Estimating the Impact of a Pigouvian Tax on Denim Jeans in Canada

Suha Kazmi

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Abstract

This paper analyzes the Canadian market for denim jeans. Leveraging time-series data on imported denim fabric from the World Integrated Trade Solution (WITS), I construct annual estimates of jeans-equivalent prices and quantities. I simulate a 20% Pigouvian tax in 2023, calibrated to life-cycle carbon and water costs for jeans. Applying this price shock within a first-differenced log–log demand model, I estimate an own-price elasticity of –1.57, predicting a 24% short-run decline in demand relative to 2022. This mitigation policy scenario is projected to achieve environmental savings of 0.5 tonnes of CO_2-eq and 61 million litres of water—equivalent to the annual usage of 265 Canadian households.

1 Introduction

87% of Canadians own at least one pair of jeans,[1] solidifying their status as a ubiquitous wardrobe staple. Yet, despite each pair generating 33.4 kg CO_2-eq in emissions and consuming 3,781 litres of water,[2] retail prices fail to account for the substantial environmental externalities engendered by their production and consumption[3]—from cotton cultivation and textile finishing to regular laundering and final disposal.[4] This gap between private and social costs motivates the question: *how would a 20% Pigouvian tax on denim jeans in Canada affect their demand, emissions, and water use?*

[1] Ipsos, "Mark's Work Wearhouse and The Bottom Line: Canadians Love Their Jeans," 2002, https://www.ipsos.com/en-ca/marks-work-wearhouse-and-bottom-line-canadians-love-their-jeans.

[2] Levi Strauss & Co., *The Life Cycle of a Levi's 501 Jean – Lifecycle Assessment Upyear*, Levi Strauss & Co., 2015, https://www.levistrauss.com/wp-content/uploads/2015/03/Full-LCA-Results-Deck-FINAL.pdf.

[3] Impact Institute, *The True Price of Jeans*, technical report (Impact Institute, 2019), https://impactoud.one-sw.nl/wp-content/uploads/2019/06/Impact-Institute-Report-True-Price-of-Jeans.pdf.

[4] Jenny Gonzales, "Blue jeans: An iconic fashion item that's costing the planet dearly," Mongabay, 2022, https://news.mongabay.com/2022/11/blue-jeans-an-iconic-fashion-item-thats-costing-the-planet-dearly/.

Using time-series data from the World Integrated Trade Solution (WITS), I convert imported denim fabric values and volumes into jeans-equivalent prices and quantities. I then estimate a log–log demand model, applying a first-differenced OLS regression. This approach yields a short-run own-price elasticity of –1.57. Within a partial-equilibrium framework, I simulate a 20% tax-induced price hike in 2023, predicting a 24% decline in demand relative to 2022. This change is projected to reduce emissions by 0.5 tonnes of CO_2-eq and save 61 million litres of water.

2 Data

2.1 Dataset Description

This analysis utilizes two sources of annual time-series data covering the 2000 to 2024 period: denim trade records from the World Integrated Trade Solution (WITS),[5] and consumer price indices for clothing and footwear from Statistics Canada.[6]

In the absence of publicly available market data specific to Canadian jeans, I use WITS trade values (in thousands of US$) and volumes (in kilograms) for Canadian imports of "coloured denim with <85% cotton, >200 mg^2", which most closely resembles traditional woven inputs. To capture total domestic demand, abstracting away from country-specific tariffs and trade distortions, I restrict the dataset to the "World" partner category. Data for 2017 are missing. All values are reported on a cost-insurance-freight (CIF) basis.

2.2 Variable Construction

I clean and harmonize the annual WITS files, rescale trade values to their original magnitudes, and drop irrelevant columns. I then join this dataset with Statistics Canada's Consumer Price Index (CPI) series using year as the key.

I construct jeans-level price and quantity variables as proxies for market equilibrium outcomes, assuming that all Canadian jeans consumption is import-driven. Although import prices inherently differ from final retail prices, I consider them indicative of supply-side costs that are passed through to consumers over time. To deflate nominal prices into real terms, I apply the CPI series (2002 = 100), re-indexed to 2022.

Whereas all jeans vary by weight and environmental footprint, I assume uniformity based

[5] World Bank (World Integrated Trade Solution Database), 2025, https://wits.worldbank.org/.
[6] (Table 18-10-0005-01: Consumer Price Index for Clothing and Footwear, Annual Average, Not Seasonally Adjusted, Statistics Canada), 2025, https://doi.org/10.25318/1810000501-eng.

on Levi's 501 Original model—selected as the representative industry benchmark due to their global popularity,[7] Levi Strauss & Co.'s dominance in the Canadian jeans market,[8] and wide recognition of their 12 oz (0.34 kg) weight as typical for mid-weight denim.[9] I leverage this as a conversion factor to whittle down total denim fabric volumes into equivalent quantities of jeans:

$$\text{Quantity}_{Jeans}\ (\text{pairs}) = \frac{\text{Quantity}_{Denim}\ (\text{kg})}{\text{Weight}_{Levi's\ 501}\ (\text{kg})} = \frac{\text{Quantity}_{Denim}\ (\text{kg})}{0.34\ \text{kg}}$$

Likewise, I calculate real prices per pair as the ratio of total denim value to estimated jeans quantity, adjusted for sector-wise inflation:

$$\text{Price}_{Jeans}\ (\text{US\$/pair}) = \frac{\text{Value}_{Denim}\ (\text{US\$})}{\text{Quantity}_{Jeans}\ (\text{pairs})} \times \frac{100}{\text{CPI}_{Clothing}}$$

I calculate environmental outcome variables by scaling quantity with per-unit life-cycle estimates for emissions and water use, drawn from Levi Strauss & Co.'s internal sustainability analysis:[10]

$$\text{Total Emissions}_{Jeans} = 33.4\,\text{kg CO}_2\text{-eq} \times \text{Quantity}_{Jeans}$$

$$\text{Total Water Consumption}_{Jeans} = 3781\,\text{litres} \times \text{Quantity}_{Jeans}$$

2.3 Exploratory Analysis

Figure 1 shows a steady decline in imported denim volume since 2000, along with a sharp drop in nominal value after 2005. To isolate this metric from noise, Figure 2 presents it separately. Because jeans prices are constructed as the ratio of value to volume, these trends suggest that they actually rose for much of the period—even as national appetite for denim declined. Figure 3 corroborates this: real jeans prices climbed until 2014, then became volatile. These patterns offer preliminary support for the downward-sloping demand curve formalized in Section 4.

[7] Fashionista, *Fashion History Lesson: Levi's 501 Jeans*, 2023, https://fashionista.com/2023/05/levis-501-jeans-history-popularity.

[8] CSIMarket, "LEVI's Market Share Relative to Its Competitors, as of Q1 2025," 2025, https://csimarket.com/stocks/competitionSEG2.php?code=LEVI.

[9] Ellen Rubin, "The Denim Weight of Jeans: A Clear and Simple Guide," Unsustainable Magazine, 2022, https://www.unsustainablemagazine.com/the-denim-weight-of-jeans-guide/; DenimHunters, "Denim Weight: What Is 'Ounce' and Why Does It Matter?," https://denimhunters.com/denim-wiki/denim-explained/denim-weight/; David E. White, "How Heavy Is Your Denim? Know the Weight!," 2021, https://www.davidewhite.com/post/how-heavy-is-your-denim-know-the-weight; Levi Strauss & Co., "Denim Dictionary," 2023, https://www.levi.com/US/en_US/features/denim-dictionary.

[10] Levi Strauss & Co., *The Life Cycle of a Levi's 501 Jean – Lifecycle Assessment Upyear*.

Although the 2008–2009 financial crisis coincided with a fall in both value and volume, no clear response is evident during the COVID-19 pandemic. This leaves the influence of external shocks on demand for jeans somewhat ambiguous.

