The Unequal Gains from Product Innovations: Evidence from the US Retail Sector

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September 21, 2017

Introduction

- Who benefits from innovation?
  - *Income channel*: extensive literature on skill-biased technical change [Acemoglu 1998, Goldin and Katz 1998, Autor, Levy and Murnane 2003]
  - *Expenditure channel*: new products can affect purchasing-power across income groups directly (by targeting specific groups) and indirectly (through competition with existing products)
- This paper investigates the impact of product innovations on inequality through the expenditure channel
  - Theory:
    Shifts in income distribution $\mapsto$ Increased demand for premium products
    $\mapsto$ Shift in direction of product innovations
    $\mapsto$ Increase in purchasing-power inequality
  - Several empirical tests support this theory, primarily using scanner data in US retail sector
- This has implications for inflation inequality and the price indexation of certain government programs

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Motivating Example: Cost of Detergent (per 100 Loads)

More

	BEFORE	AFTER
HIGHER PRICE	**$10**   **All Liquid** UPC 9 53228 02121 9	
LOWER PRICE	**$5**   **All Powder** UPC 7 74205 55160 4	

Motivating Example: Cost of Detergent (per 100 Loads)

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1 Increased demand

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1 Increased demand

2 Increased entry

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1 Increased demand

2 Increased entry

3 Increased price competition

Main Findings

- **In retail sector (2004-2015), higher-income households experienced a faster increase in product variety and lower inflation on continued products**
  - Annual inflation was 65 basis points lower for households earning above \$100k vs. below \$30k

- **This was largely due to the supply response to changes in demand induced by shifts in the income distribution**
  - Research design in two steps:
    - ★ Identify effect of demand on supply using changes in age and income distributions over time as demand shifters
    - ★ Apply point estimates to changes in demand induced by shifts in US income distribution
  - Accounts for over 80% of inflation difference
  - Simple model rationalizes evidence (endogenous entry and markups)

Related Literatures

- Literature on innovation and inequality
  - Factor-augmenting technical change: Goldin and Katz (1998), Acemoglu (1998, 2002, 2007), Krusell, Ohanian, Rios-Rull and Violante (2000), Greenwood and Yorukoglu (1997), Galor and Moav (2000), Garicano and Rossi (2004)
  - Sector-augmenting technical change: Acemoglu and Linn (2004), Acemoglu, Aghion, Bursztyn and Hemous (2012), Boppart and Weiss (2013) and Comin, Lashkari and Mestieri (2016)
  - Product cycle: Schumpeter (1942), Vernon (1966), and Matsuyama (2002)
  - Contribution: show theoretically and empirically the implications of endogenous innovations across product space for inequality
- Literature on inflation inequality
  - Extensive literature investigating inflation experiences of different household groups: Amble and Stewart (1994), Garner, Johnson and Kokoski (1996) and Hobijn and Lagakos (2003), Murphy and Garvey (2004), Chiru (2005), McGranahan and Paulson (2005)
  - Recent work measuring inflation inequality using scanner data: Broda and Romalis (2009), Argente and Lee (2016), Kaplan and Schulhofer-Wohl (2016)
  - Contribution: show long-term trend of inflation inequality in scanner data (not business-cycle phenomenon) and importance of aggregation bias

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Summary

- **In retail, inflation was much lower for higher-income households...**
- **...because supply responds to changes in demand...**
- **...induced by shifts in the income distribution.**

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Roadmap

1. Data
2. Inflation across Income Groups
3. The Response of Supply to Market Size Effects

Roadmap

1. **Data**
2. Inflation across Income Groups
3. The Response of Supply to Market Size Effects

Scanner Data

- Nielsen Homescan Consumer Panel [Aguiar & Hurst 2007, Einav, Leibtag & Nevo 2008, Broda & Romalis 2009, Broda & Weinstein 2010, Stroebel & Vavra 2014]
  - Households scan prices and quantities for products with barcodes sold in US from 2004 to 2013 (e.g in department/grocery/drug/convenience stores)
  - Household characteristics: income, age, education, occupation, MSA, composition, ...
  - Representative of 40% of household expenditures on goods, 15% of total household expenditures More on Consumptions Baskets

HIGHER PRICE

LOWER PRICE

HOUSEHOLD SUPPLIES	GENERAL MERCHANDISE	BEAUTY AND HEALTH	ALCOHOL	FOOD

NEW

HIGHER PRICE

LOWER PRICE

HOUSEHOLD SUPPLIES

GENERAL MERCHANDISE

BEAUTY AND HEALTH

ALCOHOL

FOOD

Roadmap

1. Data
2. **Inflation across Income Groups**
3. The Response of Supply to Market Size Effects

Roadmap

1. Data

2. Measuring Inflation across Income Groups
    1. **Price changes for continued products** (90% of spending)
    2. Valuing new and exiting products
    3. Aggregation bias
    4. Evidence outside retail

3. The Response of Supply to Market Size Effects

Price Changes for Continued Products

- Different price indices put different weights on the product-level price changes (substitution):

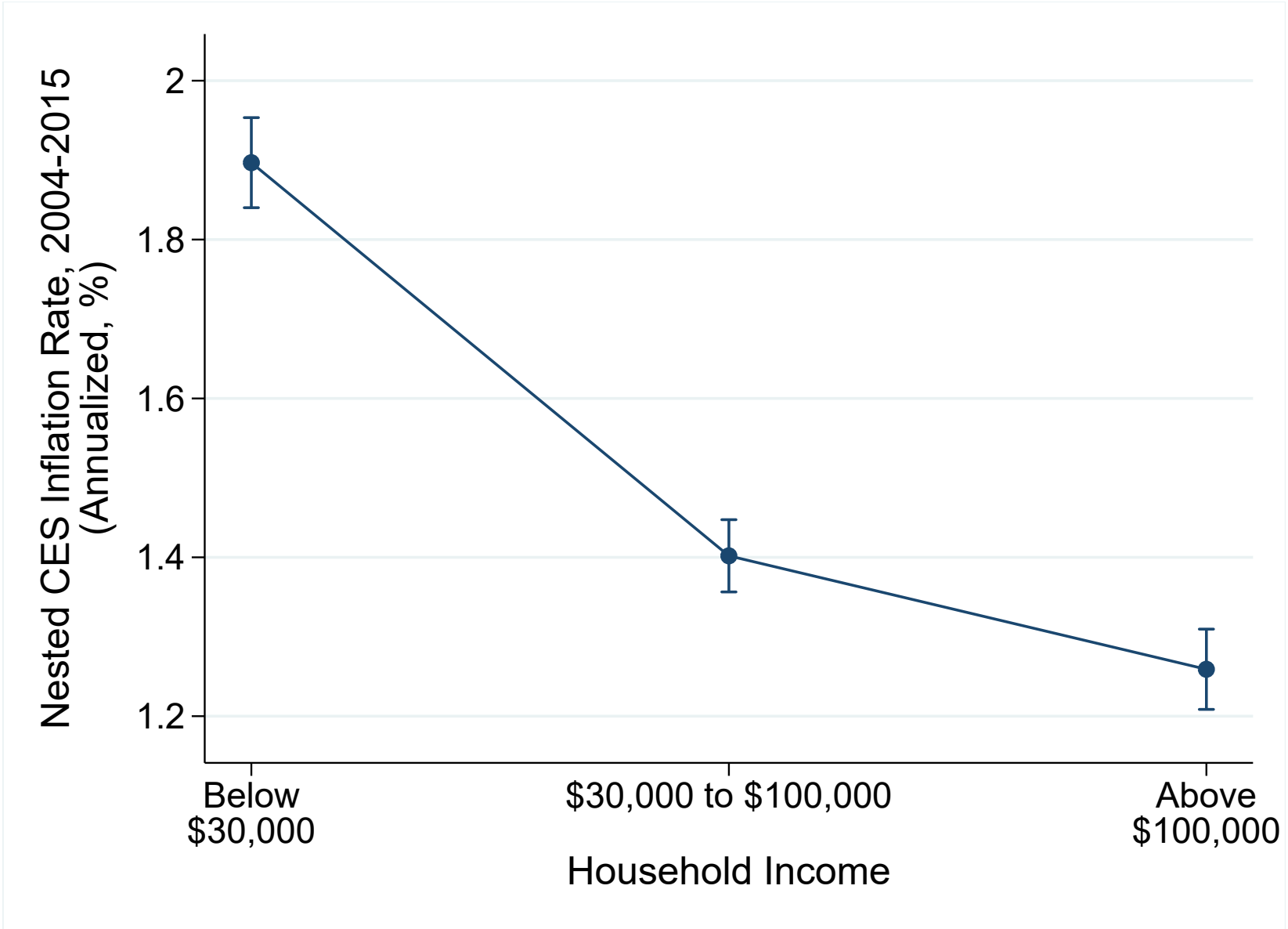
$$\textit{Laspeyres Index}: \quad P^L \equiv \sum_{u=1}^{n} \frac{p_u^t}{p_u^0} s_u^0$$

$$\textit{CES Exact Price Index}: \quad P^{CES} \equiv \Pi_c \left(\frac{p_u^t}{p_u^0} \right)^{w_{ut}}$$

  with p_u^t price, s_u^t spending share and w_{ut} Sato-Vartia (1976) weights.

