Essays in Empirical Industrial Organization

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Introduction

- Traditional empirical models of demand often make the following assumptions:
  1. Full information: consumer considers all products
  2. Static choice: consumer only considers purchasing for current period
  3. Additively-separable demand shocks
- Do we make the right conclusions if these assumptions do not hold?
  - Estimators may become inconsistent, but does it matter qualitatively?
- Are there questions we cannot answer maintaining the standard assumptions?
  - We cannot evaluate counterfactuals that affect information or dynamics

Research Proposal

1. **Inertia in the market for mobile telephony**
2. **Collusion in the Austro-Hungarian Sugar Industry 1889-1914**

   with Nikolaus Fink, Philipp Schmidt-Dengler, and Christine Zulehner
3. **Revisiting demand estimation in storable goods markets**

Chapter 1

Inertia in the market for mobile telephony

Motivation

- Despite availability of cheaper offers, significant inertia in mobile telephony market RTR
- Over the course of two years, consumers can leave up to 450€ on the table
- Regulators try to lower several frictions at once: EU directive 2018/1972, TKG (2021)
- **Research Questions:**
  - Which market frictions matter most for explaining observed inertia?
  - What is the optimal regulatory response? Should consumers be "forced to make a choice"?

Approach

- Gather plan-level data that includes both within- and between provider switching
- Estimate a structural model of demand that accounts for several sources of inertia
  - Taste
  - Switching cost
  - Inattention
  - Limited consideration
- Evaluate different policy options in counterfactual scenarios where frictions are removed

Related Literature

- **Demand estimation for telecom services.** Train, McFadden, and Ben-Akiva (1987), Viard (2007), Grubb and Osborne (2015), Bourreau, Sun, and Verboven (2021), Weiergraeber (2022)

- **Quantification of frictions.** Shcherbakov (2016), Heiss et al. (2021), Abaluck and Adams-Prassl (2021), Dressler and Weiergraeber (2023)

- **Smart defaults and other policies targeting inertia**: Gravert (2024), Handel and Kolstad (2015), CMA, BEREC

Data

I construct a data set on individual-time-product level by matching two data sources:

- Survey[1]
  - $N = 2000$–3000 Austrian consumers Sampling
  - Consumer sociodemographics, user type, search behaviour (all in 2024Q1) Full list
  - Current and previous plan choice in 2022-2024 Timing
- Tarife.at
  - Plan prices and characteristics 2019Q2-2024Q1 Full list

[1] The survey is joint work with a FWF/DFG funded research group led by Christine Zulehner and Heiko Karle.

Screenshot of Survey

Willkommen zu einer anonymen Umfrage der Universität Wien, Innsbruck, und Frankfurt School of Finance & Management.
Thema: Konsumentenverhalten am Markt für Handytarife.
Dauer: 15 min.
Möchten Sie teilnehmen?

- ○ Ja
- ○ Nein

→

Model

- Following Abaluck and Adams-Prassl (2021), I combine a conditional logit with consideration sets
- 3 channels how characteristics $\mathbf{x}_{jt}$ and demographics $\mathbf{z_i}$ affect whether consumer chooses plan j

Utility

$$\begin{aligned} u_{ijt} &= \mathbf{x}'_{jt}\beta + \zeta \cdot Switch_{ijt} + \xi_j + \varepsilon_{ijt} \\ &= \delta_{ijt} + \varepsilon_{ijt} \end{aligned}$$

Attention

$$\mu_{it} = Pr(\text{shop around}) := \Lambda(\mathbf{x}_0, \mathbf{z}_i, \xi_j)$$

Consideration

$$\phi_{ijt} = Pr(\text{consider product } j) := \Lambda(\mathbf{x}_{jt}, \mathbf{z}_i, \xi_j)$$

- where ε_{ijt} is distributed i.i.d. type 1 extreme value, ξ_j is a brand fixed effect, and $\phi_{i0t} = 1$

Conditional choice probabilities

- Choice probabilities $s_j^\star$ depend on consideration – consumer only chooses from products in consideration set C

$$s_j^\star(\mathbf{x}_t \mid C) = \begin{cases} \frac{\exp(\delta_j)}{\sum_{k \in C} \exp(\delta_k)} & \text{if } j \in C \\ 0 & \text{otherwise} \end{cases}$$

- The probability that a consumer chooses from consideration set C is

$$\pi_C(\cdot) = \prod_{j \in C} \phi_j(\cdot) \prod_{j' \notin C} (1 - \phi_{j'}(\cdot))$$

