ELASTICITY OF TOTAL FACTOR PRODUCTIVITY WITH RESPECT TO TRADE OPENNESS IN THE CASE OF EMERGING COUNTRIES: A SURVEY OF ESTIMATES[1]

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Introductory remarks

The purpose of this paper is to provide estimates, available in existing empirical studies, on the elasticity of total factor productivity (TFP) with respect to the degree of openness of the economy, with an emphasis on emerging or developing economies, this elasticity having here the symbol **e**. These studies are a sub-set of a larger empirical effort which tried to assess the impact of trade openness on economic growth, the latter being defined as GDP real growth, without necessarily looking at the partial impact of trade openness on TFP.

The basic methodology which was adopted by the authors for the estimation of **e** relied invariably upon the use of a two-step procedure. In a first step, they estimated themselves TFP, on the basis of a growth accounting procedure assuming a Cobb-Douglas production relationship, or simply used an already computed TFP index. In a second step, they regressed TFP on an indicator of the degree of openness of the economy and, very often, on other possible determinants of TFP, such as schooling, governance or local R&D expenditures. This enabled them to obtain an estimate for **e** as the partial derivative of ln TFP with respect to ln of openness or as the partial derivative of the % change in TFP with respect to the % change in openness, both relationships assumed to be linear[2].

According to the case, *overall* openness was measured as the share of total exports and imports in GDP, the share of exports in GDP, or the share of imports in GDP.

As far as *sector* openness is concerned, it was measured as the share of total sector exports and imports in sector domestic output, the share of sector exports in sector domestic output, the share of sector imports in sector domestic output, the share of total

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[2] In some cases, the TFP function was expressed in terms of second differences (Δ ln TFP = …).

sector exports and imports in sector value added, the share of sector exports in sector value added, or the share of sector imports in sector value added.

The available analysis tries to support the well-known assumption that both exports and imports have spillovers effects on economic growth and TFP. It is assumed that exports force local firms to become more productive, though there remains a possible "selection bias" to the extent that it may work the other way around, the initially most productive firms being in a better position to penetrate foreign markets. Some authors tested for this possible two-way causality. On the other hand, imports of final consumer products are assumed to encourage, on the part of local firms, imitation and better quality standards, whereas imports of intermediate and capital goods are assumed to transfer R&D from innovating countries to the importing countries. This transfer can, however, also occur through inward FDI. As such, it is not surprising that the available empirical literature provides several analyses where both imports of intermediate and capital goods and FDI are tested for their separate impacts on growth and TFP.

If we concentrate on the spillovers of imports, the studies surveyed below fall into two categories:

1. studies of a traditional nature where the import share, or *import intensity*, is only considered;

2. studies which take also into account the *import composition*, the latter being measured as an import-share weighted sum of the R&D stocks of the trade partners, a concept which was pioneered by Coe, Helpman and Hoffmaister (1997). This concept (symbol S) can be expressed for the importing country i as:

$$Si = \sum \text{over } j \ (Mij \ / \ Mi) \ RDj$$

where j is the country of origin of the imports, Mij the imports of country i from contry j, Mi the imports of country i, and RDj the R&D intensity of the source country j, the latter being for instance measured as the share of R&D expenditures in the GDP of country j. In other words, country i increases the R&D spillovers effects from importing if it increases the share of R&D intensive countries in the composition of its import basket.

Example: country i imports from 2 countries (A and B), 25% from country A and 75% from country B, with A having a R&D intensity of 0.020 and B having a R&D intensity of 0.015. In this case, Si = 0.0163. Let us now assume that country i increases the import share of country A, the more R&D intensive country, from 25% to 40%, the share of country B decreasing, as such, from 75% to 60%. In the new situation, Si increases from 0.0163 to 0.0170.

As we shall see, in most studies of this nature, j was restricted to developed countries and Mij to imports of capital goods.

Let us conclude this brief introduction by saying that since this survey is basically addressed to CGE modelers, namely those of the PEP international research network, it ignores studies which did not use, in the TFP function, an indicator of openness per se, but other indicators which are more related to trade liberalization, such as the nominal tariff, the effective protection rate, or the foreign exchange premium. The reason is that such variables are, in general, already present in the CGE model, in one form or another, entering the export and import functions and affecting, as such, the openness indicator itself, through changes in exports and imports[3]. It also ignores estimates of the elasticity of TFP with respect to a composite variable including, generally in a multiplicative manner, openness to trade and human capital, such a composite variable not appearing in standard CGE models.

