Ageing Population and its Macroeconomic Consequences in Japan: A Survey

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Contents

1. Motivation

✔Japan has been one of spearheads of the global change of aging population, with almost a quarter century of rapid aging.

✔Simultaneously, Japan's economy has been suffering from low growth, deflationary pressure, and mounting public debts in the last quarter century. Did rapid aging cause or at least aggravate these problems?

✔ We explore relationship between aging and economic performance by comparing a conventional relationship of key macroeconomic variables ignoring aging effects and the actually observed one which is influenced by ongoing aging population (though mostly qualitatively, not quantitatively, due to our survey nature of investigation).

✔We find : Aging (coupled with other factors) had (1) unexpected dynamic deflationary effects on inflation and (2) reduced unexpectedly the effectiveness of Keynesian aggregate-demand management policy (= business cycles implications).

✔We find: Aging's negative effects on such long-run variables as potential growth are more than expected.

✔ (If time permits,) We also examine (though tentatively) the impact of aging in Japanese financial markets.

2. Explanatory Framework: A Variant of Textbook Keynesian Models of Rigid Prices and Wages

In period t, wages W_t, prices P_t and capital stocks K_t are given (predetemined). Then, aggregate demand is determined by a familiar multiplier relationship through the IS relation: $Y_t = C(Y_t) + I(r_{t-1}) + G_t$.

$$\text{Aggregate Demand (IS Relation): } Y_t = Y^P + \frac{1}{s_\Delta}\left\{\widetilde{I(r_{t-1})} + \widetilde{G_t}\right\}$$

where $Y^P = C^P + I^P + G^P$ is trend or potential GDP (consisting of trend consumption expenditure C^P, trend investment I^P, and trend government expenditure G^P), s_Δ is the marginal saving rate and thus $1/s_\Delta$ is an income multiplier), $\tilde{I} = I - I^P$ is investment above own trend which is determined by last period's real interest rate r_{t-1}, and $\widetilde{G_t}$ is an exogenous government expenditure above own trend. Then, labor demand $L^D(Y_t, K_t)$ is determined by the production function $Y_t = F(L_t^D, K_t)$, and the Wage Phillips Curve determines nex period's wage

$$\text{Wage Phillips Curve: } \frac{W_{t+1} - W_t}{W_t} = -\gamma\left\{\frac{L_t^S - L^D(Y_t, K_t)}{L_t^S}\right\} + \eta$$

where L_t^S is the labor supply and $(L_t^S - L^D)/L_t^S$ is the unemployment rate, $\gamma > 0$ is the slope, and $\eta > 0$ is a constant determined by long-run wage-inflation expectations. The next period's price $P_{t+1} = \lambda_{t+1}W_{t+1}$ is a mark-up over the next period's wage (marginal cost) W_{t+1} where the mark-up λ_{t+1} is dependent on price-setting firms' market power. Thus, the price inflation π_{t+1} in the next period is the sum of the change in market power and the wage inflation.

$$\text{Price Inflation: } \pi_{t+1} = \frac{P_{t+1} - P_t}{P_t} = \left(\frac{\lambda_{t+1} - \lambda_t}{\lambda_t}\right)\frac{W_{t+1}}{W_t} + \left(\frac{W_{t+1} - W_t}{W_t}\right)$$

Then, the rest of the economic variables are determined in the following way. Monetary policy determines nominal interest rate by a Taylor Rule $i_t = g\{\pi_t, (Y_t - Y^P)\}$, which in turn detemines the real interest rate through the Fisher relation $r_t = i_t - \pi_{t+1}^e$, where π_{t+1}^e is the expected inflation rate of the next period formed in this period. This real interest rate determines the next period's investment $\widetilde{I(r_t)}$. Finally, the next period's capital stocks are determined by capital formation equation $K_{t+1} - K_t = I(r_{t-1}) + \delta K_t$.

2. Explanatory Framework: Derivation of Aggregate Demand (IS Relation)

✔ This slide shows the derivation of the aggregate demand determination.

Derviation of the IS Relations: First, Consumption, Investment and Government Expenditure are defined in the followint way, where $(1 - s_\Delta)$ is the marginal propensity to comsume by definition.

$$C_t(Y) = (1 - s_\Delta)(Y_t - Y^P) + C^P : \text{Consumption in Period } t$$

$$I_t = \widetilde{I(r_{t-1})} + I^P : \text{Investment in Period } t$$

$$G_t = \widetilde{G_t} + G^P : \text{Government Expenditure in Period } t$$

where trend or potential GDP is ¶

$$Y^P = C^P + I^P + G^P$$

Consequently, the following transformations are straightforward.

$$Y_t = [(1 - s_\Delta)(Y_t - Y^P) + C^P] + \left[\widetilde{I(r_t)} + I^P\right] + \left[\widetilde{G_t} + G^P\right]$$

$$= (1 - s_\Delta)(Y_t - Y^P) + C^P + I^P + G^P + \widetilde{I(r_t)} + \widetilde{G_t}$$

$$= (1 - s_\Delta)(Y_t - Y^P) + Y^P + \widetilde{I(r_t)} + \widetilde{G_t}$$

Thus, we have

$$s_\Delta Y_t = s_\Delta Y^P + \widetilde{I(r_t)} + \widetilde{G_t}$$

which implies

$$Y_t = Y^P + \frac{1}{s_\Delta}\left\{\widetilde{I(r_t)} + \widetilde{G_t}\right\}$$

3-1. Impacts of Aging on Labor Markets: Wage Inflation or Deflation?

✔Wage Phillips Curve

Wage Inflation ≈ (- γ) *Unemployment Rate + Long-Run Wage-Inflation Expectations

Unemployment Rate = (Labor Supply − Labor Demand) ∕ Labor Supply

Aging population means decrease of Labor Supply. *Ceteris Paribus*, it REDUCES Unemployment and thus becomes an INFLATIONARY pressure.

However, aging population may reduce potential GDP (and actual GDP) at the same time. *Ceteris Paribus*, it reduces Labor Demand, and thus it INCREASES Unemployment. Thus it is a DEFLATIONARY pressure.

