Extensive Margin Adjustment of Multi-Product Firms and Risk Diversification

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The views expressed in the paper are those of the authors and do not necessarily represent the views of the Central Bank of Brazil, IMF, its Executive Board, or IMF management.

Motivation

- Creative destruction is an essential component of efficient resource allocation by "cleansing out" unproductive arrangements and freeing up resources for more productive uses (Schumpeter, 1939).

- Recent studies document a long-run secular decline in business dynamism (job creation and destruction) in the U.S. (Brookings 2014, Haltiwanger 2015, Decker et al. 2015).

- So far, studies on industry dynamics and resource allocation have almost exclusively focused on firm's entry and exit, as well as job creation and destruction associated with such dynamics.

- In standard macro literature, firms are often treated as producers of a single (final goods) product. That is, "Firm=Product"

Motivation

- In reality, however, Firm $\neq$ Product $\Longrightarrow$ Firm $= \cup$ Product$_i$
- We look at a new dimension of firm's dynamism' measured by a (multi-product) firm's product scope adjustment (extensive margin), by product turn-over rate from creation and destruction.
- $\Delta V_t = \sum_{i \in I(t)} P_{ikt} Q_{ikt} - \sum_{i \in I(t\text{-}1)} P_{ikt-1} Q_{ikt-1} =$

$$\underbrace{\sum_{i \in I(t) \cap I(t\text{-}1)} \Delta P_{ikt} Q_{ikt}}_{\text{Intensive Margin}} + \underbrace{\sum_{i \in I(t) \cap I(t-1)^c} (P_{ikt} Q_{ikt} - 0)}_{\text{EM: Goods Introduced}} + \underbrace{\sum_{i \in I(t-1) \cap I(t)^c} (0 - P_{ikt-1} Q_{ikt-1})}_{\text{EM: Goods Disappeared}}$$

This paper

- Document the evolution of product turnover using a rich U.S. micro-data in both pre- and post-crisis period, focusing on firm (who) and product (what) attributes.
- Link turnover rate with risk diversification by establishing empirical relationship between the flexibility of product turnover and measurements of risk diversification.
- Propose a theoretical model linking extensive margin adjustment and risk diversification, Calvo-type frequency of product scope adjustment (λ)
  - Optimal scope of products of a firm (cannibalization effects)
  - Calvo-type model with a fixed probability of extensive margin adjustment with a firm choosing to adjust product scope or not

Main Findings

- The dynamism defined by the product scope adjustment has been on the decline, dating back to pre-crisis, only to have excerbated since the crisis.

- Since the GFC,
  - the largest firms (top 10th percentile) increased their contribution of total value through creation, which was at the cost of the medium-sized firms (top 20th to 50th percentile) that experienced a concomitant decline in their share.

  - Since 2012, the reverse pattern is observed, as both small (bottom 50th percentile) and medium-sized firms have increased their turnover rate, mainly driven by their contributions through introducing new goods.

Main Findings

- Empirical findings suggest that a higher turnover rate is associated with an improved (financial) risk diversification
  - Firms with higher flexibility in extensive margin adjustment is associated with lower excess return, driven mainly by the introduction rate.
  - Higher product turnover also helps to eliminate risk.
  - As a result of one std ($\approx 20\%$) decline in the turnover rate, led to an increase of 2% risk and excess return
- A simple model with a Calvo-type product scope adjustment rate

Related Literature

- Optimal Product Scope and Multi-Product Firm Pricing
  - Empirics: Broda and Weinstein (2007), Bernard et al. (2011), Bhattarai and Schoenle (2014)
  - Model: Bhattarai and Schoenle (2014), Eckel et al. (2015), Feenstra and Ma (2009), Mayer (2014), Hottman et al. (2016)
- Endogeous Product Selection
  - Boyan and Jovanovic (1982), Hopenhayn (1992), Ericson and Pakes (1995), Melitz (2003), Bernard, Redding and Schott (2007)
- Firm entry in asset pricing
  - Bidian et al. (2013), Lopez (2015), Scanlon (2008)
- Diversification and risk
  - Sharpe (1964), Romer (1990), Grossman and Helpman (1991), Koren and Tenreyro (2013)

Some Facts on Product Creation, Destruction and Turnover

Data Description

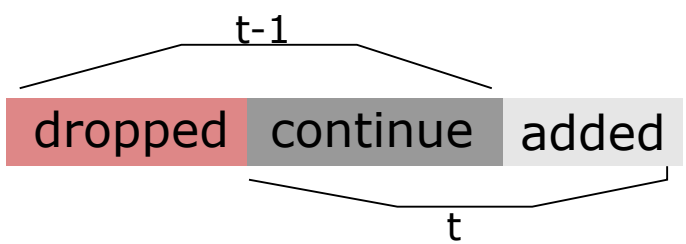
1. Data: AC Nielsen Homescan (creation/destruction of products covering non-durable food items + personal care + housekeeping supplies etc., nearly $\frac{1}{3}$ of CPI basket), CRSP and Bloomberg (balance sheet and stock information)

2. Time Horizon: 2004-2014

3. Number of Firms: Listed (203 firms) + Unlisted firms

Measures of Product Scope Adjustment (Broda and Weinstein (2008))

- Creation rate: Value of new UPCs (t,t-1)/Total Value (t)
- Destruction rate: Value of disappearing UPCs (t,t-1)/Total value (t-1)
- Turnover rate: Creation rate + Destruction rate



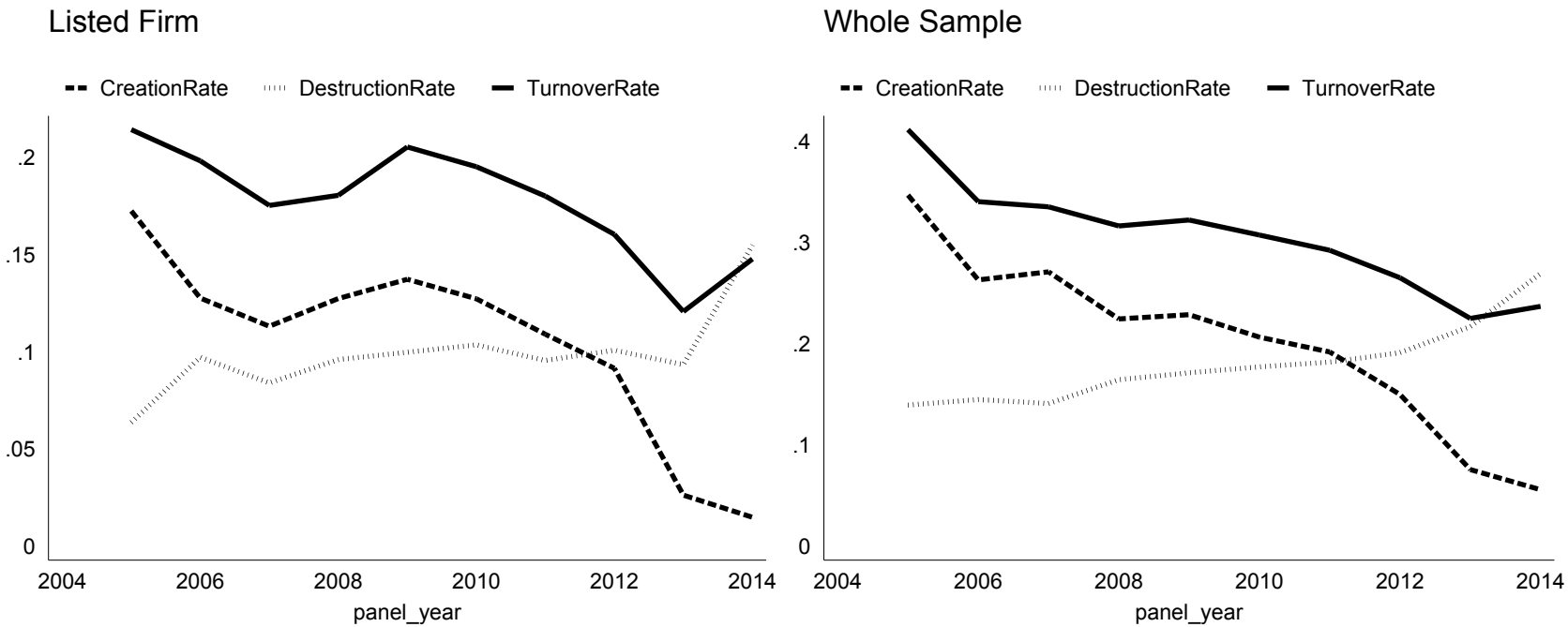
$$turnover_t = \frac{added + dropped}{all} \in [0, 1]$$

Summary Statistics

VARIABLES	N	mean	sd
destruction rate	1413	0.171	0.153
introduction rate	1413	0.139	0.163
turnover rate	1413	0.265	0.182
destruction rate (wt)	1413	0.090	0.176
introduction rate (wt)	1413	0.102	0.187
turnover rate (wt)	1413	0.170	0.226

- Compared to firm establishment turnover (Davis and Haltiwanger, 1992), four times higher creation rate - about 40% of of household expenditures come from goods produced in the last 4 years, while about 10% of total output comes from new establishments).

