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2011/53/ST

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January 13, 2011

I am grateful for financial support from the INSEAD Alumni Fund, and I would like to thank Jasjit Singh, Bruce Kogut, Henrich Greve, Anil Gupta, Brian Wu, Brian Silverman and Anita McGahan for helpful ideas and comments, Fu Qiang for discussion, and participants at the National University of Singapore POGI Conference, CRES Strategy Seminar at Washington University, INSEAD Economics Symposium. The usual disclaimer applies.

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Abstract

An often contentious issue is how spillovers affect foreign versus domestic industry leadership in a developing economy, for instance, whether policies favour domestic firms. To address such issues it is important to understand the baseline effect of spillovers on industry leadership, which I focus on. I develop a formal model that compares the effect of different types of spillovers on industry leadership. I find that spillovers driven by absorptive capacity, versus by demonstration effects, are more likely contentious as: domestic leadership is higher; outcomes are more sensitive to host country policies; and the firm dynamics, such as entry and exit, due to the spillovers are harder to observe. Thus baseline expectations of which firms lead an industry depend on the types of spillovers.

Keywords: Spillovers; Firm and Industry Dynamics; Entry and Exit

1 Introduction

The liberalisation of industries in developing economies is an important element of the transition towards more market-oriented, capitalist economic systems, such as in China, India, and the former communist countries in Eastern Europe. Liberalisation is often a contentious policy initiative and hence the interest in deepening the understanding of the effects of liberalisation on an industry. An issue that receive attention, a key concern in strategy, is whether the leading players in the industry emerge to be foreign versus domestic. These issues of firm dynamics within an industry undergoing liberalization are all but settled. For instance, there is currently a lively debate on the attractiveness of China to foreign firms. Some prominent multi-nationals have complained about the difficulty of winning in the Chinese market due to market distortions: for instance, the CEO of GE has voiced concerns that "I'm not sure that in the end they want any of us to win or any of us to be successful". However, a response is that "China is ever more open for business", a large and competitive market, and not that distortionary policies are the determining factor.[1]

However, to assess the effects of potential distortions requires a baseline firm dynamics against which to compare. In a developing economy undergoing a liberalisation such a baseline is not straightforward. There are typically different types of firms, not just private domestic firms, such as foreign firms and state-owned firms. Not only, these diverse types of firms are not competitively separated. A key link across these types of firms is technological spillovers, in particular from foreign to domestic firms. However, the effect of spillovers on industry leadership is not necessarily clear. Spillovers may affect a broad set of firms in the industry, with an effect on average industry technology, whereas industry leadership refers to the subset of firms with greater resources and capabilities, in the right tail of the distribution.

Indeed, although spillovers are usually a policy goal, the empirical literature on spillovers in developing economies has found mixed results (Blomström and Kokko 1998, Aitken and Harrison 1999, Gorg and Greenaway 2004, Meyer and Sinani 2009, Altomonte and Pennings 2009). A key reason for mixed results are the offsetting effects on domestic firms of the positive effects from

[1] For instance, comments by the CEO of GE, Jeff Immelt, about the treatment of foreign companies in China: "I'm not sure that in the end they want any of us to win or any of us to be successful", as reported in the Financial Times, in an article titled "American business sours on China" on July 13, 2010 (Rachman 2010). A response by the minister of commerce of China, Chen Deming, reassures that "China remains open for business" and the understanding that ""FDI fosters innovation" and "China wants to make better use of the knowledge and expertise of multinationals", in a comment entitled "Thriving China ever more open for business" in Financial Times July 25, 2010 (Deming 2010).

technology transfer and the negative effects from increased competitive pressure due to the foreign firms,which are empirically are hard to disentangle. Thus although some degree of spillovers are to be expected in a developing economy,spillovers are at times contentious.

To illustrate, in China there are differences across industry sectors. In high speed trains foreign firms entered joint ventures that were in part designed to transfer technology in return for market access. However, much faster than had been expected by foreign firms, in just a few years Chinese firms have emerged as leading firms. There is disagreement about why the Chinese firms developed technologically so fast; in particular, the extent to which this is due to inappropriate use of foreign firm technology versus development of own R&D capabilities, building on the legitimate base of technology acquired from the foreign firms. In textile machinery a leading European multi-national firm was surprised at the speed at which the best of the Chinese private competitors developed, even though there was much more limited change amongst the weaker competitors. Much of the learning was driven by reverse engineering of the Western products, which is not necessarily in violation of intellectual property laws but does require skilled engineers due to the complexity of the integrated machines. In contrast, liberalisation of retailing has led to a mix of foreign and domestic firms emerging as industry leaders, replacing the prior substantial state-owned presence. Spillovers from foreign to domestic firms occur, such as due to labor mobility and inspiration from foreign stores,but tend not to be so contentious.[2]

Thus the effect of spillovers on industry leadership is in some cases contentious as the competitive process is considered to be distorted. However, to assess the extent of distortions there is a need for an appropriate baseline expectation for firm dynamics: what firms would emerge as leaders if firm dynamics were driven by some degree of legitimate spillovers and ensuing competitive effects.

I contribute to understanding this baseline by developing a formal model. This allows me to highlight how this common feature of liberalisation, technology spillovers from foreign to domestic firms, sheds light on the issue of industry leadership. In addition, in a formal model I am able to separately consider the effects of foreign firm spillovers and competitive pressure, which leads to

[2] For instance, in high speed trains in 2004 Japan's Kawasaki Heavy Industries (KHI) partnered with China's CSR Qingdao Sifang. This was a contentious deal: At the time the Chairman of Central Japan Railway, Yoshiyuki Kasai, advised KHI gainst the deal due to the risk of creating a low cost competitor. Six years later the risk has materialised: Sifang has "digested" the KHI technology and does not need the partnership anymore. The speed of technological catch-up was much faster than had been imagined at the time of the deal (Dickie 2010). In retail there has been substantial growth of private and foreign players and some restructuring of state-owned firms (e.g., Industry Updates 2008, Zhu 2005). For case of Saurer in textile machines see Ryans 2005.

suggestions for how to empirically disentangle these phenomena and highlights why certain types of spillovers are more likely contentious.

In the model there are two types of firms: domestic and foreign firms. I aim to keep the firm dynamics within each type of firm relatively straightforward so as to focus on the effects of spillovers. I develop the model in stages, first specifying how domestic and foreign firms differ[3], and add spillovers that transfer technology from foreign to domestic firms. I then consider how domestic firm entry and exit responds to the effect of spillovers, building on basic building blocks of models of industry evolution.[4]

The baseline firm dynamics due to spillovers are likely to substantially differ across industries and countries: indeed, it is in part this variation which makes the need for clarity on the baseline important. Considering the impact of spillovers on industry leadership the impact is likely to differ depending on the mechanism through which spillovers occur. In particular, two mechanisms highlighted in the literature (e.g., Spencer 2008) are spillovers driven by demonstration effects and by domestic firm's absorptive capacity. Demonstration effects are likely to be greater for weaker domestic firms, as these firms have a larger the technology gap versus foreign firms. On the other hand, spillovers driven by domestic firms' absorptive capacity (Cohen and Levinthal 1990, Zahra and George 2002) are likely to favour the technologically stronger firms, as these firms are more likely to have better absorptive capacity due to, for instance, employee technical skills. Also, the strength of the absorptive capacity effect is likely to vary systematically across countries. For instance, R&D spend as a proportion of GDP varies substantially across countries (Figure 1): China has R&D intensity comparable to some developed economies, and substantially greater than other countries with comparable GDP per capita. Consequently, the extent to which spillovers are driven by absorptive capacity depends both on industry characteristics and national institutions.

To show the consequence of these differences within an industry on industry leadership, in the model I compare spillovers driven by demonstration effects versus absorptive capacity. The proportion of leading firms that are domestic depends on the distribution of domestic firms over technology

[3] In a different model set up, as based on population ecology, Zhou and Van Witteloostuijn (2010) take a similar approach of adapting a base model to fit transition economies by varying the selection process by type of firm (foreign, private and state-owned firms).

[4] There is a rich literature on models of industrial organization for industries with private firms. For instance, the literature on the birth of new industries and subsequent evolution to maturity, the industry life cycle, has been subject of much theoretical and empirical investigation (for instance, including Jovanovic 1982, Klepper and Graddy 1990, Hopenhayn 1992, Klepper 1996, McGahan, Argyres and Baum 2004, McGahan 2004).

resources, and the total number of domestic firms. Spillovers driven by demonstration effects have a limited direct effect on industry leadership, as few leading firms are affected by these spillovers, but there is some effect on industry leadership through increased entry. In contrast, spillovers driven by absorptive capacity increase domestic industry leadership directly, as better firms receive most of the spillovers, and indirectly as there is entry to replace weak firms that exit. Hence, the impact of spillovers on industry leadership depends on the type of spillovers.

Based on these findings I make three contributions. First, I highlight how different types of spillovers lead to distinct firm dynamics: this contributes to explaining the diverse patterns of spillovers and industry leadership across industries, such as high speed trains versus retail, by highlighting the difference in baseline firm dynamics across such industries. Second, I provide an explanation for why spillovers driven by absorptive capacity are more likely to be contentious, as: domestic leadership is higher; outcomes are more sensitive to host country policies; and the firm dynamics, such as entry and exit, due to the spillovers are harder to observe. Third, the findings indicate potential ways to disentangle the effect of spillover of technology from the foreign competitive pressure, a key challenge in the literature on spillovers.

In the rest of the paper I develop the model in stages, discussing the relevant literature at each stage, starting with spillovers and then adding entry and exit of domestic firms. I conclude with a discussion of the results and implications for empirical research.

2 Model set-up

The model is of an industry in which there are two types of firms: domestic and foreign. Within each type of firm I aim to keep the model relatively straightforward, as subsequently I add spillovers.

Domestic and foreign firms are often distinguished along two dimensions relating to the degree of technological and managerial know-how and the extent to which a foreign firm knows the local market and has connections to local businesses and government (Hennart 2009). Foreign firms are typically viewed as having a higher level of technology know-how in a developing economy context; hence the interest in spillovers. In the model I capture this by having firms characterized by a variable that refers to as the level of technology resources, which represents the aggregation of a firm's technological and managerial resources. I assume that firms have heterogeneous technology resource levels, with the average level higher for foreign firms than domestic firms.

Along the other dimension foreign firms are considered to have less knowledge of the local market and weaker connections with local stakeholders, which gives rise to liability of foreignness. In the model I capture this bundle of firm resources with a variable I refer to as local market resources. I assume that firms have heterogeneous local market resource levels, with the average level lower for foreign firms than domestic firms.

Hence I have two types of firms distinguished by two characteristics that are simple representations of more complex underlying bundles of resources and capabilities. For simplicity I assume that a firm's characteristics do not change over time, other than due to spillovers.[5] Specifically, firm i has technology resource level of v_i and local market resource level of m_i.

Throughout I illustrate the model equilibrium with numerical solutions due to the nonlinear aspects of the model once spillovers and competitive dynamics are introduced. The model set-up and algorithm used to calculate the numerical solutions is based on Costantini 2010, and Costantini and Melitz 2008. The numerical solutions are based on parameters in Table 1, which aim to replicate typical empirical values.

