The Selection Effect of International Competition (*a.k.a.:* Trade-revealed TFP)

Andrea Finicelli, Patrizio Pagano, and Massimo Sbracia

Massimo Sbracia
massimo.sbracia@bancaditalia.it

DG ECFIN's 5th Annual Research Conference
Brussels, October 16-17 2008

Motivation

- **The Ricardian model does not deliver a positive effect of trade openness on the TFP.** One can build textbook examples in which one country holds a comparative advantage in the production of low-productivity goods, so that its TFP diminishes after openness
- Yet, growing empirical evidence — especially studies based on firm-level data — is pointing out that trade has a significant positive impact on TFP
- **One question we tackle here is: are those textbook examples "theoretically" robust?**

Our main findings: Theory (i)

- We build on the Ricardian trade model of Eaton and Kortum, from which **we obtain a closed-form expression of the TFP of the tradeable sector:**
- The TFP of the tradeable sector of an open economy with perfectly competitive markets = autarky TFP augmented by a measure of trade openness (*trade-revealed TFP*)
- Then: **trade openness always raises the TFP of the tradeable sector**, a remarkable difference with respect to standard Ricardian models

Our main findings: Theory (ii)

- The result is proved under the assumptions of the EK model: Fréchet distribution and mutual independence of country technologies. BUT: neither of these assumptions is necessary! **The prediction that TFP rises is very general**
- **It holds for correlated Fréchet distributions**, with the extent of the productivity gain decreasing as correlation increases
- **Under mutual independence, it holds for any distribution of country technologies**, including, then, all the distributions used in this literature, such as Pareto, Weibull, uniform

Our main findings: Theory (iii)

- **With perfect competition we are able to obtain the same result as Melitz**, BUT there are key differences about the way in which the TFP increases
- Here firms do not self-select. **It is international competition that forces them to exit: not only firms with low-productivity, but also firms with high-productivity** (*selection effect of international competition*)
- TFP increases because the exit of "some" high-productivity firms is more than compensated by the exit of "many" low-productivity firms

Other findings: Evidence (i)

- **The model yields a simple method to quantify this effect.** For a sample of 19 OECD countries, the contribution of international competition to the TFP of the manufacturing sector was, on average, 9.4% in 2002 (5.8% in 1985)
- **We link model parameters to the TFP of the tradeable sector relative to that of another country.** Then, we can estimate it: (*i*) the resulting TFP (*trade-revealed TFP*) is a real estimate (not just a residual), (*ii*) it requires data on bilateral trade flows instead of hard-to-get data on the volume of physical capital

Other findings: Evidence (ii)

- Finally, **we focus on the manufacturing TFP of Italy, relative to that of the US**, and compare it with a development-accounting TFP (and with other estimates)
- Results show that **the dynamics of the two variables are surprisingly similar, but an appealing difference in levels emerges**: our *trade-revealed TFP* no longer yields the puzzling result that Italy is the most productive country in the world

EK redux

a. Consumers have CES preferences

b. Trade barriers are modeled as iceberg costs, $d_{ni} \geq 1$

c. Perfect competition and constant returns-to-scale

d. Heterogeneous firms with Fréchet-distributed technologies

Technologies I

$z_i(j)$ is efficiency of country i in producing the tradeable good j, with $i \in \{1, ..., N\}$ and $j \in [0, +\infty)$;

$$q_i(j) = z_i(j) \cdot I_i(j) \quad ,$$

$q_i(j) =$ amount of good j produced by the representative firm of country i

$I_i(j) =$ amount of input needed to produce that output (the bundle of input will include labor and intermediate goods)

Technologies II

For each country i, the $z_i\left(j\right)$ are extracted from a country-specific Fréchet distribution: $Z_i \sim Frechet\left(T_i, \theta\right)$

$$\Pr\left(Z_i < z\right) = \exp\left(-T_i \cdot z^{-\theta}\right) \quad ,$$

with $T_i > 0$, $\theta > 1$, and $\left\{Z_i\right\}_{i=1}^{N}$ mutually independent

