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Xiaming Liu, David Parker, Kirit Vaiyda and Yingqi Wei

The Department of Economics
Lancaster University Management School
Lancaster LA1 4YX
UK

THE IMPACT OF FOREIGN DIRECT INVESTMENT ON LABOUR PRODUCTIVITY IN THE CHINESE ELECTRONICS INDUSTRY

By

Xiaming Liu*, David Parker*, Kirit Vaidya* and Yingqi Wei*

***THE ASTON RESEARCH CENTRE**

IN ASIAN BUSINESS AND MANAGEMENT

ASTON BUSINESS SCHOOL

ASTON UNIVERSITY

BIRMINGHAM B4 7ET

UK

***DEPARTMENT OF ECONOMICS**

LANCASTER UNIVERSITY MANAGEMENT SCHOOL

LACASTER LA1 4YX

UK

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Abstract

Foreign direct investment (FDI) may have a positive impact on labour productivity in recipient industries through direct introduction of capital, technology and management skills and indirectly through spillover effects on domestic firms. This study uses a model intended to examine the overall effects of inward FDI in the Chinese electronics industry. A panel data set is used for 41 sub-sectors of the industry in 1996 and 1997 having differing levels of FDI. Labour productivity is modelled as dependent on the degree of foreign presence in the industry and other variables, namely capital intensity, human capital and firm size for scale factors. Various econometric estimation techniques for panel data are compared to obtain an appropriate statistical model. The results suggest that foreign presence in the industry was associated with higher labour productivity.

Key words: FDI, Labour Productivity, China, Electronics Industry.

JEI: F21, L63

I Introduction

The role of foreign direct investment (FDI) in productivity growth has long been of interest to academics and policy-makers. As noted in Balasubramanyam et al [1996], it is the ability of FDI to transfer not only production knowledge but managerial skills that distinguishes it from all other forms of investment, including portfolio investment and foreign aid.

The impact of FDI on productivity can either be direct or indirect. Inward FDI is associated with the introduction of additional capital and new production and managerial skills that have a direct effect on productive efficiency. FDI also provides indirect effects by knowledge diffusion [Blomstrom and Kokko, 1998]. It is sometimes suggested that the most significant channels for the dissemination of modern technology are external effects or “spillovers” from FDI, rather than formal technology transfer agreements [see for example, Mansfield and Romeo, 1980; Blomstrom, 1989].

This paper reports research into the impact of FDI on labour productivity using a panel data set from the Chinese electronics industry for 1996 and 1997. Labour productivity is modelled as dependent on the degree of foreign presence in the industry and other explanatory variables which are known to have a positive impact on productivity, namely capital intensity, human capital and firm size for scale factors. Foreign presence in the industry reflecting cumulative FDI is found to be associated with higher labour productivity, although human capital for 1996 and firm size for both 1996 and 1997 have higher estimated elasticities.

The paper is organised as follows. The next section details the potential impact of FDI on productivity in terms of direct and indirect effects and reviews relevant previous studies. The model, data and methodology are introduced in Section III of the paper followed by the results from the statistical estimations, in Section IV. The final section of the paper, Section V, presents the conclusions and discusses the implications for policy makers and company managers.

II FDI and Productivity

Inward FDI has been identified as an important source of efficiency gains during economic development in the host country [see for example, Fleisher and Chen, 1997; Walz, 1997; Markusen and Venables, 1999; de Mello, 1999]. In particular, it has been viewed as an important source of both direct capital inputs and technology and knowledge spillovers [Blomstrom and Kokko, 1998] and therefore has been introduced as a separate variable, in addition to labour and capital, in the traditional production function. For instance, Balasubramanyam et al [1996] adopt the following model to assess the impact of FDI on growth in developing countries:

$$y = \alpha + \beta l + \gamma (I / Y) + \psi (FDI / Y) + \phi x \qquad (1)$$

where y is the growth rate of GDP, l is the growth rate of labour input, I is domestic investment, FDI is foreign direct investment, Y is domestic GDP and x is the growth rate of exports. Using a sample of 46 developing countries, their study concludes that the beneficial effect of FDI, in terms of enhanced economic growth, is stronger in those countries which purse an outwardly-oriented trade policy than it is in those countries adopting an inwardly-oriented policy. Since this type of model looks at both the direct and indirect impacts of FDI at the macro level, we may refer it as to an ‘overall impact model’.

By contrast, a number of studies of FDI focus on the indirect impact only. An early contribution to the theoretical literature on spillovers was made by Caves [1971, 1974] who identified various external effects when examining the general welfare impact of FDI. Caves [1974, p. 176] noted that productivity spillovers occur when the multinational firm ‘cannot capture all quasi-rents due to its productive activities, or to the removal of distortions by the subsidiary’s competitive pressure'. He divided the external benefits into three categories. First, multinational firms may raise productivity levels among locally owned firms in the industries which they enter by improving the allocation of resources in those industries. Where FDI occurs in industries with high entry barriers, monopolistic distortions and their associated inefficiencies are reduced. Second, through either the multinational’s competitive force or demonstration effect, locally-owned firms operating in imperfect markets may be induced to achieve a higher level of technical or X-efficiency [Leibenstein, 1966]. Lastly, the presence of multinational subsidiaries in an industry may speed the process or lower the cost of the transfer of technology. The threat of competition may stimulate domestic firms to innovate. Imitation effects and the movement of personnel trained by multinational subsidiaries also enhance the transfer of technology to local firms.