The following conventions have been adopted in the present text. CO, PE, ME and **e** mean countries studied, period covered, methodology used, and estimate of the elasticity. When estimates are followed by *, ** or ***, the latter represent significance at the 10%, 5%, and 1% respectively. When estimates are followed by a number in brackets, the latter is the t – Student value. When an estimate is not significant at the 10% level, the symbol **ns** is used.

Multi-country studies

1. Senhadji (2000)

   CO: 83 countries of which 23 are industrial countries and 60 emerging ones. PE: 1960-94.

   ME: GDP growth is estimated on the basis of a Cobb-Douglas production function (CD) with constant returns to scale to capital and labor (corrected for schooling), without TFP. The resulting estimate of GDP growth is subtracted from the observed GDP growth, the difference giving the TFP component of GDP growth. E.g., if observed GDP growth is 4% and estimated GDP growth 3%, 1% is attributed to TFP. The latter is then regressed on *the share of imports in GDP*, and other variables (the initial ratio of the stock of human capital and physical capital, life expectancy, variations in terms of trade, level of inflation, public consumption, current account convertibility, capital account convertibility, etc.). **e** is thus the partial derivative of TFP, as estimated above, with respect to the share of imports in GDP.

   e:

   0.00247*** (0.00134), when both current account convertibility and capital account convertibility are considered;

   0.00229** (0.00135), when only current account convertibility is considered;

[3] Going from trade liberalization to trade openness does not, however, necessarily mean that both variables have a comparable impact on TFP. E.g. Cavalcanti Ferreira and Luiz Rossi (2003) found, in the case of Brazil, that trade liberalization had a significant impact on TFP, whereas trade openness had not.

0.00229*** (0.00133), when only capital account convertibility is considered

2. Miller and Upadhyay (2002)[4]

CO: 83 countries classified into 3 income groups (low-income, middle-income and high- income) and 4 geographical regions, namely Africa, Latin America, emerging Asia, and developed countries (Europe, North America, Australasia and Japan) PE: 1960-89.

ME: the initial estimation equation is a generalized CD production function written as $\ln y = \ln A + \alpha \ln k + (\alpha + \beta - 1) \ln L + f(\text{dummy variables}) + \varepsilon 1$, where y is real GDP per worker, A an index of TFP, k physical capital stock per worker, L the labor force, and $\varepsilon 1$ the error term.

The estimation equation, which explains TFP, is:

$\ln A$ or $\ln TFP = a1 + a2 \ln H + a3\, x + a4 \ln tot + a5 \ln pd + a6 \ln (1 + \pi) + a7$ (standard deviations of OPEN, tot, pd and π over five-year sub-periods) $+ \varepsilon 2$

where ln A is derived from the first equation, H is human capital, x *the share of exports in GDP*, tot the terms of trade, pd the local price deviation from purchasing power parity, π the inflation rate, and $\varepsilon 2$ the error term.

e is thus a3, i.e. the elasticity of TFP with respect to the share of exports in GDP[5].

e:

If income categories are based on 1960-64 average income: 0.1237*** (6.08) (all countries), 0.1040*** (3.66) (low-income), 0.0936** (2.44) (middle-income), 0.1923*** (3.5) (high-income);

If income categories are based on 1970s average income: 0.1237*** (6.08) (all countries), 0.0942*** (2.73) (low-income), 0.0700** (2.22) (middle-income), 0.1771*** (3.53) (high-income);

0.0827** (2.43) (Africa), 0.1482*** (3.91) (Latin America), 0.0822[6] (1.32) (emerging Asia), 0.0725* (1.56) (developed countries).

3. Engelbrecht (2002)

[4] This is an updated version of Miller and Upadhyay (2000).
[5] Total exports and imports over GDP was used by the authors as an alternative measure of trade openness but was not significant at the 10% level.
[6] Significant at the 20% level.

CO: 61 emerging countries. PE: 1971-90.

ME: the author uses the TFP index which was calculated by Coe, Helpman and Hoffmaister (1997) for 77 developing countries over the 1971-90 period. Deleting from the sample 16 mainly African countries, he then uses, among other specifications, the following estimation equation:

$\Delta \ln TFP = a1 + a2 \Delta \ln S + a3 \Delta M + a4 \Delta E + \varepsilon$

where Δ indicates the 4-year change to 1975, and 5-year changes to 1980, 1985 and 1990, and where S is the import-share weighted sum of R&D stocks of 22 industrial trading partners, as defined above, M *the share of machinery and equipment import in GDP*, E the secondary school enrolment ratio, and ε the error term.

