Unraveling firms: Demand, productivity and markups heterogeneity

by E. Forlani, R. Martin, G. Mion & M. Muûls

Discussant: Sabien Dobbelaere

Vrije Universiteit Amsterdam, Tinbergen Institute and IZA

4th WB-BE research conference:

Labor Markets: Growth, productivity and inequality

Madrid - June 16, 2016

Outline

1. Contribution
2. Baseline model
3. Estimation algorithm
4. Empirical application
5. Comments/suggestions

Contribution (1)

Production functions are a fundamental component of all economics and TFP is the most celebrated residual in the world of economics

- Following the seminal paper of Marschak and Andrews (Ectra,1944), the econometric literature on estimating microeconomic production functions had devoted much attention to the problem of biases and approaches to solving them (see Ackerberg-Caves-Frazer,Ectra,2016)

Contribution (2)

Estimation of demand is key to welfare analysis and economic policy evaluations

- Following the seminal paper of Stone (EJ,1954) and the influential book of Deaton and Muellbauer (,1980), the econometric literature on estimating demand systems has advanced dramatically (Redding-Weinstein,mimeo,2016)
- Has been used to examine IO questions of market power, mergers, innovation, tariffs and valuation of new brands in differentiated-products markets

Contribution (3)

This paper contributes to these two strands of literature

- by developing a novel econometric framework that allows for three-dimensional firm heterogeneity: productivity, demand and markups
- while imposing restrictions that are mild given the state of literature (Foster-Haltiwanger-Syverson,AER,2008, De Loecker-Warzynski,AER,2012; Dobbelaere-Mairesse,JAE,2013)
  - Exploit standard identifying assumptions in the TFP estimation literature
    - cost minimization
    - Markov process for TFP
    - presence of variable and predetermined inputs
  - Impose explicit assumptions about preferences and market structure

Contribution (4)

Exploiting information on firm-level prices, their methodology allows to quantify the importance of the three dimensions of heterogeneity in explaining key firm-level outcomes

- Application to export status and firm size based on firm-level production data for about 5.000 Belgian manufacturing firms covering the period 1996-2007

Very interesting and relevant paper

Baseline model (1)

Production

Assumptions

- Cobb-Douglas production technology with Hicks-neutral productivity term A_i
- Labor and materials: static inputs in production (free of adjustment costs)
- Capital: dynamic input, predetermined in the short run
- Perfectly competitive input markets
- Static cost minimization for L and M:

$$\min_{L_i, M_i} \{L_i W_L + M_i W_M\} \quad s.t.\ Q_i = A_i L_i^{\alpha_L} M_i^{\alpha_M} K_i^{\gamma - \alpha_L - \alpha_M}$$

From the FOCs, it follows that: $\frac{\partial C_i}{\partial Q_i} = \frac{1}{\alpha_L + \alpha_M} \frac{C_i}{Q_i}$

Baseline model (2)

Demand and market structure

Assumptions

- Monopolistically competitive industry
- Continuum of firms each producing one variety of a differentiated good
- Generalized CES preferences

A representative consumer faces the following maximization problem:

$$\max_{Q}\left\{\int_{i\in I}\frac{\eta_i}{\eta_i-1}\left(\Lambda_i Q_i\right)^{\frac{\eta_i-1}{\eta_i}}di\right\}\quad s.t.\ \int_{i\in I}P_i Q_i di = B$$

Profit maximization of firm i implies that:

$$P_i = \mu_i\frac{\partial C_i}{\partial Q_i}\quad \text{with}\quad \mu_i = \frac{\eta_i}{\eta_i-1}$$

Baseline model (3)

Structure on process driving unobservable endogenous variables

Assumptions

- Unobservable productivity $(\ln A_{it} = a_{it})$ and demand shocks $(\ln \Lambda_{it} = \lambda_{it})$ follow first-order exogenous Markov processes

$$\begin{aligned} a_{it} &= \phi_a a_{it-1} + \nu_{ait} \\ \lambda_{it} &= \phi_\lambda \lambda_{it-1} + \nu_{\lambda it} \end{aligned}$$

Timing: Each firm i sets simultaneously Q_i, L_i and M_i, given K_i, W_L, W_M, a_i, λ_i and μ_i

Estimation algorithm (1)

To identify the parameters of interest (productivity shocks a_{it}, demand shocks λ_{it} and markups μ_{it}), the authors implement a two-stage approach

