Price Discrimination in Supply Chains

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Markup welfare costs

In supply chains, heterogeneous **linear markups** affect welfare because:
(Edmond, Midrigan & Xu, 2023)

1. Act as a tax in production
2. Harm aggregate TFP through production factor misallocation
3. Distort firm entry

Price discrimination

amazon business

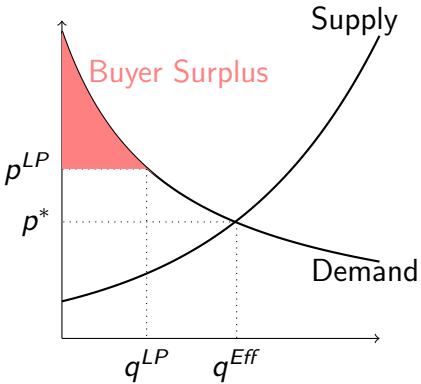
Quantity Discounts

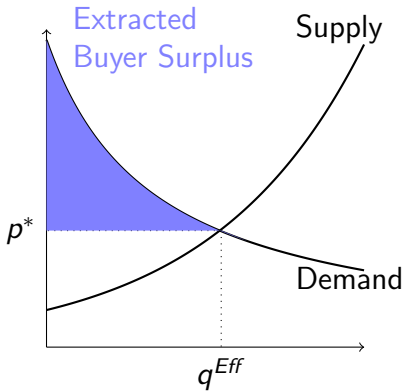
Save 5% or more with Quantity Discounts on over 60 million products starting at just two units of the same item.

Price discrimination implications

- Under price discrimination in supply chains, the average price is not fully allocative
- Average markups are no longer a sufficient statistic to measure inefficiencies
- Need a different approach to study the "tax" on production, resource missallocation and firm entry

Linear marked up price vs. 1st degree price discrimination





Nontrivial welfare effects relative to linear prices:

- Improved resource allocations $(+)$
- Lower buyer surplus harms entry $(-)$

This paper: What we do

Price discrimination descriptive evidence:

- Firm-to-Firm transactions for Chile descriptive statistics

Model

- Based on quantity discounts price discrimination literature + third-degree
- Supply chain with endogenous entry
- Firms can price discriminate, but also face price discrimination as buyers

Model quantification and counterfactuals

- Calibrate the model using Chilean data
- Compare welfare under planner vs linear pricing vs price discrimination

This paper: What we find

Descriptive Evidence

- Price discrimination is prevalent in the data; both second and third-degree

Model: Price discrimination (PD) vs Linear Prices (LP)

- PD increase expected firm-level output but decrease firm entry
- Outputs dominate; welfare is higher under PD relative to LP
- Under PD, markups' negative effects on welfare are 65% of those in LP setups

Why should we care?

- Policy to eliminate inefficiencies is different in PD than in LP

Literature

Firm-level distortions and macroeconomic outcomes

Hopenhayn (1992), Restuccia and Rogerson (2008), Hsieh and Klenow (2009, 2014), Bento and Restuccia (2017), De Loecker, Eeckhout, and Mongey (2022), Peter and Bornestein (2024)

Within supply chains

Baqaee and Farhi (2020), Bigio and La'O (2020), Baqaee and Farhi (2021), Edmond, Midrigan, and Xu (2023), Burstein, Cravino, and Rojas (2024), Boehm, Oberfield, South and Waseem (2024)

Price discrimination

Mussa & Rosen (1978), Borenstein (1985), Wilson (1993), Goldberg (1996), Stole (2007)

Agenda

1. Descriptive Evidence
2. Model
3. Counterfactuals and Model Quantification
4. Conclusion

Data sources

Invoice example

Invoice transactions for the universe of Chilean formal firms for 2018

- Around 1.3 billion transactions
- More than 10 million different products
- Data on prices and quantities for every product transacted

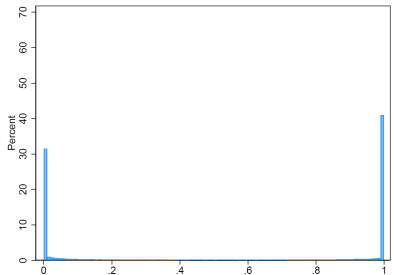
Merged with the firm's accounting balance sheet data

- Sales, materials, investment, 6-digit industry
- Employer-employee: Wages, headcount employees
- Capital stock and investment