- For every consumer and time period, consideration set probabilities π_C sum up to 1

Unconditional choice probabilities

- We need to weigh each conditional choice probability $s_j^\star(\mathbf{x}_t \mid C)$ with probability that the consumer chooses from consideration set C, π_C
- This implies the following unconditional choice probabilities s_j

$$s_j(\cdot) = \mu(\cdot) \sum_{C \in \mathbb{P}(j)} \pi_C(\cdot) s_j^\star(\cdot \mid C) \quad \text{for } j \neq 0,$$
$$s_0(\cdot) = \mu(\cdot) \sum_{C \in \mathbb{P}(0)} \pi_C(\cdot) s_j^\star(\cdot \mid C) + (1 - \mu(\cdot))$$

- where $\mathbb{P}(j)$ is the set of consideration sets which include product j (and the previous plan)
- If a consumer does not shop around, $\mu = 0$, she chooses her previous plan $s_0 = 1$

Identification

- Key challenge: disentangle different sources of inertia
- We need an assumption to identify cross-characteristics responses, e.g., $\frac{\partial s_j}{\partial x_{j'}} \rightarrow$ No time varying unobserved product characteristics that correlate with observed variables
- Consideration probabilities π_C are identified from asymmetric demand responses (violation of Slutsky Symmetry)
  - Intuition: consumers switch away when their current plan increases in price, but not when other plans decrease in price
  - In the model this can only happen because of inattention/limited consideration
  - Technically, a (testable) rank condition on the coefficient matrix of choice share differences between goods needs to be fulfilled
- Latent choice probabilities $s^\star(\quad | C)$ are identified from absence of nominal illusion
- Given identification of $\frac{\partial s_j}{\partial p_{j'}}, \pi_C, s_j^\star$, identification of mean preferences is standard (how choice shares vary with characteristics)

Estimation

- I estimate the model by maximum likelihood

$$\log \mathcal{L}(y_{it}; X, \theta) = \sum_{i=1}^{N} \sum_{t=1}^{T} \sum_{j \in \mathcal{J}_{it}} \mathbb{1}_{y_{it}=j} \log s_{itj}(\mathbf{x}_t, \mathbf{z}_i; \theta)$$

- where y_{it} is the index of the product that consumer i chooses in period t
- Computational challenge:
  - large number of consideration sets ($2^{\#\text{products}}$)
  - but many fringe firms, largest 5 providers capture ~97% market share
  - aggregation over plans by user types (low, medium, high, power user)

Next Steps

- Run pre-test and final survey (expected: 2024Q2)
- Expand model to account for heterogeneities
- Coding up estimator and estimate model
- Simulate counterfactuals and compare switching rates $\frac{1}{N}\sum_{i=1}^{N}(1 - s_{i0})$:
  - Forced attention/choice: $\mu = 1$
  - Remove switching cost: $\xi = 0$
  - Full consideration: $\phi = 1$
  - Differences in switching rates reveal relative importance of frictions

Chapter 2

Collusion in the Austro-Hungarian Sugar Industry 1889-1914

with Nikolaus Fink, Philipp Schmidt-Dengler, and Christine Zulehner

Motivation

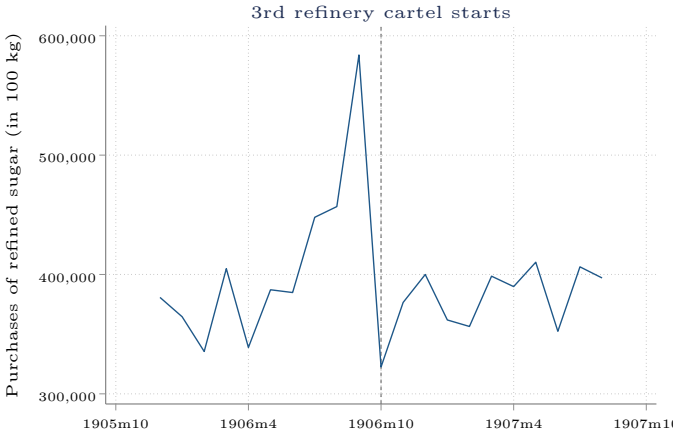
- Sugar industry was an important industry for the monarchy (10% of total trade flows)
- Series of *legal* cartels between 1889-1914
- Observing cartel dates we can estimate demand, supply, and (changes in) conduct
- Cartel dates were public information which appears to have triggered stockpiling
- Research questions:
  - What is the average degree of collusion? What is the counterfactual competitive price?
  - Did storing behaviour reduce the welfare costs of cartelisation?
  - Did integrated cartels obtain higher markups than downstream-only cartels?