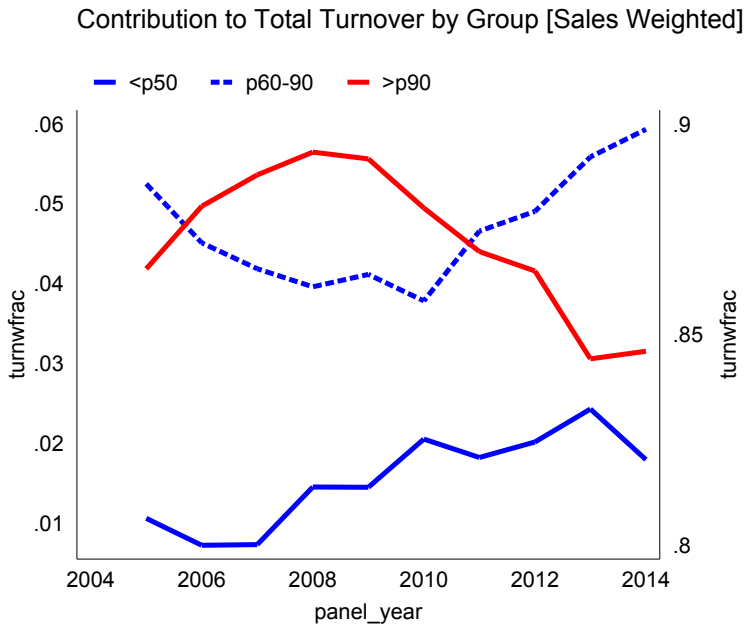
Product Turnover



- A decline in turnover rate, dating back to pre-crisis, has exacerbated since the crisis.
- The pattern of turnover rate resembles that of creation rate.

Product Turnover Dynamism: By Firm Size

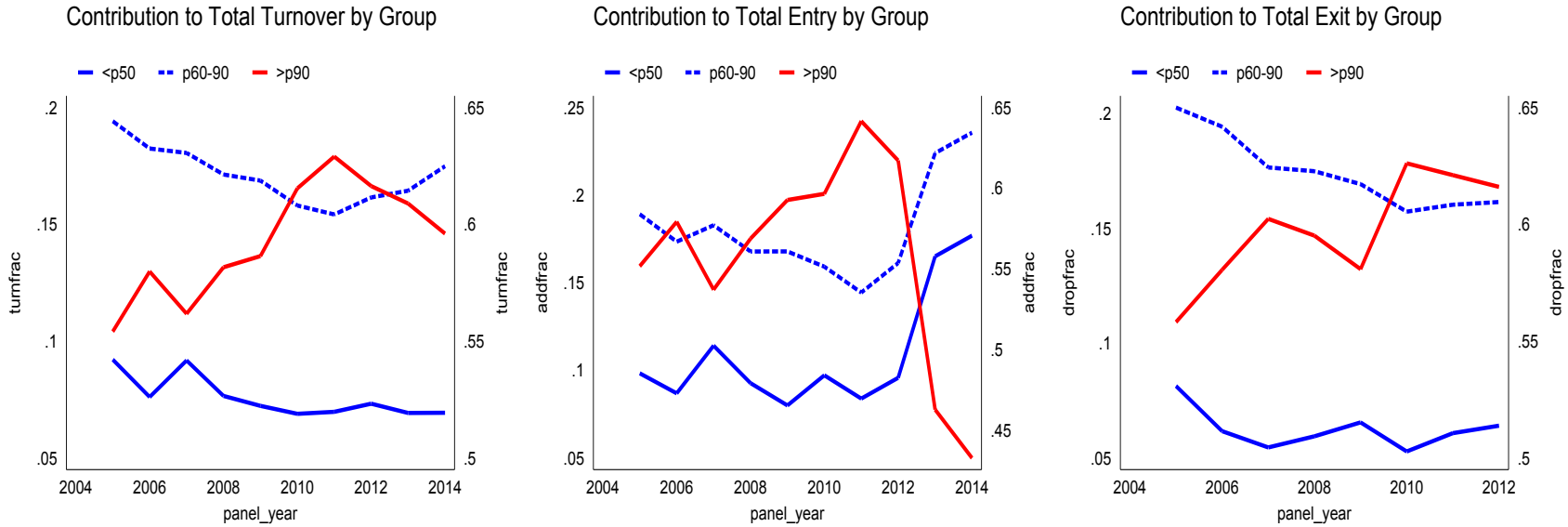
How much does large (medium-sized/small) firms contribute to the total value change from product turnover?



- The share of value change due to product turnover explained by the large firms peaked in 2008 (90%), while declined sharply since (85% in 2014).

Product Entry/Exit Dynamism: By Firm Size

Among the goods introduced and destroyed at time t, how many of the products are introduced by large firms, medium-sized vs. small firms?

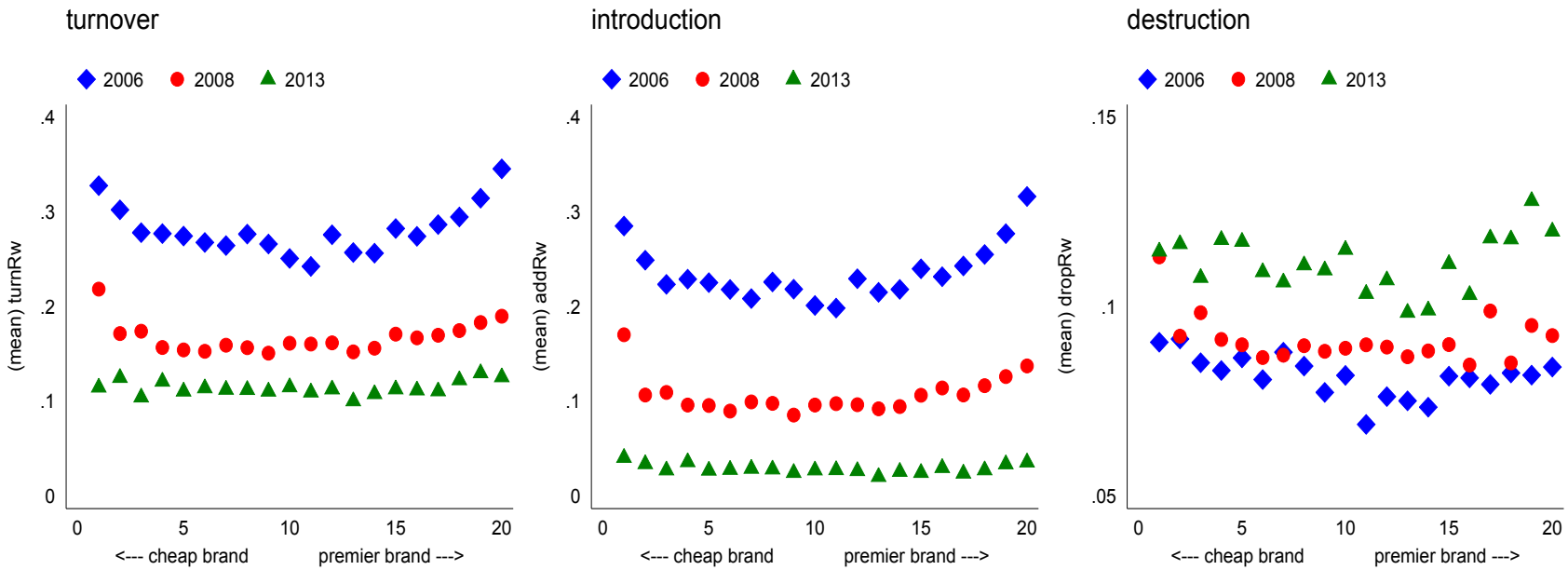


- 2008-2010: Large firms ↑ from 55% (in 2007) to 63% (peak in 2010). Medium and small-sized firms ↓.

