DISCUSSION PAPER SERIES

IZA DP No. 3378

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February 2008

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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ABSTRACT

Brain Drain and Productivity Growth: Are Small States Different?*

This paper examines the impact of North-South trade-related technology diffusion on *TFP* growth in small and large states in the South. The main findings are: i) *TFP* growth increases with North-South trade-related technology diffusion, with education, and with the interaction between the two, and it decreases with the emigration of skilled labor (brain drain); ii) these effects are substantially (over three times) larger in small states than in large ones. Small states also exhibit a much higher brain drain level. Consequently, the brain drain generates greater losses in terms of *TFP* growth both because of its greater sensitivity to the brain drain and because the brain drain is substantially larger in small than in large states.

JEL Classification: F22, J61

Keywords: brain drain, technology diffusion, trade, productivity growth

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* We would like to thank Alan Winters and seminar participants at the December 2006 World Bank conference on "Small States: Growth Challenges and Development Solutions" for their helpful comments and suggestions. The views expressed in this paper are those of the authors and do not necessarily reflect those of the World Bank, its Board of Executive Directors, or the governments they represent.

1. Introduction

An important literature exists on the effects of countries' human capital on their productivity growth, with most studies conducted in a closed-economy context. This paper focuses on the differential impact of the brain drain in small and in large states. It examines the impact of North-South trade as a vehicle of technology diffusion, as well as the impact of human capital, on total factor productivity (*TFP*) growth in the South.

Specifically, it provides empirical analysis of the impact on *TFP* growth of i) trade-related technology diffusion, human capital, and country size, ii) the interaction of trade-related technology diffusion and country size, and of human capital and country size, iii) the interaction between trade-related technology diffusion and human capital, and iv) the interaction between trade-related technology diffusion, human capital and country size.

Section 1.1 deals with the impact of trade on technology diffusion and productivity growth, Section 1.2 provides figures on the brain drain for various categories of countries and regions, and Section 1.3 presents the main findings.

1.1. Trade-Related Technology Diffusion and Productivity Growth

Until about two decades ago, while trade theory emphasized the importance of trade liberalization, empirical estimates of the gains from trade were found to be disappointingly small. The development of endogenous growth theory in the 1980s (Romer 1986, Lucas 1988) allowed policy reform to generate large gains by moving the economy to a higher growth path. Grossman and Helpman (1991) expanded the endogenous growth model by applying it to the open economy. Based on the idea that goods embody technological know-how, they showed that countries can acquire foreign knowledge through trade and increase their growth rate through trade liberalization.

Coe and Helpman (1995) provided an empirical implementation of that model. They constructed an index of ‘foreign R&D’, defined as the trade-weighted sum of trading partners’ R&D stocks, and found for OECD countries that both domestic and ‘foreign R&D’ have a large and significant impact on TFP, and that the latter increases with the economy’s openness. Coe et al. (1997) examined the impact of North-South trade-related technology diffusion on TFP in the South and obtained similar results. This led to other studies by, inter alia, Engelbrecht (1997), Falvey et al. (2002), and Lumengo-Neso et al. (2005), which have tended to confirm Coe and Helpman’s (1995) findings. Other studies have extended the approach to the industry level, including Schiff and Wang (2006) who added South-South trade-related technology diffusion to the analysis and found a positive impact on TFP in the South, though a smaller one than that obtained from North-South trade.

1.2. Brain Drain

This paper focuses on the impact of the brain drain and whether it is different for small than for large states. Brain drain figures are presented in Table 1. The figures are based on Docquier and Marfouk (2006). The table presents skilled and overall emigration rates in 2000, as well as the ratio of the former to the latter (the schooling gap), for 46 small developing states – defined by the UN as states with population below 1.5 million – and for other categories of interest. Skilled workers are defined as those with university education.

Row 1 of Table 1 shows that small developing states experience an extremely high level of brain drain (43.2%). In other words, 3 out of every 7 individuals with university education lives outside their country of origin. This rate is 2.8 times as large as the 15.3% overall migration rate.