This approach emphasises the externalities or indirect impact on local firms in an industry subject to inward FDI [Findlay, 1978; Das, 1987; Walz, 1997]. The very presence of multinational corporations exerts contagion, demonstration and competition effects on local firms and therefore helps raise their productivity. A model can be developed - termed a ‘productivity spillover model’ - that contrasts with an overall impact model as introduced earlier. One such model is as follows:

$$lp_l = f(ci_l, lq_l, fs_l, fp, ov) \qquad (2)$$

That is, the labour productivity in local firms (lp_l) is influenced by the capital intensity (ci_l) and labour quality (lq_l) in local firms, the size of local firms (fs_l), foreign presence (fp) in the industry, and a vector of other possible explanatory variables (ov) such as the industry concentration ratio, R&D intensity in local firms and the technology gap between local and foreign firms.

FDI can however have some offsetting negative effects to the positive effects on local productivity. As Aitken and Harrison [1999] argue, the entry of foreign firms producing for the local market can draw demand from local firms, causing them to cut production. Thus, the productivity of local firms would fall as they are forced back up their average cost curves. As a result, net local productivity can decline.

The first econometric test for productivity spillovers from FDI was carried out by Caves [1974] using cross-sectional Australian manufacturing data for 1966. Using an augmented production function, Caves found that the very presence of foreign firms had a positive impact on labour productivity in the industries studied. Subsequent studies of this type by Globerman [1979] for Canada, by Blomstrom and Persson [1983], Kokko [1994], and Blomstrom and Wolff [1994] for Mexico, by Kokko, Tansini and Zejan [1996] for the Uruguayan manufacturing sector, and by Liu et al [2000] for UK manufacturing, confirm positive productivity spillovers from FDI.

On the other hand, the study of Haddad and Harrison [1993] for Morocco concludes that foreign presence has no significant effect on local labour productivity. The paper concludes that large technology gaps inhibit spillovers from FDI to local firms in Moroccan manufacturing. Grether [1999] finds that FDI has a positive influence on productivity efficiency at the plant level, but not at the sector level in Mexican manufacturing. Aitken and Harrison [1999] conclude that FDI negatively affects the productivity of locally owned plants in Venezuelan industry.

Although there are a number of empirical investigations of the role of FDI in economic growth or productivity in various developing countries, there appear to be few econometric studies carried out for China. The regional study by Fleisher and Chen [1997] is an exception and another recent study by Dougherty [1997] attempts to assess the impact of international technology transfer on total factor productivity in some broadly defined industrial sectors. The paucity of such work is surprising given the perceived importance of inward FDI in China’s case [Kueh, 1992; Chen et.al., 1995; Wang, 1997; Strange, 1998]. Between 1985 and 1997 total inward FDI to China totalled around US$242bn or almost 15% of total fixed investment in the economy [*Almanac of China’s Foreign Economic Relations and Trade* 1997/98; Strange, 1998, pp. 26-32]. By the end of 1999, China had approved 341,812 foreign invested enterprises, and pledged and realised FDI were US$ 613.8 and 307.9 billions respectively [People’s Daily, Overseas Edition, 26/01/2000]. Since 1993 China has recorded some of the largest inflows of FDI of any country.

Turning to the Chinese electronics industry, according to the *Yearbook of China’s Electronics Industry, 1997* and *1998*, foreign capital accounted for as much as around 25% of total capital in this industry. This makes the industry an obvious candidate for an examination of FDI impact. In the 1980s electronics products were in short supply in China, especially consumer electronics, and a government programme called ‘550 machinery and electronic projects’ was launched to develop substitute products for imports [Shi, 1998, 53-54]. This led to a large flow of inward investment in the form of technological collaboration and joint ventures, which continues. By 1995 the electronics industry recorded the largest amount of FDI of any industry in China, accounting for around 11% of all FDI [Wang, 1997]. One recent study of tape recorder manufacture in China found evidence of higher productivity in firms with private capital and especially foreign investment than in state-owned enterprises, but the precise importance of FDI compared to other possible explanatory variables was not pursued [Shi, 1998]. The study was based on a questionnaire survey of enterprises in the industry and a small number of in-depth case studies. The result was mainly qualitative responses. By contrast, the research reported in this paper formally models the role of FDI and other possible contributions to productivity and for the entire Chinese electronics industry, and should contribute to the empirical literature on the impact of FDI in developing countries. The next section of the paper details the model, data and methodology used in the current study.

III Model, Data and Methodology

In this study a simple theoretical model for productivity impact is used to assess the overall impact of FDI on the Chinese electronics industry alongside other possible explanatory variables. The model is as follows:

$$LP = F(CI, FS, LQ, FP) \qquad (3)$$

LP, CI, FS, LQ and FP are as defined for Equation 2 above. The basic difference between Equations (2) and (3) is that there is no subscript in the latter. This implies that the LP, CI, FS and LQ variables in Equation (3) do not distinguish between local and foreign firms. Rather they are the integrated measures of labour productivity, capital intensity, firm size and human capital of *both* local and foreign firms. In other words, Equation (3) examines both the direct and indirect impacts of foreign firms on the overall labour productivity in China’s electronics industry. Other possible factors impacting on labour productivity (recognised in *ov* in Equation 2) will, of course, be reflected in the residual in the estimation results. This way of modelling FDI impact is caused by a lack of detailed data, and has an important limitation, i.e. it cannot assess the respective effects of FDI on productivity in local and foreign owned sectors.