T_i, the **state of technology**, reflects country i's *absolute advantages*

θ, the **"precision"** of Z_i, is inversely related to dispersion of Z_i and the gains from trade (*comparative advantages*)

Our first contribution: the TFP of tradeable goods

- The mean of Z_i refers to the theoretical distribution of the productivities of *all tradeable goods*, i.e. includes also goods that would be produced only under autarky
- **We can use the model to single out the distribution of the productivities of the firms who actually engage in the production of some goods**
- We call this random variable TFP_i and we prove the following result:

Proposition 1

Proposition (1)

If $Z_i \sim$ *Fréchet* (T_i, θ) *and markets are perfectly competitive then:*

$$TFP_i \sim \textit{Fréchet}\left(\Lambda_i, \theta\right) \; ,$$

where

$$\Lambda_i = T_i + \sum_{k \neq i} T_k \left(\frac{c_k d_{ik}}{c_i} \right)^{-\theta} \; . \tag{P1}$$

The mean $E\left(\text{TFP}_i\right) = \Lambda_i^{1/\theta} \cdot \Gamma\left(\frac{\theta-1}{\theta}\right)$ is our *trade-revealed TFP*

Proposition 2

Proposition (2)

$$\Lambda_i = T_i \left(1 + \frac{IMP_i}{PRO_i - EXP_i} \right) \quad . \tag{P2}$$

A by-product of Prop. 2 is a Ricardian measure of trade openness: instead of the sum of nominal imports and exports scaled by the nominal GDP or by GDP in PPP US$ (Alcalá-Ciccone, 2004), **Ricardian trade theory suggests to use the value of total absorption scaled by the value of the domestic production sold domestically**

"How" TFP increases: EK versus Melitz (i)

- Essential ingredients: two countries (n and i), no trade barriers (i.e. $d_{ni} = d_{in} = 1$), no intermediate goods ($\beta = 1$), identical input costs (i.e. $c_n = c_i = 1$); then country i produces and exports good j if and only if $z_i(j) \geq z_n(j)$
- **Any firm can survive or die after openness**, and the probability of surviving (dying) is increasing (decreasing) in its own productivity. The probability of surviving for a firm with productivity $z > 0$:

$$\Pr(Z_i \geq Z_j | Z_i = z) = f(z) = \exp\left(-T_n \cdot z^{-\theta}\right)$$

is always included in the open interval $(0, 1)$ and $f' > 0$

"How" TFP increases: EK versus Melitz (ii)

- "Exceptional export performance"
- Reintroduce trade barriers (otherwise all producers would also export); distribution of the productivities of the exporters:

$$exporters_i \sim Fréchet\left(T_i + T_n \cdot d_{ni}^{\theta}, \theta\right)$$

$$\text{while: } \mathrm{TFP}_i \sim Fréchet\left(T_i + T_n \cdot d_{in}^{-\theta}, \theta\right)$$

- $E\left(exporters_i\right) > E\left(\mathrm{TFP}_i\right)$. BUT: in Melitz even the worst exporter has a higher productivity than the best non-exporter; **here few "bad" exporters and "good" non-exporters coexist with many "good" exporters and "bad" non-exporters**

Extension: are the propositions robust? (i)

- **The Fréchet assumption is not necessary**
- In the simplified setup, the result $E\left(\mathrm{TFP}_i\right) \geq E\left(Z_i\right)$ can be written as:

$$E\left(Z_i | Z_i \geq Z_n\right) \geq E\left(Z_i\right)$$

- This inequality does not hold for all the joint distributions of Z_i and Z_n. However:
- **The assumption of independence is sufficient for it to hold**, irrespectively of the distribution of Z_i and Z_n. In other words: **under mutual independence TFP always rises after openness**

Extension: are the propositions robust? (ii)

- **The independence assumption is not necessary**
- A multivariate extension of the Fréchet distribution:

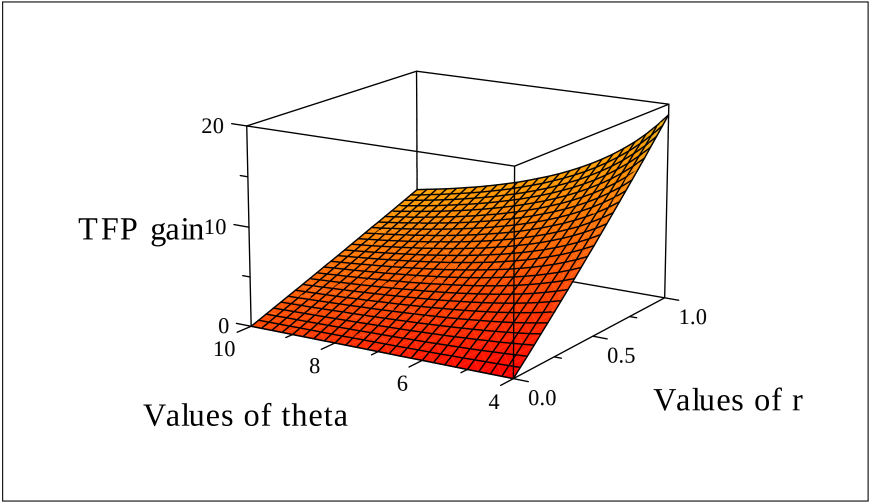
$$\Psi_{i,n}(z_i, z_n) = \exp\left\{ -\left[\left(T_i \cdot z_i^{-\theta} \right)^{1/r} + \left(T_n \cdot z_n^{-\theta} \right)^{1/r} \right]^r \right\}$$

$r = 1$: then Z_i and Z_n are independent

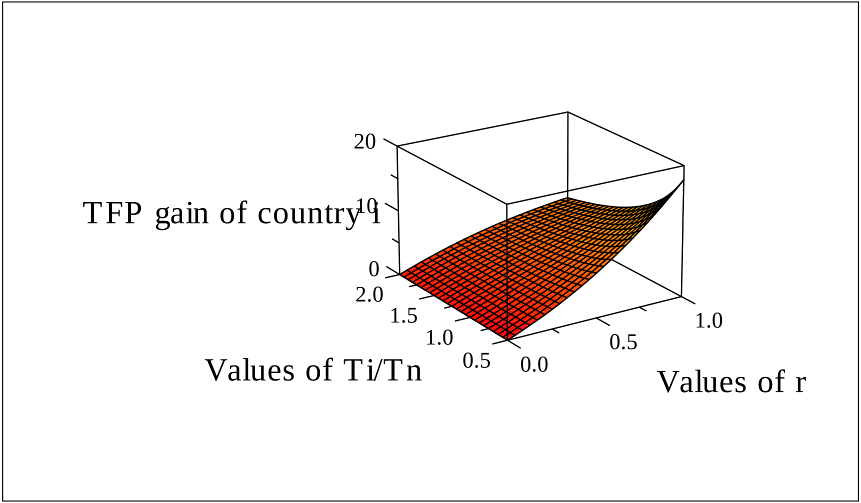
$r < 1$, then Z_i and Z_n are positively correlated

$r \to 0$, then the correlation between Z_i and Z_n tends to 1

Trade with a symmetric country



Trade with an asymmetric country



Measuring the selection effect

- Denote:

$$\Omega_i = 1 + \frac{IMP_i}{PRO_i - EXP_i}$$

- then the TFP gain is $(\Omega_i)^{1/\theta}$
- (memo: gain in real wages is $(\Omega_i)^{1/\theta\beta}$)
- we follow Alvarez and Lucas and set $\theta = 6.67$