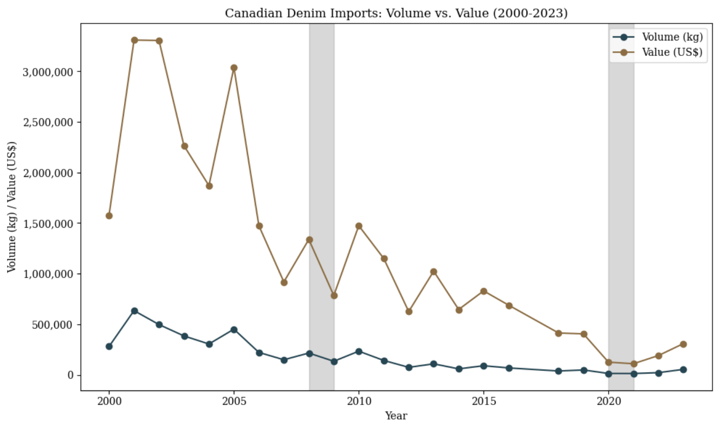


Figure 1: Imported denim volume and value, 2000–2023. Grey bands denote global macroeconomic shocks.

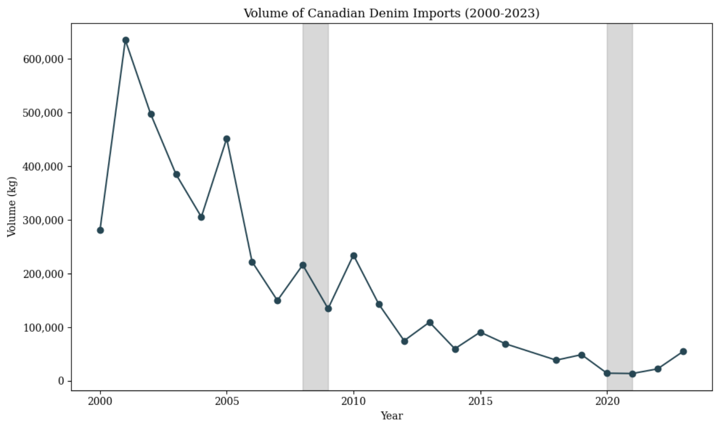


Figure 2: Volume of imported denim, 2000-2023.

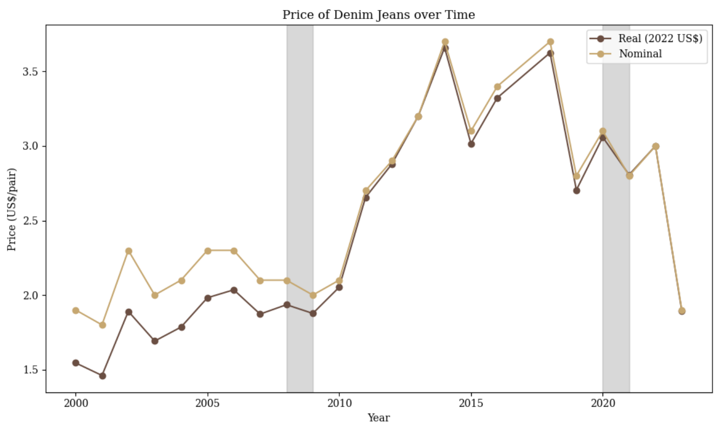


Figure 3: Real vs. nominal jeans prices, 2000–2023.

3 Literature Review

The current literature has extensively explored the environmental footprint of denim, the theoretical grounds for corrective taxation, as well as the behavioural patterns that characterize fashion consumption. I synthesize these conceptual and empirical insights to flesh out the rationale behind designing a mitigation policy for Canada, in the form of a Pigouvian tax on denim jeans.

3.1 Ecological Damage

Denim production is distinctively resource-intensive and harmful for the environment, accounting for approximately 1% of global greenhouse gas emissions—a share intensified by fast fashion consumption patterns such as impulse buying and early disposal.[11] Khatun (2024) attributes a staggering 15.33 kg CO_2-eq to the weaving phase alone,[12] nearly half of the life-cycle benchmark adopted in this paper. 'Sustainable' alternatives for denim jeans are no panacea, either: Semba, Furukawa, and Itsubo (2024) report that woven bagasse-based yarn emits over 15 kg CO_2-eq per pair.[13] This indicates that meaningful emissions reduction requires not just cleaner materials, but categorical limits on production achievable only by the moderation of final demand.

Contextualizing more broadly, the fashion industry is responsible for roughly 10% of global carbon emissions—more than all international aviation and maritime shipping combined—and 20% of wastewater production.[14] Jeans are a quintessential hallmark of this system, projected to grow from a $64.5 billion market in 2020 to $95 billion by 2030.[15] With per-capita fast fashion emissions exceeding those in most developing countries by over 50%,[16] Canada is a prominent textile polluter which yet manufactures almost none of the denim it consumes.

Despite effectively outsourcing carbon-intensive denim production, Canada is not absolved of its environmental toll. Athey (2022) documents the prevalence of denim-derived microfibres throughout Canadian aquatic ecosystems, from the Great Lakes to the Arctic,

[11] Fahad Asmi et al., "Ecological Footprint of Your Denim Jeans: Production Knowledge and Green Consumerism," *Sustainability Science* 17 (2022): 1781–1798, https://doi.org/10.1007/s11625-022-01131-0.

[12] Murshida Khatun, "Life Cycle Assessment of Jeans Production Using Organic and Conventional Cotton," *Tekstilec* 67, no. 2 (2024): 139–150, https://doi.org/10.14502/tekstilec.67.2023073.

[13] Toshiro Semba, Ryuzo Furukawa, and Norihiro Itsubo, "Carbon Footprint for Jeans' Circular Economy Model Using Bagasse," *Sustainability* 16, no. 6044 (2024), https://doi.org/10.3390/su16146044.

[14] United Nations, "UN Alliance For Sustainable Fashion Addresses Damage of 'Fast Fashion'," 2019, https://news.un.org/en/story/2019/03/1035161.

[15] Zhikun Li et al., "The Carbon Footprint of Fast Fashion Consumption and Mitigation Strategies: A Case Study of Jeans," *Science of The Total Environment* 924 (2024): 171508, https://doi.org/10.1016/j.scitotenv.2024.171508, https://www.sciencedirect.com/science/article/pii/S0048969724016498.

[16] Li et al.

and traces their release to laundering at the final consumer stage.[17] These fibres are not environmentally benign—they contain chemical additives for which no known removal technologies exist. This asymmetric burden, between upstream production and downstream harm, strengthens the case for cutting consumption off at the source.

Beyond environmental damage, denim production also imposes severe human costs throughout its supply chain. Lebby (2021) highlights exploitative and hazardous working conditions within cotton harvesting and denim finishing, including exposure to silicosis-inducing sandblasting.[18] These occupational harms comprise a portion of the social cost sewn, with invisible thread, into each pair of denim jeans.

3.2 Pigouvian Pricing in Fashion

The foundational logic of a Pigouvian tax lies in aligning private costs with social damages by pricing externalities at their marginal harm, thereby promoting a more efficient, welfare-maximizing equilibrium.[19] In the case of denim, most environmental harm is incurred during upstream manufacturing in jurisdictions typically beyond Canadian regulatory reach. Yet, because demand originates in Canada and consumers are the marginal decision-makers, the most actionable policy lever lies downstream: a tax at the point of sale. Life-cycle assessments facilitate this by quantifying per-unit emissions and water use, making jeans a viable target for environmental pricing since they are sold in discrete, countable units—allowing their external costs to be directly baked into consumer prices.