Whether aging population is ultimately inflationary or deflationary depends on these two factors, and thus it is an empirical question.

HOWEVER, regardless of whether aging is ultimately inflationary or deflationary, DECREASING Unemployment SHOULD RAISE WAGE INFLATION.

Then, what happened in reality in Japan?

3-1. Impact of Aging in Labor Markets: Flat or Even Positively Sloping Phillips Curve

Wage Phillips Curve in Japan

Legend:
- 1991M2-1997M5
- 1997M5-2000M11
- 2000M11-2008M2
- 2008M2-2012M4
- 2012M4-

X-axis: Unemployment Rate (employee-based) (%)
Y-axis: Wage Inflation (base wage) (%)

Annotations on chart: 1991M2, 1997M5, 2008M2, 2012M4, 2000M11

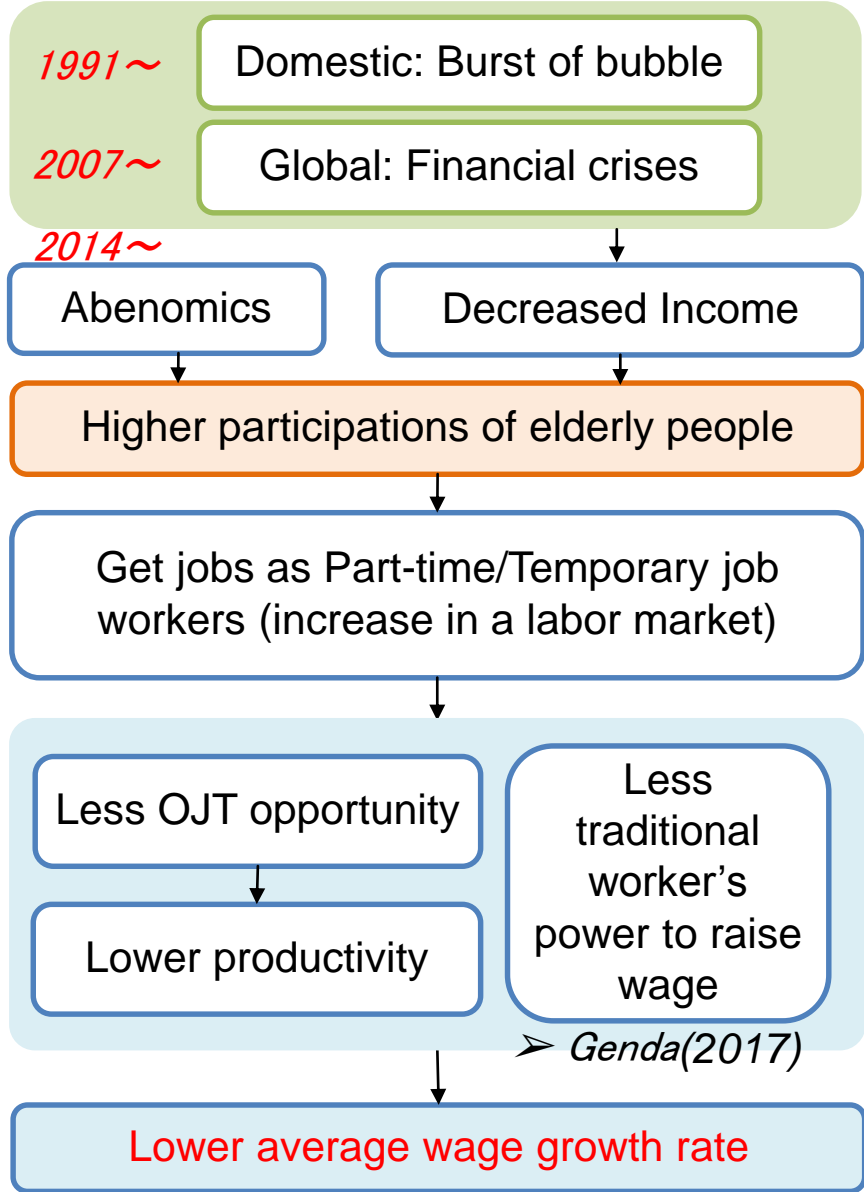Unemployment Decreases and Wage Inflation Decelerates
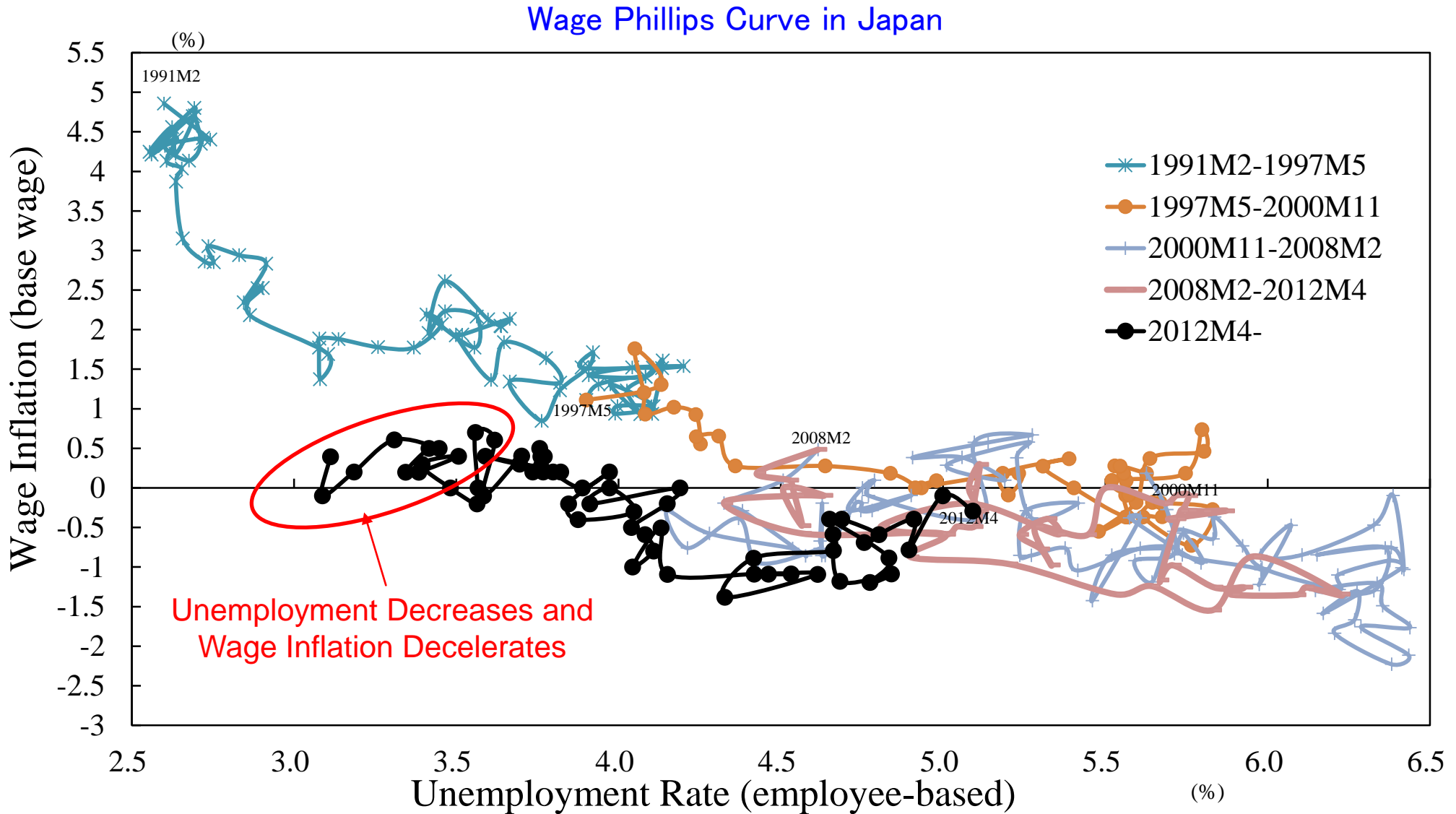
3-1. Impact of Aging in Labor Markets: Why Is Ph.Cur. Flat or Even Positively Sloping?