Related Literature

- **Estimation of conduct in the sugar industry:** Genesove and Mullin (1998)
- **Estimation of conduct in homogeneous good industries:** Porter (1983)
- **Factors determining cartel success:** Levenstein and Suslow (2006)

  $\rightarrow$ *We estimate conduct taking into account stockpiling dynamics* (monthly data)

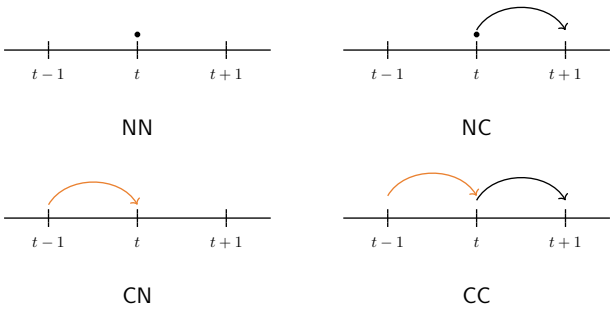
Hints of stockpiling



Data source: Centralverein der Rübenzuckerindustrie

Methodology: Demand

- We adapt the dynamic model from Hendel and Nevo (2013) which allows for storage
- 4 states, where state C ("cheap") occurs in period t if $p_t \leq p_{t+1}$ More on assumptions



- **Instruments:** price of raw sugar (global market), tax on refined sugar, cartel dates

Methodology: Supply

- Supply: generalisation of static and symmetric Cournot (for now)

$$\text{FOC:} \quad P(Q) + P'(Q) \underbrace{\theta}_{\text{as if } \theta := \frac{dQ}{dq_j}} q_j = MC(W, ST)$$

- Current information on MC:
  - MC did not vary with quantity (according to Genesove and Mullin 1998)
  - Raw sugar was turned into refined sugar in fixed proportion (1.11:1)
- Conduct parameter θ (elasticity adjusted price-cost markup):

$$\frac{\theta}{N} = \frac{\frac{P-MC}{P}}{\frac{1}{\eta}}$$

Next Steps

- Finish coding up estimator
- Expand specification for supply side
- (Digitalise more data)
- Estimate demand, supply, and conduct
- Simulate counterfactuals
  - Price under cournot competition: $\frac{\theta}{N} = \frac{1}{N}$
  - Collusive price in absence of stockpiling

Elasticity in absence of stockpiling

Chapter 3

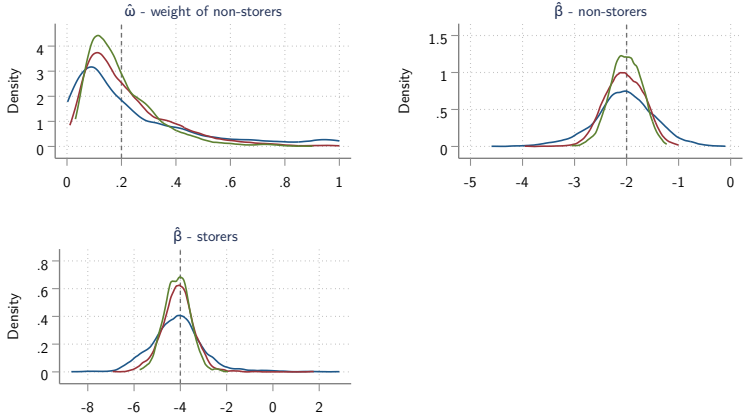
Revisiting demand estimation in storable goods markets

Outline

- Demand for storable goods can feature stockpiling dynamics
- The resulting non-linearities can give rise to *non-additively separable* demand shocks
- Hendel and Nevo (2013) derive such a model, but eventually ignore non-separable shocks
- So do Wang, Rojas, and Colantuoni (2017) who adapt that model
- Research questions (data):
  - Can we ignore non-additively separable shocks if they are present? (simulated data)
  - Should we include them in our model in the first place? (scanner data)