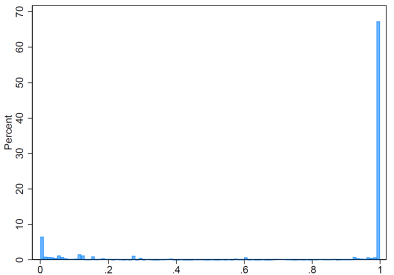
Sales partition: Number of firms

$$X_i = \begin{cases} 0 & \text{if all sales go to final consumers} \\ 1 & \text{if all sales go to other firms} \end{cases}$$

Panel A. Number of Firms



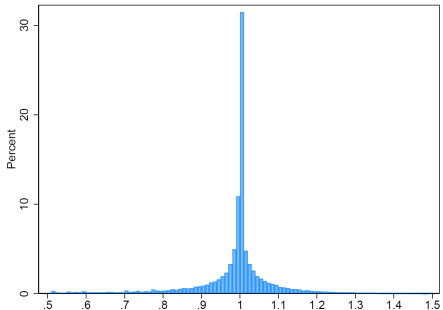
Panel B. Sales weighted



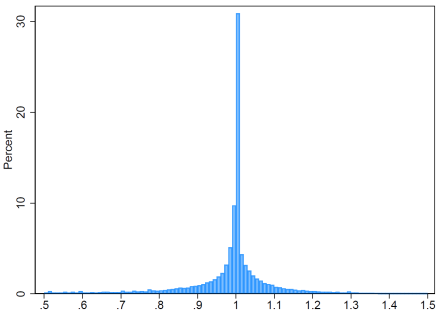
- More than 70% of firms sell only to final consumers or to other firms By sector

Price dispersion

Panel A. June 2018



Panel B. June 19th 2018

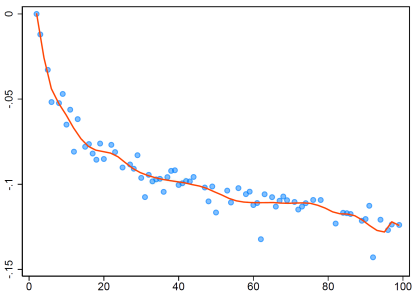


- $\theta_{ig} = \frac{p_{ijg}}{\bar{p}_{ig}}$
- Variance of $\log \theta_{ig} = 0.65$ (excluding products with one transaction)
- No price dispersion in around 30% of transactions

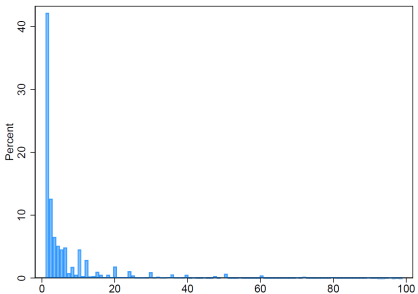
Quantity discounts evidence (second degree)

$$\ln p_{ijg} = \beta_0 + \sum_{r=1}^{100} \beta_r \ln \mathrm{Q\ bin}_r + \ln \psi_{ijg} + \ln \epsilon_{ijg}$$

Panel A. Quantity discounts fixed effects



Panel B. Quantity traded histogram



- Marginal discount diminishes with quantities Average effect By industry

Price dispersion on buyers (third degree)

- Under pure second-degree: fix quantity, price variance should be zero
- Group X:{Seller-Product-Month + Quantity, Buyer}

$$C_X = \frac{\text{Standard deviation } p_X}{\text{median } p_X}; \quad X \in \{\text{Seller-Product + Quantity, Buyer}\}$$

	C_X				
	p10	p25	Median	p75	p90
Seller - product	0.00	0.01	0.06	0.17	2.5
Seller - product - quantity	0.00	0.00	0.04	0.14	1.41
Seller - product - quantity - buyer	0.00	0.00	0.00	0.04	0.24

- Evidence of quantity menus by buyer

Recap of empirical evidence

1. Firms sell predominantly to other firms or final consumers
2. Evidence of price dispersion on around 70% of transactions
3. Marginal discount decreases with quantity
4. Quantity buyer menus seem prevalent (2nd + 3rd degree price discrimination)

