



THE UNIVERSITY
OF BRITISH COLUMBIA

Eliminating the Penny in Canada: An Economic Analysis of Penny-rounding on Grocery Items

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Economics (B.A.) and Combined Mathematics and Statistics (B.Sc.)

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\$1.96



\$1.95

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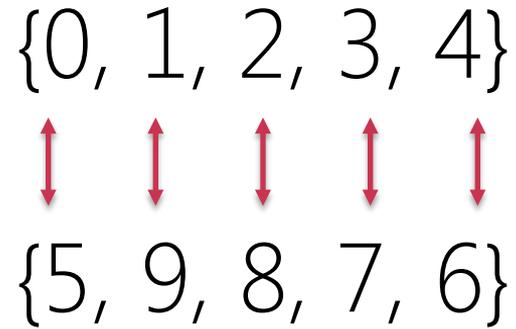
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For the last digit of prices:



If every digit has equal chance of appearing,
the net effect of penny-rounding is 0.



- 82.5% of goods in US convenience stores (Lombra 2001) and 60.8% of the grocery price data for this study end in "9".



Research Questions:

From real price distributions, does penny-rounding really have a net effect of zero?

If not, will rounding on groceries benefit the retailers or consumers?

ORIGINALITY & VALUE

- Few studies (only found three) in policy-decisions or economics have investigated the influence of eradication of penny on a micro-scale.
 - These studies used inapplicable assumptions.
 - Ex. Lombra (2001) did not take rounding down and sales taxes into account.
 - Ex. Chande (2003) used only Tim Horton's menu (123 price data) and applied 15% tax.

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 - Ex. Chande (2003) used only Tim Horton's menu (123 price data) and applied 15% tax.
- This study takes an innovative approach by using two new factors: 6 different tax rates and 1- to 10-item transactions.



Methodology:

- Stage 1. Hand-collection of grocery prices in three representative grocery stores (18,095 prices collected in total)
- Stage 2. Simulated baskets of different items on Python (10 in total) & applied 6 different taxes
- Stage 3. Constructed a distribution of final digits from each basket's total bill

