Demand or productivity: What determines firm growth?

Andrea Pozzi[1] Fabiano Schivardi[2]

[1]EIEF

[2]LUISS and EIEF

OECD conference on Understanding productivity growth
Paris, 22-23 October 2013

Motivation

- Modern theories of industry dynamics collapse individual heterogeneity to a single parameter (Jovanovic 1982, Hopenhayn 1992, Ericsonn and Pakes 1995)

$$x_i \cdot F(K, L)$$

- What is x_i? If homogeneous good, only difference can be in physical productivity
- This is the approach of a large empirical literature in IO (Bartelsmann and Doms, 2000) and trade (Melitz 2003)
- Important to distinguish, not only for measurement reasons (Klette and Griliches, 1996; Foster et al., 2008)
- Why negleted? Data requirements stringent: firm level prices

Our Contribution

1. We exploit rich data with unique information on firm level prices to study how demand and productivity contribute to firm growth
2. We disentangle idiosyncratic supply and demand components
3. We analyze the transmission mechanism from shocks to growth
4. Insights about the nature of the frictions that prevent firms from growing $\Rightarrow$ misallocation

Preview of the results

- Demand shock as (if not more) important as TFP shocks to explain firm growth
- Transmission: Firms only partially react to shocks
- React less to productivity than to demand shocks
- Importance of frictions that depend on the nature of the shock
- Asymmetry can be explained by heterogeneity in ability of firms in undertake restructuring
- Growth opportunities left on the table due to *within the firm* obstacles to growth - different from the growing literature on misallocation

Literature

- Industry dynamics (Dunne at al., 1998)
  - We add an understudied source of heterogeneity and show it is important
- Foster, Haltiwanger, and Syverson (2008)
  - First to look at demand and productivity, linking them to survival
  - Nearly homogeneous goods with meaningful quantity data. We use information on firm prices
  - We consider firm growth
- Literature on misallocation (Hopenhayn and Rogerson (1993), Hsieh and Klenow (2009)) and on managerial practices (Bloom and Van Reenen, 2007)
  - We show the presence of frictions dampening response to shocks
  - We highlight the importance of frictions with effects dependent on the nature of the shock, not typically considered by the literature

Model: Monopolistic competition with Cobb-Douglas production

- Model serves two purposes:
    1. It guides the identification of shocks
    2. It supply a frictionless benchmark to assess transmission
- CES demand: $Q_{it} = P_{it}^{-\sigma} \Xi_{it}$
    - Ξ is perceived value/quality of the good NOT embodied in physical attributes
- Cobb-Douglas production: $Q_{it} = \Omega_{it} K_{it}^{\alpha} L_{it}^{\beta} M_{it}^{\gamma}$

Solution

$$
\begin{aligned}
q_{it}^* &= c_q + \frac{\sigma}{\theta}\omega_{it} + \frac{(\alpha+\beta+\gamma)}{\theta}\xi_{it} \\
p_{it}^* &= c_P - \frac{1}{\theta}\omega_{it} + \frac{(1-\alpha-\beta-\gamma)}{\theta}\xi_{it} \\
x_{it}^* &= c_x + \frac{(\sigma-1)}{\theta}\omega_{it} + \frac{1}{\theta}\xi_{it}
\end{aligned}
$$

- where $\theta = \alpha + \beta + \gamma + \sigma(1 - \alpha - \beta - \gamma)$,
- $x = k, l, m$; c_q, c_p, c_x are constants
- Role of RTS

Data: INVIND survey + balance sheets

- Collected yearly (from 1984) by the Bank of Italy
- Representative of 50+ manufacturing firms
- Select Textile and leather, Metals, Mechanical -monopolistic competition
- Descriptive Tables: Levels, Growth rates
- Main variables:
  - Δp: Distribution; mean 2.1%, s.d. 0.6%
  - Capital stock: self reported change in technical capacity
  - Capital utilization: average 81%, s.d. 13%