3 Spillovers from foreign to domestic firms

I next introduce technological spillovers from foreign to domestic firms, as this is an important within-industry link across firms in developing economies.[6] Two aspects of the model determine the spillovers. First, I have foreign firms choose whether or not to localise, which leads to an increase in local market resources at the cost of a decrease in technology resources. Although the empirical studies on spillovers generally do not incorporate a choice by foreign firms of whether or not to facilitate (or tolerate) technology spillovers, typically in return for improved local market access, the relevance of this trade-off is often apparent. For instance, the trade-off between improved market access and risk of loss of technology is core to the decision of whether to joint venture at time of market entry (Makino and Delios 1996, Luo 1997, Muller and Schnitzer 2006, Wei, Liu and Wang 2008) or post-entry (Puck, Holtbrügge and Mohr 2009), with the joint venture decision also affected by local factor and product market conditions (Hennart 2009), other firm's choices (Guillen 2003,

[5] Allowing for firm characteristics to vary over time is feasible but introduces complexity that does not help understand the impact of spillovers, which is my main focus.

[6] More generally, spillovers are from more to less technologically advanced firms, which could include spillovers from advanced domestic firms to foreign firms. In a developing economy context the main focus has been on foreign to domestic spillovers and hence, for simplicity, I focus on just this type of spillover.

Xia, Tan, Tan, 2008), and institutional arrangements (Feinberg and Majumdar 2001, Xia, Boal and Delios 2009). Also, importantly, a perceived risk of joint ventures is broader technological spillovers beyond those to the immediate joint venture partner (Zhang, Li, Hitt and Cui 2007). Hence, in the model I have the spillovers generated by those foreign firms that choose to localise.

In terms of spillovers I focus on horizontal spillovers, with particular interest in the distribution of spillovers across firms. Empirical evidence for productivity spillovers is stronger for developing than developed economies, but still not always positive (Gorg and Greenaway 2004, Meyer and Sinani 2009, Altomonte and Pennings 2009). For instance, a growing body of literature on spillovers in China finds mixed evidence over time (Table 2). The typical empirical specification considers whether the presence of foreign firms affects the productivity of domestic firms, net of a standard set of controls. There is increasing evidence of vertical spillovers (Javorcik 2004, Blalock and Simon 2009, Liu, Wang. and Wei 2009), especially to benefit upstream suppliers whereas the evidence on horizontal spillovers is more mixed.

Within the literature on spillovers competitive effects are considered primarily as a negative effect on domestic firms, through a market-stealing effect, which offsets positive spillovers. Empirically the competitive effect may not be readily separated out and hence these negative spillovers are one explanation for low or negative overall horizontal spillovers (Aitken and Harrison 1999, Altomonte and Pennings 2009). This reflects that a primary motivation for the literature on spillovers is to provide evidence of the effect of opening an economy to foreign firms on economic growth, through the effect of foreign firms on domestic firm productivity. Less common is a focus on the strategic interaction between foreign and domestic firms, even though there is evidence of effects between both sets of firms (Chang and Xu 2008, Sembenelli and Siotis 2008), not just from foreign firms to domestic firms.

Interestingly, within these mixed results there are indications that various mechanisms may play a role in generating spillovers (Spencer 2008). Evidence that spillover effects occur at a national level, not just within local areas, suggests a demonstration effect (Chang and Xu 2008). However, other evidence points to the importance of absorptive capacity (Cohen and Levinthal 1990, Zahra and George 2002) in determining spillovers (Borensztein, De Gregoriob, Lee 1998, Mancusi 2008, Blalock and Simon 2009, Meyer and Sinani 2009, Zhang, Li, Li and Zhou 2010). Hence, in the model I contrast the effect of spillovers driven by demonstration effects versus absorptive capacity.

I next describe the model set up: first the foreign firm localisation decision, and then the pattern of spillovers across domestic firms.

Foreign firm choice of whether to localise

In the model I aim to capture foreign firm's trade-off of facilitating technology transfer in return for improved local market resources. I have foreign firms choose whether to localise or not, and refer to the foreign firms that continue as is as non-localised foreign firms. For ease of exposition I use the term 'localised' as a label to denote foreign firms that choose to transfer some technology resources in return for improved local market resources.[7]

The effect on foreign firms of choosing to localise is a decrease in technology resource of I_v^{DF} percent and increase in local market resource of I_m^{DF} percent:

$$I_v^{DF}(v_i) = \lambda[(\frac{\bar{v}^D}{v_i})^{\eta^v} - 1] \tag{1}$$

$$I_m^{DF}(m_i) = (\frac{\bar{m}^D}{m_i})^{\eta^m} - 1 \tag{2}$$

The change in technology resources depends on the ratio of average level of technology resource for domestic firms, $\bar{v}^D$, versus the foreign firm, v_i: on average the ratio is less than one resulting in negative $I_v^{DF}(v_i)$. For local market resources the equivalent ratio is on average greater than one, resulting in positive $I_m^{DF}(v_i)$. The parameters η^v and η^m determine the extent to which the difference in resource levels is reduced. I assume technological transfer occurs faster than development of local market resources, so set $\eta^v = 1/2$ greater than $\eta^m = 1/3$. In addition, for technology resources the magnitude of change, I_v^{DF}, depends on the degree of institutionally determined ease of technology transfer, denoted by λ. The ease of technology transfer captures the range of institutional factors that determine technology transfer, including enforcement of intellectual property protection (with stricter enforcement corresponding to a higher value of λ) and availability, cost and skill of engineers (with more low cost, skilled engineers corresponding to a higher value of λ), as well as industry specific characteristics that affect ease of technology transfer, such as product complexity and patentability.

[7] For simplicity I have foreign firms make a binary choice of whether or not to localise while recognizing that there is a spectrum of choices as to how much technology to transfer and how much local market know-how to develop, and the contractual form of the foreign firm entry (e.g., wholly owned versus joint venture).

To determine whether to localise foreign firms compare the value of the firm if localise versus stay as is:

$$V^F(v_i, m_i) = \max \left\{ \begin{array}{cc} \frac{\pi(v_i, m_i)}{(1-\beta)} & \text{if do not localise} \\ \frac{\pi(v_i(1+I_v^{DF}(v_i)), m_i(1+I_m^{DF}(m_i)))}{(1-\beta)} & \text{if localise} \end{array} \right\} \tag{3}$$

where the value of a foreign firm depends on the ongoing per-period profits of $\pi(v, m)$ discounted at a rate β. The net benefits of localisation depend on the effect on profitability of a shift in foreign firm's resource levels to higher local market resources and lower technology resources. This leads to:

- The choice of whether to localise leads to a split in the set of foreign firms. An increase in ease of technology transfer, higher λ, leads to a lower proportion of foreign firms to localise and with on average a lower level of technology amongst firms that localise.

Firms with limited local market resources benefit the most from localisation, and firms with low technology resources have the least negative effect from transfer of technology. Hence, foreign firms with low levels of both resources localise, whereas foreign firms with high levels of both resources do not localise: hence, at intermediate levels of resources there is a cutoff between firms that do and do not localise. With a greater ease of technology transfer, a higher λ, the negative effect of localisation increases, with no change in the benefit, and thus the cutoff shifts towards a lower technology level. Hence, less firms localise and those that localise have a lower average level of technology. These patterns are illustrated in Figure 2. As the ease of technology transfer, λ, affects the proportion and resource levels of foreign firms generating spillovers, I later compare the effect of spillovers at different levels of ease of technology transfer.

Spillovers driven by demonstration effects

In terms of which foreign firms generate spillovers to domestic firms I make the simplifying assumption that only the foreign firms that choose to localise generate spillovers across domestic firms.[8] The magnitude of the spillover effect depends on two elements. One is the ease of technology transfer, λ, which is common across domestic firms. A second is the set of foreign firms from which a domestic firm, with resource level v_i, may learn from: more foreign firms at a higher technology level than

[8]For instance, a more complex set up could have differential spillovers from the two sets of foreign firms with due weighting.

the focal domestic firm lead to greater spillovers. That is, the relevant foreign firms are those that have localised and that have technology better than the focal domestic firm: hence the set depends on the domestic firm's technology level. For a focal domestic firm with technology resource v_i, the number of foreign firms with technology resources above v_i is $M^{Fr}(v_i)$ and the average technology level of these firms is $\bar{v}^{Fr}(v_i)$.

I first specify how spillover vary across domestic firms when spillovers are driven by demonstration effects. Specifically, I model the spillovers from the localised foreign firms to a domestic firm as an I_v^{FDd} percent increase in technology resources:

$$I_v^{FDd}(v_i) = \lambda\{[(\frac{\bar{v}^{Fr}(v_i)}{v_i})^{\eta^v} - 1](\frac{M^{Fr}(v_i)}{M^D})^{\eta^v}\} \tag{4}$$

The first term, λ, is the ease of technology transfer: the higher, the greater the spillovers. Within the square brackets, the ratio in curved brackets is the technology gap between the domestic firm and the relevant set of foreign firms: the greater the gap, the larger the spillover effect. The power η^v determines how much of this gap is closed by the spillover effect. The second ratio is the number of relevant foreign firms (scaled by the common factor, the number of domestic firms): the more foreign firms to learn from, the greater the spillovers.

This specification leads to a non-uniform spillover effect across firms, illustrated in Figure 3. For domestic firms with very low resource levels there is a large spillover effect: the technology gap is large and almost all of the localised foreign firms to learn from. For domestic firms with higher technology level, the technology gap is moderate and there are only some of localised foreign firms to learn from. For a high enough technology resource level, the relevant number of localised foreign firms, $M^{Fr}(v_i)$, drops to zero resulting in no spillovers. Hence, the spillover effect decreases as domestic firm technology resources increases. The spillovers are strongest for firms with lower levels of technology. Hence the main effect on the distribution of domestic firms over resource levels is to increase the peak of the mass of domestic firms, due to the increase in technology resources of smaller firms.

Spillovers driven by absorptive capacity

I next specify how spillover vary across domestic firms when spillovers are driven by absorptive capacity. Whereas with demonstration effects the technology gap drives spillovers, with absorptive capacity the combination of foreign and domestic firm technologies drives spillovers. Specifically, I model the spillovers from the localised foreign firms to a domestic firm as an I_v^{FDa} percent increase in technology resources:

$$I_v^{FDa}(v_i) = \lambda\{[(\frac{\bar{v}^{Fr}(v_i)}{\bar{v}^D})^{\eta^v} - 1](\frac{M^{Fr}(v_i)}{M^{Dr}(v_i)})^{\eta^v}\} \tag{5}$$

Again, the first term, λ, is the ease of technology transfer: the higher, the greater the spillovers. Within the square brackets, the ratio in curved brackets is the technology of the relevant set of foreign firms (scaled by a common factor, the technology of the average domestic firm): that is, a domestic firm with higher technology has a set of foreign firms to learn from with higher average technology leading to greater spillovers. The second ratio is the number of relevant foreign firms to learn from scaled by the number of domestic firms with technology above that of the focal firm: that is, the extent to which the focal domestic firm has other domestic firms with similar technology aiming to learn from the foreign firms.