Finding 1-1.

- (1) A higher participation rate of elderly and women, and (2) a larger share and importance of part-time/temporary job workers implies the lower-wage portion of labor supply is increased. Thus, although observed unemployment is notably lower, the average wage inflation is not higher to the same extent, even if both portions have the same wage Phillips curve.

- (3) Increased importance of part-time/temporary jobs weakens the bargaining power of full-time/permanent job workers in their wage negotiation and (4) a fear of losing jobs and being replaced by part-time/temporary workers makes full-time/permanent job workers hesitate to require higher wages.

Both effects reduce the slope of the Wage Phillips curve.

➢ *GENDA, Yuji, et al (2017)* 人手不足なのになぜ賃金が上がらないのか *(Why Are Wages Not Raised?) Tokyo: Keio University Press, April .*

1991～ Domestic: Burst of bubble

2007～ Global: Financial crises

2014～

Abenomics → Decreased Income

Higher participations of elderly people

Get jobs as Part-time/Temporary job workers (increase in a labor market)

Less OJT opportunity → Lower productivity

Less traditional worker's power to raise wage

➢ *Genda(2017)*

Lower average wage growth rate

Finding 1-2.

■ The infiltration process of information and communication technology (ICT) would cause a transition of labor demand.

➢ *Center for Research and Development Strategy, Japan Science and Technology Agency*（2015），"科学技術イノベーション政策の科学における政策オプションの作成～ICT分野の政策オプション作成プロセス～," CRDS-FY2015-RR07.

Finding 1-3.

■ "The employment-unfriendly characteristics of ICT …affect the efficiency of the labour market. On the supply side, a large number of medium-skill workers lose their traditional jobs. On the demand side, technologically demanding job vacancies increase as eligible workers are in chronically short supply. ..(O)ld workers compete with young ones to crowd the latter out, hampering human capital investment in young workers. This has a large negative effect on long-run efficiency."

➢ NISHIMURA, Kiyohiko G.（2016），"Trois Changements « Sismiques » dans l'Économie Mondiale et Leurs Enjeux de Politique Économique", *Revue d'Économie Financière*, No 121 (Mars) 131-144.

"Ubiquity" of IOT/ICT increases demand for labor flexible enough to adopt new technology
➢ *CRDS(2015)*

Change in a labor market

Medium–skill	**Technology-oriented**
Supply = Excess	Supply = Short
Demand = Decrease	Demand = Increase

In Japan,

Existing Older worker	**Younger people**
・Hard to be fired	・Easy to be replaced
・Long-term, full-time, permanent jobs	・Short-term, part-time, temporary jobs
Lower productivity	Less human capital

➢ *Nishimura(2016)*

Mismatch of technology and labor
→ Inefficiency
→ Lower potential growth

Lower average wage growth rate

3-2. Impacts of Aging on Macroeconomic Consumption

✔ Aggregate Demand Determination

Real GDP = Potential GDP + {1／(marginal saving rate)} *(Δ Investment + Δ Gov. Expenditure)

Potential GDP = Trend Consumption + Trend Investment + Trend Gov. Expenditure

Thus, the impacts of aging on macro consumption are divided into

those on Trend (Potential) Consumption and

those on marginal saving rate, affecting multiplier effects of policy

We found that the net effect of aging population is to decrease Trend Consumption, which in turn REDUCES Potential GDP and ultimately leads to DEFLATIONARY pressures on wages and prices. This effect is somewhat expected but the degree of the effect exceeded expectations.

We found the net effect of aging population is to increase marginal saving rate, and thus DECREASE the multiplier and the effectiveness of macroeconomic aggregate demand management policies. This effect is not anticipated.

3-2. Impacts of Aging on Macroeconomic Consumption: Trend Consumption

Trend Consumption:

There was general agreement that aging would lower trend consumption.

Still, the recent slump of household consumption is surprising.

