FDI AND SPILLOVERS IN CHINA: NON-LINEARITY AND ABSORPTIVE CAPACITY

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FDI and Spillovers in China: Non-linearity and absorptive capacity

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Abstract

Using a fixed effect variance decomposition model, we estimate SUR models to analyze FDI spillovers from contagion and spillovers from competition on local firms in China. While the former type of spillover mainly depends on the degree of foreign presence in the local industry, the latter kind is related to how foreign and local firms interact. The main conclusion is that FDI has been beneficial for the Chinese economy, but that spillovers are not evenly distributed across firms and industries. Spillovers from contagion tend to exhibit an inverse U-shaped pattern with respect to the degree of foreign presence at the industry level, whereas spillovers from competition exhibit a more linear pattern with respect to the level of technological sophistication in foreign firms. Industries with high absorptive capacity and/or high efficiency are the ones best equipped to take advantage of spillovers from foreign-owned firms. Moreover, there are signs of substantial competition between foreign-owned firms: an increase in the foreign capital share in an industry seems to have a stronger effect on incumbent foreign-owned firms than on domestic firms.

Keywords: Spillovers, China, FDI, Fixed effect variance decomposition

JEL codes: C33, F21, F23, O53

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1. Introduction

In 2008, China celebrated the 30th anniversary of its first market-oriented economic reforms. The success of the reform program can hardly be questioned. With an average annual GDP growth rate around ten percent during the past decades, a rapid fall in the number of people living below the poverty line, and broad improvements in many social indicators, China is one of the few countries that have reached most of the millennium development targets. Much of the credit for these achievements is due to increasing outward orientation. From a position as a remarkably isolated economy during the *Cultural Revolution*, China has become one of the world's two largest exporters (competing with Germany for the top position), one of the largest importers, and a major destination for foreign direct investments (FDI).

Although inflows of FDI have been important as a source of capital during some periods, investment has still mainly been financed from domestic sources: China has not been a capital-starved developing economy for many years. At the same time as the domestic capital stock has grown, Chinese industry has experienced significant productivity growth and Chinese firms have been catching up to Western standards. As a result, the view on foreign-owned firms has slowly changed. The image of foreign multinational corporations (MNCs) has changed from apparently superior organizations that demonstrated valuable new technologies and managerial skills, but rarely competed directly with local firms, to regular competitors that operate in the same market segments as domestic firms. In a few sectors, foreign MNCs dominate the market, but most industries have local as well as foreign-owned firms among the leading players.

The dominant view in the academic literature is that FDI has been highly beneficial for China, although some studies have recently argued that the spillover benefits from FDI to local firms have diminished (Liu 2008, Ljungwall and Tingvall 2008, Ma and Zhang 2008). There is a wide range of mechanisms through which the local market may benefit from foreign presence: the increase in competition encourages efficient resource use in local companies, foreign demand of goods and labor benefits local suppliers and workers, the exports from foreign MNCs make

Chinese products known in world markets, the technologies and managerial skills applied in foreign enterprises provide important benchmarks for local firms, and so forth. The purpose of this paper is to focus specifically on how the presence of foreign firms affects the productivity of local firms through technology spillover" – instances where the productivity or technology of local firms changes as a result of foreign presence without any market transactions that explicitly compensate or reward the foreign firm for the possible benefits accruing to local companies. More precisely, we address some of the apparent inconsistencies in the extant literature on the impact of FDI on the Chinese economy, and analyze non-linearities and inter-industry differences in the incidence and importance of spillovers in Chinese manufacturing. These types of inter-industry differences may go a long way towards explaining the divergent views in the current Chinese debate on spillovers from FDI.

2. Earlier studies and methodological framework

The presence of technology spillovers in the Chinese manufacturing sector is well documented, although there is substantial disagreement in the literature regarding how general these externalities are (see Liu 2008 for a recent review). For example, Chen (2003) and Pan (2003) conclude that the presence of foreign MNCs has generally contributed to spillovers and productivity increases in domestic Chinese firms, while Ma and Zhang (2008) argue that spillovers are insignificant, or perhaps even negative. It is therefore now surprising that several studies have tried to explain these divergent results. One of the fundamental insights in this strand of research is that it is not only the volume of FDI that determines whether spillovers will materialize and how significant they will be. The presence of foreign MNCs creates a potential for learning and technology diffusion, but factors like the absorptive capacity of local firms and the size of the technology gap between foreign and local firms contribute to determine how much technology that is actually diffused from foreign to local firms. Like early analyses such as Cohen and Levinthal (1989) and Kokko (1994), several studies on China have focused on identifying the role of technology gaps between foreign and local firms and local absorptive capacity. For example, Chen (2003) and Zhou (2005) have noted that sectors with a smaller technology gap between local and foreign firms benefited more from FDI spillovers, since shortcomings in local absorptive capacity arguably prevented local firms from learning from foreign companies with more advanced technology. In a similar vein Yonglai *et. al*., (2005) and Lu and Zhang (2004) have argued that local learning capacity, proxied with the quality of human resources in the firm, is the key determinant of local firms' ability to absorb FDI spillovers. However, there does not seem to be any linear relation between the technology level of the industry and the presence of spillover benefits. Focusing exclusively on high-tech sectors, Jiang and Zhang (2006) were unable to find any general pattern for how foreign presence influenced local productivity. In 6 out of the 28 high-tech sectors included in their analysis, they detected strong FDI spillovers, a few sectors (including computer manufacturing) showed negative spillovers, while there were no clear signs of any impact from FDI on local productivity in the remaining industries.

Other studies have focused on ownership and country-of-origin effects. Differentiating between FDI from OECD countries and overseas Chinese firms, Buckley *et al*. (2004) found more consistent positive effects from FDI made by overseas Chinese firms. In a later study (Buckley *et al*. 2006), the same authors found that FDI from Western countries generated greater spillover in technology intensive industries, while FDI from overseas Chinese firms has stronger positive effects in labor intensive sectors. It should be noted that these results are also related to the findings regarding absorptive capacity and technology gaps: FDI from Western countries is likely to embody more advanced technology than FDI from overseas Chinese firms, and the absorptive capacity of local firms in labor intensive sectors is weaker than that of technology intensive sectors. Buckley et al. (2006) also tried to differentiate between state owned and private Chinese firms, and found that state owned firms benefited from Western as well as overseas Chinese FDI. Private Chinese firms, on the other hand, only benefited from overseas Chinese FDI.

Using more recent data, Ma *et al*. (2008) addressed similar questions, but reached different results. Their results indicated that FDI from overseas Chinese firms has had negative effects on Chinese local firms, while FDI from OECD countries resulted in positive externalities on local firms. The differences between these two studies may indicate that the impact of FDI may have changed over time, differs by sectors or being non-linear. In particular, it is possible that the technologies used by overseas Chinese firms were "appropriate" from a learning or technology absorption perspective at some time in the past, but that their role may have diminished as the overall capacity of Chinese industry has improved.