Hence at low levels of technology the magnitude of spillovers increases with technology level. At low technology, an increase in domestic firm technology leads to an increase in $\bar{v}^{Fr}(v_i)$ and decrease in $M^{Dr}(v_i)$ but limited change in $M^{Fr}(v_i)$, as most foreign firms have substantially higher technology resources. However, at high levels of technology, an increase in technology eventually leads to $M^{Fr}(v_i)$ reducing to zero, as only the foreign firms that localise generate spillovers. Hence, the maximal spillovers occur at an intermediate level of technology. This results in a shift to the right of the right tail of the distribution of domestic firms, as illustrated in Figure 4.

Comparing the pattern of spillovers driven by demonstration effects versus absorptive capacity highlights the non-uniform effect across firms.

- With demonstration effects the main shift in domestic firm's technology is for firms with lower levels of technology resources. In contrast, with absorptive capacity the highest spillovers are for domestic firms with relatively high technology resources.

Spillovers driven by absorptive capacity have a greater effect on the right tail of the distribution of domestic firms over resource levels, and thus industry leadership. However, this change in the distribution of technology resources across firms is not sufficient to determine the effect on industry leadership: in addition the number of domestic firms is required which depends on exit and entry.

4 Adding domestic firm dynamics: Entry and exit

The spillovers on average increase technology resources. This increases competitive pressure in the industry, thus the weaker domestic may exit. Also, the increase in technology resources raises firm profits which induces entry; in turn, higher entry raises competitive pressure thus reducing the attractiveness of entry. Hence the number of domestic firms is determined by the combined effects of spillovers on entry and exit. I next add entry and exit of domestic firms to the model: the overall structure of the model is summarised in Figure 5.

In terms of exit, I have incumbent firms decide whether to exit by comparing the value of continuing in the industry to the value of exit, which I set to zero. The value of continuing in the industry is a flow of profits, $\pi(v, m)$, discounted at a rate β. In addition I assume that each period a domestic firm may exit with probability δ, which is meant to capture the various reasons for exit not included in the model. Thus the value of a domestic firm is:

$$V^P(v,m) = \left\{ \begin{array}{cc} \frac{\pi(v,m)}{(1-\beta\delta)} & \text{if continue in the industry} \\ 0 & \text{if exit the industry} \end{array} \right\} \tag{6}$$

Consequently firms with negative profits choose to exit the industry, which corresponds to firms with sufficiently low levels of technology and local market resources.[9] This is illustrated in Figure 6,panel (a).

As there is ongoing exit of incumbents due to the exogenous risk of exit, an industry equilibrium with a stable number of firms over time requires ongoing entry. I model a simple entry process: pre-entry all potential entrants are the same and incur a sunk cost, S, to enter. Post-entry each entrant discovers its level of resources, with the probability of an entrant having resource combination $\{v, m\}$ given by the probability distribution $g(v, m)$. This is meant to capture the notion that firms enter an industry and discover over time their productivity (as in Jovanovic 1982, Hopenhayn 1992), but

[9] Due to the presence of fixed costs, sufficiently low resource levels lead to low firm revenues, sufficient to cover marginal costs but not fixed costs.

without modelling the dynamic process of changes in resource levels over time. Firms with higher resource levels continue in the industry as incumbents. Hence in the model the average resource level of incumbents is higher than of entrants, which replicates the common empirical pattern of entrants on average being smaller than incumbent firms (Dunne, Roberts and Samuelson 1988, Bartelsman, Scarpetta and Schivardi 2003). Hence post entry private firms have a range of technology and local market resources, reflecting the typical heterogeneity of resource levels present in an industry. This is illustrated in Figure 6,panels (b) and (c).

A prospective entrant determines the attractiveness of entry by comparing the expected value post entry, due to the uncertainty over post entry resource levels, with the sunk cost of entry:

$$V^E = \int_{v',m'} V^P(v',m')dG_E(v',m') - S \tag{7}$$

I assume there is a large enough set of potential entrants that if the value of entry is positive there is additional entry. However, increased entry decreases firm profits due to increased competitive pressure. Consequently, the number of entrants rises up to the point at which the value of entry is zero. The number of entrants does not rise further as otherwise entrants would have a negative expected value of entry and choose not to enter. In turn, the number of entrants determines the number of incumbents.

In sum, the equilibrium conditions determine the number of domestic firms and distribution of firms, and hence the extent to which leading firms in the industry are domestic. Here I provide intuition for the equilibrium conditions, which I describe more formally in the appendix. The foreign firms choose whether to localise, which leads to spillovers on domestic firms. Incumbent domestic firms choose whether to exit. This sets an exit region: poor resource combinations at which domestic firms choose to exit. The value of entry depends on the exit region, that is the chance of the entrant continuing in the industry, the resource level of the entrants, including the effect of spillovers, and the total number of entrants, as this affects competitive pressure in the industry. The number of entrants is such that the expected value of entry is zero: If the value of entry were positive the number of entrants would rise, whereas if negative there would be no entry. Also, the number of continuing entrants must be the same as the number of incumbent firms that exit, as I consider equilibria with a stable number of firms. The number of firms entering determines the overall competitive pressure in the industry: the foreign and incumbent strategy choices need to be consistent with this degree of competitive pressure.

To compute the model I need to specify how firm resource levels determine firm profits, $\pi(v, m)$. This requires determination of firm revenues and costs: here I provide a brief outline, with the functional forms used described in the appendix. Throughout I assume total revenues of the industry are constant, so as to consider the issues addressed in the paper net of changes in industry size. To determine firm revenues I specify that firms compete as monopolistic competitors, which assumes that all firms produce a distinct variety of product with market shares dependent on firm marginal cost and the degree of demand-side substitutability across products (parameterised by σ). Firms with lower marginal cost charge a lower price and thus capture a higher market share, generating higher revenues and profits. Firm costs depend on marginal costs and a fixed cost, F, common to all firms. Marginal costs depend on the level of technology and local market resources, with higher levels of resources leading to lower marginal cost, and on the degree of substitutability of technology resources and local market resources (parameterised by α).

5 Industry leadership with different types of spillovers: Numerical results

To highlight the effect of different types of spillovers on industry leadership I next compare four scenarios. I start with a scenario with no foreign firms, so as to provide a baseline with only domestic firms. Then I introduce foreign firms, but with no spillovers. Hence, there is only the competitive pressure from foreign firms to domestic firms. Finally I introduce spillovers, comparing the effect of spillovers driven by demonstration effects versus absorptive capacity. Across these scenarios I keep the ease of technology transfer the same, at $\lambda = 0.5$: I subsequently consider the effect of changes in this parameter. The key metrics describing the scenarios are in Table 3 and the distribution of firms over levels of technology resource is in Figure 7. I highlight key patterns in the numerical solutions through a series of remarks.

- With no foreign firms, there is a single peak of domestic firms across levels of technology resources.

Domestic firms are the subset of entrants with higher levels of technology and/or local market resources, as domestic firms with low levels of technology and local market resources exit. In this scenario just over half of entrants exit.

- With foreign firms and no spillovers, the distribution of domestic and foreign firms across levels of technology resource has two distinct peaks, with foreign firms comprising the bulk of firms with higher levels of technology resources.

The foreign firms have on average a higher level of technology resource and lower level of local market resources than domestic firms. The foreign firms account for part of the demand, leaving a reduced level of demand for domestic firms. The reduced level of demand leads to fewer domestic firms. As the foreign firms have higher resource levels, the drop in number of domestic firms is greater than the increase due to foreign firm: hence, the total number of firms drops (Table 3). As there are no spillovers, the distribution of domestic firm resources is the same as in the scenario with no foreign firms: hence, the price index and exit cut off are the same.

- With spillovers, relative to the case with no spillovers, the average level of technology rises in the industry. This leads to an increase in the number of domestic firms. Hence industry technological leadership has a greater proportion of domestic firms.

In terms of industry leadership, the number of domestic firms with high level of technology resources depends on the distribution of domestic firms and the total number of domestic firms. Spillovers raise technology resource levels: a shift in the distribution of resources (Figures 3 and 4). This makes entry more attractive, all else the same, as an entrant benefits from the spillovers. However, this results in increased entry and hence more incumbent firms. The higher entry rate leads to greater competitive pressure, a lower price index, and thus lower profits: in equilibrium the increase in number of firms is enough to reduce the expected value of entry back to zero. Hence industry leadership shifts towards domestic firms, as domestic firms are more productive and are increased in number.

Comparing across the scenarios with spillovers:

- With spillovers driven by absorptive capacity, versus demonstration effects, the exit cutoff is higher.

Spillovers raise competitive pressure in the industry as increasing level of technology resources. With spillovers driven by absorptive capacity, the stronger domestic firms become stronger. In contrast, the weaker firms receive limited spillovers and face increased competitive pressure: hence, the marginal firms exit, resulting in a higher exit cut off. In contrast, with spillovers driven by demonstration effects the greatest spillovers are for the weaker firms, on the margin of exit. This makes survival in the industry easier but is in part offset by higher competitive pressure: hence, limited change in exit cut off.

Hence, including the direct effects of spillovers and the knock-on effect on exit, spillovers driven by absorptive capacity increase technology resources by both shifting the right and left tails of the distribution of firms over technology resources to the right. In contrast, with spillovers driven by demonstration effects most of the shift is near the center of the distribution.

- With spillovers driven by absorptive capacity, versus demonstration effects, there is a smaller increase in number of firms.

With spillovers the value of entry increases, as post-entry resource levels are higher, which induces an increase in entry. With spillovers driven by absorptive capacity this is mitigated by the increase in exit cut off: hence, only a modest increase in number of firms. In contrast, with spillovers driven by demonstration effects there is a larger increase in number of firms as there is only a limited change in exit cut off.

In summary, in terms of industry leadership, as compared to the scenario with foreign firms and no spillovers:

- With spillovers foreign firm industry leadership is reduced: the proportion of firms with high technology that are foreign falls. With spillovers driven by demonstration effects the increase in domestic firm leadership is in part due to an increase in number of domestic firms, as well as a shift in firm technology resource levels. With spillovers driven by absorptive capacity the increase in domestic firm leadership is primarily due to an increase firm resource levels, with a smaller effect from an increase in number of firms. Overall, spillovers driven by absorptive capacity increase domestic leadership more so than spillovers driven by demonstration effects.

Effect of change in ease of technology transfer

I next consider the effect of a change in the ease of technology transfer, λ, with a focus on how this affects the difference between the types of spillovers. An increase in ease of technology transfer reduces the number of foreign firms localising (Figure 8, panel (a)). At a sufficiently high level no foreign firms localise: this results in no spillovers and thus no difference between the two spillover scenarios. A decrease in ease of transfer directly reduces the extent of spillovers: at the extreme this leads to zero spillovers. Hence, for sufficiently high or low values of ease of technology transfer there are no spillovers. Consequently the maximal level of spillovers, the highest average level of technology, and the minimal extent of foreign industry leadership are at an intermediate level of ease of technology transfer (Figure 8, panels (b) and (c).