S is, as such, the measure of trade composition and M the measure of trade intensity.

a3 can be considered as an approximation of **e**.

e: 0.310 (0.140), when E is measured with respect to secondary school age population; 0.300 (0.145), when E is measured with respect to total population.

4. Xu and Chiang (2005)

CO: 48 countries classified, on one hand, into developed and developing countries, and, on the other hand, into middle-income and low-income developing countries.
PE: 1980-2000.

ME: using a generalized CD production function, the authors compute ln TFP as $\ln Y - \alpha \ln L - \beta \ln K$, where Y is the observed real GDP, L the labor force, and K the capital stock. Two estimation equations are then used to look at the determinants of TFP.

1st equation: $\ln TFP = a1 + a2 \ln SD + a2 \ln SF + a3 M . \ln S + \varepsilon1$

where SD is the domestic R&D patent stock, SF is the foreign R&D patent stock, whereas M . ln S is a composite multiplicative variable where M is *the share of imports in GDP* and S is as defined above. M . ln S captures, as such, the effects of *both* trade intensity (M) and trade composition (S), these effects being kept separate in Engelbrecht (2002) where they are additive.

a3 is an approximation of **e** in the case of TFP *level* regressions. It takes the following values:

0.31*** (0.04) (developed countries), 0.24*** (0.07) (developing countries), 0.59*** (0.08) (middle-income developing countries), ns (low-income developing countries).

2nd equation: GTFP = a4 + a5 RDL + a6 GAP + a7 PFL + a8 ΔM.ln S + ε2

where GTFP is the TFP growth rate, RDL the R&D expenditure per worker, GAP the ratio of US TFP to the country's TFP, PFL the inflow of foreign patents per worker, and where ΔM . ln S takes into account the change in M . ln S via *a change in import intensity*.

a8 is an approximation of **e** in the case of TFP *growth* regressions. It takes the following values:

0.21*** (0.07) (developed countries), 0.23* (0.13) (developing countries), 0.21** (0.08) (middle-income developing countries), ns (low-income developing countries).

5. Schiff, Wang and Olarreaga (2002)

CO: 25 developing countries. PE: 1976-98. The analysis is restricted to the manufacturing sector which is broken down into 16 industries.

ME: basically as in Xu and Chiang (2005), with three exceptions:

i. the CD production function, used to compute ln TFP, exhibits constant returns to scale with respect to capital and labor;
ii. there are two variables of the M . ln S type, one taking into account the R&D embodied in capital goods imported from developed countries, the other taking into account the R&D embodied in capital goods imported from other developing countries. *Note:* the sector import intensity which enters the definition of M is measured with respect to the sector value added;
iii. the estimates are only TPF *level* regression results.

The estimated equation is:

ln TFP = a1 + a2 ln NRD + a3 ln SRD + a4 E + a5 G + dummies + ε

where NRD and SRD are M . ln S in the case where capital goods are imported from respectively, developed and other developing countries, E is the secondary school completion ratio for the population 25+ and G is the average of six governance indicators. a2 and a3 are approximations of **e,** depending on the origin of the capital goods imports.

e:

Origin of the capital goods

	Developed countries a2	Other developing Countries a3
Manufacturing	0.122*** (2.85)	0.070** (2.2)[7]
Food, beverage, tobacco	ns	ns
Textiles, apparel, leather	ns	0.22*** (3.12)
Wood products, furniture	ns	0.21*** (3.16)
Paper, paper products, printing	ns	ns
Chemicals, drugs, medicines	0.56*** (3.76)	- 0.16* (- 1.89)
Petroleum refineries and products	0.41*** (4.05)	ns
Rubber and plastic products	ns	ns
Non-metallic mineral products	ns	0.07** (2.03)
Iron and steel	2.43** (2.22)	ns
Non-ferrous metals	1.59*** (3.43)	ns
Metal products	0.12* (1.86)	0.09** (2.1)
Non-electrical machinery, office and computing machinery	0.42** (2.39)	ns
Electrical machinery and communication equipment	- 0.28** (- 2.21)	0.26*** (3.88)
Transportation equipment	1.12*** (4.52)	ns
Professional goods	- 0.38** (- 2.12)	0.26*** (2.91)
Other manufacturing	- 0.30* (- 1.71)	0.23** (2.5)

6. Blyde (2004)

CO: 22 Latin American and Caribbean countries. PE: 1980-97.