Chen and Chen (2005) have suggested another possible explanation for the divergent results. As pointed out by Kokko (1996), it is likely that technology spillovers are not only influenced by the amount of foreign investment in the market, but also by the intensity of competition between foreign and local firms. It is likely that the spillover effects will vary between industries even if the foreign ownership (or employment) shares are identical, if the foreign firms in one of the industries are in direct competition with local firms, whereas the foreigners in the other industry focus on specific niches where locals are not very active, or if the foreign and local firms have found an oligopolistic equilibrium where they do not challenge each other. When there is direct competition, spillovers will arguably be more likely and perhaps also larger, because rivalry for market shares will force local firms to invest in imitation, learning, and other ways to improve productivity and competitiveness. Taking these considerations into account, Chen and Chen (2005) argue that spillovers that are related to the degree of foreign presence (spillovers from "contagion") are found in large parts of the manufacturing industry, but that the additional impact of competition is mainly seen in sectors where the technology gap is not too large. Moreover, comparing the two sub-periods 2000-2002 and 2003-2005, Chen and Di (2008) suggest that the relative importance of "contagion" (spillovers related to the volume of FDI in the industry) and "competition" (spillovers related to how foreign and local firms interact) may be changing over time. A similar attempt to go beyond the amount of inward FDI as a determinant for spillovers is found in Li et al. (2009), who included a proxy for the technology gap in their econometric analysis. The results suggest that foreign presence had a significant positive impact on the productivity of local firms during the period 1998-2005, but that the impact of the technology gap has varied over time.

The assumption that competition between foreign and local firms affects the incidence and importance of spillovers complicates the analysis of the impact of inward FDI. An obvious question is how to measure or proxy the nature of the relation between foreign and local firms. One approach, following Kokko (1996), is to focus on the joint behavior of foreign and local firms. Do they push each other and compete for the same customers, or have they carved out their own niches of the market where each type of firm operates without much concern for the other type? In essence, this amounts to asking whether the behavior of foreign firms, e.g. regarding productivity and choice of technology – rather than only the volume of FDI – has any impact on the productivity and technology of local firms. An added complication in this setup is that these productivity effects are likely to bi-directional, going both from foreign to domestic firms and from domestic to foreign firms. In particular, if domestic firms are able to improve their technological capability and productivity, it is likely that the foreign firms in their industry are forced to upgrade their productivity, either by using existing resources more efficiently or by importing new technologies from their parent company. In other words, competition implies that the productivities of foreign and local firms are to some extent jointly determined. Hence both the volume of FDI and the quality of the receiver and transmitter come into play. Taking these considerations into account it is motivated to estimate spillovers using a seemingly unrelated regression (SUR) model set-up.

The estimation of spillovers is complicated not only by the bilateral nature of the process. Since we are dealing with panel data, it is necessary to consider how unobservable fixed effects should be treated. In the current context, controlling for fixed industry effects is important not only to avoid omitted variable bias, but also in order to avoid confusing general industry productivity effects with competition effects or spillovers. However, controls for fixed effects often tend to overlook information from slowly changing variables. In this specific context, this is an important concern, since many of the variables we use have more cross sectional than longitudinal (within) variation: estimations using traditional fixed-effect models are likely to be inefficient.

Plumper and Troeger (2007) have recently suggested an approach that appears to provide an attractive solution to the problem. They present a method entitled "Fixed Effect Variance Decomposition" (FEVD), which picks up unobservable fixed effects at the same time as it allows estimation of fixed effects and efficient estimation of slowly changing variables. To analyze spillovers between foreign and local firms, we therefore apply the FEVD method in a SUR-model framework. This allows us to both handle the bilateral nature of spillovers as well to tackle the issue that fixed effects brings in.

With this as a background, we will proceed to explore the possible non-linear nature of spillovers as well as industry heterogeneity in spillovers.[2] To this end, we construct industry groups based on their absorptive capacity and the technology gap between foreign and local firms, and analyze how contagion and competition spillovers vary in these dimensions.

The results support the assumption that spillovers by competition can be observed in most industries, irrespective of the productivity of foreign firms, whereas spillovers from contagion exhibit an inverted U-shaped relation to the level of foreign presence. When exploring industry heterogeneity, we find that industries with high absorptive capacity and/or relatively high efficiency typically benefit more from spillovers than low-end industries. Benchmarking with foreign firms, we find that local firms tend to benefit more from spillovers from competition than foreign firms. This is intuitive since foreign owned firms typically are more productive than local

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[2] The non-linear nature of spillovers has also been highlighted by e.g. by Blomström and Kokko (2001) and later by Chen (2005)

firms. For spillovers from contagion on the other hand we find that presence of foreign firms seems to affect other foreign firms more than it affects local firms.

The next section discusses data and the model, section 4 focuses on estimation issues and summarizes the results, and section 5 concludes.

3. Data, modelling spillovers, variables and the model

3.1 Data

The data for this study stem from the China National Bureau of Statistic. The information covers the manufacturing sector, spanning the period 2000-2005 with a breakdown to the 4-digit industry level (195 industries). For each industry, we have information about ownership status, which allows us to distinguish between foreign-owned firms and several categories of locally-owned companies. These include state-owned firms as well as various forms of privately owned companies – private firms, joint stock companies, limited liability companies, and cooperatives. For each industry and ownership code (foreign domestic), the data set contains information such as the number of employees, valued added, investments and capital, and a host of other industry characteristics.

3.2 Modelling spillovers

The vast majority of older studies of spillovers – such as Findlay (1978) and Koizumi and Kopecky (1977) – assumed spillovers to be proportional to foreign presence and independent of the relative technology gap between local and foreign owned firms. An important feature of more elaborated models, such as Cohen and Levinthal (1989), is that not only the volume of external knowledge but also the capacity of the receiver is important for technology spillovers to take place. That is, without sufficient technological capability, it is difficult to absorb available external technology. This does not presuppose that the relation between technological capability and spillovers is linear.

The argument for a non-linear relation between the productivity gap and spillovers is that if domestic and foreign owned firms are at the same technological level and using identical technologies (no technology gap), there is not much technology that could potentially spill over. At the same time, it may be unrealistic to expect substantial spillovers if the technological gap is very wide and foreign and domestic firms are far from each other in the technology space, using widely different technologies. Therefore, there might be an intermediate range with an optimal technology gap from a technology spillover perspective.

Another insight is that the actions of local and foreign firms are interdependent and that spillovers are jointly determined by the behavior of the two types of firms. This insight draws on models of international R&D competition (Spencer and Brander 1983), foreign investment decisions (Horstmann and Markusen 1987, 1989) and international transfers of product technology (Jensen and Thursby 1986). In this tradition, Wang and Blomström (1992) argue that spillovers are an endogenous outcome of the interactions between foreign and local firms. Their model has two key predictions on spillovers: (i) the technology gap between local and foreign firms diminishes with local firm's learning efforts and (ii) some spillovers are proportional to the size of the technology gap. Hence, in line with Cohen and Levinthal (1989), the Wang-Blomström (1992) model also suggest that the extent of spillovers is not determined by the degree of foreign presence alone.

Taking these findings into account, we construct a simultaneous model, in which each firm's productivity is partly determined by its rival's productivity. We include two measures of spillovers: (i) the traditional volume of FDI, which we assume will reflect the contagion effect[3] and (ii) the productivity of the competitors, capturing spillovers from competition.[4] In both cases we explore the curvature of the relationship by applying a non-linear system equation. The

[3] The contagion effect can be proxied by the share of industry employment, capital or production; though most studies seem to prefer the employment variable. Following Keller and Yeaple (2003) we calculate foreign presence on a detailed industry level.

[4] Cantwell (1989) shows that the effects of US direct investment on local technological capability in Western Europe 1955-75 were most beneficial in industries in which local firms were most competitive to begin with.

heterogeneity of spillovers is then analyzed by separating industries with respect to the technology gap and absorptive capacity.