Comparing across the spillover scenarios, with spillovers driven by absorptive capacity the ease of technology transfer has a greater effect on foreign firm's technology leadership. Spillovers driven by absorptive capacity are more sensitive to the localised foreign firms's average technology resource levels, not just the number of foreign firms that localise. In addition, from a public policy perspective two goals are often to achieve maximal average level of technology and high proportion of domestic firms with high levels of technology resources. However, the optimal ease of technology transfer is not necessarily the same for both goals. The more the focus is on domestic leadership, versus average level of technology, the higher the optimal ease of technology transfer.

In summary, with spillovers driven by absorptive capacity, relative to demonstration effects, the policy choices affecting ease of technology transfer have a greater effect on which outcome is achieved and to what extent this is achieved: hence, policy choices with such spillovers are more likely to be contentious.

Effect of less exit of domestic firms: presence of state-owned firms

Part of the difference between spillovers driven by absorptive capacity versus demonstration effects is due to changes in exit of domestic firms. The set-up assumes domestic firms exit if with sufficiently low resource levels. However, in liberalising emerging markets there are often state-owned firms, or firms receiving some support from the state, such that these firms are unlikely to exit.

To illustrate the effect of including state-owned firms, I introduce a third type of firm, state-owned firms, and refer to the other domestic firms as private firms. The state-owned firms have resource levels on average the same as private entrants. The state-owned firms are not subject to exit, so their average resource levels are lower than for domestic firms. As I consider situations in which the industry is in a stable equilibrium with no change in the total number of firms over time, this implies no entry of state-owned firms.[10]

The presence firms with relatively low resource levels that do not exit, the state owned firms, reduces the difference between the two spillover scenarios: Table 5. In particular, the major change is in the absorptive capacity scenario, comparing with the results in Table 3. Hence, an important part of the difference between the different types of spillovers is indeed through the effect on exit, even though this is an indirect effect. Further, if as part of a liberalisation more firms become subject to exit pressure, such as through reform of state-owned firms, this would lead to larger differences between the types of spillovers.

Robustness to parameter changes

I next show the robustness of the basic patterns described above to changes in four key parameters: market size, R; fixed costs, F; demand-side substitutability across products, σ; and the substitutability of technology and local market resources in production, α. Table 5 contains the results for the effect of the change in parameter on scenarios with spillovers driven by demonstration effects and absorptive capacity.

An increase in market size leads to more domestic firms as technology leaders because the number of domestic firms increases. The difference between the two types of spillovers remains. An increase in fixed costs (higher F) primarily increases the private firm exit cut off. The difference in exit cut off between the types of spillovers remains. Hence there is no major change in the pattern of spillovers or the indirect effect through exit: industry leadership is similar to the base case scenario. A decrease in commoditisation (lower σ) reduces the impact of differences in resource levels: the industry has lower competitive pressure on firms and hence exit cut offs are much lower. The decrease in competitive pressure matters more when spillovers are driven by absorptive capacity, as this affects the effect occurring through a change in exit. A decrease in resource substitutability (lower α) increases the value of resource configurations with a mix of both types of resources, more like domestic firms and less like either foreign firms. Hence, a greater proportion of foreign firms localise, which increases spillovers but does not affect the difference between the spillover scenarios.

[10] In terms of how state-owned firms set prices, I assume that state-owned firms that if private would not exit the industry set the same prices as private firms with the same resource levels: that is, these state-owned firms maximise profits. In contrast, I assume state-owned firms with low resource levels, that if private would exit, set lower prices than if maximising profits so as to increase market share: the price is what these firms would charge if their technology resources were high enough to avoid exit. Thus the inefficient state-owned firms, as in the exit region, charge lower prices than their profit maximising level which increases overall competitive pressure in the industry.

Hence, comparing across scenarios, from the perspective of foreign firms the tougher scenario remains the one with spillovers driven by absorptive capacity than demonstration effects: foreign firms account for a smaller share of technology leaders.

6 Discussion and concluding comments

The results highlight that the baseline expectation of which firms may emerge to lead an industry is contingent on the type of spillovers: in particular, spillovers driven by absorptive capacity lead to more domestic firms amongst industry leaders. The structure of the argument is in several steps, outlined in Figure 5: each of the steps could be empirically tested. In summary, foreign firms split in terms of how much they localise, which determines potential spillovers. The distribution of spillovers across resource levels depends on the type of spillovers and leads to a direct effect on firms. In turn, this affects firm exit, as spillovers raise competitive pressure in the industry. Finally, entry depends on the spillovers and exit policies. Hence, the effect of spillovers is both a direct aspect plus an indirect effect through changes to firm dynamics of entry and exit.

The results are illustrated through the use of numerical solutions due to the nonlinear aspects of the model. Changes in key parameters indicate that these basic patterns persist, even though the magnitude of effects may change. Hence, the numerical solutions should be interpreted more as shedding light on the direction of effects than the magnitude of effects. Also, certain aspects of the model are kept deliberately straightforward, such as the lack of entry and exit of foreign firms, which could, at the cost of additional complexity, be introduced in the model.

With these limitations in mind, returning to the examples in the introduction the model results help explain cross-sector patterns in foreign versus domestic industry leadership. In high speed trains the emergence of a few technologically advanced firms is consistent with spillovers driven by absorptive capacity. High speed trains are a complex product integrating various component technologies. In contrast, in retailing many Chinese retailers have emerged, including single stores and small chains: spillovers driven by demonstration effects seem very relevant. Textile machines is instead an intermediate case, as Chinese firms in general imitated aspects of the multi-national's products, but some Chinese firms with own R&D capability absorbed much more technology. Hence, from the foreign firm's perspective sectors such as high speed trains are particularly tough in terms of spillover effects: that is, the baseline expectations for success should depend on country and industry.

An additional issue is how observable are the firm dynamics associated with each type of spillover. With demonstration effects the main impact is on firms at the center of the distribution, plus an increase in number of domestic firms. This is a relatively visible process, as dealing with the mass of firms in the industry and entry. In contrast, with spillovers driven by absorptive capacity relatively few firms in the tails of the distribution of firms are primarily affected. In the left tail there is exit boundary, and in the right tail there is a rightward shift. Also, there is limited change in the overall number of firms. Hence, most of the effect of spillovers driven by absorptive capacity occurs within a few firms. This makes for an intrinsically more opaque change processes, for instance making it harder to distinguish technological improvement due to spillovers driven by absorptive capacity versus theft of intellectual property.

Although some of the difference across industries and countries reflects relatively exogenous factors, some of variation could be due to policy choice. The model findings highlight that for the policy choice for ease of technology transfer the optimal level depends on the policy goal, such as maximal spillovers versus domestic industry leadership. Also, the policy choice for ease of technology transfer matters more with spillovers driven by absorptive capacity. Hence, it is in such sectors that more active policy intervention is likely. This is likely to make the spillovers a more contentious issue in such sectors: that is, more contentious in high speed trains than retail.

Hence, different types of spillovers not only lead to distinct baseline firm dynamics but also differ in the ease of observing these firm dynamics and sensitivity to policy choices. As a consequence, sectors such as high speed trains, versus retailing, are likely to be contentious from a spillover perspective, even if there were no distortionary policies: thus it is important to adjust the baseline expectations for industry leadership to the type of spillovers.

Taking the chain of logic from spillovers to industry leadership as given, one implication is to consider what determines the type of spillovers. Whether an industry in a specific country has spillovers driven more by demonstration effects or absorptive capacity in part depends on factors that from the perspective of firms in the industry are often largely exogenous: technological characteristics of the industry as well as national factors, such as availability of the relevant skilled people. Hence, one empirically testable hypothesis is that across industries in developing, liberalising economies there is large variation in technological and institutional factors that shape the types of spillovers and thus the success of foreign versus domestic firms. For instance, across developing countries there is substantial variation in R&D spend (Figure 1): this suggests systematic differences in availability of scientists and engineers, and thus in ability to absorb spillovers driven by absorptive capacity.

Considering the literature on spillovers, the findings suggest one approach addressing the tough empirical question of separating the positive spillover of technology from the negative competitive effects (Aitken and Harrison 1999, Chang and Xu 2008). The model set-up and results suggest that one approach is to consider patterns across firms within an industry, as competitive pressure and spillovers are likely to have different patterns across firms. The model highlights two effects of competitive pressure: one on the exit boundary, which is stronger for spillovers driven by absorptive capacity; a second one uniform across firms as due to a change in entry levels. In contrast, the spillovers across firms are not uniform, either due to demonstration effects or absorptive capacity. The distinct patterns across firms for competitive pressure and spillovers provides an opportunity to separately identify these effects empirically.

At present the model contrasts different scenarios. The findings suggest that an interesting avenue for future research is to consider the period-by-period transition from one to another of these scenarios. In particular, from an industry with only domestic firms to one with foreign firms and spillovers. The key processes that form the model are likely to operate at different speeds: for instance, the foreign competitive pressure may continue even once spillovers have taken effect, and spillovers driven by demonstration effects may take less time to materialize than spillovers driven by absorptive capacity. Also, there may be a wave of entry, as entry is a forward looking decision. Hence, there could be rich firm dynamics. This would be of interest as providing another opportunity to disentangle competitive pressure from spillovers. Also, although the literature on spillovers tends to focus on the average spillovers over a certain time period, there is evidence that spillovers vary over time. For instance, a set of empirical studies on China that cumulatively cover an extended period of time indicate that horizontal spillovers decrease over time, shifting towards negative: Table 2, in which the studies are sorted by the years covered in the data set (not the year of publication) with the main results for spillovers from foreign to domestic firms indicated (which all papers include, though some focus on related but different issues).[11] In addition, over the time period encompassed by the studies there have been substantial changes, including reform of state owned firms, accession to

[11] There has been a series of studies that consider spillovers in China, typically including spillovers between foreign and domestic firms and other related issues: Liu 2002, Buckley, Clegg and Wang 2002, Buckley, Clegg and Wang 2007, Hu and Jefferson 2002, Tian 2007, Liu 2008, Wei and Liu 2006, Liu, Wang and Wei 2009, Wei, Liu and Wang 2008, Wang and Yu 2007, Zhang , Li., Li.and Zhou 2010, Chang and Xu 2008.

WTO and expansion of export markets (Huang 2010). These are changes in the institutional policy environment, which the model results suggest are likely to have substantial effects on spillovers and which firms lead the industry. Hence, a direction for future research is to consider how spillovers vary over time as the industry evolves.

In conclusion, I have focused on how horizontal spillovers affect industry leadership in the context of a liberalizing developing economy. I have considered spillovers in an industry context that has different types of players, foreign and domestic, linked by competitive interactions and spillovers, and heterogeneity of firms within each type of player. The findings highlight how different types of spillovers affecting a broad set of firms in the industry lead to changes in industry leadership, the right tail of better performing firms. Spillovers driven by demonstration effects have a limited direct effect on industry leadership, as few leading firms are affected by these spillovers, but there is some effect on industry leadership through increased entry. In contrast, spillovers driven by absorptive capacity increase domestic industry leadership directly, as better firms receive most of the spillovers, and indirectly as there is entry to replace weak firms that exit. The difference in how the types of spillovers affect firm dynamics provides an explanation for the diverse patterns of spillovers across industries, and suggests that spillovers driven by absorptive capacity are more likely to be contentious as have a greater effect on domestic industry leadership, lead to harder to observe firm dynamics, and are more likely to have actively managed policies as the effects are sensitive to policy choice.