Estimation: Demand

- Availability of prices as changes forces us to translate everything to first differences
- Taking logs and differences, demand is

$$\Delta q_{it} = \sigma \Delta p_{it} + \Delta \xi_{it} \tag{1}$$

- With a consistent estimate of σ: $\widehat{\Delta \xi_{it}} = \Delta q_{it} - \hat{\sigma} \Delta p_{it}$
- A question in INVIND offers the chance to recover σ: *Consider now a thought experiment: if your firm raised today sale prices by 10%, what do you think would be the percentage variation of nominal sales, under the assumption that competitors do not change their prices and everything else holds equal?"*
- We use the sectoral average of the self-reported σ. Results: around 5 - Figure Table

Estimation: Production function

- Estimate in first differences, with firm level deflators
- Endogeneity in inputs: control function (Olley and Pakes, 1996) modified to account for two unobservables and first differencing: Production function results
- Model frictionless, but estimates robust to adjustment costs:
  - Frictions that do not enter the production function pose no problem
  - Disruption costs problematic – but we measure utilized capital and hours
  - Robustness check with Δ over three years: disruption costs are not those driving the result
  - Alternative estimation methods
- Descriptive statistics for TFP and ξ

The impact of TFP and ξ on firm growth

- Output growth process:

$$\Delta q_{it} = \Delta\omega_{it} + \alpha\Delta k_{it} + \beta\Delta l_{it} + \gamma\Delta m_{it}$$

- Total differentiation wrt shocsk:

$$\frac{d\Delta q_{it}}{d\Delta\omega_{it}} = \underbrace{1}_{\text{direct effect}} + \underbrace{\alpha\frac{\partial\Delta k_{it}}{\partial\Delta\omega_{it}} + \beta\frac{\partial\Delta l_{it}}{\partial\Delta\omega_{it}} + \gamma\frac{\partial\Delta m_{it}}{\partial\Delta\omega_{it}}}_{\text{indirect effect}}$$

$$\frac{d\Delta q_{it}}{d\Delta\xi_{it}} = \alpha\frac{\partial\Delta k_{it}}{\partial\Delta\xi_{it}} + \beta\frac{\partial\Delta l_{it}}{\partial\Delta\xi_{it}} + \gamma\frac{\partial\Delta m_{it}}{\partial\Delta\xi_{it}}$$

Reduced form growth regressions

- As TFP and ξ are exogenous, run:

$$\Delta y_{it} = a_0 + a_1 \Delta TFP_{it} + a_2 \Delta \xi_{it} + a_X X_{it} + e_{it}$$

- Pool obs. across sectors. Include year*sector dummies and area dummies. Bootstrapped s.e.
- Exclude the (few) observations at full capacity ($u_{it} = 1$)
- Experiment with many specifications (F.E., TFP estimates, sectoral regressions...)

Results: Sales and Output

	Sales		Price	Output	
	(1)	(2)	(3)	(4)	(5)
	Nominal	Real		Nominal	Real
ΔTFP	0.66***	0.82***	-0.17***	0.85***	1.03***
	(0.019)	(0.024)	(0.005)	(0.024)	(0.023)
$\Delta\xi$	0.44***	0.29***	0.13***	0.37***	0.24***
	(0.007)	(0.008)	(0.002)	(0.006)	(0.007)
Observations	6,566	6,566	6,555	6,587	6,543
R^2	0.70	0.50	0.76	0.61	0.53

- One s.d. increase in TFP increases output by 11%, for demand 12%

Results: Variable inputs

	(1) Hours worked	(2) Intermediate inputs	(3) Utilized capital
ΔTFP	0.05***	0.23***	0.02
	(0.019)	(0.043)	(0.024)
$\Delta\xi$	0.11***	0.41***	0.11***
	(0.006)	(0.011)	(0.008)
Observations	6,527	6,569	6,509
R-squared	0.12	0.30	0.09

Results: Quasi-fixed inputs

	(1) Employment	(2) Hires	(3) Separations	(4) Investment rate
ΔTFP	0.08***	0.09***	-0.01	0.06**
	(0.013)	(0.017)	(0.017)	(0.02)
$\Delta\xi$	0.08***	0.07***	-0.02***	0.04***
	(0.004)	(0.005)	(0.005)	(0.007)
Observations	6,517	6,565	6,571	5,334
R-squared	0.12	0.11	0.04	0.04

