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

Xavier Jaravel, London School of Economics

September 21, 2017
Introduction

- Who benefits from innovation?
  - **Income channel**: extensive literature on skill-biased technical change
  - **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 $\Rightarrow$ Increased demand for premium products
    - $\Rightarrow$ Shift in direction of product innovations
    - $\Rightarrow$ 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
Introduction

Who benefits from innovation?

- *Income channel:* extensive literature on skill-biased technical change

- *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 ⟹ Increased demand for premium products
  ⟹ Shift in direction of product innovations
  ⟹ 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
Introduction

Who benefits from innovation?

- **Income channel**: extensive literature on skill-biased technical change
- **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 \(\Rightarrow\) Increased demand for premium products  
  \(\Rightarrow\) Shift in direction of product innovations  
  \(\Rightarrow\) 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
Motivating Example: Cost of Detergent (per 100 Loads)

**BEFORE**

- **$10**
  - All Liquid
  - UPC 9 53228 02121 9

**AFTER**

- **$5**
  - All Powder
  - UPC 7 74205 55160 4

**HIGHER PRICE**

- All Liquid
  - UPC 9 53228 02121 9

**LOWER PRICE**

- All Powder
  - UPC 7 74205 55160 4
## Motivating Example: Cost of Detergent (per 100 Loads)

<table>
<thead>
<tr>
<th>BEFORE</th>
<th>AFTER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$10</strong></td>
<td><strong>$21</strong></td>
</tr>
</tbody>
</table>
| ![All Liquid](image1)  
All Liquid  
UPC 9 53228 02121 9 | ![Tide Pods](image2)  
Tide Pods  
UPC 8 2218 00201 5 |
| **$5** | **$8** |
| ![All Powder](image3)  
All Powder  
UPC 7 74205 55160 4 | ![All Powder](image4)  
All Powder  
UPC 7 74205 55160 4 |

- **Higher Price**
  - All Liquid
  - Tide Pods
- **Lower Price**
  - All Powder
Motivating Example: Cost of Detergent (per 100 Loads)

**BEFORE**

- **All Liquid**
  - UPC: 9 53228 02121 9
  - Price: $10

- **All Powder**
  - UPC: 7 74205 55160 4
  - Price: $5

**AFTER**

- **Tide Pods**
  - UPC: 8 2218 00201 5
  - Price: $21

- **All Liquid**
  - UPC: 9 53228 02121 9
  - Price: $8

- **All Powder**
  - UPC: 7 74205 55160 4
  - Price: $5

**Increased demand**

1. Higher price
2. Lower price
Motivating Example: Cost of Detergent (per 100 Loads)

BEFORE

$10
All Liquid
UPC 9 53228 02121 9

LOWER PRICE

$5
All Powder
UPC 7 74205 55160 4

AFTER

$21
Tide Pods
UPC 8 2218 00201 5

$8
All Liquid
UPC 9 53228 02121 9

HIGHER PRICE

$5
All Powder
UPC 7 74205 55160 4

Increased demand

1

Increased entry

2
Motivating Example: Cost of Detergent (per 100 Loads)

**BEFORE**
- **$10**
  - All Liquid
  - UPC 9 53228 02121 9

**AFTER**
1. **$21**
   - Tide Pods
   - UPC 8 2218 00201 5
2. **$8**
   - All Liquid
   - UPC 9 53228 02121 9

**HIGHER PRICE**

**LOWER PRICE**
- **$5**
  - All Powder
  - UPC 7 74205 55160 4
- **$5**
  - All Powder
  - UPC 7 74205 55160 4

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**
  - 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**
  - 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
Related Literatures

- Literature on innovation and inequality
  - 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
  - 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
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.
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.
In retail, inflation was much lower for higher-income households...

...because supply responds to changes in demand...

...induced by shifts in the income distribution.
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


- 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**
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):

  \[ P^L \equiv \sum_{u=1}^{n} \frac{p^t_u}{p^0_u} s^0_u \]

  \[ P^{CES} \equiv \prod_c \left( \frac{p^t_u}{p^0_u} \right)^{w_{ut}} \]

  with \( p^t_u \) price, \( s^t_u \) 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

![Graph showing Nested CES Inflation Rate, 2004-2015 (Annualized, %) across different household income levels. The graph shows a downward trend as income increases from Below $30,000 to Above $100,000. With more income groups, across departments, across years, and by age-income groups. Additional checks available.]
No Differential Substitution Effects

Difference Between Annualized Average Inflation Rates (pp) for Households with Income Below $30k and Households with Income Above $100k