Preliminary Monte Carlo Results

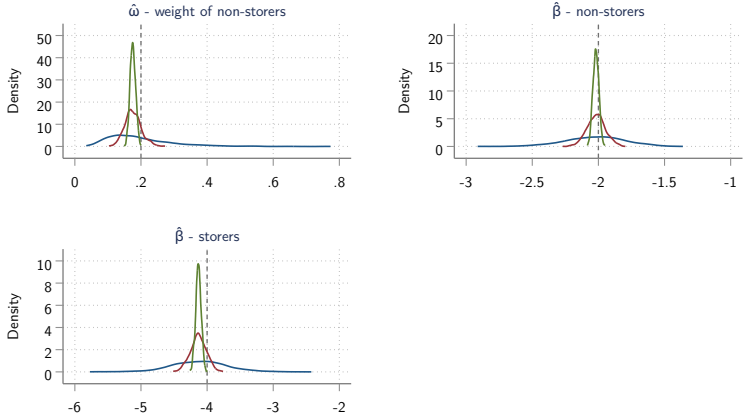
Small Sample



Repetitions = 1000
Sample Sizes: 100, 200, 300

Preliminary Monte Carlo Results

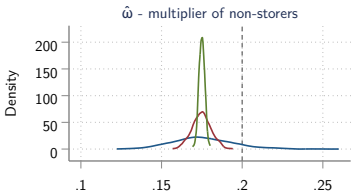
Large Sample

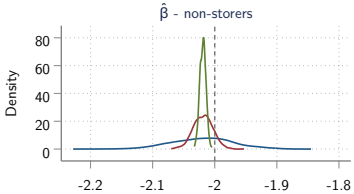


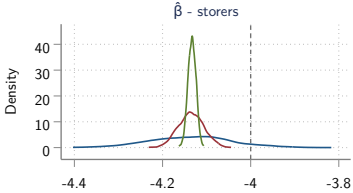
Repetitions = 1000
Sample Sizes: 500, 5000, 50000

Preliminary Monte Carlo Results

Huge Sample







Repetitions = 1000
Sample Sizes: 10000, 100000, 1000000

Discussion

- Distributions center to the left of true values
- $\hat{\beta}^s$ performs worse than $\hat{\beta}^n$
- In sum, estimator that ignores shocks is inconsistent

Next Steps

- Code up the full original estimator (panel setting)
  - Store dimension
  - Three differentiated products (Pepsi, Coca-Cola, store brand)
- Estimate model with and without non-separable shocks on observational data

Research Proposal

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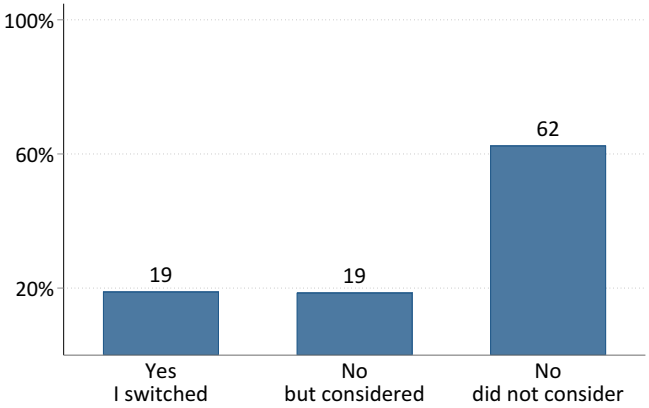
Appendix 1

Did you switch provider in 2019-2021?

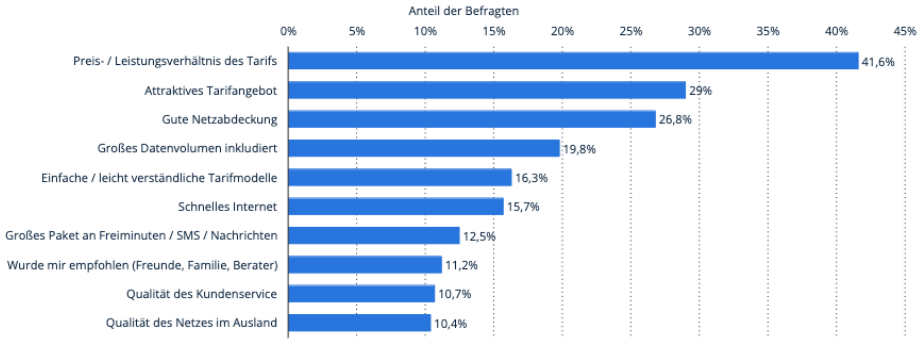


Data source: RTR (2021) Back

Why did you choose your current provider?

Aus welchen Gründen haben Sie sich für Ihren aktuellen Mobilfunkanbieter entschieden?