The data used for estimations are from the *Yearbook of China's Electronics Industries, 1997* and *1998*. The electronics industry in the yearbook is divided into nine categories, namely (I) radar, (II) communications equipment, (III) broadcasting and TV, (IV) computers, (V) components, (VI) measurement equipment, (VII) special equipment, (VIII) household electronic appliances, and (IX) other electronic devices. These categories are then divided into 47 sub-sectors. The sub-sectors are detailed in Table 1 along with information on firm size and the capital/labour ratio. As is evident from the table, foreign capital accounted for varying percentages of total capital in the different sub-sectors. For instance, in the complete radar manufacturing sector, foreign capital amounted to a mere 0.02% of total capital; whereas it amounted to 85.6% of total capital in the electronic dry battery sub-sector. Because of some missing data, our sample consists of 41 sub-sectors only.

(Table 1 here)

The log-linear functional form of Equation (3) for our panel data set is

$$lp_{it} = \beta_{0t} + \beta_{1t} ci_{it} + \beta_{2t} fs_{it} + \beta_{3t} lq_{it} + \beta_{4t} fp_{it} + \varepsilon_{it} \qquad (4)$$

i = 1, …, N (N = 41); t = 1996, 1997

where *i* and *t* denote the cross-section and time series observations respectively. ε_{it} is a disturbance term which varies across individuals and time and $\varepsilon_{it} \sim N(0, \Sigma)$, where Σ is a positive definite matrix. The low case indicates the logarithm, and all variables in the sample are in real term. The variables in Equation (4) are defined as follows:

lp, labour productivity, is measured as the ratio of value added to the number of average annual employees in each sub-sector of the electronics industry.

ci, capital intensity, is the ratio of the net value of fixed capital stock to the number of average annual employees in each sub-sector.

fs, firm size, is the industrial sales revenue divided by the number of firms in each sub-sector.

lq, labour quality or human capital, is the number of engineers and managers divided by the total number of average annual employees in each sub-sector.

fp, foreign presence, this is measured by the ratio of foreign capital to total capital in each sub-sector.

The coefficients βs in Equation (4) are directly the productivity elasticities with respect to the various explanatory variables. All these coefficients are assumed to be positive leading to a rise in labour productivity. Capital intensity (ci) means the amount of capital commanded by each worker. The firm size variable (fs) represents scale economies. Labour quality (lq) or human capital indicates the level of knowledge or skills of the labour force. Admittedly, this variable, being the ratio of managers and engineers to all employees, is a proxy indicator of true labour quality. Ideally, the labour quality variable would reflect the education and skills attainment of all staff. Unfortunately, published data do not exist at the electronics industry level in China to construct a superior indicator. The proxy variable used is best seen as reflecting the skill level in terms of management training and learning including tacit knowledge held by management and engineers in the electronics sector.

This study is particularly interested in the coefficient on foreign presence (fp). The inflow of FDI normally implies the introduction of a package of capital, technology and managerial skills. Thus, the hypothesis tested is that *FDI has had a positive impact on labour productivity in the electronics industry in China directly and indirectly by its contagion, demonstration and competition effects.* However, it could also be argued that FDI is attracted because of the high productivity in the host country. This gives rise to a possible endogeneity problem.

Given that China is experiencing dramatic changes, coefficients in Equation (4) are initially allowed to vary across time. Thus, the following system was first estimated.

$$lp_{i,1996} = \beta_{0,1996} + \beta_{1,1996} fp_{i,1996} + \beta_{2,1996} fs_{i,1996} + \beta_{3,1996} ci_{i,1996} + \beta_{4,1996} lq_{i,1996} + \varepsilon_{i,1996} \qquad (4.1)$$

$$lp_{i,1997} = \beta_{0,1997} + \beta_{1,1997} fp_{i,1997} + \beta_{2,1997} fs_{i,1997} + \beta_{3,1997} ci_{i,1997} + \beta_{4,1997} lq_{i,1997} + \varepsilon_{i,1997} \qquad (4.2)$$

However, the cost of allowing coefficients to vary is a relatively small number of degrees of freedom in each cross section equation, which may lead to an inefficient use of information. Therefore, a Wald test was conducted to examine whether it is possible to impose constant coefficient restrictions on any explanatory variables over time.

A system of equations can be estimated in any of six ways, depending on whether there exists endogeneity, measurement errors, and groupwise heteroscedasticity and contemporaneous correlation in the errors across equations. Since standard econometrics textbooks for system analysis [e.g. Judge, *et. al*. 1985; Greene 2000] offer full descriptions of the estimation techniques and statistic tests, only a brief review is provided here. Ordinary least squares (OLS) is the most efficient estimation technique if none of the above problems exists. Weighted ordinary least squares (WLS) is the OLS version accounting for groupwise heteroscedasticity only. Two-stage least squares (2SLS) is a technique accounting for endogeneity and measurement errors. Weighted two-stage least squares (W2SLS) is the 2SLS version accounting for groupwise heteroscedasticity. The seemingly unrelated regression estimation (SURE) method accounts for both heteroscedasticity and contemporaneous correlation. Finally, three stage least squares (3SLS) is the 2SLS version of the SURE method, therefore, it is an appropriate estimation method if all four problems exist.