- CES Ideal for UPC-Store
- Paasche
- Geometric Paasche
- Tornqvist
- Geometric Laspeyres
- Walsh
- CES Ideal
- Fisher
- Marshall-Edgeworth
- Laspeyres
- CES Ideal for UPC-Local Market
Roadmap

1. Data

2. Inflation across Income Groups
   1. Price changes for continued products
   2. Valuing new and exiting products
   3. Aggregation bias
   4. Evidence outside retail

3. The Response of Supply to Market Size Effects
Inflation Difference between High- and Low-Income Households, 2004-2013 (Annualized, pp)

- Nested CES, Estimated Elasticities (Median of 6.5)
- Nested CES, Elasticity=2.09 from Handbury (2013)
- Nested CES, Elasticity=4 from Dube et al (2005)
- Nested CES, Elasticity=7 from Montgomery and Rossi (1999)
- Nested CES, Elasticity=11.5 from Broda and Weinstein (2010)
- Nested CES-Translog, Estimated Semi-Elasticities (Median of 1.06)
Roadmap

1. Data

2. Measuring Inflation across Income Groups
   1. Price changes on continued products
   2. Valuing new and exiting products
   3. Aggregation bias
   4. Evidence outside retail

3. The Response of Supply to Market Size Effects
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]

$$\pi^H - \pi^L \approx \left( \sum_C (s^H_C - s^L_C) \pi_C \right) + \sum_C \overline{s}_C (\pi^H_C - \pi^L_C)$$

with $s^i_C$ share of spending of income group $i$ on $C$, $\pi^i_C$ the inflation experienced by income group $i$ on $C$, $\pi_C$ 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:

<table>
<thead>
<tr>
<th>Aggregation Level (Broad to Narrow)</th>
<th>Share of Inflation Difference Explained (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>8.6</td>
</tr>
<tr>
<td>(e.g. fresh produce vs. health and beauty care)</td>
<td></td>
</tr>
<tr>
<td>Product Group</td>
<td>21.4</td>
</tr>
<tr>
<td>(e.g. deodorant vs. hair care)</td>
<td></td>
</tr>
<tr>
<td>Product Module</td>
<td>42.8</td>
</tr>
<tr>
<td>(e.g. men’s vs. women’s hair coloring)</td>
<td></td>
</tr>
</tbody>
</table>

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)
Aggregation Bias

- “Between” decomposition:

<table>
<thead>
<tr>
<th>Aggregation Level (Broad to Narrow)</th>
<th>Share of Inflation Difference Explained (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>8.6</td>
</tr>
<tr>
<td>(e.g. fresh produce vs. health and beauty care)</td>
<td></td>
</tr>
<tr>
<td>Product Group</td>
<td>21.4</td>
</tr>
<tr>
<td>(e.g. deodorant vs. hair care)</td>
<td></td>
</tr>
<tr>
<td>Product Module</td>
<td>42.8</td>
</tr>
<tr>
<td>(e.g. men’s vs. women’s hair coloring)</td>
<td></td>
</tr>
</tbody>
</table>

- 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)
Roadmap

1 Data

2 Measuring Inflation across Income Groups
   1 Price changes on continued products
   2 Valuing new and exiting products
   3 Aggregation bias
   4 Evidence outside retail

3 The Response of Supply to Market Size Effects
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
Relative price index is normalized to 1 in 1953. Laspeyres inflation rates are computed using 1980-1985 expenditure shares.
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:

  \[ \alpha^{Q1} = 18\% \quad \alpha^{Q5} = 12\% \]

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

  \[
  \left( \Delta \log(Y^{Q1}) - \Delta \log(Y^{Q5}) \right) - \left( \alpha^{Q1} \Delta \log(P^{Q1}) - \alpha^{Q5} \Delta \log(P^{Q5}) \right) \\
  \text{Income: } -0.93 \text{ pp} \\
  \left( (1 - \alpha^{Q1}) \Delta \log(\tilde{P}^{Q1}) - (1 - \alpha^{Q5}) \Delta \log(\tilde{P}^{Q5}) \right) \\
  \text{Inflation Outside Retail} > 0 \\
  \text{Retail Inflation: } 0.22 \text{ pp}
  \]

  Income:
  -0.93 pp

  Retail Inflation:
  0.22 pp

  Inflation Outside Retail:
  > 0
Roadmap

1. Data

2. Inflation across Income Groups

3. The Response of Supply to Market Size Effects
Descriptive Evidence

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

- Is this causal?
Roadmap

1. Data

2. Measuring Inflation across Income Groups

3. The Response of Supply to Market Size Effects
   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
  - Conduct analysis at national level
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
  - Conduct analysis at national level
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
  - Conduct analysis at national level
Spending on Baby Diapers by Age Groups

![Graph showing the fraction of total spending on diapers accounted for by age group (%)]
Spending Across Quality Ladder by Income Groups

