Inward FDI and host country productivity: evidence from China's electronics industry

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Industry cross-sectional studies of spillover effects from inward foreign direct investment (FDI) have reported many conflicting findings. This study focuses on a single sub-sector to investigate whether more robust findings can be discerned, and whether spillovers decline over time. Data for China's electronics industry for 41 sub-sectors for the years 1996, 1998, 2000 and 2001 are employed. The key finding is evidence that spillover benefits to China's domestic industry decline over the period. This suggests that host productivity gains via learning from FDI have a life cycle. However, our findings for a positive effect for State-owned enterprises in the regressions suggest that joint ventures with foreign affiliates may be an effective long term route to embed these local firms in the learning network of transnational corporations. This study also finds that transnational corporations are attracted to higher productivity sub-sectors, implying that, without appropriate steps (as taken in this study), a bias exists towards findings of positive spillover effects.

Keywords: foreign direct investment, China, electronics industry, productivity.

Introduction

There has been a great deal of research examining whether foreign affiliates exhibit higher levels of productivity than local firms (see, for example, Aitken and Harrison, 1999). The premise

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for this is that the firm-specific assets of transnational corporations (TNCs) increase productivity in FDI-receiving firms (Egger and Pfaffermayr, 2001). If this is the case, one would expect FDI to enhance overall industry performance as measured, for example, by labour productivity through this direct effect on foreign affiliate performance. Empirical research supports the view that firms with foreign equity participation outperform firms that are entirely locally-owned (see, for example, Blomström and Sjöholm, 1999).

A second source of impact from FDI on the performance of host country industry is that the presence of TNCs generates spillovers to other firms (Caves, 1974). Recently, research has focused on the question of the existence of such spillover effects from foreign to locally-owned firms in the form of increased productivity. These are known as productivity or technological spillovers (Kokko, 1996; Aitken and Harrison, 1999; Buckley *et al*., 2002). Studies in this vein investigate the extent to which the presence of technologically-advanced foreign affiliates stimulates growth in the performance of local firms. To date, most studies find that spillovers benefit the productivity of local firms. However, little attention has been given to the investigation of the conditions under which spillovers might be large, non-existent or indeed negative.

In this article we pursue the idea that the overall productivity effects of FDI may neither be as uniform, nor as high, as many studies suggest. In examining the productivity impacts of foreign ownership in China's electronics industry, we address two questions. First, do the productivity spillover effects tend to diminish over time, following the establishment of foreign affiliates? Second, does FDI affect all market segments within an industry, or only certain segments? The article is therefore an advance on those existing studies that use China's data for a number of industries taken as a whole (see for example, Liu, *et al*., 2000; Buckley, *et al*., 2002). Such studies simply search for the presence of spillover effects at the industry level at a snapshot in time. Such an approach may mask the true relationship between inward FDI and host country productivity

growth. A further distinctive feature of this article is that it examines the impact of inward FDI on overall productivity, that is to say the combined productivity of local and foreign-owned firms, whilst explicitly controlling for industry specific effects. The previous literature typically focuses on either the impact of FDI on GDP growth or on domestic firms alone.

China's electronics industry produces a wide range of household appliances, from refrigerators, air conditioning, cleaning, ventilating and heating appliances to kitchen, cosmetic and health care equipment, and a variety of accessories. China's open door policy (since 1978) has prioritized the securing of inward FDI as a means for upgrading domestic manufacturing capabilities. Judged simply in terms of the volume of inward FDI, the industry under study represents a success. Today, AT&T, Hewlett Packard, Hitachi, IBM, NEC, Olivetti, Philips, Samsung, Siemens, Toshiba, amongst others, have made substantial investments in China. At the same time, China's electronics industry has experienced dramatic growth. Our data show that, from 1996 to 2001, FDI in this industry has increased by a factor of 2.53, to come to account for more than 30% of the industry's total capital. Both sales revenue and industrial exports have grown over three fold. Exports of electronics goods reached $70 billion in 2001, accounting for 24.3% of China's total exports in 2001, compared with 14.2% in 1996. In view of this profile, China's electronics industry offers an ideal opportunity to conduct a micro-level investigation of the FDI-productivity relationship and its development.

This article proceeds as follows: section II briefly reviews the literature on FDI and productivity. Section III presents the methodology and data. The empirical results are presented in section IV and are discussed in section V. The last section offers conclusions.

Literature Review

Firm-specific intangible assets, such as technological know-how, marketing and management skills, favourable relationships with suppliers and customers, and reputation, have

played a dominant role in the conventional theory of FDI. John H. Dunning's eclectic paradigm (Dunning, 1981, 1988) combines ownership, internalization and location advantages to explain the existence and growth of TNCs. The paradigm posits that all three conditions must be satisfied for potential investing firms to find FDI worthwhile.

The same argument can be put in another way. For FDI to occur, all that is required is for TNCs to be more efficient than their indigenous counterparts when operating in the same location. It follows that the ownership advantages of foreign affiliates should lead to relatively higher performance than their indigenous counterparts (Wang *et al.* 2002). The notion of this productivity differential, in effect, underlies the specialized literature on the industrial "catch up" that occurs as a result of FDI (Perez, 1997). This provides the basis for the general hypothesis that FDI generates host country productivity growth (Driffield, 2001).