Gründe für die Wahl des aktuellen Mobilfunkanbieters in Österreich 2021



18 **Beschreibung:** Bei einer Meinungsumfrage in Österreich aus dem Jahr 2021 über die Gründe bei der Wahl des Mobilfunkanbieters, gaben 41,6 Prozent der Befragten an, sich vor allem wegen des Preis-Leistungsverhältnisses des Tarifs für einen bestimmten Anbieter entschieden zu haben. 26,8 Prozent der befragten Teilnehmer gaben eine gute Netzabdeckung als Grund an. Empfehlungen durch Freunde, Familie oder Berater waren nur für 11,2 Prozent der Befragten entscheidend. Mehr

Hinweis(e): Österreich; 6. Mai 2020 bis 6. Mai 2021; 39791 Befragte; ab 14 Jahre; Repräsentativ für die österreichische Bevölkerung; Top 10

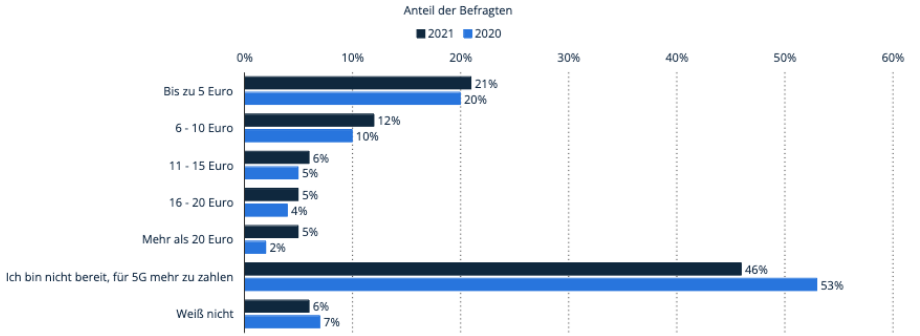
Quelle(n): Marketagent

statista

Willingness to pay for 5G

Wenn 5G zehnfach schnelleres Internet bereitstellt, wie viel sind Sie bereit, mehr zu zahlen?

Zahlungsbereitschaft für 5G in Österreich 2021



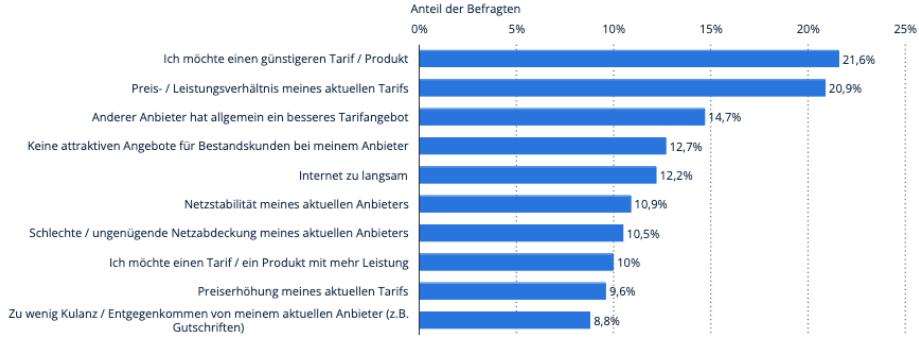
35 **Beschreibung:** Laut einer Umfrage von Deloitte im Jahr 2021 waren 46 Prozent der Befragten in Österreich nicht bereit, für eine 5G-Verfügbarkeit, die ein zehnfach schnelleres Internet bereitstellt, mehr Geld zu zahlen. Im Jahr 2020 waren es mit 53 Prozent noch etwas mehr. Mehr
Hinweis(e): Österreich; Sommer 2021; 1000 Befragte
Quelle(n): Deloitte

statista

Why do you consider switching provider?

Aus welchen Gründen haben Sie vor Ihren aktuellen Mobilfunkanbieter zu wechseln?

Gründe für einen Anbieterwechsel in Österreich im Jahr 2021



25 **Beschreibung:** Bei einer Meinungsumfrage in Österreich aus dem Jahr 2021 zu den Gründen für einen gewünschten Mobilfunkanbieterwechsel gaben mit 21,6 Prozent die meisten der Befragten an, einen günstigeren Tarif haben zu wollen. 20,9 Prozent der befragten Österreicher nannten als Grund dafür, warum sie (eher) den Anbieter wechseln würden, das Preis- / Leistungsverhältnis ihres aktuellen Tarifs. Mehr
Hinweis(e): Österreich; 5. Mai 2020 bis 5. Mai 2021; 7.928 Befragte*; ab 14 Jahre; Repräsentativ für die österreichische Bevölkerung, Top 10 ; * Basis: Entscheidungsträger bzgl. der Wahl eines Mobilfunkanbieters würden (eher) den Mobilfunk-Anbieter [...] Mehr
Quelle(n): Marktagent

