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Productivity and the international firm: dissecting heterogeneity

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Higher productivity of multinational firms and exporters has been widely documented in the literature, but the sources of this heterogeneity are still a black box. Using an original dataset on Italian firms, we show that higher total factor productivity of international firms can be to some extent explained by higher R&D intensity and managerial capabilities. However, our results suggest that heterogeneity is more in the *slope* than in the *constant* of the production function. In particular, allowing international firms to have different return to labour and capital inputs, we are able to account for their entire productivity *premium*. This has implications for both labour and capital market reforms.

Keywords: total factor productivity; firm heterogeneity; exporters; multinational firms

JEL Classification: E22, L22, M2, O3

Introduction

Recent theoretical and empirical literature has widely documented a superior performance of international firms: multinationals are more productive than exporters, which in turn outperform purely domestic firms (Greenaway and Kneller 2006, Wagner 2007, Mayer and Ottaviano 2008,, ISGEP 2009). Most of the theoretical literature left these premia in a black box and considered them the result of a random draw, which assigns different productivity to different firms, and thus induces the self-selection of some of them (the most productive) into export or FDI (Helpman *et al*. 2004). Recent theoretical models have put forward the idea that firms may 'dress-up' before entering international markets, by investing in R&D and thus increasing total factor productivity prior to starting exporting (Costantini and Melitz 2008). Schmitz (2005), among others, has pointed out that firms in more competitive environments, such as the international markets (as opposed to smaller domestic markets) are more likely to adopt new technologies and achieve higher productivity than firms just having a monopoly power. Holmes *et al*. (2008) show that this is due to the decrease in switchover disruption implicit in higher competitiveness. Other theoretical and empirical works have submitted that the crux of higher productivity of international firms may be in the choice of the technology and the use of specific inputs, such as skilled labour, IT capital or management practices, and in their complementarity. For example, Yeaple (2005) builds a model where firms, born identical, choose different technologies, characterized by different skill-intensities. Firm heterogeneity arises because firms endogenously choose to employ different technologies and then systematically hire different types of workers. Bloom *et al*. (2007) show that the total factor productivity (TFP) of US multinationals in the UK is mainly due to the higher returns to their IT capital, and claim that this pattern may be

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explained by the fact that the US firms' organization allows them to use new technologies more efficiently. Black and Lynch (2001) show that workplace practices and IT had a significant impact on the TFP of a sample of US firms over the 1987–1993 period. Bloom and Van Reenen (2007) report a similar impact of management practices on productivity from 732 medium-sized manufacturing firms in the US, France, Germany and the UK. Bresnahan *et al*. (2002) find positive effects of a measure of organizational capital[1] on productivity both directly and through its interaction with capital. Similarly, Brynjolfsson and Hitt (2002) find a positive and sizeable effect of information technology on productivity over long periods (5–7 years) in a sample of US firms and claim that the observed contribution of computerization is accompanied by relatively large and time-consuming investments in complementary inputs, such as organizational capital, that may be omitted in conventional productivity calculations.

In this paper we explore the black box. We test whether, and to what extent, heterogeneity in firms' TFP can be attributed to higher R&D investment and/or to the use of more knowledge workers (such as workers in managerial and clerical occupations), or if alternatively heterogeneity is a matter of how firms use their inputs. This hypothesis is linked to the fact that workers and capital may be more productive in international firms, either because of their higher quality, or due to the firms' superior managerial practices and organizational capital. In other words, we dissect heterogeneity in productivity associated with firms' internationalization, by distinguishing to what extent differences in productivity are due to (i) differences in TFP (modelled as the constant of the production function), or (ii) how firms choose their production function and how productive individual inputs are, by considering the possibility of different slopes of the production function.

Using an original dataset of Italian firms, we estimate firms' TFP using different parametric methods (such as OLS to Olley-Pakes and Levinshon-Petrin, firm fixed effects or GMM) and we consistently find sizeable TFP premia for international firms (exporters and multinationals). Our results are robust to estimation methods. These premia substantially shrink if we allow for higher use of knowledge workers (such as managers and other white collar employees, including R&D personnel) in international firms, but still remain positive and significant (especially for multinationals). However, if we allow for heterogeneity in the slope of the production function, multinationals exhibit a significantly higher return to capital and TFP premia for international firms vanish. We interpret this as evidence that heterogeneity across firms with different international exposure is *not in the constant*, but rather *in the slope* of the production functions.

The rest of the paper proceeds as follows: in section 2 we describe the data. Section 3 presents the main results considering first homogeneous production functions across firms and then allowing for heterogeneous production functions. Section 4 provides a (slightly formal) discussion of the rationale for the different results in section 3. Section 5 concludes, drawing implications for policy reform.

1. Data

Our empirical analysis is carried out using an original dataset obtained by matching and merging data from the 8th and 9th waves of a survey carried out by Capitalia-Unicredit (an Italian commercial bank) and the ICE-Reprint dataset.

