Growth Through Creation and Destruction of Supply Chains

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Value of Entry and Exit

- How does supplier entry/exit affect customers?
- If input is creatively destroyed, how big is innovation step-size?
- If new input is added, how strong is love of variety?
- Either way, entry-exit changes consumer surplus.
- Scant evidence on engine of growth and returns to specialization.

This Paper

- Same forces appear in supply chains.
- “Consumer surplus” reflected in cost/price of downstream firm.
- **Micro**: measure surplus and relate to “step-size”/“love-of-variety.”
- **Macro**: growth accounting with supplier churn.

Selected Literature

- Production networks and extensive margin:
  Baqaee (2018), Baqaee-Farhi (2020), Carvalho-Nirei-Saito-Tahbaz-Salehi (2021), Lim (2017), Miyauchi (2018), Tintelnot-Kikkawa-Mogstad-Dyne (2018), Elliot-Golub-Leduc (2020), Arkolakis-Huneeus-Miyauchi (2021), Acemoglu-Tahbaz-Salehi (2022), Taschereau-Dumouchel (2020).

- Schumpeterian and expanding varieties models of entry and exit:
  Dixit-Stiglitz (1977), Krugman (1979), Romer (1987), Dhingra-Morrow (2019), Matsuyama-Ushchev (2020), Zhelobodko-Kokovin-Parenti-Thisse (2012), Baqaee-Farhi-Sangani (2020), Garcia-Hsieh-Klenow (2019), Akcigit-Kerr (2018), Bilbiie-Ghironi-Melitz (2005), Alessandria-Choi (2007).

- Adjustment of price indices due to entry and exit:
  Feenstra (1994), Broda-Weinstein (2006, 2010), Feenstra-Weinstein (2017), Aghion-Bergeaud-Boppart-Klenow (2019), Blaum-Lelarge-Peters (2018), Gopinath-Neiman (2014), Arkolakis-Demidova-Klenow-Rodriguez (2008).

- Valuing new goods
  Hicks (1940), Hausman (1996), Foley (2022).

Agenda

Microeconomic Analysis

Macroeconomic Analysis

Conclusion

Setup

- Downstream firm has variable cost function

$$C(\boldsymbol{p}, A, Y) = c(\boldsymbol{p}, A)\, Y,$$

  where $\boldsymbol{p}$ is price of inputs, A is technology.

- Downstream firm charges price

$$P = \mu \frac{\partial \log C}{\partial \log Y}.$$

- Define average cost to be

$$AC = \frac{C(\boldsymbol{p}, A, Y)}{Y}.$$

- How do changes in supply chain affect downstream price?

Consumer Surplus

- Share of expenditures on input i:

$$s_i(\boldsymbol{p}) = \frac{p_i x_i}{C(\boldsymbol{p}, A, Y)}.$$

- Suppose the price of some input falls from p_i' to p_i.

- Define resulting "consumer" surplus as

$$\delta_i - 1 = \frac{\int_{p_i}^{p_i'} x_i(\boldsymbol{p}) dp_i}{p_i x_i(\boldsymbol{p})} \geq 0.$$

  Area under the demand curve relative to spending.

- Strictly positive if the demand curve is downward sloping.

Thought Experiment

- Suppose some new suppliers are added.
- Either because of “creative destruction” or “expanding varieties.”
- For the time being, hold everything else constant
  (i.e. markup, technology, prices of all other suppliers).

Creative Destruction

- Creative destruction if replaced by a lower-cost competitor.
- Gap between best and second-best denoted $\log \frac{p_i'}{p_i} = Z_i$.
- Group inputs into types θ by Z_θ with mass M_θ.

Lemma (Creative Destruction)

If ΔM_θ suppliers are creatively destroyed, then

$$\Delta \log AC \approx -s_\theta \Delta M_\theta (\delta_\theta - 1),$$

where $\delta_\theta - 1 \approx Z_\theta$.

Expanding Varieties

- Let $\mathcal{C}$ be HSA, then share of i is

$$s_i(\boldsymbol{p}) = s_i(\frac{p_i}{D(\boldsymbol{p})}),$$

where $D(\boldsymbol{p})$ is defined by

$$\int s_i(\frac{p_i}{D(\boldsymbol{p})})di = 1.$$

- $D(\boldsymbol{p})$ is **not** ideal price index.