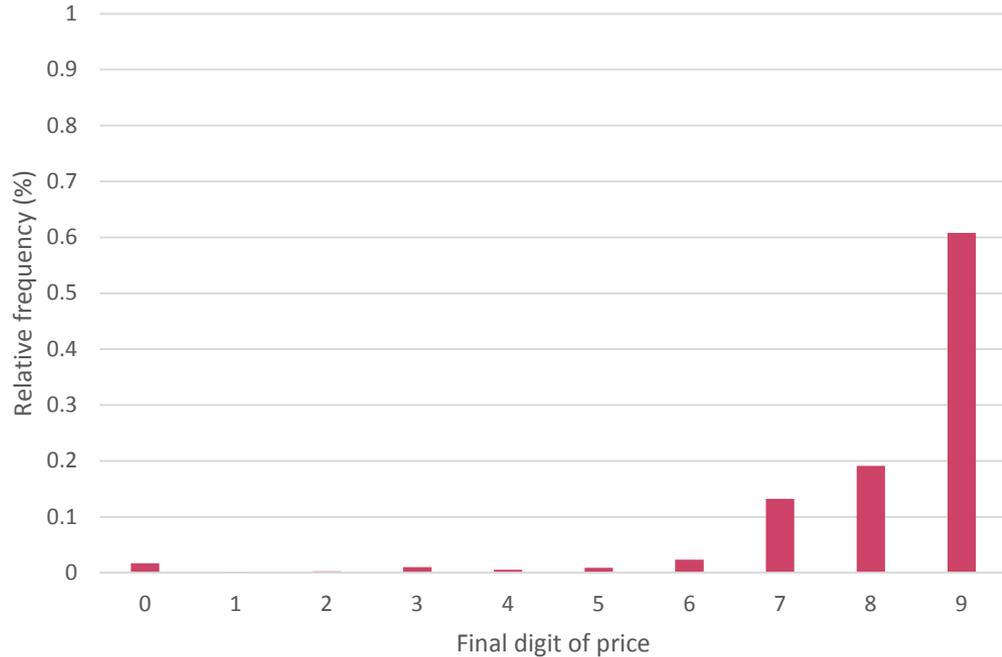
STAGE 1: PRICE COLLECTION

- At each grocery store,
 - 1. Take photos of item prices from each category
 - Excluded meat, vegetables, and fruits
 - 2. Record prices on Excel
 - 3. Categorize items as “tax-applicable” or “tax-exempt”



	A	B	C	D
1	Beverages	Bakery / Bread	Canned food	Dairy
2	0.5	0.32	0.69	0.99
3	0.69	0.65	0.79	1.09
4	0.79	0.69	0.89	1.19
5	0.89	0.79	0.98	1.39

DISTRIBUTION OF FINAL DIGIT FOR 18,095 PRICES



➤ Left-skewed distribution, with majority ending in '9'.

STAGES 2 & 3: COMPUTER SIMULATIONS ON PYTHON

- 1. For each of 1- to 10-item transactions, simulate 10,000 random baskets based on the Excel price list (sampling with replacements)
- 2. Apply 6 different provincial sales taxes to the items that need to be taxed (i.e. cleaners and personal items but not food items) in each transaction
- 3. Graph the distribution of the last digit for each combination after respective provincial tax
- 4. Round the total bill and calculate the net effects of rounding

Table I: Six Different Total Sales Tax Across Provinces

PROVINCES	TOTAL SALES TAX (%)
Alberta	5
Saskatchewan	10
British Columbia	12
Manitoba; Ontario	13
Québec	14.975
New Brunswick; Newfoundland & Labrador; Nova Scotia; Prince Edward Island	15

$$\chi^2 = \sum_{i=0}^9 \frac{(O_i - E_i)^2}{E_i}$$

O_i = number of observations of digit i

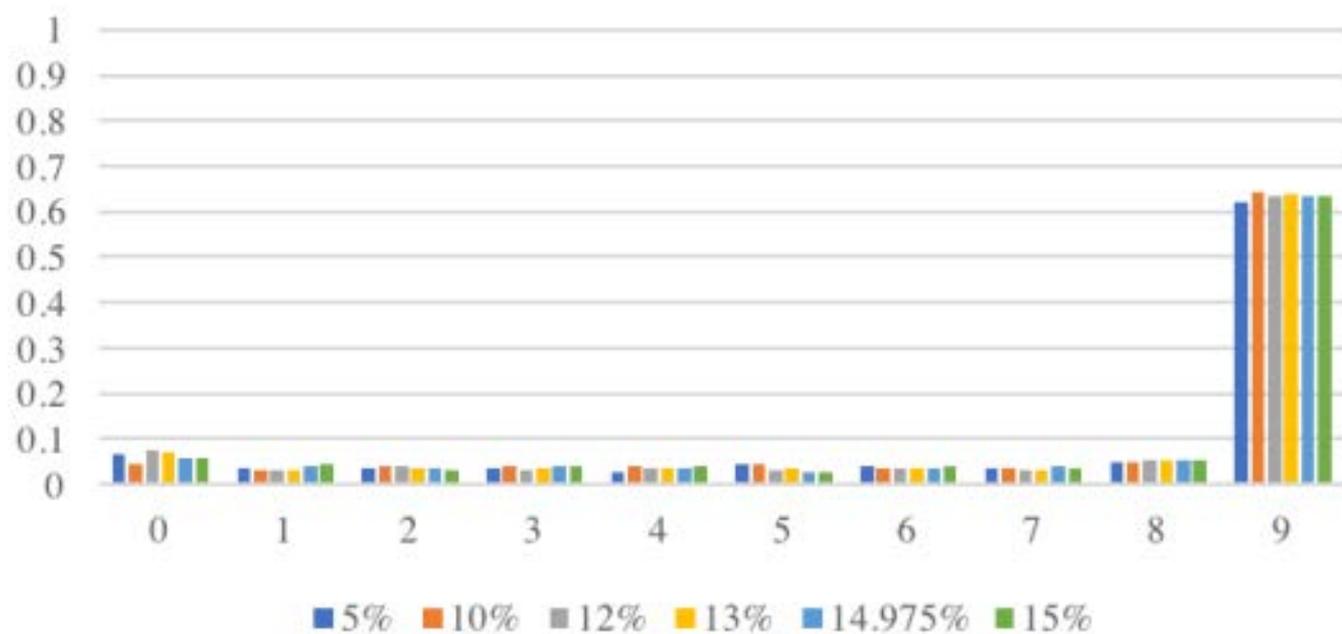
E_i = expected frequency of observing digit i

