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Why Has China Grown So Fast? The Role of International Technology Transfer

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Abstract
Chinese economic growth has been spectacular in the last 30 years. We investigate the role of International Joint Ventures with Technology Transfer agreements, an understudied area. Technology transfer is the traditional mechanism for developing countries to "catch up" and has been a key component of Chinese economic policy. We collect original survey data on Chinese firms and their joint ventures and match this to administrative data on firm performance. To identify the causal effect of joint ventures we use time-varying and province-specific policies at the time when a firm was born. International joint ventures have large effects on productivity especially when combined with a technology transfer component. We estimate that without International joint ventures China's growth would have been about one percentage point lower per annum over the last three decades.

JEL Classifications: O32, O33
Keywords: China, technology transfer, joint ventures, productivity

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INTRODUCTION

One of the enduring assumptions in economic growth is that developing countries will be able to "catch up" with rich countries due to the process of technology transfer through capital moving from developed to emerging economies. Through the vehicle of foreign direct investment (FDI), the more advanced technology embodied in capital from developed countries induces faster growth in developing ones. Specifically, an FDI spillover occurs when foreign direct investment increases the productivity of domestic firms and the value of the benefits is not completely internalized by the multinational corporation. This will result in transmission of technology and productivity gains to the developing country, permitting them to grow faster and eventually "catch up." This theory, though, has had limited empirical support due to the difficulty of measuring the transfer of technology. The emergence of China offers an opportunity to measure and examine the mechanisms through by which a country can "catch up". Has its decades-long policy of managing technology transfers resulted in productivity gains that hastened its remarkable economic growth?

China is the leading destination for FDI among developing countries and is some distance from the technology frontier. Its FDI policy is geared at developing international joint ventures (IJVs) between a Chinese and foreign firm and attracting technology to improve productivity of domestic firms, e.g. locating foreign firms within Special Economic Zones. The bulk of FDI is invested in the form of joint ventures, which are thought to have a greater likelihood of inducing technology-related spillovers to domestic firms. The prospect for such productivity gains is strong in China, though there is limited direct evidence for China and other economies. Thus China is an ideal testing ground for whether formal IJV technology transfer agreements are an effective mechanism for development.

This paper analyses an original, national Chinese enterprise survey designed to provide such evidence, spanning the period from 2000 to 2005. The survey investigates a key trait of Chinese-foreign joint ventures, which is the signing of a technology transfer agreement at the time of establishing the IJV. This provides a rare instance of a direct measure of technology transfers, while most studies infer transfers from foreign presence in the sector or province, the percentage of foreign equity ownership, or some other indirect evidence. In other words, indirect effects are

often measured but not direct ones. Our sample is drawn from comprehensive enterprise data held by the Chinese National Bureau of Statistics, which permits the creation of a panel that allows for estimation of productivity differences between firms which benefit from technology transfers and those which do not. The data allows direct measure of technology spillover in the form of transfer, along with other elements of a firm production function.

Our specifically designed data set allows us to measure technology transfer at the inception of an IJV. We observe the legal agreements that include technology transfers set up at the establishment of the IJV and this provides a unique opportunity to assess a direct effect of gaining technology at the start of a firm. The analysis will also shed light as to whether the vehicle of FDI matters (e.g. if the foreign investment is in the form of a joint venture as compared with a wholly foreign owned entity) and most importantly, whether explicit technology transfers result in increased firm productivity.

We find that IJVs are associated with significantly higher productivity, but this effect is driven by those ventures that have an explicit technological transfer component. An empirical challenge is that there is no within firm variation in IJVs over our sample, so we cannot include firm-specific fixed effects. Consequently, we construct instrumental variables using province level policy-instruments dated at the time of firm-set up (e.g. openness to FDI at the firm's birth year). We can include firm age and province level dummies in the first and second stage equations and identify solely from this province by age interaction. These IV estimates suggest that the relationship between productivity and international joint venture is causal (and is underestimated by OLS). This appears to give some support to the policy of the Chinese government (and perhaps other developing nations) to promote technology transfer IJVs and sheds light on the classic mechanism for "catch up" growth.