Corrective fashion taxes have been gaining traction internationally. In 2024, France's National Assembly passed legislation authorizing surcharges of up to €10 per item on fast fashion goods, explicitly framing the measure as a 'sin tax' on environmentally destructive overconsumption.[20] This precedent crucially demonstrates the administrative feasibility of taxing garments, the discursive framing of fashion as a socially harmful good akin to alcohol or tobacco, and a growing consensus that high-volume apparel production must be tackled head-on with fiscal measures. Sweden's chemical tax on imported fashion goods provides another example; Multala, Wagner, and Wang (2022) show that Pigouvian taxes in fashion often outperform alternatives, such as durability standards or clothing libraries, in terms of welfare outcomes.[21] The authors acknowledge that such instruments often face

[17] Samantha Nicole Athey, "Microplastics and Other Anthropogenic Contaminants: From Source to Sink in the Canadian Environment" (PhD thesis, University of Toronto, 2022), https://utoronto.scholaris.ca/items/4fe41e02-41ab-4088-8767-0c399605cf30.

[18] Sharmon Lebby, "Is Denim a Sustainable Fabric?," 2021, https://www.treehugger.com/is-denim-a-sustainable-fabric-5116034.

[19] Garth Heutel, *In Defense of Alternatives to Pollution Pricing*, technical report (Economists for Inclusive Prosperity, 2020), https://econfip.org/wp-content/uploads/2020/05/26.In-Defense-of-Alternatives-to-Pollution-Pricing.pdf.

[20] Meital Peleg Mizrachi, "Navigating Global Fashion Policy: Labor, Environment, and Future Directions for Sustainability," *Academia Environmental Sciences and Sustainability* 1 (2024): 1–8, https://doi.org/10.20935/AcadEnvSci7452.

[21] Brendan Multala, Jeffrey Wagner, and Yiwei Wang, "Durability standards and clothing libraries for strengthening sustainable clothing markets," *Ecological Economics* 194 (2022): 107358, https://doi.org/10.1016/j.ecolecon.2022.107358.

industry resistance but emphasize that a credible tax threat can itself serve as a backstop, preemptively incentivizing firm compliance.

The appeal of a Pigouvian tax is reinforced by jarring claims of underpricing in fashion: Springmann (n.d.) estimates that the failure to price embedded emissions effectively subsidizes the industry by $17 billion each year.[22] A targeted tax can correct this market distortion by directly incorporating the costs borne by the environment, workers, and downstream communities into consumer prices—forcing buyers to confront the externalities attributable to their purchases, thereby curbing overconsumption.

Demand-side tools are increasingly favoured over hyped but ineffective circular strategies. Simpkins (2021) finds that recycling and clothing-sharing programs can generate emissions comparable to, or even exceeding, those of standard consumption due to 'rebound effects', wherein 'sustainable' behaviour paradoxically drives higher overall use.[23] Conversely, price disincentives directly suppress virgin production and compel consumers to extend the lifespans of their existing garments—an approach Simpkins identifies as more effective.

3.3 Consumer Behaviour

The case for taxing denim at the point of consumption is further complemented by behavioural evidence. Consumers in high-income countries typically own multiple pairs of jeans, many of which are discarded well before end-of-life.[24] Li et al. (2024) estimate that second-hand trading could reduce fast fashion emissions by up to 90%,[25] underscoring the environmental gains achievable through policies that moderate new purchases and stimulate circular fashion as an incidental benefit.

Dastur (2024) reports a 36% decline in the average number of times a garment has been worn over the past 15 years,[26] reflecting the rapid product turnover inherent to fast fashion. Huang et al. (2025) offer additional context, estimating that jeans are washed every 10 wears and discarded after just 20[27]—a strikingly short lifespan considering denim's historical reputation for durability.[28] These findings emphasize how consumer choices di-

[22] Marco Springmann, "Carbon Tariffs: An Instrument for Tackling Climate Change?," AXA Research Fund, https://axa-research.org/funded-projects/climate-environment/carbon-tariffs-an-instrument-for-tackling-climate-change.

[23] Graham Simpkins, "Patching Up Denim Emissions," *Nature Reviews Earth & Environment* 2 (2021): 378, https://doi.org/10.1038/s43017-021-00177-5.

[24] Asmi et al., "Ecological Footprint of Your Denim Jeans: Production Knowledge and Green Consumerism"; Li et al., "The Carbon Footprint of Fast Fashion Consumption and Mitigation Strategies: A Case Study of Jeans."

[25] Li et al., "The Carbon Footprint of Fast Fashion Consumption and Mitigation Strategies: A Case Study of Jeans."

[26] Zeenia Dastur, "Jeans that don't cost the earth," Green Climate Fund, 2024, https://www.greenclimate.fund/story/jeans-don-t-cost-earth.

[27] Chi-Shih Huang et al., "Upcycling Aquaculture Waste for Textile Functional Material to Facilitate the Creation of Novel and Sustainable Jeans," *Journal of Engineered Fibers and Fabrics* 20 (2025): 1–8, https://doi.org/10.1177/15589250241312302

[28] Lynn Downey, "A Short History of Denim," Levi Strauss & Co., 2014, https://www.levistrauss.com/wp-content/uploads/2014/01/A-Short-History-of-Denim2.pdf.

rectly undermine product longevity and drive resource waste, supporting the need for demand-side regulation to directly address the root of the problem.

Moreover, they lay bare the core issue: the environmental cost of denim extends well past the factory floor. It continues to accumulate through use, disposal, and beyond. Unlike circular solutions, which hinge on idealistic assumptions about behavioural change, a price mechanism directly curtails the frequency and volume of new purchases—the true catalyst of environmental harm in fashion markets.

3.4 Empirical Gaps and Contribution

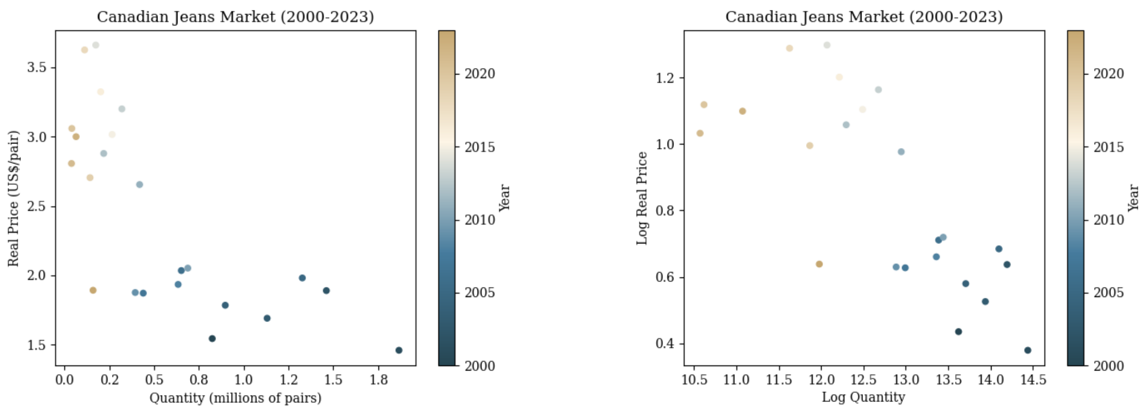
Despite a multiplicity of evidence on denim's environmental footprint, empirical research quantifying demand responsiveness to fiscal instruments in this domain remains scarce. The sector's price sensitivity is often discussed in the context of fast fashion's "race to the bottom" pricing, but not formally derived.[29] To my knowledge, no study has estimated a short-run price elasticity specific to denim, jeans, nor modelled the environmental impacts of a corrective tax on either, in Canada or elsewhere. This paper aims to bridge both gaps by offering first-order quantitative estimates of demand elasticity and the environmental benefits of price-based regulation in this sector, thereby illustrating the policy relevance of even modest corrective taxes in high-consumption markets such as Canada.

4 Model

4.1 Demand Framework

Price and quantity exhibit a negative relationship consistent with downward-sloping demand (Figure 4a). A log-log transformation linearizes this pattern more effectively than semi-log alternatives, allowing the slope coefficient to be interpreted as a constant own-price elasticity (Figure 4b).

