COMING IN AT A TRICKLE:
THE OPTIMAL FREQUENCY OF PUBLIC BENEFIT PAYMENTS

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Motivation: optimal design of public payment schedules

Governments offer public transfer payments to qualifying citizens which pay out at regular intervals (UBI, UI, Social Security/SSI, SNAP/WIC)

Example: pay cycle lengths for 36 OECD countries w/universal public pensions

- 31 operate on (semi-)monthly systems
- 2 every two weeks (Australia/New Zealand)
- 2 annually (Iceland/Ireland)
- 1 every two months (Japan)

Also calendar variation within countries ("5th Friday" or "birthday" rules)

- Pro: fixing a calendar date for payments good if otherwise non-salient
- Con: can magnify welfare losses from self-control problems, liquidity constraints, etc.

Extant research examines design of these programs in terms of limiting moral hazard, financing, redistributive consequences
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**One big (nest) egg, or many small ones?**
What we do

Policy question

How should governments set the frequency of benefit payments?

- Introduce **sufficient statistics** approach to determining optimal pay frequency
  - Regulator faces tradeoff: \( \uparrow \) frequency \( \implies \uparrow \text{admin costs} \text{ and } \downarrow \text{welfare loss from consumption non-smoothing} \)
  - Model can flexibly accommodate various **behavioral frictions**
  - Complements work on pay timing from employer’s POV (Parsons & Van Wesep 2013)

- Empirical application to national Japanese Pension System (JPS)
  - High-frequency retail scanner data linked to loyalty point cards
  - Can separate prices from quantities to isolate consumption, retailer responses
  - Lower-frequency payments feasible alternative to raising normal retirement age
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Basic modeling framework

- Govt. picks $T$ to minimize welfare loss subject to balanced budget

\[
\min_T \left\{ -p \cdot \lambda(T) + \left( p \cdot b(T) + \mu(T) \right) \right\}
\]

- Govt. sets length of pay cycle $T^*$ to equate the marginal reduction in the welfare loss to marginal cost of reducing $T$

\[
\frac{p \cdot \lambda'(T^*)}{\text{marginal benefit}} = \frac{\mu'(T^*) + p \cdot \bar{B}}{\text{marginal cost}}
\]

- Depends on fraction of recipients $p$, the average daily benefit amount $\bar{B}$, slope of welfare loss $\lambda'(T)$ and cost function $\mu'(T)$

- Key challenge: admin costs and welfare losses not directly observed
  - Exploit local exposure to 1980s pension system reform which moved $T = 90 \rightarrow 60$
  - Admin costs increase by 4% $\implies$ fairly flat cost function
What underlying behaviors could generate non-smoothing?

   - No retirement consumption drop + similar responses by income based on store quality

2. Near-rationality (Kueng 2018): welfare loss is small relative to permanent income
   - Payday spending similar across distribution of avg. total spending

3. Consumption commitments: timing of bills matches timing of income
   - Chetty & Szeidl (2007); Vellekoop (2018) focus on mortgage payments
   - We use data on predominantly perishable, non-durable goods spending

4. Present-bias: approx. log-linear decline in consumption in between paydays
   - Shapiro (2005); Huffman & Barenstein (2005); Mastrobuoni & Weinberg (2009)

5. Mental accounting: people behave as if they have a license to spend on payday
   - Thaler (1999); Gelman et al. (2014); Olafsson & Pagel (2018); Farhi & Gabaix (2020)
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**Intuition: optimal frequency under two “naive” internalities**

- **Quasi-hyperbolic discounting:** with $\beta \cdot \delta$ discounting, as $\beta \to 1$, consumption declines almost linearly over pay cycle at rate $f(t) = \nu \cdot t$

- Mental accounting (“payday liquidity”): extra spike in consumption on payday $x(T)$
  - For log utility, inc. frequency of payments ($T \downarrow$) can improve welfare if...

\[
\frac{(1 + x(T)) \cdot \log(1 + x(T))}{loss \text{ from spike magnitude as } T^{\uparrow}} > \frac{T \cdot x'(T)}{gain \text{ from subdivision as } T^{\uparrow}}
\]

- $\lambda'(T)$ quantitatively very similar regardless of underlying behavioral mechanism
  - True for a wide range of parameter values (i.e. not just in our setting)

- Calibrated model offers support for monthly payment schedules

Jump to: LaPoint (Yale) & Sakabe (LMU) Optimal Payment Frequency NBER Japan Project 2023
Intuition: Optimal Frequency under Two “Naive” Internalities

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LaPoint (Yale) & Sakabe (LMU)
Empirical setting: Japanese public pension system

- Largest public pension fund in the world ($474 bil. paid out annually)

- Structure similar to U.S. Social Security
  - Early retirement age 60, normal retirement age 65, late retirement until age 70

- Paydays scheduled for the 15th of each even month
  - If scheduled date falls on Saturday, Sunday, or public holiday, moved to first previous non-holiday weekday \( \Rightarrow \) random variation in pay cycle length

- Three other advantages to the Japanese setting:
  1. Difficult to buy in bulk due to storage costs \( \Rightarrow \) spending \( \approx \) consumption
  2. Universal health insurance \( \Rightarrow \) little need to save for uncertain medical expenses
  3. Pension payments account for \( > 80\% \) of income for recipients (survey evidence)
**Timestamped retail data on shopper spending histories**

- **Hourly** retail scanner data from Japanese marketing research firm
  - Covers regional grocery store chains for 2011-14
  - Prices and quantities at barcode level

- **Shoppers’ purchase history connected to loyalty point card**
  - Basic demographic info: store/chain ID, Census region, gender, and age (MM/YYYY)
  - Use age to determine pension eligibility (intent to treat)
  - Scale up by claiming probability from retirement surveys (95% claim by age 65)

- Apply restrictions to obtain set of regular (weekly) shoppers and stores visited
  - Final sample: 511 stores spread across 21 chains, 416,726 unique shopper IDs
  - 38% above normal retirement age, 51% reach early retirement age
Baseline: high-frequency event study around paydays

\[
\frac{X_{i,c,t}}{X_{i,c}} = \sum_{j=-7}^{+7} \beta_j \cdot Payment_{i,t+j} + \delta_{dow} + \phi_{wom} + \psi_{my} + \xi_h + \eta_i + \epsilon_{i,c,t}
\]  

- Hetero. treatment effects due to preferences over store brands
- Use 10%↑ to calibrate behavioral frictions underlying \( \lambda(T) \)
  - Same as spike in spending on perishables
  - \( \implies \nu = 0.2\% \) daily consumption decline in between paydays
- Spending concentrated in splurge goods like prepared foods (22%↑) and alcohol (28%↑)

LaPoint (Yale) & Sakabe (LMU)  Optimal Payment Frequency  NBER Japan Project 2023
Calendar variation in intervals to test for pent-up demand

\[
\frac{X_{i,c,t}}{X_{i,c}} = \beta \cdot \text{Payday}_t \times \text{Length}_{t \in p} + \delta_{\text{dow}} + \phi_{\text{wom}} + \psi_{\text{my}} + \xi_h + \eta_i + \epsilon_{i,c,t}
\]

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\[\text{Attention} \quad 0.13 \text{ p.p. inc. in payday spending for each extra day in pay cycle} \ p\]
Limited evidence in favor of liquidity/near-rationality story

\[ X_{c,t} / \bar{X}_{i,c} = \beta_i \cdot Payday_t + \delta_{dow} + \phi_{wom} + \psi_{my} + \xi_h + \epsilon_t \]

- Run separate time series regression for each shopper age \( \geq 65 \)
- Sort \( \hat{\beta}_i \) by \( i \)'s quantile of avg. total pay cycle expenditures
- Total spending reasonable proxy for permanent income (Kueng 2015,18)
- Stable avg. payday response across PI dist.
Separating retailer responses from “splurge” spending

- Formally decompose observed store-level daily inflation $\Delta \Phi_{s,t}$ into...
  - **Consumer variety effects:** buying more barcodes in set of commonly purchased goods $\Omega^*$
  - **Consumer substitution effects:** quality upgrading $\Omega_{new}$ vs. $\Omega_{old}$
  - Retailer response: sales or change in discount rate or regular price within $\Omega^*$

**Punchline:** quantitatively small retail pricing response, driven by targeted temporary sales strategy on payday

- For above (below-) median priced goods, payday sales 1.5 p.p. less (more) likely, with 1 p.p. less (more) generous discounts
- Effect on $\Delta \Phi_{s,t}$ quantitatively important only for prepared foods
- Uniform pricing across stores (DellaVigna & Gentzkow 2019) → use chain $\times$ time FEs
- Robust to choice of temporary sales filter (Kehoe-Midrigan or Nakamura-Steinsson)

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**LaPoint (Yale) & Sakabe (LMU)**

**Optimal Payment Frequency**

**NBER Japan Project 2023**
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Menu cost model

LaPoint (Yale) & Sakabe (LMU)  
Optimal Payment Frequency  
NBER Japan Project 2023
**Illustration: Counterfactual "Last Price" Index**

- **Idea:** Hold fixed barcode-level \( p \) to isolate demand changes.