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Table 1: Calibration: Model parameters

Parameter		Parameter value
Parameters for all scenarios		
Resources		
Resource: technology (v) and local market (m)	v and m	Range of [0.2, 20] across a grid of 150x150 to allow a sufficiently broad range of levels of resources
Production		
Elasticity of substitution of resources	α	1.6
Fixed costs	F	40 per quarter
Demand		
Total industry revenues	R	100,000
Elasticity of substitution	σ	4
Number of firms		
Foreign firms		50
Domestic firms		Determined endogenously
Distribution of firms over resource levels		For technology and local market resources, respectively, random draw of resource level based on lognormal distribution with mean and std dev log of:
Private firms		mean (1.5, 2.5); std dev (0.6,0.6)
Foreign firms		mean (5.0, 1.5); std dev (0.4,0.4)
Private firms entry and exit		
Entry sunk cost	S	800
Exit death shock	δ	10% per year
Discount factor	β	0.95 per year
Parameters for spillovers		
Technology	η^v	1/2
Local market	η^m	1/3
Ease of technology transfer	λ	Range of [0,1]

Table 2: Selected literature on spillovers in China. Articles ordered by dates covered by data set to highlight pattern of results over time

Years covered by data	Paper	Data	Results: spillovers from foreign to domestic firms* Foreign to domestic	Foreign to SOE	Foreign to collective	Foreign to private
Productivity as outcome						
1993-1998	Liu (2002)	Panel of manufacturing in SEZ		+	n.s.	n.s.
1995	Buckley, Clegg and Wang (2002)	Cross-section of manufacturing		n.s. NHMT; - HMT	+ NHMT; n.s. HMT	
1995	Buckley, Clegg and Wang (2007)	Cross-section of manufacturing			+ curvilinear NHMT; n.s. HMT	
1995-1999	Hu and Jefferson (2002)	Panel for textiles and electronics industries	n.s. Textiles; - Electronics; - NHMT; n.s. HMT	- Textiles; n.s. Electronics		
1996-1999	Tian (2007)	Panel of manufacturing	+			
1995-1999	Liu (2008)	Panel of manufacturing	- level; + growth			
1998-2001	Wei and Liu (2006)	Panel of manufacturing	n.s. inter-region; + intra-region; + both NHMT and HMT			
1998-2001	Liu, Wang and Wei (2009)	Panel of manufacturing		- horizontal; + vertical		- horizontal; n.s. vertical
1998-2001	Wei, Liu and Wang (2008)	Panel of manufacturing	curvilinear: + initially, then -			
2001	Wang and Yu (2007)	Cross-section of manufacturing	curvilinear: + initially, then -			
1998-2003	Zhang, Li, Li and Zhou (2010)	Panel of manufacturing	- linear, and - quadratic			
Firm survival as outcome						
1998-2005	Chang and Xu (2008)	Panel of industrial firms	national: + for NHMT, n.s.for HMT ; regional: n.s. for NHMT, - for HMT;			

* n.s. indicates not significant; HMT refers to foreign firms from Hong Kong, Macau or Taiwan, whereas NHMT refers to foreign firms from other countries

Table 3: Model results for scenarios differing by presence of foreign firms and type of spillovers

(a) Number of firms by type of spillover

Scenario	Type of spillovers	Ease of technology transfer, λ	Foreign: Not localise	Foreign: Localise	Domestic	Total
No foreign firms	None	n.a.	-	-	300	300
No spillovers	None	n.a.	50	-	242	292
Spillovers	Demonstration effects	0.5	23	27	250	300
Spillovers	Absorptive capacity	0.5	21	29	243	293

(b) Key outcome variables

			Industry competitiveness and productivity			Foreign performance and technology leadership	
Scenario	Type of spillovers	Ease of technology transfer, λ	Industry price index*	Exit cut-off: % of entrants (domestic firms) that exit immediately	Average level of technology*	Foreign firm average profits*	Foreign proportion of firms with high level (>5) of technology resources
No foreign firms	None	n.a.	1.00	52%	0.82	n.a.	0%
No spillovers	None	n.a.	1.00	52%	1.00	1.00	68%
Spillovers	Demonstration effects	0.5	0.98	50%	1.00	0.98	63%
Spillovers	Absorptive capacity	0.5	0.97	52%	1.04	0.95	51%

* Normalised by dividing by value for scenario with no spillovers

Table 4: Effect of change in ease of technology transfer

(a) Number of firms by type of spillover

Scenario	Type of spillovers	Ease of technology transfer, λ	Foreign: Not localise	Foreign: Localise	Domestic	Total
Spillovers	Demonstration effects	0.90	37	13	250	300
		0.70	31	19	250	300
		0.50	23	27	250	300
		0.30	9	41	247	297
		0.10	1	49	234	284
Spillovers	Absorptive capacity	0.90	36	14	245	295
		0.70	30	20	245	295
		0.50	21	29	243	293
		0.30	8	42	240	290
		0.10	1	49	231	281

(b) Key outcome variables

			Industry competitiveness and productivity			Foreign performance and technology leadership	
Scenario	Type of spillovers	Ease of technology transfer, λ	Industry price index*	Exit cut-off: % of entrants (domestic firms) that exit immediately	Average level of technology*	Foreign firm average profits*	Foreign proportion of firms with high level (>5) of technology resources
Spillovers	Demonstration effects	0.90	0.98	50%	1.00	0.96	68%
		0.70	0.98	50%	1.00	0.96	68%
		0.50	0.98	50%	1.00	0.98	63%
		0.30	0.98	50%	1.00	1.03	63%
		0.10	0.99	51%	1.00	1.23	67%
Spillovers	Absorptive capacity	0.90	0.98	51%	1.02	0.96	68%
		0.70	0.98	51%	1.03	0.95	62%
		0.50	0.97	52%	1.04	0.95	51%
		0.30	0.96	53%	1.05	0.97	52%
		0.10	0.98	52%	1.03	1.18	61%

* Normalised by dividing by value for scenario with no spillovers

Table 5: Effect of change in key model parameters on model results for different types of spillovers

(a) Number of firms by type of spillover

Scenario	Type of spillovers	Ease of technology transfer, λ	Foreign: Not localise	Foreign: Localise	Domestic	Total
(i) Increased market size (R=1.2x base case)						
Spillovers	Demonstration effects	0.5	23	27	310	360
Spillovers	Absorptive capacity	0.5	21	29	302	352
(ii) Increased fixed costs (F=1.2x base case)						
Spillovers	Demonstration effects	0.5	21	29	221	271
Spillovers	Absorptive capacity	0.5	19	31	215	265
(iii) Decreased commoditisation (σ= base case/1.2)						
Spillovers	Demonstration effects	0.5	28	22	377	427
Spillovers	Absorptive capacity	0.5	27	23	370	420
(iv) Decreased resource substitutability (α= base case/1.2)						
Spillovers	Demonstration effects	0.5	15	35	259	309
Spillovers	Absorptive capacity	0.5	13	37	233	283
(v) With state-owned firms that do not exit (100 state owned firms, versus 0 in base case)						
Spillovers	Demonstration effects	0.5	30	20	312	362
Spillovers	Absorptive capacity	0.5	29	21	308	358

(b) Key outcome variables

			Industry competitiveness and productivity			Foreign performance and technology leadership	
Scenario	Type of spillovers	Ease of technology transfer, λ	Industry price index*	Exit cut-off: % of entrants (domestic firms) that exit immediately	Average level of technology*	Foreign firm average profits*	Foreign proportion of firms with high level (>5) of technology resources
(i) Increased market size (R=1.2x base case)							
Spillovers	Demonstration effects	0.5	0.92	50%	0.97	0.98	58%
Spillovers	Absorptive capacity	0.5	0.91	52%	1.01	0.95	47%
(ii) Increased fixed costs (F=1.2x base case)							
Spillovers	Demonstration effects	0.5	0.99	54%	1.04	0.98	63%
Spillovers	Absorptive capacity	0.5	0.98	56%	1.08	0.95	51%
(iii) Decreased commoditisation (σ= base case/1.2)							
Spillovers	Demonstration effects	0.5	0.58	35%	0.90	0.94	63%
Spillovers	Absorptive capacity	0.5	0.58	37%	0.92	0.92	54%
(iv) Decreased resource substitutability (α= base case/1.2)							
Spillovers	Demonstration effects	0.5	0.41	47%	1.00	0.90	60%
Spillovers	Absorptive capacity	0.5	0.41	49%	1.06	0.92	48%
(v) With state-owned firms that do not exit (100 state owned firms, versus 0 in base case)							
Spillovers	Demonstration effects	0.5	0.98	50%	0.91	0.97	70%
Spillovers	Absorptive capacity	0.5	0.98	51%	0.92	0.95	63%

* Normalised by dividing by value for scenario with no spillovers

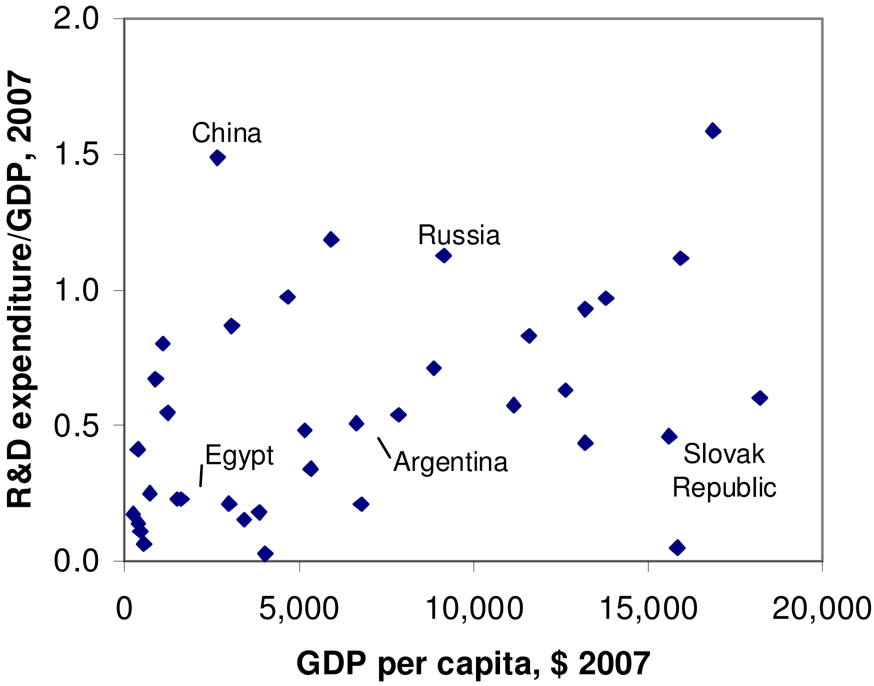

Figure 1: Variation across lower income countries in R&D intensity: R&D expenditure as % GDP versus GDP for countries with GDP below $20,000. Selected countries indicated to highlight variation across countries. Source World Bank Development Indicators.