Necessary statistic tests were carried out to determine an appropriate statistical model and avoid biased or misleading results. The Lagarange multiplier (LM) statistic (λ_{LM1}), under the null hypothesis of equal variances between two cross-section equations, was used to choose between OLS and WLS and between 2SLS and W2SLS.

$$\lambda_{LM1} = \frac{N}{2}\sum_{t=1}^{2}[\frac{\hat{\sigma}_t^2}{\hat{\sigma}^2} - 1]^2 \sim \chi^2(1)$$

where $\hat{\sigma}_t{}^2$ represents the disturbance variances and $\hat{\sigma}^2$ is a simple average of the sum of $\hat{\sigma}_t{}^2$. The statistic λ_{LM1} is asymptotically distributed as $\chi^2(1)$.

To choose between the OLS and SURE models, Breusch and Pagan (1980) derive an LM test (λ_{LM2}) for the null hypothesis that Σ is a diagonal matrix. They show that

$$\lambda_{LM2} = Nr_{12}^{\ 2} \sim \chi^2(1)$$

where r_{12} is the residual cross-sectional correlation coefficient. The statistic λ_{LM2} is asymptotically distributed as $\chi^2(1)$.

Finally, given the possible endogeneity of *fp* and the measurement error of *lq*, the Hausman (HS) test was employed. The test is based on the existence of two estimators, b_{3sls} and b_{sure}, which are estimators of the regressors in the 3SLS and SURE models respectively,

$$HS = N[b_{3sls} - b_{2sls}]'\{Var[b_{3sls} - b_{2sls}]\}^{-1}[b_{3sls} - b_{2sls}] \sim \chi^2(k)$$

where *k* is the number of unknown parameters in b_{3sls} and b_{sure} and *Var* is the variance-covariance matrix. Large values of the LM and HS statistics argue in favour of the WLS model against the OLS model, the W2SLS model against the 2SLS model, the SURE model against the OLS model, and the 3SLS model against the SURE model, respectively.

Considering the nature of the data set, a test for multicollinearity was also performed. Finally, in order to avoid model mis-specification, Ramsey's RESET test was conducted.

IV Empirical Results

Table 2 presents the descriptive statistics, and Pearson correlation coefficients and Spearman rank correlation coefficients between variables involved in the analysis. The difference between the Pearson correlation and Spearman rank correlation lies in the assumption about variables. To make an inference about the population correlation, the former strictly requires that the two variables follow the normal distribution. The latter is a non-parametric approach to correlation and does not have such a requirement. Carefully checking the data, we found that the variables expected *fp* and *lq* were normally distributed. Therefore, in Table 2, the results from both correlation tests are presented, even though they tell a similar story. The results showed that *ci* is correlated with *fp*, *fs* and *lq* at the 1% level. For this reason, we suspected the existence of multicollinearity. Gujarati [1995] proposes several methods to identify multicollinearity. Here, the method of auxiliary regressions was adopted. According to the rule of thumb, if R^2s from the auxiliary regressions are less than the R^2 of Equation (4) above, there is no severe multicollinearity problem. The maximum value of R^2s from the auxiliary regressions in this study was 0.36, which is much less than the R^2 of Equation (4) (see Tables 3 and 4). Therefore, we drew the conclusion that there is no serious multicollinearity problem in our study.

(Table 2 here)

The results from the OLS, WLS, 2SLS, W2SLS, SURE and 3SLS are presented in Table 3. Following the discussion in the previous section, four tests were performed to compare the six statistical models. The LM statistics of 3.3459 and 3.9442 were statistically significant at the 10% and 5% level respectively, indicating the existence of heteroscedasticity and contemporaneous correlation. However, comparing 2SLS and W2SLS, we could not find groupwise heteroscedasticity. The significant value of the HS statistic of 142.1511 favoured the 3SLS model against the SURE model. The conclusion is that the 3SLS model is an appropriate one. In addition, 3SLS is an instrumental variable method. This can be used to check the robustnes of the results conditional on the possible presence of measurement errors for labour quality. Thus, our interpretation of the econometric estimations was based on this model. Finally, the chi-squared values of Ramsey's RESET statistic were 3.3241, 3.4755, 4.1366 and 4.0961, which were not significant. Therefore, we accepted the null hypothesis, that the model is not mis-specified.

(Table 3 here)

The results from the Wald test 1 showed that the imposition of constant coefficient restrictions on all four explanatory variables (*fp*, *fs*, *ci*, and *lq*) across time was rejected by WLS, SURE and 3SLS. However, constant coefficients on *fp*, *fs*, and *ci* across time were accepted by all models (see Wald test 2 in Table 3). Table 4, therefore, presents the results of the econometric estimations with constant coefficient restrictions on these three variables.

(Table 4 here)

An economic interpretation of the estimation results, as presented in Tables 3 and 4, can now be provided. Though the results from various statistical models are provided, for the purpose of comparison, our explanation is based on the 3SLS model, as it proved to be the best statistical model. Column 5 of Table 3 shows the results for 1996 and 1997. For 1996, the coefficient for the capital intensity variable (*ci*) has the expected positive sign but is marginally statistically insignificant (probability = 0.2536). This indicates that capital intensity may not be a very important determinant of labour productivity in China's electronics industry and at first this may appear to be a surprising result. However, a number of different electronics sub-sectors are included in the data set, as detailed in Table 1, and some are not particularly capital intensive in nature. Examples include special equipment and parts for radar, calculator manufacture, and the electronic toy manufacturing sectors, where the capital/labour ratio is less than or around 1. By contrast, the equivalent ratio in video manufacture is 19.53 and in air conditioner production 17.13 in 1996. The statistically insignificant result for capital stock may, therefore, mask a differing importance of capital intensity across the sub-sectors. To study this, however, would require collecting data at the firm or intra-sub-sector level because the relevant information is not available in the official Chinese statistics. The results reported here simply show that, in aggregate, a rise in capital intensity was not highly associated with a rise in labour productivity. A similar word of caution is appropriate when interpreting the firm size, labour quality and foreign presence explanatory variables. This study is concerned with discovering the importance of each of these variables in determining labour productivity at the aggregated, industry level.