The table also shows a brain drain for small (all) high-income states of 23% (3.5%) or a ratio of 6.5 for small versus all states. The same ratio for developing countries is (43.2 / 7.4) or close to 6. In other words, the impact of country size on the brain drain seems robust across a wide range of incomes. Moreover, the brain drain for all developing countries (7.4%) is over twice that of high-income countries (3.5%) and the schooling gap is close to four times as high (4.9% versus 1.3%).

The region with the highest small-state brain drain (74.9%) is the Caribbean (in "Latin America and the Caribbean"), and Table 2 shows that several states' brain drain is well above 80%. The East Asia and Pacific region (mainly the South Pacific islands) follows, with a brain drain of 50.8%, with several countries over 70% (Table 2). Sub-Saharan Africa is next with 41.7%, with several countries over 60% (Table 2).[1]

Thus, as far as small states are concerned, three out of four skilled Caribbean individuals live outside their country of origin, two out of four in East Asia and Pacific, and two out of five in Sub-Saharan Africa. Though Sub-Saharan Africa (SSA) has the lowest brain drain among these three regions, its schooling gap is more than double that in the other two developing regions. The main reasons are the wider income gap with developed countries and the smaller share of skilled individuals in the population.

1.3. Main Findings and contributions

The contribution of this paper to the open-economy endogenous growth literature is twofold. First, it offers an empirical analysis of the relationship between trade-related technology diffusion, country size and productivity growth. Second, it examines how the impact on productivity growth of

[1] Table 2 also shows countries in Central America (Belize) and the Mediterranean (Malta) with brain drain above 50% and Cyprus with brain drain above 30%.

changes in such variables as the level of education, trade-related technology diffusion, and both, is affected by country size. The main findings are:

i) Trade-related technology diffusion has a positive impact on productivity growth that is several times larger for small states than for other countries. Consequently, an increase in the degree of openness has a greater impact on productivity growth in small than in large states.

ii) Similarly, education has a positive impact on productivity growth that is several times larger for small than for large states. Hence, the brain drain's negative impact on productivity growth in small states is a multiple of that for other countries.

iii) In terms of interaction effects, the impact of trade-related technology diffusion on productivity growth increases with the level of education, and this increase is also several times larger for small than for large states. Consequently, the brain drain reduces productivity growth both directly as well as through its interaction with trade-related technology diffusion, with a greater reduction for small than for large states.

These findings imply that productivity growth in small states is more sensitive than in large ones to changes in the brain drain, in trade-related technology diffusion, in levels of education, and to the interaction between changes in these variables.

The rest of the paper is organized as follows. Section 2 provides the empirical implementation. Section 3 describes the data and Section 4 presents the empirical results. Section 5 concludes.

2. Empirical Implementation

Coe and Helpman (1995) set up the empirical framework to estimate the impact on TFP of North-North trade-related technology diffusion. The studies in the trade-related technology diffusion followed that approach with minor modifications. The equation Coe and Helpman use is:

$$\log TFP_{ct} = \alpha + \lambda_c + \lambda_t + \beta^d \log RD_{ct}^d + \beta^f \log RD_{ct}^f + \varepsilon_{ct}; \beta^d, \beta^f > 0, \quad (1)$$

where $\lambda_c\,(\lambda_t)$ is a country (time) fixed effect, RD_{ct}^d (RD_{ct}^f) is the domestic (foreign) R&D stock, ε is an error term, and subscript *c* (*t*) denotes country (year).