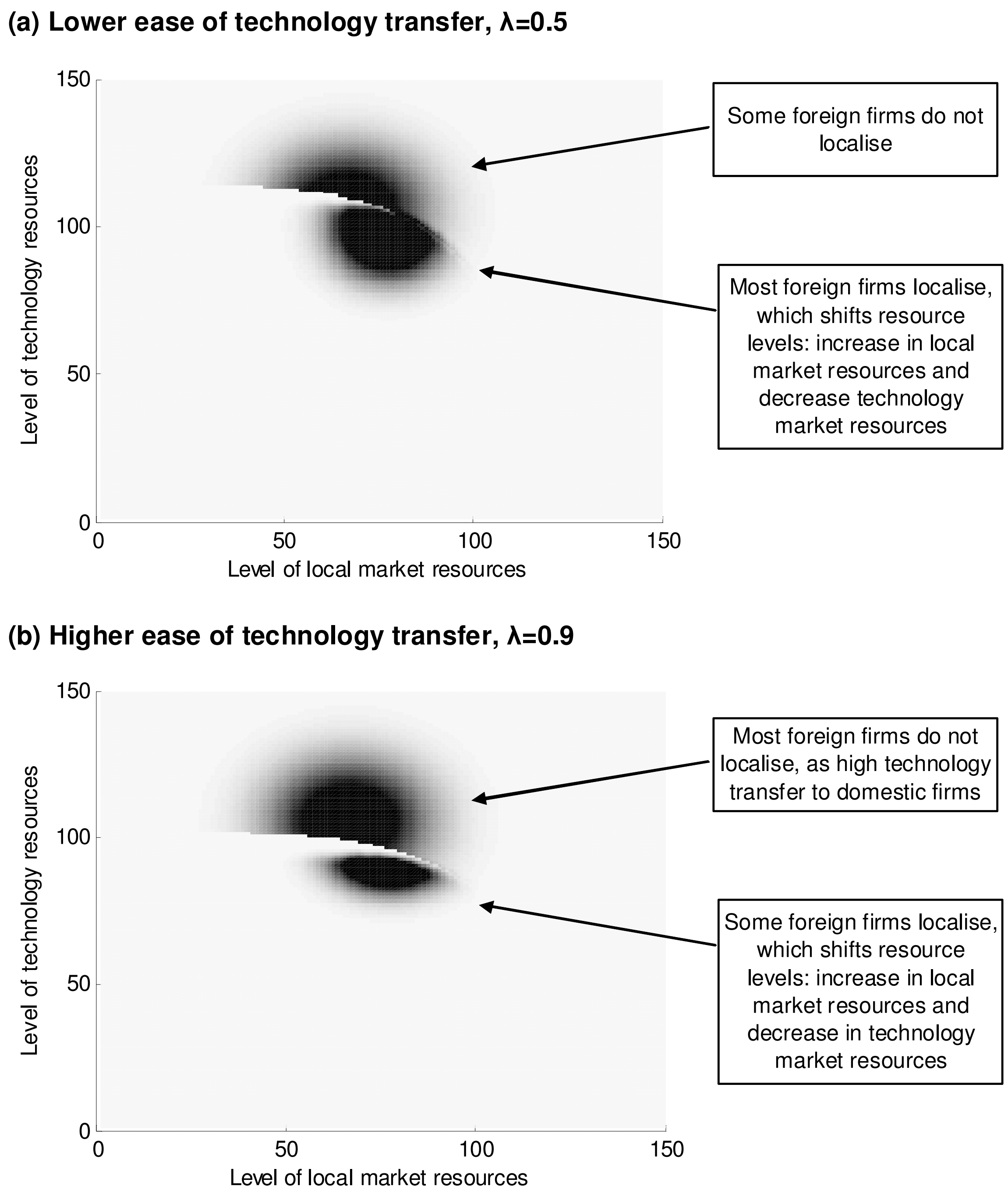

Figure 2: Foreign firm localisation at different levels of ease of technology transfer, λ: Distribution of foreign firms that do and do not localise across grid of technology resources and local market resources

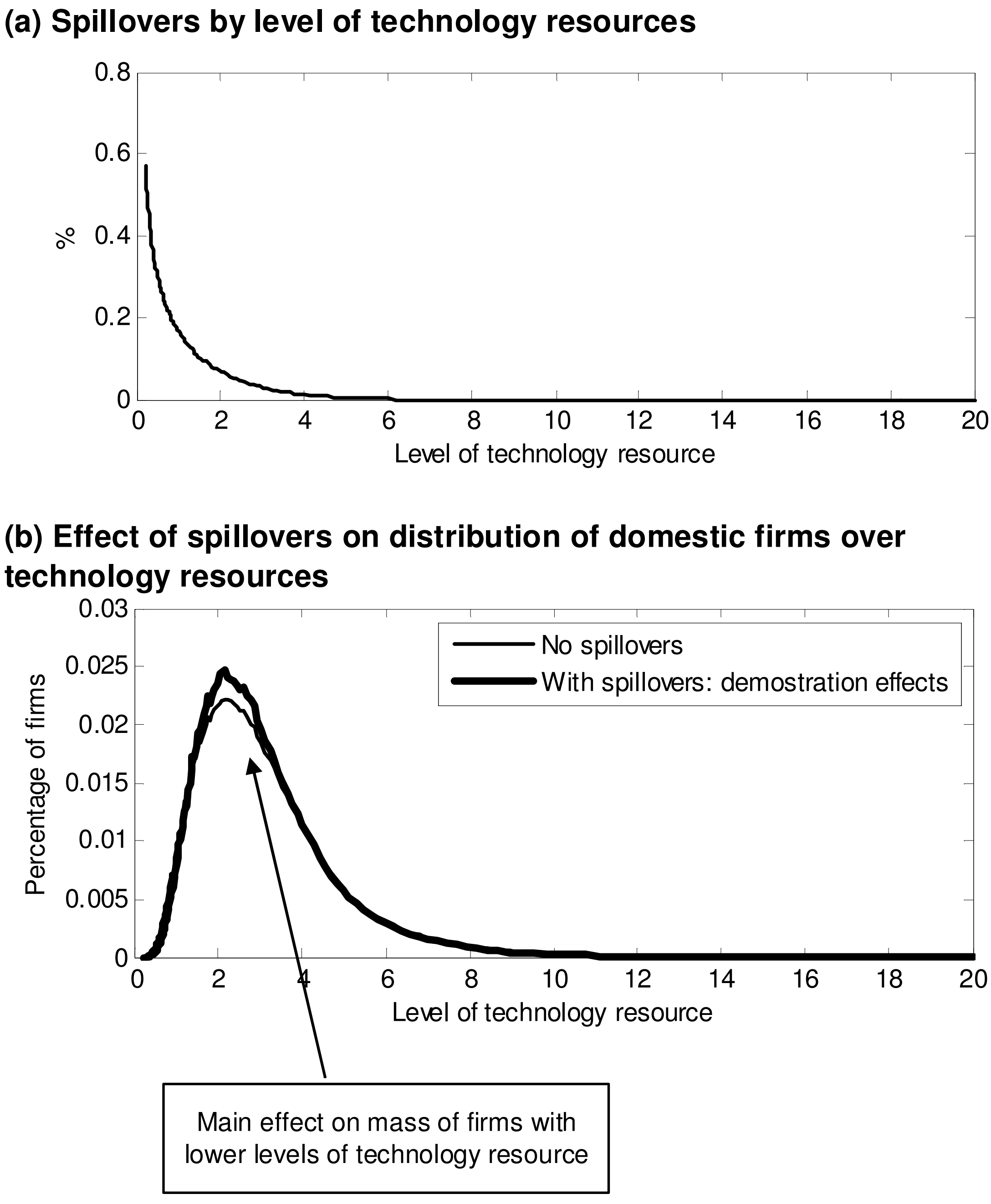

Figure 3: Spillovers driven by demonstration effect: Magnitude of spillovers and effect on distribution of domestic firms

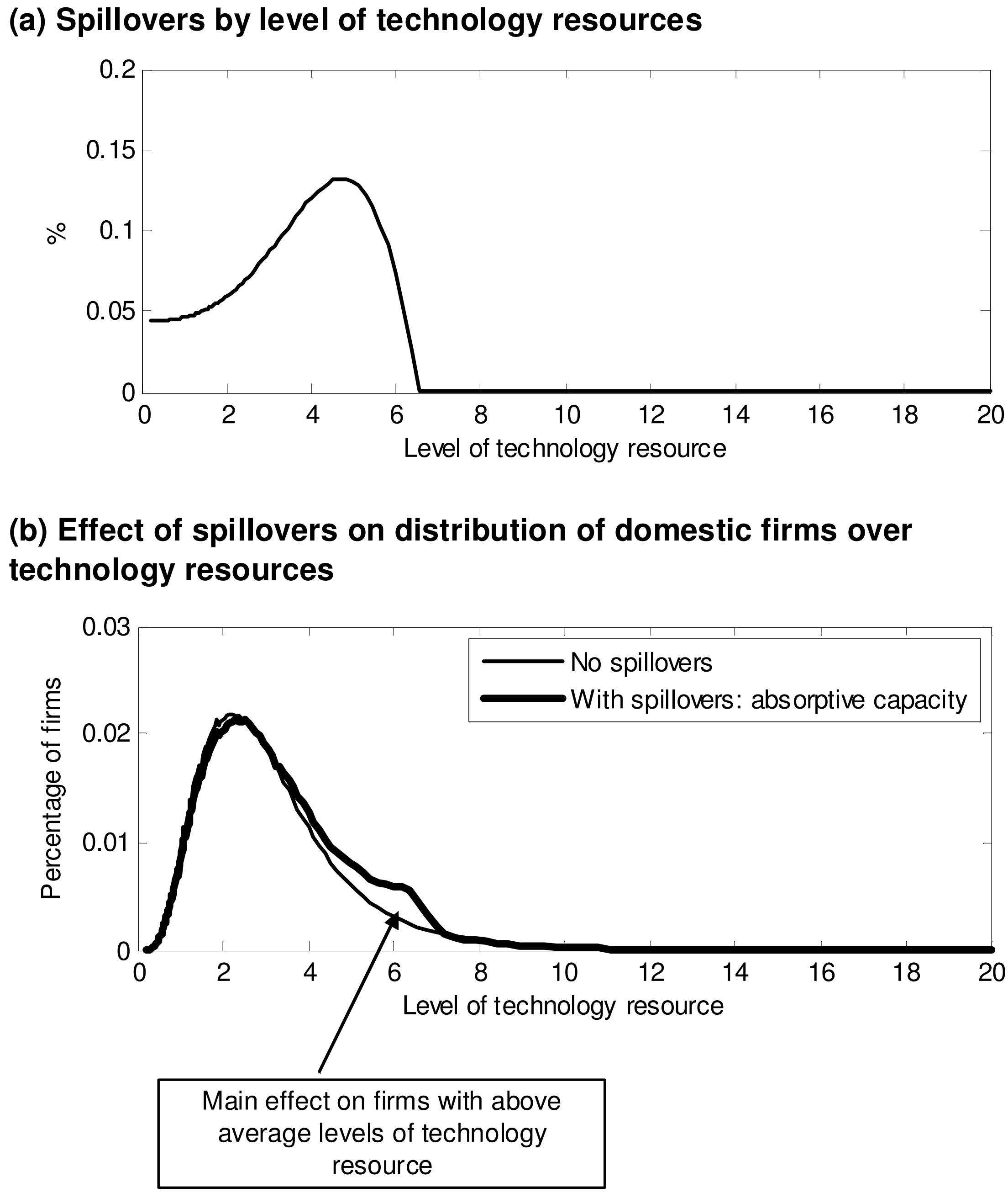

Figure 4: Spillovers driven by demonstration effect: Magnitude of spillovers and effect on distribution of domestic firms