Turning to the other explanatory variables for 1996, the firm size variable (*fs*) has the expected positive sign and is statistically significant at the 1% level. The coefficient of 0.34 implies that a 1% increase in the firm size will result in a 0.34% increase in the labour productivity. This finding supports the existence of important scale economies in electronics manufacturing in China.

The labour quality variable (*lq*) also has a significant and positive sign. The labour productivity elasticity with respect to this explanatory variable is as high as 1.16 in 1996. This means that a 1% rise in human capital leads to slightly more than 1% rise in labour productivity. In terms of the magnitude, human capital is the most important determinant of labour productivity among the explanatory variables. This is not a surprising finding, however, given the potential importance of education and skill enhancement in raising economic efficiency, as reported in numerous studies [e.g. Lee and Lee, 1995; Eicher, 1996; Fleisher and Chen, 1997]. At the same time, the result may be biased by the human capital variable used, the ratio of managers and engineers to all employees. This should be borne in mind when interpreting this result. As explained earlier, the proxy variable used was determined by the limitation of Chinese published statistics.

Finally, the coefficient on the foreign presence variable (*fp*) is statistically significant and positive. This indicates that multinational corporations in China's electronics industry play a positive role in enhancing labour productivity, as expected. However, compared with the other explanatory variables, the magnitude of the foreign variable is low (0.14 in 1996).

One important feature for 1997 in Column (5) of Table 3 is that labour quality is no longer statistically significant. A careful examination of the raw data indicates that the number of engineers in 1997 is much smaller than in 1996. We tried to find out reasons for this dramatic fall without success, but gather that this is the main cause of the insignificance of the labour quality variable.

Another important feature is that the significance level of the coefficient on foreign presence fell from 1% in 1996 to 10% in 1997. Since the extent to which local firms benefit from the very presence of foreign firms depends largely on their own technological capabilities, the fall in the significance of FDI may be a consequence of the big decline in the number of engineers who are the driving force of technical competence. The elasticity of foreign presence (0.24) is, however, greater than the elasticities for capital intensity (0.17) and human capital (0.10), in 1997, and these coefficients are not significant at the 10% level or better. As in the case of 1996, the coefficient on firm size is highly significant.

Column (7) of Table 4 presents the 3SLS results when the constant coefficient restrictions are applied to foreign presence, firm size and labour quality. These results are consistent with those in column (5) of Table 3. It was found that FDI does have a positive and significant impact on productivity in China's electronics industry. In addition, firm size and labour quality-1996 have a positive and significant influence. Capital intensity and labour quality-1997 have the expected positive sign, but their effects on labour productivity are not statistically significant.

Caution must be exercised when one interprets the productivity impact of FDI in China. As mentioned earlier, the current study only examined the influence of FDI on the combined productivity of local and foreign owned sectors because of the lack of separate data on productivity, capital intensity, firm size and human capital for these two sectors. Thus, while Blomstrom and Wolff (1994) and Kokko et al (1996), among others, find a positive impact of FDI on the productivity in local firms in developing countries, the current study could only show that FDI has a positive impact on the combined productivity of local and foreign firms. Unlike Aitken and Harrison (1999), who assess the impact of FDI on foreign-invested and local enterprises respectively at the firm level, we were not able to separate the FDI effects on foreign subsidiaries from the effects on local firms. Data limitations also prevented us from examining the regional effect of FDI, and how FDI impacts in different organisational forms, e.g. joint ventures and wholly owned subsidiaries.

Despite these limitations, the central message from this study is that China's electronics industry as a whole appears to benefit from the presence of foreign firms in terms of labour productivity. Therefore, an increase of FDI in the industry may further enhance productivity.

V Conclusions

This paper has examined the impact of FDI on labour productivity in China's electronics industry using panel data for 1996 and 1997. Official government data were used, which divide the industry into 47 sub-sectors. The impact was assessed alongside other possible explanatory variables, namely capital intensity, labour quality and firm size for scale effects. A model was established that incorporates both direct and indirect (spillover) effects of inward FDI on productivity in the industry. The role of FDI was measured in terms of the degree of foreign presence in each of 41 of the sub-sectors of the Chinese electronics industry (six sub-sectors had to be eliminated from the study because of incomplete data).

The estimation results indicate that all explanatory variables have the expected, positive sign. FDI has a positive impact on labour productivity in the Chinese electronics industry. In terms of the relative magnitude of the impact on labour productivity, the human capital variable was the most important determinant, followed by firm size and then foreign presence (FDI) in 1996. However, because of a significant drop in the number of engineers, the human capital variable was not statistically significant in 1997.