The above argument concerns the direct effects of FDI, i.e. the productivity growth contributed by foreign affiliates themselves. A further body of studies has arisen that focuses on the productivity spillover benefits associated with the presence of such affiliates. Positive spillovers arise when the productivity of locally-owned firms is enhanced through access to the leading-edge technologies employed by foreign affiliates (Feinberg and Majumdar, 2001). This access is not associated with a transaction (either in an external or internal market), and therefore the resulting locally-owned firms' productivity growth is an external or spillover benefit.

More recently, a number of theoretical reasons for negative spillover effects have been put forward. The key argument is that at greater levels of foreign presence, negative effects start to become apparent, and may begin to counteract the positive effects on local firms' productivity. Foreign affiliates may be able to draw demand away from their local counterparts through the introduction of new differentiated products and through process innovation leading to price reductions. As a result, the

productivity of local firms might fall owing to a "market stealing" effect (Aitken and Harrison, 1999).

The identification of negative effects also opens up the possibility that net positive spillover effects may diminish over the duration of foreign affiliates' operations. The dynamics of this process might be as follows. In the initial period when foreign affiliates are rare and just beginning operations, spillovers would be of small absolute magnitude. Locally-owned firms growing within a closed economy typically have weak technological capabilities. Local firms' capabilities are insufficient to enable them to appreciate the value of externally-generated knowledge, and restrict their ability to absorb the potential spillovers created by foreign affiliates. In these circumstances it is possible that that limited positive spillovers might occur through "demonstration effects" and "contagion effects", but not through pro-competitive effects. This is because locally-owned firms are concentrated in the standardized segments of industries that foreign affiliates avoid.

With the passage of time, foreign affiliates become more fully integrated into host countries' business networks, as their localisation rates rise and they establish links with local suppliers. Foreign affiliates' superior technological, marketing and management skills become more familiar to locally-owned firms and, as a result, those local firms with rising technological capacity have greater opportunities to absorb spillovers. At some point, however, the amount that local firms can learn from foreign affiliates will decrease. This occurs as the steady state of technological flow from parent firms to their foreign affiliates takes over from the initial transfer of technological stock. Accordingly, the scope for positive spillover effects from assimilating foreign technology diminishes. However, competitive effects may become more important. The incentives to locally-owned firms to become more efficient rises through competition, as they move into the same market segments as foreign affiliates. Eventually, it can be foreseen that spillover effects become exhausted, and any positive impact of foreign presence on host country productivity becomes indiscernible.

This last point may be one explanation for the prevalence of studies that report negligible or inconclusive effects of foreign presence (e.g. Aitken and Harrison, 1999; Haddad and Harrison, 1991). If so, we might take this prevalence as an indication that spillovers vary over time, and that it is quite reasonable to expect the magnitude of spillovers to change with the length of time that foreign affiliates have been operating in a host country. Further, inconclusive results could be generated by the concurrence of such a decline in positive spillovers and the appearance of spillovers with opposite effect.

A further and little researched dimension to spillover effects is the speed with which foreign presence is built up. T. Perez (1997) points out a theoretically inverse link between the magnitude of spillover benefits and the speed of foreign penetration. When locally-owned firms, even those with a relatively small technological gap behind foreign affiliates, face rapidly increasing foreign penetration, they may be driven out of the market.

More complex distributional effects may also exist. It can be argued that positive spillovers favour certain groups of local firms. Foreign entry into a host market increases the intensity of competition and forces domestic firms to become more efficient (Kokko, 1996). But the scope for such spillover benefits will vary. M. Blomström and F. Sjöholm (1999) argue that there are more significant spillover benefits to non-exporting than exporting firms, on the grounds that export oriented firms already face competition from the international market. The ability of local firms to absorb foreign know-how is also critical to spillover benefits. This capacity depends on firms' technological competence (Liu et al., 2000). Local firms with high competence are expected to benefit more from spillovers. Furthermore, competence is associated with the type of ownership of local firms. Empirical work suggests that industries dominated by state ownership are less able to benefit from the presence of foreign affiliates, and therefore reap fewer spillover benefits compared to industries in which private ownership is more pronounced.

If we look at the literature, the evidence for positive spillovers from FDI predominates (Caves, 1974; Globerman, 1979; Liu et al., 2000; Zhu and Tan, 2000). It has also been found that positive spillovers are highest in those industries in which the technology gap is small, thus allowing local firms to benefit from their technologically advanced foreign counterparts (Kokko, 1996).

A number of recent studies, however, have identified negligible spillovers (Haddad and Harrison, 1991) or negative spillovers (Singh, 1992; Aitken and Harrison, 1999). More recent research on Chinese data shows that State-owned enterprises can experience negative spillover effects, while collectively owned enterprises benefit from foreign presence (Buckley et al., 2002). This wide variation in findings suggests that positive spillover effects are by no means guaranteed, and that their presence depends on extraneous economic and technological factors (Sjöholm, 1999).

