
EC791- International Trade
Empirics of Firm-Level Productivity: a Survey

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Introduction

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When introducing **models with heterogeneous firms**, we motivated them with a series of facts highlighting **differences in firm-level performance** between exporters and non-exporters.

Here is a **survey of empirical articles** on the relationship between firm-level productivity, other measures of performance, and export status.

References:

- Bernard, Jensen, Redding and Schott (2007) JEP, “Firms in International Trade”
- Bernard and Jensen (1999) JIE, “Exceptional Exporter Performance: Cause, Effect, or Both?”
- Bernard and Jensen (2004) REStat, “Why Some Firms Export”
- Bernard, Jensen and Schott (2006) JME, “Trade Costs, Firms, and Productivity”
- Pavcnik (2002) ReStud, “Trade Liberalization, Exit, and Productivity Improvements”
- Tybout (2005) HIT, “Plant- and Firm-Level Evidence on the ‘New’ Trade Theories”
- Roberts and Tybout (1997) AER, “The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs”

Bernard, Jensen, Redding and Schott (2007)

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- JEP article: put the literature into perspective, linking empirical evidence with the “new trade theory”.
- Establish and describe three main facts:
 1. **LIMITED PARTICIPATION:** not all firms export.
 2. **SELECTION:** exporters are “better” than non-exporters along a number of dimensions.
 3. Effects of trade on **REALLOCATIONS AND PRODUCTIVITY** (*à la Melitz*).

Limited Participation

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- Among all firms in the U.S. in 2000:
 - only 4% export;
 - the top 10% exporters account for 96 % of total exports.
- Among manufacturing firms:
 - only 18% export;
 - large variation in participation within manufacturing: only 5% of firms export in “*printing and related support*”, 38% of firms export in “*computer and electronic products*”;
 - exports are a small share of firms’ total sales: from 7% of total sales in “*beverages and tobacco*” to 21% in “*computer and electronic products*”. The average across sectors is 14%.

Limited Participation

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⇒ Higher export intensity in more “skill-intensive” sectors? Could be in line with H-O models... But H-O cannot explain limited participation or intra-industry trade. These aspects call for **variety-motivated trade**.

Selection

Exporters are different:

1. employ more workers (119% more);
2. have higher sales (148% higher);
3. have higher value-added per worker (26% higher);
4. have higher TFP (2% higher);
5. pay higher wages (17% higher);
6. are more capital-intensive (K/L 32% higher);
7. are more skill-intensive (employ 19% more skilled vs unskilled labor).

Evidence for **selection**: exporters were different prior to start exporting. Very limited evidence in favor of “learning by exporting”, see BJ (1999).



This suggest the existence of **entry costs**: see Roberts and Tybout (1997), Das, Roberts and Tybout (2007).

[Differences in factor intensity do NOT support H-O: we observe the same differences between exporters and non-exporters across countries.]

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Reallocations and Productivity

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Trade liberalization induces:

- exit of domestic low-productivity firms
- entry of foreign high-productivity firms



As a result, **aggregate productivity increases.**

Empirical evidence in support of this mechanism in Pavcnik (2002), looking at Chilean data, BJS (2006) for the U.S.

Tybout (2005) is a survey of other studies on the topic.

[All this evidence is consistent with the mechanism in Melitz-type models.]

Data

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BJRS assembled one of the best existing datasets to study U.S. trade:
LFTTD (Linked-Longitudinal Firm Trade Transaction Database)

- merges data from U.S. Census and U.S. Customs
- contains all U.S.-related international trade **transactions**, 1992-2000
- for each transaction, it records:
 - product
 - value and quantity
 - date
 - trading partner country
 - transport mode
 - identity of US firm involved
- ideal to distinguish between firms' extensive margins (number of products sold/bought, number of export destinations) and intensive margin (quantity/value traded).

Other Facts

The detail of LFTTD allowed to uncover more detailed statistics:

- **Concentration of trade:**

- the top 1% of trading firms by value account for 80% of the total value of trade
- the top 10% of trading firms by value account for 95% of the total value of trade

(need a productivity distribution with huge dispersion and/or very high elasticity of substitution to account for this).