- 2012-: Both large and medium-sized firms have recovered the pre-crisis level of their contribution to product turn-over.

- Dynamics driven by product introduction!

Product-level Dynamism along the Price Spectrum



- Turnover rate shifted downward dramatically since 2008 onward.
- While the downward shifts in turnover and creation are observed across the board, goods at the extreme in the price spectrum (top and bottom 10 percentile) declined the most.
- Destruction more active in the premium brands since the crisis.

Why Would Product Turnover Flexibility Matter for Excess Return?

Intuition: C-CAMP Recap

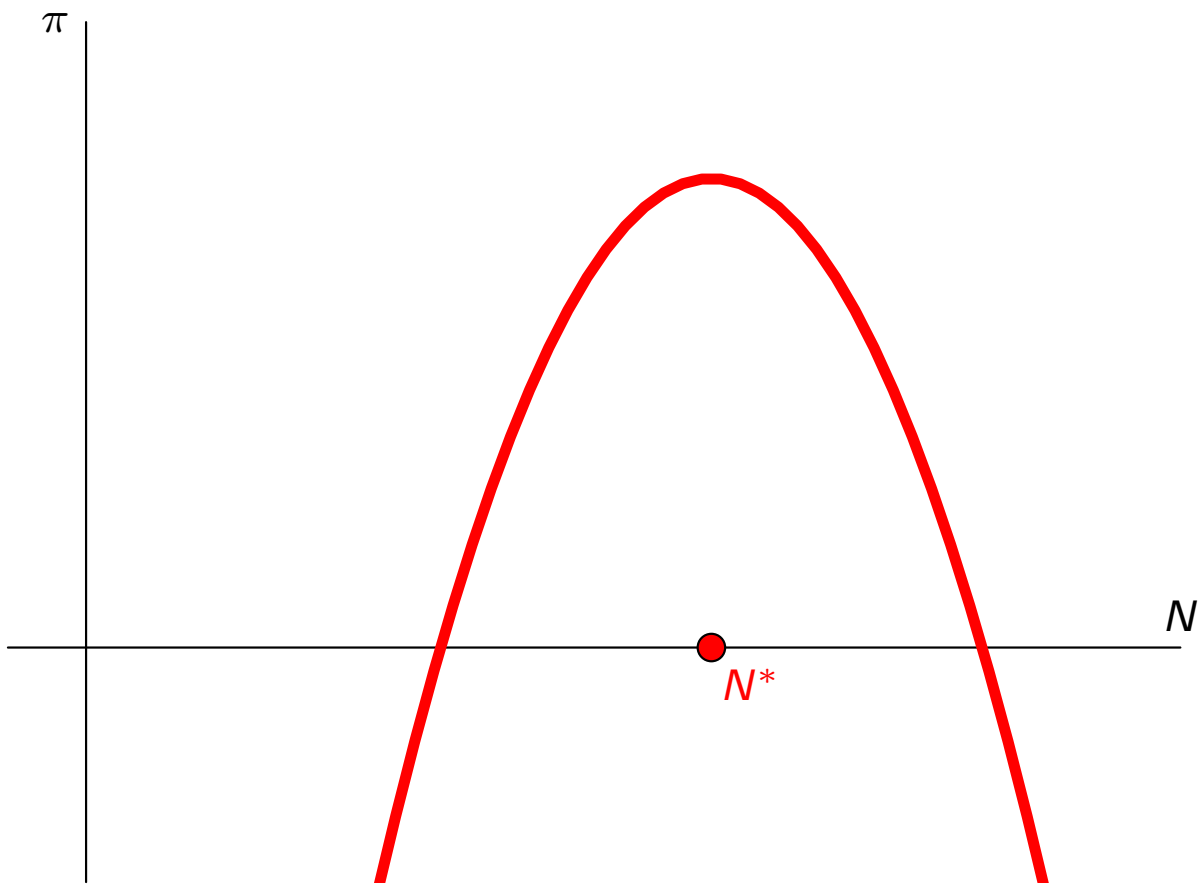
$$
\begin{array}{lrl}
\text{Household:} & \max_{C_t, B^i_{t+1}} & \mathbb{E}\left[\sum_{t=1}^{\infty} \beta^t \ln C_t\right] \\
& s.t. P_t C_t & = P_t Y_t + \sum_{j=1}^{J} B^j_t (Q^j_t + D^j_t) - \sum_{j=1}^{J} B^j_{t+1} Q^j_t \\
\text{Return rate } j: & & R^j_{t+1} = \frac{Q^j_{t+1} + D^j_{t+1}}{Q^j_t} \\
\text{Pricing kernel:} & 1 & = \mathbb{E}_t\left(R^j_{t+1} M_{t+1}\right), \ \forall j \\
& & \text{where } M_{t+1} = \beta u'(C_{t+1})/u'(C_t) \\
& \mathbb{E}_t R^j_{t+1} - R^F_{t+1} & = -R^F_{t+1} Cov\left(R^j_{t+1}, M_{t+1}\right) \\
& & = -R^F_{t+1} \beta Cov\left(R^j_{t+1}, C_t P_t / C_{t+1} P_{t+1}\right)
\end{array}
$$

- Compensation for risk! Want to hold assets that provide insurance, that pay when marginal utility is high. Risky asset pays when SDF is low, MU is low, so better provide higher expected return.

From Product Turnover Flexibility to $\mathrm{Cov}(R^j_{t+1}, M_{t+1})$

shock $\Longrightarrow$ flexible firm ($\lambda = 0$) changes to $\widetilde{N}^*$ $\Longrightarrow \Delta\pi = 0$

shock $\Longrightarrow$ inflexible firm ($\lambda = 1$) can't change at all, $\Longrightarrow \Delta\pi < -\pi^*$



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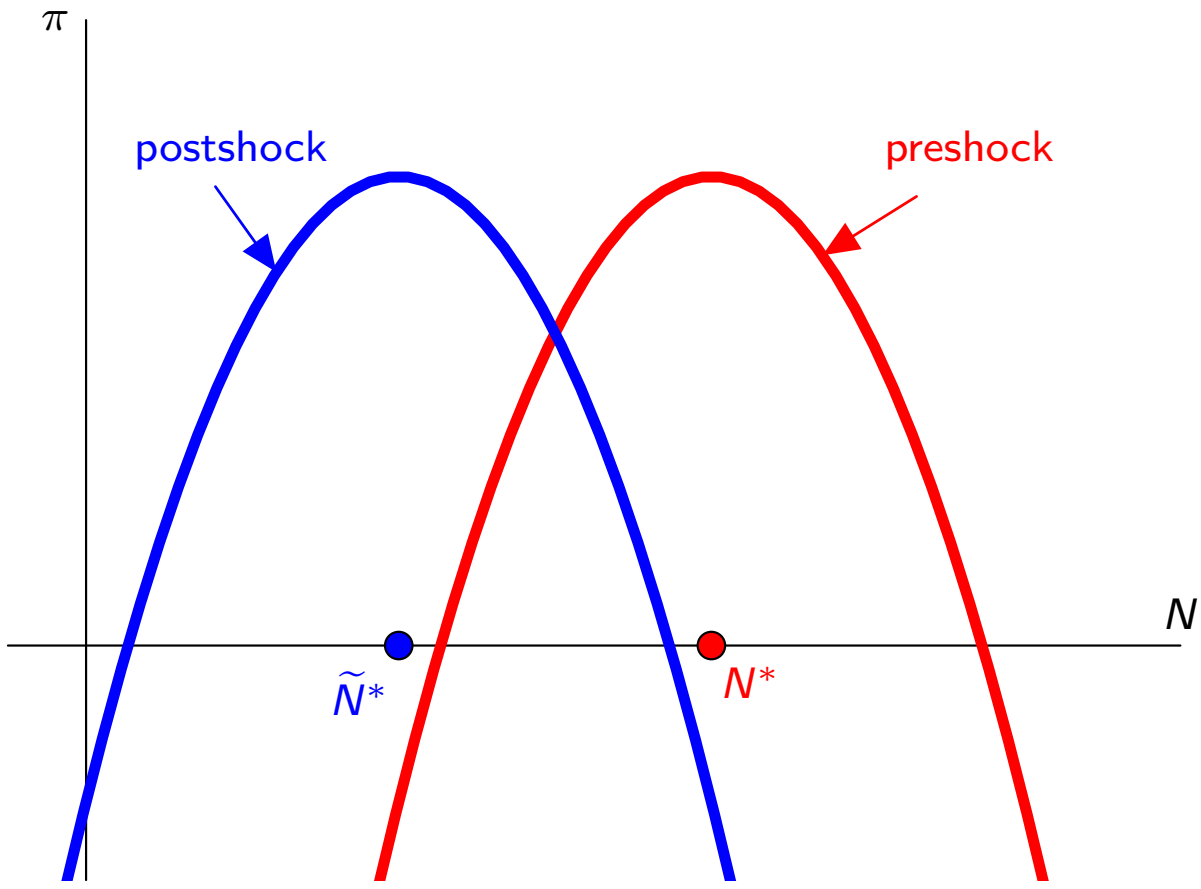