- If i enters, then

$$\delta_i - 1 = \frac{\int_{p_i}^{\infty} x_i(\boldsymbol{p})dp_i}{p_i x_i}.$$

Expanding Varieties

- Group inputs into types θ by δ_θ with mass M_θ.

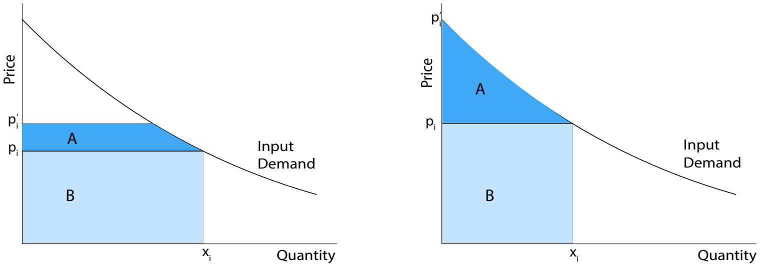
Lemma (Expanding Varieties)

For a mass ΔM_θ of new suppliers, we have

$$\Delta \log AC \approx -s_\theta \Delta M_\theta (\delta_\theta - 1).$$

- CES, $s(x) = x^{1-\sigma}$ and $\delta_\theta - 1 = \frac{1}{\sigma - 1}$.
- Similar if we use Kimball.

Surplus Creation is Key



(a) Creative destruction (b) Expanding variety

- Either way, sufficient statistic is

$$\delta_i - 1 = \frac{A}{B}.$$

Very different to Feenstra (1994) — no reliance on CES or elasticity of substitution.

Putting it all together

Proposition (Combined Shocks)

Allowing everything to change, to a first-order, we can write

$$\Delta \log AC \approx \underbrace{\sum_{i \in N} s_i \Delta \log p_i}_{\textit{intensive margin}} - \underbrace{\sum_{\theta \in \Theta} s_\theta \Delta M_\theta (\delta_\theta - 1)}_{\textit{extensive margin}} + \underbrace{\frac{\partial \log \mathcal{C}}{\partial \log A} \Delta \log A}_{\textit{technology}},$$

- We also have

$$\Delta \log AC = \Delta \log MC.$$

  and

$$\Delta \log P = \Delta \log AC + \Delta \log \mu,$$

- Motivates empirical specification to identify $\delta_\theta - 1$.

Data

- Prices from survey of $\sim 8,000$ manufacturing firms in Belgium (Prodcom).
- Firm-to-firm input-output table from VAT receipts.
- Balance sheet information from annual tax accounts.
- Administrative customs data on imports and exports.

Outcomes of Interest

- For each firm in Prodcom:
  - Average unit-values in place of price .
  - Ratio of Materials + labor (+ capital) to quantity for avg. cost.
  - $\Delta \log \textit{revenues} - \Delta \log \textit{total variable costs}$ to estimate markup.
  - Use $\Delta \log MC = \Delta \log P - \Delta \log \mu$.
- We use these as left-hand side variables.

Estimation

- To estimate δ, motivated by Proposition 1:

$$\Delta \log AC_{it} = \beta \times \text{exit share}_{it} + \text{controls}_{it} + \varepsilon_{it}.$$

- Also use $\Delta \log P_{it}$, $\Delta \log \mu_{it}$, and $\Delta \log MC_{it}$ on LHS.
- Exits of upstream firms can be endogenous:
  - Common shocks to suppliers and their customers.
  - Reverse causality.

Identification Challenge

- We instrument the right-hand side variable by

$$\widehat{\text{exit share}}_{it} = \sum_{J\in\mathcal{I}}\sum_{j\in J}\frac{p_{j,t}x_{ij,t}}{\sum_{J\in\mathcal{I}} P_{iJ,t}X_{iJ,t}}\widehat{\text{exit}}_{jt}, \qquad (1)$$

  and $\widehat{\text{exit}}_{jt}$ is a predictor of supplier j's exit at time t.

- Two different instruments for supplier exits:
  - *Financial shock*: Suppliers' short-term debt obligations interacted with aggregate interest rate changes
  - *Demand Shock*: Suppliers' initial sales shares to non-manufacturing industries interacted with changes in those industries' sales.
- Control for downstream firm's own financial/demand shock.