3.3 Estimation model and variables

The analysis is based on detailed 4-digit industry level data and we set up a simultaneous equation system that attempts to capture spillovers related to the extent of foreign presence as well as spillovers related to the competition between foreign and domestic firms. The system is illustrated by equations (1) and (2) below.

$$\ln\left(\frac{VA}{L}\right)_{it}^{d} = \propto + \beta_1 (spill.comp.)_{it-1}^{f} + \beta_2 (spill.contagion)_{it-1} + \beta_3 ln(k)_{it}^{d} + \beta_4 ln(L)_{it}^{d} + \beta_5 (C3)_{it} + \beta_6 (export)_{it}^{d} + \gamma_t + \eta_i^{d} + \varepsilon_{it}^{d} \qquad (eq.1)$$

$$\ln\left(\frac{VA}{L}\right)_{it}^{f} = \propto + \beta_1 (spill.comp.)_{it-1}^{d} + \beta_2 (spill.contagion)_{it-1} + \beta_3 ln(k)_{it}^{f} + \beta_4 ln(L)_{it}^{f} + \beta_5 (C3)_{it} + \beta_6 (export)_{it}^{f} + \gamma_t + \eta_i^{f} + \varepsilon_{it}^{f} \qquad (eq.2)$$

Super-indices (d,f) indicate foreign and domestic, respectively. The variable intended to capture spillovers from competition is indexed with the competitor, since local firms are assumed to be affected by foreign firms and vice versa. The eta (η) variable is a fixed effect variance decomposition variable that will be discussed at some length in next section. Equation (1) suggests that the average value added per employee of locally-owned firms is partially determined by the two spillover variables (spillovers from competition defined as the labor productivity of your competitor and spillovers from contagion defined as industry employment share in foreign owned firms). Due to possible endogeneity and impact lag, the spillover variables are lagged one period.[5]

[5] The main argument for possible endogeneity is that foreign firms might choose to enter industries where local firm productivity are originally relatively high, so the productivity of two type of firms are related from the very beginning. It is also likely that spillovers do not materialize immediately, which suggests that some lag structure should be included in the model.

The control variables are employment, the level of industry concentration C3, capital intensity and export intensity, the variance decomposition variable (η) included for soaking up fixed effects (discussed below), period and industry dummies.[6] The concentration measure captures the possibilities to engage in monopoly or oligopoly pricing, which may impact labor productivity. Capital intensity captures choice of technology (labor or capital intensive production) and may also be related to firms' absorptive capacity. The export intensity indicates whether firms are targeting the local or international market and may also be a competitiveness indicator. Equation (2), for foreign-owned firms, is symmetric to the one for local firms. To account for simultaneity and correlated errors and to improve the efficiency of the estimation, we follow Kokko (1996) and estimate the system by way of a seeming unrelated regression system (SUR).[7] To capture non-linear spillovers, we include higher order terms of the two spillover variables.

4. Results

4.1 Basic models

Table 1 presents the results from our basic model for domestic firms. As a benchmark, we start with an OLS model without any spillover variables included, and notice that the capital intensity variable has the expected positive sign and that both export intensity and average firm size record significant negative coefficients. Having labor productivity as the dependent variable, it is not uncommon in studies of developing countries to find a negative coefficient for the export variable – this mainly captures the country's comparative advantages in labor intensive industries. Similarly, the negative impact of the firm size variable is also likely to be explained by the fact that China has comparative advantages in labor intensive industries rather than high value added capital intensive industries.[8] We also notice that the concentration ratio measure suggest a

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[6] Industry dummies are defined at the 2-digit level.

[7] For details, see e.g. Greene, (1998).

[8] We can not exclude the possibility that the negative relation between IRS (firm size) and productivity may partly be driven by inefficient but large and protected SoE:s.

positive correlation between industry concentration and productivity, while size captured by employment turns out to be non-significant.

In estimation 1.2, the model is augmented by adding lagged values for the two spillover variables. Both spillovers variables turn out strongly significant without upsetting the results for the control variables. One drawback of these models is that despite the inclusion of industry dummies at the 2-digit level, the OLS estimations fail to fully capture unobservable fixed effects. Estimation 1.3 therefore employs a fixed effect (FE) model, although it suffers from the general weakness of FE-models, namely low efficiency. It is therefore not surprising that the fixed effect model in estimation 1.3 records a general drop in the significance of most variables. In addition to the general reduction in significance, it can be seen that our both spillover variables and the export variables become insignificant.

The efficiency problem of the fixed effect estimator is particularly cumbersome when the explanatory variables have little variation over time. This trade-off between efficiency and un-biasedness is noticed by Beck (2001: 285), who argues that "Although we can estimate (…) with slowly changing independent variables, the fixed effect will soak up most of the explanatory power of these slowly changing variables. Thus, if a variable (…) changes over time, but slowly, the fixed effects will make it hard for such variables to appear either substantively or statistically significant". Hausman-Taylor models may resolve this problem, but may be inefficient and biased if instruments are weak. Instead, we use the FEVD model proposed by Plumper and Troeger (2007).

FEVD is a three stage method. In the first stage, unit fixed effects are obtained through the estimation of a fixed effect model. In the second stage, by regressing the retrieved unit effects on time invariant and almost time invariant variables, the unit effects are decomposed into an explained and unexplained part. Finally, in the third stage, the target equation from stage one is re-estimated now augmented with the unexplained part from stage, two capturing unobserved unit effects. Plumper and Troeger (2007) show that the efficiency of FEVD estimation of slowly changing variables is substantially better than that of standard fixed effect models – in particular, the relative advantage of FEVD models compared to fixed effect estimations increases as the "within" variance of a variable diminishes in comparison with it's "between" variance. As a rule of thumb, FEVD is preferable to fixed effect models if the ratio of "between" to "within" variance exceeds 1.5. As seen in Appendix Table A1, all right hand side variables applied here have greater between than within variance, suggesting that FEVD estimation may be a way to improve on the FE model and at the same time control for unobservables.[9]

In estimation 1.4 we therefore re-estimate the FE model by way of FEVD. The FEVD estimation increases the overall significance and gives strongly significant coefficients for both spillover variables as well as for the formerly insignificant export variable. In models 1.5 and 1.6, we test the sensitivity of the FEVD specification by changing the set of variables included in step two of the FEVD procedure. More precisely, in model 1.5 we drop the 2-digit industry dummies from all estimation steps in the model, which increases the burden on the variance decomposition variable (ETA) to capture unit effects. This adjustment increases the significance of the ETA variable somewhat, but leaves the estimates of the variables almost unchanged: this indicates that the variance decomposition absorbs unit effects properly. Another consideration is how to define the set of slowly changing variables included in the second step. In estimation 1.6, we define all right hand side variables except for the time dummies as time invariant/slowly changing variables. Again, the results are robust with respect to the specification of the FEVD model.

The results presented in Table 2 indicate that foreign and domestic firms are mutually dependent. Keeping this in mind, it may be possible to further improve the analysis by estimating seemingly unrelated regression models (SUR). We have therefore estimated FEVD-

[9] Details on the SUR-FEVD estimations is given in the Appendix, for further details of the FEVD method, see Plumper and Troeger (2007)

SUR variants of the relevant models: to save on space, the estimation results are found in Appendix Tables A2 and A3. To ensure that we are not violating any distributional assumptions, the SUR models are bootstrapped.[10]

Table 1. Basic models, dependent variable, labor productivity.