Agenda

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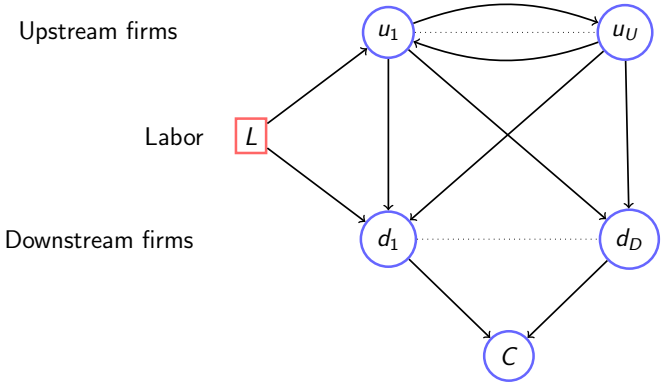
3. Counterfactuals and Model Quantification
4. Conclusion

Supply Chain Structure



Setup: Representative Consumer

- CES aggregator on downstream varieties, z

$$Y = \left(\int_{z_0} q(z)^{\frac{\sigma-1}{\sigma}} M_z \mu(z) dz \right)^{\frac{\sigma}{\sigma-1}}$$

- M_z is the mass of downstream firms and $\mu(z)$ is the density of type z firms
- Offer labor and owns firms and receive their profits
- Budget constraint:

$$Y = wL + \Pi^U + \Pi^D$$

Setup: Firms

- Firm partition on Upstream (sells to other firms only) and downstream firms (sell to final consumers only)
- z is a downstream variety and ζ an upstream variety productivity, $\gamma \in \{z, \zeta\}$
- Production function:

$$q_\gamma = \gamma \left[\alpha \ l(\gamma)^{\frac{\eta-1}{\eta}} + (1-\alpha) m(\gamma)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad \gamma \in \{z, \zeta\}$$

- m is a CES bundle of upstream varieties:

$$m(\gamma) = \left[\int_{\zeta_0} m(\gamma, \zeta)^{\frac{\sigma-1}{\sigma}} M_\zeta \mu(\zeta) d\zeta \right]^{\frac{\sigma}{\sigma-1}}$$

Setup: Entry

- Unbounded pool of prospective entrants that are ex-ante identical
- Pay a sunk cost c_e in units of labor
- Upon entry, firms draw a type from a common distribution $G(\gamma)$, $\gamma \in \{z, \zeta\}$
- Firms choose whether to enter the upstream or downstream
- Free entry into both firms groups ($\mathbb{E}[\pi_\gamma] = c_e w$); M_z, M_ζ are endogenous

Assumptions

1. Upstream firms charge nonlinear prices (2nd degree)
2. Different prices menus to upstream and downstream (3rd degree)
3. Downstream firms charge linear prices to the representative consumer with normalized to 1 price
4. Firms' productivity follows a Pareto distribution with tail parameter κ
5. Firms are infinitesimal and take other firms' pricing strategies as given
6. Aggregate labor supply is exogenous

Upstream profit maximization problem

Guess

- Upstream firm chooses a two-part tariff marginal cost

Mechanism design problem

- Chooses a transfer T and and quantities m, separately for upstream and downstream firms

$$\max_{\substack{\{T(z,\zeta),m(z,\zeta)\},\\ \{T(\zeta',\zeta),m(\zeta',\zeta)\}}} \Pi_\zeta = \underbrace{\mathbb{E}_z\left[T(z,\zeta) - c_\zeta\, m(z,\zeta)\right] M_z}_{\text{from dowstream}} + \underbrace{\mathbb{E}_\zeta\left[T(\zeta',\zeta) - c_\zeta\, m(\zeta',\zeta)\right] M_\zeta}_{\text{from other upstream}}$$

Subject to

- Individual Rationality (IR): Buyers receive non-negative surplus from buying
- Incentive Compatibility (IC): Buyers self-select into their tailored menu

Upstream price scheme

Proposition 1: A flat fee and a linear component describe the solution to the mechanism design problem of the seller: solution strategy

$$T(\gamma,\zeta) = F_\gamma(\zeta) + p(\zeta)m(\gamma,\zeta), \quad \gamma \in \{z,\zeta\}$$

Flat fee: Extract surplus of lower (upstream or downstream) type

Linear allocative markup: $p(\zeta) = \dfrac{\rho}{\rho-1}c(\zeta), \quad \rho = \dfrac{\sigma\kappa}{\sigma-1}, \quad \rho > \sigma$

- Two flat fees, one for upstream and one for downstream firms: second-degree
- Allocative markup is smaller than linear price markup ($\rho > \sigma$)