The Capitalia-Unicredit surveys were carried out in 2001 and 2004, using questionnaires administered to a representative sample of Italian manufacturing firms and covering, respectively, 1998–2000 and 2001–2003. The surveys include all firms with more than 500 employees whereas a sample of smaller firms is selected using a sampling design stratified

by geographical area, industry, and firm size. The actual sample gives a fairly accurate picture of the Italian manufacturing industry (see the discussion of Table 1 below). The surveys provide information on a wide range of firms' characteristics, including the ownership and workforce structure, investment and innovation behaviour, internationalization, and financing structure.[2] Balance sheet information is also available (with some missing data) for the 1998–2003 sample period. For the period 2001–2003, we have information for 4277 firms included in the 9th survey; out of this sample, 2097 firms were also in the previous survey (the one covering the period 1998–2000) and can thus be observed over a six-year period. As shown in Table 1, due to missing values and cleaning procedures,[3] we end up with up to 16,779 firm-year observations (10,950 when considering only firms included in both surveys). The distribution of our sample by geographic area, size and sector of activity – reported in Panels B, C and D of Table 1 – supports the idea that this sample is an accurate representation of the distribution of manufacturing firms in the Italian economy. In particular, most economic activity is concentrated in the Northern regions of the country (66.7% of all firms are in the North-West or in the North-East), only a relatively small proportion of firms is medium-large (less than 10% of firms have more than 250 employees) and, as far as sectoral specialization is concerned, a relatively low share of firms operate in high-tech industries, while more activity is concentrated in medium-low technology industries, such as the textile-apparel-footwear (where most of the Made-in-Italy products come from) and the non-electrical machinery and equipment industries.

The Capitalia surveys, though allowing us to distinguish domestic firms from firms selling part of the production abroad through exports, do not allow us to identify firms controlling foreign plants and carrying out international production. Hence, we also merge information from the ICE-Reprint dataset which allows us to single out Italian multinationals, i.e., domestic-owned firms which have affiliates abroad.[4] Both indicators of international status (i.e. being an exporter and/or being a multinational firm) are referred to 2001.[5]

As illustrated in Table 1, on average, about 9% of firms are multinationals, 65% are non-multinational exporters, while one-fourth of the firms are not international (purely domestic firms). International firms are relatively more concentrated in the North of Italy (68.8% of exporters and 79.7% of multinational firms), tend to be larger (only 13.4% of multinational firms have fewer than 50 employees), and are concentrated in the machinery and equipment industry or in textile and footwear (in the case of exporters). Table 2 provides information on some basic characteristics of our sample, according to the international status of the firms.

These descriptive statistics confirm that firms rank according to their degree of internationalization: multinationals are the largest, the most productive, have a higher capital intensity, are the most likely to be a limited company (ltd), to introduce innovations, to invest in machinery, equipment and ICT, have the highest share of workers engaged in R&D, and employ more managers and clerks. Non-international (domestic) firms, on the other hand, have lower values for all of these characteristics, while non-multinational exporters stand in between. Hence, the international status seems to be positively correlated with productivity and with a number of other characteristics.

2. Results

In order to compute differences in TFP across international and non-international firms, we first estimate the labour and capital output elasticity from a Cobb-Douglas production function where output is measured by the log of value added (deflated using 2-digit production price indexes) and inputs are the log of tangible fixed assets (net of depreciation and

Table 1. Sample size, by year, geographical area, firm size and sector.

	Non-internationalized	Non-multinational exporters	Multinational Firms	Total
Panel A				
1998	538	1103	111	1752
1999	550	1130	112	1792
2000	552	1138	114	1804
2001	952 (611)	2492 (1210)	385 (125)	3829 (1946)
2002	957 (601)	2598 (1197)	404 (120)	3959 (1918)
2003	889 (546)	2393 (1077)	361 (110)	3643 (1733)
Total number of firms	4438 (3398)	10,854 (6855)	1487 (697)	16,779 (10,950)
%	26.4 (31.0)	64.6% (62.6)	8.9% (6.4)	100.0
Panel B				
North-West	31.1	37.5	43.7	36.4
North-East	25.7	31.3	36.0	30.3
Centre	21.0	18.0	13.7	18.4
South	22.2	13.1	6.7	15.0
Total	100.0	100.0	100.0	100.0
Panel C				
11–20 employees	42.4	23.4	3.2	26.7
21–50 employees	35.4	34.4	10.2	32.5
51–250 employees	19.7	34.7	46.2	31.8
251–500 employees	1.5	3.7	19.3	4.5
500+ employees	1.0	3.8	21.1	4.6
Total	100.0	100.0	100.0	100.0
Panel D				
Food and beverages	13.8	9.2	6.5	10.2
Textiles	6.4	8.6	6.6	7.9
Wearing apparel	1.9	3.9	3.5	3.3
Leather and footwear	2.2	5.3	2.7	4.3
Wood and paper	7.9	4.9	5.2	5.8
Publishing	5.1	1.8	0.8	2.6
Coke, petroleum refining and rubber	4.9	6.3	6.5	5.9
Chemical	5.0	5.3	6.5	5.3
Non-metallic mineral products	12.0	4.0	4.8	6.2
Basic metal	3.2	3.6	3.0	3.5
Fabricated metal products	19.7	11.3	9.6	13.3
Machinery and equipments	5.4	17.2	24.2	14.7
Electrical machinery	4.9	6.5	7.9	6.2
Transport equipments	2.7	2.5	2.6	2.5
Furnitures	2.8	5.6	4.6	4.8
Other industries	2.0	4.1	5.3	3.6
Total	100.0	100.0	100.0	100.0

