	(13)	[0.170]	-3.362	0.033	-0.246	47	6

Notes: The descriptions are the same as in Table 1, except for [5]. [5] For the GMM (DIF) estimator, the moment restrictions (9) and (13) are used, and for the GMM (SYS) estimator, the moment restrictions (9), (11), and (14) are used.

Table 4. Equation (8) with $\alpha = 0$

Estimation equation: $\Delta c_{it} = \beta \Delta y_{it} + TD_t + \eta_i + v_{it}$

(a) Estimator: GMM (DIF)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-	-	0.271	3.70	-	-	27.26	(19)	[0.099]	-4.588	2.008	-0.377	47	6
1983-1988	-	-	0.205	3.88	-	-	29.90	(19)	[0.053]	-4.812	1.185	0.304	47	6
1984-1989	-	-	0.180	2.53	-	-	32.33	(19)	[0.029]	-4.389	0.902	0.223	47	6
1985-1990	-	-	0.156	2.52	-	-	33.18	(19)	[0.023]	-4.045	1.143	-0.497	47	6
1986-1991	-	-	0.055	0.65	-	-	27.28	(19)	[0.098]	-3.768	1.316	-0.607	47	6
1987-1992	-	-	0.061	0.84	-	-	26.77	(19)	[0.110]	-3.911	1.793	-1.254	47	6
1988-1993	-	-	0.082	1.45	-	-	22.37	(19)	[0.266]	-4.092	1.981	-0.702	47	6
1989-1994	-	-	0.108	1.82	-	-	23.41	(19)	[0.220]	-4.355	1.305	-0.367	47	6
1990-1995	-	-	0.125	1.61	-	-	21.03	(19)	[0.335]	-4.757	0.929	-0.654	47	6
1991-1996	-	-	0.190	2.58	-	-	25.97	(19)	[0.131]	-4.849	1.316	-0.664	47	6
1992-1997	-	-	0.267	5.81	-	-	23.23	(19)	[0.227]	-4.718	1.792	0.442	47	6
1993-1998	-	-	0.256	4.39	-	-	31.92	(19)	[0.032]	-4.020	1.718	0.590	47	6
1994-1999	-	-	0.219	3.23	-	-	30.56	(19)	[0.045]	-3.528	1.311	-1.500	47	6
1995-2000	-	-	0.238	4.85	-	-	23.77	(19)	[0.205]	-3.398	1.324	-1.152	47	6
1996-2001	-	-	0.229	4.14	-	-	20.52	(19)	[0.364]	-3.927	0.862	0.222	47	6
1997-2002	-	-	0.217	3.61	-	-	26.76	(19)	[0.110]	-4.182	0.789	0.697	47	6

(b) Estimator: GMM (SYS)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-	-	0.204	3.22	-	-	30.82	(27)	[0.279]	-4.365	2.108	-0.441	47	6
1983-1988	-	-	0.144	2.16	-	-	35.41	(27)	[0.129]	-4.478	0.649	0.574	47	6
1984-1989	-	-	0.076	1.52	-	-	38.03	(27)	[0.077]	-4.216	-0.057	1.181	47	6
1985-1990	-	-	0.057	0.97	-	-	39.95	(27)	[0.052]	-4.050	0.387	-0.012	47	6
1986-1991	-	-	0.060	0.76	-	-	34.00	(27)	[0.166]	-3.790	1.335	-0.594	47	6
1987-1992	-	-	0.086	1.52	-	-	33.46	(27)	[0.182]	-3.979	1.831	-1.091	47	6
1988-1993	-	-	0.097	1.50	-	-	31.47	(27)	[0.252]	-4.065	1.883	-0.600	47	6
1989-1994	-	-	0.090	2.04	-	-	32.52	(27)	[0.213]	-4.281	1.283	-0.382	47	6
1990-1995	-	-	0.106	1.90	-	-	30.39	(27)	[0.297]	-4.623	0.849	-0.598	47	6
1991-1996	-	-	0.167	2.80	-	-	31.69	(27)	[0.244]	-4.882	1.184	-0.553	47	6
1992-1997	-	-	0.212	6.01	-	-	35.09	(27)	[0.137]	-4.792	1.389	0.700	47	6
1993-1998	-	-	0.192	3.95	-	-	38.26	(27)	[0.074]	-4.103	1.419	0.827	47	6
1994-1999	-	-	0.236	4.58	-	-	34.25	(27)	[0.159]	-3.522	1.322	-1.556	47	6
1995-2000	-	-	0.253	6.60	-	-	30.52	(27)	[0.291]	-3.440	1.344	-1.180	47	6
1996-2001	-	-	0.208	3.85	-	-	27.89	(27)	[0.417]	-4.067	1.000	0.268	47	6
1997-2002	-	-	0.214	3.52	-	-	36.72	(27)	[0.100]	-4.196	0.773	0.703	47	6

Notes: The descriptions are the same as in Table 1, except for [5]. [5] For the GMM (DIF) estimator, the moment restrictions (9), (10), and the moment restrictions $E[\Delta v_{it}] = 0$ for $t = 2, \ldots, T$ are used, and for the GMM (SYS) estimator, the moment restrictions (9), (10), (11), (12), and the moment restrictions $E[\eta_i + v_{it}] = 0$ for $t = 1, \ldots, T$ are used.