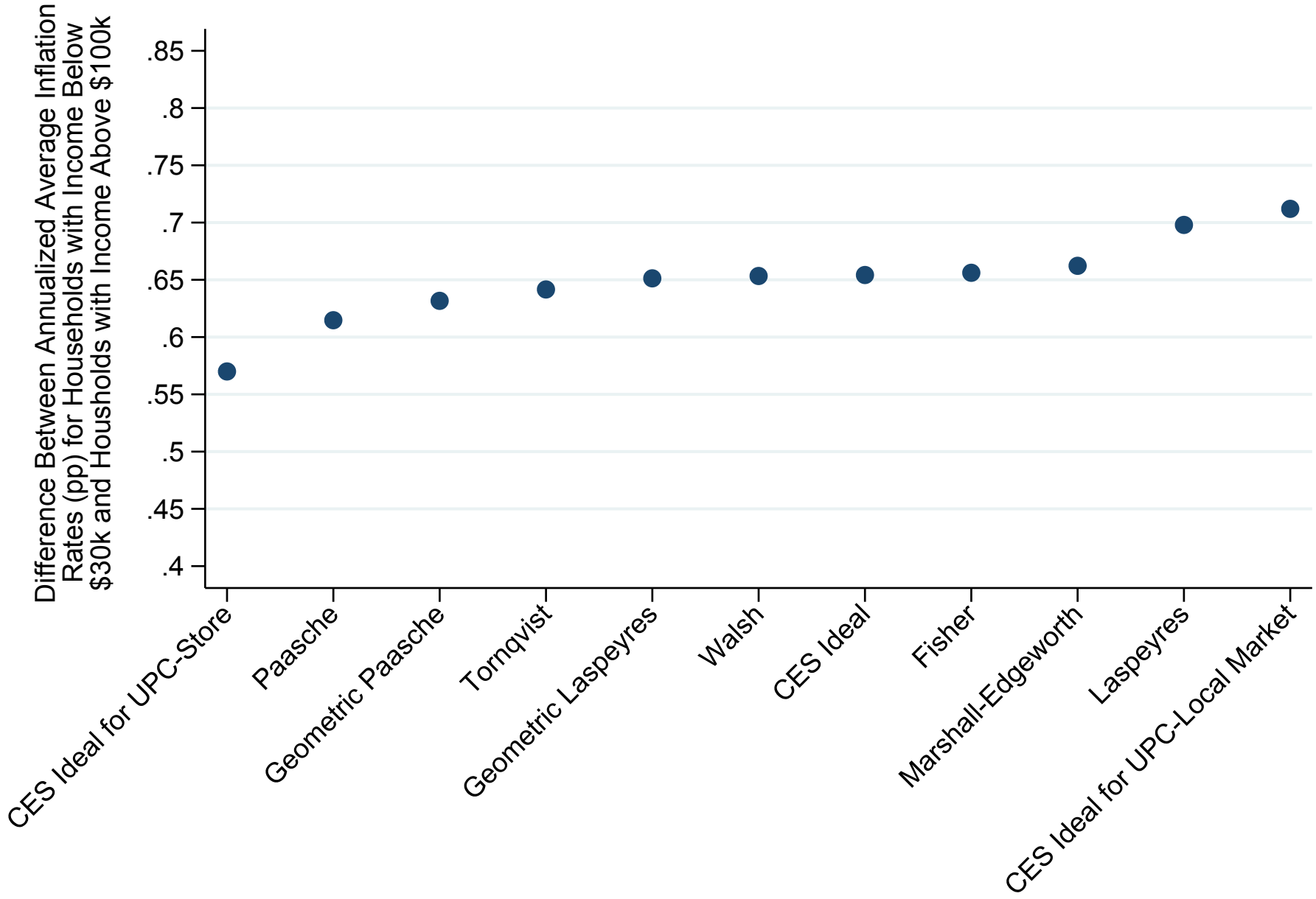
- Compute separate price indices across income groups
  - In baseline result: three income groups, price index is nested CES, and product u is a UPC

Price Changes for Continued Products



With More Income Groups | Across Departments | Across Years | By Age-Income Groups | Additional Checks

No Differential Substitution Effects



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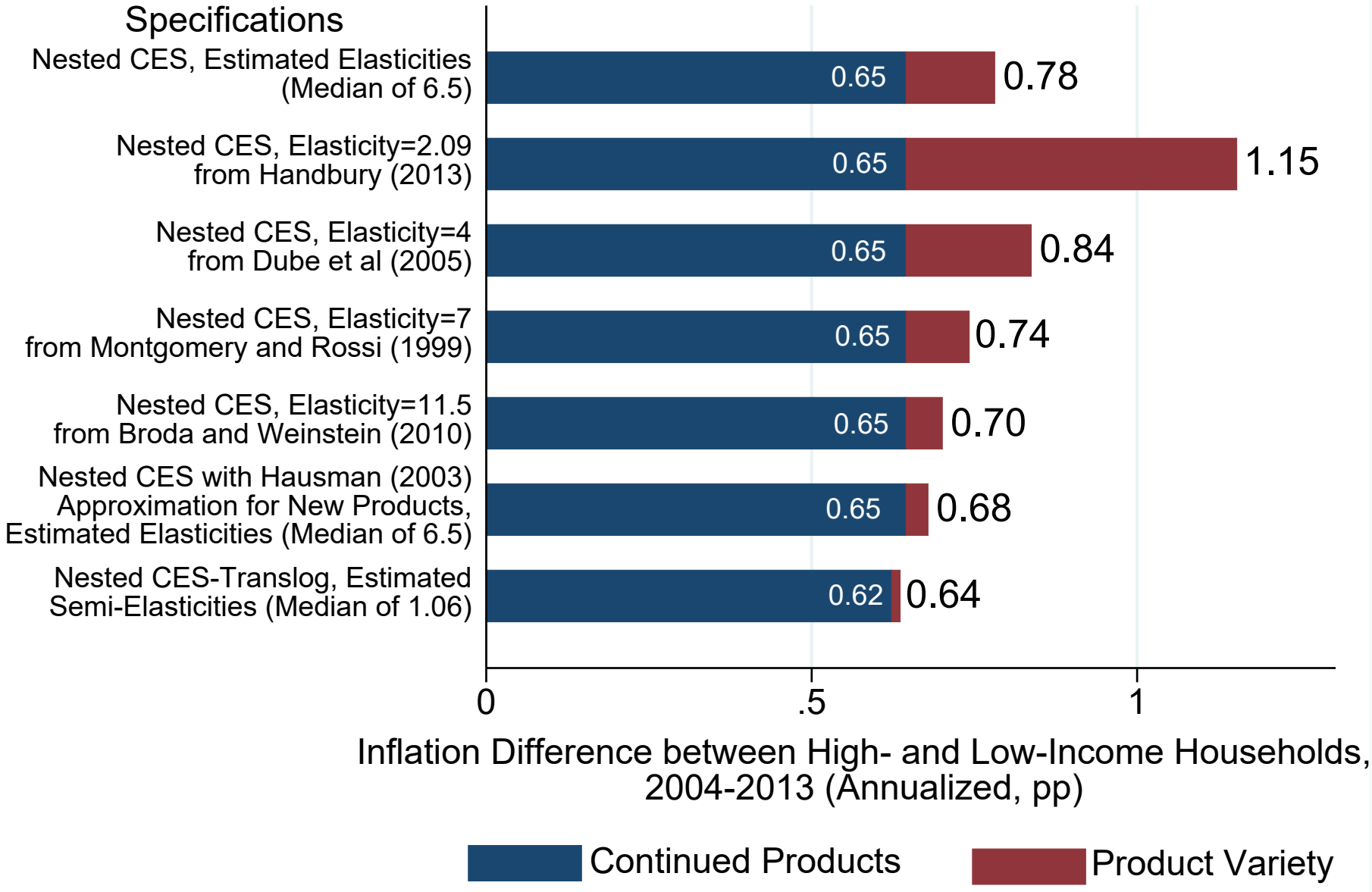

Detailed Estimation Results

Roadmap

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    1. Price changes on continued products
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Decomposition of Inflation Difference

- Classifying products into categories indexed by C, the inflation difference between high- and low-income can be decomposed as: [Diewert 1975]

$$\pi^H - \pi^L \approx \underbrace{\left(\sum_C (s_C^H - s_C^L)\pi_C \right)}_{Between} + \underbrace{\sum_C \overline{s_C}(\pi_C^H - \pi_C^L)}_{Within}$$

with s_C^i share of spending of income group i on C,
π_C^i the inflation experienced by income group i on C,
π_C average inflation rate in C,
$\overline{s_C}$ average spending share in C.