The findings from this study have implications for policy makers and enterprise management. Firstly, there are implications in terms of the future restructuring of the Chinese electronics industry. The industry suffers from a large number of under-utilised production units scattered across the country. This results from poor communications and regional loyalties, the decision in the Maoist period to disperse industrial production around the country to minimise the threat from military attack and, more recently, from managers and local party officials using their greater autonomy from central planning to build more factories [Shi, 1998]. The economic reforms in the 1980s, especially the 'contract responsibility system', devolved more control of production to the local and enterprise levels [Lardy, 1994; Naughton, 1994; Parker and Pan, 1996]. By the beginning of 1997 there was a total of 3,417 electronics enterprises of which 335 were officially classified as large-sized enterprises, 591 as middle-sized and 2,491 as small-sized. There were also a large number of producers in many of the sub-sectors. For instance, under the category of electronic components there were 1,325 firms [Zhang, 1999]. The positive and significant coefficient on the firm size variable confirms the importance of scale economies at a time when many enterprises produce very similar products and at low scales of production. From the findings reported here, adjustment of the size structure of the electronics industry in favour of a smaller number of larger enterprises can be expected to improve productive efficiency. At the enterprise level, management of enterprises producing similar products may need to consider merging with each other in order to increase efficiency.

Secondly, China is endowed with a large pool of relatively cheap labour. The positive and significant coefficient on labour quality for 1996 (there was an insignificant coefficient on labour quality, probably due to the fall in the number of engineers, in 1997) suggests that human capital may be a very important determinant of labour productivity in the electronics sector. The result suggests that more investment in education and training, reflected in this study because of data limitations in terms of engineering and managerial skills, might significantly enhance labour productivity. The larger the proportion of engineers in total employees, the higher the firm's technological competence. Thus, the recruitment of more qualified engineers and the provision of more on-the-job technical training should help a firm to benefit more from the contagion and demonstration effects of foreign presence and from competition with foreign firms.

Lastly, and importantly, the results of the research reported in this paper confirm that encouraging inward FDI into the electronics sector in China may be expected to have a beneficial effect on labour productivity. The results, therefore, support the findings from other studies, such as Shi’s [1998] study of Chinese tape recorder manufacture, that inward FDI does produce economic benefits in terms of higher productivity. However, the research results also suggest that the importance of FDI can easily be exaggerated. In this study, the positive effects on productivity of foreign presence in the industry were found to be smaller than the benefits from enhancing human capital (in 1996) and from the benefits of increasing the scale of production, through a programme of production rationalisation (applies to both 1996 and 1997). At the firm level, managers need to recongise that the presence of FDI in the industry is only one possible determinant of labour productivity.

Three areas can be identified for future research. A first is to collect the data at the firm level so that the relationship between FDI impact and different organisational forms can be investigated. The impact of FDI on joint ventures, wholly owned enterprise and local firms may be different (see, for example, Aitken and Harrison, 1999). A second is to compare the impact of FDI from different host countries. For instance, the influence of FDI from developing countries may well be different than that from developed countries. Finally, the hypothesis in the study is that foreign presence raises labour productivity; but it could be that high labour productivity attracts FDI. While an instrument variable method - 3SLS - was used in the study to deal with this possible simultaneity problem, it would be ideal to assess more formally the causal relationship using time-series data over a longer period.

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Table 1. China's Electronics Industry

Category	Share of Foreign Capital (%)		Capital - labour ratio		Capital - output ratio		firm size	
	1996	1997	1996	1997	1996	1997	1996	1997
I. Radar								
1. Complete radar manufacture	0.02	1.79	2.0412	2.1039	0.3945	0.2809	47,052	70,572
2. Special equipment and parts for radar	1.82	1.65	0.8136	0.8319	1.2035	1.7896	2,632	2,163
3. Other radar manufacture	NA	NA	1.1111	0.9904	0.7246	0.3527	351	527
II. Communications Equipment								
4. Wire transmission equipment manufacture	1.60	NA	1.5734	1.5944	2.2449	1.5491	1,664	1,989
5. Wireless transmission equipment manufacture	13.93	19.64	4.7502	5.2545	1.1439	2.1420	35,990	29,860
6. Exchange equipment manufacture	34.87	31.39	8.7983	8.0327	0.9691	0.8866	15,299	20,548
7. Wire communications terminal equipment	38.60	38.09	3.1152	3.0594	1.4577	1.0300	5,592	5,793
8. Wireless communication terminal equipment	24.73	37.16	5.1589	6.7364	0.2338	0.4310	36,665	48,460
9. Other communications equipment manufacture	20.38	9.00	3.0875	3.4852	1.7896	1.1706	4,336	5,638
III. Broadcast and TV								
10. Broadcast and TV equipment manufacture	2.08	3.40	2.4256	2.0797	2.6742	2.3360	1,390	1,742
11. TV set manufacture	26.73	29.10	4.5117	5.7702	1.4175	1.1291	21,478	27,831
12. Radio and recorder manufacture	36.31	37.76	3.0902	2.965	1.4850	1.0446	7,863	10,848
13. Video manufacture	46.16	46.12	19.5264	16.329	4.8372	1.2257	28,363	33,131
14. Other broadcast and TV product manufacture	18.06	24.42	3.1223	4.5401	3.2480	1.3113	1,253	2,031
IV. Computer								
15. Complete computer manufacture	18.18	15.08	4.2649	5.0392	0.9443	0.9281	19,583	22,288
16. Computer exterior equipment manufacture	56.94	38.10	5.7508	6.0438	1.3805	0.6084	16,346	19,816
17. Command instrument	NA	NA	1.1118	1.2452	2.0721	1.9415	12,432	10,811
18. Computer necessary accessories manufacture	20.27	18.13	5.1913	6.212	1.2546	1.0375	2,714	4,140
19. Software manufacture	20.72	9.55	7.0187	4.4597	0.2762	0.7410	762	7,273
20. Calculator manufacture	22.34	71.81	0.556	1.613	0.4227	2.6783	4,419	4,804
21. Computer repairing	NA	NA	1.6135	0.5673	29.8500	NA	1	NA
22. Other computer product manufacture	71.02	72.42	9.3033	8.8966	2.3079	1.8651	5,453	10,692
V. Electronics Components								
23. Electronic micro-electrical machine	33.02	30.20	2.6077	2.9531	1.8369	2.4553	4,390	4,103
24. Electronic electrical wire and cable manufacture	11.13	11.57	3.586	4.0781	1.1500	0.8266	7,021	8,107
25. Electronic storage battery	4.26	28.62	1.2208	1.6386	1.4666	1.8104	2,306	7,732