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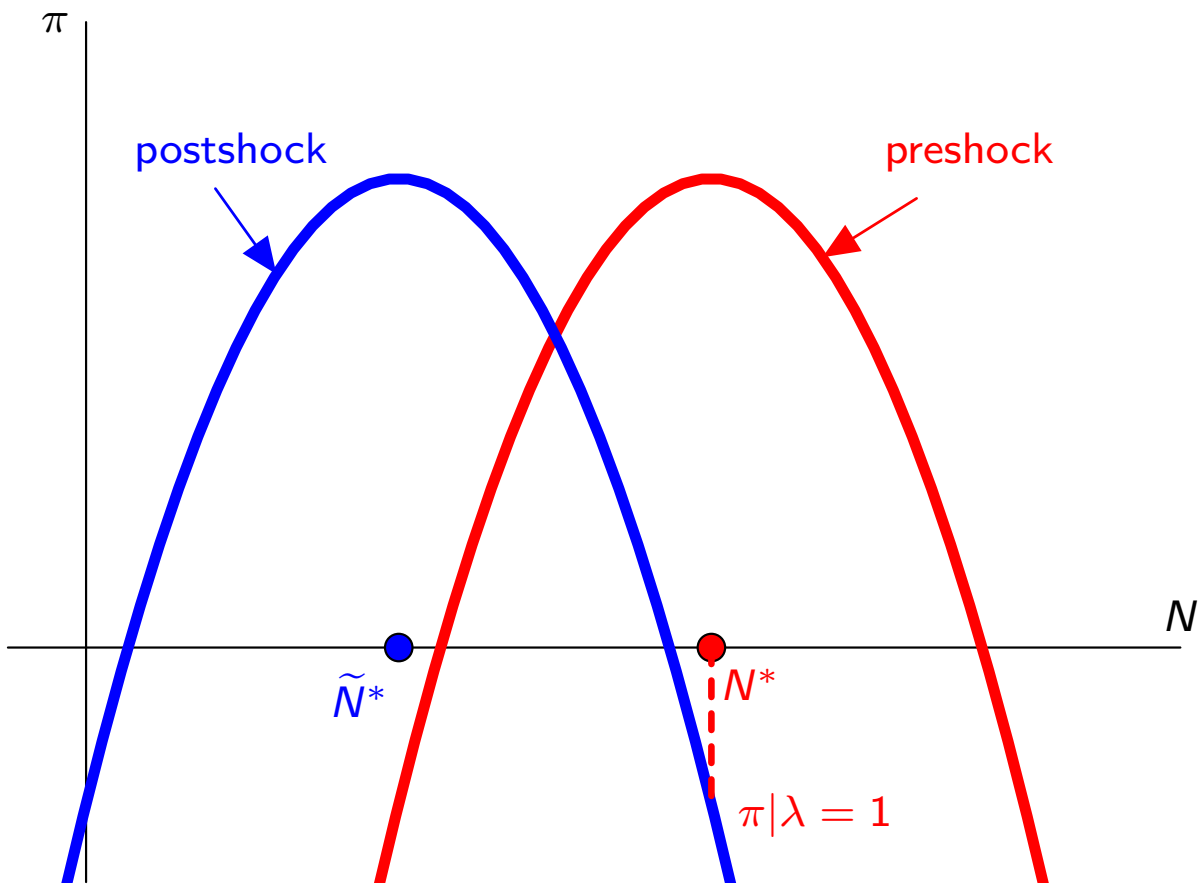

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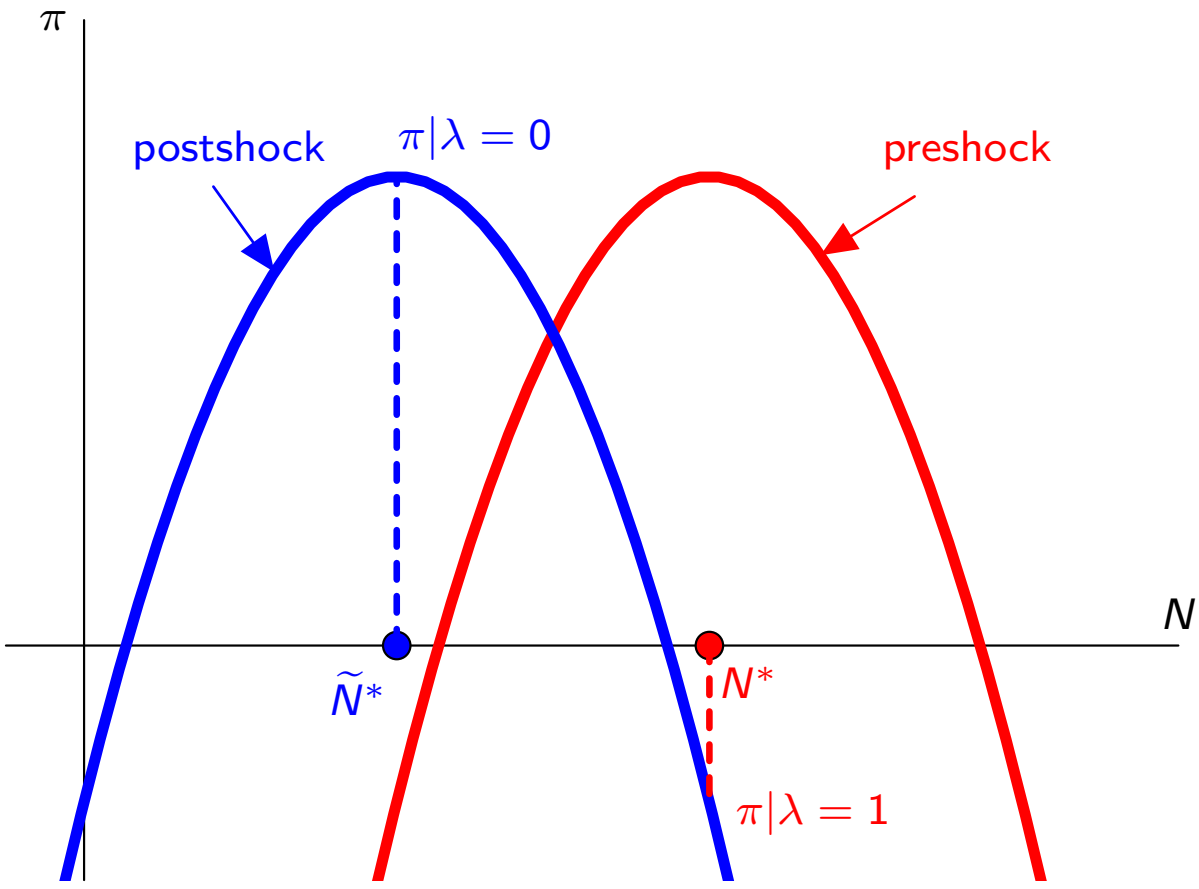