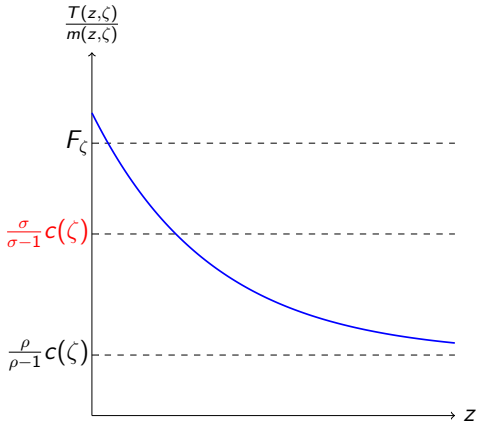
Upstream unit price scheme to downstream firms

Unit price paid by downstream firms:

$$\frac{T(z,\zeta)}{m(z,\zeta)} = \frac{F_z(\zeta)}{m(z,\zeta)} + p(\zeta)$$

- The flat fee unit price share is decreasing in firm productivity
- Complete market coverage (all types have positive virtual utility)

details



Inefficiencies: Intensive margin

▸ Linear price BMK

Aggregate markup $\mathcal{M}$

Acts as a uniform tax on production

$$\mathcal{M} = \underbrace{\frac{M_z}{M}\int_{\zeta_0} \mu_z \frac{l_z}{L_z} dz}_{\textit{Downstream}} + \underbrace{\frac{M_\zeta}{M}\int_{z_0} \mu_\zeta \frac{l_\zeta}{L_\zeta} d\zeta}_{\textit{Upstream}}$$

Markup heterogeneity upstream vs. dowsntream

Generate factor misallocation which harm Aggregate TFP

$$\text{TFP} = \left[\int_\gamma \left(\frac{\mu_\gamma}{\mathcal{M}}\right) \gamma^{\sigma-1} d\gamma\right]^{\frac{1}{\sigma-1}}, \quad \gamma \in \{z, \zeta\}$$

Inefficiencies: Extensive margin

Downstream

- Pay flat fees without receiving, lower profits relative to upstream firms.
- $\Longrightarrow$ Mass of upstream to downstream firms ratio is distorted

Upstream

- Allocative markup distorts profits distribution
- $\Longrightarrow$ Entry upstream is distorted

Welfare: Price discrimination (PD) vs linear pricing (LP)

In this economy, GDP and welfare are given by:

$$Y = \left(\int_{z_0} q(z)^{\frac{\sigma-1}{\sigma}} M_z \mu(z) dz \right)^{\frac{\sigma}{\sigma-1}} \propto \underbrace{\mathbb{E}_z[q(z)]}_{\text{Intensive margin}} \quad \underbrace{M_z}_{\text{Extensive margin}}$$

- PD generates higher output per firm because of lower "output tax": $\mathbb{E}_z[q(z)]^{\text{PD}} > \mathbb{E}_z[q(z)]^{\text{LP}}$
- On average firms use more labor; less labor to allocate to entry: $M_z^{\text{PD}} < M_z^{\text{LP}}$
- Effects on welfare will depend on what margin dominates

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Two counterfactuals

Planer pricing (as in Baqaee and Farhi, 2021)

- Firms must charge markups to incentivize the optimal entry level
- But markup distorts input choices by acting as a uniform tax on production
- An output subsidy can restore undistorted marginal-cost, conditional on entry
- The subsidy is paid via a lump sum tax to the representative consumer

Linear prices (as in Edmond, Midrigan & Xu, 2023)

- Linear markup over marginal cost from monopolistic competition

Optimal policy to implement the efficient allocation

Intensive margin output subsidies

- Downstream: LP markup inverse, $\tau_z = \frac{\sigma-1}{\sigma}$
- Upstream : PD allocative markup inverse, $\tau_\zeta = \frac{\rho-1}{\rho}$

Both paid by a lump-sum taxed to the representative consumer

Extensive margin entry subsidy:

- Downstream: Flat fees from upstream firms, $F_z M_\zeta$
- Upstream: Profits from linear pricing minus allocative markup profits from PD to restore CES linear markups

The first financed by upstream firms and the second by a lump-sum tax on the representative consumer

Assumptions and parametrization

- $\eta = 1$ to ensure equilibrium existence and uniqueness
- $\implies$ Cobb-Douglas production functions