The structure of the paper is as follows. Section I sketches some theoretical perspectives, section II describes the data, section III the empirical model, section IV the results and section V concludes.

I. THEORETICAL PERSPECTIVES

The literature on how "catching up" occurs centers on the movement of capital from more advanced to less developed countries. The neoclassical growth mechanism has therefore generated a vast literature on the spillover effects of inward foreign direct investment on the host country. There are both direct and indirect channels for FDI spillover. Direct channels are explicit technology transfers, such as technology transfer agreements between the foreign and Chinese partners in a joint venture, which have not been measured in the literature. Indirect channels are copying products produced by a multinational in a local market, hiring workers trained by the multinational or pro-competitive effects such as through horizontal and vertical linkages. Horizontal spillovers may take place when local firms improve their efficiency by imitating the technology of foreign firms in the local market through observation or hiring workers trained by the foreign company. Or, another type is the introduction of competitive forces if the presence of a multinational company increases the competition in a market or sector in the host country and induces local firms to become more productive or seek out new technology. Multinationals will wish to protect their position and have an incentive to prevent technology leakages and spillovers from taking place. Further, there are two types of vertical linkages: upstream and downstream. There are fewer incentives for multinationals to protect against backward linkages with upstream suppliers of their intermediate inputs. Local suppliers can receive direct technology transfers, indirect transfers through observation, and benefit from larger markets and scale improvements in productivity. Downstream or forward linkages from a multinational can benefit a local firm by providing more advanced and better intermediate goods, and create a market for complementary services. Clustering of FDI into Economic Zones in China provide another sort of effect, namely, network externalities which generate the prospect of knowledge diffusion and the creation of external economies by firms.

The implication of these studies is that joint ventures, rather than wholly-owned foreign enterprises, are more likely to produce productivity and innovation gains as vertical linkages offer more avenues for transmission of know-how and working alongside more advanced foreign partners offers more occasions to learn. By not separating the different types of FDI, the effects of spillovers can be confounded, especially since FDI can also exert competitive pressures on domestic firms that may improve but may also overwhelm their productive capacity. Therefore, we distinguish between IJVs and wholly-owned foreign enterprises in this paper. Both have the

potential to embody positive FDI spillover, but the structure of IJVs is more conducive to transmission of know-how.

Numerous theories of FDI spillover and the role of multinationals choosing to invest across borders include Rodríguez-Clare (1996), and specifically as a catalyst or hindrance for industrial development linking such effects to growth (see e.g., Markusen and Venables 1999; Lall 1978). In the empirical literature, there is some evidence of limited FDI spillover in OECD countries (Blomström and Kokko 1998), though given the proximity of these countries to the technology frontier and their similar levels of development; it is perhaps not surprising to not find large effects. There is also some evidence from developing countries. These studies have found minimal or negative effects (Haddad and Harrison 1993 for Morocco; Aitken and Harrison 1999 for Venezuela; Djankov and Hoekman 2000 for the Czech Republic; Konings 2001 for Bulgaria, Romania, and Poland). By contrast, other studies find positive effects (Blomström 1986 for Mexico; Javorick 2004 for Lithuania). These findings suggest that the contextual factors will affect whether a country benefits from FDI, but also that separating the vehicles for FDI is important, as the studies like Javorick (2004) highlight vertical rather than horizontal linkages as being conducive to positive spillovers in the host country. Nevertheless, there remain measurement issues since the spillover is still inferred from measuring the extent of FDI or foreign presence in an industry or sector rather than directly measured as a transfer of technology.

For China, there are studies which find that FDI both improves firm productivity and contributes to economic growth. For instance, Hu, Jefferson and Qian (2005) and Chuang and Hsu (2004) find that find that FDI improves firm productivity. Zhang and Felmingham (2002) find that FDI contributes positively to economic growth. The mechanisms, however, are, like the larger literature, inferred indirectly as foreign ownership share or presence of multinationals is used as a proxy for technology transfers. The studies are largely only able to proxy FDI spillover due to the lack of a direct measure. In some instances, measures of technology licensing are used (e.g., Jefferseon and Su 2006) which is a more precise measure, though they are subject to issues of endogeneity as they are likely to be signed by firms which are willing to pay for the license due to their being more productive. Nevertheless, our findings support the conclusions that firms which have received a transfer of technology are more productive.