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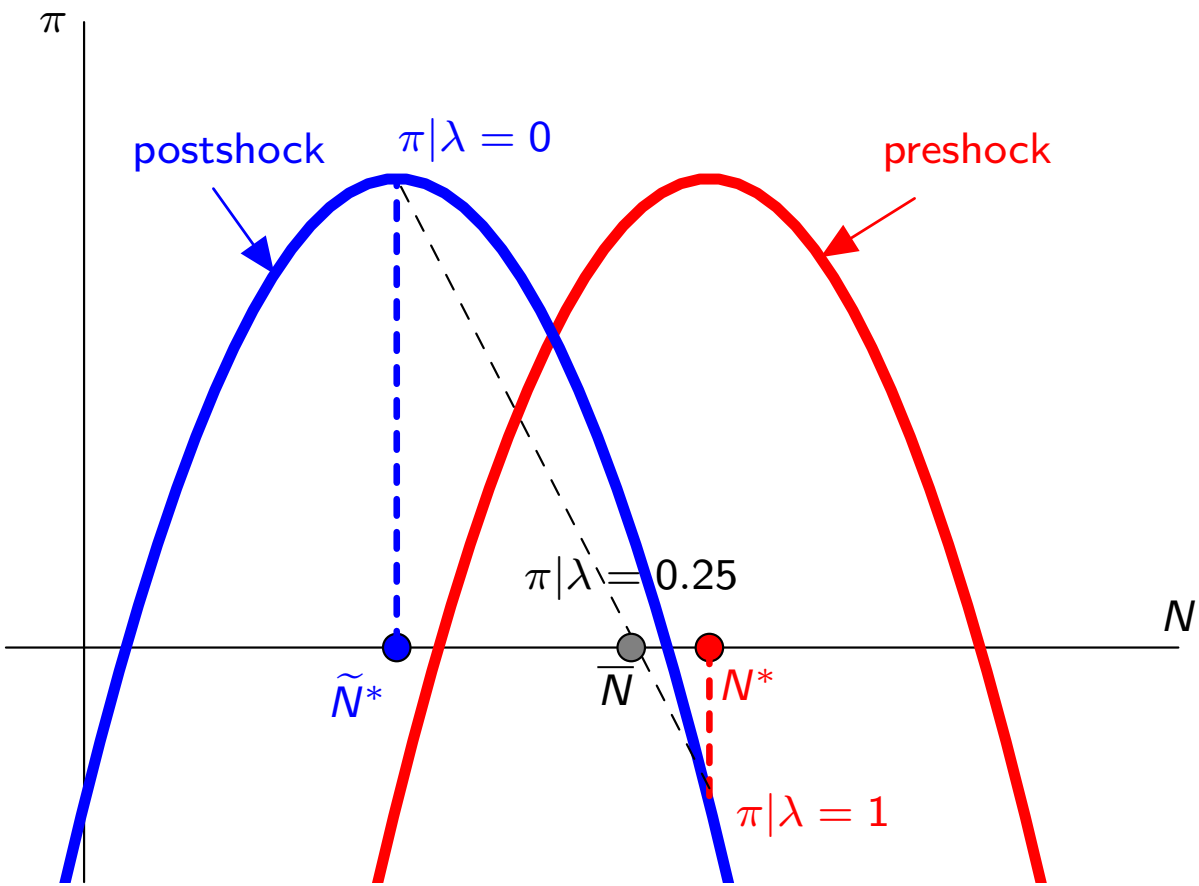


Empirical Analysis: Product Scope Adjustment and Risk Diversification

Empirical Analysis: Product Scope Adjustment, Risk Diversification

Panel Regression 1: Product Scope Adjustment & Excess return

- $R_{it} = \alpha_i + \alpha_t + \gamma_1 creation_{it} + \gamma_2 destruction_{it} + \eta \mathbb{X}_{it} + \epsilon_{it}$

- one standard deviation increase in turnover (≈ 0.2) $\rightarrow$ 2% decrease in annual excess return

	(1) YearFE	(2) +industryPortfolio	(3) +R&D	(4) +#upc	(5) turnover	(6) +#UPC
introduction%	-0.104*	-0.106*	-0.106*	-0.109*		
	(0.06)	(0.06)	(0.06)	(0.06)		
destruction%	0.014	0.002	0.002	0.004		
	(0.06)	(0.06)	(0.06)	(0.06)		
turnover%					-0.107*	-0.107*
					(0.06)	(0.06)
#UPC				-0.031***		-0.030***
				(0.01)		(0.01)
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	1413	1413	1413	1413	1413	1413
r2	.2868	.2976	.2977	.2982	.2977	.2983

$\mathbb{X}$: market value, price-to-book ratio, beta, leverage, cash flow, turnover, spread, gross margin, age, industry characteristics

Panel Regression 2: Product Scope Adjustment & Risk

- $-Cov(R_{it}, C_t/C_{t+1}) = \gamma_1 creation_i + \gamma_2 destruction_i + \eta \mathbb{X}_i + \epsilon_{it}$
- one standard deviation increase in turnover (≈ 0.2) $\rightarrow$ 2 standard dev decrease in risk

	(1) Baseline b/se	(2) +R&D b/se	(3) +#UPC b/se	(4) turnoverRate b/se	(5) +#UPC b/se
introduction%	-0.011*	-0.010*	-0.010*		
	(0.005)	(0.005)	(0.005)		
destruction%	-0.004	-0.003	-0.005		
	(0.006)	(0.006)	(0.006)		
turnover%				-0.010**	-0.009**
				(0.002)	(0.002)
#UPC		0.000**			0.000*
		(0.000)			(0.000)
N	203	203	203	203	203
r2	.2247	.2328	.2256	.2262	.2316

Robustness Check: Controlling for Turnover Based on Retailer/HH-Manufacturer Relationships

- Construct the product turnover rates for each retailer and household to control for the role of retailer and demand in the equilibrium level of product turnover.

	return rate			risk		
	retailer	HH	both	retailer	HH	both
turnover%	-0.108*	-0.111*	-0.109*	-0.008***	-0.007**	-0.007**
	(0.061)	(0.060)	(0.061)	(0.001)	(0.003)	(0.001)
Retailer						
introduction%	Y		Y	Y		Y
destruction%	Y		Y	Y		Y
Household						
introduction%		Y	Y		Y	Y
destruction%		Y	Y		Y	Y
N	1413	1413	1413	203	203	203
r2	.2977	.2976	.2978	.2517	.2625	.2821

Do Retailers/Households Treat Firms Differently?

- Short answer: seems not in our sample
- Compare the firm-retailer/-HH zip specific turnover rate vs. leave-one-out retailer/HH zip turnover rate on the firm

Retailer	introduction	destruction	turnover
Average of the Rest	0.921***	0.921***	0.929***
	(0.01)	(0.01)	(0.01)
N	181168	181168	181168
HH zip	introduction	destruction	turnover
Average of the Rest	0.995***	0.995***	0.995***
	(0.00)	(0.00)	(0.00)
N	3589279	3589279	3589279

A Model of Product Scope Adjustment and Asset Pricing

Model

- Introduce firm's flexibility of extensive margin to a standard model with household and firm to highlight the dynamics of product turnover and asset pricing

- Key Ingredients
  - Optimal product scope: **cannibalization effect** due to the substitutability between intra- and inter-firm goods (Hottman et al. 2016, forthcoming QJE)

  - Product turnover "cost": **Calvo-type** probability (1-λ) to reset product scope

"Sticky" Product Turnover Rate

- Is Calvo-type set-up reasonable? That is, could product turnover rate be understood as an inherent feature of a firm, such as price/wage rigidity in the literature?

- Yes. Although turnover rate is counter-cyclical, firm's relative extensive margin adjustment is quite stable.