Coe et al. (1997) use a similar model to explain North-South trade-related technology diffusion. However, due to lack of data for most developing countries, the equations they estimate do not include domestic R&D. They only use the foreign R&D stock RD^f, which is referred to in this paper as 'North foreign R&D' and is denoted by '*NRD*' in our study. Abstracting from domestic R&D is unlikely to be a major problem because most of the world's R&D is performed in developed countries.[2]

Following Coe and Helpman (1995) and Coe et al. (1997), we define the variable 'North-foreign R&D' of developing country *c*, NRD_c as:

$$NRD_c \equiv \sum_k \frac{M_{ck}}{GDP_c} RD_k, \quad (2)$$

[2] In 1990, 96% of the world's R&D expenditures took place in industrial countries (Coe et al., 1997). The share was 94.5% in 1995 (calculated from the World Bank database). Moreover, recent empirical work has shown that much of the technical change in individual OECD countries is based on the international diffusion of technology among the various OECD countries. For instance, Eaton and Kortum (1999) estimate that 87% of French growth is based on foreign R&D. Since developing countries invest much fewer resources in R&D than OECD countries, foreign R&D must be even more important for developing countries as a source of growth.

where c indexes developing countries, k indexes OECD countries, GDP_c is the value added of country c, M_{ck} is the value of imports of country c from OECD country k, and RD_k denotes the R&D stock in OECD country k. The time variable t is omitted for simplicity. Equation (2) says that, for any country c, *NRD* is the sum, over all OECD countries k, of the R&D stock of country k, weighted by country c's imports from OECD country k divided by country c's GDP.

We estimate *TFP* equations as a function of *NRD* and a human capital variable, namely the average number of years of education for the population aged 25 and above, denoted by *YE*. We further add a dummy variable for small states, *S*3, in order to examine whether their impact on TFP growth differs from that of large ones. The number of countries with a population of 1.5 million or less (on average over the period) in our sample of fifty developing countries is too small to be of much relevance. We use instead a population of 3 million or less as our definition of 'small state', with nine countries or 18% of the sample fitting the definition.

In the empirical estimation, we also introduce several interaction terms. Two of them are interactions between each of the two explanatory variables and *S*3, i.e., *NRD***S*3 and *YE***S*3. The other two are interactions between the two explanatory variables both for small and large states, i.e., *NRD***YE* and *NRD***YE***S*3. A positive sign for the first two interaction variables would imply that the productivity-growth impact of *NRD* and *YE* is larger in small states, and similarly, a positive sign for *NRD***YE***S*3 would imply that the impact of *NRD***YE* is larger in small states.

The estimation equation is specified in terms of five-year changes in the log of *TFP* (Dlog*TFP*), in the log of *NRD* (Dlog*NRD*) and in *YE* (D*YE*), i.e.:

$$D\log TFP_{ct} = \alpha + \beta_N D\log NRD_{ct} + \beta_Y DYE_{ct} + \beta_S S3 + \beta_{NS} D\log NRD_{ct} * S3 + \beta_{YS} DYE * S3$$
$$+ \beta_{NY} D\log NRD_{ct} * DYE_{ct} + \beta_{NYS} D\log NRD_{ct} * DYE_{ct} * S3 + \sum_{c=2} \gamma_c D_c + \sum_{d=2} \gamma_d D_d + \varepsilon_{ct}, \qquad (3)$$

where $D_c(D_d)$ indicates country (year) dummies, capturing country- (year-)specific fixed effects. The equations estimated in Section 4 include equation (3) and variants thereof.

3. Data Description

The data covers 50 developing (and transition) countries and 15 industrialized OECD trading partners over the period 1976 to 2002. The 50 developing countries -- with small states in italics – are: Bangladesh, Bolivia, Bulgaria, Cameroon, Chile, Colombia, *Cyprus*, Ecuador, Egypt, El Salvador, Ethiopia, Greece, Guatemala, Hong Kong (China), Hungary, India, Indonesia, Iran, I.R. of, Israel, Jordan, Kenya, Korea, *Kuwait*, *Latvia*, *Macao (China)*, Malawi, Malaysia, *Malta*, Mexico, Morocco, Myanmar (Burma), Nepal, Nigeria, *Oman*, Pakistan, *Panama*, Peru, Philippines, Poland, Romania, Senegal, Singapore, *Slovenia*, Sri Lanka, Tanzania, *Trinidad & Tobago*, Tunisia, Turkey, Uruguay and Venezuela.

