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Non-linearity and Absorptive Capacity

Taotao Chen
Tsinghua University
Ari Kokko (ako.int@cbs.dk)
Copenhagen Business School and Stockholm School of Economics
Patrik Gustavsson Tingvall
Stockholm School of Economics

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Center for International Business and Emerging Markets
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Copenhagen Business School
Porcelænshaven 24B
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FDI and Spillovers in China: Non-linearity and Absorptive Capacity

Taotao Chen [a]
Ari Kokko [b c]
Patrik Gustavsson Tingvall [c]

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 are more linear with respect to the level of technological sophistication of 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.

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

JEL codes: C33, F21, F23, O53

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[a] School of Economics and Management, Tsinghua University, Beijing, China. chentt@sem.tsinghua.edu.cn.

[b] Department of International Economics and Management, Copenhagen Business School, Frederiksberg, Denmark, ako.int@cbs,dk

[c] China Economic Research Center, Stockholm School of Economics, Stockholm, Sweden, ari.kokko@hhs.se and patrik.gustavsson@hhs.se.

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 developing countries that have reached most of the millennium development targets. From a position as a remarkably isolated economy China has become one of the world's largest; exporter, importer, and a major destination for foreign direct investments (FDI).

At the same time, the domestic capital stock has grown and the Chinese industry has experienced significant productivity growth, in many cases catching up to Western standards. As a result, the attitudes toward foreign-owned firms have 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 analyze how the presence of foreign firms affects the productivity of local firms through "technology spillovers" – 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-linearity's 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), Yao (2006), Giorgioni, *et al*., (2006), and Pan (2003) conclude that the presence of foreign MNCs has generally contributed to spillovers and productivity increases in domestic Chinese firms, while e.g. Ma and Zhang (2008) argue that spillovers are insignificant, or perhaps even negative. It is therefore not 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. 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. Following early analyses like 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. More recently Hong *et al*., (2009) analyzed the relation between FDI spillovers in China and provincial absorptive capacity, and found substantial differences across Chinese provinces.[1] In a similar vein Yonglai *et. al*. (2005) and Lu and Zhang (2004) 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, and there were no clear signs of any impact from FDI on local productivity in the remaining industries.[2]

Variations in FDI with respect to the spillover channel (backward or forward linkages) and the type of industry (capital or labor intensive) were analyzed by Lai *et al*. (2009). They only found positive spillovers from backward linkages, a result consistent with Kirkulak *et al*. (2009) who also found backward linkages to be more important than forward linkages in China. Using firm level data Blake *et al.* (2009) analyzed various channels for FDI spillovers and found exports from MNCs to be the most prominent source of spillovers.

Other studies have focused on ownership and country-of-origin effects. Differentiating between FDI from OECD countries and overseas Chinese firms, Buckley *et al*. (2005) found more consistent positive effects from FDI made by overseas Chinese firms. In a later study (Buckley *et al*. 2007a), the same authors found that FDI from Western countries generated greater spillover in technology intensive industries, while FDI from overseas Chinese firms had stronger positive effects in labor intensive sectors. Buckley *et al*. (2007b) differentiated

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[1] Madriaga and Ponchet (2007) apply spatial econometric techniques to analyze how FDI spillovers are transmitted across space in China.

[2] To avoid the industry heterogeneity problem, some studies have focused on a single industry. One such example is Buckley *et al*. (2007c) who analyzed FDI spillovers in the Chinese automotive industry.

between state-owned and private Chinese firms, and found that state-owned firms benefited from both Western FDI and FDI from overseas Chinese. Private Chinese firms, on the other hand, only benefited from overseas Chinese FDI.

Ma *et al*. (2008) addressed similar questions, but reached different results. Their results indicated that FDI from overseas Chinese firms had negative effects on Chinese local firms, while FDI from OECD countries resulted in positive externalities for local firms.

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 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) argued 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) suggested 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. Their 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. Hence both the volume of FDI and the quality of the receiver and transmitter come into play.