- **Small trade flows:**

- firms trade small fractions of their total sales
- most firms trade with a small number (often 1) of countries (see EKK):
 - 64% of U.S. exporters export to 1 destination, and their total export account for 3.3% of total U.S. exports;
 - 13.7% of U.S. exporters export to 5 or more destinations, and their total export account for 92.9% of total U.S. exports.

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Other Facts (contd.)

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- **Multiproduct firms:**

- 42.2% of U.S. exporters sell only 1 product abroad, and they account for 0.4% of U.S. total exports
- 25.9% of U.S. exporters sell 5 products or more abroad, and they account for 98% of U.S. total exports
- positive correlation between the number of products a firm sells and the number of countries it sells to. Both are correlated with other firm characteristics.

New papers on multiproduct firms: BRS (2010), Melitz and Ottaviano (2012), Arkolakis and Muendler (2010).

- **Importers:**

- many of the characteristics found for exporters also hold when looking at importing firms
- many exporters are also importers (see literature on the fragmentation of production).

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● Success and Export

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Bernard and Jensen (1999)

On the direction of causality between **productivity advantage** and **export status**: are ex-ante good firms that become exporters, or they become better by exporting?

The evidence points towards **selection**, but to establish it we need to look at **differences in performance before-during-after periods of export**.

Important question, also for export-promotion policy.

Empirical work with US manufacturing data 1984-1992.

Success and Export Status

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3 possibilities:

1. **SUCCESS LEADS TO EXPORT:** exporting is costly, so only larger and more productive firms can afford it. Hence larger and more productive firms become exporters. (**SELECTION**, modeled in Melitz-type frameworks).
2. **EXPORT LEADS TO SUCCESS:** exporting is “good for a firm”. Since competition is tougher in foreign markets, firms must “improve their performance” to survive there.
⇓
If true, post-entry performance should be better than pre-entry performance for exporters.
3. **EXPORT ENCOURAGES IMPROVEMENT THAT LEADS TO SUCCESS:** firms know that exporting is “good for a firm”, so they decide to export. Before starting though, they have to undertake performance improvements to succeed abroad.

[Notice: 2. and 3. are NOT consistent with optimal behavior!]

Success and Export Status (contd.)

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To distinguish among the 3 possibilities above:

- Look at **measures of performance before entry**:
 - divide sample period in 2 sub-periods, and compare:
 1. non exporters
 2. firms that do not export in the 1st sub-period, but do in the 2nd.

⇒ they find that firms that become exporters in the 2nd sub-period are **ex-ante larger, more productive, and pay higher wages** than all-time non-exporters (supports hypothesis 1., but does not exclude 2., 3.).

Success and Export Status (contd.)

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- Look at **growth in measures of performance** in the years immediately before entry into export

⇒ they find that growth is higher for firms that will start exporting (could support both 2.,3.).

Success and Export Status (contd.)

- Is there an **effect of exporting on firm performance?** (hyp. 2.)
To find out, run reduced-form regressions of **changes in performance measures** on **initial export status**, controlling for other plants characteristics.

Findings:

- exporters display higher growth in employment and sales over a 1-year period;
- no significant results for other measures of performance and over longer periods.

⇒ Mixed evidence, gives no support to hypothesis 2.

NO CONVINCING EVIDENCE THAT EXPORTING LEADS TO PRODUCTIVITY GROWTH!

Success and Export Status (contd.)

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- **Switching pattern:** the data display a lot of entry in/exit from the export market, suggesting that **initial export status** is poorly correlated with **subsequent exporting**.
⇒ Not much support for the hypothesis that exports lead to improved performance (hyp. 3.).

Bernard and Jensen (2004)

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Identify the **factors that induce a firm to start exporting**. They examine:

1. size
2. labor force composition (quality of workforce)
3. product mix (introduction of new products)
4. past performance
5. entry costs
6. spillovers
7. Government intervention

Census data 1984-1992. Export boom in late 80s generates around 10% of switches into and out of exports every year.