TFP gains from openness

	1985	1990	1995	2002	mean 85-02
Australia	3.4	3.2	4.2	4.9	3.9
Austria	7.5	9.1	10.0	14.5	10.4
Belgium	20.2	19.5	22.7	34.1	23.4
Canada	6.4	6.7	9.8	9.8	8.8
Denmark	9.5	10.3	11.5	16.4	11.7
Finland	4.2	4.7	5.0	5.6	5.1
France	3.4	4.5	4.8	5.8	4.7
Germany	4.0	4.3	4.1	5.8	4.5
Greece	4.7	6.2	6.7	7.0	6.5
Italy	2.6	2.8	3.5	4.2	3.3
Japan	0.5	0.6	0.6	0.8	0.6
Netherlands	13.4	15.5	15.6	20.7	16.8
New Zealand	5.6	6.1	6.3	7.4	6.2
Norway	8.5	8.5	8.7	8.8	8.7
Portugal	2.7	5.8	6.9	9.1	6.7
Spain	2.2	3.6	4.2	5.6	4.2
Sweden	5.9	6.0	7.4	7.6	7.0
United Kingdom	4.9	5.3	6.1	7.3	5.9
United States	1.4	1.6	1.8	2.2	1.8
mean across countries	5.8	6.5	7.4	9.4	7.4

Measuring manufacturing TFP: three steps

1. Estimate a testable implication that relates trade data to trade barriers and a country dummy that depends on its state of technology and labor costs (*a competitiveness index*)
2. Use estimated competitiveness indexes and data on nominal wages to extract states of technology
3. Use Proposition 2 to compute trade-revealed TFPs

Step 1: estimating competitiveness

From market shares and prices EK obtain:

$$\log\left[\left(\frac{X_{ni}}{X_{nn}}\right)\left(\frac{X_{ii}/X_i}{X_{nn}/X_n}\right)^{\frac{1-\beta}{\beta}}\right] = S_i - S_n - \log d_{ni},$$

with:

$$S_i \equiv \frac{1}{\beta}\log\left(T_i\right) - \theta\log\left(w_i\right)$$

$$\log d_{ni} = \theta d_k + \theta m_n + \theta b + \theta l + \theta a$$

Step 2: extracting technologies

- From the S_i's extract the T_i's as:

$$T_i = \left[\exp\left(S_i\right) \cdot w_i^{\theta}\right]^{\beta}$$

  where

$$w_i = comp_i \cdot \exp\left(-gh_i\right) \ ,$$

  $comp_i$ nominal compensation per worker; $g = 0.06$ return on education; h_i average years of schooling; $\theta = 6.67$

- Exchange rates to convert wages in a common currency: EK use market rates, we show it is better to use PPPs

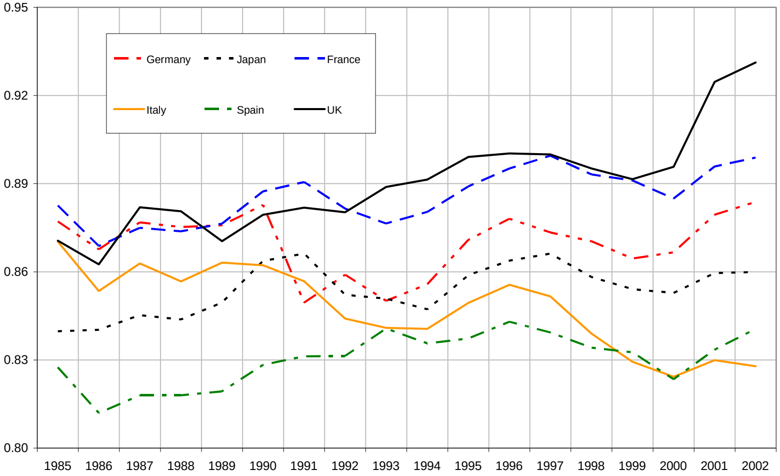
Step 3: trade-revealed TFPs

Finally:

$$\lambda_i = \left[\frac{T_i}{T_{us}} \cdot \frac{\Omega_i}{\Omega_{us}} \right]^{1/\theta} \quad ,$$

(the subscript *us* refers to the United States)

Results


0.95
0.92
0.89
0.86
0.83
0.80
Germany
Japan
France
Italy
Spain
UK
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002