	Introduction Rate		Destruction Rate		Turnover Rate	
	Bottom	Top	Bottom	Top	Bottom	Top
Bottom	0.66	0.34	0.71	0.29	0.68	0.32
Top	0.09	0.91	0.08	0.92	0.09	0.91

Household

A representative household in the economy has GHH preference, choosing between consumption and labor, purchasing nominal bond B_t, and receiving dividend from firms.

$$\max \quad \sum_{t=0}^{\infty} \beta^t \left[\ln C_t - \chi \frac{L_t^{1+1/\phi}}{1+\frac{1}{\phi}} \right]$$

$$s.t. \quad P_t C_t + B_{t+1} = W_t L_t + (1+i_t) B_t + \int_0^1 \int_0^1 D_{fkt} \, df dk$$

$$3 - \textit{layer Aggregate} : C_t = \left[\int_0^1 C_{kt}^{\frac{\sigma_k - 1}{\sigma_k}} \, dk \right]^{\frac{\sigma_k}{\sigma_k - 1}}, \ \textit{across sectors}$$

$$C_{kt} = \left[\int_0^1 C_{fkt}^{\frac{\sigma_f - 1}{\sigma_f}} \, df \right]^{\frac{\sigma_f}{\sigma_f - 1}}, \ \textit{across firms}$$

$$C_{fkt} = \left[\int_0^{N_{ufkt}} C_{ufkt}^{\frac{\sigma_u - 1}{\sigma_u}} \, du \right]^{\frac{\sigma_u}{\sigma_u - 1}}, \ \textit{across products}$$

Price of the Product

Abstract from sticky price

$$\text{technology}: Y_{fkt} = Z_t L_{fkt}$$

$$\text{s.t. demand}: C_{ufkt} = C_t P_t^{\sigma_k} P_{kt}^{\sigma_f - \sigma_k} P_{fkt}^{\sigma_u - \sigma_f} P_{ufkt}^{-\sigma_u}$$

- **cannibalization effect**: reduction in profits from existing UPCs (intra-firm) by introducing a new product + increase in profits from new UPCs (inter-firm) by introducing a new product (Hottman et al. 2016)
  - Flexible price: $P_{ufkt} = \frac{\sigma_f}{\sigma_f - 1} \frac{W_t}{Z_t}$ (vs. $P_{ufkt} = \frac{\sigma_u}{\sigma_u - 1} \frac{W_t}{Z_t}$)
  - Intuition: $P_{fkt}^{\sigma_u - \sigma_f} P_{ufkt}^{-\sigma_u}$ is choice variable rather than $P_{ufkt}^{-\sigma_u}$

Product Scope Determination (Without Friction)

- Cannibalization effect wrt individual product

$$-\frac{\partial C_{ufkt}}{\partial N_{fkt}}\frac{N_{fkt}}{C_{ufkt}} = \frac{\sigma_u - \sigma_f}{\sigma_u - 1}$$

  - $\sigma_u = \sigma_f$: cannibalization effect is zero, new product's consumption completely comes from the other firms' sale

  - $\sigma_u \to \infty$: cannibalization effect is one, perfect substitutes within firm

- Cannibalization effect wrt firm

$$\frac{\partial C_{fkt}}{\partial N_{fkt}}\frac{N_{fkt}}{C_{fkt}} = \frac{\sigma_f - 1}{\sigma_u - 1}$$

- Following Bergin and Corsetti (2008), assume fixed cost of maintaining the variety in each period: F units of effective labor.

- If the firm can freely adjusts product scope, then the optimal number of products is determined by

$$N_t = \left[\frac{C_t}{F(\sigma_u - 1)}\right]^{\frac{\sigma_u}{\sigma_u - 1}}$$

Product Scope Determination (With Friction)

- Assume Calvo type of adjustment friction: firm can adjust product scope with probability $= 1 - \lambda$ in each period

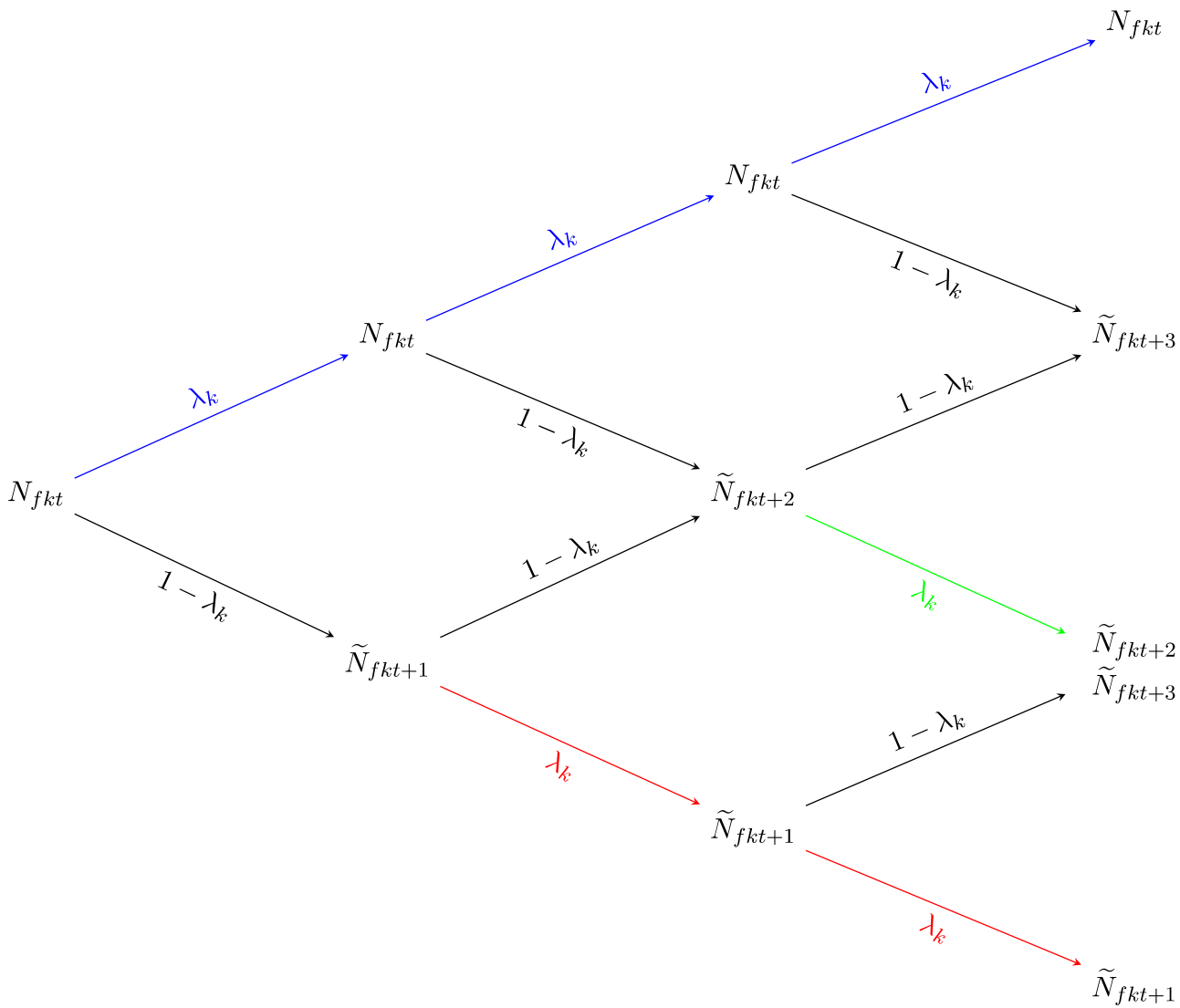
- In each period, firm sets $\widetilde{N}_{fkt}$ to maximize the expected profit

$$\max_{\widetilde{N}_{fkt}} \quad \sum_{j=0}^{\infty} \beta^j \lambda_k^j \mathbb{E}_t \left\{ \frac{\Lambda_{t+j}}{\Lambda_t} \left[\int_0^{\widetilde{N}_{fkt}} \left(P_{ufkt+j} - MC_{t+j} \right) C_{ufkt+j} du - F \widetilde{N}_{fkt} MC_{t+j} \right] \right\}$$

$$s.t. \quad C_{ufkt+j} = C_{t+j} P_{t+j}^{\sigma_k} P_{kt+j}^{\sigma_f - \sigma_k} P_{fkt+j}^{\sigma_u - \sigma_f} P_{ufkt+j}^{-\sigma_u}$$

$$\Longrightarrow \quad (\sigma_u - 1) \widetilde{N}_{fkt}^{\frac{\sigma_u - \sigma_f}{\sigma_u - 1}} = \frac{\left(\frac{\sigma_f}{\sigma_f - 1} \right)^{-\sigma_f} \sum_{j=0}^{\infty} \beta^j \lambda_k^j \mathbb{E}_t \left[\frac{\Lambda_{t+j}}{\Lambda_t} MC_{t+j}^{1-\sigma_f} C_{t+j} P_{t+j}^{\sigma_k} P_{kt+j}^{\sigma_f - \sigma_k} \right]}{\sum_{j=0}^{\infty} \beta^j \lambda_k^j \mathbb{E}_t \left[\frac{\Lambda_{t+j}}{\Lambda_t} MC_{t+j} F \right]}$$

Return Rate



present value of firm:

$$V_t = \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\beta^k C_t}{C_{t+k}} D_{t+k}$$

return rate:

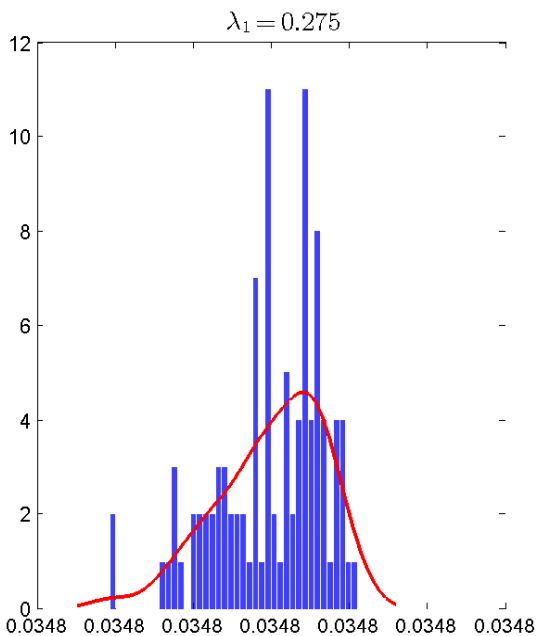
$$R_t = \frac{V_t}{V_{t-1} - D_{t-1}}$$

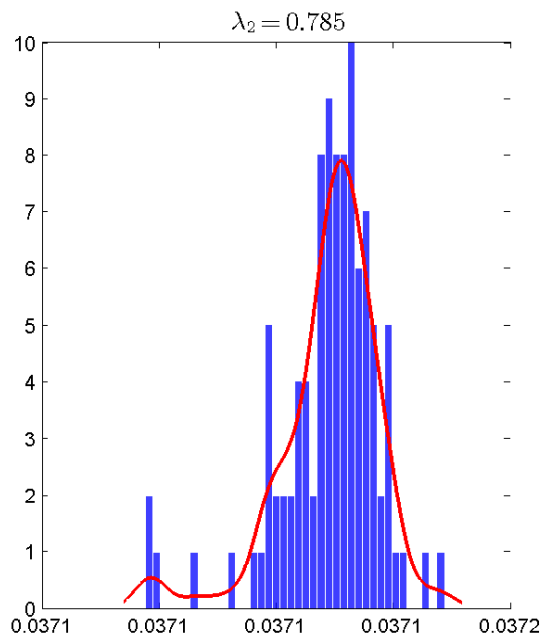
Simulation - Return Rate

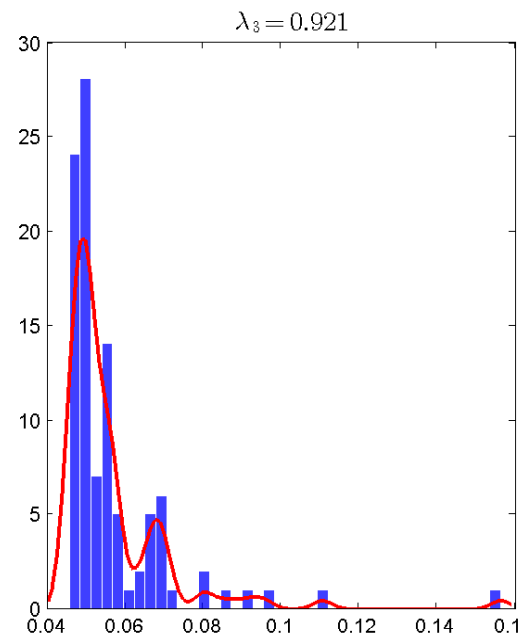
- Set σ_k to be 2 which aligns with the literature and σ_f, σ_u to 3.9,6.9, the median of the estimates from Hottman et al. (2016).

- For the Calvo coefficients, we use the tertiles (27.5%, 78.5%, 92.1%) of variety change's frequency from our Nielsen sample.

- Simulate 100 firms of 3 groups for 1000 periods with the first 800 periods burn-in.

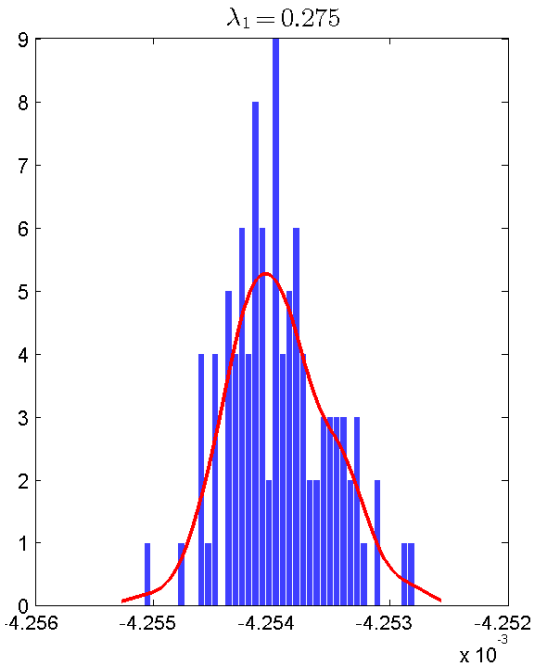


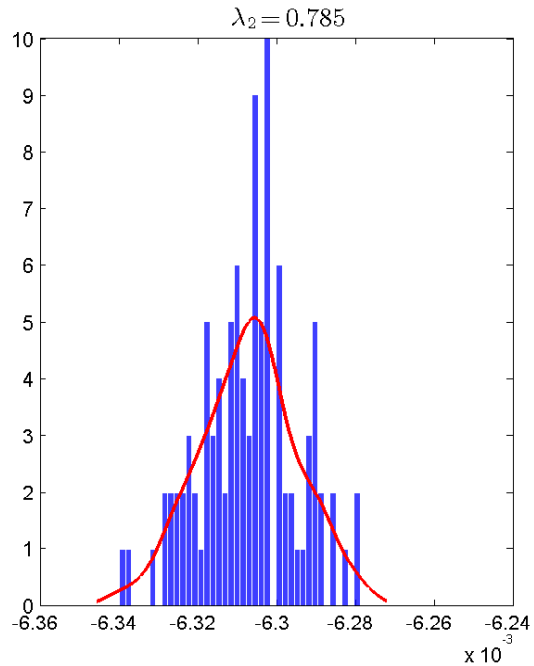


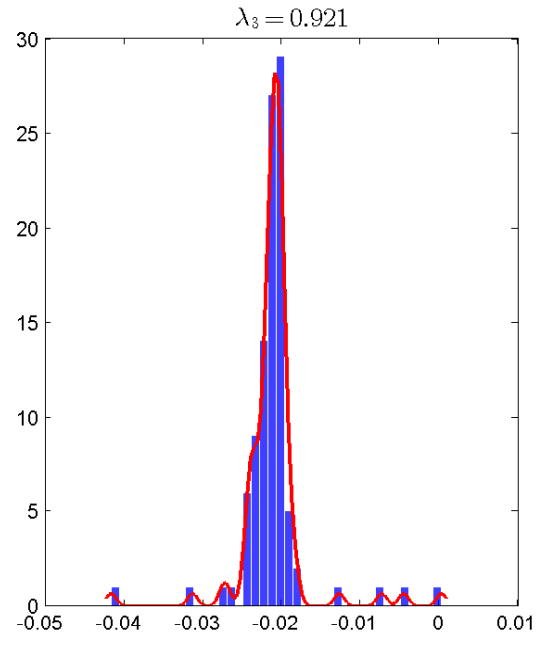


Simulation - Risk

Also shows the negative relationship present in the empirical results which is that the risk increases with the rigidity in product scope adjustment.