The log *TFP* index is calculated as the difference between the logs of value-added and primary factor use, with the inputs weighted by their income shares, i.e., $\ln TFP = \ln Y - \alpha \ln L - (1-\alpha)\ln K$, where α is the mean labor share over the available time period. The labor share is derived as the ratio of the wage bill over value added.

Fixed capital formation used to construct capital stocks, value added, labor and wages, is from the World Bank data set described in Nicita and Olarreaga (2006), all reported in current US dollars at the 3-digit ISIC codes (Revision 2). Value-added is deflated by the US GDP deflator (1991=100). Fixed capital formation is also deflated by the US GDP deflator (1991=100), and capital stocks are derived from the deflated fixed capital formation series using the perpetual inventory method with a 5% depreciation rate.[3] The *TFP* index is constructed using the deflated value added, capital stocks, labor and its average income share with the formula provided.

R&D expenditure for the 15 OECD countries is taken from OECD ANBERD with ISIC Revision 2 (2002) covering data from 1973 to 1998, and ANBERD with ISIC Revision 3 (2006) covering data from 1987 on. Since ANBERD ISIC 2 and ISIC 3 have 12 years of data overlapping, we are able match the different specifications. The R&D stock in each country is constructed from R&D expenditures using the perpetual inventory method with a 10% depreciation rate.

Bilateral trade data of the 50 developing countries with the 15 industrialized OECD countries at the 4-digit ISIC 2 level are taken from Nicita and Olarreaga (2006). We construct bilateral trade shares for each of the 50 developing countries with respect to each of the 15 OECD countries, as defined in equation (2).

Average years of education, tertiary education completion ratio, and secondary school completion ratio for the population aged 25 and above are obtained by annualizing the five-year averages in Barro and Lee (2000). There are several countries included in the sample that are not included in the Barro and Lee dataset. We matched each of these countries with other countries included in Barro and Lee, using real GDP per capita and government expenditure as a share of GDP per capita.

Observations for a typical country consist of five five-year periods. With 50 developing countries and no missing observations, that would give a sample size n = 250. However, we have some missing observations (with n = 230) for production and trade data, and the sample is unbalanced.

[3] Given that the data reported in Nicita and Olarreaga (2006) are in current US dollars, we use the US GDP deflator. In the empirical analysis, country-specific as well as year dummies are used in order to control for some of the distortions possibly introduced by the conversion.

4. Empirical Findings

Given that changes in openness, foreign R&D and education are unlikely to have an immediate impact on productivity growth, we specify the estimated equations in terms of five-year changes in the log of *TFP*, the log of *NRD*, and in *YE*., where "D" before the variable indicates a five-year change. In other words, the estimated equations are specified in terms of the growth rate of *TFP* and *NRD*, and in terms of the change in *YE*. We estimate nine equations, all variants of equation (3) above. The results are presented in Table 3.

Table 3 shows that the coefficient β_N of Dlog*NRD* is positive and significant in all nine regressions. Denote the coefficient β_N for small states by β_{NS} (equation (3)). The value of β_N ranges from .269 to .615, but falls to a range of .269 to .397 when the variable Dlog*NRD***S*3 is included in the regression. For instance, in equation (1), β_N = .490 (significant at the 1% level). It falls to .269 (significant at the 10% level) in equation (2). On the other hand, β_{NS} = .964 (significant at the 1% level) in the same equation. The impact ϕ_{NS} of Dlog*NRD* on Dlog*TFP* in small states is $\phi_{NS} \equiv \beta_N + \beta_{NS}$ = .269 + .964 = 1.233. Thus, the impact of Dlog*NRD* in small states is over four times the impact in large countries, i.e., $\phi_{NS} > 4\beta_N$. The same result obtains in equations (6) and (9), while $\phi_{NS} > 3\beta_N$ in equations (5) and (8).