- **Two-step procedure:**
  1. Event study w/outcome \( \Delta \Phi_{s,t} \)
  2. Same event study w/outcome \( \Delta \Phi^{\text{last}}_{s,t} \) and take difference in coefficients.

- **Check robustness to measures of “last” prices**
  - Last month index (diagram)
  - Last week index using prices in week before payday.
No clear retailer pricing response around payday

- Store level average price index $\Phi_{s,t}$
- Retailer response $= \Delta \Phi_{s,t} - \Delta \Phi_{s,t}^{last}$
- $< 10\%$ of store-level inflation around payday due to retail price changes
- $\Rightarrow$ “menu costs” sufficiently large that $P(T) \equiv P$ is a reasonable simplification
Natural experiment to estimate slope of admin cost function

\[ p \cdot \lambda^\prime(T^*) = \mu^\prime(T^*) + p \cdot \bar{B} \]

- Use 1988 reform to the JPS which only altered pay frequency without changing eligibility criteria or generosity of benefits
  - Transitioned from payments every 3 months to every 2 months \((T = 90 \rightarrow 60)\)

- **Identification**: exploit fact that municipal budgets differentially exposed to admin costs of the reform depending on whether they have one of 312 local JPS branch offices
  - Local offices run day-to-day operations of JPS w/o managing pension funds
  - Admin costs: applications, reconciling benefits, confirming eligibility, investigating fraud

- **Data**: local public spending on elderly welfare benefits from PM’s Cabinet Office
  - National welfare programs, so per capita non-JPS spending differenced out

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- **marginal benefit**
- **marginal cost**

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**DiD analysis** \[\implies \approx 4\% \uparrow \text{ in admin costs from moving } T = 90 \rightarrow 60\]

\[
\log \mu_{j,t} = \beta \cdot \text{Branch}_j \times Post_t + \gamma_j + \delta_t + \epsilon_{j,t}
\]  \hspace{1cm} (4)

- **Small uptick in costs among JPS branch cities starting in FY 1987**
- **Branch office cities more populated, but similar per capita spending on elderly**
- **At most, covariate-adjusted uptick in costs of 7%**

**Notes:** Municipal spending in thousands of real 2012 JPY on administering the pension system and elderly welfare benefits divided by the number of persons over age 65 residing in the municipality.
Optimal frequency flat w.r.t. inverse IES $\rho$

- $T^*$ very weakly decreasing in $\rho$ (out to 6 decimals), regardless of type of internality
- Logic: welfare loss $\lambda(T^*)$ varies a lot with $\rho$, but marginal loss $\lambda'(T^*)$ does not
Optimal Frequency Concave w.r.t. Convexity of Admin Costs

Quasi-hyperbolic Discounting

Payday Liquidity

- Calibration: suppose \( \mu(T) = \kappa_\ell / T^\ell \) and for each power \( \ell \) set \( \kappa_\ell \) so that \( \mu(60) \) equals the administrative service costs reported for FY 2011

- For \( \ell < 0.5 \) daily frequency ("continuous trickle") would be optimal
Implications for pension eligibility age reforms

More than 1.2 million march in France over plan to raise pension age to 64

Protesters aim to ‘bring France to standstill’ as President Macron struggles to delay retirements by 2 years

Many countries with pay-as-you-go systems raising retirement age to cut costs as birth rate declines

- Japan: phased increase in NRA from 65 to 70
- France: April 2023 increase from 62 to 64 → protests!
- UK: phased increase from 65 to 67 between 2020 to 2028

Alternative: cut admin costs by sending same pension amount but divided into fewer payments

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Cost Comparisons: Eligibility Age vs. Payment Frequency Reforms

- Consider April 2021 Japanese plan to raise NRA for flat-rate pensions from 65 to 70

- **Counterfactual:** what would be the increase in pay cycle length $\Delta T > 0$ required to reduce costs by an equivalent amount to raising the NRA?

  - **Answer:** equivalent to moving along the cost function $\mu$ from $T = 30$ (our upper bound optimum) to $T = 45$, or payments every 6.5 weeks
    - 36.12 billion JPY in initial annual savings at stake
    - Assume distribution of claiming ages from Japanese Pension Survey in 2021 $\rightarrow$ valid if moral hazard is minimal
    - Caveat: ignores the revenue side, so opportunity cost of keeping NRA fixed might be greater

- In practice, gains to increasing $T$ and NRA simultaneously (“double dividend”)
  - Intuition: govt. FOC easier to satisfy when fraction eligible declines $\Rightarrow T^* \uparrow$
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Conclusion: Support for Prevalence of Monthly Pay Cycles

- **First paper** to consider payment frequency as a policy parameter

- Framework is simple, but can be applied to any country and public benefit program with data on costs and high-frequency recipient behavior

- In the empirical application, we show:
  - Large spike in expenditures on payday which appears to be unrelated to liquidity proxies
    - Mental accounting, or consumer type switching within pay cycle
  - Limited evidence of retailer price discrimination $\Rightarrow$ menu costs are large
  - Calibrated model yields optimal frequency $\leq 1$ month

- Variety/substitution effects are important drivers of prices during peak demand periods $\Rightarrow$ implications for debate on inflation due to COVID-19 stimulus payments

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  - Large spike in expenditures on payday which appears to be unrelated to liquidity proxies
    - Mental accounting, or consumer type switching within pay cycle
  - Limited evidence of retailer price discrimination \[\Rightarrow\] menu costs are large
  - Calibrated model yields optimal frequency \(\leq 1\) month

- Variety/substitution effects are important drivers of prices during peak demand periods \[\Rightarrow\] implications for debate on inflation due to COVID-19 stimulus payments

- Lowering pension frequency might be more attractive than raising retirement age
Conclusion: Support for Prevalence of Monthly Pay Cycles

- **First paper** to consider payment frequency as a policy parameter

- Framework is simple, but can be applied to any country and public benefit program with data on costs and high-frequency recipient behavior

- In the empirical application, we show:
  - Large spike in expenditures on payday which appears to be unrelated to liquidity proxies
    - Mental accounting, or consumer type switching within pay cycle
  - Limited evidence of retailer price discrimination \( \Rightarrow \) menu costs are large
  - Calibrated model yields optimal frequency \( \leq 1 \) month

- **Variety/substitution effects** are important drivers of prices during peak demand periods \( \rightarrow \) implications for debate on inflation due to COVID-19 stimulus payments

- **Lowering pension frequency** might be more attractive than raising retirement age
THANK YOU!
Contributions to the literature

- **Consumer responses to the timing of (regular) payments:**
  - Stephens (2003, 2006); Shapiro (2005); Dobkin & Puller (2007); Mastrobuoni & Weinberg (2009); Foley (2011); Stephens & Unayama (2011); Evans & Moore (2012); Gelman et al. (2014); Olafsson & Pagel (2018); Vellekoop (2018); Baker (2018); Baugh & Wang (2021); Baugh & Correia (2022); Zhang (2022); Gross, Layton, Prinz (2022)

- **Motivations for consumption non-smoothing behavior:**
  - Zeldes (1989); Thaler (1999); Huffman & Barenstein (2005); Chetty & Szeidl (2007); Broda & Parker (2014); Farhi & Gabaix (2020); Kueng (2015, 2018); Parker (2017); Hastings & Shapiro (2018); Chevalier & Kashyap (2019); Baugh, Ben-David, & Parker 2021