This article seeks to explore whether the strength of host country productivity benefits reported for China's manufacturing industry as a whole can be supported by data at the sub-sector level for one industry - electronics - using a panel of data covering four years. This study fills a gap in knowledge concerning the existence of sub-sector-specific effects and the possibility that productivity benefits from FDI decline over time. Both are notably under-researched questions.

Methodology and data

A simple model is employed to investigate the impact of FDI on the productivity of China's electronics industry, both locally and foreign-owned, along with appropriate controls. The model is as follows:

$$LP_{ij} = C + \beta_1 KL_{ij} + \beta_2 INT_{ij} + \beta_3 LQ_{ij} + \beta_4 FS_{ij} + \beta_5 FP_{ij} + \varepsilon_{ij} \quad (1)$$

Following the practice of existing studies, we assume that value-added per worker (*LP)* in a sub-sector of China's electronics

industry, is a function of foreign presence (*FP*), represented by the foreign equity share in each sub-sector. We expect that FP exerts a positive and significant impact on LP.

Our multivariate analysis includes a set of control variables that may influence labour productivity: the capital labour ratio (*KL*), which is constructed to control for capital intensity; intangible assets per employee (*INT*) serves as a proxy for the stock of knowledge accumulated by firms from past R&D investment in the form of technological competence; labour quality (*LQ*) measures by the share of engineers and managers in total employment; and fixed assets per worker (*FS*) captures firm scale economies. These variables increase our confidence in the robustness of the findings through controlling for influences other than foreign presence. All variables are in logarithmic form, and ordinary least squares (*OLS*) is employed throughout.

Previous studies have typically estimated some variant of equation (1) using a cross section of industries. These studies are unable to control for differences in productivity between industries that might be correlated with, but not caused by, foreign presence. If foreign affiliates locate in more productive industries, then a positive association between the foreign capital share and productivity will be found even if no spillovers take place (Aitken and Harrison, 1999). If so, it is likely that the results will tend to overstate the true positive impact of foreign capital participation. To avoid this problem, we estimate equation (1) using a panel data set within a single industry. The panel nature of our data allows us to track the same industry over time. Hence we are able to allow for other time-invariant industry specific effects, such as infrastructure and technological opportunity. Data are not available with which to investigate these effects econometrically; nevertheless these factors may affect the level of productivity. Investigating at the sub-sectoral level enables us to control for the potential endogeneity of foreign ownership and overall productivity within the industry (Aitken and Harrison, 1999).

Panel data estimation, however, does not allow us to observe whether and to what extent the magnitude of spillover effects changes over time. To do so is an important objective of this article, and therefore cross-sectional estimations are also conducted to investigate this. We examine the effect of FDI on the level of domestic labour productivity for every year and also on the growth of productivity over the period of study. The growth specification is included because it is deemed to be a way to avoid the causality problem at the micro-level[1] (Sjöholm, 1999).

The data employed for estimation in this study are from the *Yearbook of China's Electronics Industry*, for the years 1996, 1998, 2000 and 2001. Industry-level data are preferred because there is more variation in the FDI variable. In the *Yearbooks*, the electronics industry is divided into nine categories: (1) radar; (2) communications equipment; (3) broadcasting and TV; (4) computers; (5) components; (6) measurement equipment; (7) special equipment; (8) household electronic appliances; and (9) other electronic devices. These categories are then divided into 47 sub-sectors. Due to data imperfections, our sample consists of 41 sub-sectors for the years 1996, 1998, 2000 and 2001, yielding a total of 164 observations in the form of a panel.

Table 1 shows that labour productivity in the electronics industry as a whole in 2001 was about 2.5 times that of 1996, while the foreign capital share remained almost unchanged. *Prima facie*, this might indicate that productivity growth over the period might not, at least in the largest measure, be attributable to the direct impact of foreign capital participation.

[1] The drawback of a levels specification is that the direction of causality between FDI and productivity is not clear, since it is likely that foreign affiliates may locate in above-average productivity industries. Although our data constitute a panel, there are observations only for four years. This period is not long enough to allow us to test causality between overall productivity and FDI. However, employing Chinese manufacturing industry data, Buckley et al. (2002) found that causality runs as expected from FDI to growth rather than the other way around.

Table 1. Summary (Observations=41) statistics

Items	1996		1998		2000		2001		2001/ 1996
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean
Labour productivity	3.95	4.83	5.30	5.26	8.99	6.63	9.80	7.45	2.45
Capital-labour ratio	6.71	4.33	9.82	6.67	13.37	10.87	13.25	11.77	2.01
Intangible assets per worker	1.01	0.99	1.22	.04	0.45	0.98	1.52	1.19	1.50
Employment share of engineers & managers	0.25	0.09	0.26	0.11	0.29	0.12	0.29	0.12	1.16
Fixed assets per firm	4007	4885	6794	8933	11566	14745	10147	11571	2.53
Foreign capital share	0.32	0.19	0.34	0.27	0.26	0.22	0.33	0.27	1.03

Source: authors.