Table 1. China's Electronics Industry (continued)

Category	Share of Foreign Capital (%)		Capital - labour ratio		Capital - output ratio		firm size	
	1996	1997	1996	1997	1996	1997	1996	1997
V. Electronics Components								
26. Electronic dry battery	85.64	65.92	10.948	8.5111	1.9266	1.5116	8,119	9,356
27. Electronic component manufacture	24.66	30.31	2.6621	2.8217	1.4817	1.2577	2,311	2,791
28. Electron component special material	37.90	39.81	3.8232	4.1193	2.6569	2.4924	1,770	1,756
29. Other electronic component product manufacture	32.24	28.05	1.8898	2.3527	1.2310	1.2414	1,846	1,782
VI. Electronic Measuring Equipment								
30. Electron measuring instrument	6.33	4.81	1.535	3.0203	1.9339	2.5273	875	1,287
31. Other electronic measuring instrument	23.11	23.86	3.209	3.8147	1.0055	1.9468	1,353	1,664
VII. Electronics Special Equipment								
32. Electronic special equipment manufacture	29.60	30.85	2.4722	2.6925	2.0760	1.6978	1,909	2,233
33. Electronic industrial mould and gear manufacture	21.37	29.72	2.1239	2.2468	2.2547	2.3486	450	378
34. Other electronic equipment manufacture	19.98	21.10	1.8728	2.4302	0.8281	1.3382	1,670	1,906
VIII. Household Electronic Appliances								
35. Refrigerator manufacture	49.20	24.04	8.4187	7.1028	1.1475	1.5895	44,028	45,920
36. Electrical fan manufacture	NA	NA	0.8038	0.7106	1.0601	0.8965	578	490
37. Air conditioner manufacture	61.67	NA	17.1252	4.2786	1.0919	-0.4815	53,907	3,118
38. Electric Heating equipment	85.39	72.66	4.4848	3.669	1.6776	2.4463	16,938	4,942
39. Electronic toy manufacture	27.29	54.67	0.9721	1.2001	0.4541	0.6705	3,191	566
40. Other household electronic appliance	35.88	55.77	5.2104	7.5628	2.2309	0.9893	4,891	14,128
41. Others	30.92	31.41	3.1692	4.1512	1.9804	0.9419	1,219	2,360
IX. Electronic Device								
42. Bulb manufacture	57.26	55.62	3.9214	4.6323	1.7591	1.4340	1,808	2,114
43. Electrical vacuum valve device manufacture	29.51	32.47	8.1349	9.6979	1.3912	1.6176	35,240	36,686
44. Semi-conductor device manufacture	16.12	17.31	2.0152	2.4327	2.0497	1.8858	1,148	1,489
45. Integrated circuit manufacture	36.57	37.93	8.7623	11.1766	3.0552	3.0956	8,121	9,252
46. Electronic device material manufacture	30.69	28.64	5.2775	5.6236	1.4230	1.1630	4,801	6,843
47. Other electronic device product manufacture	40.72	31.10	7.2736	9.7312	2.1352	2.1004	2,299	4,160

NA = not available

Table 2. Descriptive Statistics and Correlations

Panel A					Panel B					
	Minimum	Maximum	Mean	Std. Deviation	Correlations	lp	fp	fs	ci	lq
lp	7.0983	12.5045	10.1742	.8867	lp	1	.331***	.691***	.644***	.320***
fp	-3.8897	4.4502	3.0979	1.1605	fp	.204*	1	.209*	.391***	-.304***
fs	5.9344	11.1644	8.5722	1.2555	fs	.615***	-.008	1	.483***	.163
ci	-.2491	2.9723	1.5210	.6509	ci	.532***	.283***	.431***	1	.307***
lq	-2.1298	-.1736	-1.4201	.3218	lq	.349***	-.170	.139	.301***	1

Notes: 1. *, ** and *** denote significant at the 10%, 5% and 1% level, respectively (2-tailed).

2. The lower part of Panel B in the table displays the Pearson's correlation coefficients, and the Spearman's rank correlation coefficients are shown above the diagonal.