[29] Li et al., "The Carbon Footprint of Fast Fashion Consumption and Mitigation Strategies: A Case Study of Jeans."



(a) Real prices vs. quantities. **(b)** Log real prices vs. log quantities.

Figure 4: Observed demand in the jeans market, 2000-2023.

Hence, I adopt a single-good, constant-elasticity framework to model short-run demand in the Canadian denim jeans market:

$$\ln(Q_{j,t}) = \beta_0 + \beta_1 \ln(P_{j,t}) + \epsilon_t$$

- $Q_{j,t}$ is the estimated quantity of jeans sold in Canada, in year t.
- $P_{j,t}$ is the estimated average real price per pair.
- β_0 is the intercept term.
- β_1 is the own-price elasticity of demand.
- ϵ_t is the error term capturing unobserved variation.

4.2 Structural Assumptions

This partial-equilibrium model captures consumer responses to price changes in the short-run, conditional on several simplifying assumptions:

- Market supply and structure are fixed. Firms do not enter, exit, or adjust production in the short-run.
- All jeans sold in a given year are manufactured from denim fabric imported in that same year. There is no domestic production, inventory, or importation of finished jeans.

- All imported denim fabric is used exclusively for jeans. There is no material waste, resale, or allocation to other product categories (e.g., dungarees, shorts, skirts, shirts, jackets, bags, shoes, furniture).
- All jeans are homogeneous and identical to the Levi's 501 Original. There is no variation across any product dimension, including weight (e.g., lightweight, midweight, heavyweight); style or silhouette (e.g., wide-leg, mom, bootcut, skinny); rise (e.g., low-rise, mid-rise, high-rise); dye or wash (e.g., stone, acid, rinse, light, medium, dark); weave pattern (e.g., twill, broken twill, crosshatch, jacquard, fingerprint); textile composition (e.g., cotton, lycra, elastane, polyester); functional or aesthetic features (e.g., hardware, pockets, belt loops, patchwork, embroidery, distressing); and size (e.g., waist, inseam length, petite, tall, plus-size).
- There are no qualifying or feasible substitutes (e.g., second-hand, sustainable, or non-denim bottoms).
- All consumer segments exhibit the same own-price elasticity.
- Consumption occurs entirely within the current period. There is no intertemporal substitution (e.g., stockpiling).
- Non-price determinants of demand (e.g., income, fashion trends, seasonal preferences, demographic shifts) are fixed.
- Canada is a single, price-integrated market with no regional variation.

4.3 Empirical Relevance

The theoretical model treats β_1 as the structural elasticity through which policy-induced price changes map into quantity responses. Thus, a 20% Pigouvian tax enters as an exogenous increase in $P_{j,t}$, which is then translated by β_1 into a corresponding change in $Q_{j,t}$. The empirical analysis that follows estimates this parameter using observed variation in price and quantity over time.

5 Estimation

5.1 Regression Specification

To estimate β_1, I apply ordinary least squares (OLS) to annual data from 2000 to 2023, constructed from WITS import records as outlined in Section 2. Consistent with the theoretical model introduced in Equation 4.1, I derive a first-differenced log–log specification to capture the short-run price–quantity relationship:

$$\Delta \ln(Q_{j,t}) = \hat{\beta}_1^{\Delta} \Delta \ln(P_{j,t}) + \varepsilon_t$$

This approach explicitly tracks year-over-year changes, isolating short-run demand responsiveness and mitigating bias from long-term trends. The dependent variable is the natural logarithm of jeans quantity sold, and the regressor is the natural logarithm of real price. Since the dataset is nationally aggregated with no cross-sectional variation, fixed effects do not apply.

5.2 Identification Assumptions

To interpret $\hat{\beta}_1^{\Delta}$ as the short-run own-price elasticity of demand, the following additional assumptions must hold:

- There is a strictly linear relationship between log price and log quantity. Figure 4b empirically supports this.
- Error terms exhibit constant variance (i.e., no heteroskedasticity) and independent distribution (i.e., no autocorrelation) across observations. Otherwise, standard errors would be unreliable, overstating statistical significance or compromising hypothesis tests of whether the elasticity estimate differs from zero.
- Price and quantity data are accurately measured. Any CIF import price variation fully passes through to retail prices without absorption by supply chain agents. Chernoff and Alexander (2019) support this: Canadian retailers—especially direct importers—fully pass through cost reductions from exchange rate appreciation to retail prices without adjusting markups.[30] Otherwise, the elasticity estimate would be biased towards zero (i.e., underestimating demand responsiveness).
- Price variation is exogenous to demand shocks, uncorrelated with the error term, and driven by international supply-side factors (e.g., input costs, exchange rates, trade policy). Bouakez and Rebei (2008) support this: exchange rate pass-through to Canadian import prices is stable and unaffected by domestic monetary policy, consistent with price movements being driven by external cost shocks.[31] Otherwise,

[30] Alex Chernoff and Patrick Alexander, "Exchange Rates, Retailers, and Importing: Theory and Firm-Level Evidence," 2019, Staff Working Paper, https://doi.org/10.34989/swp-2019-34, https://www.bankofcanada.ca/wp-content/uploads/2019/09/swp2019-34.pdf.

[31] Hafedh Bouakez and Nooman Rebei, "Has Exchange Rate Pass-Through Really Declined? Evidence from Canada," *Journal of International Economics* 75, no. 2 (2008): 249–267, https://doi.org/10.1016/j.jinteco.2007.12.004.

if demand for jeans is positively (e.g., rising consumer tastes for denim) or negatively (e.g., recession reducing demand for non-essentials) correlated with price, the elasticity estimate would be biased upward (i.e., overestimating demand responsiveness) or downward (i.e., underestimating demand responsiveness), respectively.

5.3 Instrumental Variables Proposal

In practice, price and demand tend to move together in apparel markets.[32] Media-driven trends and short product life cycles—reinforced by viral exposure, celebrity influence, and parasocial engagement—can induce endogenous price movements, posing a serious threat to identification. If supply and demand indeed are determined simultaneously, the elasticity estimate would be biased and its validity undermined.

To address this, I conceptualize a hypothetical instrumental variables (IV) strategy that leverages variation in international shipping costs from the US and China—Canada's two largest denim fabric suppliers[33]—as instruments for retail-level jeans prices. Since these costs are embedded in CIF values for imported denim, any supply-side shocks would mechanically induce variation in the prices of jeans, thereby satisfying the relevance condition.

The exclusion restriction, which requires that freight rate shocks affect jeans demand only through their effect on prices, is less defensible. Shipping costs may well co-move with macroeconomic factors (e.g., inflation) that simultaneously influence Canadian demand. Still, under the strong assumption that they do not, this proposal parallels established precedent for using transport costs to isolate exogenous price variation in trade contexts.[34]

[32] Genessa M. Fratto, Michelle R. Jones, and Nancy L. Cassill, "An Investigation of Competitive Pricing among Apparel Retailers and Brands," *Journal of Fashion Marketing and Management* 10, no. 4 (2006): 387–404, https://doi.org/10.1108/13612020610701938.

[33] (Canada Denim, with ¿=85% cotton, >200g/m^2 imports by country in 2023, World Integrated Trade Solution (WITS)), 2023, https://wits.worldbank.org/trade/comtrade/en/country/CAN/year/2023/tradeflow/Imports/partner/ALL/product/521142.

[34] Colin J. Hottman and Ryan Monarch, "A Matter of Taste: Estimating Import Price Inflation across U.S. Income Groups," *Journal of International Economics* 127 (2020): 103382, https://doi.org/10.1016/j.jinteco.2020.103382; Chernoff and Alexander, "Exchange Rates, Retailers, and Importing: Theory and Firm-Level Evidence."