Note: Missing and "anomalous" values in output (value added) and inputs (number of employees, number of managers, clerks and production workers) are excluded. Values of output and inputs are considered "anomalous" when a firm-year value is more than three times or less than one-third the median value for each firm. The table reports the number of observations for which all information needed to calculate TFP is available after cleaning.
The sample includes observations from all firms surveyed in the 9th Capitalia Survey (2001–2003). For about 60% of these firms we were able to gather information also from the 8th Capitalia Survey (1998–2000). In brackets we report the number of observations for 2001–2003 in the sample of firms which are in both surveys.

Table 2. Characteristics of the sample firms, by international status.

	Non-internationalized		Non-multinational exporters		Multinational firms		Total	
	mean	Sd	mean	sd	mean	sd	mean	sd
Value added per worker	45,960	(27,894)	50,022	(30,386)	64,436	(48,530)	50,238	(32,182)
Capital per worker	49,128	(72,078)	42,651	(52,663)	55,809	(78,735)	45,539	(61,134)
N. employees	49.6	(104.5)	105.9	(328.7)	391.4	(659.6)	116.5	(345.8)
Share of firms								
Ltd.	20.8%		41.5%		76.5%		39.2%	
Innovating products	19.2%		41.1%		52.3%		36.3%	
Innovating processes	35.7%		42.1%		52.0%		41.3%	
Innovating organization	17.6%		26.9%		39.7%		25.6%	
Investing in mach. and eq.	85.0%		89.2%		94.3%		88.5%	
Investing in ICT	63.0%		73.4%		86.5%		71.8%	
Share of workers								
Employed in R&D	1.9%		3.8%		3.9%		3.3%	
Employed as managers	2.8%		3.7%		4.7%		3.6%	
Employed as clerks	20.2%		24.5%		31.2%		24.0%	
Employed in production	69.0%		66.4%		62.4%		66.8%	

AQ9 deflated using the price index of machinery and equipment) and the log of the number of employees. In line with Van Biesenbroeck (2007a, 2007b), we use several estimation methods. In particular, (i) a standard OLS, (ii) OLS with sector-time, region and size class dummies (OLS-D), (iii) Olley-Pakes (OP) and (iv) Levinsohn-Petrin (LP) semi-parametric methods, (v) firm fixed-effects (using within-group transformation (FE), (vi) as well as one-year (DIF1) and (vii) three-years differences (DIF3)), and (ix) a dynamic model estimated using GMM-DPD.

Table 3 reports the coefficients estimated from the different methods. As it is well known in the literature,[6] OLS tends to give upward biased estimates, with returns to scale well above 1 due to the correlation between input use and productivity, while fixed-effects

Table 3. Estimated coefficients of the production function.

	Labour		Capital		
	Coeff.	Std. Err.	Coeff.	Std. Err.	RTS
OLS	0.899	(0.005)	0.165	(0.003)	1.065
OLS+DUM	0.799	(0.010)	0.179	(0.003)	0.978
OP	0.860	(0.009)	0.041	(0.019)	0.900
LP	0.736	(0.015)	0.079	(0.014)	0.816
FE	0.461	(0.016)	0.099	(0.006)	0.560
GMM	0.688	(0.141)	0.171	(0.066)	0.859
DIF1	0.329	(0.021)	0.087	(0.007)	0.416
DIF3	0.428	(0.021)	0.089	(0.009)	0.517

models give downward biased due to limited within-group variation (especially in short panels) which exacerbates measurement errors. In between these two extremes are all other parametric and semi-parametric methods. With the estimated labour and capital elasticities in hand, we could get estimates of firms' TFP, as

$$\log(\hat{TFP}_{it}) = y_{it} - \hat{\beta}^{l} l_{it} - \hat{\beta}^{k} k_{it}$$

Table 4 shows that the different methods yield remarkably high correlation in TFP measures (as in Van Biesenbroeck, 2007). There is a low correlation between the fixed-effect and the OLS measures, otherwise all measures are correlated at 90% or more. For the sake of brevity, the following analysis will be carried out using TFP only OLS-D, OP and LP estimators.[7]

With these sets of estimates of firm-level TFP, we can now explore differences in TFP between international firms (identified as exporters and multinationals) and non-international firms. We regress firm (log) TFP on two dummies taking value 1 for multinational firms and non-multinational exporters (the baseline category is non-exporting firms) and a vector of controls, which include dummies for sector and time, firm location (regions), size class, and other firm characteristics. Results are reported in Table 5.