Estimating $\delta - 1$

	Δ log average Cost						
Exit share	-0.179***	0.861*	0.823**	1.143**	1.935***	1.331***	1.254***
	(0.012)	(0.452)	(0.394)	(0.460)	(0.474)	(0.376)	(0.354)
Controls	Y	N	Y	Y	N	Y	Y
Specification	OLS	IV	IV	IV	IV	IV	IV
Instrument		finance	finance	finance	demand	demand	demand
FE	ind×year	ind×year	ind×year	firm+ind×year	ind×year	ind×year	firm+ind×year

- Columns (1)-(4) use rate shocks, (5)-(8) use demand shocks.
- Controls: price of imports, price of prodcom suppliers, own finance/demand shock, wage bill, capital costs.
- Estimates consistent with $\delta - 1 \approx 1$.
- Under CES with expanding varieties, this implies $\sigma \approx 2$
- Under creative destruction, step size is 100 log points.

Other Outcomes

	dlogmc	wdlogp	dlogmu	dlogmc	wdlogp	dlogmu
Exit share	1.034***	0.704***	-0.330	1.097***	-0.056	-1.153***
	(0.384)	(0.236)	(0.283)	(0.339)	(0.081)	(0.331)
Controls	Y	Y	Y	Y	Y	Y
Instrument	finance	finance	finance	demand	demand	demand
FE	ind×year	ind×year	ind×year	ind×year	ind×year	ind×year

- Increase in $\Delta \log P/\mu \approx \Delta \log \textit{avg. cost}$.
- Model predicts $\Delta \textit{avg.cost}$ and $\Delta \textit{marg.cost}$ similar.
- Incomplete “pass-through” but much lower for demand instrument.
- However, $\Delta \log \mu$ and $\Delta \log P$ need not (and are not) similar.

Robustness

- Measuring average variable cost without including capital.
- Changing fixed effects.
- Robust to changes in product-mix.
- Robust to using lagged-shares for instrument.
- Measuring markups via production function estimation.
- Trimming tails more aggressively.
- Weighting results by $\log$ sales.

Agenda

Microeconomic Analysis

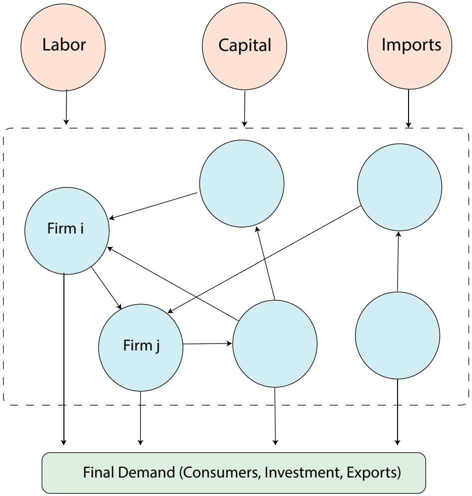
Macroeconomic Analysis

Conclusion

Aggregate Consequences

- Creation and destruction of links changes buyer's price.
- Changes in prices propagate along existing supply lines.
- Eventually hits final consumers & changes real aggregate output.

Circular Flow



Environment

- Producer i at time t has technology

$$y_{i,t} = F_{i,t}\left(\{X_{iJ,t}\}_{J\in\mathcal{I}}, \{l_{if,t}\}_{f\in\mathcal{F}}\right).$$

Environment

- Producer i at time t has technology

$$y_{i,t} = F_{i,t}\left(\{X_{iJ,t}\}_{J\in\mathcal{I}}, \{l_{if,t}\}_{f\in\mathcal{F}}\right).$$

- Inputs from industry J used by i given by

$$X_{iJ,t} = g_{iJ,t}\left(\{x_{ij,t}\}_{j\in J}\right) = \left(\sum_{j\in J} \bar{x}_{ij,t}^{\frac{1}{\sigma_{iJ}}} x_{ij,t}^{\frac{\sigma_{iJ}-1}{\sigma_{iJ}}}\right)^{\frac{\sigma_{iJ}}{\sigma_{iJ}-1}},$$

Environment

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- Final output is

$$d\log Y_t = d\log E_t - \sum_{i\in C_t} \frac{p_{i,t}c_{i,t}}{\sum_{j\in C_t} p_{j,t}c_{j,t}} d\log p_{i,t},$$

and

$$\log Y_{t+T} - \log Y_t = \sum_{s=t}^{t+T} d\log Y_s.$$

Micro-Effect of Churn

- For aggregation, we rely on CES.
- If elast. of subs. between cont. & non-cont. suppliers constant:

$$\Delta \log P_{iJ,t} \approx \Delta \underbrace{\log p_{iJ}^{cont}}_{\substack{\text{continuing} \\ \text{price changes}}} - \underbrace{\frac{1}{1-\sigma_{iJ}} \Delta \log s_{iJ}^{cont}}_{\text{value of churn}},$$

using Feenstra (1994).

