Estimation of Production Function 3

Applications

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Applications

- Tons of applications using estimated production function and productivity.
- I focus on two applications:
  - Reallocation analysis: Olley and Pakes (1996,EMA)
  - Measurement of markup: De Loecker and Warzynski (2013, AER), De Loecker and Eckhaout (2017)
- See reading list for other selected applications.

Olley and Pakes (1996)

- Empirical question: How did the prodcutivity evolve in telecommunication equipment industry.
- Motivation: change in the regulatory environment & technology
- They use estimates of production function to construct productivity and answer these questions.

A bit more Background

- AT&T has maintained an exclusive monopoly in telecommunication services.
- Western Electric (subsidiary of AT&T) supplied around 90% of AT&T's equipment purchase.
  - equipment: telephone sets, private branch exchange (PBX)
  - free from competitive pressures in the equipment market.
- 1978: Registration and certification program (by FCC)
  - allow for connection of private subscriber equipment to the telecommunication network owned by AT&T.
- January 1982: Consent Decree
  - Divestiture of AT&T's regional operating companies.
  - Regional Bell operating companies (RBOC) are free to purchase equipment from any supplier and are prohibited to produce equipment by themselves.
  - Implemented in 1984.

Decomposition Methods

- Decomposition of aggregate productivity in the industry

$$\begin{aligned}\Omega_t &\equiv \sum_i s_{it}\omega_{it} \\ &= \underbrace{N_t^{-1}\sum \omega_{it}}_{average\ \ productivity:\bar{\omega}_t} + \underbrace{\sum(\omega_{it}-\bar{\omega}_t)(s_{it}-\bar{s}_t)}_{allocation\ \ term:\Gamma_t^{OP}} \end{aligned} \quad (1)$$

- The table in the next slide shows the deconposition result
  - Col 1: Ω_t
  - Col 2: $\bar{\omega}_t$
  - Col 3: Γ_t^{OP}
  - Col 4: $Corr(k_{it}, \omega_{it})$

Results from Decomposition Analysis

TABLE XI

DECOMPOSITION OF PRODUCTIVITY[a]
(EQUATION (16))

Year	p_t	$\bar{p}_t$	$\Sigma_i \Delta s_{it} \Delta p_{it}$	$\rho(p_t, k_t)$
1974	1.00	0.90	0.01	−0.07
1975	0.72	0.66	0.06	−0.11
1976	0.77	0.69	0.07	−0.12
1977	0.75	0.72	0.03	−0.09
1978	0.92	0.80	0.12	−0.05
1979	0.95	0.84	0.12	−0.05
1980	1.12	0.84	0.28	−0.02
1981	1.11	0.76	0.35	0.02
1982	1.08	0.77	0.31	−0.01
1983	0.84	0.76	0.08	−0.07
1984	0.90	0.83	0.07	−0.09
1985	0.99	0.72	0.26	0.02
1986	0.92	0.72	0.20	0.03
1987	0.97	0.66	0.32	0.10

[a] See text for details.

Pavcnik (2002, REStud)

- Research Question: The effects of trade liberalization on plant productivity in Chile.
  - Implemented a trade liberalization program during 1974-1979.
  - Eliminate non-tariff barriers, reduce tariff rates (10% ad valorem in 1979)
- Important question from policy perspectives.
- Provide empirical findings consistent with Melitz (2003, EMA)
  - The model predicts that opening trade leads to
    - reallocation of resources
    - the more productive firms to enter the export market and gain the revnue,
    - and simultaneously force the least productive firms to exit.
    - the aggregate industry productivity is grown by the intra-industry reallocation
- Use OP framework to estimate plant-level productivity.
- Results: Trade liberalization affects both reallocation channel and average productivity.