Comparison with the Data

	Simulation			Data		
	Bottom	Middle	Top	Bottom	Middle	Top
Return Rate	10%	3.8%	3.4%	14%	10%	9%
Risk Premium	0.02	0.0063	0.0042	0.016	0.012	0.009

Conclusion

- Investigate how firm's flexibility on extensive margin adjustment as a measure of dynamism
- Using a rich U.S. microdata, document the change in turnover rate correlating with firm and product attributes, in both pre- and post-GFC.
- Establish the risk compensation role of flexibility of extensive margin adjustment
- Provide a model incorporating product scope determination of a multi-product firm and standard measures of diversification (excess return and volatility of stock returns)

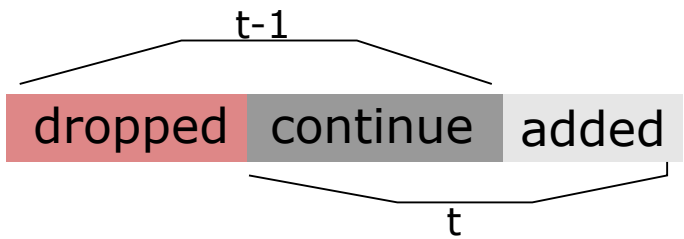
Extra Slides

Data

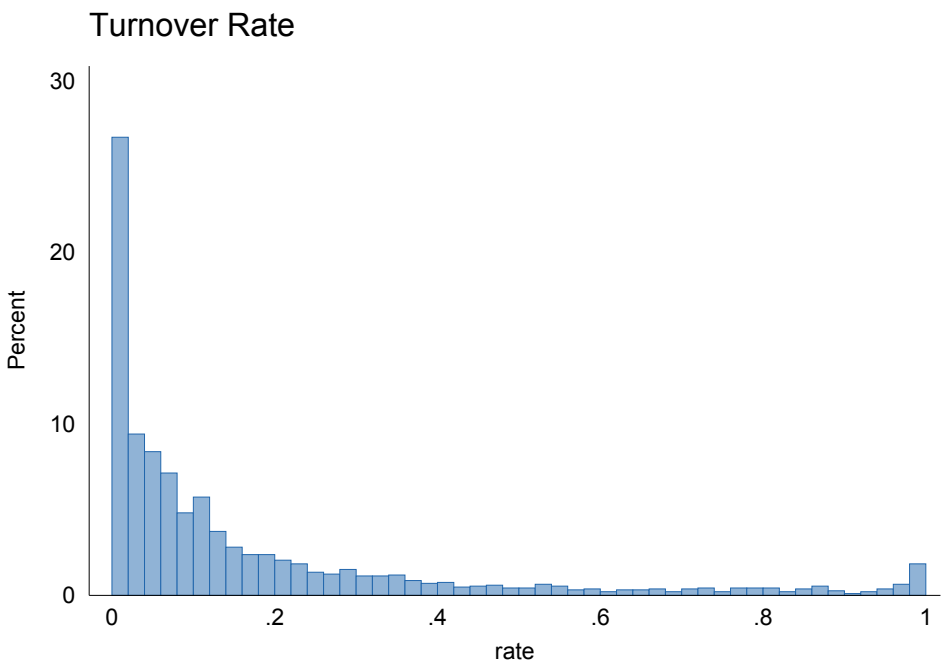
AC Nielsen Homescan : introduction/destruction of products

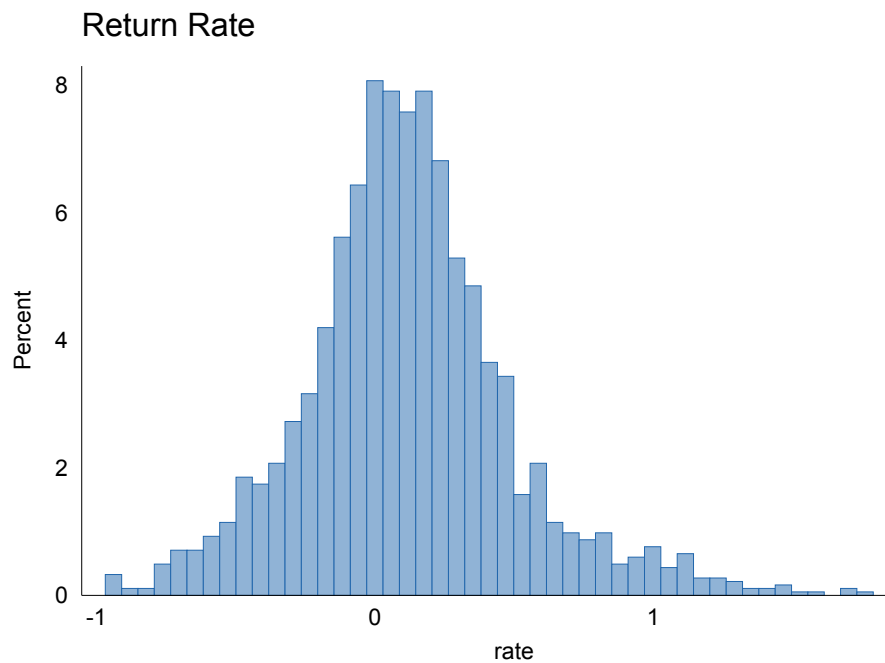
CRSP and Bloomberg : balance sheet and equity information

$\Longrightarrow$ 203 firms, 2004 - 2014



$$turnover_t = \frac{dropped + added}{all} \in [0, 1]$$





High Product Turnover Group vs. the Low - Firm Characteristics

	Introduction Rate			Destruction Rate		
	Bottom	Top	pvalue	Bottom	Top	pvalue
firm characteristics						
size (in m$)	0.02	0.02	0.61	0.01	0.02	0.40
book-to-market ratio	3.78	5.43	0.09	4.83	4.39	0.65
beta	1.98	1.65	0.56	1.95	1.68	0.64
leverage	0.64	1.15	0.14	0.78	1.01	0.51
cash flow	1.23	0.98	0.63	0.84	1.37	0.32
turnover (in m$)	37.01	23.61	0.41	21.41	39.05	0.28
spread	0.33	0.34	0.90	0.34	0.33	0.84

"Sticky" Product Turnover Rate

- Could product turn-over rate be understood inherent feature of a firm, such as price/wage rigidity in the literature?

- Although turnover rate is counter-cyclical (consistent with Broda and Weinstein), firm's relative extensive margin adjustment is quite stable.

	Introduction Rate		Destruction Rate		Turnover Rate	
	Bottom	Top	Bottom	Top	Bottom	Top
Bottom	0.66	0.34	0.71	0.29	0.68	0.32
Top	0.09	0.91	0.08	0.92	0.09	0.91

High Product Turnover Group vs. the Low - Firm Characteristics

	Introduction Rate			Destruction Rate		
	Bottom	Top	pvalue	Bottom	Top	pvalue
firm characteristics						
size (in m$)	0.02	0.02	0.61	0.01	0.02	0.40
book-to-market ratio	3.78	5.43	0.09	4.83	4.39	0.65
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Product-Level: Which products are destroyed? Introduced

$$Add_{pft} = \beta_1 \ln sales + \beta_2 \ln price + \alpha_p + \alpha_t + \epsilon_{pft}$$
$$Drop_{pft} = \beta_1 \ln sales + \beta_2 \ln tenure + \beta_3 \ln price + \alpha_p + \alpha_t + \epsilon_{pft}$$

	(1) Destruction b/se	(2) Introduction b/se
sales	-0.054***	-0.017***
	(0.00)	(0.00)
tenure	0.392***	
	(0.00)	
price	-0.045***	0.064***
	(0.00)	(0.00)
N	6.7e+06	6.7e+06
r2	.5344	.5334

Portfolio Analysis

	Bottom	Top	Difference	(p-value)
introductionRate				
ReturnRate	2.06	1.08	0.98	0.07
R(3factor)	1.28	0.48	0.80	0.02
R(5factor)	1.08	0.39	0.69	0.03
destructionRate				
ReturnRate	2.29	1.13	1.17	0.95
R(3factor)	1.46	0.53	0.93	0.98
R(5factor)	1.27	0.46	0.81	0.98

Panel Regression 2: Product Scope Adjustment & Asset Volatility

$$vol_{it} = \alpha_i + \alpha_t + \gamma_1 creation_{it} + \gamma_2 destruction_{it} + \eta \mathbb{X}_{it} + \epsilon_{it}$$

	(1) YearFE	(2) +ind.Portfolio	(3) +R&D	(4) +#UPC	(5) turnover	(6) +#UPC
introduction%	-1.072**	-1.045**	-1.046**	-1.027*		
	(0.53)	(0.52)	(0.52)	(0.52)		
destruction%	-0.268	-0.279	-0.278	-0.281		
	(0.41)	(0.42)	(0.42)	(0.41)		
turnover%					-0.956**	-0.947**
					(0.47)	(0.47)
#UPC				-0.273*		-0.276*
Other Controls	Yes	Yes	Yes	Yes	Yes	
N	1413	1413	1413	1413	1413	1413
r2	.2928	.2941	.2942	.296	.2938	.2957