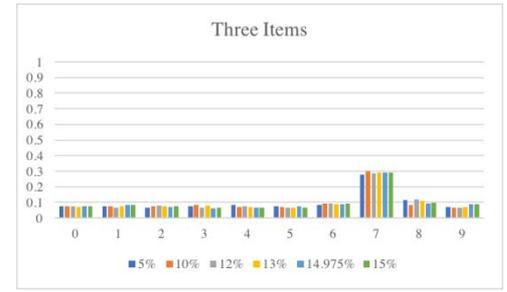
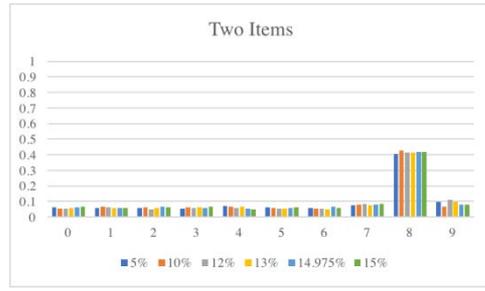
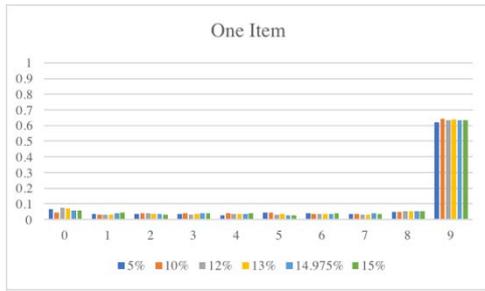


Results:

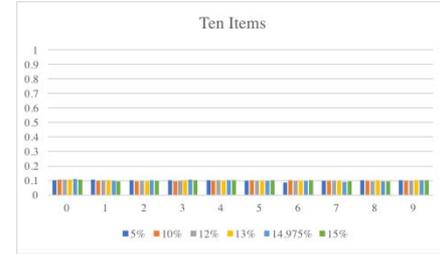
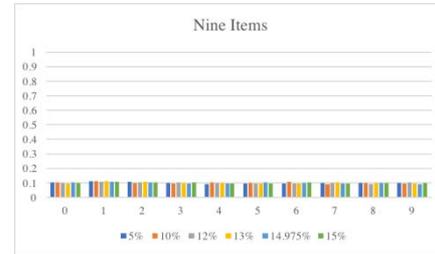
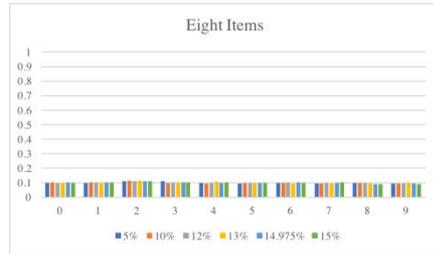
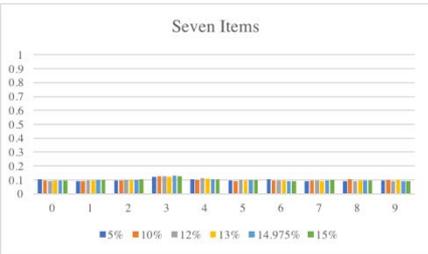
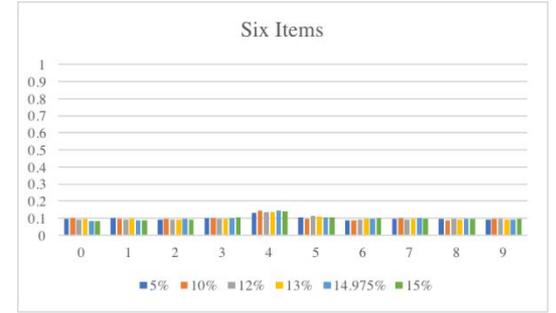
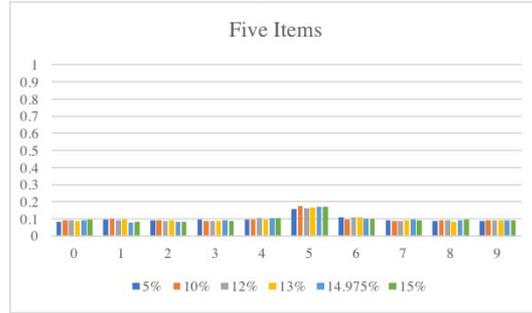
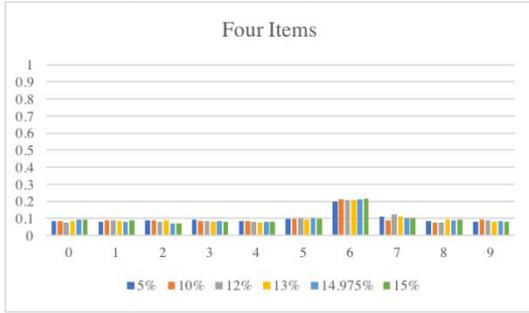
- Only 1-item and 2-items have non-zero rounding effect at 5% level.
- 3 to 10 items have no rounding effect.
 - From Pearson's chi-squared test, we find that the 3~10 items have uniform distributions— hence zero rounding effect.

One Item





By Pearson's chi-square test at 5% level, only these two are NOT statistically uniform distributed!



How does this affect consumers in Canada in terms of financial loss?

RESULT ANALYSIS

- Calculating the **annual aggregate net rounding effects**, or known as the net amount Canadian consumers pay to grocery stores on a yearly basis due to rounding.

Net rounding from consumers to grocers

= (% trans. in cash & under \$15) × (Total number of grocery trips by all Canadian households per year) × (Avg. probability of rounding up 1¢ for one- and two-items) × \$0.01

*= (39.2% × 64.3%) × (174 × 13.3 million) × 67.0% × \$0.01
= \$3.91 million*

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= (39.2% × 64.3%) × (174 × 13.3 million) × 67.0% × \$0.01 × 83.7%

= \$3.91 million × 83.7%

= \$3.27 million

What does **\$3.27 million** “rounding tax” imply for a typical grocery store in Canada?

A typical grocery store in Canada receives an estimated additional **\$157** (**$\$3.27 \text{ million} \div 20,771 \text{ grocery stores}$**) in revenue from rounding.

RESULT ANALYSIS

- Consistent with Lombra (2001), firms gain from penny-rounding at the expense of the consumers. But after taking sales taxes and rounding down into account, the conservative net gain is \$3.27 million and not \$318~\$818 million
- Contrary to previous study by Chande (2003), there is a non-zero effect of penny-rounding on one- and two- items.

1. IMPLICATIONS FOR BUSINESSES

➤ Strategic pricing:

- Case 1: Under the 5% sales tax in Alberta, a shampoo that sells for \$6.73 has an after-tax price of \$7.07, which is rounded down to \$7.05



- Two-cent loss to the store.