Introducing a benchmark

- Given estimates of $\sigma, \alpha, \beta, \gamma$ compute the implied elasticities:

$$\Delta q^{*}_{it} = \frac{\sigma}{\theta} \Delta TFP_{it} + \frac{(\alpha + \beta + \gamma)}{\theta} \Delta \xi_{it}$$

- We can compare them with those we get from the data

	$\Delta(p+q)$		Δq		Δp		Δx	
	Pred.	*Act.*	*Pred.*	*Actual*	*Pred.*	*Actual*	*Pred.*	*Actual*
ΔTFP	2.2	0.85	2.8	1.03	-0.56	-0.17	2.2	0.1
$\Delta\xi$	0.56	0.37	0.44	0.24	0.11	0.13	0.56	0.21

- Lower response than that predicted by the frictionless model
- Large deviations following TFP shocks

Implications for misallocation

- Deviations from the frictionless models more substantial for TFP
  $\Rightarrow$ Asymmetric adjustment costs
- Growing literature on the effects of misallocation on aggregate productivity (Hsieh and Klenow, 2009)
- Typically focused on external obstacles: labor market regulation, corruption ...
- They should have symmetric effects on the two shocks
- Consistent with *within the firm* obstacles to growth

Asymmetry and reorganization

- When demand increases, just modify the scale of operation
- TFP shocks shift cost functions. Transformative events that require reorganization of work routines within the firm
  - Example: ICT adoption requires reorganization, changing the skill mix... (Bresnahan et al., 2001; Caroli and Van Reenen, 2001)
- Bloom, Van Reenen an Sadun: large cross firms heterogeneity in managerial practices
- Better practices make adjusting to (particulary TFP) shocks easier

Organizational inertia: four proxies (dummies)

$$\Delta y_{it} = b_0 + b_1 \Delta TFP_{it} + b_2 D_R \Delta TFP_{it} + b_3 \Delta \xi_{it} + b_4 D_R \Delta \xi_{it} + b_5 D_R + b_6 X_{it} + e_{it}$$

1. Self reported: Firms that did not meet their investment plans are asked why. “Reasons related to internal organization of the firm" most often quoted (60%): “inertia" dummy
2. Family firms – Bloom and Van Reenen, Lippi and Schivardi (2013): worse managerial practices
3. Managerial quality: fixed effect of executives (Abowd et al. 1999)
4. Education of the workforce – complementary to restructuring – Caroli and Van Reenen 2001, Bresnahan et al., 2002

Results: organizational hurdles

	Self reported		Family firm	
	Output	Price	Output	Price
ΔTFP	1.092***	-0.178***	1.112***	-0.179***
	(0.041)	(0.009)	(0.038)	(0.007)
ΔTFP $\times$Hurdle	-0.142**	0.023*	-0.164***	0.030***
	(0.056)	(0.012)	(0.051)	(0.009)
$\Delta\xi$	0.245***	0.131***	0.244***	0.131***
	(0.011)	(0.003)	(0.010)	(0.002)
$\Delta\xi\times$ Hurdle	-0.001	-0.002	-0.007	-0.003
	(0.015)	(0.004)	(0.015)	(0.004)
Hurdle	0.006**	-0.001	-0.007**	0.002***
	(0.003)	(0.001)	(0.003)	(0.001)
Observations	4,970	5,000	6,219	6,258
R-squared	0.52	0.76	0.53	0.76