JAPAN real GDP Growth: Percent Change from Quarter One Year Ago

—GDP(Expenditure Approach)

—Consumption ofHouseholds
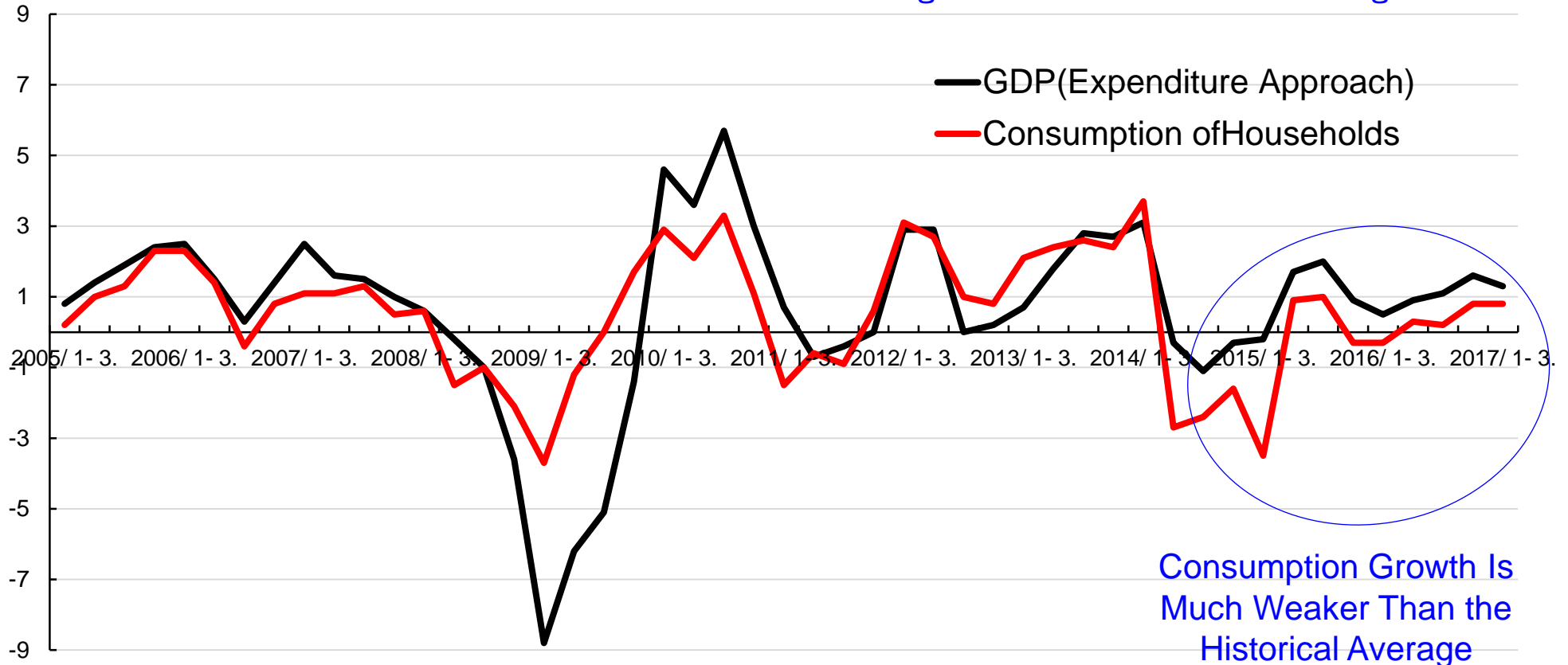
Consumption Growth Is Much Weaker Than the Historical Average

Finding 2-1.

■ Elderly people have different consumption baskets compared with younger people, in which the elderly spend more on foods and health care, and less on information and education. Also, because of the limitation of the accessibility to distant retail outlets due to their ages, they use retail stores which are located near their houses and department stores more often, and use less supermarkets and discount stores. These differences of consumption baskets and behaviors make the inflation rate which the elderly people faces higher by 2.0%p than the average inflation rate.

➢ *UNAYAMA, Takashi and Masayuki Keida (2011)「高齢者世帯の消費行動と物価指数」RIETI Discussion Paper Series 11-J-047, Research Institute of Economy, Trade & Industry, IAA, April.*
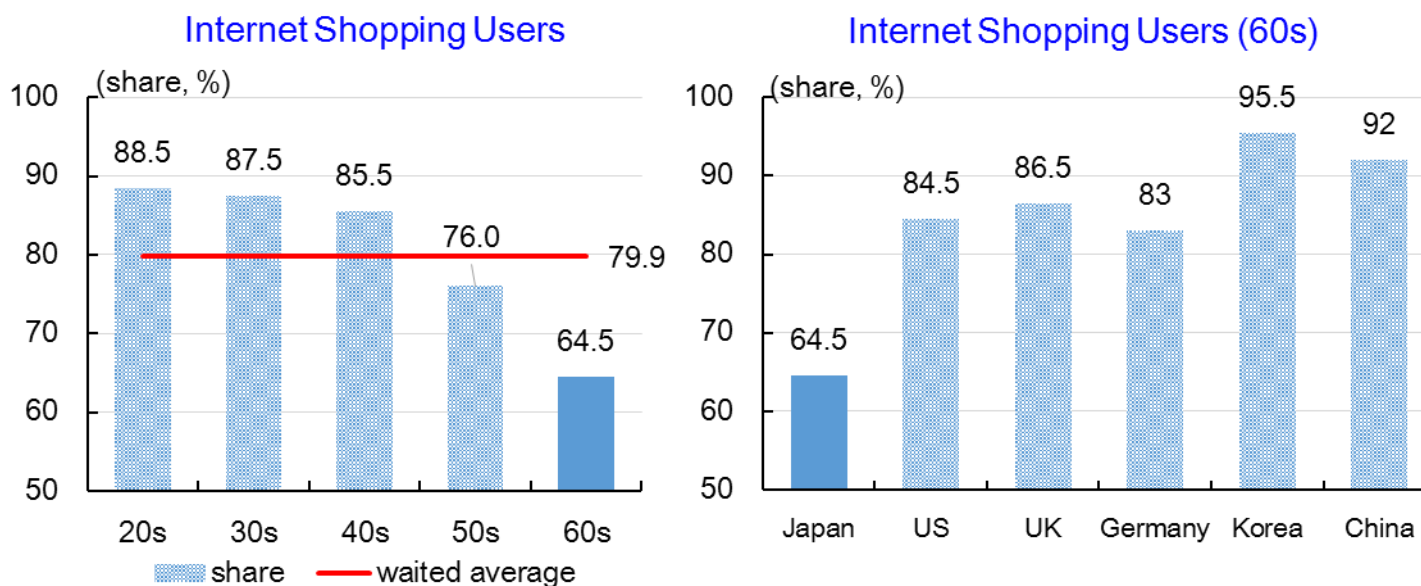
Consequently, aged people have a smaller purchasing power and thus their trend consumption is lower than young people.