The crucial element, therefore, provided in this paper is a direct measure of technology transfers from FDI. Taken in the form of IJVs, there is also scope for indirect spillovers from learning by working alongside more productive foreign firms. With a direct measure, we can estimate whether IJVs embodying technology transferred from multinationals are more productive, providing evidence on direct FDI spillover and shedding on the mechanism for "catch up" growth.

II. DATA

Detailed descriptive information about the data can be found in the Data Appendix, but we sketch the main issues here. The primary data set used in this paper is comprised of a national firm-level survey conducted in 2006 which was then matched by China's National Bureau of Statistics (NBS) to their annual enterprise survey to create a panel from 2000 to 2005 containing data to estimate production functions (output, capital, materials, etc.). The survey questionnaire was designed by an international research team including the authors, and carried out by NBS with support from the World Bank. The survey was conducted in the summer of 2006 on 1,268 firms in 12 cities (province in parentheses): Beijing (municipality), Changchun (Jilin), Chifeng (Inner Mongolia), Dandong (Liaoning), Hangzhou (Zhejiang), Shijiazhuang (Hebei), Shiyan (Hubei), Shunde (Guangdong), Wujiang (Jiangsu), Xian (Shaanxi), Zibo (Shandong), Chongqing (municipality). The NBS takes considerable care with their annual enterprise survey such that the figures match data obtained independently by the Chinese tax authorities.

After matching the data to the NBS panel, observations with incomplete information were eliminated, so the data used is comprised of unbalanced panel data from 1,201 industrial firms for the years 2000-2005, for which 2005 provides survey information as well as the NBS data. The information was also checked against provincial level data, which revealed that the sub-sample is broadly in line with the provincial averages. Comparison with the averages for other studies using the large NBS firm-level data set (Dougherty *et al.*, 2007) yielded similar results. Also in line with most enterprise firm studies, the survey only covered firms with an annual sales volume larger than 5 million Yuan following the standard NBS practice (e.g. Jefferson and Su, 2006). The

NBS data set only includes firms in the production industries (mainly manufacturing but also a small number of firms in mining or utilities).

The survey data comprises a large number of variables: labor, production and environmental management, as well as market environment, infrastructure, investment and innovation. We also have additional information on joint venture firms where the Chinese partner entered into a technology transfer agreement with a foreign partner. This variable is unique to our dataset and to our knowledge has not been analyzed formally before. This aside, the survey data allows us to distinguish private Chinese firms established during the reform era of the 1990s from privatized, formerly state-own enterprises (SOE).

As a result of this information, we can divide our sample firms into seven ownership categories: (1) SOEs, (2) privatized SOEs, (3) private Chinese firms, (4) IJV, (5) IJV which signed a technology transfer agreement, (6) wholly-owned foreign enterprises from Greater China, and (7) wholly-owned foreign enterprise from other countries (we also know the nationality of the IJV). These categories are mutually exclusive. We also combine the IJV categories in some of our analysis. In addition, we have information on whether firms are listed on a Chinese stock exchange.

Table 1 shows the breakdown of our sample by type of ownership and presence of international joint ventures. We have 172 IJVs constituting 13.5% of our sample, but 63 of these were with "Greater China" (Taiwan, Hong Kong and Macau). Of the remainder 29 were technology transfer related and 80 were not IJVTTs. It is possible that the firms which entered into joint ventures have different productivity levels than those who did not. As nearly all joint ventures are formed with SOEs as a matter of regulatory approval, the Chinese government mandated the joint venture as a result of foreign investment policy. In principle the government could wish to either bolster loss-making firms (which was common in the 1990s) with productive partners to save jobs (positive selection into IJVs) or choose better performing SOEs to produce with foreign firms (negative selection into IJVs). As most of the productive SOEs were privatized or remained solely in

national hands, the likely candidates for joint ventures were those which could not be sold off and were small enough to not warrant rescue as a "key industry." This implies that the Chinese partners are likely to be the ones that were not strong enough to either keep or sale; making them the likely candidates for IJVs. If this is the case negative self selection is more likely and OLS estimates of the effects of IJVs will be biased downwards. These concerns motivate our instrumental variable strategy to deal with this endogeneity issue.