1. IMPLICATIONS FOR BUSINESSES

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- Case 1: Under the 5% sales tax in Alberta, a shampoo that sells for \$6.73 has an after-tax price of \$7.07, which is rounded down to \$7.05



- Two-cent loss to the store.

- Case 2: If the store prices the shampoo at \$6.74, then the after-tax is \$7.08, which is rounded up to \$7.10

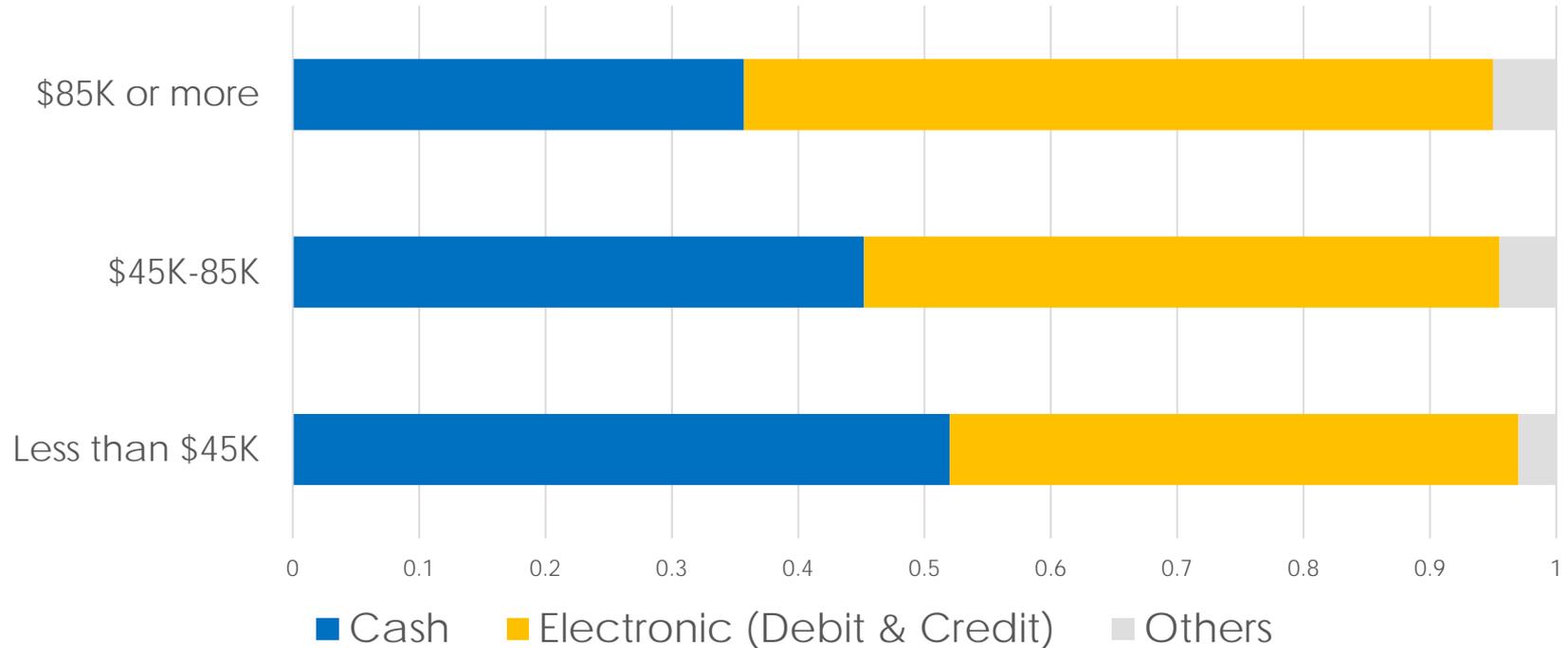


- Gains five cents compared to Case 1

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- A strategic pricing of +\$0.01 leads to a profit of +\$0.05 for firms
 - For a store that conducts 1000 transactions per day, this act of strategic pricing attracts an additional \$50.00 in revenue per day.