The estimates are consistent with the descriptive statistics of Table 1, and support the idea that Italian multinationals and non-multinational exporters are more productive (in terms of TFP) than domestic non-exporting firms, after controlling for sector, region, size and time differences. The magnitude of this premium is consistent across methods: for multinational firms it goes from 16% in the OLS-D estimates to 23% in the OP estimates;[8] for exporters it varies from 6.5% (with OLS-D) to 7.9% (with OP). We also control for further sources of heterogeneity in firm productivity, which can be correlated with the international status. We add a dummy indicating whether the firm is incorporated, three dummies taking value 1 if the firm has introduced product, process or organizational innovation over the past three years, two dummies capturing investments in machinery and equipment and in ICT, and the share of employees engaged in R&D activities. The numerical magnitude of the coefficients on the multinational firm and non-multinational exporter dummies is slightly lower than in the initial model, but these controls do not seem to explain much of the TFP premia of international firms. A more sizeable drop in productivity premia is observed when we control for the skill composition. The share of managers and other white collar employees is strongly associated with firm TFP and, upon their inclusion, the TFP premia slide by more than 30%.

Results presented in Table 5 support the idea that not all the heterogeneity among firms with different international engagement can be explained by differences in the constant of

Table 4. Correlation of TFP measures.

	OLS	OLS_D	OP	LP	FE	GMM	DIF1	DIF3
OLS	1.00							
OLS_D	0.98	1.00						
OP	0.87	0.92	1.00					
LP	0.82	0.91	0.99	1.00				
FE	0.61	0.76	0.88	0.95	1.00			
GMM	0.89	0.96	0.96	0.97	0.90	1.00		
DIF1	0.52	0.68	0.83	0.91	0.99	0.85	1.00	
DIF3	0.58	0.73	0.87	0.94	1.00	0.88	1.00	1.00

Table 5. Two-steps estimation of productivity premia of Italian international firms, 1998–2003.

	OLS_D	OLS_D	OLS_D	OP	OP	OP	LP	LP	LP
Multinational firm	0.149***	0.123***	0.072***	0.210***	0.161***	0.112***	0.202***	0.170***	0.121***
(dummy)	(0.026)	(0.026)	(0.025)	(0.028)	(0.028)	(0.026)	(0.028)	(0.028)	(0.026)
Non-MN exporter firm	0.063***	0.053***	0.034**	0.076***	0.057***	0.037**	0.073***	0.060***	0.041***
(dummy)	(0.015)	(0.015)	(0.014)	(0.016)	(0.016)	(0.015)	(0.016)	(0.015)	(0.014)
Ltd. company		0.112***	0.078***		0.172***	0.139***		0.168***	0.135***
		(0.015)	(0.014)		(0.016)	(0.015)		(0.015)	(0.014)
Product innovator		–0.042***	–0.040***		–0.044***	–0.042***		–0.041***	–0.040***
(dummy)		(0.013)	(0.012)		(0.013)	(0.013)		(0.013)	(0.013)
Process innovator		–0.009	0.001		0.005	0.015		0.003	0.013
(dummy)		(0.012)	(0.011)		(0.012)	(0.012)		(0.012)	(0.012)
Organization innovator		–0.005	–0.013		–0.003	–0.011		–0.003	–0.011
(dummy)		(0.014)	(0.013)		(0.015)	(0.014)		(0.014)	(0.014)
Investment in machinery		–0.007	0.011		0.034	0.050**		0.022	0.039*
(dummy)		(0.022)	(0.020)		(0.022)	(0.021)		(0.022)	(0.021)
Investment in ICT		0.011	–0.007		0.003	–0.014		0.008	–0.009
(dummy)		(0.014)	(0.013)		(0.015)	(0.014)		(0.014)	(0.014)
Share of R&D workers		0.342***	–0.006		0.281***	–0.053		0.259***	–0.075
		(0.080)	(0.079)		(0.080)	(0.080)		(0.078)	(0.079)
Share of managers			0.902***			1.001***			0.978***
			(0.124)			(0.123)			(0.122)
Share of clerks			0.788***			0.739***			0.740***
			(0.043)			(0.045)			(0.044)
Constant	8.510***	8.516***	8.367***	10.024***	10.178***	10.033***	10.205***	10.005***	9.861***
	(0.065)	(0.067)	(0.065)	(0.068)	(0.072)	(0.070)	(0.070)	(0.070)	(0.068)
R-squared	.153	.165	.241	.359	.279	.336	.259	.376	.426
N. observations	16779	16758	16752	16779	16758	16752	16779	16758	16752
N. firms	4131	4131	4131	4131	4131	4131	4131	4131	4131