Finding 2-2.

■ In Japan, old people's usage of internet shopping services is substantially lower than the other age groups, and also lower than those in other countries. One of the reason of lower usage rate is their legacy use of old equipment in accessing the internet. For example, elderly people tend to use more feature phones and less smart phones (The share is: feature phone 62.0%, smart phone 35.0%).

➤ *Ministry of International Affairs and Communications (2016)* "平成28年度情報通信白書," *pages 167, July.*

Internet Shopping Users

(share, %)

20s	30s	40s	50s	60s
88.5	87.5	85.5	76.0	64.5

waited average: 79.9

☐ share ── waited average

Internet Shopping Users (60s)

(share, %)

Japan	US	UK	Germany	Korea	China
64.5	84.5	86.5	83	95.5	92

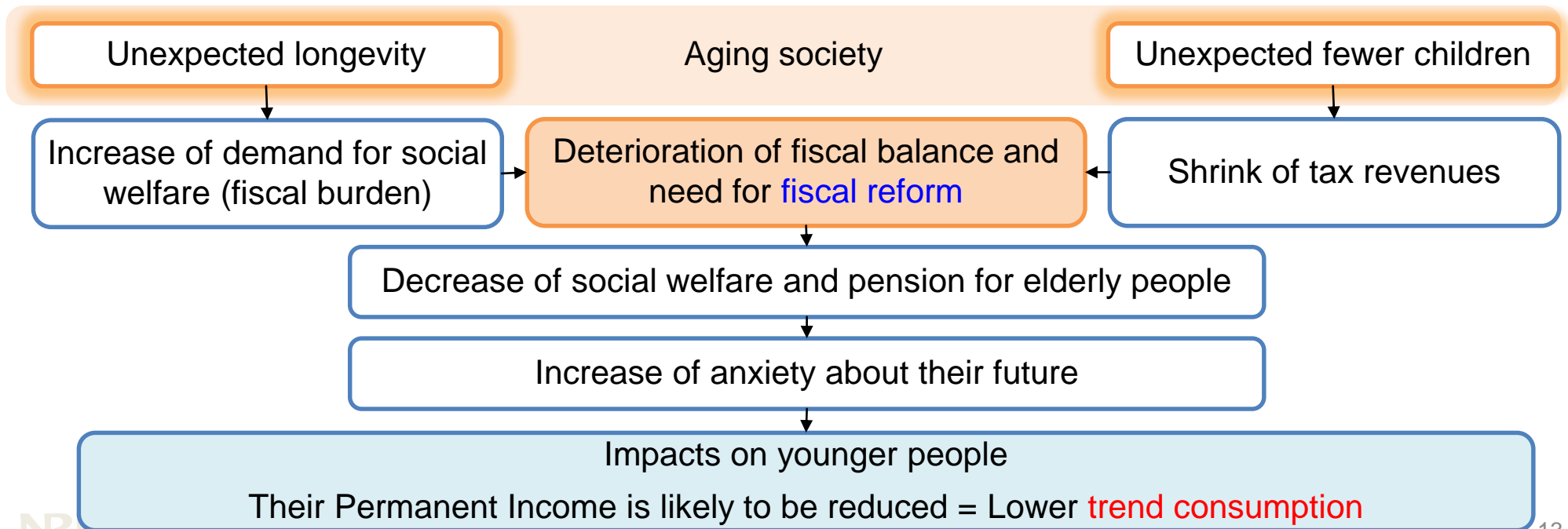**Consequently, aged people have a higher shopping cost, which results in a smaller purchasing power and thus their trend consumption is lower than young people.**

3-2. Impacts of Aging on Macroeconomic Consumption: Trend Consumption (3)

Finding 2-3.

■Aging population and future uncertainty have large negative impacts on younger population's perceived trend or permanent income.

■A survey showed that there was an increase of the future anxiety among younger generation including teenagers. They have strong anxieties about the health condition of themselves and their parents, increase of tax and premium, and sustainability of public social welfare system. This makes people to shrink their consumption for today.

➢ *MATSUSHITA, Motoko, et al (2013), "なぜ、日本人はモノを買わないのか?: 1万人の時系列データでわかる日本の消費者," 東洋経済新報社, July 2013.*

Unexpected longevity	Aging society	Unexpected fewer children
Increase of demand for social welfare (fiscal burden)	Deterioration of fiscal balance and need for fiscal reform	Shrink of tax revenues

Decrease of social welfare and pension for elderly people

Increase of anxiety about their future

Impacts on younger people

Their Permanent Income is likely to be reduced = Lower trend consumption

Finding 2-4.

■ The relative poverty rate over 65 years old is higher than the one of the younger people. And because the share of elderly people has been growing, the overall relative poverty rate becomes higher than before.

➢ *Cabinet Office, Ministry of Internal Affairs and Communications and Ministry of Health, Labour and Welfare (2015) "相対的貧困率等に関する調査分析結果について," pp7-11, December.*

Finding 2-5.

■ The share of elderly people who think their savings are not sufficient reaches 57% and it is the highest among other advanced countries. The main purpose of their savings is to prepare for diseases and elderly care payments (62.3%).