6 Results

6.1 Regression Estimates

Table 1: OLS Regression Results: First-Differenced Log-Log Specification

Dep. Variable:	log_q_diff	R-squared:	0.219
Model:	OLS	Adj. R-squared:	0.179
Method:	Least Squares	F-statistic:	5.594
No. Observations:	22	Prob (F-statistic):	0.0282
Df Residuals:	20	Log-Likelihood:	-15.382
Df Model:	1	AIC:	34.76
Covariance Type:	nonrobust	BIC:	36.95

	Coefficient	S.E.	t	P> |t|	[0.025	0.975]
Intercept	-0.0602	0.109	-0.552	0.587	-0.288	0.167
log_p_diff	-1.5683	0.663	-2.365	0.028	-2.951	-0.185

Omnibus:	1.074	Durbin-Watson:	2.226
Prob(Omnibus):	0.584	Jarque-Bera (JB):	0.801
Skew:	0.060	Prob (JB):	0.670
Kurtosis:	2.073	Cond. No.	6.09

Table 1 presents results from the first-differenced specification, which eliminates β_0 and isolates short-run variation using 22 year-on-year pairs. $\hat{\beta}_1^{\Delta} = -1.57$, significant at the 5% level, implies that a 1% increase in price is associated with a 1.57% decrease in quantity demanded over a one-year horizon—a relatively elastic response. Although the specification explains a small share of the variance ($R^2 = 0.22$), this is unsurprising given the expected volatility (e.g., exchange rate effects) of annual trade data, which underpins the constructed price and quantity measures.

6.2 Model Diagnostics and Validation

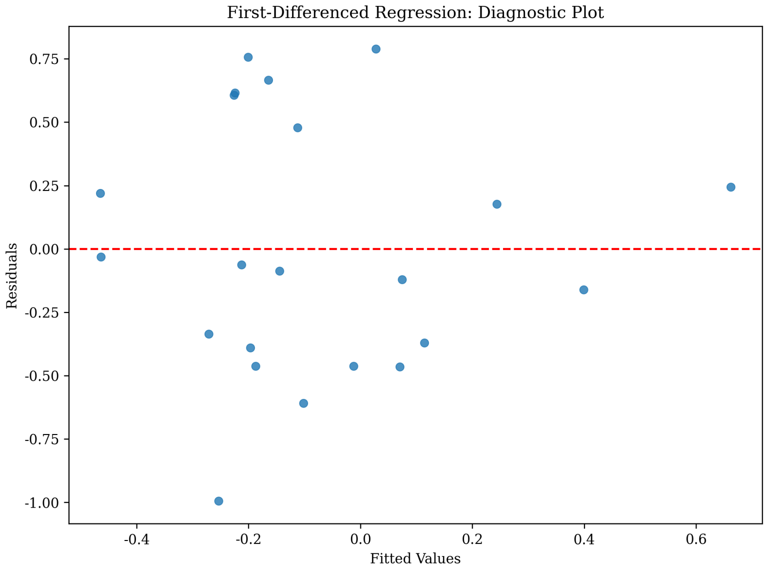


Figure 5: Residuals vs. fitted values for the first-differenced regression. No clear pattern suggests homoskedasticity and linearity.

The differenced specification exhibits tight clustering along the 45-degree line, indicating normally distributed residuals (Figure 5). White's test ($p = 0.31$) indicates homoskedasticity, while the Durbin–Watson statistic (2.23) rules out residual autocorrelation. These diagnostics support the validity of OLS estimation, justifying the use of $\hat{\beta}_1^{\Delta} = -1.57$ to simulate short-run demand responses to tax-induced price shocks in Section 7.

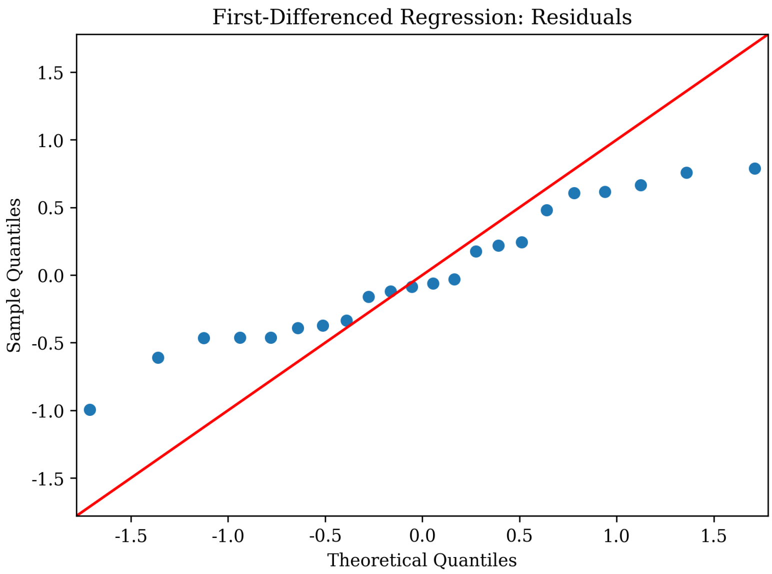


Figure 6: Q-Q plot of residuals for the first-differenced specification.

7 Counterfactual Analysis

7.1 Policy Shock and Rationale

I simulate the impact of a 20% Pigouvian tax imposed in 2023 on denim jeans sold in Canada, assuming full incidence on consumers. Each pair of jeans emits 33.4 kg CO_2-eq (0.0334 tonnes) and consumes 3,781 litres (3.781 m^3) of water over its full life-cycle.[35] I consider a socially optimal policy that internalizes these externalities by imposing a Pigouvian tax equal to the total environmental cost per unit of the final good—a finished pair of jeans, denoted j:

$$\text{EnvironmentalCost}_j = \text{CarbonCost}_j + \text{WaterCost}_j$$

To compute the marginal carbon cost of jeans, I multiply per-unit carbon emissions by the social cost of carbon, which Prest et al. (2022) estimate to range between \$100 and \$200 per tonne CO_2.[36] I conservatively adopt the upper bound:

$$\begin{aligned}\text{CarbonCost}_j &= \text{Carbon Emissions}_j \times \text{Social Cost of Carbon} \\ &= 0.0334\,\text{t CO}_2 \times 200\,\text{US\$/t CO}_2 \\ &= \text{US\$6.68}\end{aligned}$$

For the water cost, I follow Impact Institute's (2019) methodology, converting euros to U.S. dollars at the prevailing exchange rate:[37]

$$\begin{aligned}\text{WaterCost}_j &= \text{Water Consumption}_j \times \text{Economic Cost of Water} \\ &= 3.781\,\text{m}^3 \times \frac{2.80\,€/\text{m}^3}{2000\,\text{L}} \times 1000\,\text{L/m}^3 \\ &= 3.781\,\text{m}^3 \times 1.40\,€/\text{m}^3 \\ &\approx \text{US\$6.04}\end{aligned}$$

Thus, the estimated marginal social cost of the environmental externalities imposed by a single pair of denim jeans is:

$$\text{EnvironmentalCost}_j = \text{US\$6.68} + \text{US\$6.04} = \text{US\$12.72}$$

[35] Levi Strauss & Co., *The Life Cycle of a Levi's 501 Jean – Lifecycle Assessment Upyear*.
[36] Brian C. Prest et al., "Social Cost of Carbon Explorer," Resources for the Future (RFF), 2022, https://www.rff.org/publications/data-tools/scc-explorer/.
[37] Impact Institute, *The True Price of Jeans*.