Notes: Dependent variable is $\log(TFP_{it}^{est}) = y_{it} - \hat{\beta}_l^{est} l - \hat{\beta}_k^{est} k$, where the superscript *est* denotes the estimation methods used in the first step: OLS_D, OP or LP. Asterisks denote significance levels: *** p<1%, ** p<5%, * p<10%. Standard errors are clustered by firm. Each regression controls of sector, time, sector x time, region and firm size fixed effects.

the production function. Even after controlling for a large number of firm characteristics, sizeable differences in estimated TFP remain. In the following we explore whether and to what extent these differences are robust to different assumptions on the slope of the production function. In particular, we allow for heterogeneity in the labour and capital elasticities across firms. In Table 6 we allow for sector and size heterogeneity in the production functions, by interacting the labour and capital inputs with industry and size dummies, respectively. Since our results are not particularly sensitive to the estimation method, we report results only on the OLS-D estimator. This allows us to keep computation simple as well as simultaneously estimate the parameters of the production function and the international status dummies, instead of resorting to the two-step approach illustrated above. In column A we replicate the results of the first column in Table 5 where we assumed that all firms shared the same production technology. We show that, under this assumption, multinational firms and exporters have a significantly higher intercept relatively to firms serving only the domestic market, suggesting a TFP premium of 15% for multinationals and 6% for exporters. These premia appear to be robust to the assumption of sector and size-specific production function parameters. Indeed, columns B and C suggest that labour and capital elasticities differ substantially across sectors and firms, but allowing for this heterogeneity in parameters does not affect the numerical magnitude of the coefficients of the international firms' dummies. Things change remarkably in Table 7, where we allow for heterogeneity in the production function parameters also across the internationalization status, by interacting labour and capital inputs by the multinational and exporter dummies. Column D suggests that multinational firms have a significantly higher return to capital than domestic firms. Once we allow for this heterogeneity in the shape of the production function, we do not have any evidence of a higher TFP for international firms. This is robust to the specification of a very flexible production function, where parameters are allowed to differ also across sectors and firm size. Results in column F suggest that, once accounted for sector and size heterogeneity in parameters, international firms have a slightly higher return to capital, even if with a rather large standard error – probably due to some correlation with size-inputs interactions – and this seems to capture the difference in intercepts, which becomes non-statistically significant.

A number of reasons may contribute to explaining why international firms have a different production function. First, by organizing production across borders, multinational firms (and to some extent other internationalized firms, such as exporters, which may also be engaged in import of intermediates and outsourcing) keep higher value added activities and use capital more intensively. Second, capital and labour may have different quality since international firms may require a wider use of ICT to coordinate activities across borders. Third, labour composition may differ and complementarities with the use of capital may emerge in international firms, if they are to implement better management practices.

Indeed, our results are consistent with Bloom *et al*. (2007) who find that, once controlling for the higher productivity in the use of IT capital, multinational firms (and US multinationals in particular) are not more productive than UK national firms. Furthermore, the link between superior management practices and higher productivity in international firms has been documented extensively by Bloom and Van Reenen (2007) with reference to a large sample of European and US firms. Finally, a recent study by Csillag and Koren (2009) on wages in Hungarian firms provides evidence consistent with the interpretation that international firms may use more productive capital in combination with more skilled workers. They find that machine operators working on imported machines earn 16% more than those working on domestic machines and one third of this wage gap is due to the

Table 6. One-step estimation of productivity premia of Italian international firms, 2003–2008.

Method: OLS	A		B		C	
Multinational firm (dummy)	0.153***		0.147***		0.133***	
	(0.026)		(0.026)		(0.025)	
Non-MN Exporter (dummy)	0.064***		0.063***		0.065***	
	(0.015)		(0.015)		(0.015)	
Coefficients on capital and labour	*k*	*l*	*k*	*l*	*k*	*l*
	0.176***	0.787***	0.310***	0.633***	0.257***	0.406***
	(0.011)	(0.020)	(0.026)	(0.043)	(0.026)	(0.062)
Interacted with sector dummies *Baseline: Food and Beverages*						
Textiles			–0.158***	0.118*	–0.145***	0.142**
			(0.039)	(0.062)	(0.037)	(0.060)
Wearing apparel			–0.147***	0.165***	–0.137***	0.236***
			(0.045)	(0.064)	(0.042)	(0.068)
Leather and footwear			–0.173***	0.207***	–0.157***	0.247***
			(0.035)	(0.060)	(0.035)	(0.059)
Wood and paper			–0.070	0.093	–0.072	0.119
			(0.059)	(0.105)	(0.046)	(0.080)
Publishing			–0.194***	0.374***	–0.204***	0.425***
			(0.051)	(0.084)	(0.044)	(0.075)
Coke, petroleum refining and rubber			0.026	–0.040	–0.019	0.028
			(0.090)	(0.133)	(0.060)	(0.088)
Chemical			–0.189***	0.271***	–0.213***	0.319***
			(0.046)	(0.065)	(0.047)	(0.071)
Non-metallic mineral products			–0.074*	0.119**	–0.073*	0.115**
			(0.040)	(0.058)	(0.039)	(0.057)
Basic metal			–0.147**	0.191**	–0.156***	0.203**
			(0.059)	(0.084)	(0.058)	(0.081)

Table 6. (*Continued*).