- Conduct decomposition for various levels of aggregation, using the nested CES price index for continued products

Aggregation Bias

- "Between" decomposition:

Aggregation Level (Broad to Narrow)	Share of Inflation Difference Explained (%)
Department	**8.6**
(e.g. fresh produce vs. health and beauty care)	
Product Group	**21.4**
(e.g. deodorant vs. hair care)	
Product Module	**42.8**
(e.g. men's vs. women's hair coloring)	

More Decomposition Results

- This explains why old literature has found much smaller inflation inequality [Hobijn & Lagakos 2003, McGranahan & Paulson 2005, Chiru 2005]
  - Contrast with recent literature on inflation using scanner data: Argente and Lee (2016), Kaplan and Schulhofer-Wohl (2016)

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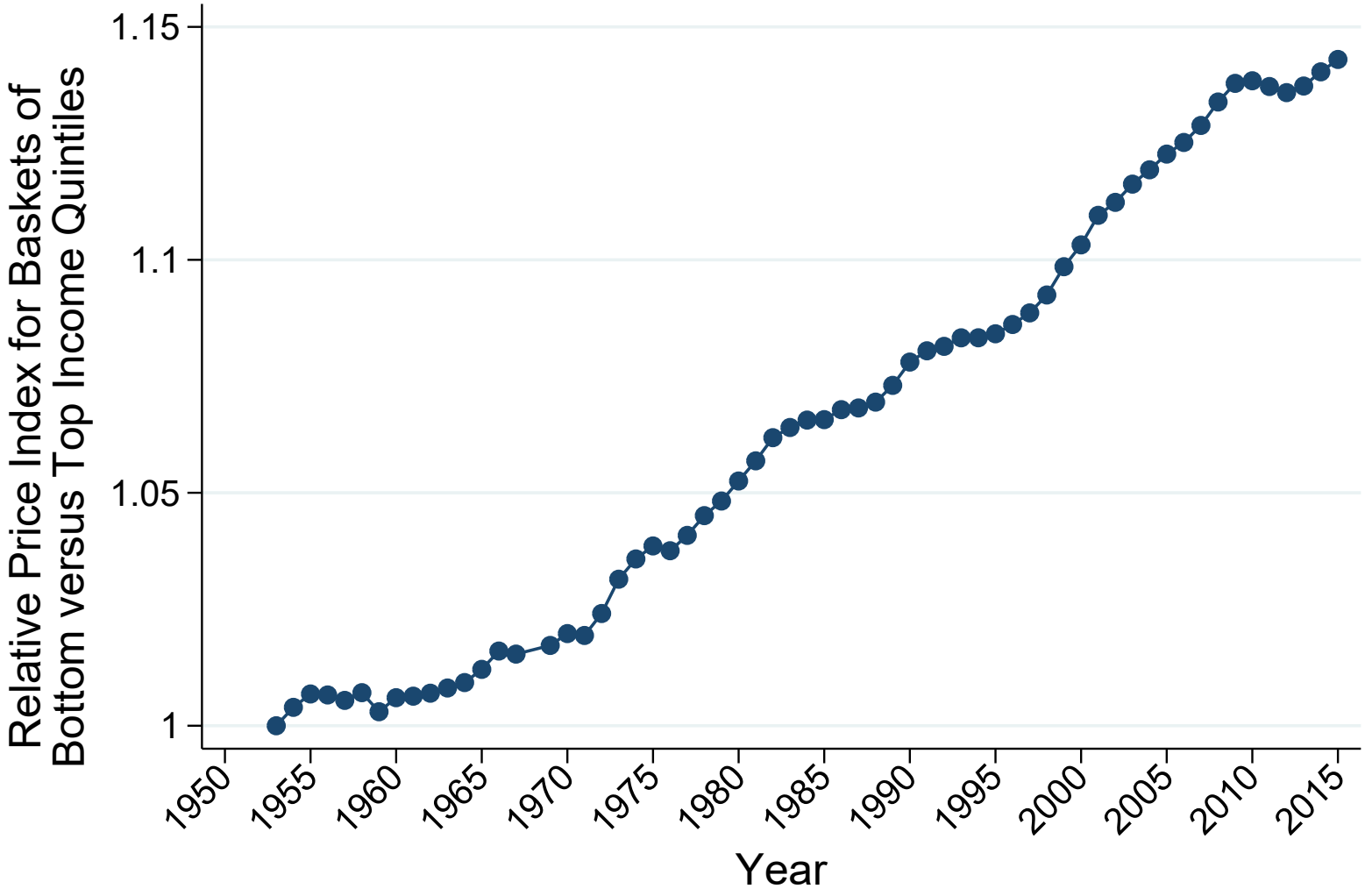
Evidence Outside Retail

- Use CPI and CEX data to assess patterns outside retail: [McGranahan & Paulson 2005]
  - Price series on 48 expenditure categories going back to 1953, covering full consumption basket
  - Using expenditure shares fixed at 1980-1985 levels, compute inflation for baskets of households in top vs. bottom income quintiles
  - Subject to aggregation bias, but still useful

Long-Term Inflation Inequality



Relative price index is normalized to 1 in 1953.
Laspeyres inflation rates are computed using 1980-1985 expenditure shares.

Robustness TFP Analysis Patent Analysis

Implications for Inequality

- Over 2004-2015, nominal increase in food stamp benefits should have been 31.4% (instead of 23.2%) to preserve purchasing power
- From CEX, spending shares in (Nielsen) retail for top and bottom income quintiles are:

$$\alpha^{Q1} = 18\% \qquad \alpha^{Q5} = 12\%$$

- Under Cobb-Douglas upper nest, change in purchasing-power inequality per year over 2004-2015 given by:

$$\underbrace{\left(\Delta log(Y^{Q1}) - \Delta log(Y^{Q5})\right)}_{\textit{Income:}-\mathbf{0.93\ pp}} - \underbrace{\left(\alpha^{Q1}\Delta log(\mathbb{P}^{Q1}) - \alpha^{Q5}\Delta log(\mathbb{P}^{Q5})\right)}_{\textit{Retail Inflation: }\mathbf{0.22\ pp}}$$
$$- \underbrace{\left((1-\alpha^{Q1})\Delta log(\widetilde{\mathbb{P}}^{Q1}) - (1-\alpha^{Q5})\Delta log(\widetilde{\mathbb{P}}^{Q5})\right)}_{\textit{Inflation Outside Retail}>0}$$

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Descriptive Evidence

- Product modules that grow faster characterized by:
  - Faster increase in product variety Graph
  - Increasing competition between manufacturers Graph
  - Lower inflation on continued products Graph
  - More spending from high-income households Graph
- Is this causal?

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    1. **Effect of demand on supply**
    2. Do changes in the income distribution imply large inflation inequality?
    3. Simple model

Effect of Demand on Supply

- Growth of demand in a given part of product space over time depends on:
  - Initial spending shares of household groups
  - Changes in number of households in each group
  - Changes in per-capita spending of households groups
- Bartik-style research design [Bartik 1991; Blanchard and Katz 1992; Acemoglu and Linn 2004; Dellavigna and Pollet 2007; Goldsmith-Pinkham, Sorkin and Swift 2016]:
  - Use component of demand growth coming from change in number of households, keeping spending share as in initial period
  - Measure supply response using two outcomes: spending on new products and price changes for continued products
- Implement using 108 age-income groups (9 income groups and 12 age groups) and product-module-by-price-decile cells across product space
  - Changes in age-by-income distribution measured in Current Population Survey between 2000-2004 and 2011-2015
  - Conduct analysis at national level