- **Retailer pricing during peak demand periods:**
  - Warner & Barsky (1995); MacDonald (2000); Chevalier, Kashyap, Rossi (2003); Nevo & Hatzitaskos (2006); Hastings & Washington (2010); Goldin, Homonoff, & Meckel (2022)

- **Retirement consumption puzzle:**
  - Bernheim, Skinner, & Weinberg (2001); Aguiar & Hurst (2005); Battistin et al. (2009); Stephens & Unayama (2012); Agarwal, Pan, Qian (2015); Olafsson & Pagel (2020)
Japan’s mandatory public pension system (JPS) has two tiers

- National pension (NP): flat-rate pension with compulsory coverage for residents age 20-59
- Employee pension insurance (EPI): earnings-related pension with compulsory coverage for those employed full-time by private company with \( \geq 5 \) workers
- NP and EPI implemented jointly as one system (i.e. same payment timing)

Other features related to payment amounts

- Earnings test: if working beyond age 65, EPI benefit reduced or suspended if monthly EPI payment + wages > 460,000 JPY
- Normal retirement at age 65, with early (60-64) or deferred (66-70) collection possible
- Not very generous compared to other OECD countries: 2012 full NP amount was 780,100 JPY (\( \approx \$7,800 \)) per year for 40 years of contributions
How are JPS benefits paid out?

- Both NP and EPI payments are distributed regularly on the 15th of even months.
- If scheduled benefit delivery date falls on a Saturday, Sunday, or public holiday, it is moved to the first previous non-holiday weekday.
- 22 delivery dates in our sample time period: 15 on the 15th, 4 dates moved to the 14th, and 3 moved to the 13th.
- Payments usually arranged via bank transfer when pensioners submit a form to local city office to begin claiming benefits.
  - Local city offices not directly involved in remitting payments.
  - But involved in processing applications and withholding taxes from pension payments.
Transfer of collected/deducted contributions

Pension beneficiaries


JPS Headquarters

Contributions

[ Contributions ]
[ nationally ]
All Japan Federation of National Health Insurance Organizations

[ Insured persons' data ]
[ each prefecture ]
Prefectural Association

[ each municipality ]

Local residential tax

[ Insured persons' data ]
[ nationally ]
Council for Local Tax

[ each municipality ]

Mutual aid associations*

* Excluding the Association for Local Government Officials which has other identical collection scheme

Transfer of collected/deducted contributions

Municipal offices (wide area association)

Main deck

Sample benefit schedule

Main deck

- Single claimant retiring at age 65 with full 40 years of contributions, no retirement bonus
  - \[ \Rightarrow 44\% \text{ replacement rate} \]

Main deck

LaPoint (Yale) & Sakabe (LMU)

Optimal Payment Frequency

NBER Japan Project 2023
Regular shoppers with $\geq k$ store visits each month

- Baseline: always restrict to weekly shoppers ($k \geq 4$)
- Defining regular shopper panel helps pin down consumption
- Non-regular shoppers either have access to storage or do their spending elsewhere
- Check results similar for $k = 2$ (every other week)
Retail Expenditures Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>All Goods</th>
<th>Raw Foods (Perishables)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. daily expenditures (JPY)</td>
<td>2,603</td>
<td>1,149</td>
</tr>
<tr>
<td>Avg. monthly expenditures (JPY)</td>
<td>35,184</td>
<td>14,048</td>
</tr>
<tr>
<td>Avg. number of monthly trips</td>
<td>13.0</td>
<td>11.5</td>
</tr>
<tr>
<td>Avg. periodicity</td>
<td>2.0</td>
<td>2.3</td>
</tr>
<tr>
<td>% Female shopper</td>
<td>65.7%</td>
<td>65.5%</td>
</tr>
<tr>
<td>% Early retirement age</td>
<td>45.5%</td>
<td>45.5%</td>
</tr>
<tr>
<td>% Normal retirement age</td>
<td>31.2%</td>
<td>31.5%</td>
</tr>
<tr>
<td># Stores</td>
<td>511</td>
<td>510</td>
</tr>
<tr>
<td># Shoppers</td>
<td>409,439</td>
<td>416,726</td>
</tr>
</tbody>
</table>
Average Monthly Spending: FIES vs. Scanner Data Shoppers

A. All Food

- FIES monthly spending = 47506 JPY

B. Raw Foods

- FIES monthly spending = 21630 JPY

- Match FIES monthly spending for shoppers who go to store every other day, on average
- Daily spending non-monotonic in trip frequency $\rightarrow$ use weekly shoppers as baseline
<table>
<thead>
<tr>
<th>One-digit Category</th>
<th>Two-digit Category</th>
<th>Four-digit Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fruits &amp; vegetables</td>
<td>Fresh fruits</td>
<td>seasonal fruits, imported fruits, assorted fruits, fruit-related products,</td>
</tr>
<tr>
<td></td>
<td>Fresh vegetables</td>
<td>leafy veg., stalk veg., root crops, edible plants, edible seeds, mushrooms, germinated veg., assorted veg.</td>
</tr>
<tr>
<td>Processed fruits &amp; vegetables</td>
<td>Processed fruits</td>
<td>frozen fruits, cut fruits, boiled veg., frozen veg., cut veg.</td>
</tr>
<tr>
<td></td>
<td>Processed vegetables</td>
<td></td>
</tr>
<tr>
<td>Fresh fish</td>
<td>Fresh fish</td>
<td>round items, filet, shellfish, assorted fish</td>
</tr>
<tr>
<td></td>
<td>Sashimi</td>
<td>brick form, sashimi, tataki, raw fish, assorted fresh fish</td>
</tr>
<tr>
<td>Preserved fish products</td>
<td>Salted &amp; dried fish</td>
<td>boiled fish, frozen fish, seasoned fish, pickled fish, salted fish, dried fish, fish eggs, seaweed</td>
</tr>
<tr>
<td>Raw meat &amp; poultry</td>
<td>Beef</td>
<td>wagyu, domestic beef, imported beef, domestic pork, imported pork</td>
</tr>
<tr>
<td></td>
<td>Pork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chicken</td>
<td>domestic chicken, imported chicken, brand name chicken, duck meat</td>
</tr>
<tr>
<td></td>
<td>Meat varieties</td>
<td>lamb, horse meat, minced meat, offal, raw meat, eggs, dairy products</td>
</tr>
<tr>
<td>Grains</td>
<td>Cereals</td>
<td>powder, rice, mochi, raw noodles, dough, bread, cereal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One-digit Category</th>
<th>Two-digit Category</th>
<th>Four-digit Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other processed foods</td>
<td>Seasonings</td>
<td>cooking oil, spices, condiments, spread/dips, toppings, rice seasoning</td>
</tr>
<tr>
<td></td>
<td>Dry produce</td>
<td>dried fish, dried fruits</td>
</tr>
<tr>
<td></td>
<td>Processed food</td>
<td>pickled items, processed fish, pastes, cooked beans, processed meats</td>
</tr>
<tr>
<td></td>
<td>Instant foods</td>
<td>cup noodle, instant soup, frozen foods, sealed rice pouch</td>
</tr>
<tr>
<td>Prepared foods</td>
<td>Semi-prepared dishes</td>
<td>fried, simmered, grilled, Japanese, Western, Chinese</td>
</tr>
<tr>
<td></td>
<td>Side dishes</td>
<td>fried, grilled, grilled eel, Japanese, Western, Chinese</td>
</tr>
<tr>
<td></td>
<td>Bento</td>
<td>cooked rice, sushi, bread dishes, noodle dishes</td>
</tr>
<tr>
<td>Sweets and desserts</td>
<td>Confectionery</td>
<td>toppings, jelly/pudding, ice cream, frozen confections, candies/cookies, rice crackers</td>
</tr>
<tr>
<td>Non-alcoholic beverages</td>
<td>Beverages</td>
<td>coffee/tea, milk-based drinks, vegetable/fruit drinks, soft drinks</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Alcohol</td>
<td>beer, liqueurs, wine, liquor, sake</td>
</tr>
<tr>
<td>Tobacco</td>
<td>Tobacco</td>
<td>tobacco</td>
</tr>
<tr>
<td>Other discretionary</td>
<td>Other</td>
<td>flowers, gifts/confections, kiosk goods, service counter goods</td>
</tr>
</tbody>
</table>
### Payday Spending Responses by Margin and Goods Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Overall</th>
<th>Incl. Chain FEs</th>
<th>Intensive</th>
<th>Extensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>All goods</td>
<td>0.059***</td>
<td>0.099***</td>
<td>0.096***</td>
<td>0.001***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Raw foods</td>
<td>0.053***</td>
<td>0.093***</td>
<td>0.093***</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Prepared foods</td>
<td>0.079***</td>
<td>0.212***</td>
<td>0.219***</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Sweets/desserts</td>
<td>0.069***</td>
<td>0.166***</td>
<td>0.167***</td>
<td>0.006***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.137***</td>
<td>0.275***</td>
<td>0.281***</td>
<td>0.004***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.053)</td>
<td>(0.051)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Fresh produce</td>
<td>0.044***</td>
<td>0.077***</td>
<td>0.076***</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Fresh fish</td>
<td>0.060***</td>
<td>0.226***</td>
<td>0.225***</td>
<td>0.001**</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Meat &amp; poultry</td>
<td>0.049***</td>
<td>0.141***</td>
<td>0.132***</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Grains</td>
<td>0.024***</td>
<td>0.092***</td>
<td>0.073***</td>
<td>0.001+</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.009)</td>
<td>(0.008)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Non-alcoholic beverages</td>
<td>0.048***</td>
<td>0.110***</td>
<td>0.101***</td>
<td>0.005***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Tobacco</td>
<td>0.137***</td>
<td>0.135</td>
<td>0.140+</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.086)</td>
<td>(0.079)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Processed fruits/vegetables</td>
<td>0.051***</td>
<td>0.180***</td>
<td>0.120**</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.039)</td>
<td>(0.037)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Preserved fish</td>
<td>0.028***</td>
<td>0.064***</td>
<td>0.060***</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.011)</td>
<td>(0.010)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Other processed foods</td>
<td>0.056***</td>
<td>0.107***</td>
<td>0.102***</td>
<td>0.003***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
</tbody>
</table>