Method: OLS	A	B		C	
Fabricated metal products		–0.144***	0.181***	–0.136***	0.189***
		(0.032)	(0.050)	(0.031)	(0.049)
Machinery and equipments		–0.213***	0.273***	–0.211***	0.315***
		(0.031)	(0.049)	(0.031)	(0.050)
Electrical machinery		–0.217***	0.276***	–0.225***	0.334***
		(0.033)	(0.054)	(0.037)	(0.062)
Transport equipments		–0.130***	0.137**	–0.138***	0.193***
		(0.045)	(0.068)	(0.043)	(0.068)
Furnitures		–0.202***	0.242***	–0.187***	0.266***
		(0.037)	(0.060)	(0.037)	(0.060)
Other industries		–0.196***	0.228***	–0.193***	0.287***
		(0.042)	(0.066)	(0.042)	(0.042)
Interacted with size dummies *Baseline: 11–20 employees*					
21–50 employees				0.042***	0.259***
				(0.016)	(0.064)
51–250 employees				0.072***	0.216***
				(0.018)	(0.059)
251–500 employees				0.191***	–0.001
				(0.042)	(0.099)
500+ employees				0.338***	–0.144
				(0.087)	(0.105)

Table 6. (*Continued*).

Method: OLS	A		B		C	
Constant	8.580***	8.580***	7.225***	7.225***	8.590***	8.590***
	(0.137)	(0.137)	(0.300)	(0.300)	(0.344)	(0.344)
R-squared	.891	.891	.896	.896	.899	.899
N. obervations	16779	16779	16779	16779	16779	16779
N. Firms	4131	4131	4131	4131	4131	4131

Notes: Dependent variable is $\log(TFP_{it}^{est}) = y_{it} - \hat{\beta}_l^{est} l - \hat{\beta}_k^{est} k$, where the superscript *est* denotes the estimation methods used in the first step: OLS_D, OP or LP. Asterisks denote significance levels: *** p<1%, ** p<5%, * p<10%. Standard errors are clustered by firm. Each regression controls of sector, time, sector x time, region and firm size fixed effects.

Table 7. One-step estimation of productivity premia of Italian international firms, 2003–2008.

	D		E		F	
Multinational firm (dummy)	−0.651**		−0.953***		−0.114	
	(0.330)		(0.320)		(0.341)	
Non-MN Exporter (dummy)	0.020		−0.225		−0.057	
	(0.160)		(0.155)		(0.145)	
Coefficients on capital and labour	*k*	*l*	*k*	*l*	*k*	*l*
	0.166***	0.804***	0.287***	0.653***	0.249***	0.416***
	(0.012)	(0.026)	(0.027)	(0.044)	(0.027)	(0.063)
Interacted with internationalization status						
Multinational firm (dummy)	0.073**	−0.067	0.102***	−0.097**	0.019	−0.011
	(0.033)	(0.048)	(0.032)	(0.047)	(0.034)	(0.050)
Non-MN Exporter (dummy)	0.009	−0.023	0.033**	−0.044	0.015	−0.023
	(0.017)	(0.029)	(0.016)	(0.028)	(0.015)	(0.028)
Interacted with sector dummies *Baseline: Food and Beverages*						
Textiles			−0.165***	0.138**	−0.147***	0.146**
			(0.038)	(0.061)	(0.037)	(0.059)
Wearing apparel			−0.156***	0.189***	−0.142***	0.241***
			(0.045)	(0.064)	(0.042)	(0.067)
Leather and footwear			−0.180***	0.228***	−0.160***	0.251***
			(0.035)	(0.060)	(0.035)	(0.059)
Wood and paper			−0.068	0.099	−0.071	0.119
			(0.058)	(0.103)	(0.046)	(0.080)
Publishing			−0.190***	0.379***	−0.203***	0.424***
			(0.049)	(0.081)	(0.044)	(0.074)
Coke, petroleum refining and rubber			0.017	−0.028	−0.021	0.031
			(0.089)	(0.132)	(0.060)	(0.088)

Table 7. (*Continued*).