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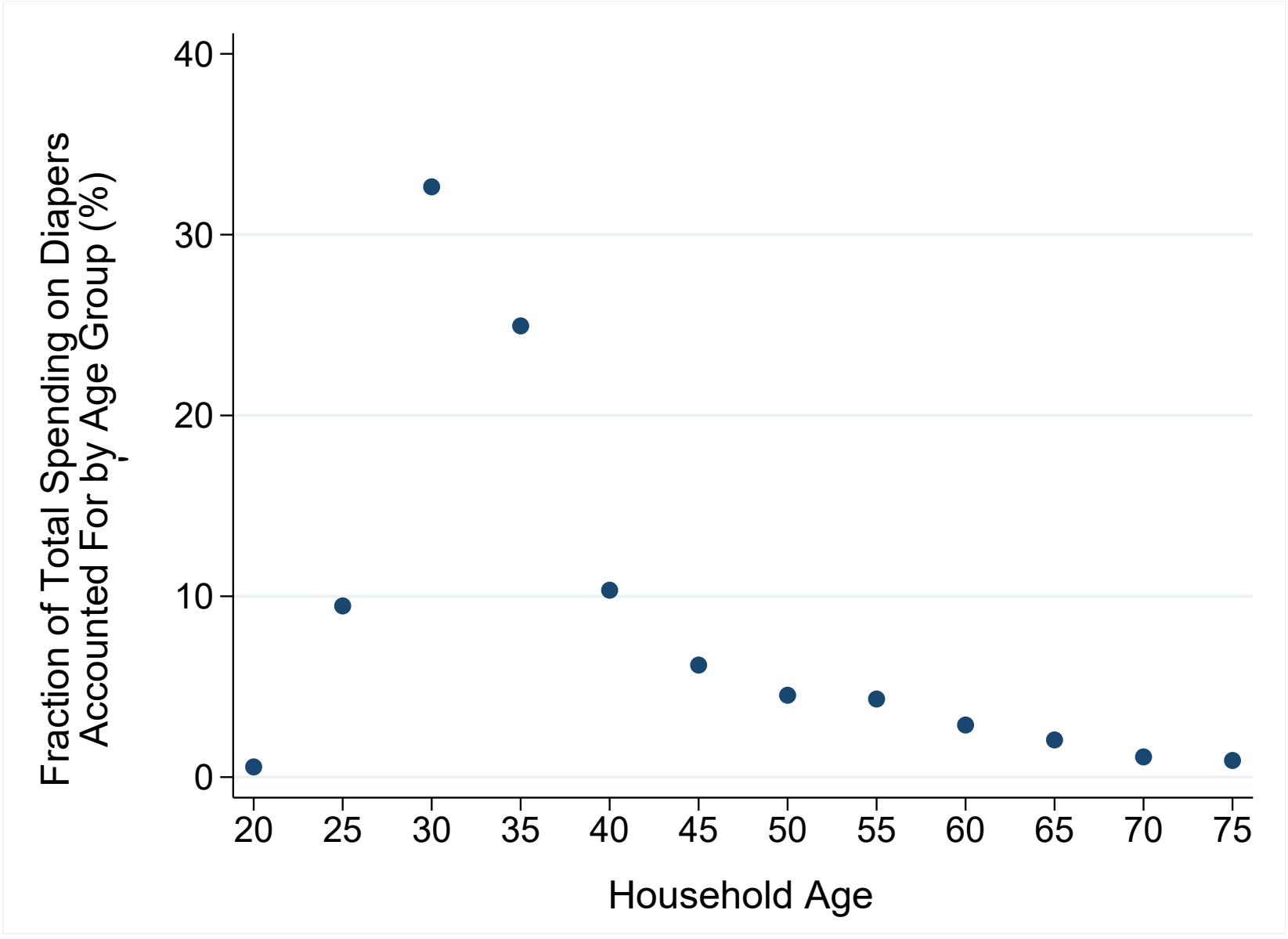
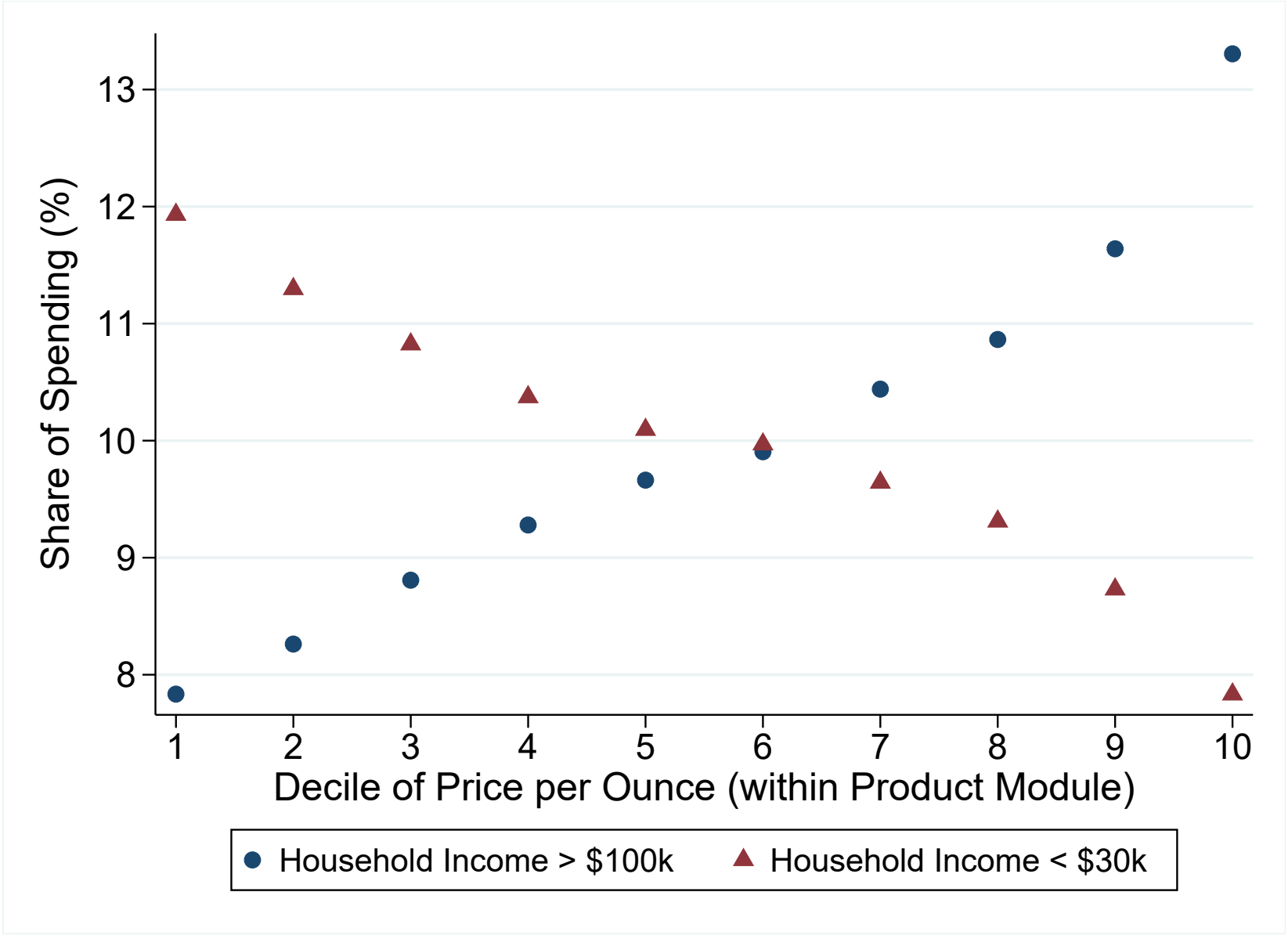
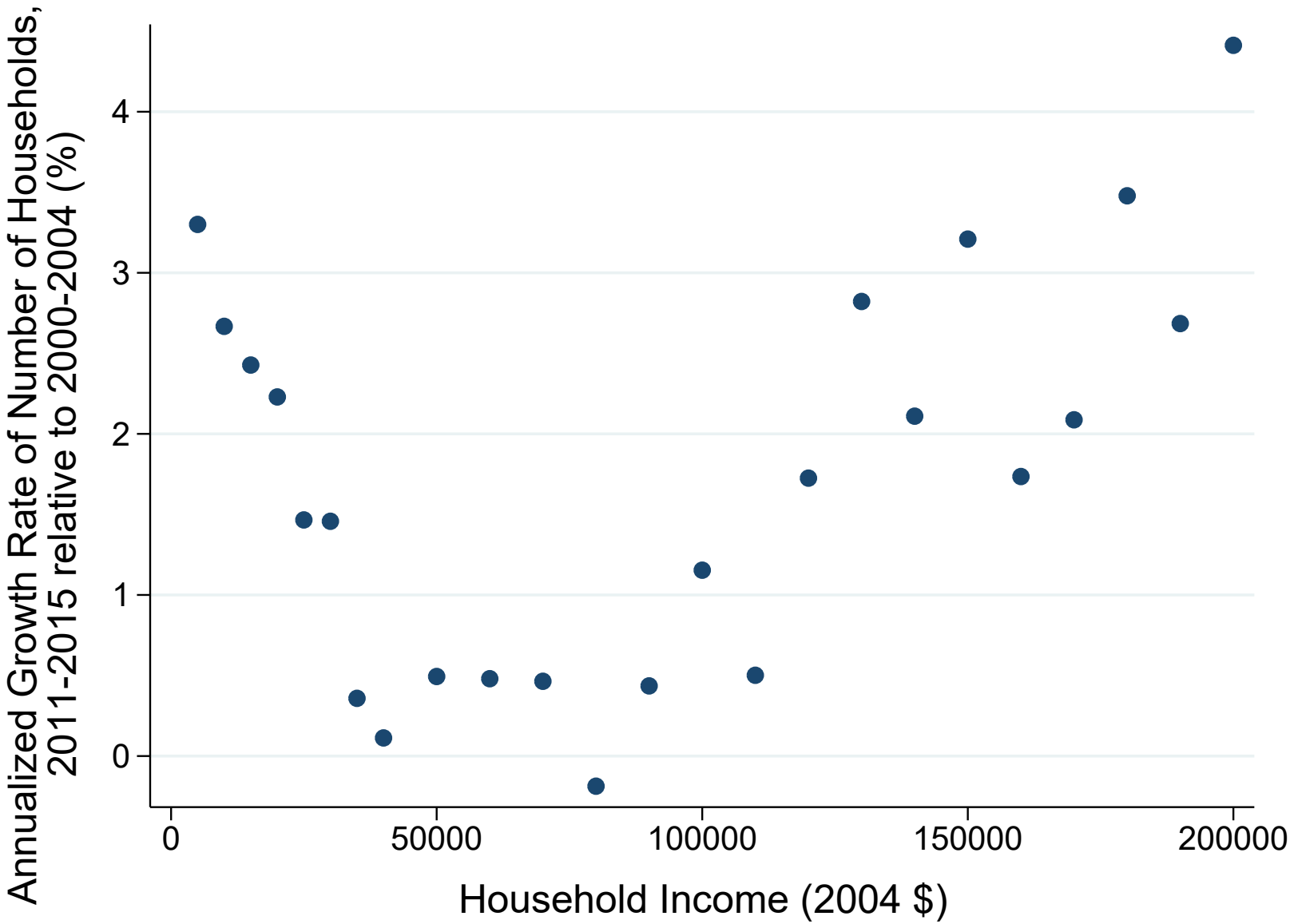
Spending on Baby Diapers by Age Groups