➢ *Cabinet Office (2016) "平成28年版高齢社会白書," p61, May.*

Holding Assets and Savings after Retirement
(over 60 years old)

	Japan	US	Germany	Sweden
Sufficient	37	69	66	73
Not Sufficient	57	25	18	19
Others				
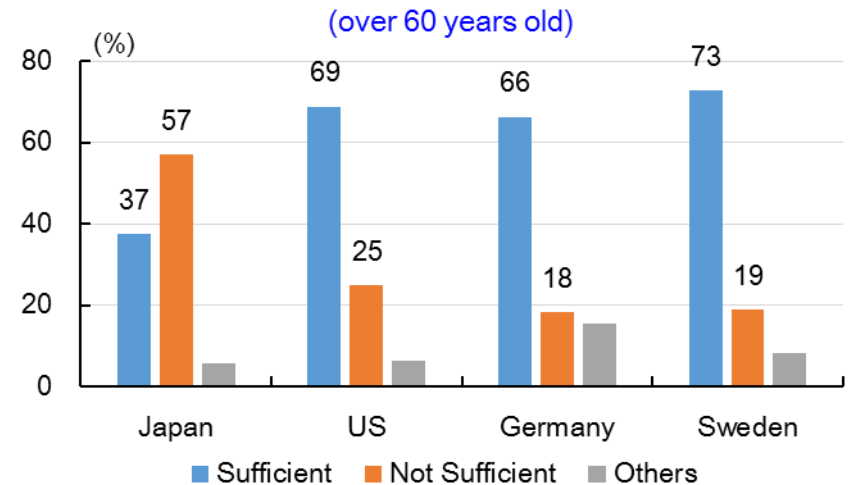
Consequently, elderly people have a substantially higher marginal saving rate than young people, which increases overall marginal saving rate, and reduces the multiplier effect of Keynesian demand-management policy.

3-3. Impacts of Aging on Firms' Behavior: Pricing and Investment

✔ Price Inflation

Price Inflation = Mark-up Inflation + Wage Inflation

✔ Aggregate Demand (IS Relation)

Real GDP = Consumption + Investment + Gov. Expenditure

Investment = ΔI (real interest rate) + Trend Investment

Thus, the impacts of aging on Price Inflation through firm's behavior are divided into

Mark-up Inflation and Trend Investment.

The net effect of aging population is to lower Mark-up Inflation, which in turn REDUCES Price Inflation directly.

Another net effect of aging population is to decrease Trend Investment, and thus DECREASE the Real GDP and INCREASE of the unemployment rate which in turn causes DEFLATIONARY pressures.

However, very few studies are available about its effects on Interest Sensitivity of Investment over Trend in Japan and elsewhere …

3-3. Impacts of Aging on Firms' Behavior: Pricing

Finding 3-1.

■ Elderly people tend to have lower inflationary expectations. They tend to rely on fewer resources of information about prices. And also they tend to change their (5-year) inflationary expectations based on the price changes of food and energy.

➢ *NISHIKGUCHI, Shusaku, Jouchi Nakashima and Kei Imakubo (2014) "家計のインフレ予想の多様性とその変化," Bank of Japan, Bank of Japan Review , 2014-J-1, March.*

■ The gap has emerged because
(A) the consumption basket for elderly people is different from that for younger people

➢ *SHIRAKI, Noriyuki and Koji Nakamura (2012) "最近の高齢者の消費動向について", Bank of Japan, Bank of Japan Review 2012-J-10, July.)*
and
(B) the cost for colleting information about prices by elderly people is higher than the cost by younger people

➢ *KOBAYASHI Keiichiro (2017) "高齢化と経済政策", Keio University, March.*
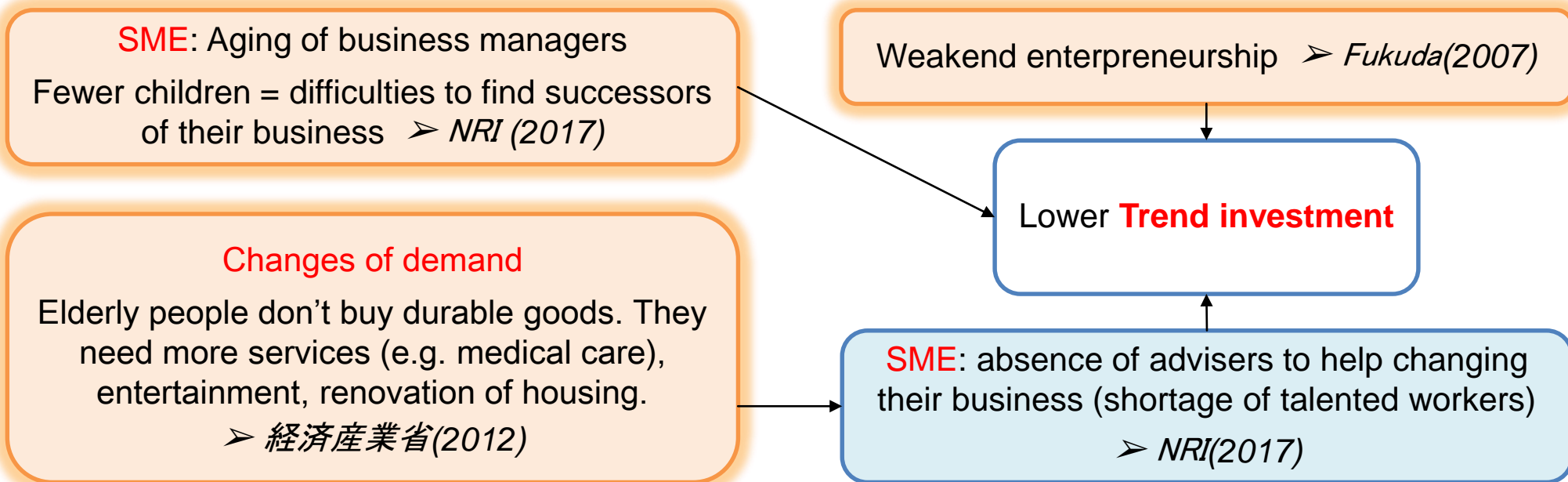
Consequently, price-setting firms are more obliged to shun increasing their prices than otherwise, since growing elderly customers are more antagonistic to price increases than the average customer.