	D	E		F	
Chemical		−0.198***	0.290***	−0.215***	0.323***
		(0.045)	(0.065)	(0.047)	(0.071)
Non-metallic mineral products		−0.069*	0.112**	−0.071*	0.111**
		(0.038)	(0.057)	(0.038)	(0.056)
Basic metal		−0.150**	0.195**	−0.156***	0.203**
		(0.059)	(0.083)	(0.058)	(0.081)
Fabricated metal products		−0.143***	0.186***	−0.135***	0.187***
		(0.031)	(0.049)	(0.031)	(0.049)
Machinery and equipments		−0.227***	0.299***	−0.215***	0.321***
		(0.031)	(0.050)	(0.031)	(0.050)
Electrical machinery		−0.222***	0.294***	−0.227***	0.339***
		(0.032)	(0.054)	(0.037)	(0.061)
Transport equipments		−0.129***	0.149**	−0.138***	0.196***
		(0.045)	(0.069)	(0.043)	(0.068)
Furnitures		−0.209***	0.260***	−0.190***	0.269***
		(0.037)	(0.060)	(0.036)	(0.059)
Other industries		−0.208***	0.259***	−0.196***	0.290***
		(0.042)	(0.067)	(0.042)	(0.066)
Interacted with size dummies *Baseline: 11–20 employees*					
21–50 employees				0.040**	0.262***
				(0.016)	(0.065)
51–250 employees				0.068***	0.221***
				(0.018)	(0.060)
251–500 employees				0.186***	0.000
				(0.043)	(0.101)

Table 7. (*Continued*).

	D		E		F	
500+ employees					0.331***	–0.142
					(0.091)	(0.110)
Constant	8.659***	8.659***	7.465***	7.465***	8.655***	8.655***
	(0.153)	(0.153)	(0.308)	(0.308)	(0.351)	(0.351)
R-squared	.891	.891	.896	.896	.899	.899
N. obervations	16779	16779	16779	16779	16779	16779
N. Firms	4131	4131	4131	4131	4131	4131

Notes: as in Table 6.

higher returns to skill on imported machines, while two thirds are due to the higher skill of imported machine operators.

3. Heterogeneity in the constant or in the slope?

The empirical evidence provided in the previous section suggests that international firms have higher TFP if we impose a homogeneous production function, while these premia disappear if we allow for heterogeneity in technology. In this section we illustrate why this may be the case.

Firm productivity can be modelled in the context of a production function such as:

$$Y_{it} = A_{it} \cdot F_{it}(K_{it}, L_{it}) \tag{1}$$

where Y, K and L denote firm output, physical capital and labour used in production, F (.) is a generic production function which transforms inputs (K and L) into outputs (Y) and A is total factor productivity, defined as a Hicks-neutral technical progress, which acts as a shifter of the production function. In principle, both F (.) and A need not be the same across firms (*i*) and over time (*t*).

Assuming a Cobb-Douglas specification for F (.) and taking logs we can write (lower-case denote natural log)

$$y_{it} = \beta_{it}^{l} l_{it} + \beta_{it}^{k} k_{it} + \alpha_{it} \tag{2}$$

To focus on differences in TFP across international and non-international firms, we can specify

$$a_{it} = \delta\, I_i + \tilde{a}_{it} \tag{3}$$

where I is an indicator variable which takes value 1 if firm *i* is internationalized. The parameter δ captures differences in TFP across international and non-international firms. Or, in other words, it allows the production function of international and non-international firms to have different constants (*heterogeneity in the constant*). By adding additional firm-level variables to this equation (such as measures of R&D and innovation or organizational characteristics of the firm), we may eventually be able to explain all the differences in the constants among firms.

If we want to estimate Equation

(3) parametrically, we need to assume $\beta_{it}^{l} = \beta^{l}$ and $\beta_{it}^{k} = \beta^{k}$. This yields the following estimating equation:

$$y_{it} = \beta^{l} l_{it} + \beta^{k} k_{it} + u_{it} \tag{4}$$

where

$$u_{it} = \delta\, I_i + \tilde{\beta}_{it}^{l} l_{it} + \tilde{\beta}_{it}^{k} k_{it} + \tilde{a}_{it} = \delta\, I_i + \tilde{u}_{it} \tag{5}$$

The parameters $\tilde{\beta}_{it}^{z} = \beta_{it}^{z} - \beta^{z}$ with $z = l$ and k, reflect the heterogeneity of firm *i* in its returns to capital and labour with respect to the average return to inputs among all firms in

the sample, while $\tilde{a}_{it}$ is a measure of a firm's ability to increase the returns of both inputs, i.e., the TFP. Plugging (5) into (4) and estimating the resulting equation, δ may not only capture differences in the constant of the production function ($\tilde{a}_{it}$), but also heterogeneity in the slopes ($\tilde{\beta}^z_{it}$). The extent of this bias would depend on the correlation between the $\tilde{\beta}^z_{it}$ s and the internationalization status (I). For example, if international firms use more advanced physical or IT capital, they would exhibit higher $\tilde{\beta}^k_{it}$. If we do not allow for different slopes of the production function across firms, we may wrongly interpret higher TFP as higher return to capital. To some extent, this amounts to mixing disembodied with embodied technical change.