This estimate closely aligns with Impact Institute's (2019) valuation of €10 ($11).[38] To price this in, I express the environmental cost as a share of the average 2023 retail price for jeans,[39] yielding the implied Pigouvian tax rate:

$$\mathrm{t}_j = \frac{\mathrm{EnvironmentalCost}_j}{\mathrm{RetailPrice}_j} \times 100\%$$

$$= \frac{\mathrm{US\$12.72}}{\mathrm{US\$61}} \times 100\%$$

$$= 20.85\%$$

For tractability, I round this down to 20%. In parallel, I simulate a 25% tariff benchmarked to real-world precedents, including the recent "Liberation Day" tariffs imposed by the EU on US denim[40] and the 24% tariff imposed by the Trump administration on Japanese denim in 2018.[41] While politically motivated, these shocks operate through the same price channel as a Pigouvian tax and can ultimately induce similar demand-side effects—particularly in Canada, which imports much of its denim. This provides a concrete analogue for the 20% scenario, reinforcing its empirical plausibility and serving as an additional robustness check for model stability. It also reframes the tax as a pragmatic repurposing of existing policy instruments: if geopolitically motivated price hikes of comparable magnitude have been historically tolerated in the denim industry, then applying the same mechanism to internalize environmental harm should rationally be seen as both socially constructive and legitimate.

7.2 Equilibrium Outcomes

I begin with the first-differenced demand specification introduced in Equation 5.1:

$$\ln(\hat{Q}_{j,t}) - \ln(Q_{j,t-1}) = \hat{\beta}_1^{\Delta} \cdot \Delta \ln(P_{j,t})$$

[38] Impact Institute, *The True Price of Jeans*.

[39] Cotton Incorporated, "Denim Jeans Outlook – 2024," 2024, https://www.cottoninc.com/market-data/supply-chain-insights/denim-jeans-outlook-2024/.

[40] Richard Davies, Finn McEvoy, and Joshua Hellings, "Liberation Day," 2025, https://www.economicsobservatory.com/liberation-day.

[41] Yang-Yi Goh, "Small Menswear Retailers Are Already Feeling the Tariffs," GQ, 2025, https://www.gq.com/story/trump-tariffs-menswear-retail.

Under a counterfactual price shock τ, where $P_{j,t} = P_{j,t-1}(1+\tau)$, the log price change becomes:

$$\Delta \ln(P_{j,t}) = \ln(1+\tau)$$

Substituting this into the model yields the predicted log change in 2023 quantity demanded, relative to the 2022 baseline:

$$\ln(\hat{Q}_{j,2023}) - \ln(Q_{j,2022}) = \hat{\beta}_1^{\Delta} \cdot \ln(1+\tau)$$

Applying the elasticity estimate $\hat{\beta}_1^{\Delta} = -1.57$ to the 20% and 25% shocks:

$$\begin{aligned}
\ln(\hat{Q}_{j,2023}) - \ln(Q_{j,2022}) &= -1.57 \cdot \ln(1.20) \approx -0.2857 \\
&\Rightarrow \Delta Q \approx -24\% \\
\ln(\hat{Q}_{j,2023}) - \ln(Q_{j,2022}) &= -1.57 \cdot \ln(1.25) \approx -0.3501 \\
&\Rightarrow \Delta Q \approx -30\%
\end{aligned}$$

The model thus predicts a 24% reduction in demand under a 20% Pigouvian tax and a 30% reduction under a 25% tariff. Figure 7 illustrates these counterfactual outcomes.

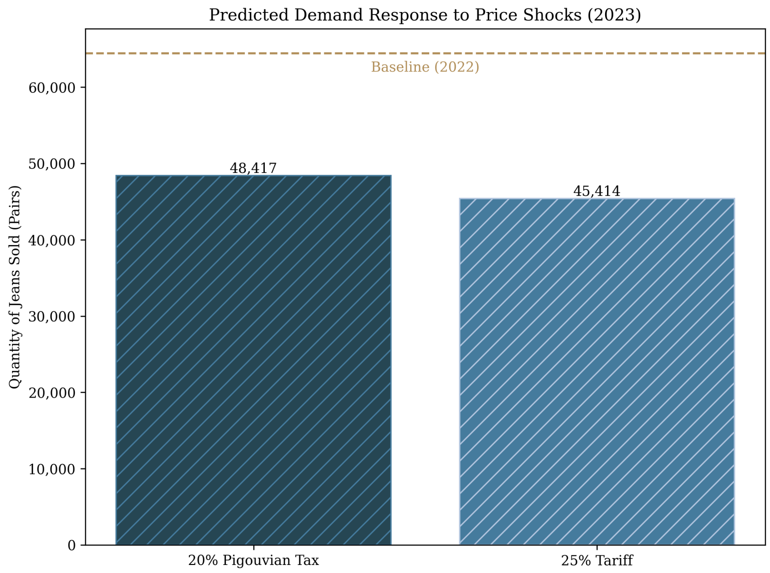
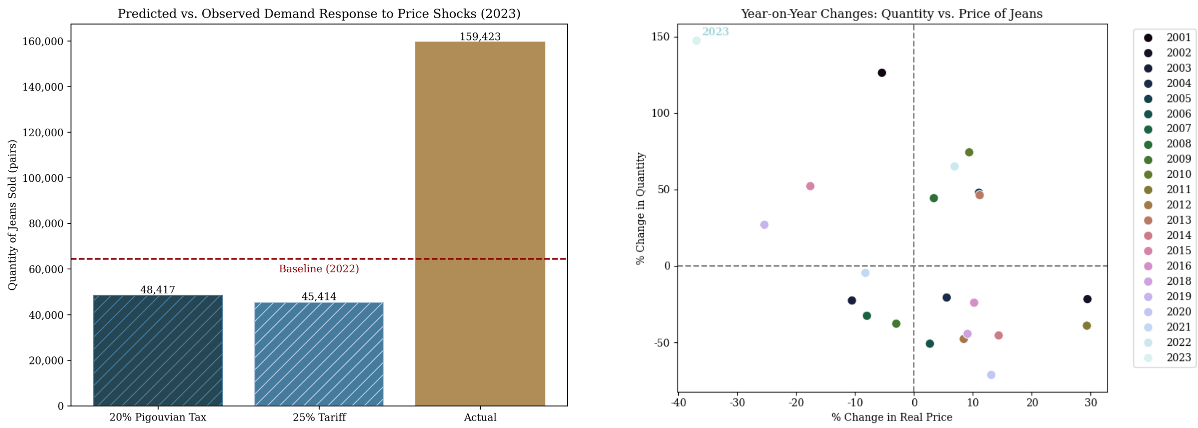


Figure 7: Predicted 2023 demand under simulated 20% and 25% price shocks. Dashed line indicates 2022 baseline quantity.

No year in the dataset exhibits a 20% price increase that could serve as a natural analogue for the proposed shock. I therefore apply the simulation to 2023, a year that presents a unique scenario: prices fell as demand rose (Figure 8b). This directionally opposite trend makes for a clean test case; rather than echoing historical patterns, the model operates under reversed conditions, exercising its predictive power to simulate a shock that never occurred. By revealing how demand would have shifted had prices risen instead, this approach improves interpretability. As shown in Figure 8a, simulated demand under the shocks falls sharply below the observed 2023 levels. No major unique domestic supply, demand, or policy shocks occurred in this year, aside from sector-specific fluctuations in energy prices,[42] minimizing the risk of confounding factors. Macroeconomic and industry conditions further support the candidacy of 2023: denim[43] and textile[44] imports normalized post-pandemic, apparel prices remained broadly stable,[45] while shipping and cotton input costs declined.[46]



(a) Predicted vs. observed 2023 demand under simulated 20% and 25% price shocks. Dashed line indicates 2022 baseline quantity.

(b) Observed year-on-year changes in jeans price and quantity. 2023 marked as outlier.

[42](The Daily — Canadian International Merchandise Trade: Annual Review 2023, Statistics Canada), 2024, https://www150.statcan.gc.ca/n1/daily-quotidien/240509/dq240509a-eng.htm.

[43]See Figure 2.