Further information on the share of foreign capital in each sub-sector is detailed in table 2. As is evident from the table, foreign capital accounted for a varying percentage of the total in different sub-sectors. For instance, in 2001 the foreign capital share was a mere 1.6% in "electronic heating equipment"; whereas it amounted to 99.4% in the "calculator" sub-sector.

While the overall foreign capital share remained almost unchanged over the period, the distribution of the foreign capital share changed considerably, i.e. there has been significant variation in the data. The share decreased by 98% in "electronic heating equipment", while there was almost a 21-fold increase in "wire transmission equipment". From 1996 to 2002, in about half of the sub-sectors (21) the foreign capital share rose, and declined in the other half. The sub-sectors with the greatest increase in foreign capital share include "distributed communication equipment", "broadcast and TV equipment", "electronics components and electronic special equipment". Each of these are sub-sectors with particularly high growth worldwide.

Table 2. The foreign capital share of China's electronics industry 1996-2001, per cent)[a]

Category	1996	1998	2000	2001/ 2001	1996
I. Communication Equipment	26.13	32.27	19.99	35.21	1.35
1. Wire transmission equipment	1.59	24.34	20.73	33.07	20.80
2. Wireless transmission equipment	13.93	31.99	15.84	16.48	1.18
3. Exchange equipment	34.87	25.04	18.59	16.55	0.47
4. Wire communication terminal equipment	38.60	37.67	28.48	33.18	0.86
5. Wireless communication terminal equipment	24.73	36.77	21.68	62.73	2.54
6. Other communication equipment	20.38	19.38	8.83	23.51	1.15
II. Broadcast and TV	30.36	33.18	42.44	36.47	1.20
7. Broadcast and TV equipment	2.08	3.24	2.07	2.99	1.44
8. TV sets	26.73	29.45	41.17	35.34	1.32
9. Radio and recorders	36.31	36.10	48.17	55.83	1.54
10. Video	46.16	49.40	41.19	27.17	0.59
11. Other broadcast and TV products	18.06	20.71	21.54	21.46	1.19
III. Computers	35.99	27.21	20.84	23.84	0.66
12. Complete computer	18.18	12.06	15.93	22.51	1.24
13. Computer exterior equipment	56.94	43.34	34.22	38.97	0.68
14. Computing requisite accessories	20.27	10.16	3.86	6.31	0.31
15. Software	20.72	15.64	1.22	1.99	0.10
16. Calculators	22.24	42.99	88.69	99.39	4.45
17. Other computer products	71.02	65.24	59.57	63.85	0.90
IV. Electronics Components	24.31	31.56	32.71	33.83	1.39
18. Electronic micro-electrical machines	33.02	23.95	31.18	34.10	1.03
19. Electronic electrical wires and cables	11.13	13.54	16.82	18.25	1.64
20. Electronic storage batteries	4.26	29.33	7.52	31.41	7.38
21. Electronic dry batteries	85.64	85.08	77.67	71.04	0.83
22. Electronic components	24.66	33.49	36.79	38.78	1.57
23. Electronic component special materials	37.90	40.49	35.48	38.50	1.02
24. Other electronic component products	32.24	39.79	21.68	14.82	0.46
V. Electronic Measuring Equipment	11.29	11.03	8.76	10.84	0.96
25. Electronic measuring instruments	6.33	7.04	5.29	10.47	1.65
26. Other electronic measuring instruments	23.11	22.12	14.87	11.19	0.48
VI. Electronic Special Equipment	23.25	20.03	19.51	26.57	1.14
27. Electronic special equipment	29.60	28.80	29.68	22.98	0.78
28. Electronic industrial moulds and gear	21.37	21.21	21.04	23.88	1.12
29. Other electronic equipment	19.98	16.98	13.88	28.65	1.43
VII. Household Electronic Appliances	47.40	36.43	21.30	33.11	0.70
30. Refrigerators	49.19	1.50	14.32	24.04	0.49
31. Electrical fans and air conditioners	60.12	67.92	2.92	24.23	0.40
32. Electronic heating equipment	85.39	63.86	2.36	1.60	0.02
33. Electronic toys	27.29	33.64	56.68	70.97	2.60
34. Other household electronic appliances	35.88	46.43	42.53	58.61	1.63
35. Other	30.92	26.64	13.46	11.89	0.39
VIII. Electronic Devices	29.67	32.57	32.88	32.08	0.91
36. Bulbs	57.26	54.95	23.78	50.35	0.88
37. Electrical vacuum valve devices	29.51	36.03	37.81	33.60	1.14
38. Semi-conductor devices	16.12	16.18	20.60	3.46	0.21
39. Integrated circuits	36.57	40.84	15.78	29.27	0.80
40. Electronic device materials manufacture	30.69	26.98	22.91	21.02	0.68
41. Other electronic device products	40.72	15.57	7.58	32.98	0.81

Source: authors

[a] The foreign capital shares for eight aggregate sub-sectors are calculated as the sales-weighted arithmetic average