The average age of such IJVs is around 8.7 years, indicating that establishment in 1996/97, which is the same mean age as IJVs which did not sign technology transfer agreements. The oldest joint ventures were formed in 1979 at the start of market-oriented reforms. As Guangdong is included in the survey and it was one of the earliest provinces to open right at the start of reform, the data captures the earliest to the latest IJVs which received technology transfers which were in 2005.

The mean value of the agreements was 14.39 million RMB with the largest contract worth 400 million RMB. The Chinese side often insisted on these transfers as they would be less costly than presumably licensing the same technology given the monopoly pricing of intellectual property. Thus, around 43% of such agreements were bundled as part of the capital investment in the JV without payment of additional consideration, supporting the favorable position of obtaining technology via this route instead of via the open market. Around one-fifth (21.1%) of firms reported producing new products with the technology obtained in these transfer agreements.

Table 2 gives some descriptive statistics of the firms in the dataset. These are medium sized plants, with a median number of workers of 220, but spanning a wide range from one employee to 13,000. The average firm is 14 years old and has 3.2m RMB value added per worker

II. EMPIRICAL MODEL

The empirical model we estimate is based on the simple production function approach

$$q_{ijt} = \beta D_{ij} + \alpha_l l_{ijt} + \alpha_k k_{ijt} + \alpha_m m_{ijt} + \gamma x_{ijt} + u_{ijt} \quad (1)$$

where q_{ijt} is ln(output), l_{ijt} is ln(labor), k_{ijt} is ln(capital) and m_{ijt} is ln(materials) of plant i in province j at time t. The key variable is D_{ij} which indicates whether the firm is involved in an international joint venture including a technology transfer agreement (or in some specifications, any international joint venture). The x_{ijt} is a vector of control variable such as age, skills, whether the firm is multi-plant, whether the firm is listed, and a set of three digit industry, province and time dummies.

D_{ij} does not vary over time in our sample, so an empirical challenge is how to identify the causal effects of ownership type on productivity. In order to convincingly argue for a causal effect of ownership on firm productivity, we require valid and informative instrumental variables. Once in place, a joint venture rarely changes over time, thus policy conditions at the start of the firm's birth are likely to be the critical factor in determining whether or not an international joint venture was formed. Since the Chinese government allowed provinces to conduct different policies towards foreign FDI (e.g. a much more liberal approach in the Special Economic Zones), we use proxies for the policy conditions at time of firm set up as the instrumental variable. Since we know the year and province every firm was set up, such variables are defined for all our firms.

To be precise we use provincial-level FDI at time of start-up which is likely to reflect the openness of the province to foreign investment. Provinces with more liberal policies are likely to have more FDI and therefore more IJVs than those with less foreign investment. It is unclear why historical FDI would have a direct effect on current productivity, but it may have an indirect effect through affecting other productivity relevant variables. We control for these in the regressions. For example, we condition on a full set of province dummies so this non-parametrically controls for the current stock and flow of FDI in the province as these are likely to both affect productivity and be correlated with FDI at time of birth. We also examine alternative policy proxies such as exports and imports in the province at the time of the firm's start-up.

The first stage of the IV equation is:

$$D_{ij} = \pi z_{ij} + \delta' w_{ijt} + e_{ijt} \quad (2)$$

where z_{ij} is a measure of the provincial policy towards foreign IJVs and w_{ijt} are all the exogenous variables in equation (1). We use the amount of FDI in the province at year of the firm's start up as a measure of this, as provinces with more liberal approaches to FDI (e.g. special economic zones) would be much more likely to generate a start up forming as an IJV. Note that in the IV estimates we include province dummies and firm age as the IV is age by province specific. Hence a drawback of our approach is that we cannot include a full set of age by province interactions.