Results: organizational hurdles, continued

	Low mang. quality		Low HK	
	Output	Price	Output	Price
ΔTFP	1.172***	-0.201***	1.129***	-0.173***
	(0.055)	(0.012)	(0.043)	(0.007)
ΔTFP $\times$Hurdle	-0.174**	0.041**	-0.169***	0.023*
	(0.085)	(0.018)	(0.065)	(0.013)
$\Delta\xi$	0.252***	0.139***	0.239***	0.127***
	(0.016)	(0.004)	(0.013)	(0.003)
$\Delta\xi\times$ Hurdle	-0.025	0.001	0.013	0.000
	(0.023)	(0.006)	(0.019)	(0.004)
Hurdle	-0.002	0.001	-0.003	0.000
	(0.005)	(0.001)	(0.003)	(0.001)
Observations	2,050	2,065	3,647	3,669
R-squared	0.54	0.81	0.52	0.74

Conclusions

- We exploit knowledge of firm level prices to identify separately idiosyncratic demand and supply factors
- Firms under-react relatively more to TFP shocks
- Evidence consistent with frictions linked internal organization, and not only to institutional environment
- Implications on how to reduce misallocation
  1. Not only a question of gvmt policies - regulation, corruption...
  2. Managerial practices and restructuring capacity: role of corporate governance (family vs. non family) and corporate finance (PE/equity vs. bank debt)
- Managerial capacity important not only for within firm productivity growth, but also for efficient allocation of resources (between)

Dynamics

◂ Back

- Important for control function in TFP estimation
- Capital stock *in place* evolves according to

$$\bar{K}_{it} = (1 - \delta)\bar{K}_{it-1} + I_{it-1} \tag{2}$$

- Capital used for production is

$$K_{it} = u_{it}\bar{K}_{it}, \;\; u_{it} \leq 1 \tag{3}$$

- State variables: $\bar{K}$, ω and ξ. Include ξ in the control functions to relax the scalar unobservability assumption –

Dynamic programming formulation

Back

- The DP is

$$V(\bar{K}_{it}, \Omega_{it}, \Xi_{it}) = \max_{I_{it}} \{\Pi_{it} - pI_{it} + \psi E(V(\bar{K}_{it+1}, \Omega_{it+1}, \Xi_{it+1}) | \Omega_{it}, \Xi_{it})\} \quad (4)$$

subject to

$$\bar{K}_{it+1} = I_{it} + (1-\delta)\bar{K}_{it} \quad (5)$$

$$\omega_{it+1} = \rho^{\omega}\omega_{it} + \epsilon^{\omega}_{it+1} \quad (6)$$

$$\xi_{it+1} = \rho^{\xi}\xi_{it} + \epsilon^{\xi}_{it+1} \quad (7)$$

Descriptive stats: Levels

Back

	All	Textile and leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
Sales	126,619 (595,802)	54,055 (109,611)	114,224 (254,860)	169,000 (312,986)	71,758 (119,067)	116,618 (341,266)	107,045 (245,620)	483,668 (2,117,926)
Output	126,562 (572,481)	54,370 (110,007)	110,263 (234,334)	173,603 (319,110)	73,187 (121,902)	119,816 (342,676)	108,749 (247,169)	461,125 (2,018,199)
Workers	525 (2,454)	314 (559)	445 (823)	510 (972)	331 (479)	335 (903)	565 (1,271)	1,950 (8,852)
Obs.	12,110	2,718	705	1,666	1,192	1,887	3,159	783