Probit empirical model to evaluate the effects of the factors above on the probability of exporting.

Bernard and Jensen (2004)

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Identify the **factors that induce a firm to start exporting**. They examine:

1. size \Rightarrow pos. corr. with export
2. labor force composition (quality of workforce) \Rightarrow pos. corr. with export
3. product mix (introduction of new products) \Rightarrow pos. corr. with export
4. **past performance** \Rightarrow most important factor
5. entry costs \Rightarrow significant effect (see also RT 1997, DRT 2007)
6. spillovers \Rightarrow no effect
7. Government intervention \Rightarrow no effect

Census data 1984-1992. Export boom in late 80s generates around 10% of switches into and out of exports every year.

Probit empirical model to evaluate the effects of the factors above on the probability of exporting.

Bernard, Jensen and Schott (2006)

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Attempt to test **trade-induced reallocations** and their effect on **aggregate productivity** (the “Melitz” mechanism).

Link plant-level U.S. manufacturing data with industry measures of tariffs and transportation costs.

As trade costs fall:

1. industry productivity increases
2. higher probability of plant death
3. higher probability of successful exports
4. existing exporters increase their export shipments.

(all the empirical findings are in line with the mechanism of the Melitz model).

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Pavcnik (2002)

Empirical investigation of the **effects of trade liberalization on productivity** in the case of Chile.

Outline:

1. Structural estimation of a production function to obtain estimates of plant-level productivity, controlling for selection, simultaneity bias, and plant exit.
2. Relate changes in productivity to trade liberalization by exploiting variation over time and across traded and non-traded sectors.

Pavcnik (2002) (contd.)

Findings:

- Support for **within-plant productivity improvements** related to trade liberalization:
 - the productivity of plants in the traded sectors grew 3-10% more than in the non-traded sectors;
 - exiting plants are on average 8% less productive than surviving plants.

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- Support for **within-plant productivity improvements** related to trade liberalization:
 - the productivity of plants in the traded sectors grew 3-10% more than in the non-traded sectors;
 - exiting plants are on average 8% less productive than surviving plants.
- Results seem to contradict the absence of within-firm effects found in Bernard and Jensen (1999), but the two papers are testing two different things:
 - Bernard and Jensen (1999) find no evidence that exporting affects the productivity of an exporting plant;
 - Pavcnik (2002) test whether opening to trade increases the productivity of domestic plants, independently on whether they trade or not (**import competition channel**: firms must “trim their fat” to survive).

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 - Pavcnik (2002) test whether opening to trade increases the productivity of domestic plants, independently on whether they trade or not (**import competition channel**: firms must “trim their fat” to survive).
- Aggregate productivity improvements are linked to exit: reshuffling of resources from less efficient to more efficient plants (*à la* Melitz).

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Tybout, *Handbook of International Trade*

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● **Static**

● Dynamics

RT 1997

Survey of **firm-level** and **plant-level** evidence on the relationships between **pricing, firm size, export status, productivity and profitability.**

RESULTS AND “STATIC” EVIDENCE:

1. **mark-ups** fall with import competition;
2. trade competition has effects on **firm-level sales** (on average, they decline);
3. trade **rationalizes production**: the most efficient plants expand, while the least efficient contract;
4. trade **increases aggregate productivity**, via both scale effects and reallocations;
5. trade competition can also affect intra-firm efficiency (mixed evidence).

Tybout, *Handbook of International Trade* (contd.)

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● Static

● Dynamics

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EVIDENCE ON TRANSITIONAL DYNAMICS:

Interaction between **sunk costs, firm heterogeneity, and uncertainty.**

(More complex issue to address, rely on dynamic stochastic optimization).

- First papers: Dixit (1989), Baldwin and Krugman (1989): role of sunk costs and expectations in ruling exporters' behavior.
 - history-dependence: decisions depend on whether a firm is in or out of the market;
 - aggregate outcomes depend on the % of firms in each state.
 - hysteresis.
- Roberts and Tybout (1997), Das, Roberts and Tybout (2007): empirical relevance of the sunk-cost export model.
 - sunk costs are important, and more so for small firms;
 - aggregate exports are rel. insensitive to history and expectations.