The estimation of spillovers is complicated not only by the bilateral nature of the process. To the extent that the analysis covers data for several years, it is necessary to consider how to handle unobservable fixed effects. In the current context, controlling for fixed industry effects is important not only to avoid omitted variable bias, but also to avoid confusing general industry productivity level effects. 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 of interest have more cross sectional than longitudinal (within) variation: estimations using traditional fixed-effect models are therefore 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. We therefore apply the FEVD method in a SUR-model framework. This allows us to both handle the bilateral nature of spillovers and the complications related to fixed effects.

With this as a background, we will proceed to explore the possible non-linear nature of spillovers as well as industry heterogeneity in spillovers.[3] 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 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, modeling 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

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

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 or domestic), the data set contains information on the number of employees, valued added, investments and capital, and a host of other industry characteristics.

3.2 Modeling spillovers

The vast majority of older studies of spillovers – such as 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.[4] 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 gap is very wide and foreign and domestic firms are far from each other in technology space, using widely different technologies. Therefore, there might be an intermediate range with an optimal technology gap.

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

[4] An early example considering the technology gap is Findlay (1978).

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 suggests 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 and widely used "contagion effect" spillover measured as industry employment share in foreign owned firms[5] and (ii) the productivity of the competitors. In this specific setting, the term "competitors" is defined on the basis of national origin. For domestic firms, competition comes from foreigners, and for foreign-owned firms, competition comes from local firms. The underlying hypothesis is that if variations in the productivity of your competitor causes similar movements in your productivity, there is a competition effect. However, this hypothesis is requires some further adjustments to the model. First, it may take time for the competition effect to take place, motivating a lag structure. In addition, drawing on the time series definition of strong exogeniety, an impact lag is motivated.[6] Secondly, to avoid mixing up variations in productivity with general level effects, it is crucial to control for fixed effects. Third, local firm exit caused by the entry of foreign-owned firms is most likely in industries with small margins. To remove the some of the contamination on the spillover from competition variable caused by firm exit, we add a control for industry competition using the C3 concentration index. In order to extract further information from the joint behavior of foreign and domestic firms, we follow Kokko (1996) and Zellner (1962) and analyze the system in a SUR-model set-up[7]. This

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

[6] See e.g. Hendry (1995).

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

helps us account for simultaneity and correlated errors, which improves the efficiency of the estimation. The heterogeneity of spillovers is then analyzed by separating industries with respect to technology gaps and absorptive capacity. For both spillover variables, we explore the curvature of the relationship by applying a non-linear system equation.

3.3 Estimation model and variables

The empirical model is based on detailed 4-digit industry level data that is analyzed in 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.

$$\ln\left(\frac{VA}{L}\right)_{it}^{d} = \propto + \beta_1(spill.comp.)_{it-1}^{f} + \beta_2(spill.contagion)_{it-1} + \beta_3 ln(K/L)_{it}^{d} + \beta_4 ln(L)_{it}^{d} + \beta_5(C3)_{it} + \beta_6(export)_{it}^{d} + \beta_7(IRS)_{it}^{d} + \gamma_t + \eta_i^{d} + \varepsilon_{it}^{d} \qquad (eq.1)$$

$$\ln\left(\frac{VA}{L}\right)_{it}^{f} = \propto + \beta_1(spill.comp.)_{it-1}^{d} + \beta_2(spill.contagion)_{it-1} + \beta_3 ln(K/L)_{it}^{f} + \beta_4 ln(L)_{it}^{f} + \beta_5(C3)_{it} + \beta_6(export)_{it}^{f} + \beta_7(IRS)_{it}^{f} + \gamma_t + \eta_i^{f} + \varepsilon_{it}^{f} \qquad (eq.2)$$

Super-indices (d,f) indicate foreign and domestic, respectively. Spillovers from competition (*spill.comp*) are captured by labor productivity[8] and spillovers from contagion (*spill.contagion*) by the industry employment share in foreign owned firms. Other control variables include capital intensity *(K/L)* measured as assets per employee, size measured as the log of number of employees *(L)*, industry competition *(C3)* measured as share of industry sales concentrated to the three largest firms, export intensity *(export)* measured as the ratio of industry exports to sales and scale economies at the firm level (*IRS*) measured as average firm size.[9] The eta (η) variable is a

[8] More precisely, for domestic firms we use the labor productivity of foreign firms on the right hand side, while equations for foreign firms have local labor productivity on the right hand side.