Since provinces vary in size, we normalize FDI on total provincial investment and include this variable as an additional control in equations (1) and (2). The instrument's variation is essentially an interaction between firm age and provincial characteristics. We are careful to condition on other confounding influences like the linear effect of age and province effects, but we have no time varying instrument for IJV (since these do not vary over time).

III. RESULTS

A. Preliminary Descriptive Statistics

We first examine the extent of FDI in China over the past 30 years. China has been remarkably successful in attracting inward FDI since its open door policy took off in 1992. As Table 3 shows, it has received on average $62 billion per annum in FDI since then, vastly outpacing all emerging economies and around the levels of major economies. Nevertheless, FDI accounted for only 15% of total investment on average, underscoring its high savings rate which averaged between 40-50% during this period. Aside from the initial period of 1992-1996 when FDI made up as much as one-third of total investment in China, FDI has contributed less than 10% since 1997. For China, the aim is not to attract overseas investment funds to supplant inadequate savings. Instead, the nature of FDI in China is to attract technology and know-how to help its own firms learn and become more productive and competitive.

The preferred FDI vehicle, therefore, had been Chinese-foreign joint ventures, since these enable a Chinese firm to partner with a foreign one and thus enhance the prospect of positive spillovers of knowledge to China. Prior to WTO accession in 2001, IJVs (both equity and cooperative)

accounted for the bulk of FDI, around two-thirds from the early 1990s to 2000. At their peak during the 1990s, JVs accounted for as much as 35% of total investment and for 10% on average over the past 30 years or two-thirds of the total share of FDI in Chinese investment.

Since WTO membership, IJVs declined from half to just over one-fifth of FDI in 2007, reflecting the increase in the number of wholly owned foreign enterprises which do not have Chinese partners and are also geared more at the greater liberalization of China's domestic market. Although the share of IJVs has fallen as China opens up, the absolute amount of FDI in the form of joint ventures remains robust at nearly $20 billion per year, as compared with $20-30 billion in the pre-WTO years.

B. Regression Results

Table 4 presents our basic OLS estimates of the value-added production function. In column (1) the conventional factor inputs of labor and capital are significantly positive and similar to the factor shares of revenue. We find slightly decreasing returns to scale as the sum of the coefficients on labor and capital is 0.9. We have also conditioned on the proportion of managers with higher education ("% college educated") which is positive and highly significant, suggesting that human capital is important for productivity. Column (2) includes all the ownership types (privatized state owned enterprises, private Chinese firms, and two forms of wholly owned foreign enterprises - Greater China and elsewhere) the omitted base being state-owned enterprises. The key ownership variable of interest is IJV (International Joint Ventures). The coefficient on IJV is positive and highly significant whereas the coefficients on all the other ownership types are individually and jointly insignificant[1]. In column (3) we drop all the other (insignificant) ownership types. In this column an IJV is associated with 20.3 log points (22.5%) higher productivity. Column (4) repeats the specification of column (1) but includes only those IJVs that had technology transfer agreements ("IJVTT") and column (5) includes all other IJVs (i.e. international joint ventures that were not technology transfers). It is clear that the coefficient on the technology transfer IJVs is much larger than other IJVs, although both are significant at conventional levels. In the final

[1] The F-test of the joint significance of all the non-IJV ownership dummies is 0.92 (p-value = 0.45).

column, we use the wage bill as a measure of labor services instead of employment to reflect differential skill levels of the workforce[2]. As expected this variable has a coefficient that is positive and highly significant. The coefficient on IJVs is now much smaller suggesting that the ownership dummies partially reflect higher human capital in the workforce[3]. In fact, although technology transfer IJVs remains positive and significant, other forms of IJVs are insignificant.

A major problem with estimates of Table 4 is that the ownership dummies are endogenous. Consequently we present our IV results in Table 5 beginning with a specification that pools all IJVs together. The OLS coefficient in column (1) is 0.27. The first instrument we use is FDI in the province at the time of the firm's birth as this will reflect the policies of that province towards foreign firms. Since FDI will be larger in larger provinces we normalize by total investment in the province and present the first stage in column (2). The instrument is highly informative with an F-statistic of over 31. Note we include total provincial investment in all columns to make sure we are only identifying from the interaction between firm birth and policy variables. The second stage is presented in column (3) and shows that the coefficient on IJV is positive and significant with a magnitude that is larger than the OLS coefficient.