Aggregate Productivity

- Aggregate Ω_t, average $\bar{\omega}_t$, reallocation term Γ_t^{OP}

All	79	0·000	0·000	0·000	Import competing	79	0·000	0·000
	80	−0·010	0·018	−0·027		80	−0·063	0·027
	81	0·051	0·054	−0·003		81	0·032	0·092
	82	0·329	0·048	0·281		82	0·088	0·066
	83	0·174	0·010	0·164		83	0·077	0·034
	84	0·117	0·025	0·092		84	0·089	0·059
	85	0·120	−0·003	0·123		85	0·095	0·061
	86	0·193	0·066	0·127		86	0·319	0·107
Export oriented	79	0·000	0·000	0·000	Nontraded	79	0·000	0·000
	80	−0·059	−0·038	−0·021		80	0·044	0·021
	81	−0·048	−0·054	0·006		81	0·101	0·047
	82	0·591	0·040	0·551		82	0·228	0·038
	83	0·326	0·015	0·311		83	0·127	−0·004
	84	0·178	0·049	0·129		84	0·114	0·000
	85	0·203	−0·011	0·214		85	0·101	−0·040
	86	0·254	0·087	0·166		86	0·062	0·038

Regression analysis on individual productivity

- Regression in a DID framework (eq 12 in the paper)

$$\omega_{it} = \alpha_0 + \alpha_1(time)_t + \alpha_2(trade)_i + \alpha_3(trade * time)_{it} + \alpha_4 Z_{it} + v_{it}$$

  - $(trade)_i$: dummy for the trade orientation of a plant (export-oriented, import-competing).

- Note: Sample 1979-1986. Trade liberalization implemented during 1974-1979.
- Interpret as how firms in trade-oriented sector evolve in comparison with those in domestic sectors.

	(1)		(2)		(3)		(4)		(5)		(6)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Export-oriented	0·106	0·030**	0·106	0·030**	0·112	0·031**	0·098	0·048**	0·095	0·048**	0·100	0·046**
Import-competing	0·105	0·021**	0·105	0·021**	0·103	0·021**	−0·024	0·040	−0·025	0·040	−0·007	0·039
ex_80	−0·054	0·025**	−0·053	0·025**	−0·055	0·025**	−0·071	0·026**	−0·068	0·026**	−0·071	0·026**
ex_81	−0·099	0·028**	−0·097	0·028**	−0·100	0·028**	−0·117	0·027**	−0·110	0·027**	−0·119	0·027**
ex_82	0·005	0·032	0·007	0·032	0·003	0·032	−0·054	0·028*	−0·042	0·028	−0·055	0·028*
ex_83	0·021	0·032	0·023	0·032	0·021	0·032	−0·036	0·029	−0·025	0·030	−0·038	0·029
ex_84	0·050	0·031	0·051	0·031	0·050	0·031	0·007	0·028	0·017	0·028	0·007	0·028
ex_85	0·030	0·030	0·032	0·031	0·028	0·030	−0·001	0·029	0·013	0·030	−0·003	0·029
ex_86					0·043	0·036					−0·008	0·034
im_80	0·011	0·014	0·011	0·014	0·010	0·014	0·013	0·014	0·013	0·014	0·013	0·014
im_81	0·047	0·015**	0·047	0·015**	0·046	0·015**	0·044	0·014**	0·044	0·014**	0·044	0·014**
im_82	0·033	0·016**	0·034	0·017**	0·030	0·016*	0·024	0·015*	0·024	0·015*	0·025	0·015*
im_83	0·042	0·017**	0·043	0·017**	0·043	0·017**	0·040	0·015**	0·041	0·015**	0·042	0·015**
im_84	0·062	0·017**	0·062	0·017**	0·063	0·017**	0·059	0·015**	0·059	0·015**	0·061	0·015**
im_85	0·103	0·017**	0·104	0·017**	0·104	0·017**	0·101	0·015**	0·102	0·016**	0·101	0·015**
im_86					0·071	0·019**					0·073	0·017**
Exit indicator	−0·081	0·011**	−0·076	0·014**			−0·019	0·010**	−0·010	0·013		
Exit_export indicator			−0·021	0·036					−0·069	0·035*		
Exit_import indicator			−0·007	0·023					−0·005	0·021		
Industry indicators	yes		yes		yes		yes		yes		yes	
Plant indicators	no		no		no		yes		yes		yes	
Year indicators	yes		yes		yes		yes		yes		yes	
R^2 (adjusted)	0·057		0·058		0·062		0·498		0·498		0·488	
N	22983		22983		25491		22983		22983		25491	

Note: ** and * indicate significance at a 5% and 10% level, respectively. Standard errors are corrected for heteroscedasticity. Standard errors in columns 1–3 are also adjusted for repeated observations on the same plant. Columns 1, 2, 4, and 5 do not include observations in 1986 because one cannot define exit for the last year of a panel.