[9] Monetary variables are deflated using the consumer price index.

fixed effect variance decomposition variable that will be discussed in the next section, γ is a period dummy and ε is the residual. Due to possible endogeneity and impact lags, the spillover variables are lagged one period.[10]

Equation (2), for foreign-owned firms, is symmetric to the one for local firms. 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, 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.[11] The results also suggest a positive correlation between industry concentration and productivity. The size variable is non-significant, whereas the scale variable is negative and significant.

In estimation 1.2, the model is augmented by adding lagged values for the two spillover variables (spillover by contagion and spillover by competition). 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

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[10] The main argument for possible endogeneity is that foreign firms may choose to enter industries where local firm productivity is originally relatively high. It is also likely that spillovers do not materialize immediately, which suggests that a lag structure should be included.

[11] see e.g. Kokko *et al*., (2001) and references therein.

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 both spillover variables and the export variable 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 contribute to solving this problem, but may also 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 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 if the “within” variance is small relative to the “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.[12]

In estimation 1.4 we therefore re-estimate the FE model by way of FEVD. The FEVD estimation raises 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 raises the significance of the ETA variable somewhat and leaves the estimates of other 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.

Since the equations for domestic and foreign owned firms have some common variables and may be interrelated, it may be possible to further improve the analysis by estimating seemingly unrelated regression models (SUR). We have therefore estimated FEVD-SUR variants of the relevant models. To ensure that we are not violating any distributional assumptions, the SUR models are bootstrapped.[13]: The estimation results are found in Appendix Tables A2 and A3.

[TABLE 1 ABOUT HERE]

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

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

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 shows 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 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.[14]

[FIGURE 1 ABOUT HERE]

A possible criticism against this productivity driven competition spillover variable is that it could 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 are 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.

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

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 Table A2, and the results suggest that a non-linear approach is well motivated. In particular, it appears that for local firms, spillovers from contagion are highly non-linear, with spillovers having a peak at a foreign industry employment share of about 40 percent. The spillover effect diminishes with increasing foreign share, and drops to negative values at very high levels of foreign dominance.

[FIGURE 2 ABOUT HERE]

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 local firms left are enterprises operating in niches that are too small or too "primitive" to be of interest for 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. 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, with one third of the industries in each group.[15] Neither capital intensity nor productivity are likely to be perfect identifiers of the absorptive capacity of local industries: as a complement, we therefore 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 industry distribution; analogously, high-high sectors are those in the top third both in terms of capital intensity and labor productivity.[16] 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).

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[15] We use the capital intensity of foreign owned firms as measure of industry capital intensity.

[16] Following Chen (2005), we use the capital intensity and labor productivity of foreign-owned firms as the 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.

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.

[FIGURE 3 ABOUT HERE]

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.

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 matter 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.[17] For each categorization, three groups are defined: group 1 (small gap), with a productivity ratio (LP^f/LP^d) less than 1 or alternatively a relatively small distance to the technology frontier (the relative efficiency eff^d/eff^f in the top 1/3 of the sample; group 2 with a medium sized gap (LP^f/LP^d between is between 1 and 2 or eff^d/eff^f is in the middle 1/3 of the sample); and group 3 (large gap) where domestic firms are clearly behind foreign firms (labor productivity gap > 2 or eff^d/eff^f in the bottom 1/3 of the sample).[18]

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.

[FIGURE 4 ABOUT HERE]

The results suggest that domestic firms are affected by competition from foreign-owned firms in a wide range of technologies. In this context, it might be worth to stress some particular features of

[17] The distance from the frontier is estimated as minus the natural log of the technical efficiency via E(u|e) and based on stochastic production models with a disturbance that is assumed to be a mixture of two components, which have a strictly nonnegative and symmetric distribution, respectively. We use a standard set-up with value added as a function of employment, capital and period dummies. Calculations are done using STATA.