Finding 3-2.

■ Younger business managers (under 50 years old) invest significantly more than older managers. In contrast, older managers (upper 70 years old) seem to negatively affect the investments in their businesses. Also, the years in business negatively affect on the investment significantly. So, in Japan, weakened "entrepreneurship" caused by aging managers has brought about decreasing business investment.

➢ *FUKUDA, S, Munehisa Kasuya and Masayuki Keida (2007)* "企業家精神と設備投資：デフレ下の設備投資低迷のもう一つの説明," *Bank of Japan Working Paper Series 07-J-7, the Bank of Japan, March.*

SME: Aging of business managers
Fewer children = difficulties to find successors of their business ➢ *NRI (2017)*

Weakend enterpreneurship ➢ *Fukuda(2007)*

Changes of demand
Elderly people don't buy durable goods. They need more services (e.g. medical care), entertainment, renovation of housing.
➢ 経済産業省(2012)

Lower **Trend investment**

SME: absence of advisers to help changing their business (shortage of talented workers)
➢ *NRI(2017)*

Finding 3-3.

■ Elderly people consume more services such as entertainment, foods and taxi fare for comfortable lives. In addition, they spend more money for renovations of their housings and nursing care services as they get older.

■ As the share of elderly people increases, the component of the aggregate demand should change. This requires business managers to change their business.

➢ 経済産業省(2012) "産業活動分析(平成24年1～3月期."

Goods and services Items that elderly people consume more than 1.4 times comparing to the average expenditure

60～69 years old	70 years old over
Gift(money), Package travel, Fruit, Processed food	
Gardening expenditure Renovation costs Green fee	Nursing care services Ritual costs Taxi fare

However, Elderly Managers and Inflexible Management Fail to Adapt This New Environment, Which Leads to Lower Trend Investment

Finding 3-4.

■ Business managers cannot find appropriate successors for their businesses because of fewer children and low expectation about the future of their business. In addition, there are fewer opportunities for these aged managers to change their business.

➢ *Nomura Research Institute, Ltd. (2017) "「国内金融の活性化に向けた研究会」報告書," March.*

If time permits…..

Two unsettled aspects:

(1) Financial markets have been largely "ignored" by textbook or standard macroeconomic discussions. Since global financial crisis, they have become a hot issue, particularly how to incorporate them is still unsettled.

(2) Moreover, how to assess the impact of aging on financial markets is not settled either, because the way aging population affect financial market functioning is far from clear.

Question posed:

■ On one hand, does elderly people can contribute to activate financial markets by using their own resources (i.e., their asset holdings and their investment knowledge)?
■ On the other hand, does the increasing anxiety about their future make elderly people and even younger one holding their assets as cash not as equities?

3-4. Impacts of Aging on Financial Markets

Current Debate on Aging and Financial Markets

      Does an Increasing Share of Elderly People "Activate" equity markets?

      Or, Does Increased Uncertainty Associated with Aging "Reduce" Equity Holdings?

Circumstances of Japan

Because the housing price is relatively high, households face liquidity constraints

➢ *Iwaisako et al(2014)*

So, elderly people who have finished repaying their mortgages hold more financial assets

➢ *CCFSI(2017)*

Elderly people has more financial knowledge

➢ *CCFSI(2016)*

Lack of longer-run financial plans for their futures because of unexpected longevity results in the less preference for equities

➢ *Nakajyo et al(2017)*

Households have more liquidity preference and tend to make more savings because of anxiety about the future which is partly caused by the low pension replacement ratio

➢ *Aoki et al(2017)*

Increase of the share of elderly people will contribute to activate financial markets.

= Higher financial asset prices/More investment

Aging has suppressed younger generation to participate in financial markets indirectly.

= Lower financial asset prices/Fewer investment

3-4. Impacts of Aging on Financial Markets: Positive effects

Finding 4-1.

■ Because of the liquidity constraints, households which show high "real estate (residential housing) value/total assets" hold less equities.

➢ *IWAISAKO, Tokuo, Arito Ono, Amane Saito, Shigenobu Tokuda, (2014) "日本の家計のポートフォリオ選択：居住用不動産が株式保有に及ぼす影響," Real Estate Markets, Financial Crisis, and Economic Growth: An Integrated Economic Approach, Working Paper Series no.17, Institute of Economic Research, Hitotsubashi University, December 15, 2014*

Finding 4-2.

■ Elderly people have more financial assets (equities, bonds and other financial products other than savings and insurances) than younger people.
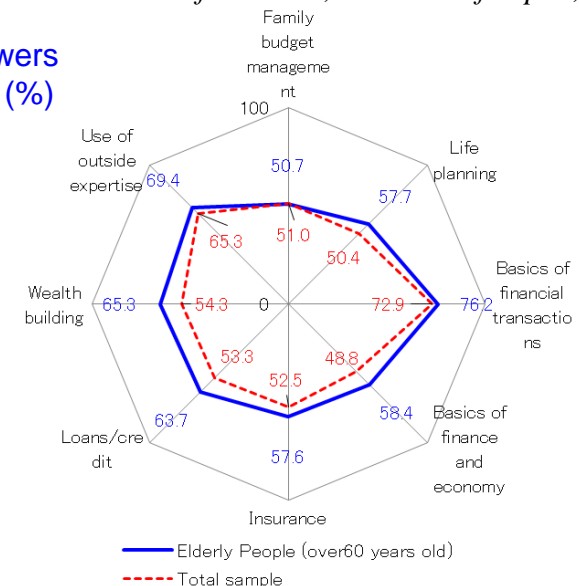
➢ *"家計の金融行動に関する世論調査［二人以上世帯調査］," The Central Council for Financial Services Information, the Bank of Japan, 2017.*

Finding 4-3.