MORE RECENT:

- Eaton et al. (2011): learning from exporting as the core mechanism behind entry and exit of small exporters.

Roberts and Tybout (1997)

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- Main idea:
 - non-exporters must pay a **sunk cost** to enter a foreign market (and become exporters);
 - if a positive shock induces **entry**, its reversal may not induce **exit** \Rightarrow **hysteresis** in trade flows.
- Test the existence of **sunk costs-induced hysteresis** by analyzing entry and exit patterns in the data.
- **Dynamic discrete choice model:**
 - current export status is a function of **previous exporting experience**, other firm characteristics, and unobserved serially correlated shocks;
 - the conditional effect of a plant's exporting history on current export status can be used to infer the importance of sunk costs.
- Data on Colombian manufacturing plants, 4 industries, 1981-1989.

Roberts and Tybout (1997): Notation

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$\pi_{it}(p_t, s_{it})$:	expected profits if exporting - expected profits if not exporting for plant i at time t ;
p_t :	market-level variables (exchange rates, demand levels, ...);
s_{it} :	plant-specific state variables;
F_i^j :	sunk cost of starting to export for plant i if it last exported at time $t - j$ (for $j \geq 2$);
F_i^0 :	sunk cost of starting to export for plant i if it never exported before;
X_i :	loss of exiting the export market for plant i

$$Y_{it} = \begin{cases} 1 & ; \text{if } i \text{ exports at time } t \\ 0 & ; \text{otherwise.} \end{cases}$$

$$Y_{it}^{(-)} = \{Y_{i,t-j} | j = 0, \dots, J_i\}$$

where J_i denotes the age of plant i ($Y_{it}^{(-)}$ is the exporting history of plant i).

Roberts and Tybout (1997): Model

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Period t exporting profits:

$$R_{it} \left(Y_{it}^{(-)} \right) = Y_{it} \left[\pi_{it} - F_i^0 (1 - Y_{i,t-1}) - \sum_{j=2}^{J_i} (F_I^j - F_i^0) \tilde{Y}_{i,t-j} \right] - \dots \\ \dots X_i Y_{i,t-1} (1 - Y_{it})$$

where $\tilde{Y}_{i,t-j} \equiv Y_{i,t-j} \prod_{k=1}^{j-1} (1 - Y_{i,t-k})$ summarizes the plant's exporting experience (= 1 if the plant was last exporting j years earlier, and = 0 otherwise).

In period t , a firm chooses future export status to maximize the expected present value of its profits. Under a recursive representation:

$$V_{it}(\Omega_{it}) = \max_{Y_{it}} \left[R_{it}(Y_{it}^{(-)}) + \delta E_t \left\{ V_{i,t+1}(\Omega_{i,t+1}) | Y_{it}^{(-)} \right\} \right]$$

where Ω_{it} denotes the plant-specific information set at time t , and $\delta \in (0, 1)$ is the discount rate.

Roberts and Tybout (1997): Model (contd.)

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Participation condition. Plant i exports at time t if:

$$\underbrace{\pi_{it}(p_t, s_{it})}_{\text{profit flow}} + \underbrace{\delta [E_t(V_{i,t+1}(\Omega_{i,t+1})|Y_{it} = 1) - E_t(V_{i,t+1}(\Omega_{i,t+1})|Y_{it} = 0)]}_{\text{continuation value}} \geq \dots$$

$$\underbrace{F_I^0}_{\text{cost of first entry}} - \underbrace{(F_I^0 + X_i)Y_{i,t-i}}_{\text{cost of exit}} + \underbrace{\sum_{j=2}^{J_i} (F_I^0 - F_i^j)\tilde{Y}_{i,t-j}}_{\text{cost of entry after } j \text{ periods without exporting}}$$

Let π_{it}^* denote the left-hand side of the participation condition: π_{it}^* is a **latent variable** representing the expected increment to gross future profits for plant i if it exports at t .