Model Parameters

	Value	Source
Labor share in production (α)	0.38	Calibrated from data
Material bundle elasticity (σ)	3	Hsieh and Klenow (2009)
Firm exit rate ($1 - \delta$)	0.15	Calibrated from data
Entry cost (c_e)	0.16	Assumed
Pareto tail (κ)	2.4	Calibrated from data

Model Quantification: Ratio vs planner pricing

	Linear Pricing (LP)	Price discrimination (PD)
Labor to materials per firm ratio (l/m)	2.25	0.96
Downstream firms expected output ($\mathbb{E}_z[q(z)]$)	0.48	0.86
Total firm mass (M)	1.27	1.11
Firm mass D to U ratio (M_D/M_U)	0.55	0.77
Firm mass Upstream (M_U)	0.85	0.94
Welfare ($Y = GDP$)	**0.62**	**0.76**

Intensive margin

- Expected firm size is half in LP but only 14% smaller in PD

Extensive margin

- The ratio of firm masses is less distorted in PD
- Distortion on upstream firms' mass is lower in PD

Welfare loss under PD is 65% of the welfare loss observed under LP

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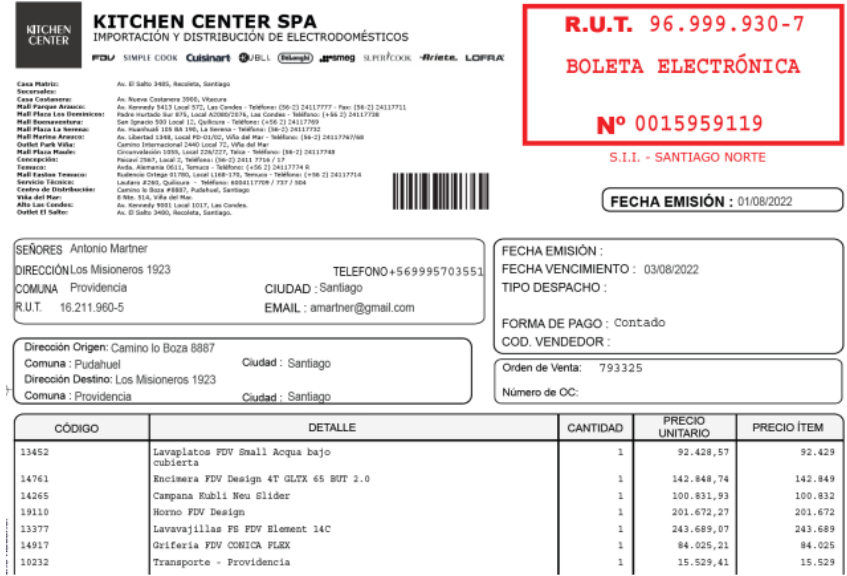
Conclusion: Markups are less costly with price discrimination

- Price discrimination is prevalent in the data
- Accounting for observed price discrimination, markups welfare costs are around 65% of costs linear price setup
- Policy instruments to correct markup distortions under price discrimination are different to linear pricing setups

Invoice Example

Go Back



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FECHA EMISIÓN : 01/08/2022

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FECHA VENCIMIENTO : 03/08/2022
TIPO DESPACHO :

FORMA DE PAGO : Contado
COD. VENDEDOR :

Dirección Origen: Camino lo Boza 8887
Comuna : Pudahuel **Ciudad :** Santiago
Dirección Destino: Los Misioneros 1923
Comuna : Providencia **Ciudad :** Santiago

Orden de Venta: 793325
Número de OC:

CÓDIGO	DETALLE	CANTIDAD	PRECIO UNITARIO	PRECIO ÍTEM
13452	Lavaplatos FDV Small Acqua bajo cubierta	1	92.428,57	92.429
14761	Encimera FDV Design 4T GLTX 65 BUT 2.0	1	142.848,74	142.849
14265	Campana Kubli Neu Slider	1	100.831,93	100.832
19110	Horno FDV Design	1	201.672,27	201.672
13377	Lavavajillas FS FDV Element 14C	1	243.689,07	243.689
14917	Grifería FDV CONICA FLEX	1	84.025,21	84.025
10232	Transporte - Providencia	1	15.529,41	15.529