statista

Sampling

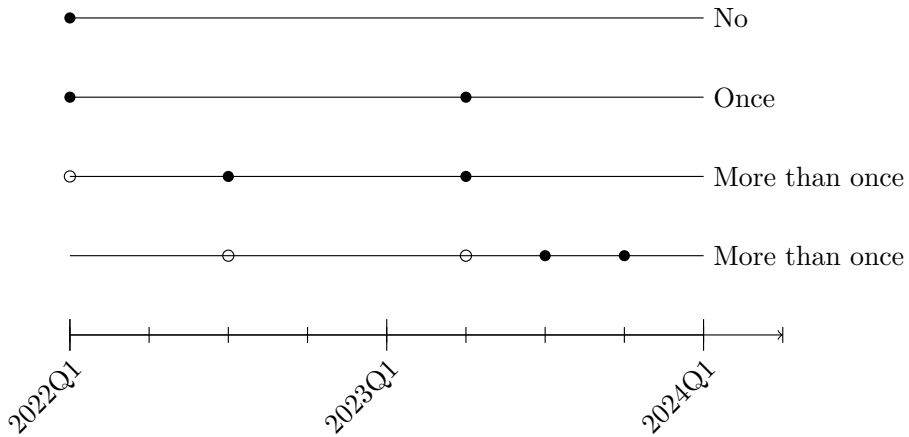
The survey filters for consumers that fulfil the following criteria:

- At least 18 years old in 2022
- They have and know about their Austrian (domestic) plan
- The plan is for retail customers
- They pay for the plan themselves
- They chose the plan

Criteria must be fulfilled for both current and previous plan Back

Possibilities of single wave

Did you switch mobile telephony plan in 2022/2023/2024? Back



Specification

Attention

$$\mu_{it} = \frac{\exp(\mathbf{x}'_{0_i t}\lambda + \mathbf{z}'_i\kappa + \xi^{in}_{\psi(0_i)})}{1 + \exp(\mathbf{x}'_{0_i t}\lambda + \mathbf{z}'_i\kappa + \xi^{in}_{\psi(0_i)})}$$

Consideration

$$\phi_{ijt} = \frac{\exp(\mathbf{x}'_{jt}\gamma + \mathbf{z}'_i\rho + \xi^{c}_{\psi(j)})}{1 + \exp(\mathbf{x}'_{jt}\gamma + \mathbf{z}'_i\rho + \xi^{c}_{\psi(j)})}$$

Choice

$$\begin{aligned} u_{ijt} &= \mathbf{x}'_{jt}\beta + \zeta_1 \cdot \mathbb{1}_{y_{it} \neq y_{it-1}} + \zeta_2 \cdot \mathbb{1}_{\psi(y_{it}) \neq \psi(y_{it-1})} + \xi^{u}_{\psi(j)} + \epsilon_{ijt} \\ &= \delta_{ijt} + \epsilon_{ijt} \end{aligned}$$

Variables $(\mathbf{z}_i, \mathbf{x}_t)$

Sociodemographics	Plan Characteristics
Gender Back	Monthly fee
Age	Annual fee
Region	SMS
Income Bracket	Minutes
Education	Gigabyte
Marital Status	5G
Household Size	Download Speed
Children	Commitment period
Employment Status	EU Roaming
User Type	Non-EU Roaming
Has searched in price comparison websites	Bundle (plan+wifi, plan+fixed line)
Has searched in local shops	Family rebate