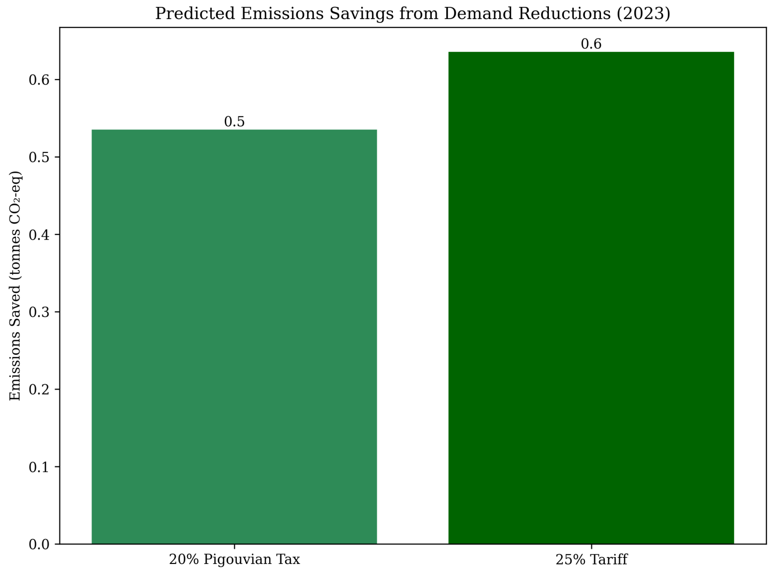
[44]Statista (Monthly Import Value of Fabric, Fiber, Yarn, Leather & Dressed Furs Canada 2015-2023), 2024, https://www.statista.com/statistics/466338/monthly-import-value-of-fabric-fiber-yarn-leather-dressed-furs-canada/.

[45]Statistics Canada, "Prices Rise at a Slower Pace in All but Two Major Components," Government of Canada, 2024, https://www150.statcan.gc.ca/n1/daily-quotidien/240116/cg-b002-eng.htm.

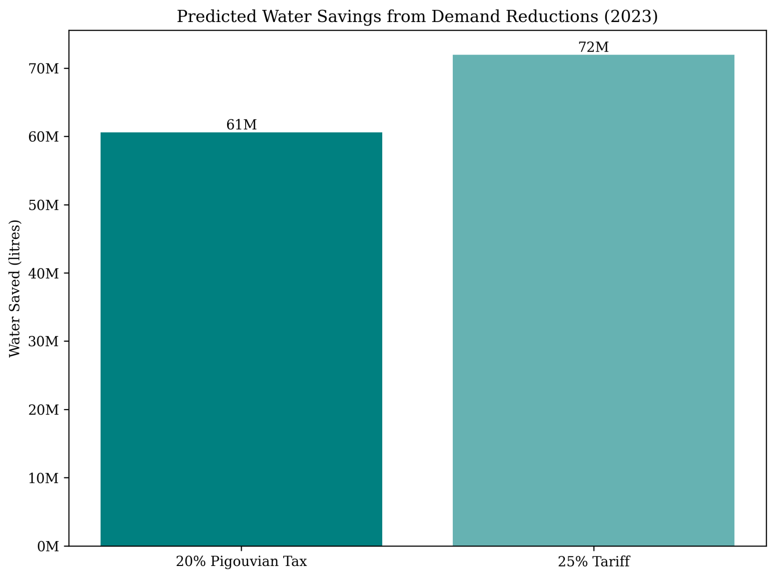
[46]U.S. Department of Agriculture, *Cotton Price Statistics 2023-2024*, technical report (U.S. Department of Agriculture, 2024), https://www.ams.usda.gov/mnreports/cnaacps.pdf; Garth Friesen, "The End of the Supply Chain Crisis Provides Inflation Relief," Forbes, 2023, https://www.forbes.com/sites/garthfriesen/2023/07/09/the-end-of-the-supply-chain-crisis-a-relief-from-inflationary-pressures/.

7.3 Environmental Outcomes

Environmental outcomes are computed by scaling predicted quantities using constant per-unit impact metrics—33.4 kg CO_2-eq and 3,781 litres per pair of jeans.[47] Larger price shocks yield proportionally greater environmental savings, reflecting the assumed constant elasticity and linear relationship between consumption and externalities.



(a) Emissions Savings (kg CO_2-eq)



(b) Water Savings (litres)

Figure 9: Predicted 2023 environmental savings under 20% and 25% price shocks, assuming constant emissions and water use per pair.

[47] Levi Strauss & Co., *The Life Cycle of a Levi's 501 Jean – Lifecycle Assessment Upyear*.

7.4 Sensitivity and Robustness

To test sensitivity, I re-simulate 2023 demand using the 95% confidence interval for $\hat{\beta}_1^{\Delta}$: $[-2.87, -0.27]$. This yields a wide range of predicted quantities—38,202 to 61,363 pairs—under a 20% tax shock. At the lower elasticity bound, where demand is highly responsive to price, predicted quantity drops sharply. At the upper bound, where demand is less responsive, the decline is smaller—yet even this moderately inelastic case falls short of the 2022 baseline (Figure 10), confirming that the tax reduces consumption across the full plausible range of elasticities. This reinforces the robustness of its directional effect.

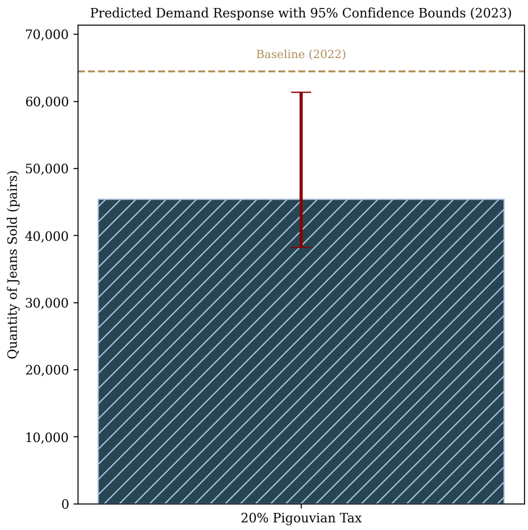


Figure 10: Predicted 2023 quantity under 20% price shock, with 95% confidence bounds on $\hat{\beta}_1^{\Delta}$. Dashed line indicates 2022 baseline quantity.

Figure 11 presents year-specific elasticities after dropping periods with minimal price variation. Clustering around $\hat{\beta}_1^{\Delta}$ supports its stability over time.

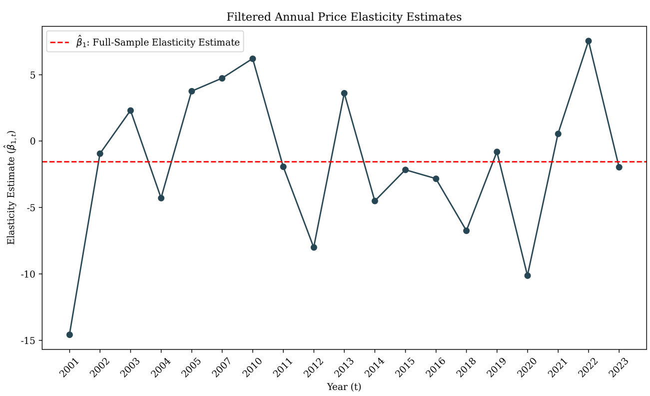


Figure 11: Filtered annual price elasticity estimates, excluding two year-pairs with $|\Delta \ln P| < 0.05$. Dashed line indicates full-sample estimate $\hat{\beta}_1^{\Delta}$.

To strengthen credibility, I simulate a placebo shock using a different, closer to ideal quasi-experimental year-pair in which real prices rose moderately and quantity declined slightly. Applying a 20% price increase to 2015 predicts 2016 demand within 1% of the actual observed quantity (Figure 12), demonstrating the empirical relevance of $\hat{\beta}_1^{\Delta}$ as a proxy for short-run demand responsiveness.