Dynamic discrete choice equation:

$$Y_{it} = \begin{cases} 1 & ; \text{ if } \pi_{it}^* - F_I^0 + (F_I^0 + X_i)Y_{i,t-i} + \sum_{j=2}^{J_i} (F_I^0 - F_i^j)\tilde{Y}_{i,t-j} \geq 0 \\ 0 & ; \text{ otherwise.} \end{cases}$$

Roberts and Tybout (1997): From Model to Estimation

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Assume: $\pi_{it}^* - F_i^0 = \mu_t + \beta Z_{it} + \varepsilon_{it}$.

The term $\pi_{it}^* - F_i^0$ summarizes exogenous plant and market characteristics. The authors assume it is composed by a time effect μ_t (which captures temporal variation in profitability and start-up costs common to all plants: credit market conditions, exchange rates, trade policy), by observable plant-specific determinants of profits and start-up costs Z_{it} (industry dummies, ownership, location, prices, wages, capital, age), and by an error term ε_{it} .

Also assume: $F_i^0 = F^0$, $F_i^j = F^j$, $X_i = X$ (sunk costs are common across plants).

Define: $\gamma^0 \equiv F^0 + X$, $\gamma^j \equiv F^0 - F^j$.

Estimating equation:

$$Y_{it} = \begin{cases} 1 & ; \text{if } \mu_t + \beta Z_{it} + \gamma^0 Y_{i,t-i} + \sum_{j=2}^{J_i} \gamma^j \tilde{Y}_{i,t-j} + \varepsilon_{it} \geq 0 \\ 0 & ; \text{otherwise.} \end{cases}$$

Testing the null hypothesis that sunk costs are NOT important is equivalent to test whether γ^0 and γ^j are jointly equal to 0.

Roberts and Tybout (1997): Estimation

Potential issues:

1. Persistence in status may be due to sources other than sunk costs, which are not included into Z_{it} and can induce serial correlation of ε_{it} .

Solution: Roberts and Tybout allow for serial correlation of the error term:

$$\varepsilon_{it} = \alpha_i + \omega_{it}, \text{ where } \omega_{it} = \rho\omega_{i,t-1} + \eta_{it}.$$

2. In a sample of T periods, the lag structure implies that we can run the estimation equation only from year $J + 1$ to year T , but one cannot treat $Y_{i,t-i}$ and $\tilde{Y}_{i,t-j}$ as exogenous variables for the first J years (“initial condition problem”).

Solution: following Heckman (1981), Roberts and Tybout use an “approximate” representation of Y_{it} for $t = 1, \dots, J$:

$$\begin{aligned} \pi_{it}^* - F_i^0 &= \lambda Z_{it}^p + \varepsilon_{it}^p \\ Y_{it} &= \begin{cases} 1 & ; \text{if } \lambda Z_{it}^p + \varepsilon_{it}^p \geq 0 \\ 0 & ; \text{otherwise.} \end{cases} \end{aligned}$$

where $\varepsilon_{it}^p = \alpha_i^p + \omega_{it}^p$, $\omega_{it}^p = \rho^p \omega_{i,t-1}^p + \eta_{it}^p$, and α_i and α_i^p are correlated.

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Roberts and Tybout (1997): Estimation and Results

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● **Results**

Estimation performed via **simulated method of moments**:

- choose an initial set of parameter values;
- by combining the distribution of errors and the observable variables, simulate Y_{it} for each plant;
- search over the parameter space to obtain trajectories for Y_{it} that are as similar as possible to the export dynamics observed in the data.

Results:

- The Wald test on the estimates of γ^0, γ^j **REJECTS** the null hypothesis that the sunk costs are zero:
sunk costs are important, exporting history matters!
- **Recent history** matters the most: previous year exporting status is the most significant variable in predicting current export status.
- Export status at longer lags is not as important: after a two-year absence from the export market, re-entry costs are **NOT** significantly different from first-time entry costs.