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

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 absorptive 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, and may be taken into account when thinking about policy implications: 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. Hence, the fact that Chinese firms are gradually becoming more advanced and catching up to foreign firms does not seem to reduce the potential benefits from FDI. It should also be noted that while firm exit is typically interpreted as a negative effect 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 inward FDI flowing to China have been beneficial for the Chinese economy in the sense that local firms have been able to take advantage of spillovers from both contagion and competition. However, spillovers are not evenly distributed across firms and industries. On the contrary, there are strong signs of non-linearity and heterogeneity. 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 more successful than low-end industries (with low absorptive capacity and/or low efficiency) in generating various spillover benefits from foreign presence. 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.

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 foreign 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, and endogeniety, and to absorb fixed effects in a manner that allows us to utilize the 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 noise, 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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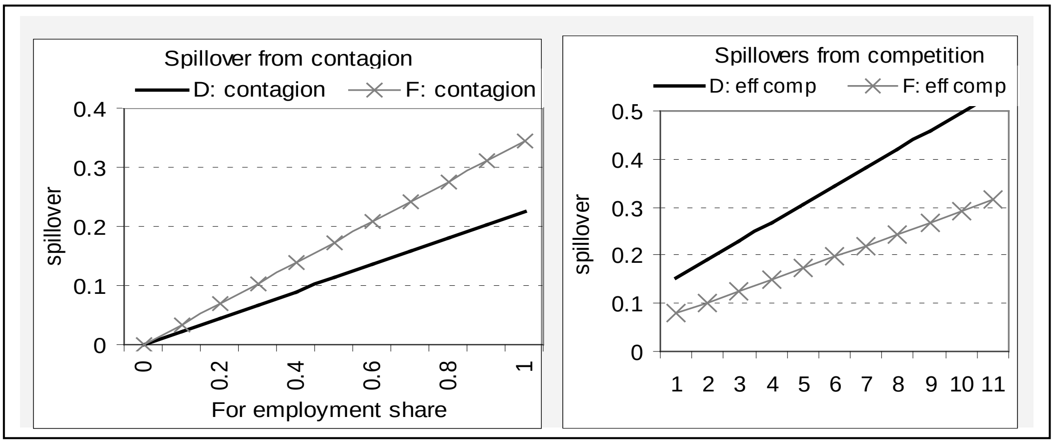
Table 1. Basic models, dependent variable, labor productivity.

	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)***
$(\text{Export intensity})_t$	-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)***
$(\text{Spillover})_{t-1}$ contagion		0.1983 (2.67)***	0.0141 (0.11)	0.1925 (3.70)***	0.2147 (5.13)***	0.1913 (3.68)***
$(\text{Spillover})_{t-1}$ 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

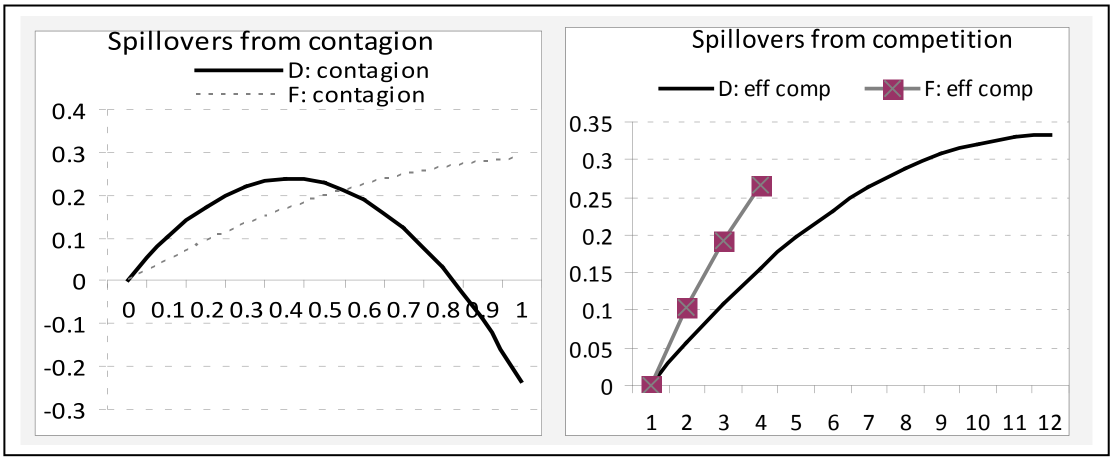
Notes: FEVD models are estimated by bootstrapping, t-value within parenthesis (.). *, **, *** indicate significance at the 10, 5 and 1 percent significance level respectively. [(a)] Time invariant/slowly changing variables used in FEVD estimation step two include: ln(L), Export intensity, spillovers from competition, spillovers from 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 without industry dummies. [(c)] Time invariant/slowly changing variables used in FEVD estimation step two include all right hand side variables except the time dummies.