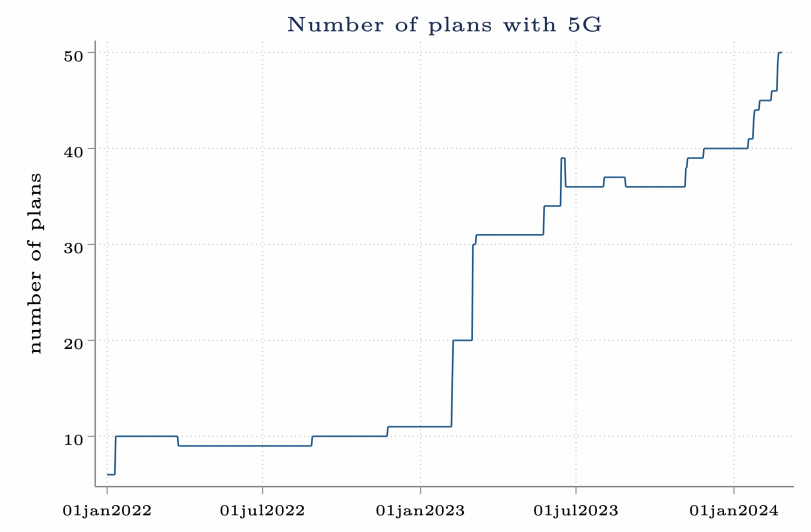
Potential further variables

- provider specific
  - brick and mortar shops by region
  - network quality by region
  - advertising expenditure over time
  - offer of phones, or at least number of phones available for bundle
- individual/demographic specific
  - ad exposure
  - proxy for ad exposure like media exposure

Why would characteristics affect attention?

- Prices
  - Reme, Røhr, and Sæthre (2022) finds increased churn rater after price changes, even after price *de*creases
  - price comparison websites offer reminders
  - can include potential savings (with come caveats) rather than price

5G


Number of plans with 5G
number of plans
50
40
30
20
10
01jan2022
01jul2022
01jan2023
01jul2023
01jan2024

What is a plan?

- Can reduce number of plans by grouping them into four categories: low (prepaid), mid, high, power
- RTR definitions for usage (gigabyte etc) available

Unobserved product characteristics

1. What would these be? I observe essentially all characteristics related to the *plan*
2. I do not observe characteristics related to the *provider/brand*, but what would this be? Customer service?
3. Does customer service vary over time? Maybe, but how much in 2-3 years? (Investment data from RTR shows no trend 2018-2022, except for covid drop in 2021)
4. Sample period has rather stable market conditions
5. Even if customer service varies over time, prices do not vary much –> would customer service then be correlated with price?

Cost shifters

- wholesale electricity prices? –> moved around a lot, while telecom prices did not move much or often
- wages in telekom industry?
- constructions cost?

These are cost components, but more fixed cost rather than marginal cost.

Hausman instruments?

- prices of same provider in different market which shares common cost shocks, but unrelated omitted product characteristics
- time period is market: lagged/future prices?
- broadband prices? (not all firms offer broadband too, are the omitted product characteristics different)

Identification of switching cost

- Assumptions
  - characteristics are exogenous
  - no consumer learning (time invariant preferences)
- Thought experiment: two products have same characteristics today, one was upgraded to 5G earlier than the other, which attracted consumers, if choice shares are different today then that can only because of switching cost
- (Churn data can also help)

Daly-Zachary Conditions

Intuition:

- All cross-derivative asymmetries are due to imperfect consideration

Conditions

- partial derivative of latent choice probability wrt to all other goods prices (compounded) exists, is non-negative and continuous
- cross-price derivatives of latent choice probabilities are symmetric
- no nominal illusion (latent choice probabilities are invariant to price shifts across the board)

Latest Policies against inertia

- EU: directive 2018/1972 "European Electronic Communications Code"
- AUT: Telekommunikationsgesetz Oct 2021 "TKG 2021"
  - 1 month cancellation period (maximum)
  - 24 months commitment (maximum)
  - Provider has to notify consumer when commitment is about to end
  - 1/year provider has to highlight cheapest plan to consumer based on usage
- If consumers have full consideration these policies have no effect
- Empirical question if they work if consumers have limited consideration

Telecommunication law (TKG 2021)

§ 135 (7)

Anbieter nach Abs. 1 haben Endnutzern, in den Fällen einer automatischen Verlängerung nach einer Befristung, zumindest einmal jährlich, jedenfalls aber zum Zeitpunkt einer Information nach Abs. 6, über den anhand ihres Nutzungsverhaltens im vergangenen Jahr bestmöglichen Tarif in Bezug auf ihre Dienste zu informieren.

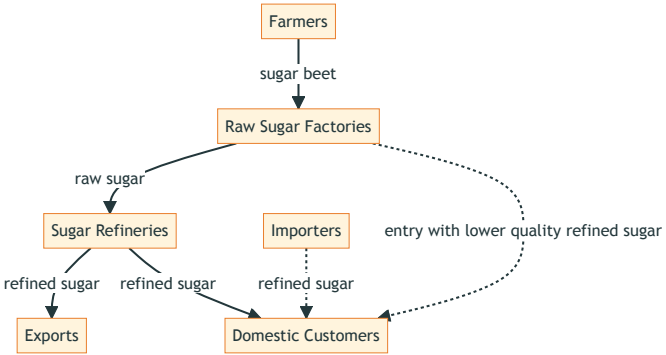
Directive

Article 105(3)