Table 3 shows that "communications equipment", "broadcast and TV" and "computers" enjoyed the highest levels of productivity. These sub-sectors are also those with heavy foreign investment, as indicated in table 2. While the overall picture conveyed by table 2 suggests a generally high penetration by foreign capital, these three sub-sectors support the view that FDI does gravitate towards the more productive sub-sectors (Aitken and Harrison, 1999).[2]

Results

We first pooled data on the 41 sub-sectors over four years and then estimated results from equation (1). These are presented in table 4. Column (1) shows that the FP variable carries a rather large, statistically significant coefficient, suggesting that firms in sub-sectors with more foreign capital are significantly more productive than those in sub-sectors with a smaller foreign

Table 3. Labour productivity of China's electronics industry, 1996-2001[a]

Category	1996	1998	2000	2001
I. Communication equipment	8.63	43.01	17.48	22.64
II. Broadcast and TV	2.61	33.35	52.69	9.94
III. Computers	4.93	16.55	13.54	15.45
IV. Electronics components	1.86	8.90	5.80	8.13
V. Electronic measuring equipment	1.09	5.84	3.42	4.74
VI. Electronic special equipment	1.63	7.81	4.42	14.21
VII. Household electronic appliances	2.60	19.36	9.13	10.76
VIII. Electronic devices	3.61	17.76	10.20	7.58

Source: authors.

[a] The remarkable fluctuations over the years are due to a number of external and internal factors. For example, the dramatic drop of productivity in 2000 over 1998 may be related to the lagged effects of the Asian crisis. Other factors include industrial restructuring, large scale redundancy in State-owned enterprises, price fluctuations and the entry of large foreign TNCs.

[2] This justifies our procedure of controlling for differences in productivity between sub-sectors.

presence. The point estimate, 0.20, suggests that a 10% increase in foreign capital share is associated with a 2% growth in overall productivity. This result is in accordance with studies by R. Caves (1974), S. Globerman (1979) and X. Liu et al. (2000), each of which finds evidence of spillovers that increase local firms' labour productivity. It also accords with studies on China (Zhu and Tan, 2000; Buckley et al., 2002).

This result, however, should be treated with some caution since the estimation does not control for sub-sector-specific productivity differences in employing a specification that is closest in spirit to earlier cross-section studies. Since the apparent effect of productivity spillovers tends to be higher when cross-sectional data are employed (Görg and Strobl, 2001), we therefore re-estimate equation (1) while controlling for sub-sector-specific productivity differences by including sub-sector dummies. The results are presented in column (2) of table 4. By comparing the two adjusted R-squares, one can see that

Table 4. The impact of FDI on productivity[a]
(Pooled estimation for 1996, 1998, 2000 and 2001)

Dependent variable: LP (Value-added per worker)	(1)	(2)
C	-0.07	
	(-0.13)	
KL (Capital-labour ratio)	0.26	0.23
	(2.61)***	(1.86)*
INT(Intangible assets per worker)	0.04	0.058
	(0.82)	(1.23)
FS (Fixed assets per firm)	0.31	0.36
	(4.72)***	(3.68)***
FP (Foreign capital share)	0.20	0.11
	(3.33)***	(1.60)
Industry dummies	No	Yes
R-square adjusted	0.48	0.64
F-statistic	31.71***	83.89***
Number of observations	164	164

Source: authors.

[a] Figures in parentheses are t statistics (two-tailed tests); *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

explanatory power is significantly increased when sub-sector dummies are included in the equation.[3]

In column (2), the coefficient on the FP variable registers the correct positive sign but fails to reach significance, indicating that the positive effect is not robust. The apparent spillover benefits of FDI in our results vanish when industry-specific productivity differences are controlled. This suggests, *prima facie*, that the positive effects of foreign presence measured in previous studies may, to some extent, be attributable to the tendency of TNCs to concentrate in more productive industries. An overview of the data in tables 2 and 3 accords with the view that foreign affiliates cluster in above-average productivity industries.

One possible explanation for the lack of robustness in the FDI–productivity relationship is that spillovers may diminish over time, leading to insignificant results from panel data. A second possibility is that FDI presence may positively affect only a selection of sub-sectors. As discussed in section II, FDI may be important in certain sub-sectors, but not in others. To investigate these possibilities, the remaining part of this section first examines whether or not there is a pattern of diminishing spillovers over time. Then we break the full sample into sub-samples based on: (1) export intensity; (2) intangible assets intensity; and (3) State capital share, to see whether spillovers benefits only pertain to local firms in certain types of industry.

Table 5 shows the results from cross-sectional estimations of equation (1) for each individual year.[4] The FP variable is positive and statistically significant in the 1996 and 1998 estimations, though the magnitudes of both coefficient and level of significance slightly decreased. However, we should note that the FP variable becomes insignificant in the regressions for 2000

[3] The sub-sector dummy variable itself also serves to eliminate a potential source of omitted-variable bias.

[4] Where heteroscedasticity exists, variance-covariance matrices have been estimated according to White's (1980) method. Ramsey RESET tests indicate that all models suffer no specification error.

and 2001. This appears to signal a declining trend in the impact of FDI spillover effects in the China's electronics industry within the period under consideration, though these effects are nevertheless significant in the growth form in column (5).