ME: basically as in Schiff, Wang and Olarreaga (2002), except that only NRD and SRD enter the TFP function, the function being:

$$\ln TFP = a1 + a2 \ln NRD + a3 \ln SRD + \varepsilon$$

e:

In the case of NRD, i.e. when **e** is approximated by a2: 0.0594*** (6.75) (one-year change in TFP), 0.0653*** (4.85) (2-year change), 0.0717*** (4.32) (3-year change), 0.0737*** (4.25) (4-year change);

[7] Schiff and Wang (2006) report more recent estimates on the basis of the same data set when the effects on the manufacturing sector are separately estimated, i.e. when SRD is deleted for the estimation of a2 and, alternatively, when NRD is deleted for the estimation of a3. In this case, a2 = 0.160*** (3.10) and a3 = 0.060* (3.09).

In the case of SRD, i.e. when **e** is approximated by a3: 0.0152*** (2.63) (one-year change), 0.0192*** (2.80) (2-year change), 0.0169*** (2.34) (3-year change), 0.0147* (1.76) (4-year change).

7. Wang (2005)

CO: 30 emerging Asian (13) and Latin American (17) countries. PE: 1981-2000.

ME: basically as in Schiff, Wang and Olarreaga (2002) except that only NRD enters the TPF function, the latter including as well an index of the country technological level (θ), a measure of inward FDI, an index of the country access to ITC, and human capital (H), the estimation equation being:

$$\Delta \ln TFP = a1 + a2 \Delta \ln \theta + a3 \Delta \ln NRD + a4 \Delta \ln FDI + a5 \Delta \ln ITC + a6 \Delta \ln H + \varepsilon$$

this meaning that the corresponding regressions are TFP *growth* regressions.

e as approximated by a3 takes the following values:

when only NRD and H are included, 0.155*** (6.79);
when FDI is also included, 0.159*** (5.71);
when all variables are included, 0.114*** (4.31)

8 Crispolti and Marconi (2005)

CO: 45 emerging countries. PE: 1980-2000.

ME: basically as in Schiff, Wang and Olarreaga (2002) and as in Wang (2005), except that there are two additional multiplicative variables, the first one combining NRD and H and the second one FDI and H, the estimation equation being:

$$\ln TFP = a0 + a1 \ln NRD + a2 \ln FDI + a3 H . \ln NRD + a4 H . \ln FDI + a5 H + \varepsilon$$

the corresponding regressions being TFP *level* regressions.

e as approximated by a1 takes the following values:

from 0.2182*** to 0.2380*** (Asia), from 0.1623 to 0.2239*** (Latin America), from 0.1642*** to 0.1826*** (Africa).

9 Coe, Helpman and Hoffmaister (1997)

CO: 77 emerging countries. PE: 1971-90.

ME: as in Engelbrecht (2002) except that composite variables NRD and E . ln S are included, the estimation equation being then:

Δ ln TFP = a0 + a1 Δ ln S + a2 Δ M + a3 Δ E + a4 Δ (NRD) + a5 Δ (E . ln S) + a6 T + ε where S, M (*share of imports of machinery and equipment from industrialized countries in GDP*), and E are defined as in Engelbrecht (2002), and where T is a time trend.[8]

e, as approximated by a2 when Δ (NRD) is ignored, takes the following values:

0.231 (0.129) when fixed effects are excluded and 0.139 (0.117) when fixed effects are included.

Note: the authors also tested for M defined as the share of *total* imports in GDP. The impact on TFP was insignificant, this suggesting that many imported consumer goods and services have no impact on TFP.

10 Ciruelos and Wang (2005)

CO: 20 developed OECD countries and 37 developing countries. PE: 1988-2001.

ME: the estimated equation is ln TFP = a1 + a2 ln NRD + a3 ln FDI + a4 H + other composite variables + ε

e, as approximated by a2, takes the following values:

0.124*** (0.014) (all countries), 0.284*** (0.029) (OECD countries), 0.130*** (0.017) (developing countries).

11. Savvides and Zachariadis (2005)

CO: 32 emerging countries, the analysis being restricted to the manufacturing sector. PE: 1965-92.

ME: the estimated equation is GTFP = a1 + a2 S + a3 H + a4 M + a4 FDI + ε

where GTFP is TFP growth in the manufacturing sector, S as defined above, H the secondary school enrolment ratio, M imported capital goods divided by total imports, and FDI the FDI to GDP ratio.

e:

[8] In fact, the study by Coe, Helpman and Hoffmaister (1997) is the seminal study which emphasized the importance of equipment and machinery imports and which triggered all other studies which included the composite variable M . ln S. As such, it should have been the first study to survey. This will be corrected in the final version of the present text.

a2: 17.3 (1.94), with a p-value smaller than 0.05, which means that a 1% increase in S increases TFP in manufacturing by … 17.3%, which is clearly a quite amazingly high magnitude when compared to results found in other studies.

a4: 0.246 (1.75), with a p-value smaller than 0.10, which means that a 1% increase in the ratio between imported capital goods and total imports increases TFP in manufacturing by 0.246%.