Aggregating

- Shephard's lemma implies

$$d\log p_{i,t} = \underbrace{d\log \mu_{i,t}}_{\text{markup}}$$

- Stack all continuing firms and invert linear system.

Aggregating

- Shephard's lemma implies

$$d \log p_{i,t} = \underbrace{d \log \mu_{i,t}}_{\text{markup}} - \underbrace{d \log A_{i,t}}_{\text{tech shock}}$$

- Stack all continuing firms and invert linear system.

Aggregating

- Shephard's lemma implies

$$d \log p_{i,t} = \underbrace{d \log \mu_{i,t}}_{\text{markup}} - \underbrace{d \log A_{i,t}}_{\text{tech shock}} + \sum_{f \in \mathcal{F}} \underbrace{\Omega^{V}_{if,t} d \log w_{f,t}}_{\text{factor prices}}$$

- Stack all continuing firms and invert linear system.

Aggregating

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$$d\log p_{i,t} = \underbrace{d\log \mu_{i,t}}_{\text{markup}} - \underbrace{d\log A_{i,t}}_{\text{tech shock}} + \sum_{f\in\mathcal{F}} \underbrace{\Omega^{V}_{if,t} d\log w_{f,t}}_{\text{factor prices}}$$
$$+ \sum_{J\in\mathcal{I}} \underbrace{\Omega^{V}_{iJ,t} \sum_{j\in C_{iJ,t}} \frac{p_{j,t}x_{ij,t}}{\sum_{k\in C_{iJ,t}} p_{k,t}x_{ik,t}} d\log p_{j,t}}_{\text{continuing input prices}}$$

- Stack all continuing firms and invert linear system.

Aggregating

- Shephard's lemma implies

$$
\begin{aligned}
d\log p_{i,t} = {} & \underbrace{d\log \mu_{i,t}}_{\text{markup}} - \underbrace{d\log A_{i,t}}_{\text{tech shock}} + \sum_{f\in\mathcal{F}} \underbrace{\Omega^{V}_{if,t} d\log w_{f,t}}_{\text{factor prices}} \\
& + \sum_{J\in\mathcal{I}} \underbrace{\Omega^{V}_{iJ,t} \sum_{j\in C_{iJ,t}} \frac{p_{j,t}x_{ij,t}}{\sum_{k\in C_{iJ,t}} p_{k,t}x_{ik,t}} d\log p_{j,t}}_{\text{continuing input prices}} \\
& + \sum_{J\in\mathcal{I}} \underbrace{\frac{1}{\sigma_{iJ}-1} \Omega^{V}_{iJ,t} d\log s^{cont}_{iJ,t}}_{\text{supplier churn}}.
\end{aligned}
$$

- Stack all continuing firms and invert linear system.

Aggregation

For each i buying from industry J, let

$$d\log\mathcal{E}_{iJ,t} \equiv \frac{1}{1-\sigma}\Delta\log s_{iJ,t}^{cont}.$$

Proposition (Growth-Accounting with Entry-Exit)

The change in aggregate output is given, to a first-order, by

$$d\log Y_t = \underbrace{\sum_{i\in C_t}\tilde{\lambda}_{i,t}d\log A_{i,t}}_{\text{technology}} + \underbrace{\sum_{f\in\mathcal{F}}\tilde{\Lambda}_{f,t}d\log L_{f,t}}_{\text{factor quantities}} + \underbrace{\sum_{i\in C_t}\tilde{\lambda}_{i,t}d\log\mathcal{E}_{i,t}}_{\text{extensive-margin}}$$
$$-\underbrace{\sum_{i\in C_t}\tilde{\lambda}_{i,t}d\log\mu_{i,t}}_{\text{markups}} - \underbrace{\sum_{f\in\mathcal{F}}\tilde{\Lambda}_{f,t}d\log\Lambda_{f,t}}_{\text{factor shares}}.$$

- Λ_f and L_f factor income share & quantity.
- A_i and μ_i technology & markup shifter of i.