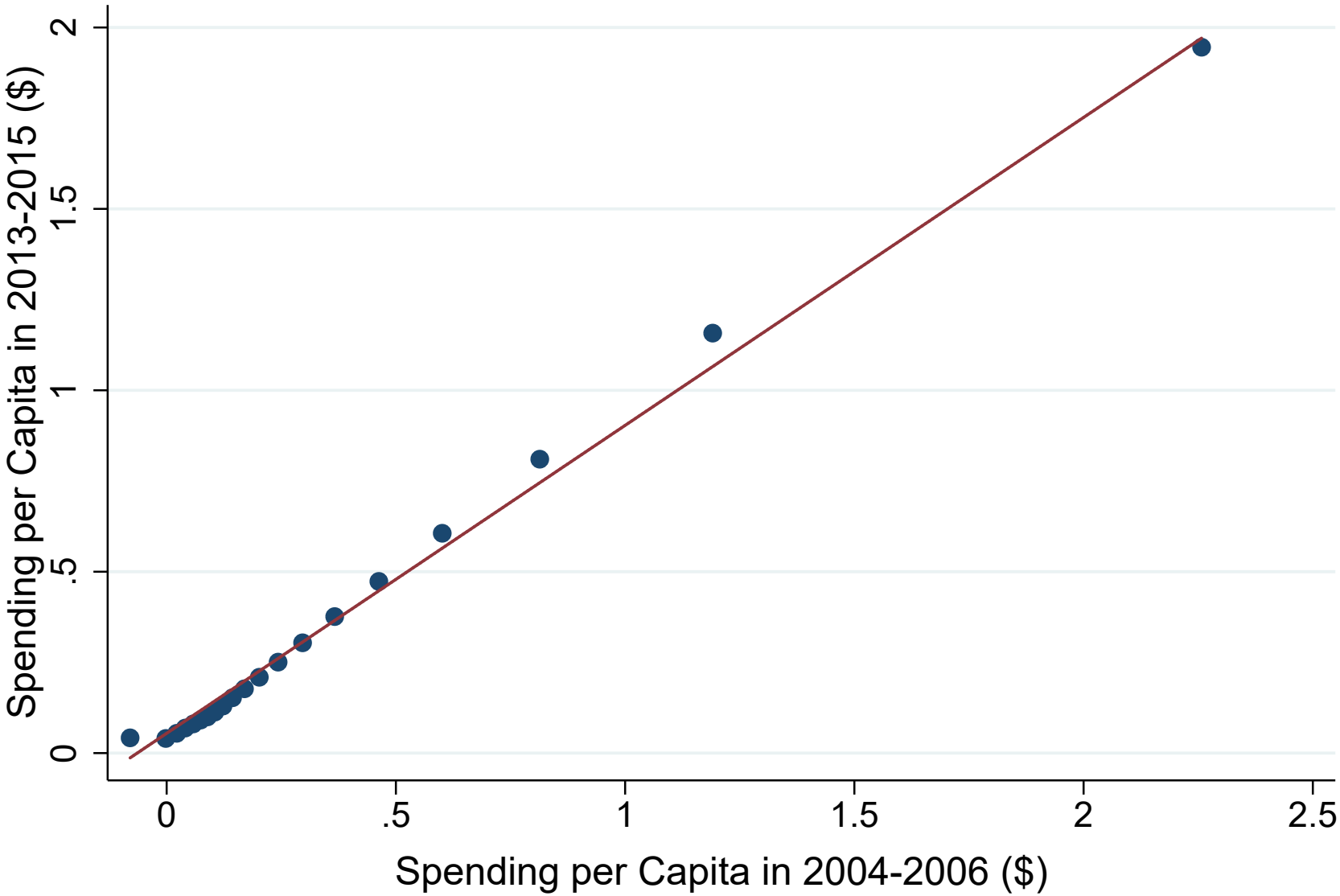
Spending Across Quality Ladder by Income Groups



Changes in Income Distribution for 30-Year-Olds (CPS Data)



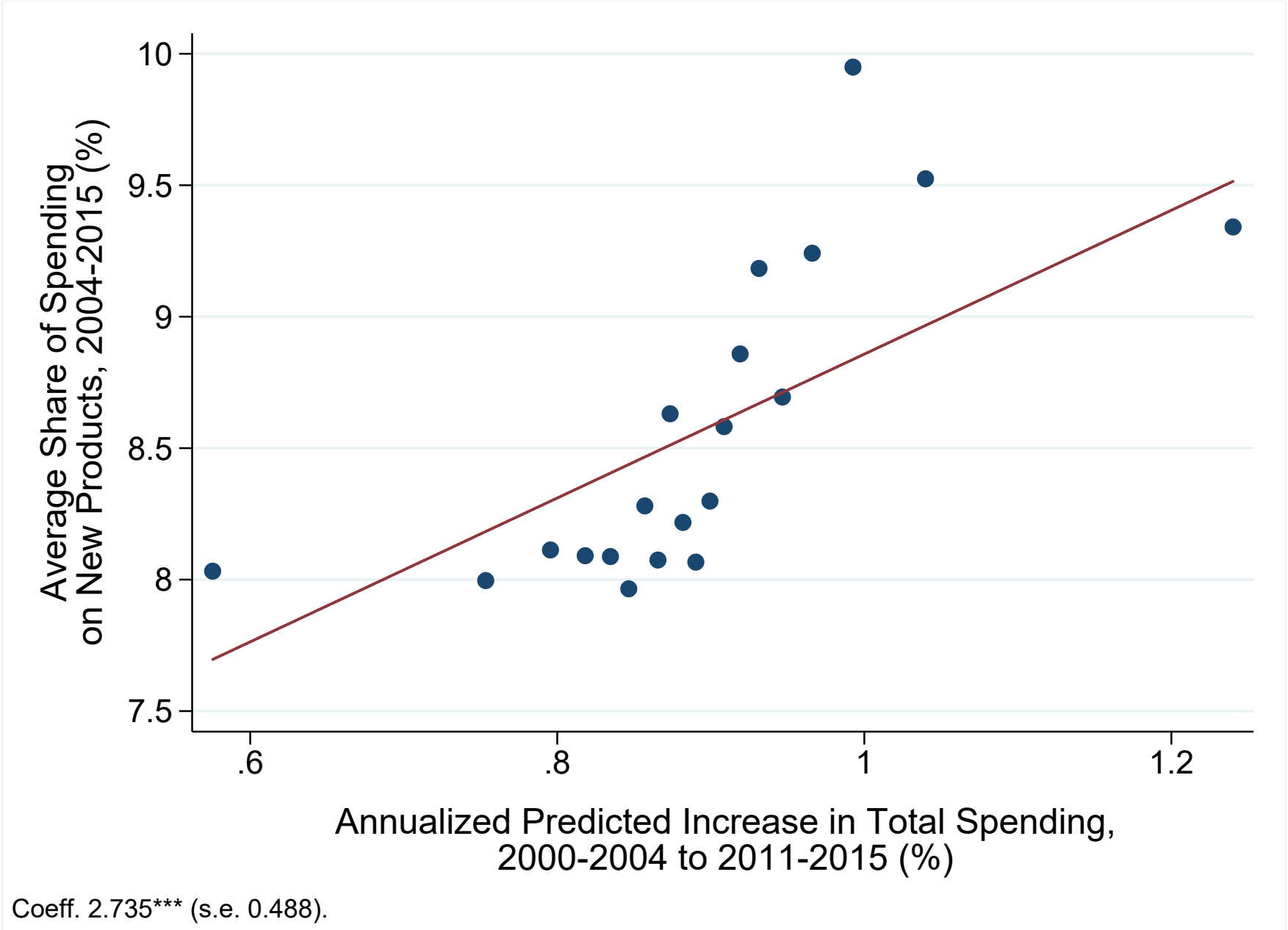
Relevance of Demand Growth Predictor



Coeff. 0.9114*** (s.e. 0.0301).
Observation is household age-income group by product module by price decile.