Since we know from Table 4 that technology transfer agreements are more strongly associated with productivity than other IJVs, we use repeat the specifications in the first three columns in columns (4)-(6) but use IJVTT instead of IJV. The OLS coefficient for IJVTT is 0.737 and this rises in the IV specification of column (3) to 2.62. The pattern persists across the table - the IV results are above the OLS results.

[2] This is a very conservative specification in the sense that including the wage bill may condition out some of the effect we are looking for. for example, if very profitable firms share some of their "rents" from technology with workers, then the wage bill can rise even if human capital remains constant (see Van Reenen, 1996).

[3] We also tried including additional human capital characteristics of the workers such as average education, days off for training and tenure. These were insignificant when added to column (6) and did not materially change the coefficients on the IJVs .

We subjected these estimates to a range of robustness tests. First, normalizing on provincial employment instead of investment made little difference: in the specification of column (3) the IV estimate on IJV was 0.870 with a standard error of 0.287. Second, conditioning on the wage bill again brings down all coefficients, but only to a minor degree. The qualitative results on the large causal effects of technology transfer agreements on productivity remains robust. Third, we examined the provinces export (and import) intensity at time of firm start up as another proxy for policy at birth. These lead to qualitatively similar results to those reported in Table 5[4].

C. Investigation of the Mechanisms behind technology transfer

We tried to investigate the mechanism through which technology transfer agreements raised TFP in Chinese firms. From the survey we have a wide range of indicators of innovation, so we investigated whether conditioning on these indicators reduces the coefficient on IJV technology transfer agreements. These indicators included the number of patents, R&D expenditure, the use of information and communication technologies, the use number of brands, the use of trademarks and the introduction of new products. The broad answer was "no". Although many of the innovation indicators were positively and significantly associated with productivity, the coefficient on IJVTT was broadly unchanged. For example, replicating the specification of Table 4 column (5) on the 2330 observations where we observe ICT leads to a coefficient (standard error) of 0.803(0.184) on IJVTT. The coefficient on the ln(ICT expenditure) variable is 0.039 with a standard error of 0.013. But the coefficient (standard error) on IJVTT falls to 0.798(0.185) – basically unchanged. We conclude that the technology transfer mechanism is not well proxied by conventional observable measures of technology or innovation. One possibility is that it reflects the transfer of managerial know how, that is valuable but hard to measure (see Bloom and Van Reenen, 2007). Another possibility is that all of these conventional measures of technology are rather poor indicators of innovation in a Chinese context where the market is still under-developed. The implication is that IJVs that included a transfer of technology imitated the existing technology, which is consistent with the "catch up" mechanism where the recipient firm/country does not

[4] For example, using the specification of column (3) and exports over investment at the time of set-up as the instrument the coefficient on IJV was 1.156 with a standard error of 0.413. The F-statistic in the first stage of the excluded instruments was 17.6, so these have less power than the FDI instruments.

expend further resources but is more productive by producing with the foreign partner's know how.

IV. MAGNITUDES AND IMPLICATIONS

Capital accumulation accounted for 3.2 percentage points of the 7.3% growth in output per worker from 1979-2004 with TFP accounting for 3.6 percentage points (Bosworth and Collins, 2008). From 1993-2004 since the take-off of the "open door" policy, capital accumulation has accounted for 4.2 percentage points of the higher 8.5% growth in China, and interestingly outweighs the contribution of TFP (3.9 percentage points). Both estimates suggest that capital accumulation has contributed around half of China's economic growth, which is in line with other estimates that find that most of China's growth is accounted for mostly by capital accumulation rather than TFP growth[5].