3. Std. Deviation denotes standard deviation.

Table 3. Results of the Econometric Estimations

(Dependent Variable = Labour Productivity in Sub-sectors of China's Electronics Industry; 1996, 1997)

Variables	OLS/WLS		2SLS/W2SLS		SURE		3SLS	
(1)	(2)		(3)		(4)		(5)	
	1996	1997	1996	1997	1996	1997	1996	1997
fp	0.1178	0.2743	0.1322	0.2852	0.1236	0.2177	0.1434	0.2392
	(0.0638)*	(0.1362)**	(0.0717)*	(0.1382)**	(0.0588)**	(0.1254)*	(0.0665)***	(0.1279)*
	(0.0598)**	(0.1276)**	(0.0672)**	(0.1295)**				
fs	0.3270	0.4376	0.3277	0.4407	0.3342	0.4232	0.3365	0.4224
	(0.0693)***	(0.1029)***	(0.0697)***	(0.1030)***	(0.0640)***	(0.0953)***	(0.0644)***	(0.0954)***
	(0.0649)***	(0.0964)***	(0.0653)***	(0.0965)***				
ci	0.2097	0.1261	0.2176	0.1219	0.1673	0.1746	0.1666	0.1715
	(0.1532)	(0.2179)	(0.1570)	(0.2184)	(0.1414)	(0.2008)	(0.1448)	(0.2012)
	(0.1436)	(0.2042)	(0.1471)	(0.2047)				
lq	1.2406	0.3301	1.1601	0.2877	1.2226	0.1197	1.1595	0.0968
	(0.2920)***	(0.3596)	(0.3004)***	(0.3666)	(0.2702)***	(0.3323)	(0.2778)***	(0.3388)
	(0.2736)***	(0.3370)	(0.2815)***	(0.3435)				
c	8.5298	5.7607	8.3532	5.6461	8.4868	5.6933	8.3189	5.6043
	(0.7135)***	(1.0123)***	(0.7219)***	(1.0194)***	(0.6613)***	(0.9377)***	(0.6687)***	(0.9436)***
	(0.6685)***	(0.9486)***	(0.6764)***	(0.9552)***				
Diagnostics								
R^2	0.6697	0.5214	0.6681	0.5210	0.6685	0.5158	0.6656	0.5153
Adjusted R^2	0.6330	0.5214	0.6312	0.4678	0.6317	0.4620	0.6285	0.4614
s.e. of regression	0.5105	0.6849	0.5117	0.6852	0.5114	0.6889	0.5136	0.6893
RSS	9.3802	16.8857	9.4253	16.9000	9.4134	17.0830	9.4946	17.1027
Wald test 1 ~ $\chi^2(4)$	OLS	WLS	2SLS	W2SLS				
	7.3325	8.3509*	6.6394	7.5616	12.4056**		11.3447**	
Wald test 2 ~ $\chi^2(3)$	1.8914	2.1541	1.7574	2.0014	1.9001		1.8160	
RESET test ~ $\chi^2(4)$	3.3241		3.4755		4.1366		4.0961	
	OLS vs. WLS 3.3459* ~ $\chi^2(1)$		*2SLS vs. W2SLS* 0.3406 ~ $\chi^2(1)$		*OLS vs. SURE* 3.9442** ~ $\chi^2(1)$		*3SLS vs. SURE* 142.1511*** ~ $\chi^2(10)$	

Notes: 1. Standard errors are in parentheses. 2. *, ** and *** denote significant at the 10%, 5% and 1% level, respectively.

Table 4. Results of the Econometric Estimations

(Dependent Variable = Labour Productivity in Sub-sectors of China's Electronics Industry; 1996, 1997)

Variables	OLS	WLS	2SLS	W2SLS	SURE	3SLS
(1)	(2)	(3)	(4)	(5)	(6)	(7)
fp	0.1582	0.1461	0.1784	0.1635	0.1335	0.1568
	(0.0651)***	(0.0547)***	(0.0708)***	(0.0636)***	(0.0576)**	(0.0649)**
fs	0.3591	0.3635	0.3623	0.3508	0.3586	0.3609
	(0.0614)***	(0.0545)***	(0.0616)***	(0.0570)***	(0.0597)***	(0.0603)***
ci	0.2502	0.2004	0.2450	0.2511	0.1862	0.1826
	(0.1314)*	(0.1183)*	(0.1334)*	(0.1244)**	(0.1293)	(0.1324)
lq	0.72257		0.6719	0.1635		
	(0.2331)***		(0.2389)***	(0.0636)***		
lq-1996		1.2511			1.1959	1.1373
		(0.2657)***			(0.2654)***	(0.2737)***
lq-1997		0.2616			0.0880	0.0697
		(0.3204)			(0.3196)	(0.3255)
c-1996	7.3344	8.1635	7.1816	7.4631	8.1850	8.0164
	(0.6156)***	(0.5797)***	(0.6220)***	(0.5782)***	(0.6139)***	(0.6242)***
c-1997	7.1681	6.5982	7.0131	7.2964	6.4592	6.3450
	(0.6245)***	(0.6695)***	(0.6311)***	(0.5903)***	(0.7057)***	(0.7151)
Diagnostics						
R^2-1996	0.6257	0.6652	0.6103	0.6320	0.6669	0.6618
R^2-1997	0.4796	0.5028	0.4899	0.4737	0.4944	0.4978
Adjusted R^2-1996	0.5841	0.6280	0.5670	0.5911	0.6298	0.6242
Adjusted R^2-1997	0.4217	0.4475	0.4332	0.4152	0.4382	0.4420
s.e. of regression -1996	0.5434	0.5139	0.5545	0.5388	0.5126	0.5165
s.e. of regression -1997	0.7142	0.6981	0.7071	0.7182	0.7039	0.7015
RSS-1996	10.6294	9.5081	11.0675	10.4513	9.4604	9.6033
RSS-1997	18.3620	17.5426	17.9991	18.5686	17.8395	17.7176

Notes: 1. Standard errors are in parentheses.

2. *, ** and *** denote significant at the 10%, 5% and 1% level, respectively.