**Notes:** Each cell in the table is the coefficient on Payment from a separate regression within a particular expenditure subcategory. Overall refers to the spending response and including shopper-day observations of zero expenditures. The second column indicates how our point estimates of the overall spending response changes when we include store chain fixed effects. The dependent variable in the intensive margin regressions is expenditures on a store visit relative to average daily expenditures. The dependent variable in the extensive margin regressions is a dummy for whether the shopper makes a purchase on a given date. In each regression, we winsorize the top 1% of total daily expenditures. Robust standard errors clustered by shopper ID in parentheses. ***p < 0.001, **p < 0.01, *p < 0.05, +p < 0.1

- Spending concentrated in discretionary goods categories
Response of Major Subcategory Expenditures to Payday

(a) Prepared Foods
(b) Sweets/Desserts
(c) Alcohol

(c) Fresh Produce
(d) Fresh Fish
(e) Meat & Poultry

(f) Grains
(g) Non-alcoholic beverages
(h) Tobacco
Testing for “pent-up demand”

- Restrict to age $\geq 65$ y.o. and interact payday dummy with length of pay cycle $p$:

$$\frac{X_{i,c,t}}{X_{i,c}} = \beta_1 \cdot \mathbb{1}(\text{Payday}_t) \times Length_{t \in p} + \beta_2 \cdot \mathbb{1}_i(\text{Payday}_t) \times (Length_{t \in p})^2$$

- Control: $\mathbb{1}(\text{Payday}_t) = 0 \implies C_0 = \bar{c}$
  - $\bar{c}$ not pinned down for pensioner pay cycles if include non-recipients in the control
  - Hence, we use $\text{Payday}_t$ rather than $\text{Payment}_{i,t}$ here

- Treatment: $\mathbb{1}(\text{Payday}_t) = 1 \implies C_0 = \bar{c} \cdot (1 + \beta_1 T + \beta_2 T^2)$
  $$\equiv x(T)$$

- $Length_{t \in p}$ varies between 57 and 62 days in our sample
Notes: The figure displays the daily time series of the Japanese Google SVI for “public pension payments.” Dashed red lines indicate scheduled pension payment dates during our sample period for the scanner data.
Consumers highly attentive to pension payment receipt

\[
\overline{SVI}_t = \sum_{j=-7}^{+7} \beta_j \cdot Payday_{t+j} + \gamma \cdot t + \delta_{dow} + \phi_{wom} + \psi_{my} + \xi_h + \alpha_p + \epsilon_t
\]

- Run time series regressions using Google SVI for “public pension payments” relative to average daily SVI as outcome
  - Include linear time trend and dummies \(\alpha_p\) for other pension system announcements
- Search activity peaks (20% ↑) on the day prior to a scheduled payday
- Placebo w/randomized paydays shows no search spike \(\implies\) inattention unlikely to play a role here
FLAT RELATIONSHIP BETWEEN PERMANENT INCOME AND PAYDAY RESPONSE

\[ X_{c.t}^i / \bar{X}_{i,c} = \beta^i \cdot Payday_t + \delta_{dow} + \phi_{wom} + \psi_{mu} + \xi_h + \epsilon_i \]

Notes: We estimate the time series regression pictured above for each individual shopper ID using all goods expenditures. The figure fits a local linear function to the relationship between payday responses \( \beta^i \) and average expenditures over the two-month pay cycle. We winsorize the top 1% of daily expenditures. 99% confidence intervals represented by the gray shaded area.
## Payday Expenditure Responses by Permanent Income Decile

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
<th>8th</th>
<th>9th</th>
<th>10th</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intensive margin</strong></td>
<td>0.106***</td>
<td>0.097***</td>
<td>0.083***</td>
<td>0.074***</td>
<td>0.069***</td>
<td>0.054***</td>
<td>0.052***</td>
<td>0.048***</td>
<td>0.035***</td>
<td>0.031***</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.009)</td>
<td>(0.008)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td><strong>Intensive margin w/controls</strong></td>
<td>0.0104***</td>
<td>0.094***</td>
<td>0.085***</td>
<td>0.073***</td>
<td>0.067***</td>
<td>0.051***</td>
<td>0.050***</td>
<td>0.046***</td>
<td>0.033***</td>
<td>0.029***</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.009)</td>
<td>(0.008)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td><strong>Total response</strong></td>
<td>0.069***</td>
<td>0.062***</td>
<td>0.047***</td>
<td>0.045***</td>
<td>0.036***</td>
<td>0.035***</td>
<td>0.026***</td>
<td>0.029***</td>
<td>0.022***</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td><strong>Extensive margin</strong></td>
<td>0.008***</td>
<td>0.007***</td>
<td>0.003*</td>
<td>0.003**</td>
<td>0.002</td>
<td>0.001</td>
<td>−0.002+</td>
<td>−0.002+</td>
<td>−0.002+</td>
<td>−0.012***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
</tbody>
</table>
Shoppers’ Payday Responses (DiD) by Age Bin

A. Weekly Shoppers

B. Very Frequent Shoppers

Notes: Point estimates relative to the 20-29 age group. Very frequent shoppers are those for whom we can match average total grocery spending with the FIES (i.e. those who visit a store, on average, at least 16 times per month). Capped bars indicate 99% confidence intervals with standard errors clustered by shopper ID.
Little difference in responses between younger vs. older pensioners

\[
X_{i,t}/\bar{X}_i = \beta_i \cdot Payday_t + \delta_{dow} + \phi_{wom} + \psi_{my} + \xi_{h} + \epsilon_{i,t}
\]

A. Weekly Shoppers

B. Very Frequent Shoppers
Payday spending response does not vary much with store quality

Using stores in all Census regions

Using only Tokyo metro stores

- Within-Tokyo analysis takes out CoL differences across areas
- Nearly identical point estimates if define store quality using equal-weighted vs. sale share-weighted (figure above) price index
\[ \tilde{\Phi}_s = \frac{1}{|T_{np}|} \sum_{t \in T_{np}} \Phi_{s,t} = \frac{1}{|T_{np}|} \sum_{t \in T_{np}} \left( \sum_{k \in \Omega_{s,t}} \omega_{k,s,t} \log p_{k,s,t} \right) \]