Efficient Economies Examples

- No markups and no entry-exit, then

$$d \log Y_t = \sum_{i \in N} \lambda_{i,t} d \log A_{i,t} + \sum_{f \in \mathcal{F}} \Lambda_{f,t} d \log L_{f,t}.$$

  Output grows *only* due to process innovation and input growth.

- No markup, and $\sigma = \infty$, with entry-exit (a la Hopenhayn, 1992), then

$$d \log Y_t = \sum_{i \in N} \lambda_{i,t} d \log A_{i,t} + \sum_{f \in \mathcal{F}} \Lambda_{f,t} d \log L_{f,t}.$$

  Supplier churn may happen, but irrelevant for growth.

Inefficient Economies Examples

- No entry-exit, but $\Delta\mu \neq 0$ (a la Baqaee and Farhi, 2019), then

$$d\log Y_t = \sum_{i\in N} \tilde{\lambda}_{i,t} d\log A_{i,t} + \sum_{f\in\mathcal{F}} \tilde{\Lambda}_{f,t} d\log L_{f,t} - \sum_{i\in N} \tilde{\lambda}_{i,t} d\log \mu_{i,t} - \sum_{f\in\mathcal{F}} \tilde{\Lambda}_{f,t} d\log \lambda_{f,t}.$$

  Changes in markups and factor shares capture reallocation.

- Constant markups and zero-profit condition with one-factor, then

$$d\log Y_t = \sum_{i\in C_t} \tilde{\lambda}_{i,t} d\log A_{i,t} + \sum_{f\in\mathcal{F}} \tilde{\Lambda}_{f,t} d\log L_{f,t} + \sum_{i\in C_t} \tilde{\lambda}_{i,t} d\log \mathcal{E}_{i,t}.$$

  Supplier-churn augments growth.

Mapping Growth Accounting to the Data

- Use ratio of total variable cost to sales to get markups.
- Combine with VAT data on firm-to-firm transactions.
- Final output is non-financial private sector continuing firms' output.
- Labor input is the change in employment FTE.
- Capital input is value of PPE + IP deflated by investment deflator.
- Other inputs are excluded firms (materials deflator) & imports (import deflator).

Estimating Key Parameter

- To estimate $1/(\sigma - 1)$, we use

$$\Delta \log AC_{it} = \beta \times \sum_{J \in \mathcal{I}} \Omega^{V}_{iJ,t} \times \Delta \log s^{cont}_{iJ,t} + \text{controls}_{it} + \varepsilon_{it}.$$

- These regressions estimate different statistics, but under CES and expanding varieties, they're the same.

- We **do not** estimate $1/(\sigma - 1)$ from expenditure-switching.

Estimating $1/(\sigma - 1)$

	dlogAC		dlogmc	
Exit share	0.699**	0.894***	0.880***	0.737***
	(0.355)	(0.267)	(0.340)	(0.237)
Controls	Y	Y	Y	Y
Instrument	finance	demand	finance	demand
FE	ind$\times$year	ind$\times$year	ind$\times$year	ind$\times$year

- Implies $\sigma \approx 2.5$ between cont. & non-cont. suppliers.

Growth Accounting — No buyer surplus, No markups

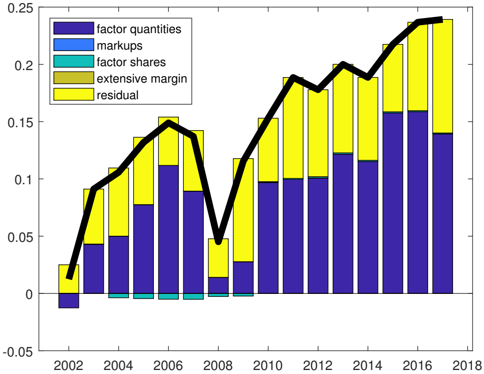

Figure: No markups or buyer surplus

- This is Solow-Hulten.