Country studies

13 Jonsson and Subramanian (2001)

CO: South Africa, the analysis being restricted to the manufacturing sector. PE: 1990-98.

ME: the estimation equation is GTFP = a1 + a2 OPEN + a3 MACH + ε[9]

where GTFP is the manufacturing TFP growth rate, OPEN *the share of total exports and imports in GDP*, and MACH the share of machinery and equipment in total investment.

e, as given by a2: 0.34 (2.50).

14 Arora and Bhundia (2003)

CO: South Africa. PE: 1980-2001.

ME: the estimation equation is ln TFP = a1 + a2 ln OPEN + a3 ln MACH + ε

where TFP is the *overall* TFP, whereas OPEN and MACH are defined as in Jonsson and Subramanian (2001).

e, as given by a2: 0.74 (26.1).

15 Cororaton (2002)

CO: Philippines. PE: 1975-99.

ME: *not clear*. Clarification should be asked from the author.

e: all that can be said is that the *share of exports and imports in GDP* has a significant impact on TFP though, because of the lack in the clarity in the methodology, the magnitude of the impact (18.7) cannot be interpreted at this stage.

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[9] Other specifications include also a tariff variable.

16 Ji (2006)

CO: China (2006), data pooled for 3 municipalities (Beijing, Shanghai, Tianjin) and 26 provinces. PE: 1990-2002.

ME: the estimation equation is $\ln TFP = a1 + a2 \ln (M \,.\, S) + a3 \ln FDI + a4 \ln S + \varepsilon$

where M and S are defined as above. *Note*: in this study, the import-weighted R&D variable appears as ln (M . S), whereas, in other studies, it appears as M . Ln S.

e as given by a2: 0.187*** (7.195) when FDI is ignored, 0.075*** (2.773) when FDI is included.

17 Schiff and Wang (2003)

CO: Mexico, restricted to the manufacturing sector. PE: 1981-98.

ME: the estimation equation is $\ln TFP = a1 + a2 \ln NRDn + a3 \ln NRDo + \varepsilon$
where NRD is defined as above, n indicating that the import-weighted R&D variable takes into account the imports from the two NAFTA partners (Canada and US), whereas NRDo indicating that it takes into account the imports from the other OECD countries.

e as approximated by a2 and a3:

a2: 0.361*** (3.01); a3: not significant

18 Kim, Lim and Park (2007)

CO: South Korea. PE: 1980-2003

ME: the estimation equation is $\Delta \ln TFP = a1 + a2 \Delta \ln IMP + a3 \Delta \ln EXP + a4 \Delta \ln GOV + a5 \Delta \ln RD + \varepsilon$

where IMP is *the share of imports in GDP*, EXP *the share of exports in GDP*, GOV the government size, and RD the share of R&D expenditures in GDP.

e as approximated by a2 and a3:

a2: 0.079* (3.24); a3: negative but not significant.

Concluding remarks

1. Most of the surveyed studies favor the use of imports, instead of exports or total exports and imports, as an indicator of trade openness[10].

2. Among the studies retaining imports as the openness indicator, most of them either use separately the import intensity (M) and the import-weighted R&D (S) or use a composite variable including both.

3. When the indicator of openness is exports divided by GDP, the elasticity maximum value with respect to TFP is around 0.1.

4. When the indicator of openness is total exports and imports divided by GDP, the elasticity is between 0.34 and 0.74.

5. When the indicator of openness is imports divided by GDP, the maximum elasticity value is 0.31.

6. When the indicator of openness is a combination of import intensity and import-weighted R&D, the elasticity maximum does not, in general, exceed 0.36, i.e. not being much higher than the elasticity with respect to import intensity only, though, as shown by Schiff, Wang and Olarreaga (2002), there can be substantial differences between production activities, at least in the case of the manufacturing sector.

7. Elasticity may vary according to the income group and the geographical location of the countries studied.

8. Elasticity may decrease if FDI is introduced as a separate determinant of TFP.

9. In several cases, the estimation procedure used by the authors asks for clarification. Such clarification can only be obtained by contacting the authors themselves.

[10] A reason for this is that imports and exports may be themselves correlated, exporting activities having a high import content in the form of intermediate and capital goods. For a discussion of the ambiguity present in the of the use of the export to GDP ratio as an indicator of openness, with an illustration on China and other East Asian countries, see also the provoking paper written on the topic by Anderson (2007).

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