A. Sales Share-Weighted Retail Chain Index

B. Equal-Weighted Average Retail Chain Index
People cross retirement age threshold $y^*$ at different times $\rightarrow 1\{age_{i,t} \geq y^*\}$

- OLS shows drop in consumption, while other DiD estimators show uptick
  - Sun & Abraham (2021): compare retirees to never treated (young)
  - de Chaisemartin & D'Haultfoeuille (2020): compare retirees to not-yet-retired (fuzzy RD)
Can write store-level inflation (geometric avg.) as the sum of three terms:

\[
\Delta \Phi_{s,t} = \frac{1}{n_{s,t}} \sum_{k \in \Omega^*} \Delta \log p_{k,s,t} + \left( \frac{1}{n_{s,t}} - \frac{1}{n_{s,t-1}} \right) \sum_{k \in \Omega^*} \log p_{k,s,t-1}
\]

\[
+ \left( \frac{1}{n_{s,t}} \sum_{k \in \Omega^{new}} \log p_{k,s,t} - \frac{1}{n_{s,t-1}} \sum_{k \in \Omega^{old}} \log p_{k,s,t-1} \right)
\]

Retail price change can be due to temporary sales or changes in regular prices.

Variety effect \( \propto \Delta \log n_{s,t} \rightarrow 6\% \) jump in \# of unique barcodes purchased on payday.

Last price index partitions \( \Omega \) into a set of common, new, and old goods.
Robustness to definition of last price index

\[ \Phi_{s,t} = \sum_{j=-7}^{+7} \gamma_{1,j} \cdot Payday_{t+j} + \delta_{dow} + \phi_{wom} + \xi_{h} + \eta_{s} + \varphi_{c,my} + \epsilon_{s,t} \]

\[ \Phi_{\text{last},s,t} = \sum_{j=-7}^{+7} \gamma_{2,j} \cdot Payday_{t+j} + \delta_{dow} + \phi_{wom} + \xi_{h} + \eta_{s} + \varphi_{c,my} + \nu_{s,t} \]

A. Month Before Counterfactual Price

B. Week Before Counterfactual Price
Variety response: 6% ↑ in # of unique barcodes purchased on payday

$$\log \tilde{n}_{s,t} = \sum_{j=-7}^{+7} \gamma_{1,j} \cdot Payday_{t+j} + \delta_{dow} + \phi_{wom} + \xi_{h} + \eta_{s} + \varphi_{c,my} + \epsilon_{s,t}$$
Response of Store-Level Major Subcategory Average Prices to Payday

(a) Prepared Foods  (b) Sweets/Desserts  (c) Alcohol

(d) Grains  (e) Non-alcoholic beverages  (f) Tobacco

(g) Processed Fruits/Vegetables  (h) Preserved Fish  (i) Other Processed Foods
Store-Level Variety Responses within Each Major Goods Subcategory

(a) Prepared Foods
(b) Sweets/Desserts
(c) Alcohol

(d) Grains
(e) Non-alcoholic beverages
(f) Tobacco

(g) Processed Fruits/Vegetables
(h) Preserved Fish
(i) Other Processed Foods
Store Pricing Responses around Payday by Major Goods Subcategory

(a) Prepared Foods
(b) Sweets/Desserts
(c) Alcohol
(d) Grains
(e) Non-alcoholic beverages
(f) Tobacco
(g) Processed Fruits/Vegetables
(h) Preserved Fish
(i) Other Processed Foods
Applying temporary sales filters

- Apply two sets of filters to separate regular prices $r_t$ from observed prices $p_t$:
  1. Rolling mode (Kehoe & Midrigan 2008,15): regular price = most common price
  2. V-shaped (Nakamura & Steinsson 2008): identify temporary sales by symmetric dips followed by rebounds → good out-of-sample prediction of sales flag in CPI microdata

- Compute store-level average temporary sales frequency $f_s$ and discount rate $d_s$ via:

$$f_s = \frac{1}{|T|} \sum_{t \in T} \left( \frac{1}{|K_s|} \sum_{k \in K_s} 1_{t \left\{ p_{s,t,k} < r_{s,t,k} \right\}} \right)$$

$$d_s = \frac{1}{|T|} \sum_{t \in T} \left( \frac{1}{|K_s|} \sum_{k \in K_s} \left(1 - \frac{p_{s,t,k}}{r_{s,t,k}} \right) \right)$$

- Tuning parameters: search for V-shape and 3-month centered mode over 42 days (1.5 months), similar patterns if search over one week
Notes: The left-hand side panels show the frequencies and discount rates under the rolling mode filter, while the right-hand side panels show the distributions when we use the V-shaped filter to identify sales. In both algorithms we search for temporary sales over a 42-day window on either side of a calendar date. Solid grey vertical lines indicate the mean daily frequency or discount rate across stores on non-paydays, while blue dashed lines show the mean across stores on paydays. The K-S p-value shows the two-sided exact p-value from a Kolmogorov-Smirnov test of equality for the payday vs. non-payday distributions.
Store-Level Temporary Sales Frequency and Discounts on Above-Median Price Goods

Notes: Includes only products which have an above-median average price within their four-digit goods category. The left-hand side panels show the frequencies and discount rates under the rolling mode filter, while the right-hand side panels show the distributions when we use the V-shaped filter to identify sales. In both algorithms we search for temporary sales over a 42-day window on either side of a calendar date. Solid grey vertical lines indicate the mean daily frequency or discount rate across stores on non-paydays, while blue dashed lines show the mean across stores on paydays. The K-S p-value shows the two-sided exact p-value from a Kolmogorov-Smirnov test of equality for the payday vs. non-payday distributions.
Notes: Includes only products which have a below-median average price within their four-digit goods category. The left-hand side panels show the frequencies and discount rates under the rolling mode filter, while the right-hand side panels show the distributions when we use the V-shaped filter to identify sales. In both algorithms we search for temporary sales over a 42-day window on either side of a calendar date. Solid grey vertical lines indicate the mean daily frequency or discount rate across stores on non-paydays, while blue dashed lines show the mean across stores on paydays. The K-S p-value shows the two-sided exact p-value from a Kolmogorov-Smirnov test of equality for the payday vs. non-payday distributions.
<table>
<thead>
<tr>
<th>Statistics for Branch vs. Non-Branch Office Cities</th>
<th>Branch (N = 239)</th>
<th>Non-branch (N = 424)</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Census population</td>
<td>12.16</td>
<td>11.07</td>
<td>1.09</td>
<td>0.00</td>
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<tr>
<td>CBD population density (1000s/km²)</td>
<td>7.66</td>
<td>5.11</td>
<td>2.55</td>
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<tr>
<td>Fraction population &gt; 65 y.o. (%)</td>
<td>10.71</td>
<td>11.17</td>
<td>-0.46</td>
<td>0.09</td>
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<tr>
<td>Fraction population &gt; 75 y.o. (%)</td>
<td>4.05</td>
<td>4.26</td>
<td>-0.21</td>
<td>0.07</td>
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<tr>
<td>%Δ75–85 population &gt; 65 y.o.</td>
<td>43.00</td>
<td>46.73</td>
<td>-3.73</td>
<td>0.02</td>
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<tr>
<td>Fraction female residents (%)</td>
<td>51.14</td>
<td>51.09</td>
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<td>0.63</td>
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<td>Fertility rate</td>
<td>2.33</td>
<td>2.28</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Log per capita income</td>
<td>7.82</td>
<td>7.79</td>
<td>0.03</td>
<td>0.01</td>
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<tr>
<td>Labor force participation rate (%)</td>
<td>50.24</td>
<td>49.71</td>
<td>0.53</td>
<td>0.06</td>
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<td>Unemployment rate (%)</td>
<td>3.48</td>
<td>3.08</td>
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<tr>
<td>Ratio of govt. expenditures to revenues</td>
<td>0.97</td>
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<td>Log welfare spending per person &gt; 65 y.o.</td>
<td>4.10</td>
<td>4.05</td>
<td>0.05</td>
<td>0.18</td>
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<tr>
<td>Log welfare spending per person &gt; 75 y.o.</td>
<td>5.08</td>
<td>5.03</td>
<td>0.05</td>
<td>0.19</td>
</tr>
</tbody>
</table>
## Effect of Pension Frequency Reform on Municipal Admin Costs