Collard-Wexler and De Loecker (2014, AER)

- Research question: Effects of a new technology (minimill) on industry-level productivity in the US steel industry.
  - minimill: new technology
  - vertically integratd (VI): old technology
- Findings:
  1. Displacement of the older technology accounts for 1/3 of the increase in aggregate productivity.
  2. Average productivity for the surviving VI producers increased as well.

New Decomposition Methods

- Let G be the set of groups of firms.
  - $G = \{minimill, VI\}$.
- Within transformation

$$\Omega_t = \sum_g s_t(g) \left(\bar{\omega}_t(g) + \underbrace{\sum_{j \in g} (\omega_{jt} - \bar{\omega}_t(g))(s_{it}(g) - \bar{s}_t(g))}_{\Gamma_t^{OP}(g)} \right) \quad (2)$$

  - $\bar{\omega}_t(g)$: average productivity in group g . $\Gamma_t^{OP}(g)$: allocation term within group g

- Between decomposition

$$\Omega_t = \bar{\Omega}_t + \underbrace{\sum_g (s_t(g) - 1/2)(\Omega_t(g) - \bar{\Omega}_t)}_{\equiv \Gamma_t^B} \tag{3}$$

  - $\Omega_t(g)$: share-weighted productivity in group g
  - $\bar{\Omega}_t = \frac{1}{2}\sum_g \Omega_t(g)$:average aggregate productivity over two groups.
  - $\Gamma_t^B = \sum_g (s_t(g) - 1/2)(\Omega_t(g) - \bar{\Omega}_t)$: allocation term between groups.

TABLE 7—STATIC DECOMPOSITIONS OF PRODUCTIVITY GROWTH CHANGE 1963–2002 (*Percent*)

Aggregate TFP $\Delta\Omega$	22.1	
Olley-Pakes decomposition:		
Unweighted average: $\Delta\,\overline{\omega}$	15.7 (0.71)	
Covariance: $\Delta\,\Gamma^{OP}$	6.4 (0.29)	
Between decomposition:		
Unweighted average: $\Delta\,\overline{\Omega}$	17.0 (0.77)	
Between covariance: $\Delta\,\Gamma^{B}$	5.1 (0.23)	
Within decomposition:	Minimills	Integrated
Aggregate TFP: $\Delta\,\Omega(\psi)$	9.6	24.3
Unweighted average: $\Delta\,\overline{\omega}(\psi)$	5.4 (0.55)	18.4 (0.83)
Within covariance: $\Delta\,\Gamma^{OP}(\psi)$	4.4 (0.45)	3.7 (0.17)

Note: The share of each component in the total aggregate productivity growth is listed in parentheses.

De Loecker and Warzynski (2013, AER)

- Measuring markup using production function.
- An alternative to using demand estimation.
- Two assumptions
  1. Cost minimization
  2. (at least) one flexible input

- Cost minimization problem

$$\min_{\{x_{jt}^v\}_{v=1}^V} \sum_v p_{jt}^v x_{jt}^v$$
$$s.t. q_{jt} = F(x_{jt}^1, \cdots, x_{jt}^V; k_{jt}, \omega_{jt})$$

  - p_{jt}^v: input price of variable (flexible) inputs
  - x_{jt}^v: input

- FOC for cost minimization:

$$p_{jt}^v = \lambda_{jt} \frac{\partial F}{\partial x_{jt}^v} \ \forall v = 1, \cdots, V$$

  - λ_{jt}: Lagrange multiplier. $\lambda_{jt} = mc_{jt}$.