2. IMPLICATIONS FOR SOCIETY

Methods of Payment (Volume)



-
- One of the first comprehensive studies to estimate penny-rounding.
 - Furthermore, with a positive annual inflation rate for many countries, it is inevitable to eliminate the lowest denomination coins.
 - Even with penny rounding, however, this study shows that the seemingly trivial effect per transaction adds up to a nontrivial “rounding tax” on consumers in the aggregate.



Summary:

- Only 1- and 2-grocery items have a non-zero rounding effect.
- Rounding imposes a tax of \$3.27 million from Canadian consumers to grocery vendors.
- A typical grocery store in Canada receives an estimated additional \$157 (*\$3.27 million ÷ 20,771 grocery stores*) in revenue from rounding.



Acknowledgements:

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FAQ

➤ **Q: So where did the pennies go?**

➤ A: The mint has been hoarding truckloads of them to American Iron and Metal Co. Inc, based in Montreal, has been awarded the contract to recycle them. The Finance Department of Canada estimates that melting down the metal from the pennies and reselling it in the industrial sector will bring in \$42.5 million in revenue.

➤ There are a large number of uses for zinc, steel and especially copper in today's global economy. Copper, being highly conductive and malleable, is used most commonly in building construction and electronic products. It's one of the most highly coveted metals in the world. ([PBS NewsHour](#)).

FAQ

➤ **Q: How much does penny removal save?**

- A: The 2012 budget announcement by the Government of Canada cited the cost of producing a penny to be 1.6 cents.
- A: The Canadian Royal Mint stated on their website that it saves Canadian taxpayers approximately \$11 million per year.

FAQ

- Q: Are businesses required to accept pennies after February 4, 2013?
- A: While businesses do not have a legal obligation to accept any particular Canadian coins or bank notes in a retail transaction, **the penny will continue to be legal tender like all other Canadian coins**, and businesses may accept the coin as a means of payment if they so choose. This is an individual business decision.

FAQ

➤ Q: Why did the government take out the penny?

➤ A: Inflation above face value and over-production: **A 2007 survey indicated that 37 percent of Canadians used pennies, but the government continued to produce about 816 million pennies per year, equal to 24 pennies per Canadian.** The Royal Canadian Mint had been forced to produce large numbers of pennies because they disappeared from circulation, as people hoarded these coins or simply avoided using them.

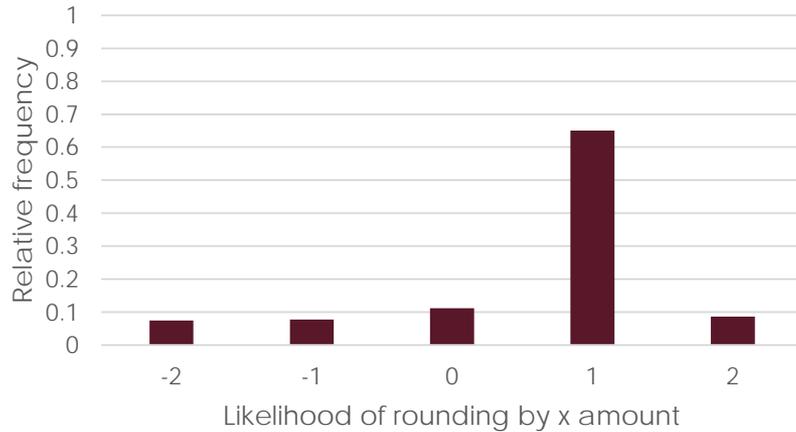
Probability of rounding up by 1 cent across all 6 tax rates:

- One-item: 59.7% - 65.1%
- Two-item: 67.1% - 73.7%
- Three- or more items: 0% (by Pearson's Chi Square)

FAQ

➤ Q: What's the distribution of rounding for one- and two- item transactions?

Distribution of Rounding for One-item



Distribution of Rounding for Two-item