Where a contract or national law provides for automatic prolongation of a fixed duration contract for electronic communications services other than number-independent interpersonal communications services and other than transmission services used for the provision of machine-to-machine services, Member States shall ensure that, after such prolongation, end-users are entitled to terminate the contract at any time with a maximum one-month notice period, as determined by Member States, and without incurring any costs except the charges for receiving the service during the notice period. Before the contract is automatically prolonged, providers shall inform end-users, in a prominent and timely manner and on a durable medium, of the end of the contractual commitment and of the means by which to terminate the contract. In addition, and at the same time, providers shall give end-users best tariff advice relating to their services. Providers shall provide end-users with best tariff information at least annually.

Appendix 2

Supply Chain of the Sugar Industry



Reasons for cartel breakdowns

Cartel	Duration	Reason for Breakdown
1st refinery cartel	1891m10-1894m9	Entry from new refineries
2nd refinery cartel	1895m11-1897m10	Start of 1st integrated cartel
1st integrated cartel	1897m11-1903m8	International trade agreement
3rd refinery cartel	1906m10- 1911m9	Start of 2nd integrated cartel
2nd integrated cartel	1911m10 -1914m8	World War I

Assumptions for dynamic model of demand

- There are two types of consumers: storers and non-storers
- They have potentially different elasticities of demand
- Storage is free for one month, but infinitely costly afterwards, no discounting
- Therefore, consumers store at most for one month
- Consumers have perfect foresight of prices in next month
- If prices today are the same as tomorrow, storers purchase today

These assumptions can be relaxed to some extent Back

Demand Specification

Aggregate purchases X_t are given by

$$\begin{aligned} X_t &= x_t^n + x_t^s \\ &= q_t^n + (\mathbb{1}_{\text{buy for t}}\, q_t^s + \mathbb{1}_{\text{buy for t+1}}\, q_{t+1}^s) \\ &= \omega e^{\alpha+\beta^n p_t+\varepsilon_t} + (1-\omega)(\mathbb{1}_{\text{buy for t}}\, e^{\alpha+\beta^s p_t+\varepsilon_t} + \mathbb{1}_{\text{buy for t+1}}\, e^{\alpha+\beta^s p_t+\varepsilon_{t+1}}) \end{aligned}$$

- Estimating Equation

$$\log X_t = \alpha + \log \tilde{X}_t + u_t$$

$$\text{where} \quad \tilde{X}_t = \omega e^{\beta^n p_t+\varepsilon_t} + (1-\omega)(\mathbb{1}_{\text{buy for t}}\, e^{\beta^s p_t+\varepsilon_t} + \mathbb{1}_{\text{buy for t+1}}\, e^{\beta^s p_t+\varepsilon_{t+1}})$$

- Estimation by GMM if shocks are ignored or if shocks $\varepsilon_t, \varepsilon_{t+1}$ are included by MSM
- MSM is needed because without simulation of $\varepsilon_t, \varepsilon_{t+1}$, we cannot evaluate the sample analog of the moment condition

Demand elasticity in absence of stockpiling

$$
\begin{aligned}
\eta := \frac{\partial Q}{\partial P}\frac{P}{Q} &= \frac{\frac{\partial}{\partial P}[\omega e^{\alpha+\beta^n P} + (1-\omega)e^{\alpha+\beta^s P}]}{Q}P \\
&= \frac{\beta^n \omega e^{\alpha+\beta^n P} + \beta^s(1-\omega)e^{\alpha+\beta^s P}}{\omega e^{\alpha+\beta^n P} + (1-\omega)e^{\alpha+\beta^s P}}P \\
&= [\beta^n \frac{\omega e^{\alpha+\beta^n P}}{\omega e^{\alpha+\beta^n P} + (1-\omega)e^{\alpha+\beta^s P}} + \beta^s \frac{(1-\omega)e^{\alpha+\beta^s P}}{\omega e^{\alpha+\beta^n P} + (1-\omega)e^{\alpha+\beta^s P}}]P \\
&= [\beta^n Qshare^n + \beta^s Qshare^s]P
\end{aligned}
$$

Back

Appendix 3

Set up

- We initialise the NLLS estimation routine with the true parameter vector
- Similar mean and sd of price, quantity, sales periods and sales definition
- Set true parameters approx. equal to their estimates
- $P_t \overset{\text{iid}}{\sim}$

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