![Graph showing spending across quality ladder by income groups. The x-axis represents deciles of price per ounce within the product module, and the y-axis represents the share of spending (%). Two groups are shown: Household Income > $100k (represented by blue dots) and Household Income < $30k (represented by red triangles). The graph illustrates that as the price per ounce increases, the share of spending decreases for both income groups, with a more pronounced decrease for the lower-income group.]
Changes in Income Distribution for 30-Year-Olds (CPS Data)

- **Annualized Growth Rate of Number of Households, 2011-2015 relative to 2000-2004 (%)**

- **Household Income (2004 $)**

The graph shows the relationship between household income in 2004 dollars and the annualized growth rate of the number of households from 2011-2015 compared to 2000-2004. The x-axis represents household income in 2004 dollars, while the y-axis represents the annualized growth rate.
Relevance of Demand Growth Predictor

![Graph showing the relationship between Spending per Capita in 2013-2015 ($) and Spending per Capita in 2004-2006 ($) with a regression line and dots representing data points. The coefficient is 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

Average Share of Spending on New Products, 2004-2015 (%)

Annualized Predicted Increase in Total Spending, 2000-2004 to 2011-2015 (%)

Coeff. 2.735*** (s.e. 0.488).
Effect of Demand on Inflation for Continued Products

![Graph showing the relationship between inflation and predicted increase in total spending. The graph includes a scatter plot with a regression line. The equation for the regression line is: Nested CES Inflation Rate. Coeff. -0.435*** (s.e. 0.0907).]
## Effect of Demand on Supply: Main Results

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

Standard errors clustered by product modules

[Interpreting Magnitudes] [More Graphs] [Robustness]
Roadmap

1. Data

2. Inflation across Income Groups

3. The Response of Supply to Market Size Effects
   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:
    \[ d_l = \sum_n s_{nl} \cdot g_n \]
    where \( n \) denote 18 household income groups, with average growth rate \( g_n \) in 1996-2006 from CPS data
  - Point estimates to get new products and price changes on continued products implied by change in demand:
    \[ \text{New Products}_l^{\text{Implied}} = 2.73 \cdot d_l \]
    \[ \Pi_l^{\text{Implied}} = -0.43 \cdot d_l \]

- Compare implied vs. actual relationships between new products/price changes and mean consumer income \( (l_l \equiv \sum_n s_{nl} l_n) \) across product space
  - Result: implied relationships account for > 80% of actual relationships
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:
    \[
    d_l = \sum_n s_{nl} \cdot g_n
    \]
    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:
    \[
    \text{New Products}^\text{Implied}_l = 2.73 \cdot d_l
    \]
    \[
    \Pi^\text{Implied}_l = -0.43 \cdot d_l
    \]

- Compare implied vs. actual relationships between new products/price changes and mean consumer income \((l_l \equiv \sum_n s_{nl} l_n)\) across product space
  - Result: implied relationships account for > 80% of actual relationships
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:
    \[ d_I = \sum_n s_{nl} \cdot g_n \]
    where \( n \) denote 18 household income groups, with average growth rate \( g_n \) in 1996-2006 from CPS data
  - Point estimates to get new products and price changes on continued products implied by change in demand:
    \[ \text{New Products}_{i}^{\text{Implied}} = 2.73 \cdot d_I \]
    \[ \Pi_{i}^{\text{Implied}} = -0.43 \cdot d_I \]

- Compare implied vs. actual relationships between new products/price changes and mean consumer income \( I_I \equiv \sum_n s_{nl} I_n \) across product space
  - Result: implied relationships account for > 80% of actual relationships
New Products From Shifts in Income Distribution

Average Share of Spending on New Products, 2004-2015 (%)

Product Modules by Price Deciles
Ranked by Mean Consumer Income (2006 $)

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

Average Annual Inflation Rate, Nested CES Price Index, 2004-2015 (%)

Product Modules by Price Deciles
Ranked by Mean Consumer Income (2006 $)

- Actual
- Predicted

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

1. Data

2. Inflation across Income Groups

3. The Response of Supply to Market Size Effects
   1. Effect of demand on supply
   2. Do changes in the income distribution imply large inflation inequality?
   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


- 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 ...

![Graph showing the relationship between average annual inflation rate and annualized predicted increase in total spending. The graph includes a linear regression line with the equation: Nested CES Inflation Rate. Coeff. -0.435*** (s.e. 0.0907).]
... due to Changes in the Income Distribution.

Average Annual Inflation Rate, Nested CES Price Index, 2004-2015 (%)

Product Modules by Price Deciles
Ranked by Mean Consumer Income (2006 $)

- 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!