	1.1 OLS	**1.2 OLS**	**1.3 FE**	**1.4[(a)] FEVD (Base mod.)**	**1.5[(b)] FEVD (No ind dum.)**	**1.6[(c)] FEVD (All slow)**
Variable	domestic	domestic	domestic	domestic	domestic	domestic
$\ln(L)_t$	0.0044 (0.38)	0.0120 (1.04)	0.0280 (0.89)	0.0129 (1.59)	0.0434 (5.87) ***	0.0118 (1.46)
$\ln(K/L)_t$	0.6347 (23.93) ***	0.5895 (21.10) ***	0.6012 (13.35) ***	0.6012 (30.73) ***	0.6011 (34.96) ***	0.5867 (30.00) ***
(Export intensity)$_t$	-0.1989 (-2.35) **	-0.2386 (-2.70) ***	-0.2368 (-1.57)	-0.2275 (-3.68) ***	-0.0489 (-0.84)	-0.2393 (-3.26) ***
(IRS)$_t$ firm size	-0.0003 (-6.45) ***	-0.0003 (-6.47) ***	-0.0005 (-5.64) ***	-0.0003 (-9.41) ***	-0.0004 (-11.68) ***	-0.0003 (-9.16) ***
(C3)$_t$ Ind. concentration	0.1591 (1.87) *	0.1898 (2.25) **	0.2049 (1.72) *	0.2049 (3.48) ***	0.2049 (3.58) ***	0.1924 (3.26) ***
(Spillover)$_{t-1}$ contagion		0.1983 (2.67) ***	0.0141 (0.11)	0.1925 (3.70) ***	0.2147 (5.13) ***	0.1913 (3.68) ***
(Spillover)$_{t-1}$ competition.		0.0817 (4.40) ***	-0.0047 (-0.22)	0.0772 (5.93) ***	0.0906 (7.50) ***	0.0812 (6.24) ***
(ETA)$_t$ variance decomp				1.00 (33.06) ***	1.00 (37.94) ***	1.00 (33.06) ***
Ind dummies	Yes	Yes	yes	Yes	no	yes
Period dummies	Yes	Yes	Yes	Yes	yes	Yes
R^2	0.70	0.71	0.68within	0.89	0.89	0.89
Obs.	896	896	896	896	896	896

Notes: FEVD models are estimated by bootstrapping, t-value within parenthesis (.). *, **, *** indicate significance at the 10, 5 and 1 percent significance level respectively. For the fixed effect model the within R^2 is presented. **(a)** Time invariant/slowly changing variables used in FEVD estimation step two are: ln(L), Export intensity, efficiency comp, contagion, firm size and industry dummies at the 2-digit level. . **(b)** Time invariant/slowly changing variables used in FEVD estimation step two are the same as in model 4 but industry dummies are left out. **(c)** Time invariant/slowly changing variables used in FEVD estimation step two are all right hand side variables except the time dummies.

The FEVD-SUR models reported in Table A2 have the same variable set-up as the FEVD model 2.4 in Table 1. Figure 1 depicts the estimated spillover function over the empirical range of the applied variables (the vertical axis displays the estimated spillover effect, while the horizontal axis show the foreign share of the industry and the productivity of the competitor, respectively). For both local and foreign firms, as depicted in Figure 1, the linear SUR-FEVD

[10] For details, see e.g. Davison and Hinkley (2006).

models indicate that the variables intended to capture spillovers from competition and contagion are both positive and significant. That is, higher productivity levels among competitors force firms to follow and raise their productivity.[11]

A possible criticism against this productivity driven competition spillover variable is that it could be argued to reflect an industry effect, capturing industry productivity differences rather than spillovers. However, as we control for unit effects and are using lagged values, the spillover hypothesis is difficult to ignore. In addition, labor productivity is (on average) higher among foreign owned firms than among local ones, indicating that there is likely to be more spillovers from foreign to domestic firms than vice versa. In line with this reasoning, Figure 1 shows that the spillover trajectory for domestic firms is higher than that for foreign owned firms. That is, foreign owned firms put more pressure on domestic firms than domestic firms seem to put on foreign owned firms. By contrast, Figure 1 also shows that the contagion variable seems to have a greater impact on foreign firms than on local ones. The likely reason is related to spillovers among foreign firms. In many market segments, it is likely that foreign firms compete more with other foreign firms than with local firms, and it is reasonable to assume that there is substantial learning and competition within the group of foreign owned firms operating in China.

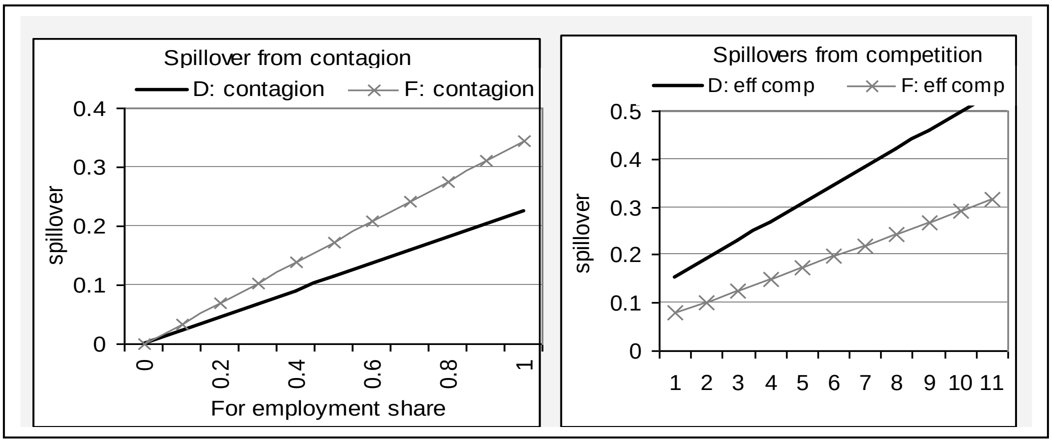
To sum up, for domestic firm, results are clear cut. Increased foreign presence has a productivity enhancing effects on local firms. This effect can be explained both by technology spillovers (including new management and organization schemes) as well as increased competition.

As discussed above, there are reasons to believe in a non-linear relation between productivity and spillovers. If spillovers exhibit a strong non-linear pattern, the results from the linear models may be misleading. Figure 2 displays estimation results from model 2 in Appendix Table A2, and the results suggest that a non-linear approach is well motivated. In particular, it

[11] For domestic (foreign) firms, spillovers from competition are driven by lagged values of the productivity among foreign (domestic) firms.

appears that for local firms, spillovers from contagion are highly non-linear, with spillovers having a peak when foreign industry employment of about 40 percent for then reaching negative values at very high levels of foreign dominance.

Figure 1. Linear model, full model specification, spillovers from contagion and competition.

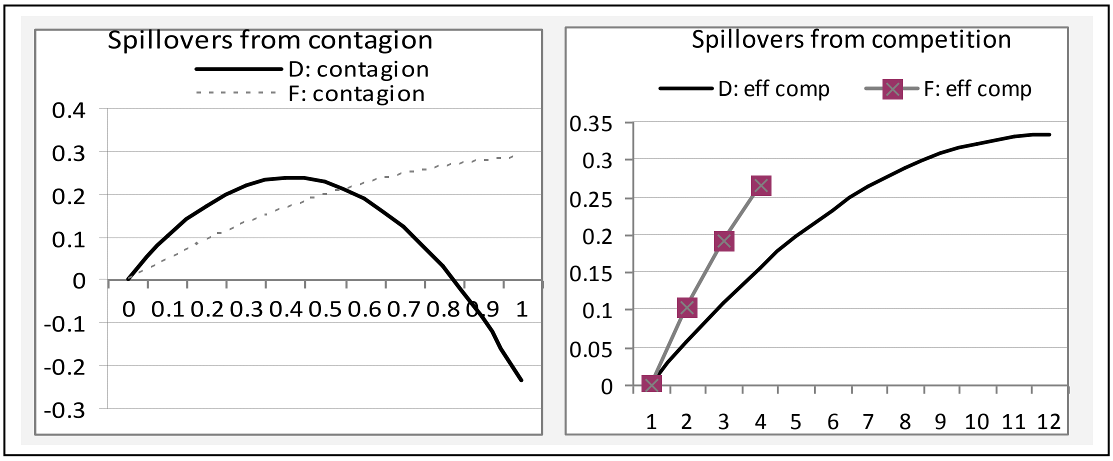


Notes: Prefix F, D: indicate impact on foreign and domestic firms respectively. Solid lines in Figure 1 are all significant at the 1 percent level. Estimation results are found in Appendix Table A2.