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



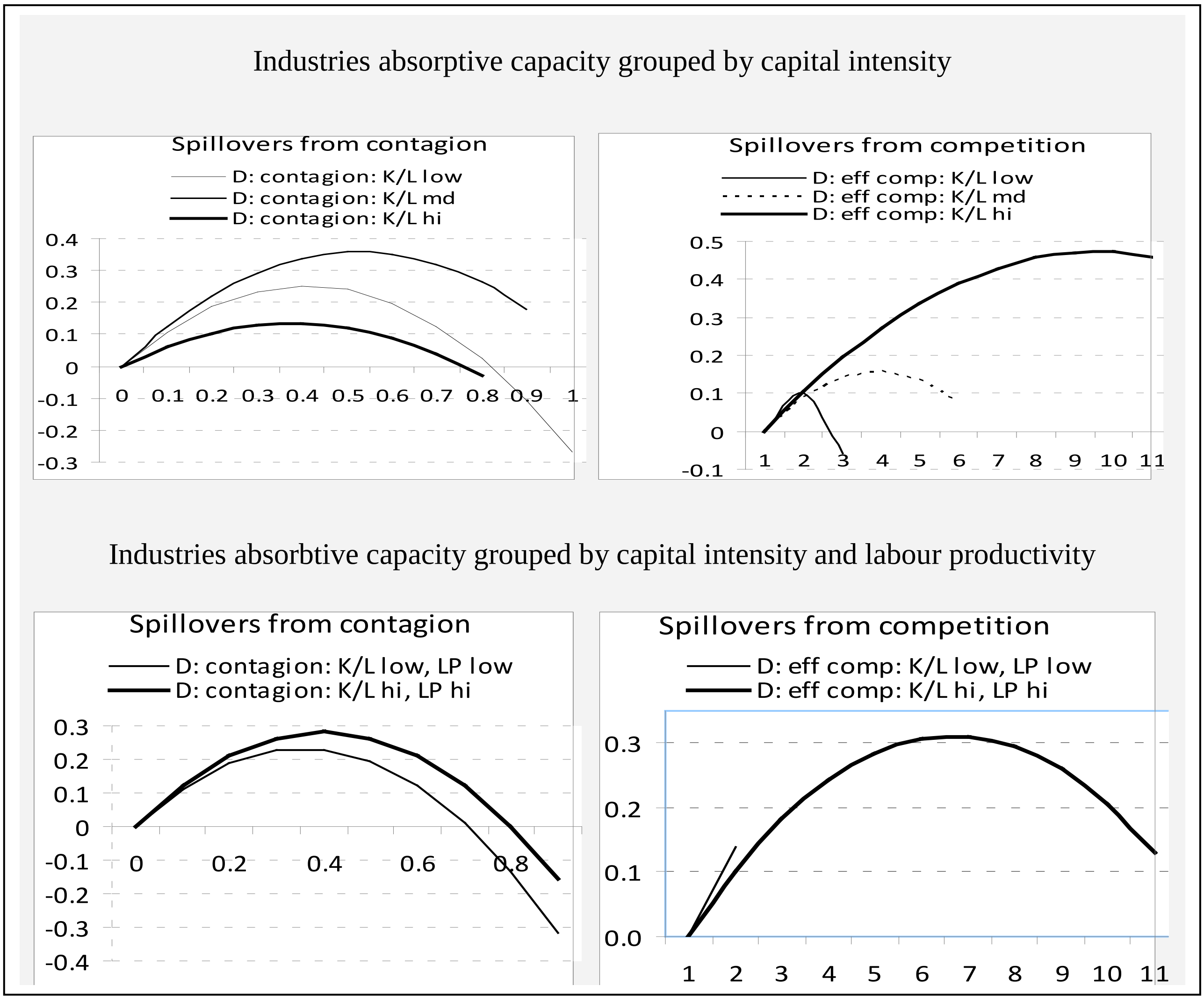
Notes: Prefix F, D: indicate impact on foreign and domestic firms respectively. Solid (non-dotted) lines in Figure 1 are significant at the 1 percent level. Estimation results are found in Appendix Table A2.