First-stage revenue equation

$$\underbrace{\frac{r_{it} - s_{Lit}\left(l_{it} - k_{it}\right) - s_{Mit}\left(m_{it} - k_{it}\right)}{s_{Mit}}}_{LHS_{it}} =$$

$$\frac{\gamma}{\alpha_M} k_{it} + \phi_a LHS_{it-1} - \phi_a \frac{\gamma}{\alpha_M} k_{it-1} + \left(\phi_\lambda - \phi_a\right) \frac{r_{it-1}}{s_{Mit-1}}$$
$$- \frac{\left(\phi_\lambda - \phi_a\right)}{\alpha_M} q_{it-1} + \frac{\left(\nu_{ait} - \nu_{\lambda it}\right)}{\alpha_M}$$

The first-stage estimation generates OLS estimates $\widehat{\frac{\gamma}{\alpha_M}} = \widehat{\beta}$ and $\widehat{\phi}_a$

Estimation algorithm (2)

Second-stage quantity equation

$$q_{it} - \widehat{\phi}_a q_{it-1} = \gamma \left[\frac{1}{\widehat{\beta}} \frac{s_{Lit}}{s_{Mit}} (l_{it} - k_{it}) + \frac{1}{\widehat{\beta}} (m_{it} - k_{it}) + k_{it} + \frac{\widehat{\phi}_a}{\widehat{\beta}} LHS_{it-1} - \widehat{\phi}_a k_{it-1} - \frac{\widehat{\phi}_a}{\widehat{\beta}} \frac{r_{it-1}}{s_{Mit-1}} \right] + \nu_{ait}$$

Using the moment condition $\mathrm{E}[\nu_{ait} k_{it}] = 0$, the second-stage estimation generates the IV estimate $\widehat{\gamma}$

Identification of three-dimensional firm heterogeneity (3)

Given the estimates $\widehat{\frac{\gamma}{\alpha_M}}=\widehat{\beta}$, $\widehat{\phi}_a$ and $\widehat{\gamma}$, one can identify firm-level productivity, demand and markup parameters:

$$\begin{aligned}
\widehat{a}_{it} &= q_{it} - \frac{\widehat{\gamma}}{\widehat{\beta}} \frac{s_{Lit}}{s_{Mit}} (l_{it} - k_{it}) - \frac{\widehat{\gamma}}{\widehat{\beta}} (m_{it} - k_{it}) - \widehat{\gamma} k_{it} \\
\widehat{\lambda}_{it} &= \frac{\widehat{\gamma}}{\widehat{\beta}} \frac{r_{it}}{s_{Mit}} - q_{it} \\
\widehat{\mu}_{it} &= \frac{\widehat{\gamma}}{\widehat{\beta}} \frac{1}{s_{Mit}}
\end{aligned}$$

3-dimensional heterogeneity: Evidence and correlation (1)

Data sources: Prodcom, firm balance sheet and micro trade data (NBB)

- 4 industries: NACE 151 (meat), NACE 212 (paper), NACE 266 (concrete) and NACE 361 (furniture)

(1) Evidence of substantial firm heterogeneity in all three dimensions:

- $\sigma_\mu \in$ [0.174 (meat)-0.313 (furniture)]
- $\sigma_a \in$ [0.503 (meat)-1.160 (furniture)]
- $\sigma_\lambda \in$ [0.614 (meat)-1.163 (furniture)]: Most dispersed

3-dimensional heterogeneity: Evidence and correlation (2)

(2) Evidence of non-zero correlation between the state variables:

- $\rho_{a,\lambda} \in [-0.910$ (furniture)--0.663 (paper)$]$
- $\rho_{\lambda,\mu} \in [0.072$ (furniture)-0.611 (concrete)$]$
- $\rho_{a,\mu} \in [-0.115$ (concrete)-0.187 (meat)$]$

(3) Comparison with other methodologies:

- Substantial TFPR-TFPQ differences across methodologies:

  $\rho_{TFPR,a} \in [0.086$ (FHS)-0.38 (DLW)$]$
- Variation in TFPR mainly due to variation in λ (DLW/FHS/OP)

Importance of the 3 sources of firm heterogeneity in explaining firm decisions (3)

(1) Export participation:

- Demand heterogeneity: Driving source generating differences across firms in export participation decisions
- Exporters seem to be more efficient, sell higher-quality goods and charge lower markups

(2) Firm size:

- Productivity heterogeneity: Driving source generating differences across firms in firm size
- Larger firms seem to be more efficient, sell higher-quality goods and charge lower markup

Model assumptions I worry about as a labor economist (1)

(1) Labor and materials: Static inputs in production:

- Acceptable for materials, far less so for labor
  - In particular given the empirical application: see Zhao (mimeo,2012) and Dhyne-Fuss-Mathieu (OBES,2015) for micro evidence on the importance of labor adjustment costs in Belgium
  - Would be interesting to use the markups estimates obtained using cost minimization conditions on both labor and materials to learn about frictions in labor demand (Petrin-Sivadasan,RESTAT,2013)