<table>
<thead>
<tr>
<th>       </th>
<th>(1)        </th>
<th>(2)        </th>
<th>(3)        </th>
<th>(4)        </th>
<th>(5)        </th>
<th>(6)        </th>
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<tbody>
<tr>
<td><strong>Branch × Post</strong></td>
<td>0.043***</td>
<td>−0.012</td>
<td>0.034</td>
<td>−0.003</td>
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<td></td>
<td>(0.017)</td>
<td>(0.014)</td>
<td>(0.023)</td>
<td>(0.016)</td>
<td>(0.026)</td>
<td>(0.017)</td>
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<td><strong>City &amp; year FEs</strong></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<td></td>
<td>✓</td>
<td></td>
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<td></td>
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<tr>
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<td>✓</td>
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<tr>
<td><strong>1985 population bin × year FEs</strong></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td><strong>1985 per capita income bin × year FEs</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
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<td></td>
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<tr>
<td><strong>N</strong></td>
<td>11,111</td>
<td>10,635</td>
<td>11,111</td>
<td>10,635</td>
<td>11,111</td>
<td>10,635</td>
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<tr>
<td><strong># Municipalities</strong></td>
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<td>663</td>
<td>635</td>
<td>663</td>
<td>635</td>
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<tr>
<td><strong>Adj. $R^2$</strong></td>
<td>0.517</td>
<td>0.554</td>
<td>0.856</td>
<td>0.863</td>
<td>0.863</td>
<td>0.866</td>
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</table>

**Notes:** The dependent variable in each regression is log expenses on elderly welfare per resident at or above age 65. $Branch_j = 1$ if municipality $j$ contains a Japan Pension System branch office. $Post_t = 1$ for years 1988–1996. All regressions include observations for years 1980 – 1996 and a full set of year fixed effects. Robust standard errors clustered at the municipality level in parentheses. Tokyo consists of the 23 central wards for which separate expenditure time series are available. Major cities consist of the historically five most populous cities outside of Tokyo: Yokohama, Nagoya, Kyoto, Osaka, and Kobe. 1985 population bin refers to quintiles of 1985 Census population. 1985 per capita income bin refers to quintiles of per taxpayer taxable income in 1985. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Details on model calibration

- **Policy parameters (based on FY 2011 data from JPS)**
  - Average daily payment per claimant: $\overline{B} = 3,462$ JPY ($\approx 32.50$)
  - Fraction of participants who receive benefits: $p = 0.3766$

- **Administrative cost function**
  - Posit cost function takes form $\mu(T) = \kappa_\ell / T^\ell$ where $\ell \geq 1$
  - For each $\ell$ calibrate scale factor $\kappa_\ell$ such that $\mu(T)$ matches reported administrative costs: $300.722$ billion JPY ($\approx 3.07$ billion)

- **QH discounting**
  - Set $f(t) = \nu \cdot t = 0.002t$ to match estimated 10% spike at payday
  - Avg. daily decline of 0.2% of consumption over pay cycle after stripping out seasonality

- **Payday liquidity**
  - Set magnitude of spike at $x = 0.1$ or $x(T) = 0.0013T$ to match baseline estimates for raw foods (perishables $\approx$ consumption)
Model Derivations
- Fraction $p$ of people receive a flat (pension) benefit every $T$ days equal to $b(T) = \bar{B} \cdot T$
- Other $1-p$ fraction are workers who earn exogenous $w(t)$ and pay lump-sum tax $\tau(b)$
- Continuous time setup because $T$ is the government’s choice variable
- Government runs balanced budget for each $t \in [0, T]$:
  $$ (1-p) \cdot \tau(b) = p \cdot b(T) + \mu(T) \implies \tau(b) = \frac{p \cdot \bar{B} \cdot T + \mu(T)}{1-p} $$
- $\mu(T)$ is an administrative cost function assumed to be weakly convex
  - Captures program costs that vary with $T$: authorizing/delivering benefits, redeeming benefits, investigating fraud
Govt. picks $T$ to minimize welfare loss subject to balanced budget.

Can write this compactly as

$$\min_T \left\{ -p \cdot \lambda(T) + \gamma \cdot \left( p \cdot b(T) + \mu(T) \right) \right\} \quad \text{with} \quad \gamma = -\frac{\partial U^*/\partial \tau}{\partial R^*/\partial \tau}$$

$\gamma$ is the marginal cost of funds (MCF), equal to unity under lump-sum taxation of workers.

Govt. sets length of pay cycle $T^*$ to equate marginal reduction in the welfare loss to marginal cost of reducing $T$

$$\frac{p \cdot \lambda'(T^*)}{\gamma} = \mu'(T^*) + p \cdot \bar{B} \quad (6)$$

Sufficient statistics: fraction of pensioners, the average daily benefit amount, slope of welfare loss and cost function.
Working households face standard consumption-saving problem:

\[
\max_{\{C(t)\}_{t \geq 0}} \int_0^T u(C(t))dt \quad \text{s.t.} \quad C(t) = S(t) + w(t) - \frac{\tau(b)}{T}
\]

Solution to this problem is full smoothing: \( C(t) = C^*, \forall t \)

Optimal consumption for pensioners is also \( C(t) = C^*, \forall t \), but suppose instead actual choice follows:

\[
C(t) = c_0(T) \cdot \exp(-f(t))
\]

\( f(t) \) captures how path deviates from optimum over pay cycle

Budget constraint \( \int_0^T C(t)dt = b(T) \) pins down the value of consumption on payday \( c_0(T) \) with \( f(0) = 0 \)
Welfare loss from non-smoothing is share $\lambda$ willing to give up to achieve $C_t = C^*$

$$\int_0^T u^r \left( c_0(T) \cdot \exp(-f(t)) \right) dt = \int_0^T u^r (\lambda \bar{B}) dt$$

$(1 - \lambda)$ is the **compensating variation** or welfare loss from non-smoothing à la Lucas (1987), which depends on $T$.

For any invertible $u(\cdot)$ we can rewrite $\lambda(T)$ as

$$\lambda(T) = \frac{T \cdot u^{-1} \left\{ \frac{1}{T} \int_0^T u \left( c_0(T) \cdot \exp(-f(t)) \right) dt \right\}}{\int_0^T c_0(T) \cdot \exp(-f(t)) dt}$$

- **Numerator:** total consumption where daily consumption is s.t. receive average daily utility over the actual consumption path
- **Denominator:** actual total consumption over the pay cycle
Marginal compensating variation: $\lambda'(T)$

- Write compensating variation $\lambda(T)$ as a function of total observed consumption $C_{tot}$ and total certainty equivalent consumption $\bar{C}$:

$$
\lambda(T) = \frac{T \times \bar{C}}{C_{tot}} \implies \lambda'(T) = \frac{(T \times \bar{C})' \cdot C_{tot} - (T \times \bar{C}) \cdot (C_{tot})'}{(C_{tot})^2}
$$

$$(C_{tot})' = \frac{\partial}{\partial T} \int_0^T c_0(T) \cdot \exp(-f(t)) = c_0 \cdot \exp(-f(T))$$

$$(\bar{C})' = \frac{\partial}{\partial T} u^{-1}\left\{ \frac{1}{T} \int_0^T u\left(c_0(T) \cdot \exp(-f(t))\right) dt \right\} \equiv U(T)$$

$$= u^{-1} \left( U(T) \right) (u^{-1})' \left( u(U(T)) \right) \cdot \frac{1}{T} \left[ u\left(c_0(T) \cdot \exp(-f(T))\right) - U(T) \right]$$
Suppose utility function takes the form:

$$u(c_0) + \beta \cdot \sum_{t=1}^{T} \delta^t u(C_t)$$

Individuals with these preferences exhibit present bias: sequence of discount rates is $1, \beta \delta, \beta \delta^2, \beta \delta^3, \ldots$, with $\beta < 1, \delta < 1$