Descriptive stats: Growth rates

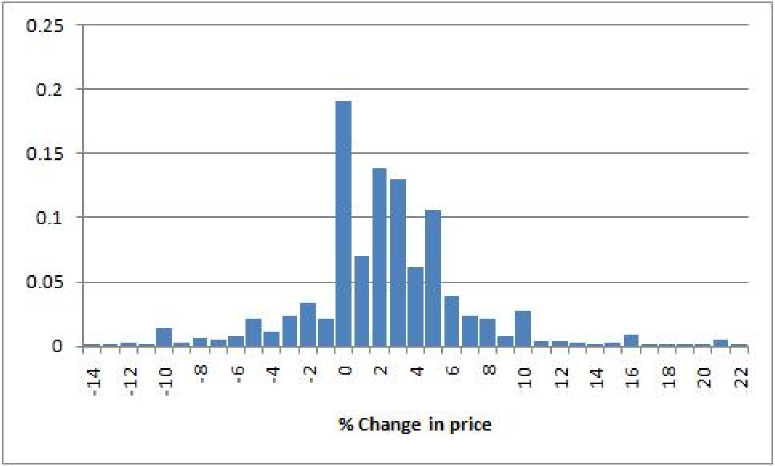
Back

	All	Textile and leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
ΔSales	.020	-.005	.027	.020	.016	.021	.036	.035
	(.19)	(.17)	(.13)	(.14)	(.18)	(.17)	(.19)	(.38)
ΔOutput	.023	-.007	.035	.029	.023	.034	.030	.043
	(.22)	(.20)	(.16)	(.20)	(.19)	(.20)	(.23)	(.30)
ΔInterm. inputs	.003	-.012	.039	.026	.027	.031	.038	.058
	(.30)	(.31)	(.25)	(.31)	(.25)	(.32)	(.34)	(.44)
Δhours worked	-.004	-.017	-.005	.001	-.008	.004	.001	-.003
	(.13)	(.14)	(.09)	(.11)	(.12)	(.14)	(.14)	(.15)
Δutilized capital	.038	.015	.052	.041	.040	.053	.043	.044
	(.20)	(.20)	(.19)	(.21)	(.20)	(.18)	(.19)	(.25)
Δprices	.021	.023	.016	.021	.026	.027	.017	.016
	(.06)	(.05)	(.08)	(.06)	(.05)	(.08)	(.06)	(.04)
Obs.	12,110	2,718	705	1,666	1,192	1,887	3,159	783

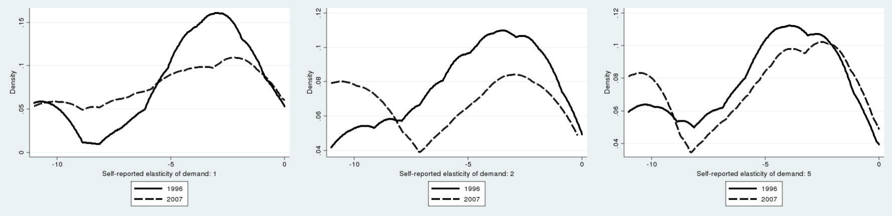
Distribution of price changes

Back

"Average yearly percentage variation of prices of goods and services sold"



Distribution of self-reported elasticity ◂ Back



Sectors: Textile and leather, Metals, Mechanical

Demand elasticity estimates Back

Sector	INVIND	OLS	IV	INVIND Single product	INVIND Non exporters
Textile and leather	4.5	.27	6.1	4.7	8
Metals	5.5	.28	4.9	6.4	7
Machinery	5	.39	5.7	5.1	7.4

Production function estimates: OP, own prices

Back

	(1) Txt+leather	(2) Metals	(3) Machinery
Δk	0.14***	0.08***	0.11***
	(0.027)	(0.028)	(0.023)
Δl	0.17***	0.24***	0.17***
	(0.025)	(0.031)	(0.029)
Δm	0.49***	0.52***	0.52***
	(0.023)	(0.023)	(0.019)
$\alpha + \beta + \gamma$	0.8	0.85	0.8
Obs.	1,800	1,354	2,071
R^2	0.67	0.65	0.72

Descriptive statistics: ΔTFP and $\Delta\xi$

Back

	N	*Mean*	*Std.dev.*	Percentiles				
				5th	*25th*	*50th*	*75th*	*95th*
Panel A: ΔTFP								
ΔTFP Olley and Pakes	7,654	.005	.13	-.15	-.04	.007	.05	.16
Δ^3 TFP	7,654	.003	.14	-.16	-.04	.003	.05	.16
Panel B: $\Delta\xi$								
Sectoral avg.	7,654	.010	.32	-.46	-.12	.01	.15	.46
Class avg.	6,490	.005	.34	-.48	-.12	.01	.14	.45
Individual reported	720	.004	.42	-.56	-.11	.03	.16	.53