Table 5. Equation (8) with $\alpha = 0$ assuming the first-order serially correlated v_{it}

Estimation equation: $\Delta c_{it} = \beta \Delta y_{it} + TD_t + \eta_i + v_{it}$

(a) Estimator: GMM (DIF)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-	-	0.393	4.26	-	-	8.95	(11)	[0.627]	-4.299	1.492	-0.159	47	6
1983-1988	-	-	0.263	4.01	-	-	11.79	(11)	[0.380]	-4.721	1.435	0.146	47	6
1984-1989	-	-	0.323	3.18	-	-	10.82	(11)	[0.459]	-3.477	1.626	-0.679	47	6
1985-1990	-	-	0.223	1.34	-	-	13.63	(11)	[0.254]	-2.981	1.357	-0.781	47	6
1986-1991	-	-	0.190	2.83	-	-	8.15	(11)	[0.699]	-3.596	1.522	-0.521	47	6
1987-1992	-	-	0.183	2.77	-	-	3.65	(11)	[0.979]	-3.930	1.773	-0.342	47	6
1988-1993	-	-	0.135	1.90	-	-	5.89	(11)	[0.881]	-4.102	1.796	-0.338	47	6
1989-1994	-	-	0.149	1.81	-	-	5.79	(11)	[0.887]	-4.485	1.254	-0.330	47	6
1990-1995	-	-	0.170	1.77	-	-	10.76	(11)	[0.463]	-4.847	1.127	-0.739	47	6
1991-1996	-	-	0.122	0.98	-	-	13.73	(11)	[0.248]	-4.821	0.781	-0.361	47	6
1992-1997	-	-	0.305	3.62	-	-	8.96	(11)	[0.626]	-4.123	1.729	0.403	47	6
1993-1998	-	-	0.187	2.40	-	-	9.87	(11)	[0.542]	-4.178	1.488	0.979	47	6
1994-1999	-	-	0.159	2.12	-	-	16.91	(11)	[0.111]	-3.743	1.290	-1.497	47	6
1995-2000	-	-	0.152	1.61	-	-	10.26	(11)	[0.507]	-3.835	1.534	-1.075	47	6
1996-2001	-	-	0.106	1.31	-	-	10.71	(11)	[0.468]	-4.592	1.814	0.707	47	6
1997-2002	-	-	0.090	1.14	-	-	9.00	(11)	[0.622]	-4.893	2.025	0.828	47	6

(b) Estimator: GMM (SYS)

Span	α	t(α)	β	t(β)	γ	t(γ)	Sargan	S-df	S-pval	AR(1)	AR(2)	AR(3)	N	T
1982-1987	-	-	0.369	6.90	-	-	14.91	(17)	[0.602]	-4.782	1.615	-0.296	47	6
1983-1988	-	-	0.281	4.58	-	-	18.61	(17)	[0.351]	-4.663	1.508	0.032	47	6
1984-1989	-	-	0.214	2.15	-	-	14.37	(17)	[0.641]	-4.141	1.124	-0.048	47	6
1985-1990	-	-	0.208	1.51	-	-	19.84	(17)	[0.282]	-3.308	1.339	-0.721	47	6
1986-1991	-	-	0.205	3.85	-	-	13.32	(17)	[0.714]	-3.660	1.563	-0.550	47	6
1987-1992	-	-	0.196	3.44	-	-	13.88	(17)	[0.676]	-3.953	1.732	-0.247	47	6
1988-1993	-	-	0.130	1.78	-	-	12.56	(17)	[0.765]	-4.102	1.809	-0.326	47	6
1989-1994	-	-	0.187	2.31	-	-	16.48	(17)	[0.490]	-4.466	1.013	-0.214	47	6
1990-1995	-	-	0.212	2.27	-	-	17.86	(17)	[0.397]	-4.615	1.185	-0.653	47	6
1991-1996	-	-	0.195	2.02	-	-	16.64	(17)	[0.479]	-4.830	1.404	-0.745	47	6
1992-1997	-	-	0.290	3.73	-	-	13.96	(17)	[0.670]	-4.349	1.794	0.377	47	6
1993-1998	-	-	0.167	2.18	-	-	19.46	(17)	[0.303]	-4.149	1.256	1.065	47	6
1994-1999	-	-	0.121	1.49	-	-	22.48	(17)	[0.167]	-3.825	1.165	-1.059	47	6
1995-2000	-	-	0.119	1.07	-	-	17.73	(17)	[0.406]	-3.894	1.576	-0.892	47	6
1996-2001	-	-	0.106	1.89	-	-	14.33	(17)	[0.643]	-4.614	1.846	0.657	47	6
1997-2002	-	-	0.134	1.35	-	-	12.89	(17)	[0.744]	-4.338	1.252	0.754	47	6

Notes: The descriptions are the same as in Table 1, except for [5]. [5] For the GMM (DIF) estimator, the standard moment restrictions $E[\Delta c_{is} \Delta v_{it}] = 0$ and $E[\Delta y_{is} \Delta v_{it}] = 0$ for $s = 1, \ldots, t-3$ and $t = 4, \ldots, T$ and the moment restrictions $E[\Delta v_{it}] = 0$ for $t = 2, \ldots, T$ are used, and for the GMM (SYS) estimator, the standard moment restrictions above and the stationarity moment restrictions $E[\Delta^2 c_{i,t-2}(\eta_i + v_{it})] = 0$ and $E[\Delta^2 y_{i,t-2}(\eta_i + v_{it})] = 0$ for $t = 4, \ldots, T$ and the moment restrictions $E[\eta_i + v_{it}] = 0$ for $t = 1, \ldots, T$ are used.