Surprisingly, the capital intensity variable (*KL*) fails to reach significance as expected in all but the regression for 2000, thereby performing inconsistently and contrary to standard results. From this we might surmize that capital intensity is a less important determinant of labour productivity in China's electronics industry, perhaps on account of the labour intensive

Table 5. The impact of FDI on productivity [a] (Cross-sectional estimations)

Dependent. Variable: LP (Value-added per worker)	Level estimation				Growth estimation
	1996	1998	2000	2001	1996-2001
	(1)	(2)	(3)	(4)	(5)
C	2.10	-0.04	-2.02	0.96	0.82
	(1.89)*	(-0.03)	(-1.54)	(0.91)	(6.14)***
KL (Capital-labour ratio)	0.10	0.01	0.69	-0.09	0.06
	(0.32)	(0.08)	(2.69)***	(-0.78)	(0.56)
INT(Intangible assets	-0.01	-0.05	-0.08	0.29	0.11
per worker)	(-0.13)	(-0.36)	(-1.74)*	(3.83)***	(1.18)
LQ (Employment share of	1.52	1.24	0.20	0.52	0.62
engineers and managers)	(4.63)***	(3.98)***	(0.46)	(1.36)	(2.65)***
FS (Fixed assets per firm)	0.20	0.44	0.28	0.27	0.13
	(1.62)	(3.43)***	(2.58)***	(3.20)***	(1.04)
FP (Foreign capital share)	0.49	0.45	-0.10	0.24	0.26
	(4.89)***	(3.23)***	(-0.71)	(1.66)	(3.38)***
R-square adjusted	0.60	0.45	0.63	0.47	0.44
F-statistic.	12.92***	7.64***	14.79***	8.17***	7.21***
Number of observations	41	41	41	41	41
Heteroscedasticity					
(F-statistic)[b]	(2.52)**	(2.00)*	(4.85)***	(4.09)***	(1.56)
Functional form					
(F-statistic)[c]	(0.85)	(0.49)	(5.68)*	(0.02)	(0.98)

Source: authors.

[a] Figures in parentheses are t statistics (two-tailed tests); *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

[b] White test (Cross term)

[c] Ramsey RESET tests are based on the squares of the fitted values (one term).

nature of this broad industry compared with developed countries. Two further factors may explain this insignificance. First, China's electronics enterprises have been under so-called "asset restructuring". This involves a substantial re-allocation of assets between firms under different ownership and between different sub-sectors within the industry to improve overall industrial efficiency. The outcome is a change in the distribution of assets between sub-sectors, causing some degree of mismatch between capital intensity and productivity. The effect may be to wash out the significance of the variable. Second, the relatively small number of observations may contribute to this insignificance. As shown in tables 4 and 6, the capital intensity variable is more often significant when the number of observations increases.

Over time, *INT* changes from insignificant to significant, while *LQ* shows quite the reverse movement – changing from significant to insignificant. Taking a broader view of learning activities, *INT* and *LQ* might be acting as proxies for different aspects of the technological capability of China's firms.[5] The significance of *LQ* in the 1996 and 1998 regressions could be construed as an indication that labour quality was the primary variable capturing the knowledge complement of domestic firms. However, the 2001 regression shows that by the end of the period *INT* has come to dominate. This pattern of results suggests that there may have been an increase in the role played by intangible assets in domestic productivity.[6] The firm size effect variable, *FS*, registers the correct sign and is statistically significant in all regressions. This suggests that industry sub-sectors populated by larger firms are more likely to achieve higher levels of productivity. This result also implies that most firms are smaller than the size of the most efficient firm in the industry, and that scale economies are available to them in the event that they grow.

Table 6 displays the results for the sub-samples. The first two columns show that those sectors in which firms are local-market oriented, the coefficient for foreign presence is positive and statistically significant at the 5 % level. On the other hand,

[5] The correlation coefficient between the two variables is very small.
[6] Although the quality of this variable is suspect, as discussed later.

export oriented sectors experience no significant productivity benefits from foreign investment. This finding agrees with Blomström and Sjöholm (1999), who have suggested that inward FDI confers little additional benefit on sectors that are already exposed to international competition by exporting to the international markets.

Contrary to expectation, the results in columns (3) and (4) show that the *FP* variable does not attain statistical significance in either the high or low intangible assets per worker sub samples. This may reflect the generally low absolute importance of intangible capital in China's industry, a characteristic that may share common roots with the widespread labour intensity. Taken together with the negative signs in earlier regressions in table 5, the performance of *INT* seems poor and unstable. This could either be an outcome of poor data quality, as Chinese firms have only recently started to calculate and report intangible assets. The problem of errors might also be

Table 6. The FDI impact and industry characteristics[a]
(Pooled estimation for sub-samples over 1996, 1998, 2000 and 2001)