Lagged effects

Back

	Output	Price	Employment	Investment rate
ΔTFP_t	0.987***	-0.160***	0.076***	0.088***
	(0.031)	(0.006)	(0.014)	(0.020)
ΔTFP_{t-1}	0.155***	-0.041***	0.110***	0.071***
	(0.020)	(0.004)	(0.014)	(0.021)
ΔTFP_{t-2}	0.036*	-0.020***	0.062***	0.069***
	(0.022)	(0.004)	(0.013)	(0.021)
$\Delta \xi_t$	0.240***	0.133***	0.075***	0.035***
	(0.010)	(0.003)	(0.005)	(0.006)
$\Delta \xi_{t-1}$	-0.027***	0.010***	0.024***	0.015**
	(0.008)	(0.002)	(0.004)	(0.007)
$\Delta \xi_{t-2}$	0.001	-0.001	0.023***	0.028***
	(0.007)	(0.001)	(0.004)	(0.007)
Observations	5,425	5,436	5,378	4,390
R-squared	0.52	0.79	0.16	0.07

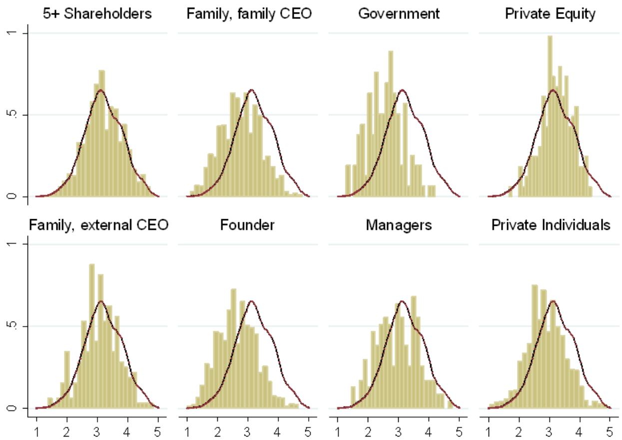
Production function estimates: OP, Sectoral deflator

Back

	Txt+leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
Δk	0.11***	0.06	0.08***	0.10***	0.07***	0.08***	0.13**
	(0.023)	(0.038)	(0.020)	(0.030)	(0.024)	(0.018)	(0.062)
Δl	0.13***	0.20***	0.17***	0.23***	0.17***	0.15***	0.31***
	(0.022)	(0.050)	(0.025)	(0.039)	(0.027)	(0.023)	(0.064)
Δm	0.43***	0.36***	0.55***	0.34***	0.47***	0.50***	0.36***
	(0.020)	(0.041)	(0.025)	(0.029)	(0.021)	(0.017)	(0.050)
$\frac{\sigma(\tilde{\alpha}+\tilde{\beta}+\tilde{\gamma})}{\sigma-1}$	0.86	0.77	1.01	.82	.86	.91	.96
Obs.	1,806	446	1,083	816	1,356	2,076	419
R^2	0.77	0.72	0.82	0.70	0.76	0.79	0.67

Management scores across ownership types

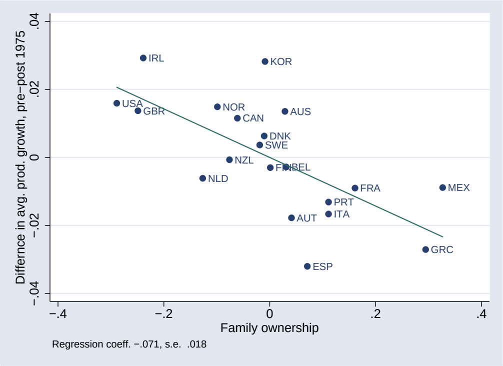
Back



Source: World Management Survey website (www.worldmanagementsurvey.org) , 20 Sept 2010.

Productivity growth changes before-after 1975 vs. family ownership, OECD excluding Japan

◂ Back



Is it just measurement error?

- Alternative explanation: just measurement error in shocks
- Cannot explain asymmetry
- High quality data
- Past shocks also matter: consistent with sluggish adjustment
- Longer lags, at which measurement error should be less important – similar results
- Measurement error should not be correlated with firm's organizational ability