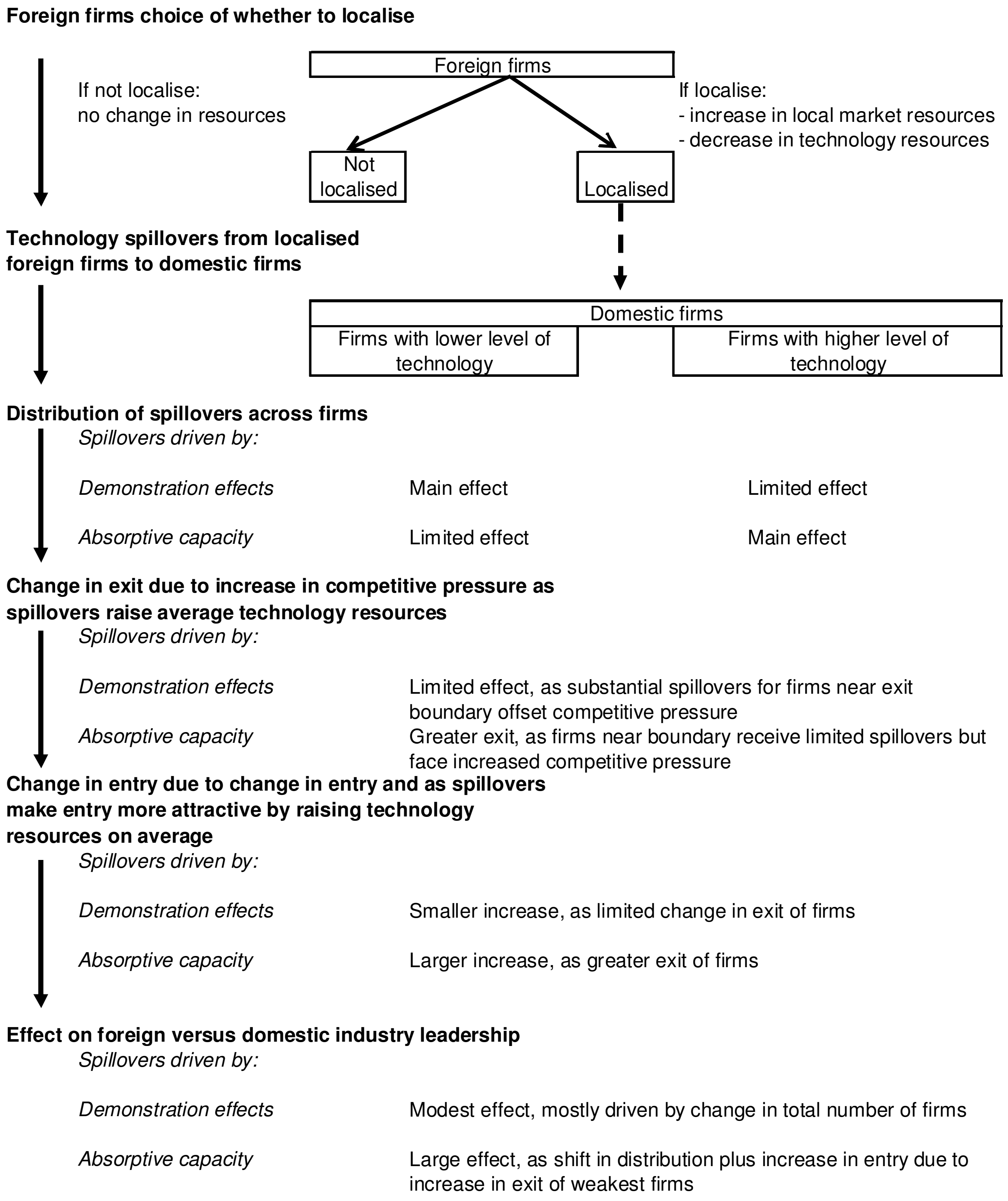

Figure 5: Overview of model to highlight key elements of model and difference in effect of spillovers driven by demonstration effects versus absorptive capacity.

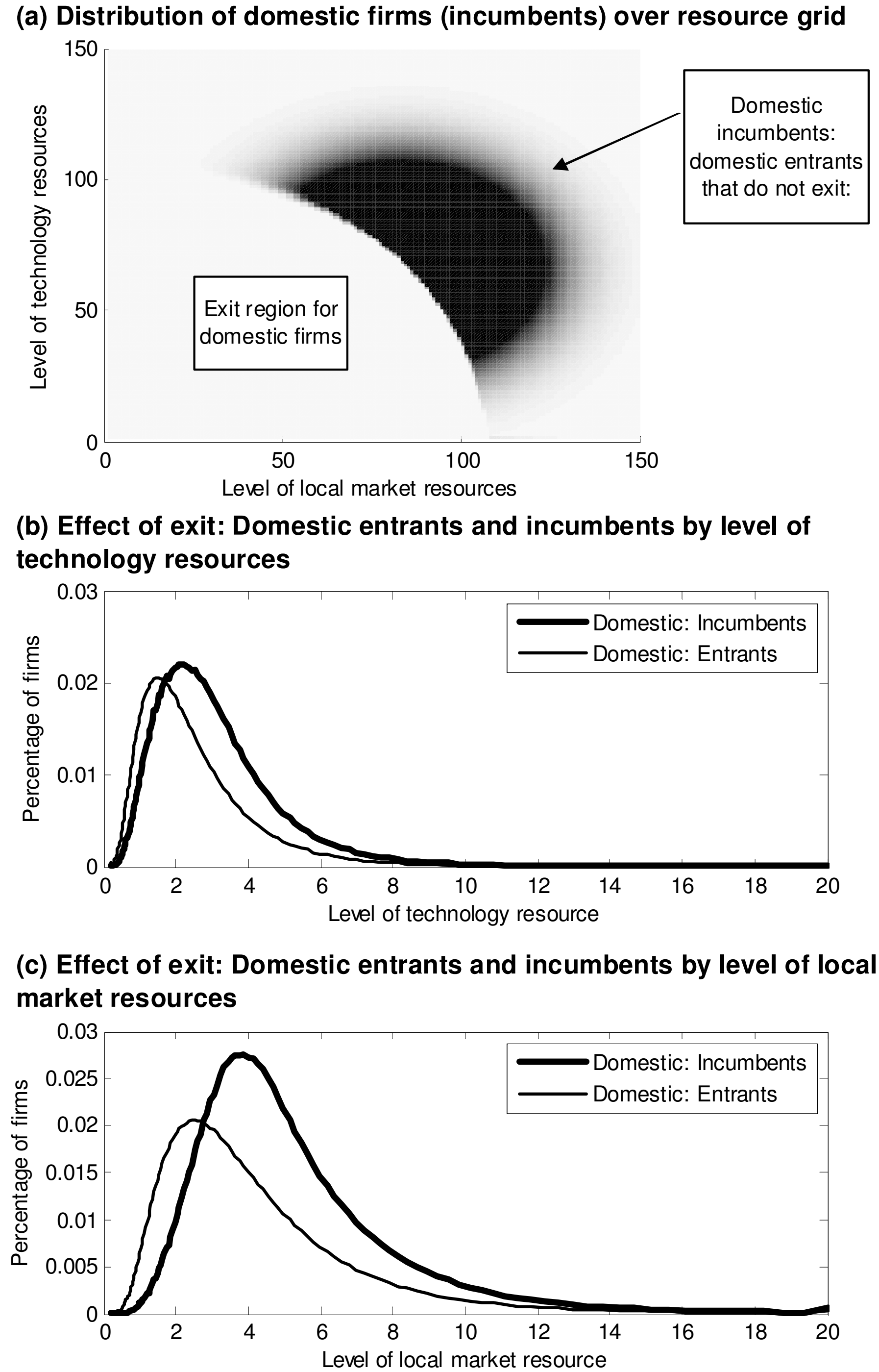

Figure 6: Distribution of incumbent domestic firms over resources as a result of exit of weaker domestic entrants

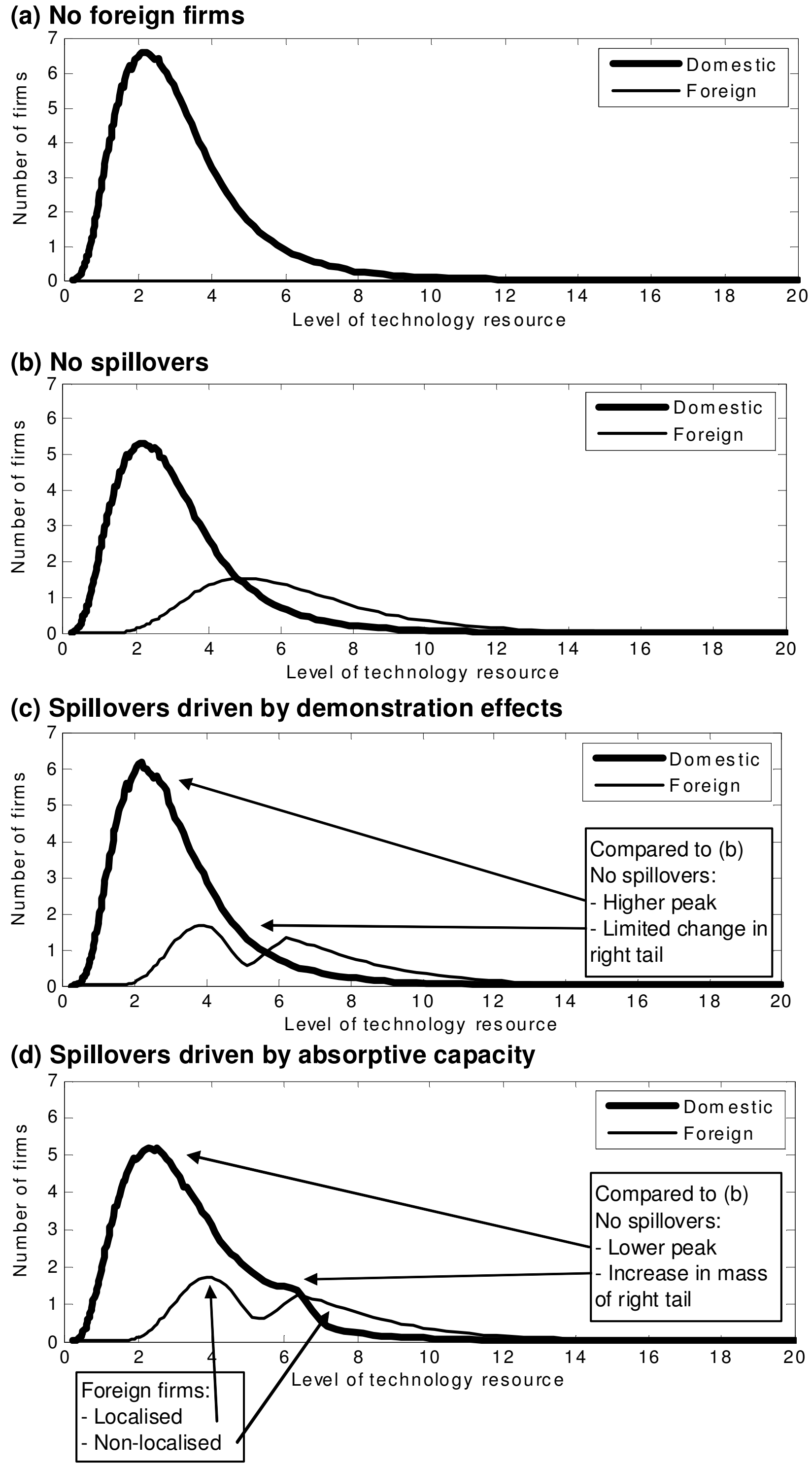

Figure 7: Distribution of domestic and foreign firms over technology resource levels: Comparison of four cases