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



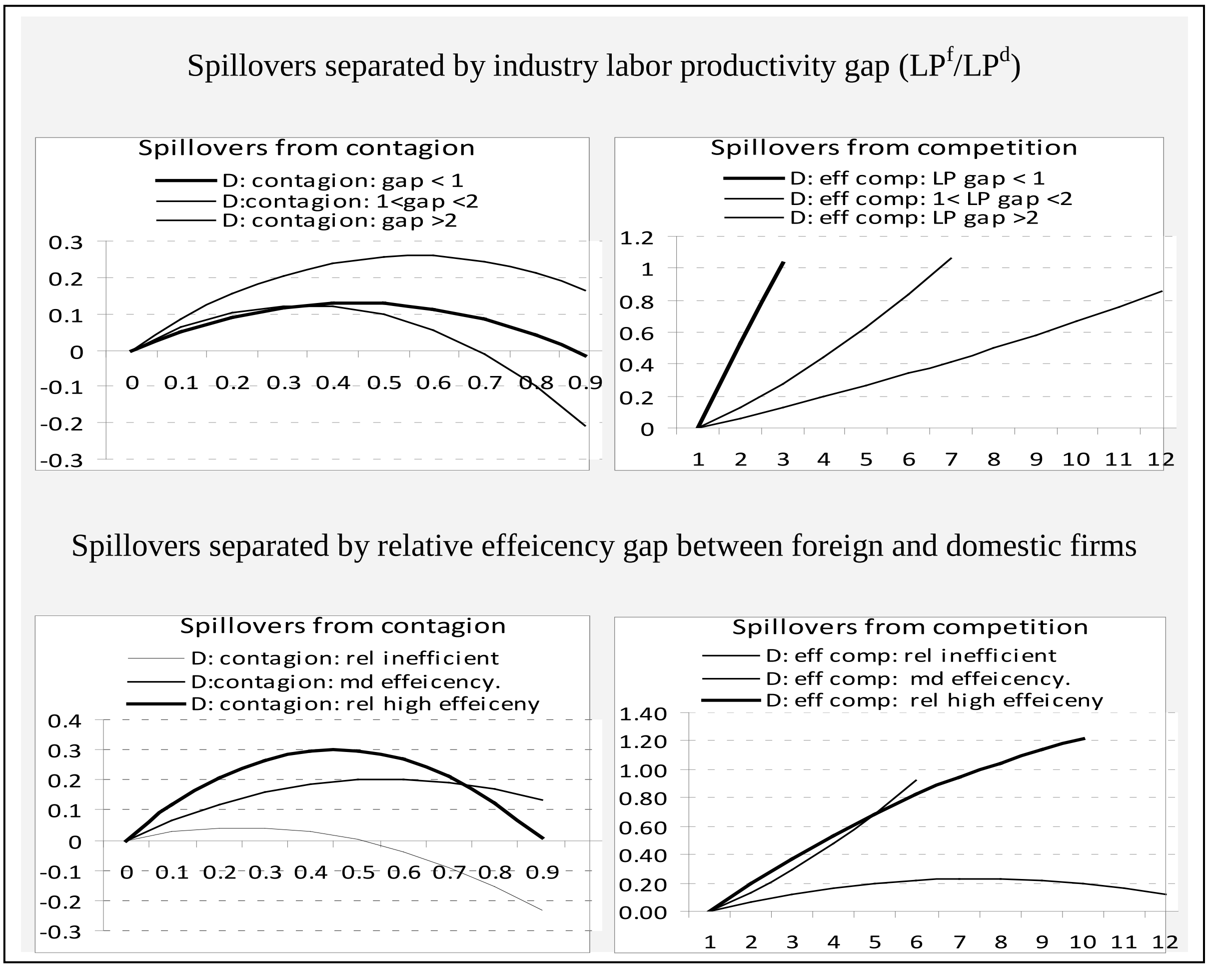
Notes: Prefix F:, D: indicate impact on foreign and domestic firms respectively. Solid (non-dotted) indicate joint significance of the first and second order polynomial on at least the ten percent significance level. Dotted lines are not significant at the ten percent significance level. Estimation results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