■ The percentage of correct answers given to true/false questions about financial knowledge was the lowest in the 18–29 age group. The percentage tended to become higher as the age rose (slightly declining for those in their 70s).

➢ *"Financial Literacy Survey: 2016 Results," The Central Council for Financial Services Information, the Bank of Japan, October 2016.*

Correct answers by category (%)

Family budget management 100 — 50.7
Life planning 57.7
Basics of financial transactions 76.2 / 72.9
Basics of finance and economy 58.4 / 48.8
Insurance 57.6 / 52.5
Loans/credit 63.7 / 53.3
Wealth building 65.3 / 54.3
Use of outside expertise 69.4 / 65.3
51.0 / 50.4

Elderly People (over60 years old)
Total sample

Finding 4−4.

■ Japanese households prefer holding safer assets and the backgrounds of this preference are; 1) less attractive of equities because of low return, 2) lack of future financial plan because of the short-time preference, and 3) preference on middle or long-run (total) return than short-run return.

➢ *NAKAJYO, Mizuki, Junnosuke Shino and Kei Imakubo, 2017. "わが国家計の金融資産選択における行動特性," Bank of Japan Review 2017-J-7, the Bank of Japan, May.*

Finding 4−5.

■ "The characteristics of Japanese household portfolios are low stock market participation rates and high proportions of money in Japanese household portfolios. The low expected stock returns, low expected inflation and high fixed costs of stock market participation are the main determinants of Japanese household portfolios. …Higher life expectancy gives households more incentive to save when they are young. This incentive to save is especially strong because the pension replacement ratio of Japan (0.6) is lower than (those of other countries e.g.) the US (0.68)."

➢ *AOKI, Kosuke, Alexander Michaelides, Kalin Nikolov (2016) "Household Portfolios in a Secular Stagnation World: Evidence from Japan," Bank of Japan Working Paper Series, the Bank of Japan, March 28.*

4. Conclusion

✔ In Japan, researches show that aging has had a deflationary pressure on the inflation rates due to

    1) increase of part-time/temporary jobs (lower wage inflation),
    2) unexpected elderly's smaller purchasing power (decrease of trend consumption),
    3) growing future anxiety (decrease of trend consumption including young generation),
    4) less business investment (decrease of trend investment), and
    5) unexpected higher marginal saving rate (weaker policy effects) .

Some of them are specific to Japan, but some may be common for advanced economies.

✔ The effects above seem to be larger than people expected. However, there is no research which examines this hypothesis in a quantitative way.

✔ We need more studies about aging effects on Interest Sensitivity of Investment over Trend in Japan.

✔ The arguments over the impacts of aging on financial markets are not settled in Japan. We need more researches which reveal how much elderly people contribute to vitalize financial markets, and which compare elderly's positive impacts with negative ones on the markets.

Thank you very much.

Please stay tuned to our research projects.

Summary of discussion in English of Financial Markets Panel meetings is available on our special website at the following address:

http://fis.nri.co.jp/en/fmp/fmp/discussion.html

Share the Next Values!

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✔The workhorse model of central banking analysis is quite similar to the simple Keynesian framework of this presentation. Here I sketch this workforce model.

See

➢ BALL, Laurence, Joseph Gagnon, Patrick Honohan and Signe Krogstrup (2016), *What Else Can Central Banks Do?,"* *Geneva Reports on the World Economy* 18, September.

✔ Frequency: Quarterly

✔ Macroeconomic Variables and Constants

$\pi_t: inflation\ in\ t$

$\pi^*: long-run\ expected\ inflation\ (which\ is\ assumed\ to\ be\ the\ central\ bank's\ inflation\ target)$

$y_t: real\ GDP\ in\ t, y^*: potential\ GDP, and\ y_t - y^*: GDP\ Gap$

$r_t: real\ interest\ rate, r^*: equilibrium\ (natural)\ real\ interest\ rate$

$\widehat{z_{t-1}}: past\ four\ quarter\ moving\ average\ of\ variable\ z\ starting\ from\ t-1, that\ is,$

$\widehat{z_{t-1}} = \frac{z_{t-1}+z_{t-2}+z_{t-3}+z_{t-4}}{4}.$

A Workhorse Model of Central Bank Analysis (continued)

1. **Price Phillips Curve**: Current inflation determined by past GDP Gap

    $$\pi_t = \pi^* + \beta(\widehat{y_{t-1} - y^*}) + \varepsilon_t^{\pi} \quad \textit{where } \varepsilon_t^{\pi} \textit{ is a transitory price or supply shock.}$$

2. **Dynamic IS Relation**: Current GDP Gap determined by past real interest rate gap

    $$y_t - y^* = \theta(y_{t-1} - y^*) - \mu(\widehat{i_{t-1} - \pi_{t-1}} - r^*) + \varepsilon_t^{y} \quad \textit{where } \varepsilon_t^{y} \textit{ is a transitory demand shock.}$$

3. **Monetary Policy (Taylor Rule)**: Current nominal rate determined by current GDP Gap and current inflation

    $$i_t = r^* + \widehat{\pi_t} + \gamma(\widehat{\pi_t} - \pi^*) - \delta(y_t - y^*)$$

Structural Changes and Potentially Affected Variables

$Long - run$ Variables, constant in the short run: $potential\ GDP\ y^*, long$

$$- run\ expected\ inflation\ \pi^*, and\ equilibrium\ real\ interest\ rate\ r^*$$

$Short - run$ Shocks: $price\ or\ supply\ shock\ \varepsilon_t^{\pi}, demand\ shock\ \varepsilon_t^{y}$

Slopes: Phillips Curve Slope $\beta, IS\ Curve\ Slope\ -\mu, and\ GDP\ Gap\ persistency\ \theta$

Finding

The main factor of the deflationary pressures from aging in Japan is "declining growth and falling land prices." In addition, the "(D)issaving by the elderly makes matters worse as it leads to real exchange rate appreciation from the repatriation of foreign assets."

➢ *Anderson, D, D Botman and B Hunt (2014) "Is Japan's Population Aging Deflationary?" IMF Working Paper 14/139, IMF, August*