The coefficient β_Y of the education variable D*YE* ranges from .721 to .807, with significance of 1% or 5% in equations (1), (2), (3) and (5). However, β_Y falls to between .194 and .310 and is no longer significant when the variable for small states, D*YE***S*3, is included in the regression. For instance, in equation (1), β_Y = .766 (significant at the 5% level). Adding D*YE***S*3 in equation (4) results in a value β_Y = .242 (not significant), with the coefficient for small states β_{YS} = 1.075. The impact of D*YE* for small states is equal to $\phi_{YS} \equiv \beta_Y + \beta_{YS}$ = 1.317, or over five times the impact in large countries, i.e., $\phi_{YS} > 5\beta_Y$. Similar results are obtained in equations (6) to (9), with the ratio ϕ_{YS} / β_Y > 6 in equation (7), > 5 in equation (8), and > 4 in equations (6) and (9).

The coefficient β_{NY} of the interaction effect Dlog*NRD**D*YE* ranges from 1.618 to 1.701, with significance level of 5% or 10%, in regressions (3), (5), (7) and (8). Once the variable Dlog*NRD**D*YE***S*3 (with coefficient β_{NYS}) is added to the regression (equation (9)), β_{NY} falls to .726 and is no longer significant. On the other hand, β_{NYS} = 2.966 (significant at the 10% level), and the impact of Dlog*NRD**D*YE* in small states is $\phi_{NYS} \equiv \beta_{NY} + \beta_{NYS} = 3.792 > 5\beta_{NY}$.

The results provided in Table 3 imply that the impact of Dlog*NRD*, D*YE* and Dlog*NRD**D*YE* on Dlog*TFP* in small states is systematically larger than that in large countries. Equation (9) – which includes all the explanatory variables and is the preferred equation – shows that the impact of Dlog*NRD* is more than 4 times greater in small states than in large countries, and the impact of D*YE* (Dlog*NRD**D*YE*) is more than 5 times greater.

As shown in Table 1, the share of migrants who are skilled is larger than the share among residents (Docquier and Schiff, 2006), implying that the brain drain lowers the average level of education *YE* and reduces productivity growth. Second, since the interaction effect of education and 'foreign R&D' (the diffusion of technology from the North to the South) is positive, it implies that the brain drain reduces the absorption capacity of developing source countries. In other words, the brain drain reduces the impact that the diffusion of technology from the North has on productivity growth, and this reduction is greater for small states than for large ones. In fact, the loss in productivity growth when this interaction effect is taken into account is close to *three times* as high (193% higher) in small states than in the other countries, rather than 16% higher when the interaction effect is not taken into account.

Third, small states also tend to suffer from significantly higher brain drain rates. Among developing countries, the brain drain in 2000 was 43.2% for small states and 7.4% for all developing countries, with the former close to six times larger than the latter. Thus, the negative impact of the brain drain is larger in small states both because TFP growth is more sensitive to the brain drain and because the brain drain is substantially greater in these states.

4.1. R&D-Intensive Industries

The industry-level data were aggregated in two industry groups: R&D-intensive industries and low R&D-intensity industries in order to examine whether there were significant differences between the two. The regressions were estimated by adding a dummy variable for R&D-intensive industries for all countries. The results are shown in the Appendix Table A1.

The preferred specification is equation (5) which includes all the variables which shows that the impact of *YE**Dr on *TFP* growth is not significant, and the impact of North-South trade-related technology diffusion (Dlog*NRD*) on *TFP* growth is the same, irrespective of the R&D intensity of the industry group. The coefficient of Dlog*NRD* is 2.95 (significant at the 1% level) while that of Dlog*NRD**Dr is .03 (not significant). The regressions were also estimated with small state dummies, with the same results. Consequently, we decided to estimate the model without disaggregating industries according to their R&D intensity.