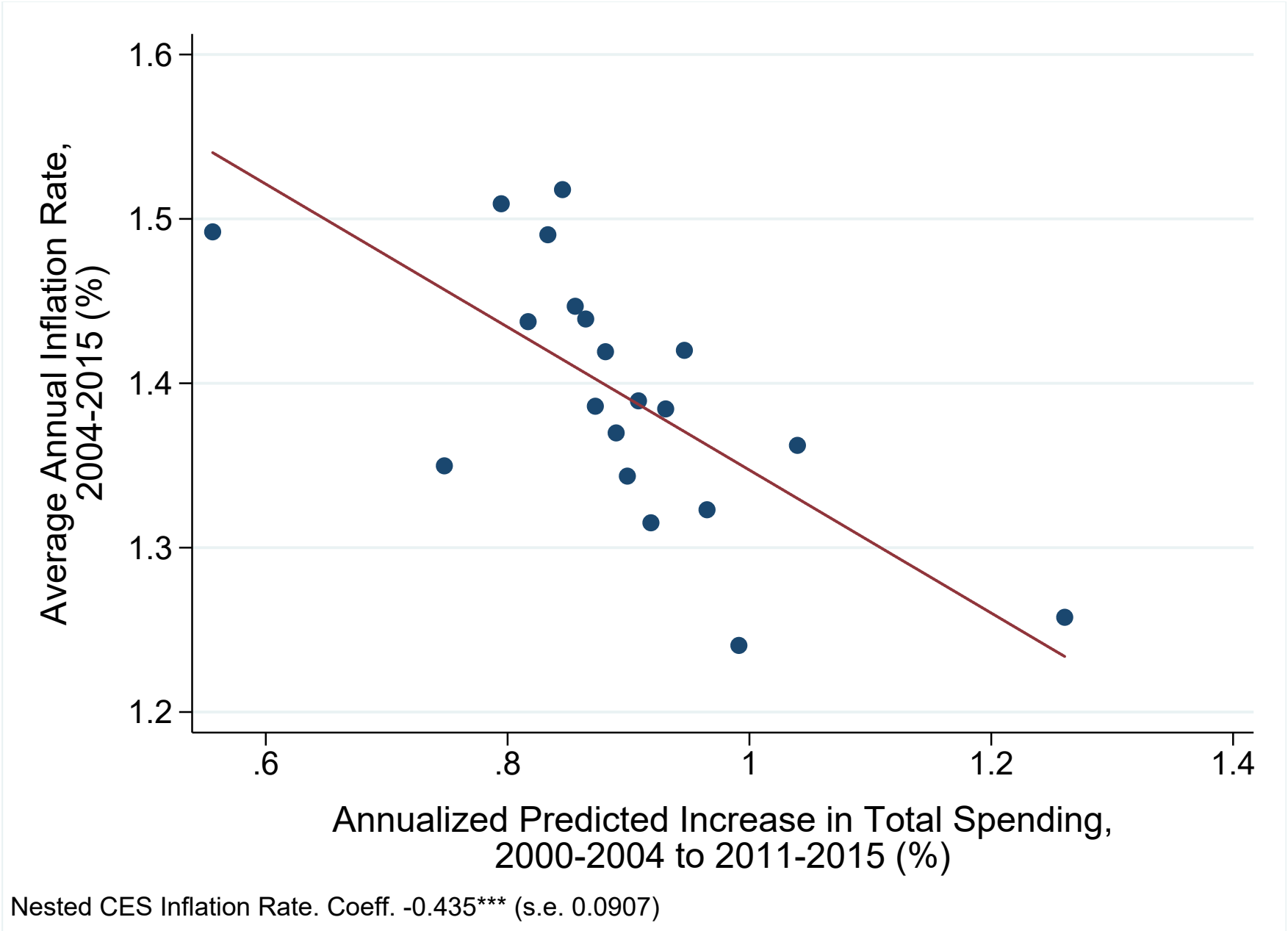
Results

Effect of Demand on New Products



Coeff. 2.735*** (s.e. 0.488).

Effect of Demand on Inflation for Continued Products



Nested CES Inflation Rate. Coeff. -0.435*** (s.e. 0.0907)

Effect of Demand on Supply: Main Results

	Share of Spending on New Products (pp)	**Continued Products Inflation Rate (pp)**
Predicted Increase in Spending, Annualized (%)	**2.7358*** **	**-0.4349*** **
	(0.4887)	**(0.1195)**
Age and Income Controls	Yes	Yes
Product Module Fixed Effects	Yes	Yes
R^2	0.54	0.52
Number of Observations	10,750	10,750
Number of Clusters	1,075	1,075

Standard errors clustered by product modules

Interpreting Magnitudes More Graphs Robustness

Roadmap

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    1. Effect of demand on supply
    2. **Do changes in the income distribution imply large inflation inequality?**
    3. Simple model

Supply Response to Shifts in Income Distribution

- Use two ingredients to build inflation inequality implied by shifts in income distribution:
  - Historical changes in the income distribution to get changes in demand:

$$d_I = \sum_n s_{nI} \cdot g_n$$

    where n denote 18 household income groups, with average growth rate g_n in 1996-2006 from CPS data Graph
  - Point estimates to get new products and price changes on continued products implied by change in demand:

$$\textit{New Products}_I^{\textit{Implied}} = 2.73 \cdot d_I$$

$$\Pi_I^{\textit{Implied}} = -0.43 \cdot d_I$$

- Compare implied vs. actual relationships between new products/price changes and mean consumer income ($I_I \equiv \sum_n s_{nI} I_n$) across product space
  - Result: implied relationships account for > 80% of actual relationships