With $u(\cdot)$ isoelastic with inverse IES $\rho$, log consumption decreases over time

$$\frac{\partial \log(C_t)}{\partial t} = \frac{1}{\rho} \cdot \log \beta - \frac{1}{T - t + 1} + \frac{1}{T - t + \beta^{-1/\rho}} < 0$$

For $\beta \approx 1$ but $\beta < 1$ this decrease is approximately linear

Embed these preferences in the general model by assuming $f(t) = \nu t$ where $\nu$ is the **daily decline** in consumption over the pay cycle
Figure 1. Monthly Consumption Pattern: $\delta = 0.97; \rho = 1$

Source: Mastrobuoni & Weinberg (2009)
With $\bar{B} \cdot T$ to spend over the time period $[0, T - 1]$, budget constraint pins down payday consumption $c_0(T)$:

$$\int_0^T c_0(T) \cdot \exp(-\nu t) \, dt = \bar{B} \cdot T \implies c_0(T) = \frac{\nu \cdot \bar{B} \cdot T}{1 - \exp(-\nu T)}$$

Assuming isoelastic utility with inverse IES $\rho$ the welfare loss is:

$$1 - \lambda(T) = \begin{cases} 
1 - \frac{1}{\bar{B}} \cdot \exp \left( c_0 - \nu T/2 \right) & \text{if } \rho = 1 \\
1 - \frac{c_0}{\bar{B}} \cdot \left[ \frac{1-\exp((\rho-1)\nu T)}{\nu T(1-\rho)} \right]^{\frac{1}{1-\rho}} & \text{if } \rho \neq 1
\end{cases}$$
Welfare loss from QH discounting

By Interval Length

By Inverse IES

LaPoint (Yale) & Sakabe (LMU)

Optimal Payment Frequency

NBER Japan Project 2023
With QH discounting, internality problem because individual overconsumes in earlier periods and underconsumes in later periods

Three features of the welfare loss \((1 - \lambda)\):

1. **Welfare loss is increasing in govt. choice of \(T\)**
   - For higher \(T\), welfare loss will be greater because integral between the optimal smooth path and QH path larger

2. **Welfare loss is increasing in \(\rho\)**
   - Higher \(\rho\) means consumption less substitutable between periods, so individual willing to pay more to get closer to consumption smoothing

3. **Optimal \(T^*\) is decreasing in \(\rho\)**
   - Govt.'s MB curve of decreasing \(T\) becomes steeper for higher \(\rho\)
Directly modeling quasi-hyperbolic discounting in continuous time is challenging because there is no clear "today" and "tomorrow"

Following Webb (2016), define $\eta$ as present period, and $0 \leq \xi \leq 1$ interval length:

$$V_\eta(C) = \int_{\eta}^{\eta + \xi} (\beta^{1/\xi} \delta)^{t-\eta} \cdot u(C(t)) dt + \beta \int_{\eta + \xi}^{\infty} \delta^{t-\eta} u(C(t)) dt$$

Utility at $t - \eta = 0, 1, 2, \ldots$ weighted by $1, \beta \delta, \beta \delta^2, \ldots$

Extra parameter $\xi$ captures time interval before present bias kicks in

Present bias in continuous time is akin to instant gratification

Implied consumption path is similar to path in discrete time setting
Recent papers find that individuals exhibit “payday liquidity”

- Spike in expenditures on payday across the income distribution
- Unrelated to expectations of future liquidity constraints
- Expenditures are smooth for the rest of the pay cycle

Simple consumption rule where $t = 0$ is payday and interval $T > 1$:

$$C_t = \begin{cases} (1 + x) \cdot \bar{c} & \text{if } t = 0 \\ \bar{c} & \text{if } t \in [1, T - 1] \end{cases}$$

If this $C_t$ is the result of utility maximization then no welfare loss

One possible utility function where this is optimal:

$$u(C) = (1 + x) \cdot \log u(C_0) + \sum_{t=1}^{T-1} \log(C_t)$$
If underlying preferences do not put extra weight on $u(C_0)$ there will be a welfare loss

- Can think of this as mental accounting under myopia

With convex administrative costs the welfare loss goes to zero as $T \to \infty$

- Trivial case where govt. faces no tradeoff
- Intuition: loss is concentrated on the initial spike, so as $T \to \infty$ loss is small relative to total consumption over the cycle

If instead allow spike to depend on pay cycle length with $x'(T) > 0$, then $T^* < \infty$

- Stephens & Unayama (2011): some evidence that $x'(T) > 0$, since MPC out of pension payments lower when $T = 90 \to 60$
- We find evidence to support this case using high frequency data
Marginal welfare loss with payday liquidity: $x(T)$

- To keep things simple, focus on log utility ($\rho = 1$)
- Welfare loss expression is the same, but now the marginal loss is:
  $$-\lambda'(T) = \left(\frac{\bar{c}/B}{T^2}\right)\left[\left(1 + x(T)\right) \cdot \log \left(1 + x(T)\right) - T x'(T)\right]$$
- Now decreasing $T$ can improve welfare if:
  $$\left(1 + x(T)\right) \cdot \log \left(1 + x(T)\right) > \frac{T \cdot x'(T)}{\text{gain from subdivision as } T \uparrow}$$
  $\text{loss from spike magnitude as } T \uparrow$

- Spike grows with $T$ due to pent-up demand (LHS), but daily loss falls as interval length increases (RHS)
- Our empirical evidence suggests linear $x(T) = 0.0023 \cdot T \implies$ welfare higher for lower $T$
Welfare loss under payday liquidity with pent-up demand $x(T)$

- $1 - \lambda(T)$ is now concave vs. convex in the QH discounting case
- Importantly, $\lambda'(T)$ has similar shape for both cases
Extensions & Counterfactuals
Baseline framework assumes consumers fully naive about overspending around payday

- Alternatively they could internalize temptation to spend earlier and adjust consumption to limit overspending by future self → “sophistication”
- If sophisticated might also want to commit to not overspending (Bryan, Karlan, Nelson 2010)

Forms of commitment devices: layaway, retirement/education savings accounts, timing services payments (e.g. utilities, mortgage) to coincide with income

Idea: more infrequent payments makes it easier for consumers to save up for large durable purchases like appliances (Zhang 2023)

**Key result:** allowing for commitment via durables purchases leads to $T^* \uparrow$, but not by much unless IES is very low ($\rho$ is very high)

- IES determines preference for commitment and lower $T$ makes it harder to commit
Simulate for range of $\rho$ and $T$ consumption path for three types of consumers who overspend on payday

- Parameterize as present-bias problem, but can map back to mental accounting via $\nu$

1. **Naive**: consumers in our baseline model who choose consumption plan $\{c_t\}_{t=0}^{T-1}$

2. **Sophisticated**: are aware of present-bias and solve for the optimal consumption plan via backwards induction to obtain $\{c_{**}^*\}_{t=0}^{T-1}$

- Algorithm: solve naive problem and iterate backwards to obtain $c_{**}^*$

3. **Sophisticated + commitment (SC)**: given access to a commitment device $z_0$ which allows withholding on payday and (linearly) amortizing in future periods

- Give up $z_0$ initially to gain $z_0/T - 1$ in future when consumption is below the smooth level due to overspending on payday

- Linear subdivision proxies for economic depreciation of durables
Solving for commitment as a function of pay cycle length

- Sophistication + commitment problem collapses to:

\[
\max_{z_0} \left\{ u(c_0^{**} - z_0) + \beta \sum_{t=1}^{T-1} \delta_t u(c_t^{**} + z_0/(T - 1)) \right\} \quad \text{s.t.} \quad \begin{cases} z_0 \geq 0 \\ c_0^{**} - z_0 > 0 \end{cases} \tag{8}
\]

- For log utility ($\rho = 1$) well-known result that no preference for commitment, so $z_0^* = 0$, meaning the slackness or “no borrowing” constraint binds

- Continuous time approximation of $c_t^{**}$ is then

\[
C(t) = \exp \left( \theta - f(t) + \zeta(t) \right) \tag{9}
\]

- Cumulative “pull-back” towards the optimum $Z(T) = \int_0^T \zeta(t)dt$ has the property $Z'(T) \geq 0 \rightarrow$ it becomes more difficult to commit with shorter pay cycles
  - $\zeta(t)$ can be non-monotonic in $t$, depending on $T$ and $\rho$
Baseline model assumes price $P$ of consumption bundle does not vary w.r.t. $T$
  ▶ Consistent w/empirical findings of minimal retailer pricing response when averaged over entire basket of commonly purchased goods

Consider two extensions with monopolistic retailers:

1. Single monopolistic chain providing the entire basket $C$ at price $P$
2. Continuum of monopolistic chains specializing in varieties

Retailers face fixed real inventory cost $\Gamma$ and menu cost for changing prices
  ▶ Both versions of model illustrate that allowing for fixed cost of changing prices $\implies T^* \downarrow$
  ▶ $\implies$ baseline calibration results provide upper bound on $T^*$
**Lemma (neutrality result)**

Consider optimal frequency model with single monopolistic chain that price discriminates on the extensive margin (i.e. $P$ changes only on the time dimension, but not by demographics) and pays menu costs in units of wage labor.