In this paper, we followed the simplest route to account for this heterogeneity, by interacting *l* and *k* with sector, size and internationalization characteristics of firms. In doing so, we have been able to reduce the remaining heterogeneity in parameters $\tilde{\beta}^l_{it}$ and $\tilde{\beta}^k_{it}$. Alternative strategies for allowing production function heterogeneity are available and deserve further investigation. Assuming perfect competition in labour and product markets, one could compute labour elasticity as the wage share in value added. Imposing constant returns to scale, the elasticity of capital is the complement to one. This, sometimes known as the index number approach, has the advantage of allowing maximum heterogeneity in production functions, but requires stronger assumptions and is subject to measurement errors (Van Biesenbrock 2007). Within the (semi-)parametric framework, one interesting direction of research is the latent-class and random parameter models, where one could impose less structure on the source of heterogeneity in parameters (Greene 2008).

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4. Concluding remarks

Using data on a large representative sample of Italian manufacturing firms over the 1998–2003 periods, we estimate the TFP premia of international firms. We confirm the evidence that, even after controlling for sector, region and time effects, as well as other firms' characteristics (such as the innovative and investing behaviour, the legal status and the R&D intensity), exporters show higher TFP than non-international firms and domestic-owned multinationals perform better than exporters. We then show that TFP premia for international firms shrink substantially once we account for the fact that these firms employ a higher share of knowledge workers, such as managers, clerks and R&D personnel. Our results are robust to various methods of estimation. Furthermore, TFP premia for international firms vanish if we account for the fact that the returns to capital and labour may differ. This suggests that firm heterogeneity is in the slopes of the production function, and not (only) in the constant.

Our results have interesting policy implications. In particular, they highlight the need to explore international trade "from below", starting from an understanding of the heterogeneous firms' behaviour. The results support the view that within the international firms there are positive externalities and learning. Furthermore, the fact that multinationals have a significantly higher return on capital than purely domestic firms, and that size significantly affects productivity premia, suggests that (smaller) domestic firms could substantially improve their performance if they were to get better access to financing. They could pool together; in addition, public intervention could go in the direction of improving access to capital markets for instance through incentivizing venture capital or allowing easier access to trade finance.

The increasing role of multinationals in Italy, despite the relatively small size of Italian firms, also has important implications for aggregate trade volumes, production and

employment in Italy, as well as for prices, tax revenues and other related issues; this role, however, depends crucially on how multinationals behave when they trade inside the firm or with arm's length customers, on how their structure responds to policy changes (for instance a lowering of trade costs), on how domestic employment and wages respond when firms establish affiliates abroad. The heterogeneity of firms' responses could guide policy prescriptions.

Finally, while in the paper we only deal with affiliates of Italian multinationals and Italian exporters, if pushed (with caution) to the limit our results could challenge the fact that countries strive to attract foreign direct investment on the grounds that knowledge brought by multinationals can spill over to domestic firms and increase their productivity. If there is no productivity premium for multinationals, once we account for differences in the slope of the production functions, this reasoning may not apply and governments may revisit their policies to attract FDI.

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Notes

1. Organizational capital is constructed from survey data as a linear combination of questions on team working and workers' authority
2. The multidimensional nature of the Capital questionnaire is one of the main reasons why these sources of data have been used extensively by many Italian researchers in recent years. Among others, it is worth mentioning a methodological work of Nese and O'Higgins (2007) on the problems of attrition bias in Capitalia, Angelini and Generale (2008) on financial constraints and firm size, and Hall *et al*. (2009) on innovation and productivity. More closely related to the present work are various studies on internationalization, innovation and productivity such as Sterlacchini (1999), Castellani (2002), Basile *et al*. (2003), Casaburi et al. (2007), Benfratello and Razzolini (2008), and Vannoni and Razzolini (2008).
3. We have dropped "anomalous" firm-year observations. "Anomalous" observations have been defined as values for inputs and output which exceeded the median for each firm by three times or were lower than one-third of the median.
4. The merge of the 2001 version of Reprint with the Capitalia survey is the result of a collaborative effort between ICE and the Centro Europa Ricerche (Cer). Reprint is the directory of Italian multinationals sponsored by ICE (Istituto per il Commercio Estero/Italian Institute for External Trade) and maintained by the Polytechnic of Milan.
5. For the sub-sample of firms included both in the 8th and 9th survey, information on the export status in 1998 was also available. Given the high degree of persistence in exporting (92% of firms exporting in the 8th survey are exporters also in the 9th), we choose to use a time invariant indicator for the export status. Therefore, we identify the international status of the sample firms in 2001 and assume it as time-invariant throughout the period.
6. For a recent discussion see Van Biesenbroeck, 2007a.
7. Results using GMM-DPD, which appear to yield rather sensible estimates, will not be reported further, since the hypotheses on the absence of second order autocorrelation and no over-identification are rejected.
8. Percentage differences in TFP can be obtained as $[\exp(\delta_j)-1]*100$, where δ_j is the estimated coefficient associated to the international status dummy.

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