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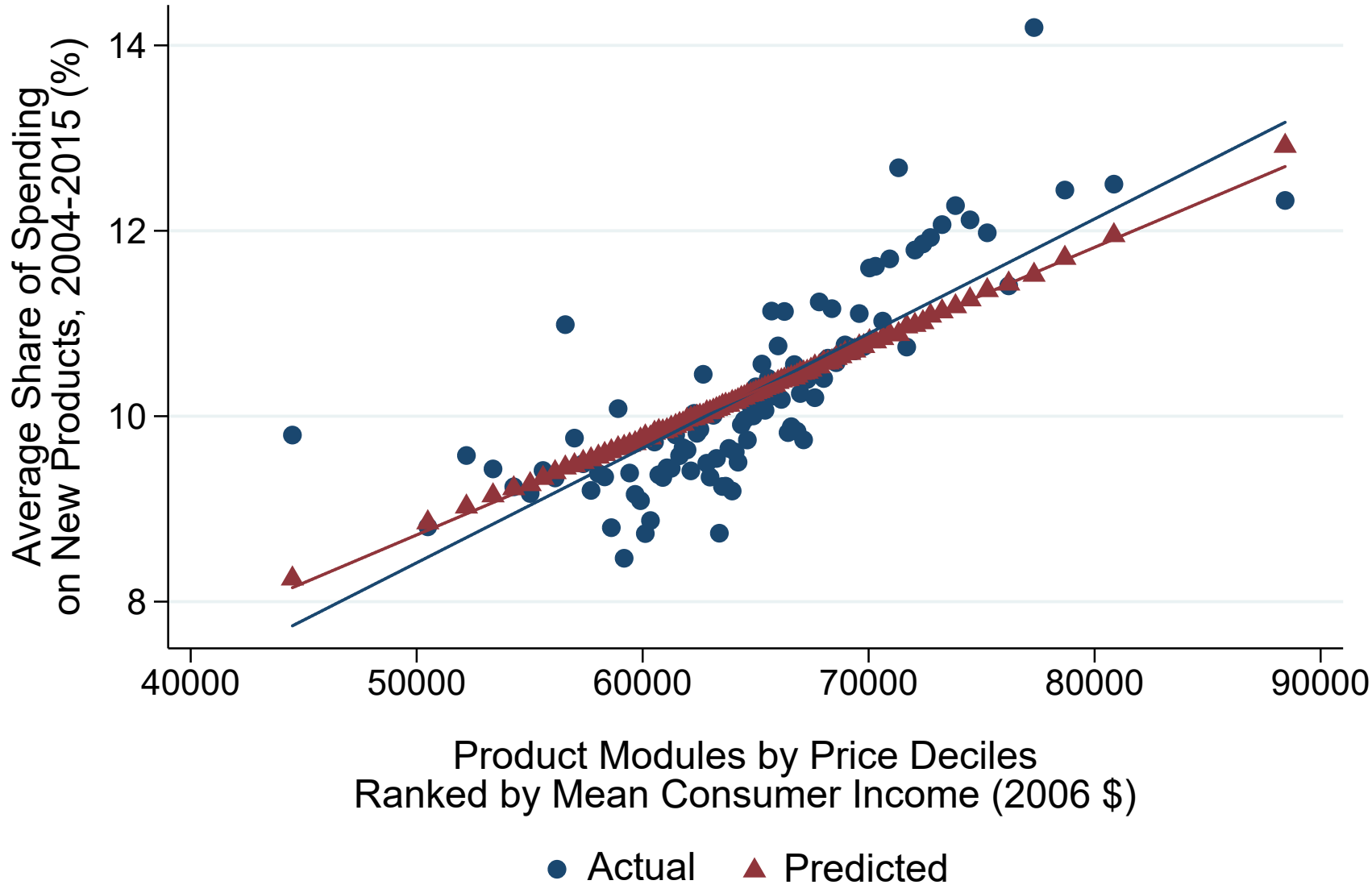
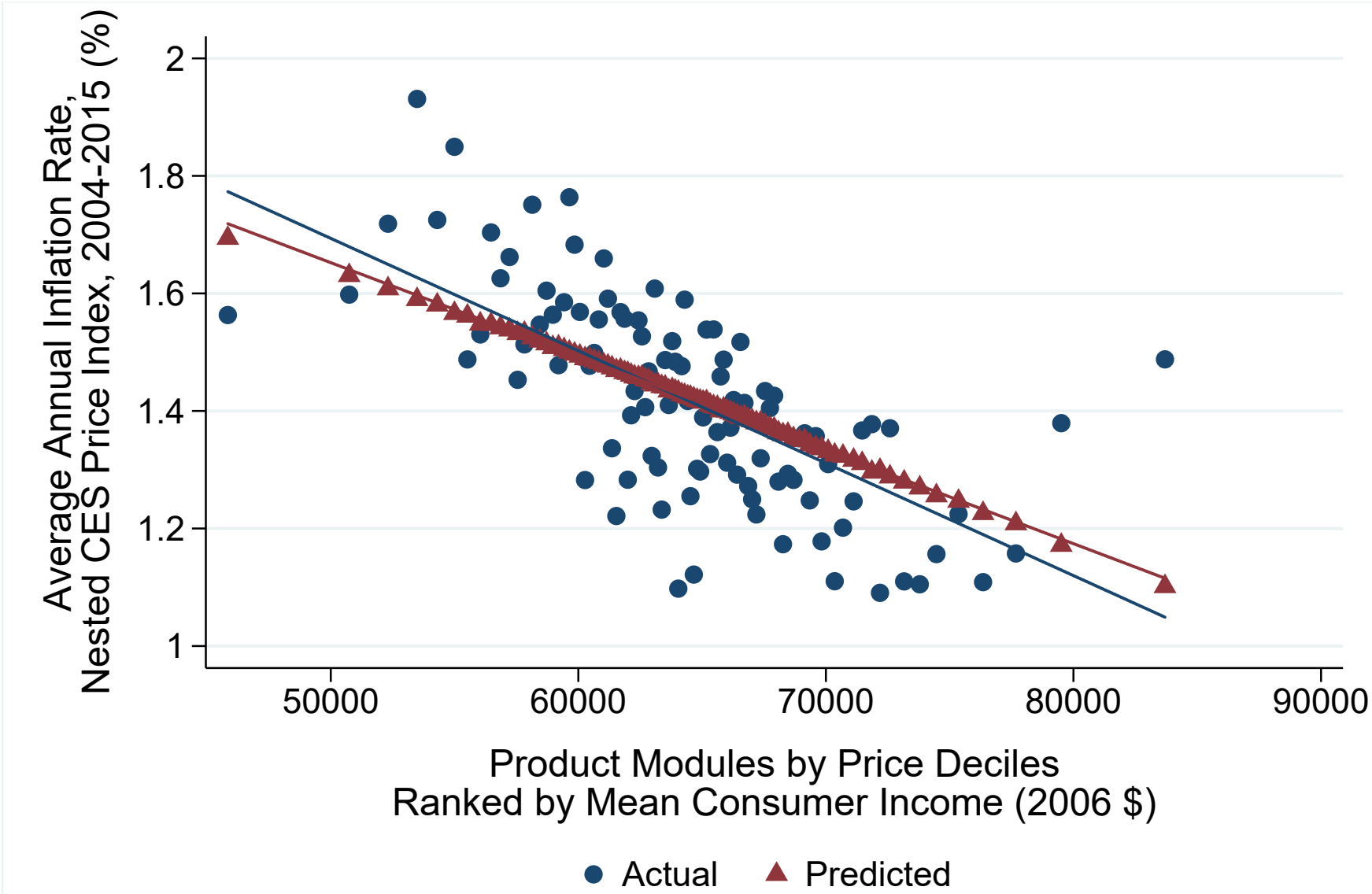
New Products From Shifts in Income Distribution



OLS fit with actual outcome: Coeff. 1.2364*** (s.e. 0.1235).
OLS fit with predicted outcome: Coeff. 1.0340*** (s.e. 0.00846).

Inflation Inequality From Shifts in Income Distribution



OLS fit with actual outcome: Coeff. -0.1912*** (s.e. 0.02886).
OLS fit with predicted outcome: Coeff. -0.15938*** (s.e. 0.000682).

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    3. **Simple model**

Overview of Model

- GE model with free entry across sectors indexed by k and L_{it} consumers of type i, with productivity Y_i, in closed economy

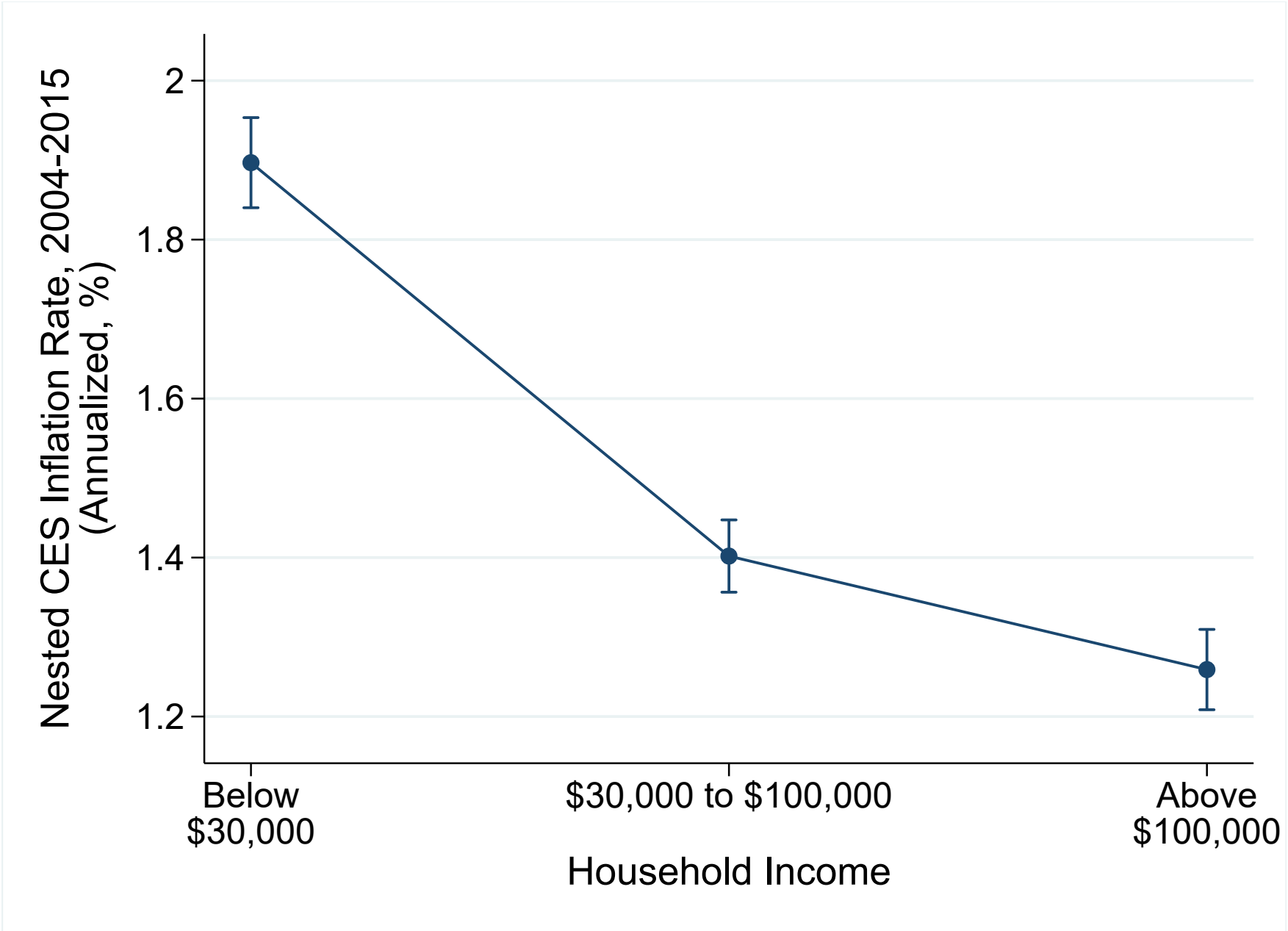
  Consumers' Problem | Firms' Problem | Closed-Form Solutions | Interpreting Magnitudes