Then there exists a set of parameters $(p, A, \kappa, \omega)$ s.t. for any $T$, consumer welfare the same regardless of whether there is price discrimination.

- Intuition: loss in utility over consumption associated with the price hike is completely offset by the reduction in disutility from labor supply
- Relies on idea that menu costs are mostly labor costs (Blinder et al. 1998)
Model with single monopolistic retailer

- Retailer sets sequence of prices $P_t$ to maximize profits:

$$\max_{\{P_t\}} \left\{ \sum_{t=0}^{T-1} P_t \cdot Y_t - W_t \cdot L_t - \kappa \cdot W_t \times 1_t - P_t \cdot \Gamma \right\}$$

- Labor $L_t$ used to satisfy non-recipient demand $F(L_t) = C_t^{NR}$

- Menu cost $\kappa \cdot W_t$ units of wages paid if change regular price ($1_t = 1$)

- Non-recipients work and incur disutility from providing labor to the retailer:

$$\max_{\{C_t,L_t\}} \left\{ \sum_{t=0}^{T-1} u(C_t) - \nu(L_t) \right\} \quad \text{s.t.} \quad P_t \cdot C_t = S_t + W_t \cdot L_t - \frac{\tau(b)}{T}$$
Govt. problem with retail pricing

\[
\min_T \left\{ -p \cdot \lambda(T) + \gamma \cdot \left( p \cdot b(T) + \mu(T) \right) + \left( U^*(C^{1, NR}(T)) - U^*(C^{0, NR}(T)) \right) \right\}
\]

\[
\begin{align*}
\text{welfare loss from non-smoothing + taxes} & \quad \text{welfare loss from price discrimination}
\end{align*}
\]

- If \( T^* \) s.t. retailer finds it unprofitable to price discriminate, \( \mathbb{I}_0 = 0 \), and non-recipients experience no utility loss.

- If instead admin costs \( \mu(T) \) are sufficiently convex, then govt. may set \( T^* \) s.t. price discrimination occurs in equilibrium.

- Parameterization: suppose payday liquid benefit recipients, non-recipients have \( u(C_t) - \nu(L_t) = \log(C_t) - \omega \cdot L_t \), and production is linear in labor \( F(L_t) = A \cdot L_t \).
Equilibrium conditions with menu costs

- Combine FOCs from the non-recipient’s problem to get profits over the pay cycle:
  \[
  \sum_{t=0}^{T-1} C_t - \omega C_t^{NR} \cdot \frac{C_t^{NR}}{A} - \kappa \cdot \omega C_t^{NR} \times 1_t - \Gamma
  \]

- Aggregate demand is the sum of the recipient (R) and non-recipient (NR) demands:
  \[
  C_t = p \cdot C_t^R + (1 - p) \cdot C_t^{NR}
  \]

- Equilibrium real expenditures of non-recipient:
  \[
  C_t^{NR} = \begin{cases} 
  \frac{A}{2\omega} & \text{if } 1_t = 0 \\
  \frac{A\left(1-p\right) - \kappa \cdot \omega}{2\omega \cdot (1-p)} & \text{if } 1_t = 1
  \end{cases}
  \]
\[ P_t = \begin{cases} \frac{2W_t}{A} & \text{if } 1_t = 0 \\ \frac{2W_t(1-p)}{A(1-p-\kappa \omega)} & \text{if } 1_t = 1 \end{cases} \]

- Payday liquid recipients \( \Rightarrow \) price discrimination if it does occur will only be profitable on payday \( \Rightarrow \) \( P_t = \frac{2W_t}{A} \) for \( t \neq 0 \)
  - Logic: \( C_t^R \) is smooth except for \( t = 0 \) when people decide to splurge
  - Assume \( \kappa \cdot \omega < (1-p) \) since \( P_t > 0 \) (disutility from labor or menu costs cannot be too large)

- Comparing profit functions, price discrimination occurs if and only if:
  \[
  x(T) > \frac{1-p}{p\bar{c} \cdot \left( (2-A)(1-p) - A \cdot \kappa \omega \right)} \cdot \left\{ \frac{A \kappa + A(1-p-\kappa \omega)}{(1-p)} \cdot \left( p\bar{c} + \frac{A(1-p)-\kappa \omega}{2\omega} \right) \right\}
  \]
Welfare neutrality of price discrimination

\[ x(T) > \frac{1 - p}{p \bar{c} \cdot \left( (2 - A)(1 - p) - A \cdot \kappa \omega \right)} \cdot \left\{ A \kappa + \frac{A(1 - p - \kappa \omega)}{1 - p} \cdot \left( p \bar{c} + \frac{A(1 - p) - \kappa \omega}{2\omega} \right) \right\} \]

- Gain from price discrimination = excess demand from price-inelastic pensioners receiving income → quantified by spike \( x(T) \) in the data

- Loss from price discrimination = menu cost + reduced demand from non-recipients

- Setting \( T \downarrow \implies x(T) \downarrow \) and menu cost becomes a larger fraction of profits

- Difference in non-recipients’ optimized level of utility when there is price discrimination is:

\[
\log(C_{NR,1}^0) - \log(C_{NR,0}^0) + \omega \cdot \left( L_1^0 - L_0^0 \right) = 0
\]

- Punchline: price discrimination is welfare neutral \( \implies \) govt. can ignore retailer!
Counterfactual exercise

What would be the increase in pay cycle length $\Delta T > 0$ required to reduce costs by an equivalent amount to raising the NRA from 65 to 70?

- Calculate increase in **penalty rates** imposed on early pensioners aged 60-69 compared to current NRA of 65
  - Current penalty: 0.4-0.5% per month until the month of 65th birthday, capped at 30%
  - Under shift in NRA to 70, overall penalty would max out at 60%

- Assume claiming rate of 10.8% persists for 65-69 age group...
  - $\implies$ fraction of eligibles $p$ decreases from 0.377 to 0.307

- Cost savings are lower if retain 30% penalty cap: 28.07 billion JPY vs. 36.12 billion JPY
**Double dividend** argument for raising the NRA

**Result:** raising retirement age pushes up the optimal pay cycle length $T^*$

- Raising NRA results in $p^{new} < p^{old} \implies$

\[
\frac{1}{p^{new}} \cdot \mu'(T^*) = \frac{\kappa \ell}{p^{new}} \cdot \left( - \ell / T^* \ell^{-1} \right) < \frac{1}{p} \cdot \mu'(T^*)
\]

- $\lambda'(T) < 0$, so as $p \downarrow$, MC of increasing frequency dominates the MB (welfare gains) from consumption smoothing

<table>
<thead>
<tr>
<th>Admin cost convexity</th>
<th>$T^*(p^{new})$</th>
<th>$T^*(p^{old})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ell = 1$</td>
<td>7.55 days</td>
<td>6.72 days</td>
</tr>
<tr>
<td>$\ell = 2$</td>
<td>19.63 days</td>
<td>18.27 days</td>
</tr>
<tr>
<td>$\ell = 3$</td>
<td>28.81 days</td>
<td>27.32 days</td>
</tr>
</tbody>
</table>