5. Conclusion

This paper examined the impact of North-South trade-related technology diffusion on *TFP* growth in the South, contributing to the open-economy endogenous growth literature by offering an empirical analysis of the impact of skilled emigration or brain drain on productivity growth, the relationship between country size and *TFP* growth, and the relationship between a combination of country size, brain drain and OECD countries' R&D, on the one hand, and *TFP* growth on the other. The main findings are:

i) Productivity growth increases with trade-related technology diffusion, and the increase is substantially larger for small states than for large ones;

ii) Education has a positive impact on productivity growth, and the increase is substantially larger for small states than for large ones;

iii) The share of migrants who are skilled is larger than the share of residents who are skilled, implying that the brain drain has a negative impact on productivity growth; the (absolute value of that) impact is larger for small than for large states;

iv) The impact of the interaction of trade-related technology diffusion and education on productivity growth is positive, and this impact is greater for small than for large states.

Thus, small states have higher levels of productivity growth than large countries, but their productivity growth is more sensitive to changes in the brain drain, to changes in trade-related technology diffusion, and to the interaction between these two changes. Moreover, small states are more open to trade and benefit therefore from higher levels of trade-related technology diffusion. This is another reason why *TFP* growth in small states would be higher and would be more sensitive to changes in trade-related technology diffusion. It would also make them more vulnerable to the brain drain.

Small states also exhibit much higher levels of brain drain, and therefore greater losses in TFP growth than other countries. Thus, the negative impact of the brain drain is larger in small than in large states both because on TFP growth is more sensitive to the brain drain and because the brain drain I substantially greater in these states.

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Schiff, Maurice and Yanling Wang. 2008 “North-South and South-South Trade-Related Technology Diffusion: How Important Are They in Improving TFP Growth?” *Journal of Development Studies* (January).

Table 1. Emigration rates (%) by country group

		2000			1990		
	N	Skilled emigration rate	Average emigration rate	Schooling gap	Skilled emigration rate	Average emigration rate	Schooling gap
Small States (pop < 1.5 million)	**46**	**43.2**	**15.3**	**2.81**	**50.0**	**15.0**	**3.34**
by population size							
Population from 0 to 0.5 million	32	41.7	21.0	2.0	46.0	20.2	2.3
Population from 0.5 to 1 million	8	47.2	15.7	3.0	45.8	14.3	3.2
Population from 1 to 1.5 million	6	40.9	9.8	4.2	68.9	9.0	7.7
by region / income							
East Asia and Pacific	12	50.8	17.0	3.0	74.2	16.9	4.4
Latin America and Caribbean	10	74.9	35.0	2.1	75.4	30.0	2.5
Sub-Saharan Africa	10	41.7	6.0	6.9	43.3	5.2	8.3
High-income countries	12	23.0	10.7	2.1	24.9	12.0	2.1
Other Groups of Interest							
Small Islands Developing States	37	42.4	13.8	3.1	45.0	11.8	3.8
Population from 1.5 to 3 million	15	20.9	7.1	3.0	25.0	5.7	4.3
Population from 3 to 4 million	13	18.5	10.0	1.8	20.7	11.1	1.9
World average	*192*	*5.3*	*1.8*	*3.0*	*5.2*	*1.6*	*3.3*
Total high-income countries	*41*	*3.5*	*2.8*	*1.3*	*3.8*	*3.0*	*1.3*
Total developing countries	*151*	*7.4*	*1.5*	*4.9*	*7.8*	*1.1*	*7.2*

Skilled (average) emigration rates and average emigration rates m are defined as number of skilled (all) migrants divided by the sum of skilled (all) migrants and the .
Schooling gap = Skilled emigration rate / Average emigration rate
Source : Docquier and Marfouk (2006)

Table 2. Highest Brain Drain in Small States in 2000 (%), by Region

Region/Country	Brain Drain (%)
1. Sub-Saharan Africa	
Cape Verde	67.4
Gambia	63.2
Mauritius	56.1
Seychelles	55.8
2. Caribbean	
Guyana	89.0
Grenada	85.1
St Vincent and the Grenadines	84.5
St Kitts and Nevis	78.5
3. Central America	
Belize	65.5
4. South Pacific	
Samoa	76.4
Tonga	75.2
Fiji	62.2
Micronesia, Federated States	37.8
5. Mediterranean	
Malta	57.6
Cyprus	33.2