Sales partition: Sales shares (excluding exports) Go Back

Sector (sales)	All to final consumer	All to other firms
Firm population	0.08	0.67
Agriculture (2%)	0.04	0.60
Mining (1%)	0.27	0.08
Manufacturing (15%)	0.05	0.68
Utilities (3%)	0.20	0.51
Construction (8%)	0.02	0.89
Retail and Wholesale (32%)	0.09	0.68
Transport (10%)	0.16	0.68
Financial Services (18%)	0.18	0.67
Real Estate Services (1%)	0.24	0.37
Business Services (7%)	0.08	0.81
Personal Services (2%)	0.68	0.10

Quantity discounts regressions

Go Back

$$\ln p_{ijg} = \beta_0 + \beta_1 \ln q_{ijg} + \ln \psi + \ln \epsilon_{ijg}$$

	(1)	(2)	(3)	(4)	(5)
ln q	-0.083	-0.051	-0.045	-0.087	-0.071
	(0.00006)	(0.0001)	(0.001)	(0.0001)	(0.00007)
FE Seller×product	✓				
FE Seller×product× buyer		✓			
High price products (>p95)			✓		
Manufacturing				✓	
Retail and wholesale					✓
Observations (millions)	92	52	3.5	25	58
Adjusted R^2	0.928	0.956	0.756	0.911	0.945

Quantity discounts evidence by seller industry

Go Back

Sector	β_1	se	N obs (millions)	Adjusted R2
Agriculture	-0.11	(0.0007)	0.5	0.95
Mining	-0.06	(0.002)	0.05	0.93
Manufacturing	-0.09	(0.0001)	25	0.91
Utilities	-0.07	(0.0005)	1.5	0.85
Construction	-0.31	(0.003)	0.2	0.92
Retail and Wholesale	-0.07	(0.00007)	58	0.94
Transport and ICTs	-0.24	(0.001)	2.7	0.85
Financial Services	-0.20	(0.002)	0.8	0.78
Real Estate Services	-0.35	(0.006)	0.9	0.84
Business Services	-0.26	(0.0003)	0.9	0.96
Personal Services	-0.16	(0.001)	0.2	0.79

Marginal cost

Go Back

$$c(\zeta) = \frac{1}{\zeta} c(w, p_m)$$

$$c(w, p_m) = \left[\alpha^{\eta} w^{1-\eta} + (1-\alpha)^{\eta} p_m^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

Solution Strategy & Mechanism

Go Back

- Initial Conjectures:
  - Two-part tariff: $T(\gamma, \zeta) = p(\zeta)m(\gamma, \zeta) + F_\gamma(\zeta)$
  - Revenue functions: $R(z) = z^\theta y(l(z), m(z))^\theta A_z$
  - Buyer valuation: $\tau(\gamma) = \gamma^{(\sigma-1)/\sigma} p_m m(\gamma_0)^{1/\sigma}$
  - Distribution: τ follows Pareto with tail parameter $\rho = \frac{\kappa\sigma}{\sigma-1}$
- Verification Process:
  - Applied envelope theorem for IC constraints
  - Derived monotonicity conditions
  - Confirmed individual rationality via zero surpluses for the lowest type

Optimal Mechanism Characteristics

Go Back

- Pricing Structure:
  - Linear price: $p(\zeta) = \frac{\rho}{\rho-1} c(\zeta)$
  - Fixed fee: $F_\gamma(\zeta) = \text{Revenue}(\gamma_0) \frac{1}{\left(\frac{\alpha}{1-\alpha}\right)^\eta \left(\frac{pm}{w}\right)^{\eta-1}+1} \left(\frac{1}{\sigma}\right)$
- Properties:
  - Complete market coverage (all types served)
  - Markup lower than standard monopolistic competition pricing
  - Information rents decrease with type concentration (κ)
- Quantity Allocation:
  - $m(\tau, \zeta)$ optimally scales with buyer type
  - Allocation satisfies both IC and IR constraints

Virtual Utility

Go Back Virtual Utility: The profits a seller gets when including a firm type γ

- Positive term: Profits from serving firm type γ
- Negative term: Information rents given to higher types to prevent mimicking lower types
- If the virtual utility is positive, serving every firm type γ is optimal.
- We can show that serving upstream and downstream lowest type is optimal under a Pareto distribution.

Inefficiencies: Linear Price Benchmark

Go Back

Linear pricing (not in supply chains)

- One inefficiency: markup that distorts input choices
- Work as an output tax

Optimal Policy

- Subsidize output to restore marginal cost pricing, conditional on entry