- Key ingredients: non-homothetic preferences and downward-sloping long-term supply curve [Bresnahan and Reiss 1991; Acemoglu 1996, 2002, 2007; Feenstra and Weinstein 2016; Comin, Lashkari, Mestieri 2016]

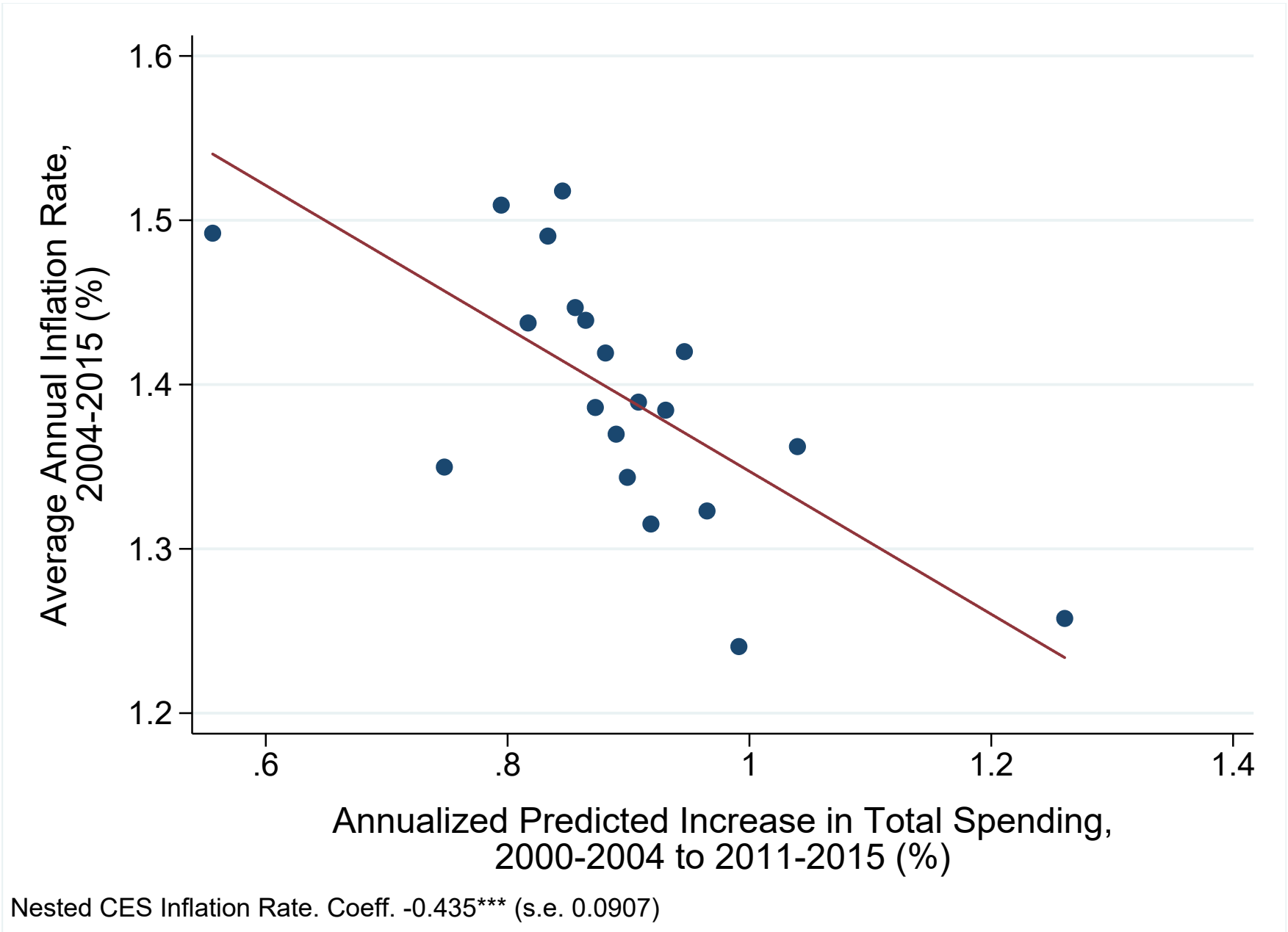
- Key prediction: given secular changes in the US income distribution, inflation inequality should be a long-term trend

Conclusion

Lower Inflation for Higher-Income Households in Retail...

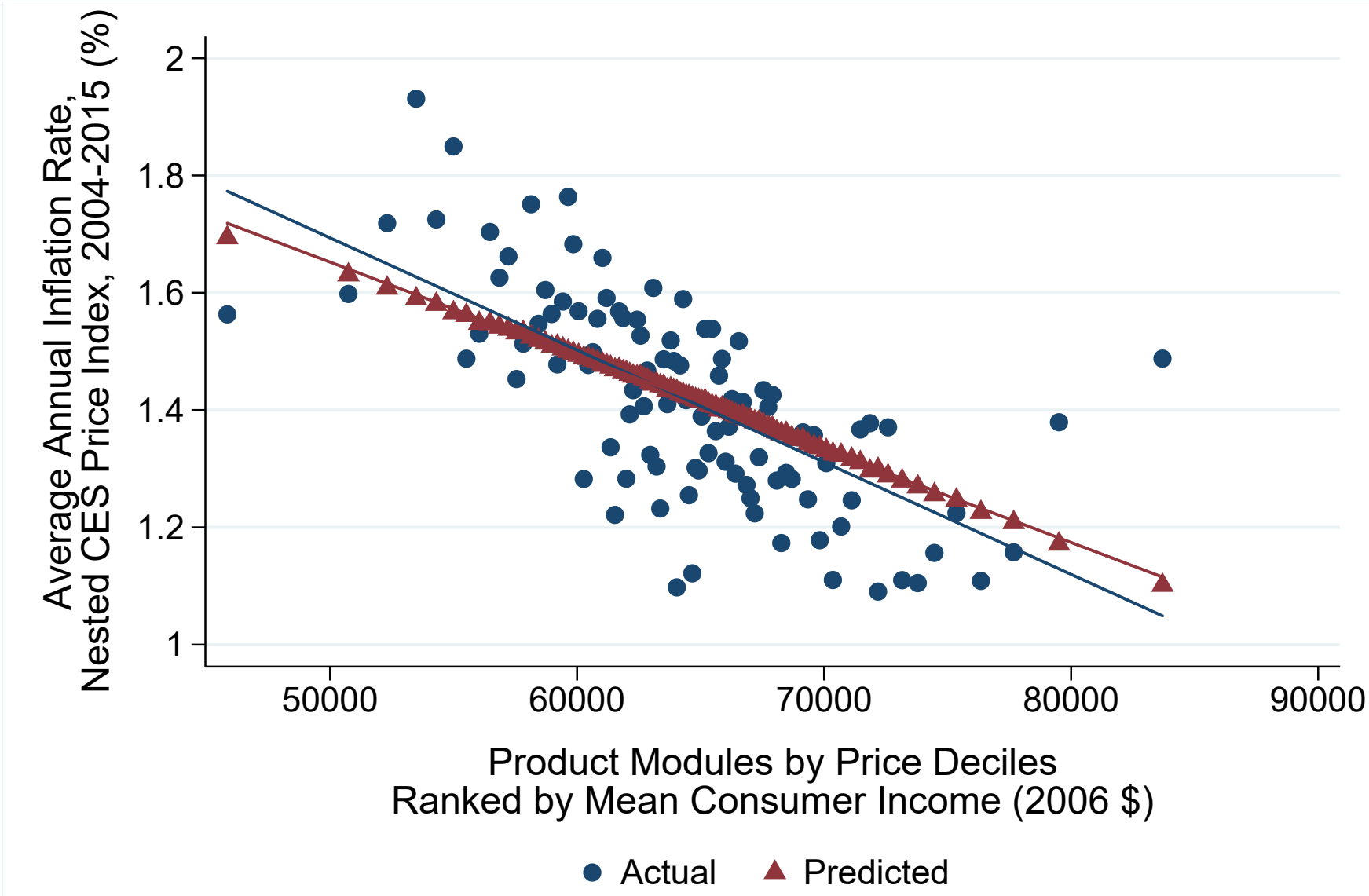


... because Supply Responds to Shifting Demand ...



Nested CES Inflation Rate. Coeff. -0.435*** (s.e. 0.0907)

... due to Changes in the Income Distribution.



OLS fit with actual outcome: Coeff. -0.1912*** (s.e. 0.02886).
OLS fit with predicted outcome: Coeff. -0.15938*** (s.e. 0.000682).

Thanks!