Spillovers from competition also appear to be non-linear, but they are always positive and diminish only at very high productivity levels, indicating that Chinese firms are affected by the competition from foreign MNCs in a wide range of industries. The non-linear reaction functions verify Kokko's (1994, 1996) suspicion that spillovers are not always linear.

One may speculate about reasons for the negative contagion spillovers observed at high levels of foreign presence. One possibility is, of course, that these are industries where foreign firms have crowded out most Chinese firms, and that the only ones left are local enterprises operating in niches that are too small or too "primitive" to be of interest for the foreign MNCs. However, a maybe more plausible explanation is that there are "strategic" sectors that are protected by the government, and where the strongest Chinese companies have a high share of governmental ownership.

Figure 2. Non-linear models, full model, spillovers from contagion and competition.



Notes: Prefix F:, D: indicate impact on foreign and domestic firms respectively. Solid lines indicate joint significance of the first and second order polynomial on at least the ten percent significance level. Dotted lines are not significant at the ten percent significance level. Estimation results are found in Appendix Table A2.

Overall, however, the main results from the linear analysis remain intact. The productivity of local firms is apparently determined both by foreign presence and foreign productivity, but there is no direct evidence that the productivity of foreign firms is affected by the productivity of their local competitors.

4.2. Heterogeneity

4.2.1 Grouping by absorptive capacity

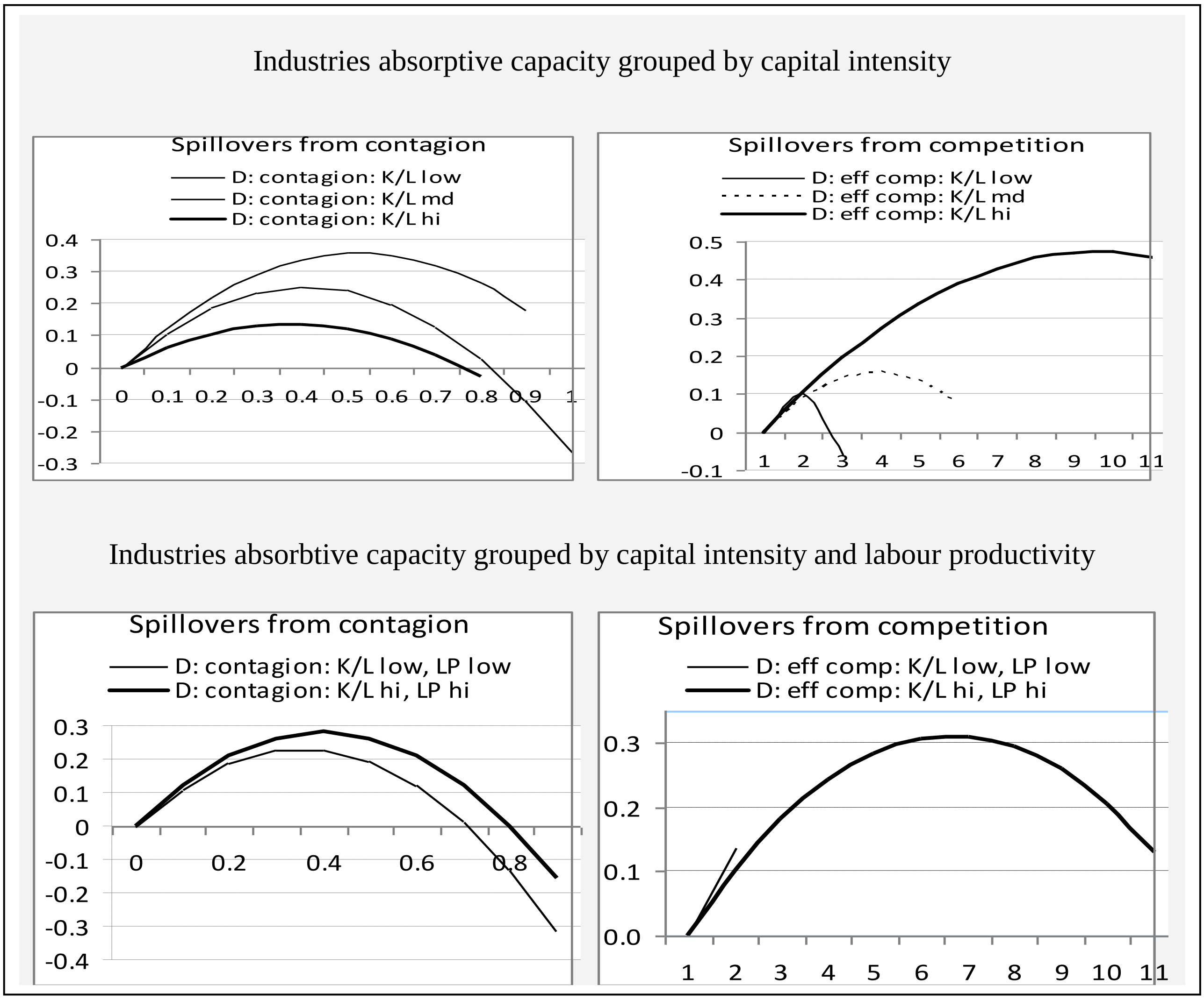
It is possible that spillovers vary between industries for other reasons than the non-linearities discussed above. For example, Cohen and Levinthal (1989) argue that firms' absorptive capacity is crucial for realizing technology spillovers. Research and development is often suggested as an indicator of such absorptive capacity. The present data set has no information on R&D outlays, and we are therefore forced to seek other indicators for absorptive capacity. Alternative proxies are capital intensity (using the embodied technological change argument by Stoneman (1983)) and productivity. To explore heterogeneity in absorptive capacity we first divide industries into low, medium, and high capital intensity. Neither capital intensity nor productivity are likely to be perfect identifiers of the absorptive capacity of local industries, so in order to distinguish industries with high absorptive capacity from industries with low absorptive capacity, we add an alternative definition of low end sectors using both capital intensity and labor productivity as indicators. Hence, we define an industry as low-low if both labor productivity and capital intensity fall within the lowest one-third of the distribution; analogously, high-high sectors are those in the top third both in terms of capital intensity and labor productivity.[12] For ease of exposition and to focus on spillovers from foreign to local firms, the subsequent figures only depict the reaction functions of domestic firms (regression results are shown in Appendix Table A3).

Dividing industries with respect to capital intensity as an indicator of absorptive capacity reveals an interesting heterogeneity. For spillovers from competition, there seems to be a clear hierarchy between industry groups. Industries with high absorptive capacity gain more from spillovers than low and medium industries, where spillovers from competition either have a low or insignificant impact. Using combined capital intensity and labor productivity as a divider, the differences between industry groups become even clearer. Absorptive capacity seems to play a crucial role for the local firms' ability benefit from competition-related spillovers.

Turning to spillovers from contagion, we see that the inverse U-shaped pattern found in Figure 2 is robust with respect to the level of absorptive capacity. Moreover, the reaction function falls within the positive segment, except at very high rates of foreign penetration (i.e. high employment shares for foreign firms). In contrast to the case for spillovers from competition, there are only small differences between the sub-samples. Hence, the capacity of low end sectors to benefit from contagion spillovers is significant even in the low-low segment.