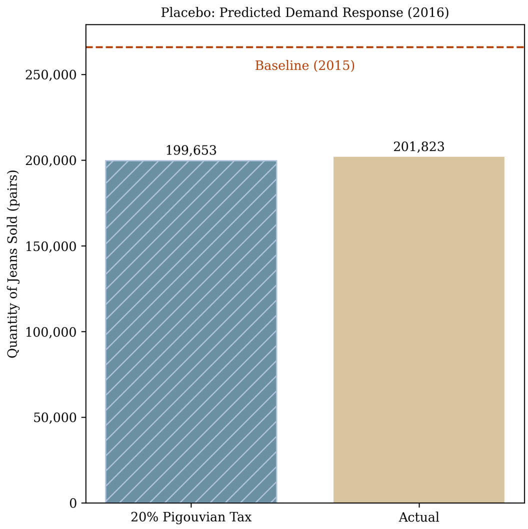


Figure 12: Placebo test. Predicted vs. observed 2016 demand under 20% price shock. Dashed line indicates 2015 baseline quantity.

8 Discussion

8.1 Summary of Results

This paper set out to determine the prospective impact of a 20% tax on denim jeans sold in Canada, designed to internalize environmental externalities within a Pigouvian framework. Through a log–log demand specification calibrated to constructed price and quantity measures for jeans, I estimated a short-run own-price elasticity of $\hat{\beta}_1^{\Delta} = -1.57$. This implies that a 20% increase in retail prices—implemented through a corrective tax reflecting life-cycle carbon and water costs—could reduce consumption by 24% within one year. The corresponding environmental benefits were estimated at 0.5 tonnes CO_2-eq emissions reduction and 61 million litres of water savings—equivalent to the annual usage of 265 Canadian households.[48] A supplementary scenario exploring a 25% shock predicted a 30% reduction in demand, providing a counterfactual benchmark comparable to historical tariffs on denim.

[48] City of Toronto, "Water Consumption - Average Household Use," 2023, https://www.toronto.ca/home/311-toronto-at-your-service/find-service-information/article/?kb=kA06g000001cvc2CAA&searchTerm=Water+consumption&.

8.2 Interpretation and Uncertainty

The elasticity estimate $\hat{\beta}_1^{\Delta} = -1.57$ is consistent with theoretical expectations for a discretionary or normal good; mid-range denim jeans (e.g., Levi's) exhibit moderate demand responsiveness to an increase in price. However, this result warrants cautious interpretation. My analysis relies on highly aggregated data on denim imports—an imprecise proxy for jeans consumption—while completely disregarding domestic production, imports of finished jeans, and making assumptions about uniformity that betray reality. Denim jeans are not a homogeneous product; they vary by fabric composition, style, quality, and market positioning (e.g., mass-market vs. luxury). As such, the reported elasticity is merely reflective of an average response.

The model's low precision is further undermined by its own reliance on a host of simplifying assumptions—the treatment of prices as exogenous to demand is especially vulnerable. Objectively, the relationship between retail prices and consumer demand for denim jeans is not the primary factor driving market behaviour. The model captures a single channel of price elasticity, neglecting seasonal trends, consumer preferences, and brand perceptions that shape demand in fashion markets. If demand shocks co-move with price as expected, the credibility of the elasticity estimate as a precise measure of responsiveness is severely compromised by measurement error. This is evident in its wide 95% confidence interval $[-2.87, -0.27]$, spanning a range almost twice the magnitude of the point estimate itself. At the upper bound, the tax could cut consumption by 52%—over double the predicted effect—whereas at the lower bound, it could induce minimal change. The crude, reductionist nature of the model imbues its results with an inherent fragility. Subsequently, the point estimate of -1.57 is best interpreted as a first-order approximation of demand responsiveness.

Environmental impact estimates are similarly constrained; the life-cycle assessment (LCA) values grounding emissions and water savings calculations are derived from Levi's 501 medium stone wash jeans—a 100% cotton product. Yet the denim fabric underpinning this analysis is composed of less than 85% cotton, the material responsible for most of denim's environmental footprint. This discrepancy implies significant specification error, especially considering that per-pair LCA estimates for water consumption range from 2,000 to 20,000 litres, depending on production practices. As such, employing single LCA values as I do here is unlikely to yield accurate predictions of the environmental outcomes attached to jeans.

8.3 Policy Relevance

Although I have little confidence in the precise magnitude of the predicted 24% reduction in consumption following a 20% price increase—owing to the model's reliance on a simplified, stylized framework—I remain confident in the directional insight that a price increase would reduce demand for denim jeans, a discretionary good. Robustness checks, placebo validation, and temporal stability in elasticity estimates lend significant credibility to this.

That being said, the projected environmental impact of a 20% tax on denim jeans is modest at best. Canada's total emissions in 2023 amounted to approximately 800 million tonnes of CO_2-eq.[49] The predicted emissions reduction of 0.5 tonnes CO_2-eq under this tax accounts for a mere 0.0000000625% of national emissions—so negligible that it raises legitimate concerns about this hypothetical policy's practical value, especially when weighed against the administrative complexity and political resistance of taxing apparel.

But focusing exclusively on this aspect risks overlooking a far more significant issue: the unnecessary, gluttonized production characterizing the fashion industry. In Vancouver alone, approximately 20,000 tonnes of textiles—equivalent to 44 T-shirts per person—are discarded each year.[50] This sobering example highlights the entrenched overconsumption of apparel in Canada and the systemic failure to meaningfully curb textile waste on a national level.

Denim, a durable fabric, should ideally be worn to its full capacity before replacement. In practice, however, Canadians face no meaningful disincentive against excessive consumption. As such, the value of a tax on denim jeans may lie less in its direct role as an emissions reduction tool and more in its ability to provoke reflection—acting as a behavioural nudge toward sustainable consumption while concretizing the environmental costs of fashion in economic terms.

8.4 Ideal Extensions

Given additional time and resources, I would enhance my analytical framework by leveraging transaction-level data on denim jeans. This would directly overcome the present limitation of relying on aggregated proxy data, facilitating a more accurate estimation of demand elasticity. Specifically, I would extend the analysis to a two-good market model, explicitly accounting for interactions between primary (new jeans) and secondary (second-hand jeans) markets. Such an approach would capture substitution effects that

[49] Our World in Data, "Greenhouse Gas Emissions," 2023, https://ourworldindata.org/greenhouse-gas-emissions.

[50] Baneet Braich, "Textile Waste Is a Growing Problem — and Canada Still Isn't Doing Enough to Solve It, Experts Say," CBC News, 2022, https://www.cbc.ca/news/canada/british-columbia/textile-waste-recycling-bc-canada-1.6357584.

are increasingly relevant, given a climate-conscious generation that both glamourizes and recognizes the environmental sensibility of shopping thrifted and vintage clothing.

This cohort is likely characterized by higher income elasticity of demand, making them more prone to switching toward second-hand alternatives in the face of a price hike on jeans. An extended analysis could systematically collect transaction data from second-hand platforms like Depop, Vinted, eBay, and TheRealReal through web scraping techniques. These marketplaces offer a diverse mix of resale options, from high-end vintage to low-cost fast-fashion resale, making them critical to capturing substitution effects between new and used jeans. However, my attempts to collect data from Depop and Vinted in the earlier stages of this project were obstructed by some notable constraints: sold items are archived, preventing access to historical sales data, while active listings can be refreshed by users, resetting the posting date and obscuring true time-on-market.

To rigorously account for consumer heterogeneity, I would employ a segmented demand model incorporating interaction terms and hierarchical random effects, varying sub-segments of the market to isolate their respective responses. This approach would capture differential elasticities and reveal nuanced patterns that are otherwise obscured in my analysis. It could also prove particularly valuable for modelling the dynamics of fast fashion retailers whose aggressively discounted, low-priced products are systematically underpriced relative to their production costs and environmental externalities.

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