Dep. Var.: LP (Value-added per worker)	Exports/Sales		Int. assets intensity		State capital share	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
KL (Capital-labour ratio)	0.11	0.51	0.29	0.32	0.47	0.24
	(0.44)	(2.98)***	(1.74)*	(1.42)	(2.49)***	(1.25)
INT (Intangible assets per worker)	0.06	0.05	0.25	-0.03	0.05	0.06
	(0.94)	(0.59)	(2.33)**	(-0.46)	(0.57)	(0.77)
LQ (Employment share of engineers and managers)	0.20	0.94	2.57	0.39	2.09	0.26
	(0.53)	(3.60)***	(4.92)***	(1.64)*	(4.63)***	(1.16)
FS (Fixed assets per firm)	0.45	-0.01	-0.02	0.23	-0.01	0.15
	(2.51)***	(-0.06)	(-0.15)	(1.59)	(-0.10)	(1.13)
FP (Foreign capital share)	-0.16	0.16	0.11	0.09	0.15	0.08
	(-0.79)	(2.17)**	(1.20)	(0.88)	(1.79)*	(0.78)
R-square adjusted	0.57	0.68	0.71	0.66	0.67	0.63
F-statistic	34.17***	47.80***	55.79***	43.61***	48.53***	39.77***
Number of observations	84	80	84	80	84	80

Source: authors.

[a] Figures in parentheses are t statistics (two-tailed tests); *, **, and *** denote significance at the 10%, 5% and 1% levels respectively.

compounded by lumpiness, caused by the absolutely low values in the data.

The third pair of sub-samples (columns 5 and 6) concerns the impact of State ownership on the FDI-productivity relationship. The results suggest that the effect of foreign presence on labour productivity is statistically significant only in sub-sectors in which the State capital share is large. At first sight, this result appears to conflict with the results of P. Buckley at al. (2002), who found that State-dominated sub-sectors in manufacturing experienced negative spillover effects. However, the purpose of the present study is to employ a more detailed unit of analysis - the single industry rather than the whole of manufacturing, and this might be expected to alter the findings. This point is taken up in the discussion section.

Discussion

Here we reflect further on some possible explanations for the unexpectedly weak role that has apparently been played by foreign affiliates in the electronics industry. First, the considerable FDI into China's electronics industry might not have been accompanied by a commensurate amount of technology transfer via FDI. In support of this, a number of studies – not specific to the electronics industry – have pointed out that there has been a lack of technology transfer via FDI into China (e.g. Chen and Zhang, 1995; Lan and Young, 1996). A possible factor behind this, and one that might be expected to influence a technology-intensive industry such as electronics, is weak intellectual property protection in China. This may discourage the transfer of all but the labour-intensive stages of production to China, and act as a disincentive to TNC's from undertaking significant technological development in the host country. The insignificant contribution of foreign affiliates to overall domestic productivity might therefore be a result of limited opportunities for technological spillovers.

A second explanation relates to the nature of the relationship between spillover effects and foreign ownership. The very high share of foreign capital may be responsible for

the unexpected findings. At greater levels of foreign presence, the market share of local firms may be cannibalized, so raising their costs of production and resulting in a "crowding out" effect. In such a situation, negative spillover effects can arise that counteract the existing positive effects, so resulting in a decline in overall spillover benefits (Buckley et al., 2003).

Third, in this article we address the bias-evident in much empirical work-towards finding a positive impact for FDI on host country productivity. Our results suggest that TNCs are attracted to higher productivity sub-sectors. We control for this effect, but the implication is that much of the prior literature may have over-estimated the impact of FDI on host country productivity. Consequently, our results stand in stronger contrast with the existing body of work and appear more unexpected than perhaps they should be.

A fourth consideration is that other factors that determine productivity may overshadow the role of FDI. For instance, despite policy efforts to foster the transfer of technology via FDI, Chinese firms may be primarily absorbing technology through imports of technology embodied in physical capital assets. A good reason for believing this is that the Government of China implemented preferential policies encouraging imports of advanced technology in the electronics industry, as a means of localizing high technology. In certain circumstances, the Government allowed machinery and equipment incorporating advanced technologies to be imported duty free. Product and process technologies imported in this way may have played a primary role in developing new electronics products and in improving the performance and quality of China's electronics industry. This inference is in line with the emerging literature on the link between international trade and international technological spillovers.

Fifth, the results in table 5 point to a diminution of spillovers over time following the establishment of foreign affiliates in sub-sectors of the electronics industry. However, it is easy to see how a snapshot of the years 1996 or 1998 could lead researchers to believe in the existence of a strong positive

and continuing relationship between foreign presence and host country productivity. Equally, the growth regression for 1996-2001 suggests the same strong relationship. However, snapshots of 2000 and 2001 would produce the opposite conclusion. These regressions make the point powerfully that the date of measurement can determine the results obtained. This may help to account for the large amount of mixed findings in the literature in studies that rely on data for just one year. But our results also indicate that a dynamic structure may exist in the relationship between foreign presence and host country productivity, which is as yet very inadequately explored. This may account for the weak effect of the foreign capital share in the last two years of our sample, and points the way for future research.