[12] Following Chen (2005), we use the capital intensity and labour productivity of foreign owned firms as norm. The reason for using foreign owned firms input composition and productivity is that foreign owned firms are less influenced by state ownership that may bias the input composition away from the market solution and therefore more precisely indicate market properties of the industries.

Figure 3. Non-linear models



Notes: Prefix D: indicate impact on domestic firms. Solid lines indicate joint significance of the first and second order polynomial on at least the ten percent significance level. Dotted lines are not significant at the ten percent significance level. Estimation results are found in Appendix Table A3.

4.2.2. Grouping industries according to the technology gap

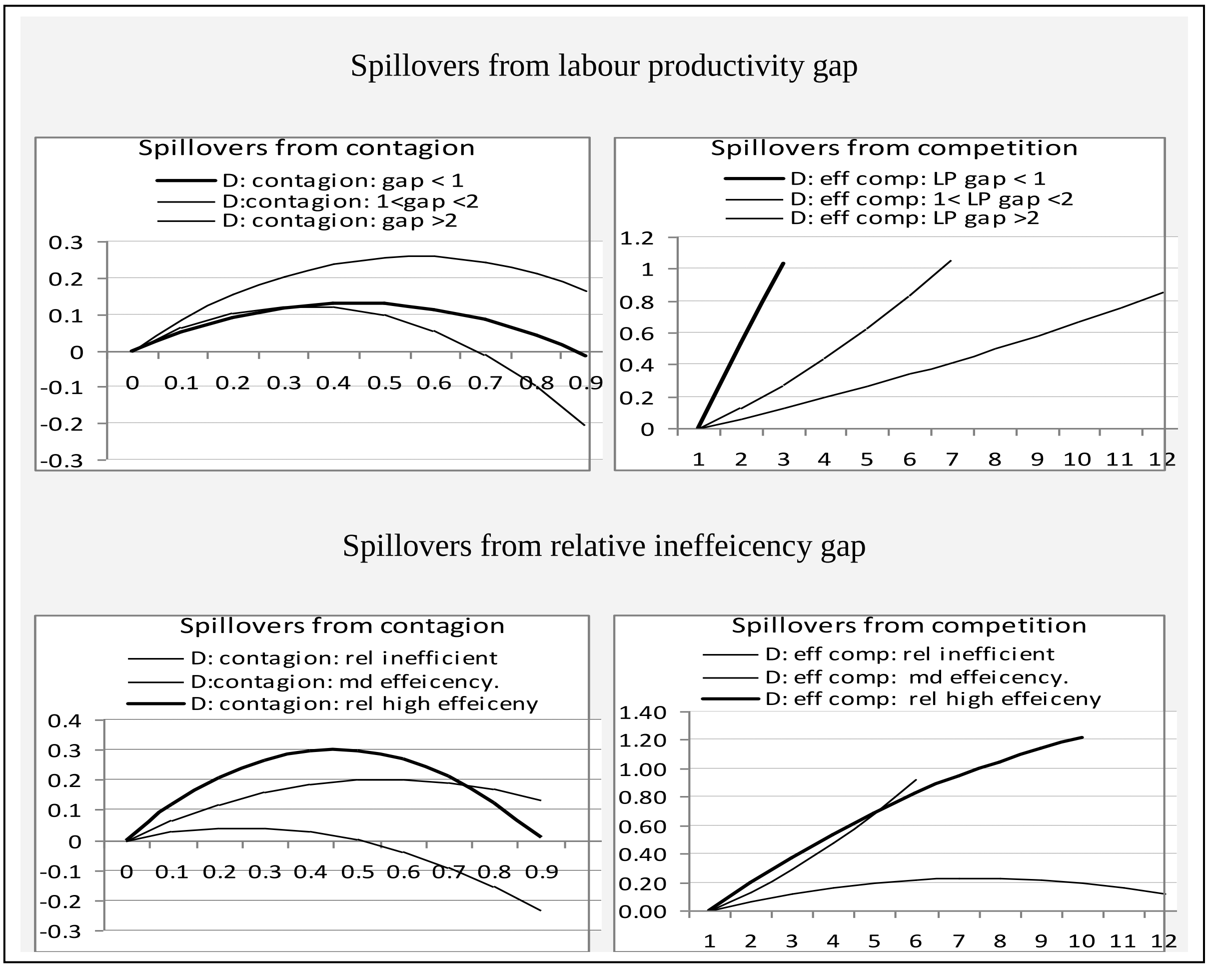
As pointed out by e.g. Cohen and Levinthal (1989) and Kokko (1994), both the absorptive capacity and the size of the technology gap matters for knowledge spillovers to take place. Moreover, within a low (or high) end industry defined according to local absorptive capacity, the productivity gap may be high or low. Hence, we proceed to analyze whether FDI spillovers vary across industries depending on the size of the technology gap between foreign and local firms. The gap is measured as the ratio of domestic to foreign labor productivity, or as the relative distance to the technology frontier, where the distance to the technology frontier is calculated by estimating stochastic production frontier models. For each categorization, three groups are defined: group 1 (small gap), with a productivity ratio less than 1 or alternatively a relatively small distance to the technology frontier; group 2 (medium sized gap); and group 3 (large gap) where domestic firms are clearly behind foreign firms (labor productivity gap > 2 or the relative distance to the technology frontier above the 67th percentile).[13]

The results suggest that spillovers from contagion take place independently of the size of the productivity gap between domestic and foreign owned firms. In line with results for absorptive capacity, Figure 4 shows that the inverse U-shaped relation for spillovers from contagion is maintained. Moreover, the strongest results seem to occur in industries with low or medium sized technology gaps. This suggests that there might be something like an optimal technology gap where spillovers are maximized, just as there might be an optimal level of contagion (or foreign presence) that maximizes the positive impact on local industry.

For spillovers from competition, the reaction functions are more linear. In line with the results in Figure 3, Figure 4 also shows that the most efficient domestic firms benefit most significantly from spillovers from competition. Hence, contrary to the contagion effects, there does not seem to be any optimal productivity gap for spillovers from competition.

[13] The three groups contain about 1/3 of the observations per group.

Figure 4. Non-linear models. Spillovers from technology gap.



Notes: Prefix D: indicate impact on domestic firms. Solid lines indicate joint significance of the first and second order polynomial on at least the ten percent significance level. Dotted lines are not significant at the ten percent significance level. Estimation results are found in Table A3.

The results indicate that domestic firms are affected by competition from foreign-owned firms in a wide range of technologies. In connection to this, it might be worth to point at some particular features of the Chinese economy that may impact the overall results. Taking the apparel sector as an example, average labor productivity is higher in domestic firms than in foreign-owned firms. The basic reason for the higher local productivity is not necessarily higher technical efficiency or more modern technology, but rather that the employees’ working hours are longer in domestic firms (and working conditions in general are poorer). At the same time, within this sector, local firms are still behind foreign firms in terms of design, management of international supply chain, marketing, and so forth, which means that there are still substantial potential benefits from knowledge transfers and spillovers from FDI.

To sum up, these results suggest that local firms with strong absorption capacity are most likely to benefit from FDI spillovers. This is well in line with the stylized facts regarding the impact of FDI in China: the relatively strong local firms possess the capacity to learn from foreign firms and respond positively to the competition exerted by foreign firms, while the weakest ones are likely to lose market shares and may eventually be forced out of business. It should be noted that while firm exit this is typically interpreted as a negative impact at the firm level, it may be positive at the macro level. The Chinese economy is growing at a high rate, and the resources freed up as relatively weak firms go out of business give opportunities for structural change and a more efficient resource allocation.