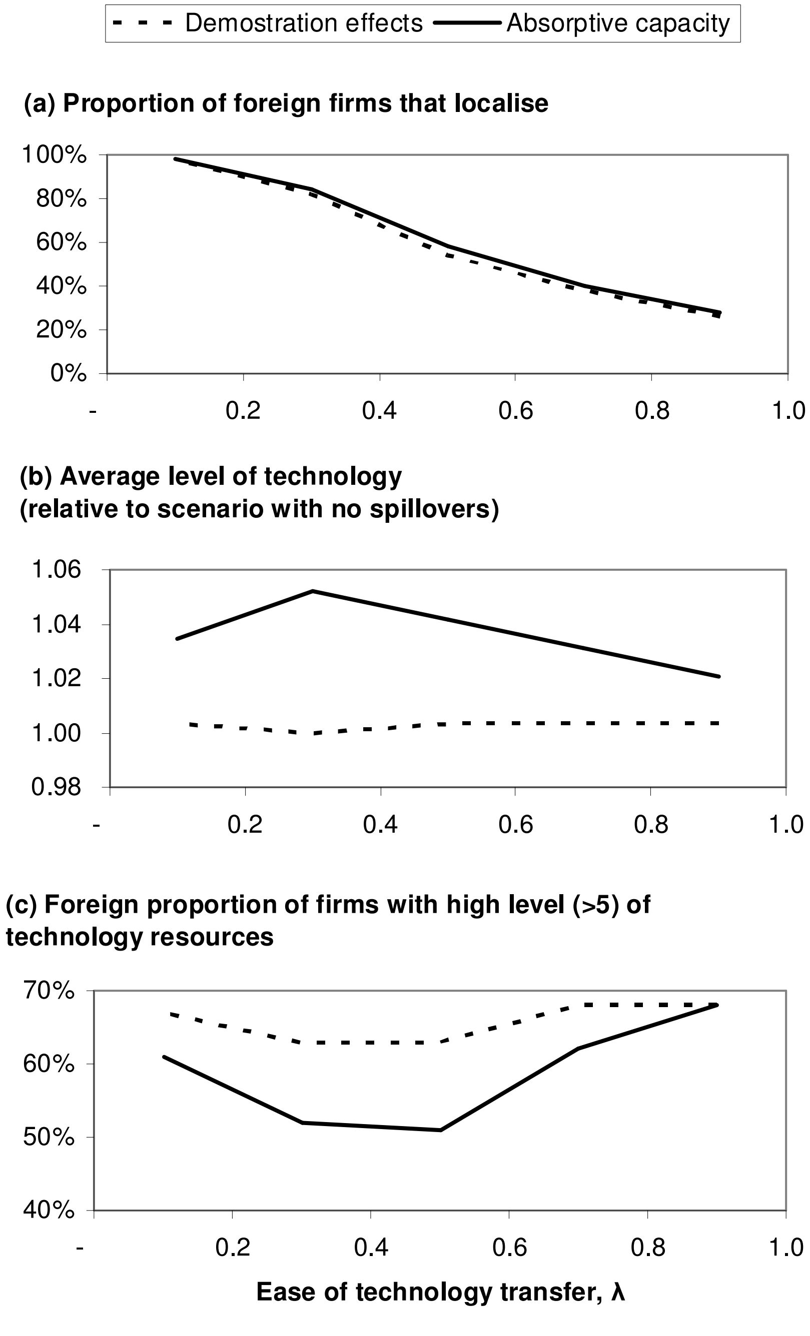

Figure 8: Effect of change in ease of technology transfer, λ, on: foreign firms that choose to localise, average technology level with spillovers, and proportion high technology firms that are foreign

Appendix

A Profits within a time period

The determination of firm profits requires specification of the product market competition: the cost of production based on the resource levels and demand for the firms' products. As I only consider a stationary equilibrium in which parameters are stable over time and firm policies, conditional on resource levels, are stable over time, below I omit the time subscript.

Production. Each firm is considered to produce a distinct variety of product with the firm's production determined by its resource stock levels: technology v and local market m. In each time period a firm produces the optimal level based on its resource stocks, hiring the necessary labor in a labor market with no frictions at a wage per unit of labor normalized to unity. The production technology has constant elasticity of substitution (C.E.S.) elasticity of substitution α between resources v and m. Production, y, is given by:

$$y = [(vl_v)^{(\alpha-1)/\alpha} + (ml_m)^{(\alpha-1)/\alpha}]^{\alpha/(\alpha-1)} \tag{8}$$

where labor hired is l_v and l_m. Based on standard derivations, marginal cost, c, is:

$$c = \left[(v)^{(\alpha-1)} + (m)^{(\alpha-1)}\right]^{-1/(\alpha-1)} \tag{9}$$

In addition, the firm incurs an overhead per-period fixed cost F. Thus in the model resource levels determine marginal cost, which in effect is a measure of the firm's competitive advantage.

Demand. The demand system is based on monopolistic competition. I assume consumer preferences across products in the industry have a constant elasticity of substitution $\sigma > 1$: a C.E.S. demand system with elasticity (Dixit and Stiglitz 1977). I assume there is a continuum of varieties produced by the firms, denoted by $\omega \in \Omega$. I assume consumers spend a fixed amount R on the products of the industry in each time period, with total industry revenues $R = QP$, where Q and P are, respectively, the aggregate quantity and price indices. Specifically, $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma}\right]^{1/(1-\sigma)}$ is the C.E.S. price index for the aggregated differentiated good and $Q \equiv \left[\int_{\omega\in\Omega} q(\omega)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$ the C.E.S. quantity index, where $p(\omega)$ and $q(\omega)$ are the price and quantity consumed of the individual varieties ω. With this demand system the firm's optimal price is a constant markup of $\sigma/(\sigma-1)$ over marginal costs, $p = (\sigma/(\sigma-1))c$, the firm's market share is $(P/p)^{\sigma-1}$ and hence revenue is $RP^{\sigma-1}p^{1-\sigma}$ and quantity produce by a firm is $q = (RP^{\sigma-1}p^{1-\sigma}/p)$.

Profits. Firm per-period profits π are revenues less marginal cost of production and fixed cost:

$$\begin{aligned} \pi &= RP^{\sigma-1}p^{1-\sigma} - qc - F \\ &= RP^{\sigma-1}p^{1-\sigma} - (RP^{\sigma-1}p^{1-\sigma}/p)c - F \\ &= (1/(\sigma-1))RP^{\sigma-1}(\sigma/(\sigma-1))^{1-\sigma}c^{1-\sigma} - F \end{aligned} \tag{10}$$

B Equilibrium Conditions

Let $\mu_{v,m}$ represent the measure function for the distribution of firms over states (v, m). An equilibrium is characterized by a price index $\{P\}$, the measure of firms in each state, $\{\mu_{v,m}\}$, and the mass of entrants $\{M_E\}$. Note that a choice of $\{P\}$ uniquely determines the time path for $\{V^P(v, m)\}$ and thus determines all the optimal choices for any firm, given its resource levels (v, m). An equilibrium must satisfy three conditions:

Firm Value Maximisation. All firms' choices for exit/continuation, conditional on v and m, must satisfy (6). In the aggregate, this means that $\mu_{v,m}$ is entirely determined by the choices for $\{P\}$ and $\{M_E\}$ such that the share δ of firms that receive the exogenous death shock and exit are replaced by the M_E new entrants, with a distribution determined by $G_E(v, m)$.

Free Entry. In equilibrium, the net value of entry V_t^E must be zero, since there is an unbounded pool of prospective entrants and entry is not limited beyond the sunk entry cost, and as if V_t^E were negative there would be zero entry.

Aggregate Industry Accounting. The mass and distribution of firms over productivity levels (aggregating over states) implies a mass and distribution of prices (applying the profit maximizing markup rule to firm marginal cost). Aggregating these prices into the C.E.S. demand system price index must yield the chosen P in every period.

C Model Algorithm

Given the demand system, each firm need only know industry aggregate outcomes for industry price P to determine its specific policies conditional on its current resources (v, m). Policy choices for domestic firms are whether to {Continue, Exit} and for foreign firms are whether to {Localise, Not localise}. Following I describe the algorithm for numerically solving the model, which comprises two steps. Step 1: set parameters. Step 2: compute the firm policies and firm-size distribution $\{\mu_{v,m}\}$ corresponding to the parameter values. Within Step 2 there is an iteration over the aggregate price for the stationary state P. The model algorith is based on that in Costantini 2010, and Costantini and Melitz 2008.

1) Set initial parameters, including for industry characteristics and grid structure.

2) P iteration: Choose candidate value for P.

- Firm Value and Policy Iteration: (i) Compute profit $\pi(v, m)$ at each resource combination $\{v, m\}$; (ii) Pick a candidate value function $V^P(v, m)$ for private firms, $V^S(v, m)$ for state-owned firms, and $V^F(v, m)$ for foreign firms; (iii) Determine policy choices{Continue, Exit} and {Localise, Not localise} at each $\{v, m\}$; (iv) Iterate the value function: The set of firm policies imply a next iteration value for the value functions; and (v) Check whether new $V^{P'}(v, m)$, $V^{S'}(v, m)$ and $V^{F'}(v, m)$ are sufficiently close to $V^P(v, m)$, $V^S(v, m)$ and $V^F(v, m)$. If not, continue iteration. If close enough, return to P iteration.
- Check the value of entry, which should be close to zero as have positive entry in stationary

state. (i) If close enough to zero, P iteration is complete; (ii) If not, then adjust candidate P accordingly: if condition is positive lower P, if negative raise P.

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