Growth Accounting — Markups but no buyer surplus

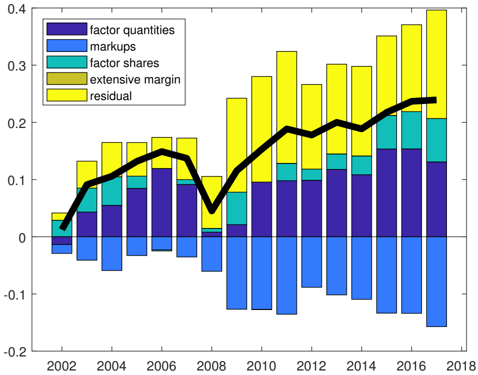

Figure: No buyer surplus $\sigma = \infty$, but positive markups

- Negative reallocation is reducing growth in Belgium – high-markup firms are shrinking.

Growth Accounting — Benchmark

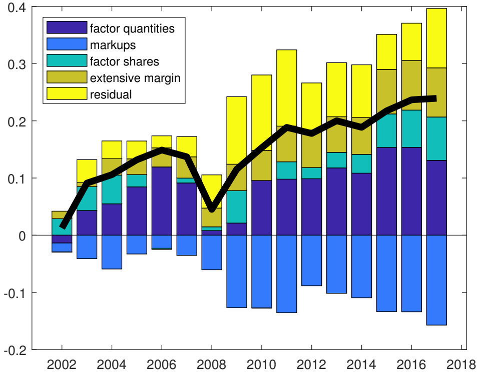

Figure: $\sigma = 4$

- Technological residual shrinks because of supplier churn.

Growth Accounting

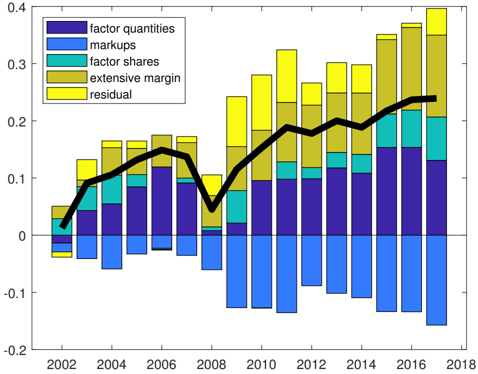

Figure: $\sigma = 3$

- Residual almost gone.

Growth Accounting — Benchmark

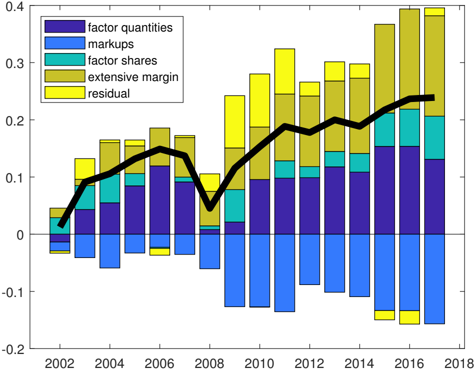

Figure: $\sigma = 2.4$

- “measure of ignorance” close to zero.

Agenda

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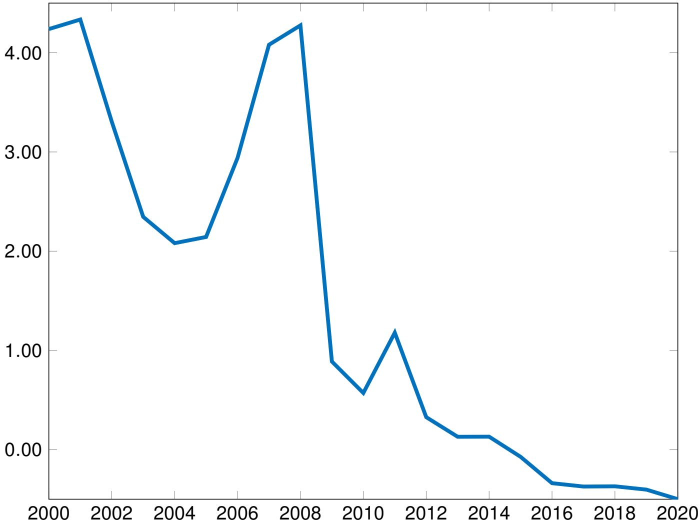
Conclusion

Conclusion

- At both the micro and macro level, supplier churn is important.
- First direct evidence on consumer surplus from supplier exit.
- Moments to match to and motivation to better understand supplier churn as major determinant of growth.

1-month money market rate



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