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. In the upper panel, groups are sorted w.r.t. the capital intensity of foreign owned firms with 1/3 of the observations in each group. In the lower panel low-low (high-high) indicate that both industry capital intensity and labor productivity belong to the bottom (top) third of the distribution. Estimation results are found in Appendix Table A3.

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



Notes: Prefix D: indicates 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. In the upper panel, a large (small) labor productivity gap indicates that domestic firms are relatively inefficient (efficient). In the lower panel, each group contains 1/3rd of the observations with the groups sorted by the ratio eff^d/eff^f , which is a measure of the relative efficiency of domestic firms in comparison with foreign-owned firms. Estimation results are found in Table A3.

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(K/L)	5.30	2.46	5.77	2.45
Export intensity	0.14	2.89	0.34	2.41
Firm size	289	2.51	282	3.33
ln(L)	10.28	5.27	9.03	3.46
	All firms			
Spillovers from contagion	0.22	3.07	..	..
Industry concentration (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
$\ln(L)_t$	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)***
$(IRS)_t$ firm size	-0.0003 (6.63)***	-6.7e-05 (-2.01)**	-0.0003 (-6.11)***	-7.2e-05 (-2.01)**
$(C3)_t$ 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)
$(ETA)_t$ 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, spillovers from competition, spillovers from 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 by K/L [(A)]		M2.Split by K/L & LP [(B)]		M3. Split by lp(f)/lp(d) [(C)]		M4. Split by gap(f)/gap(d) [(D)]	
Variable	domestic	foreign	domestic	foreign	domestic	foreign	domestic	foreign
$\ln(L)_t$	0.0126	0.0372	0.0163	0.0130	0.0141	0.0328	0.0134	0.0477
	(1.46)	(3.62)***	(1.77)*	(0.97)	(1.51)	(3.50)***	(1.50)	(4.91)***
$\ln(K/L)_t$	0.6046	0.6783	0.5753	0.7449	0.6182	0.6707	0.5901	0.7102
	(27.06)***	(24.18)***	(21.98)***	(22.19)***	(23.49)***	(26.21)***	(26.83)***	(31.09)***
$(C3)_t$	0.1759	0.2279	0.1425	-0.2226	0.1867	0.2222		0.2429
Ind. Conc.	(2.54)***	(2.88)***	(1.49)	(-1.60)	(2.80)***	(3.00)***		(3.13)***
$(\text{Export intensity})_t$	-0.2833	-0.1716	-0.3146	-0.1827	-0.1714	-0.1877	-0.1034	-0.2373
	(-4.86)***	(-2.86)***	(-3.66)***	(-2.16)**	(-3.09)***	(-2.95)***	(-1.97)**	(-4.47)***
$(\text{IRS})_t$	-0.0003	-0.0001	-0.0003	-8.9e-05	-0.0003	-0.0001	-0.0003	-0.0002
firm size	(-5.63)***	(-2.80)***	(-7.72)***	(-1.96)**	(-5.59)***	(-2.86)***	(-5.53)***	(-6.21)***
$(\text{competition})_{t-1}$	0.0023	-0.0040	0.0114	-0.0094	0.0055	0.0006	0.0007	0.0013
low-split	(1.92)*	(-1.73)*	(2.51)**	(-2.58)***	(6.87)***	(0.66)	(3.03)***	(1.17)
$(\text{competition})_{t-1}$^2	-1.3e-05	4.0e-05	-0.0001	6.2e-05	-1.6e-06	-1.4e-06	-5.4e-07	5.4e-05
low-split	(-1.06)	(1.65)*	(2.27)**	(1.44)	(-0.75)	(-0.30)	(-1.20)	(4.54)***
$(\text{competition})_{t-1}$	0.0011	-0.0007	----	----	0.0012	0.0027	0.0012	-0.0014
md.-split	(1.39)	(0.34)			(2.04)**	(3.70)***	(3.91)***	(-1.34)