The positive relationship between State ownership and domestic industrial productivity is at variance with previous research. This article concerns one industry as opposed to the whole of the manufacturing sector. It is therefore necessary to consider the special conditions that might apply to the electronics industry. First, it is a fast changing industry and this may profoundly modify the nature of the relationship between inward FDI, high State ownership and productivity. Second, a very different performance outcome is likely where inward FDI takes the form of joint ventures with successful State -owned firms, rather than competition against State-owned firms. A large number of high-technology foreign affiliates, e.g. the local affiliates of Motorola (China) are joint ventures with State-owned enterprises. These close and productive partnerships may be responsible for a sort of "crowding in" effect. Such affiliates are also often highly export oriented, and are responsible for high levels of intra-group exports.

The breaking of the data into sub-samples reveals and supports some of the above discussion. We have seen that the impact of inward FDI on host country productivity is significant only for certain groups of firms, not all. The pattern of significance gives some idea of why this might be. As prior research suggests, export oriented sub-sectors experience insignificant gains from foreign capital presence. Experience of exporting points to the existence of a learning effect for local

firms, and this learning appears to pre-empt that which might otherwise be conferred by inward FDI. This gives some support to the notion that learning via independent technology imports and via foreign presence are substitutes. It also indicates that the learning is of a "one shot" nature. A given gap in knowledge between foreign and local firms, once closed, exhausts the potential for significant spillover effects. If so, it provides some supporting evidence that host country productivity gains via learning from FDI, even when they are initially present, should be expected to diminish over time.

Conclusions

Using a small panel of China's electronics industry sub-sectors, we find partial support for the view that inward FDI has promoted overall productivity growth over the period 1996 to 2001. However, we also find some support for our argument that the impact of FDI on host country industry performance diminishes over time. Our evidence suggests that the productivity gains from FDI were significant for certain (but not all) groups of firms in China's electronics industry. This suggests that spillovers benefits do not flow automatically from FDI, but are contingent upon other factors. This article also provides some evidence to caution that sub-sector-specific productivity effects associated with, but not caused by, foreign presence exist. TNCs do appear to concentrate in more productive sub-sectors within China's electronics industry. This suggests the possibility that prior research has been biased in favour of finding stronger impacts on host country productivity. Our research also suggests that the date of measurement in cross-sectional research can be critical, and misleading if generalization is sought, when making inferences about the relationship between inward FDI and host country productivity.

We must acknowledge the limitations of our study. In particular, it should be noted that some factors that influence productivity have not been controlled for. These include variables such as R&D and imports, for which data are unavailable at this level of disaggregation. As our data are drawn from those collected by the Ministry of the Electronics Industry,

unlike the industrial census data published by the State Statistical Bureau of China, the productivity of foreign and domestically owned firms is not separately identified. While this would have been desirable, the investigation in this article has been constructed to make optimal use of the data that are available for the host country industry.

The fact that the impact of FDI on overall productivity is so sensitive to the set of sub-sectors that are selected suggests caution in inferring the existence of spillovers without first adequately controlling for industry-specific characteristics. Recent studies of spillovers from FDI suggest that such effects may be significant, but that they are not guaranteed, automatic, or free. The effects may depend to a large extent on the host country, in particular on host country industry characteristics and on the policy environment in which TNCs operate.

There are a number of policy implications that arise from our findings. First, foreign capital participation in China's industries, and sub-sectors, with low levels of exports is likely to be especially beneficial for productivity growth in China, and should be encouraged. A caveat here is that the industry concerned should be one in which export potential exists. Second, the import of technology by local firms, outside an equity relationship with TNCs, may well be an effective means to raise productivity in China, especially where there are no long-term benefits from foreign capital participation or where TNCs express little interest in investing in an industry.

Third, and linked to the previous point, joint ventures between foreign affiliates and China's State-owned enterprises, for which we find evidence of beneficial effects, may offer a more long lasting route to learning than stand-alone foreign affiliates.[7] The significance of the FP variable for sub-sectors

[7] Joint ventures between the primary affiliates of TNCs and State-owned enterprises are to be distinguished from primary affiliates that are international joint ventures, as used to be legally required in most of China's industry. The type of joint ventures referred to here are entirely voluntary, and are expected to be superior in terms of knowledge transfer and spillover benefits.

in which the State capital share is high may be a sign that joint ventures between foreign affiliates and state-owned firms can be a productive one under certain industrial conditions, as in this case. As our data show, the electronics industry is dynamic, and in these circumstances benefits are thought to arise from establishing a learning network within China linked to TNCs' international operations. It can be argued that, once linked into the international network of foreign firms, state-owned enterprises enjoy an extended opportunity to benefit from learning and knowledge transfer. In high technology industries, foreign affiliates frequently operate a learning network, both globally and locally, into which state-owned enterprises have the potential to be embedded (Buckley *et al*., 2002). This embeddedness can include joint R&D. With regard to the long term impact on host country productivity, such inward FDI might offer a significant and sustained positive impact. We can contrast this with the time-limited benefits from foreign affiliates operating in China, where foreign firms exploit an existing technological advantage created outside the host country, with little or no local linkages. ■

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