Table 4: TFP Growth and Small States

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dlog*NRD*	**.490**	**.269**	**.595**	**.509**	**.375**	**.291**	**.615**	**.397**	**.337**
	(3.71)*	***(1.83)****	***(4.18)****	***(3.87)****	***(2.42)****	***(1.98)****	***(4.33)****	***(2.57)****	***(2.14)****
D*YE*	**.766**	**.807**	**.721**	**.242**	**.761**	**.310**	**.194**	**.261**	**.296**
	(2.47)*	***(2.66)****	***(2.33)****	***(0.56)***	***(2.52)****	***(0.73)***	***(0.45)***	***(0.62)***	***(0.71)***
S3	**-.117**	**.338**	**.048**	**-.559**	**.519**	**-.087**	**-.396**	**.092**	**.206**
	(-.09)	***(0.27)***	***(0.04)***	***(-0.44)***	***(0.42)***	***(-0.07)***	***(-0.31)***	***(0.07)***	***(0.16)***
Dlog*NRD*S3*		**.964**			**.982**	**.949**		**.966**	**1.158**
		(3.12)*			***(3.21)****	***(3.09)****		***(3.17)****	***(3.59)****
Dlog*NRD D*YE***			**1.618**		**1.694**		**1.627**	**1.701**	**.726**
			(1.89)*		***(2.03)****		***(1.91)****	***(2.05)****	***(0.73)***
DYES3***				**1.075**		**1.019**	**1.082**	**1.025**	**.970**
				(1.74)*		***(1.69)****	***(1.77)****	***(1.71)****	***(1.63)****
Dlog*NRD D*YE**S*3***									**2.966**
									(1.75)*
Adj. R2	**0.25**	**0.28**	**0.26**	**0.26**	**0.30**	**0.29**	**0.27**	**0.30**	**0.31**
obs	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**

Note: Figures in parentheses are t-statistics. *** (**) (*) indicates 1(5) (10) % significance level. Figures in parentheses are robust t-statistics. The sample includes 50 developing countries covering the period of 1976 to 2002. *NRD* is trade-related North foreign R&D, defined in Section 2. *YE* is the average number of years of schooling of the population aged 25 and above. *Dr* is the dummy for R&D-intensive industries, and *S3* is a dummy variable capturing small states

Appendix

Table A1. TFP Growth and R&D Intensity

Variables	(1)	(2)	(3)	(4)	(5)
Dlog*NRD*	**0.348** ***(7.05)******	**0.289** ***(5.27)******	**0.366** ***(7.38)******	**0.373** ***(7.46)******	**0.295** ***(5.54)******
YE	**0.292** ***(5.99)******	**0.289** ***(5.97)******	**0.319** ***(6.45)******	**0.318** ***(6.47)******	**0.328** ***(6.82)******
Dlog*NRDDr**		**0.043** ***(1.30)***			**0.03** ***(1.53)***
Dlog*NRDYE**			**0.326** ***(3.33)******	**0.217** ***(2.45)*****	**0.148** ***(1.69)****
Dlog*NRDYE *Dr**				**0.068** ***(1.60)***	**0.049** ***(1.50)***
Obs.	**230**	**230**	**230**	**230**	**230**
Adj. R^2	**0.23**	**0.23**	**0.24**	**0.24**	**0.24**

Note: *** (**) (*) indicates 1 (5) (10) percent significance level. Figures in parentheses are robust t-statistics. The sample includes 50 developing countries covering the period of 1976 to 2002. *NRD* is trade-related North foreign R&D, defined in Section 2. *YE* is the average number of years of schooling of the population aged 25 and above. *Dr* is the dummy for R&D-intensive industries, and *S3* is a dummy variable capturing small states.