$(\text{competition})_{t-1}$^2	-1.9e-06	7.7e-06	----	----	9.4e-07	-2.2e-06	1.3e-06	2.6e-05
md.-split	(-0.46)	(0.42)			(1.20)	(-0.85)	(1.70)**	(3.95)***
$(\text{competition})_{t-1}$	0.0011	0.0016	0.0011	-0.0014	0.0006	0.0051	0.0020	-0.0007
hi.-split	(5.12)***	(1.50)	(3.56)***	(-1.13)	(4.13)***	(4.69)***	(6.33)***	(-0.71)
$(\text{competition})_{t-1}$^2	-6.4e-07	-2.4e-06	-9.4e-07	4.3e-06	1.6e-07	-4.9e-06	-7.2e-07	4.4e-06
hi-split	(-2.27)**	(-0.64)	(-2.31)**	(1.02)	(1.12)	(-0.95)	(-1.22)	(1.18)
$(\text{contagion})_{t-1}$	1.2320	0.3054	1.3120	0.7545		0.1005	0.3348	0.5154
low-split	(6.84)***	(1.27)	(5.26)***	(2.25)**		(0.35)	(2.12)**	(2.24)**
$(\text{contagion})_{t-1}$^2	-1.5023	-0.1414	-1.8496	-0.8287	-0.6750	0.0490	-0.6611	-0.1348
low-split	(-7.13)***	(-0.52)	(-5.39)***	(-1.99)**	(-2.15)**	(0.14)	(-3.13)***	(-0.51)
$(\text{contagion})_{t-1}$	1.3648	-0.2770	----	----	0.9354	-0.0198	0.7105	0.4703
md.-split	(5.93)***	(-0.74)			(4.83)***	(-0.09)	(4.81)***	(2.31)**
$(\text{contagion})_{t-1}$	-1.2955	1.3766	----	----	-0.8380	0.5529	-0.6219	-0.2427
md-split	(-3.19)***	(2.14)**			(-2.99)***	(1.88)*	(-2.88)***	(-0.92)
$(\text{contagion})_{t-1}$	0.6999	0.6902	1.4051	0.9988	0.7277	0.8459	1.3288	0.0057
hi-split	(4.21)***	(2.22)**	(6.47)***	(3.15)***	(4.90)***	(3.57)***	(8.65)***	(0.02)
$(\text{contagion})_{t-1}$^2	-0.9228	-0.5207	-1.7551	-0.7925	-1.0634	-0.6100	-1.4656	0.3298
hi-split	(-3.72)***	(-1.34)	(-5.79)***	(-2.00)**	(-4.84)***	(-2.29)**	(-5.96)***	(0.96)
$(\text{ETA})_t$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
var. decomp	(29.55)***	(21.30)***	(20.88)***	(16.0)***	(23.55)***	(22.04)***	(23.90)***	(17.76)***
Ind. dum.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period dum.	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 include: ln(L), Export intensity, spillovers from competition, spillovers from contagion, firm size and industry dummies at the 2-digit level.

[(A)] Model 1 are split w.r.t capital intensity of foreign owned firms with 1/3 of the observations per group.

[(B)] Model 2 is split by industry capital intensity and labor productivity with low-low (high-high) containing industries where both labor productivity and capital intensity are in the low(high) 1/3 of the industry distribution.

[(C)] Model 3 is split by size of industry labor productivity gap foreign/domestic according to: high (ratio > 2), medium (1<ratio<2), low (ratio<1). That is, in the high (low) group, domestic firms are relatively inefficient (efficient).

[(D)] Model 4 is split by relative distance to production possibility frontier foreign/domestic where low (high) indicate inefficient (efficient) domestic firms having 1/3 of the observations per group.

Table A4. Correlation matrix

Correlations, equations for domestic firms							
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
Contagion	.00	-.09	-.15	-.18	-.12	.48	-.03
Correlations, equations for foreign firms							
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
Contagion	-.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 by the df-adjustment.