5. Summary and conclusions

The main conclusion from this study is that the substantial amounts of FDI have been beneficial for the Chinese economy in the sense that Chinese firms have been able to take advantage of spillovers from both contagion and competition. However, spillovers are not evenly distributed across firms and industries. There is a substantial non-linearity and heterogeneity present. Spillovers from competition appear to develop in a rather linear manner with regard to the productivity or technological sophistication of foreign firms, while spillovers from contagion tend to exhibit an inverse U-shape pattern with respect to the degree of foreign presence. Neither of the two types of spillovers is necessarily fully proportional to the degree of foreign presence or the inflow of new FDI.

Exploring heterogeneity among industries, the results indicate a general pattern where industries with high absorptive capacity and/or high efficiency are better than low-end industries (with low absorptive capacity and/or low degree of efficiency) in absorbing spillovers. Moreover, the results of the analysis of industries with different technology gaps suggest that there may be something akin to an optimal technology gap for which spillovers are maximized. In other words, the characteristics of both foreign and domestic owned firms matter for spillovers.

It is worth noting that the results for foreign firms, which have not been discussed in detail above give some interesting results that may be useful benchmarks for local firms as well. First, foreign firms are on average more productive than local ones. It is therefore intuitive that local firms are more affected by competition with other foreign firms than with local firms. Second, the estimation results for spillovers from contagion indicate that the presence of foreign firms seems to have a stronger impact on other foreign firms than on local firms. Given that the population of domestic firms does not only consist of modern internationally oriented enterprises but also small private firms and state-owned enterprises, all having their own niches, this result is also intuitive.

From a methodological perspective, the current analysis has been designed to handle both simultaneity and unobservable fixed effects. More specifically, a fixed effect variance decomposition approach and the use of lagged spillover variables have aimed to handle dynamics, endogeneity and to absorb fixed effects in a manner that allow us to utilize cross-sectional variation in data. For future work, it would be interesting to explore similar heterogeneity at the firm level. Although such firm level data sets can be expected to contain more noice, they typically also include additional data that allow closer analysis of efficiency and absorptive capacity. In particular information on R&D and labor quality would be valuable in assessing the ability of local firms to learn from foreign firms, as well as their ability to respond positively to foreign competition.

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APPENDIX

Table A1. Descriptive statistics

Variable	Mean	be/within stdv.	Mean	be/within stdv. (rank)
	Local firms		Foreign firms	
ln(labor productivity)	3.86	1.26	4.44	1.78
ln(capital intensity)	5.30	2.46	5.77	2.45
Export ratio	0.14	2.89	0.34	2.41
Average firm size	289	2.51	282	3.33
ln(L)	10.28	5.27	9.03	3.46
	All firms			
Contagion	0.22	3.07		
C3	0.26	2.45		

Table A2. SUR FEVD[(a)] models.

	M1. SUR-FEVD linear		**M2. SUR-FEVD non-linear**	
Variable	domestic	foreign	domestic	foreign
$\ln(\text{tot L})_t$	0.0280 (3.39)***	0.0365 (3.54)***	0.0151 (1.59)	0.0363 (4.04)***
$\ln(K/L)_t$	0.6011 (26.99)***	0.6771 (29.65)***	0.6057 (32.14)***	0.6770 (27.76)***
$(\text{Export intensity})_t$	-0.2365 (-4.71)***	-0.2951 (-5.22)***	-0.2746 (-5.73)***	-0.2941 (-4.58)***
$(\text{IRS})_t$ firm size	-0.0003 (6.63)***	-6.7e-05 (-2.01)**	-0.0003 (-6.11)***	-7.2e-05 (-2.01)**
$(\text{C3})_t$ Ind. concentration	0.2049 (3.33)***	0.2195 (2.91)***	0.2033 (3.15)***	0.2318 (3.01)***
$(\text{Spillover})_{t-1}$ contagion	0.2123 (4.19)***	0.3534 (4.54)***	1.1461 (9.74)***	0.5082 (2.60)***
$(\text{Spillover})_{t-1}$ $(\text{contagion})^2$			-1.3807 (-9.42)***	-0.2225 (-1.01)
$(\text{Spillover})_{t-1}$ competition	0.0765 (5.20)***	0.0524 (2.35)**	0.0006 (3.25)***	0.0011 (1.26)
$(\text{Spillover})_{t-1}$ $(\text{competition.})^2$			-2.7e-07 (-0.94)	2.0e-07 (0.06)
$(\text{ETA})_t$ variance. Decomp	1.00 (29.20)***	1.00 (20.97)***	1.00 (32.54)***	1.00 (22.10)***
Ind dummies	Yes	Yes	yes	yes
Period dummies	Yes	Yes	Yes	Yes
R^2	0.89	0.90	0.89	0.90
Obs.	896	896	896	896

Notes: FEVD models are estimated by bootstrapping, t-value within parenthesis (.). *, **, *** indicate significance at the 10, 5 and 1 percent significance level respectively. [(a)] Time invariant/slowly changing variables used in FEVD estimation step two are: ln(L), Export intensity, efficiency comp, contagion, firm size and industry dummies at the 2-digit level.

Table A3. SUR FEVD[(a)], split by absorptive capacity and technology gap.