- FOC implies

$$\begin{aligned} \frac{p_{jt}^v}{mc_{jt}} &= \frac{\partial F}{\partial x_{jt}^v} \\ \iff \underbrace{\frac{\partial F}{\partial x_{jt}^v}\frac{x_{jt}^v}{q_{jt}}}_{elasticity} &= \frac{p_{jt}^v}{mc_{jt}}\frac{x_{jt}^v}{q_{jt}} \\ &= \frac{P_{jt}}{mc_{jt}} \underbrace{\frac{p_{jt}^v x_{jt}^v}{P_{jt} q_{jt}}}_{expenditure\ \ share} \end{aligned}$$

- Thus, we have

$$\frac{P_{jt}}{mc_{jt}} = \left(\frac{\partial F}{\partial x_{jt}^v} \frac{x_{jt}^v}{q_{jt}} \right) \cdot \left(\frac{p_{jt}^v x_{jt}^v}{P_{jt} q_{jt}} \right)^{-1}$$

- Elasticity is obtained from estimation of production function.
- Expenditure share is directly observed in most micro data on production.

Rise of Market Power (De Loecker and Eckhout 2017)

- Influential and controversial paper.
- Research question:
  - Document the evolution of markups for the US economy since 1950.
  - The macroeconomic implications of the markup (i.e., declining labor share, wage, etc)
    - (I do not focus on this hare)
- Use COMPUSTAT to estimate markup of publicly traded firms in the US between 1950 and 2014.
- Substantial increase in markup from 1980 (18%) to 2014 (67%).

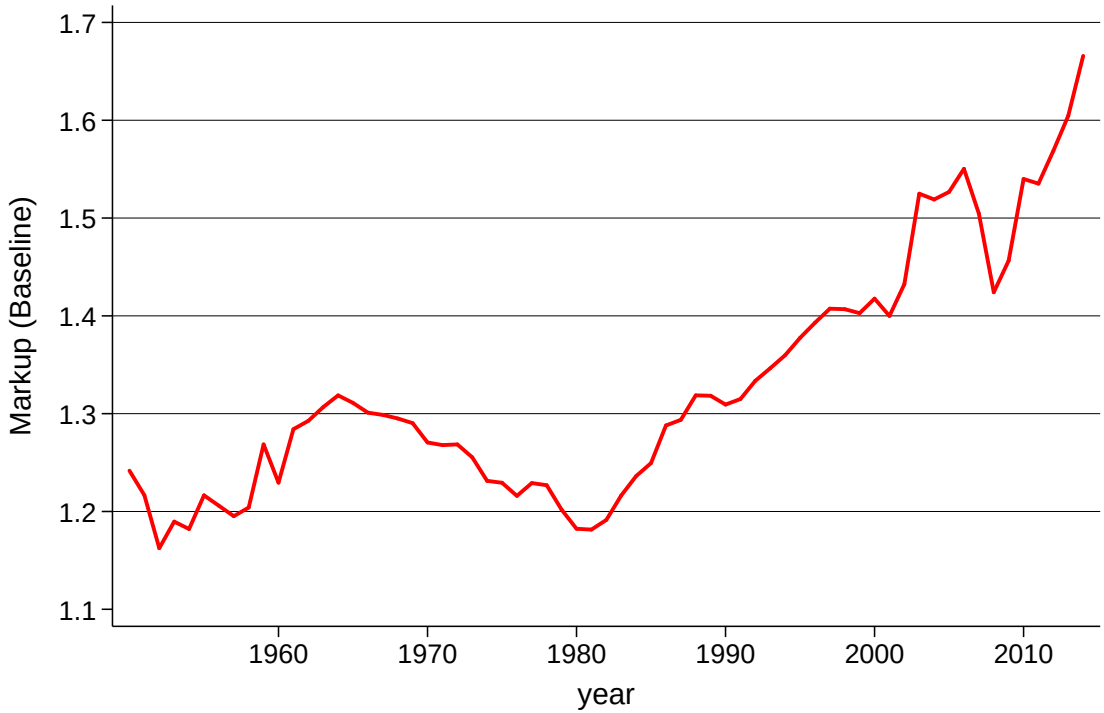

Figure 1: The Evolution of Average Markups (1960 - 2014). Average Markup is weighted by marketshare of sales in the sample.