Model assumptions I worry about as a labor economist (2)

(2) Perfectly competitive input markets

- Does the law of one wage hold?
  - Certainly not for Belgium, see Dobbelaere-Vancauteren (NBBwp,2014) on micro evidence on the type and the degree of imperfect competition in labor markets:
    - 66% of industries comprising 69% of firms are characterized by wage determination under trade unions (including Non-metallic mineral products & Furniture)
    - 22% of industries comprising 19% of firms are characterized by wage determination under oligopsonistic competition (including Paper)

Model assumptions I worry about as a labor economist (3)

(2) Perfectly competitive input markets (ctd)

- Would be interesting to identify
  - firm heterogeneity in labor market imperfection parameters (LMI) and
  - correlations between a, μ and LMI

  important for understanding the link between firm productivity differentials and wage inequality

  (see Card-Cardoso-Heining-Kline,IZAdp,2016)

Model assumptions (4)

(3) Law of motion for unobservable productivity and demand shocks:

a_{it} and λ_{it} are modelled as exogenous first-order Markov processes:

- Can the model be generalized to accommodating
  - endogenous productivity processes (De Loecker,AEJ:Micro,2013; Doralszelski-Jaumandreu,RES,2013)
  - endogenous productivity and demand processes (Jaumandreu-Mairesse,NBERwp,2010)

Estimation algorithm (5)

First-stage revenue equation estimated by OLS

$$\underbrace{\frac{r_{it}-s_{Lit}\left(l_{it}-k_{it}\right)-s_{Mit}\left(m_{it}-k_{it}\right)}{s_{Mit}}}_{LHS_{it}}=$$

$$\frac{\gamma}{\alpha_M}k_{it}+\phi_a LHS_{it-1}-\phi_a\frac{\gamma}{\alpha_M}k_{it-1}+\left(\phi_\lambda-\phi_a\right)\frac{r_{it-1}}{s_{Mit-1}}$$
$$-\frac{\left(\phi_\lambda-\phi_a\right)}{\alpha_M}q_{it-1}+\frac{\left(\nu_{ait}-\nu_{\lambda it}\right)}{\alpha_M}$$

- Not exploiting the non-linear constraint affects the estimation of $\widehat{\frac{\gamma}{\alpha_M}}=\widehat{\beta}$ and $\widehat{\phi}_a$ unless one can assume that
  - the other terms are orthogonal to the first two terms and/or
  - the coefficients $\phi_a\frac{\gamma}{\alpha_M}$ and $\left(\phi_\lambda-\phi_a\right)$ are very small

$\hookrightarrow$ Not the case, hence estimation by NLLS is necessary

Critical look at results (1)

(1) How can sector-specific correlations between a, λ and μ be rationalized?

- $\rho_{a,\lambda}$ quite robust across sectors, $\rho_{\lambda,\mu}$ and $\rho_{a,\mu}$ vary much more

(2) Comparison of the importance of a, λ and μ in explaining TFPR across methodologies: Useful but need more explanation

- What explains the larger unexplained variation in FHS *TFPR*?
- How can differences in the relative importance of the three dimensions be rationalized
  - across methodologies
  - across sectors

Critical look at results (1)

DLW TFP revenue based regressed on a, λ and μ

Industry	151	212	266	361
a	1.236***	.9342***	.9488***	.9733***
	(.0197)	(.0305)	(.0171)	(.0167)
λ	1.561***	1.448***	1.525***	1.063***
	(.02)	(.0265)	(.0183)	(.0158)
μ	-.6635***	-.485***	-.279***	-.2395***
	(.0514)	(.063)	(.0427)	(.0226)
# Obs	1233	769	1402	1561
R^2	0.558	0.619	0.639	0.263

FHS TFP revenue based regressed on a, λ and μ

Industry	151	212	266	361
a	.254**	.1858	.3797***	.2327**
	(.0155)	(.0217)	(.0205)	(.0098)
λ	.2235*	.2986**	.5891***	.2656**
	(.0156)	(.0184)	(.0194)	(.0097)
μ	.2115**	.2716***	.0241	.4876***
	(.044)	(.047)	(.0468)	(.0127)
# Obs	1235	770	1402	1566
R^2	0.159	0.223	0.168	0.250

Results: Application to export status (2)

Exporters seem to charge lower markups:

- Opposite to DLW, in line with Kilinç (mimeo,2016)

  Expected markup difference between exporters and non-exporters might be negative in a small highly open economy

  - Melitz-Ottaviano (RES,2008)-model considering a two-country world with symmetric trade barriers but asymmetric country size and efficiency distributions
  - Confirmed for Luxembourg, seem to be true for Belgium as well