Case study: Italy vs. US

Assume

$$Y_i = A_i K_i^{\alpha} H_i^{1-\alpha} \ ,$$

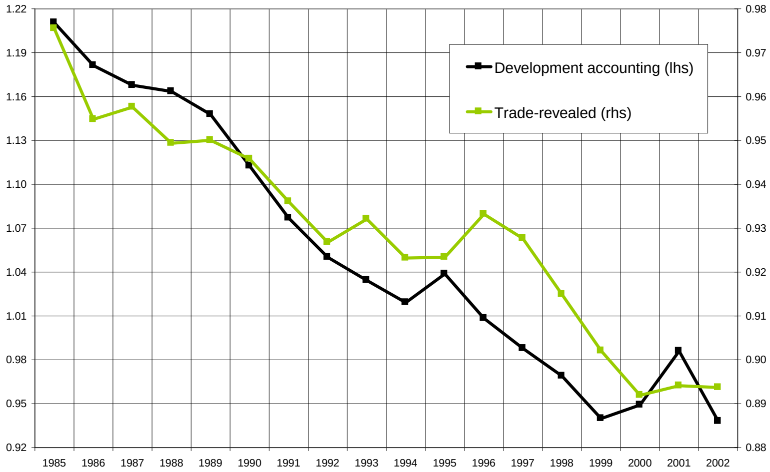
where

$$H_i = L_i \cdot \exp\left(-gh_i\right),$$

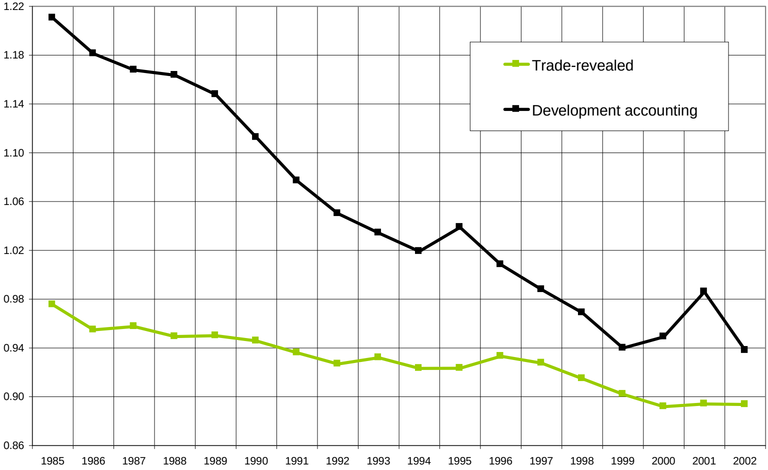
backworking TFP:

$$A_i = \left(\frac{Y_i}{L_i}\right)^{1-\alpha} \left(\frac{K_i}{Y_i}\right)^{-\alpha} \left(\frac{H_i}{L_i}\right)^{-(1-\alpha)} \quad .$$

Calibration: $g = 0.06$ and $\alpha = 1/3$; K_i from perpetual inventory; $L_i =$ worked hours in the manufacturing sector


Development accounting (lhs)
Trade-revealed (rhs)
1.22
1.19
1.16
1.13
1.10
1.07
1.04
1.01
0.98
0.95
0.92
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002

28


1.22
1.18
1.14
1.10
1.06
1.02
0.98
0.94
0.90
0.86
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Trade-revealed
Development accounting

Summary

- Development-accounting: relative TFP of Italy is equal to 1.21 in 1985, then collapses to 0.94 in 2002 — a loss of 27 percentage points!
- Trade-revealed: relative TFP is lower than 1 in 1985 (0.98), then declines to 0.89 in 2002 — a loss of 9 percentage points
- US BLS and Italy's ISTAT estimate manufacturing TFP *growth rates*: total change in the relative TFP of Italy in 1985-2002 shows a loss of 11 percentage points

Conclusion

- Our analysis unravels the probabilistic foundations of the results on trade and TFP in the Ricardian model
- We deliver the same prediction as Melitz model, but the way in which the TFP increases seems more general and consistent with the reality
- The trade-revealed methodology allows to overcome data limitations that hamper sectoral estimates of TFP
- Results from the case study seem promising and provide a sort of indirect validation of the EK model