	M1. Split K/L		M2.Split K/L & LP		M3. Split lp(f)/lp(d)		M4. Split gap(f)/gap(d)	
Variable	domestic	foreign	domestic	foreign	domestic	foreign	domestic	foreign
ln(tot L)$_t$	0.0126 (1.46)	0.0372 (3.62) ***	0.0163 (1.77) *	0.0130 (0.97)	0.0141 (1.51)	0.0328 (3.50) ***	0.0134 (1.50)	0.0477 (4.91)***
ln(K/L)$_t$	0.6046 (27.06) ***	0.6783 (24.18)***	0.5753 (21.98)***	0.7449 (22.19) ***	0.6182 (23.49)***	0.6707 (26.21) ***	0.5901 (26.83)***	0.7102 (31.09) ***
(C3)$_t$ Ind. Conc.	0.1759 (2.54) ***	0.2279 (2.88) ***	0.1425 (1.49)	-0.2226 (-1.60)	0.1867 (2.80) ***	0.2222 (3.00) ***		0.2429 (3.13) ***
(Export intensity)$_t$	-0.2833 (-4.86) ***	-0.1716 (-2.86) ***	-0.3146 (-3.66) ***	-0.1827 (-2.16) **	-0.1714 (-3.09) ***	-0.1877 (-2.95) ***	-0.1034 (-1.97) **	-0.2373 (-4.47) ***
(IRS)$_t$ firm size	-0.0003 (-5.63) ***	-0.0001 (-2.80) ***	-0.0003 (-7.72) ***	-8.9e-05 (-1.96) **	-0.0003 (-5.59) ***	-0.0001 (-2.86) ***	-0.0003 (-5.53) ***	-0.0002 (-6.21) ***
(competition)$_{t-1}$ low-split	0.0023 (1.92) *	-0.0040 (-1.73) *	0.0114 (2.51) **	-0.0094 (-2.58)***	0.0055 (6.87) ***	0.0006 (0.66)	0.0007 (3.03) ***	0.0013 (1.17)
(competition)$_{t-1}$^2 low-split	-1.3e-05 (-1.06)	4.0e-05 (1.65) *	-0.0001 (2.27) **	6.2e-05 (1.44)	-1.6e-06 (-0.75)	-1.4e-06 (-0.30)	-5.4e-07 (-1.20)	5.4e-05 (4.54) ***
(competition)$_{t-1}$ md.-split	0.0011 (1.39)	-0.0007 (0.34)	----	----	0.0012 (2.04) **	0.0027 (3.70) ***	0.0012 (3.91) ***	-0.0014 (-1.34)
(competition)$_{t-1}$^2 md.-split	-1.9e-06 (-0.46)	7.7e-06 (0.42)	----	----	9.4e-07 (1.20)	-2.2e-06 (-0.85)	1.3e-06 (1.70) **	2.6e-05 (3.95) ***
(competition)$_{t-1}$ hi.-split	0.0011 (5.12) ***	0.0016 (1.50)	0.0011 (3.56) ***	-0.0014 (-1.13)	0.0006 (4.13) ***	0.0051 (4.69) ***	0.0020 (6.33) ***	-0.0007 (-0.71)
(competition)$_{t-1}$^2 hi-split	-6.4e-07 (-2.27) **	-2.4e-06 (-0.64)	-9.4e-07 (-2.31) **	4.3e-06 (1.02)	1.6e-07 (1.12)	-4.9e-06 (-0.95)	-7.2e-07 (-1.22)	4.4e-06 (1.18)
(contagion)$_{t-1}$ low-split	1.2320 (6.84) ***	0.3054 (1.27)	1.3120 (5.26) ***	0.7545 (2.25) **		0.1005 (0.35)	0.3348 (2.12) **	0.5154 (2.24) **
(contagion)$_{t-1}$^2 low-split	-1.5023 (-7.13) ***	-0.1414 (-0.52)	-1.8496 (-5.39) ***	-0.8287 (-1.99) **	-0.6750 (-2.15) **	0.0490 (0.14)	-0.6611 (-3.13) ***	-0.1348 (-0.51)
(contagion)$_{t-1}$ md.-split	1.3648 (5.93) ***	-0.2770 (-0.74)	----	----	0.9354 (4.83) ***	-0.0198 (-0.09)	0.7105 (4.81) ***	0.4703 (2.31) **
(contagion)$_{t-1}$ md-split	-1.2955 (-3.19) ***	1.3766 (2.14) **	----	----	-0.8380 (-2.99) ***	0.5529 (1.88) *	-0.6219 (-2.88) ***	-0.2427 (-0.92)
(contagion)$_{t-1}$ hi.-split	0.6999 (4.21) ***	0.6902 (2.22) **	1.4051 (6.47) ***	0.9988 (3.15) ***	0.7277 (4.90) ***	0.8459 (3.57) ***	1.3288 (8.65) ***	0.0057 (0.02)
(contagion)$_{t-1}$^2 hi.-split	-0.9228 (-3.72) ***	-0.5207 (-1.34)	-1.7551 (-5.79) ***	-0.7925 (-2.00) **	-1.0634 (-4.84) ***	-0.6100 (-2.29) **	-1.4656 (-5.96) ***	0.3298 (0.96)
(ETA)$_t$ var. decomp	1.00 (29.55) ***	1.00 (21.30) ***	1.00 (20.88) ***	1.00 (16.0) ***	1.00 (23.55) ***	1.00 (22.04) ***	1.00 (23.90) ***	1.00 (17.76) ***
Ind. dum. Period dum.	Yes yes	Yes yes	Yes yes	Yes yes	Yes yes	Yes yes	Yes yes	Yes yes
R^2	0.89	0.90	0.92	0.94	0.89	0.90	0.89	0.90
Obs	896	896	488	488	896	896	896	896
p-val indep.	0.85		0.71		0.53		0.00	

Notes: FEVD models are estimated by bootstrapping, t-value within parenthesis (.). *, **, *** indicate significance at the 10, 5 and 1 percent significance level respectively. [(a)] Time invariant/slowly changing variables used in FEVD estimation step two are: ln(L), Export intensity, efficiency comp, contagion, firm size and industry dummies at the 2-digit level. Model 1 is split by foreign firm's capital intensity. Model 2 is split by size of industry labor productivity gap foreign/domestic. Model 3 is split by industry capital intensity and labor productivity. Model 4 split is by relative distance to production possibility frontier foreign/domestic where low(high) split indicate rel. inefficient (efficient) domestic firms.

Table A4. Correlation matrix

Correlation, domestic firms equation							
Var	$\ln(LP)^{d}$	$\ln(LP)^{f}$	$\ln(k)^{d}$	$\ln(L)^{d}$	$(IRS)^{d}$	$(exp.)^{d}$	C3
$\ln(LP)^{f}$	.57	1					
$\ln(k)^{d}$	.72	.62	1				
$\ln(L)^{d}$	.02	.00	.04	1			
IRS	-.01	.12	.28	.26	1		
$(exp.)^{d}$	-.28	-.40	-.44	.04	-.05	1	
C3	.13	.16	.28	-.57	.28	-.15	1
Contag.	.00	-.09	-.15	-.18	-.12	.48	-.03
Correlation, foreign firms equation							
Var	$\ln(LP)^{f}$	$\ln(LP)^{d}$	$\ln(k)^{f}$	$\ln(L)^{f}$	$(IRS)^{f}$	$(exp.)^{f}$	C3
$\ln(LP)^{d}$	.57	1					
$\ln(k)^{f}$	.85	.53	1				
$\ln(L)^{f}$	-.01	.15	-.12	1			
IRS	.05	.09	.03	.44	1		
$(exp.)^{f}$	-.42	.24	-.55	.32	.10	1	
C3	.16	.13	.17	-.51	.29	-.03	1
Contag.	-.09	.00	-.26	.57	.37	.55	-.03

The FEVD Model

The method relies on the robustness of the within-transformation and does not need to satisfy orthogonality of the random effects. In the estimation of the SUR-FEVD models no degree of freedom (df)-adjustment due to the inclusion of an estimated variable is done. This may lead to underestimated standard errors, though the size of the panel suggests that this problem is minor. The single equation FEVD models in Table 1 are df-adjusted. As a test of the adjustment bias we used the ado-files for STATA supported by Pluemper and obtained at www.polsci.org/pluemper/xtfevd.htm and performed single equation FEVD models (in Table 1) with and without df-adjustment. The impact of the df-adjustment on the standard errors was only minor. As an example, the df-adjustment of the single equation model 4 in Table 1 decreases the standard error from 0.0195 to 0.0173. Given the strong significance obtained for our core variables the df-adjustment is not crucial for the results. Point estimates are not affected at all by the df-adjustment.

Table A4. Correlation matrix

Correlation, domestic firms equation							
Var	$\ln(LP)^{d}$	$\ln(LP)^{f}$	$\ln(k)^{d}$	$\ln(L)^{d}$	$(IRS)^{d}$	$(exp.)^{d}$	C3
$\ln(LP)^{f}$	.57	1					
$\ln(k)^{d}$	.72	.62	1				
$\ln(L)^{d}$	.02	.00	.04	1			
IRS	-.01	.12	.28	.26	1		
$(exp.)^{d}$	-.28	-.40	-.44	.04	-.05	1	
C3	.13	.16	.28	-.57	.28	-.15	1
Contag.	.00	-.09	-.15	-.18	-.12	.48	-.03
Correlation, foreign firms equation							
Var	$\ln(LP)^{f}$	$\ln(LP)^{d}$	$\ln(k)^{f}$	$\ln(L)^{f}$	$(IRS)^{f}$	$(exp.)^{f}$	C3
$\ln(LP)^{d}$	.57	1					
$\ln(k)^{f}$	.85	.53	1				
$\ln(L)^{f}$	-.01	.15	-.12	1			
IRS	.05	.09	.03	.44	1		
$(exp.)^{f}$	-.42	.24	-.55	.32	.10	1	
C3	.16	.13	.17	-.51	.29	-.03	1
Contag.	-.09	.00	-.26	.57	.37	.55	-.03