Working on the premise that capital accumulation has accounted for about half of China's real GDP growth of 9.6% per annum since 1979; the contributions of IJVs of 9% and FDI as a whole accounting for 15% of investment translate into between 0.42 to 0.71 percentage point additions to growth. In other words, had China not attracted FDI, China would have grown slower by up to three-quarters of a percent slower, bringing the average growth rate down to 8.9 - 9.2%. Adding in the productivity boost of IJVs, IJVs are 23% more productive as compared with other firms and IJVs with technology transfer agreements hold a 73% productivity advantage (from the OLS estimates). IJVs are 15% of all firms in the 2000s, so China's GDP has been increased by between 3.45% and 10.95%, respectively. Translated this into growth terms (and assuming a cumulative process starting in 1979 for the increase in GDP by 2009) means that average growth would have been lower by 0.43% p.a. by 2009 if there had not been IJVs.

Putting all this together, we calculate that had China not attracted FDI and IJVs in particular with their potential to allow for "catching up" via technology transfers and other indirect avenues of learning, then China's annual GDP growth could have been between one-half to over a percentage

[5] For example see Zheng, Bigsten and Hu (2009) who find that TFP growth falls to 3% after the mid 1990s, while Young (2003) argues that on official figures it is 3% but would adjust it downwards to 1.4% from 1978-98.

point lower (i.e. as low as 8.5%) over the past 30 years. As IJVs were more important as a share of investment during the 1990s, accounting for around one-quarter of total investment, this is a conservative estimate. The contribution of joint ventures is therefore sizeable, as one percentage point in compound growth terms translates into large differences in income levels, as countries like India which has grown at 7-8% instead of China's 9 to 10% over the past few decades can attest.

V. CONCLUSIONS

In this paper we have examined the role that international joint ventures (IJVs) have played in increasing productivity in China. The Chinese government, like many other countries, has had an explicit policy to boost the amount of such international joint ventures (and technology transfer agreements in particular) to boost growth. Despite this, there are few assessments of the impact of international joint ventures on productivity.

This paper has tackled this lacuna by using a new survey of ownership and joint ventures in China and matched this to administrative data. We sought to identify the causal impact of IJVs by using policy variables at the time of firm start-up in the province where our firms were born. OLS and IV estimates of the impact of joint ventures suggest a large effect on firm productivity, especially for those that have explicit technology transfer agreements.

China's "catching up" is facilitated by IJVs and points the way for other developing countries. The evidence presented in this paper suggests that IJVs and technology transfer agreements in particular can contribute to the faster growth of developing countries and thus provide some direct evidence that there is the potential for "catching up" as envisioned in economic growth models.

There are many directions for future research. First, examining exogenous changes in the joint venture status of firms would obviously be beneficial in identifying the causal impact of ownership changes. There were no examples of such changes in our dataset, but by repeating such surveys in other time periods and other countries, this alternative identification strategy would be possible. Second, we have focused on the benefits of joint ventures to the firm who participates in

the partnership in China, but perhaps much larger effects could come from the spillovers that the joint venture generates for other firms in the Chinese economy (e.g. Greenstone et al, 2010). A major challenge is to try and identify such spillovers which is one of the key arguments policy makers use to justify subsidies for such activities. Thirdly, it would be good to go further in identifying the mechanism through which FDI has an effect on productivity. Is it through the importation of hard technologies? Is it the know-how in using these technologies? Or is it also a range of managerial and organizational practices that raise firm's capabilities (e.g. Bloom and Van Reenen, 2010). Finally, it would be good to embed the mechanism we focus on within a more general assessment of the causes of China's growth (see Song et al, 2011). These are all active avenues for research.

BIBLIOGRAPHY

Aitken, B.J. and Harrison, A.E. (1999). "Do domestic firms benefit from direct foreign investment? Evidence from Venezuela," *American Economic Review*, 89(3), 605-18.

Blomström, M. (2006). "Foreign investment and productive efficiency: The case of Mexico," *Journal of Industrial Economics*, 35(1), 97-110.

Blomström, M. and Kokko, A. (1998). "Multinational corporations and spillovers," *Journal of Economic Surveys*, 12(3), 247-77.

Bloom, N. and Van Reenen, J. (2007) "Measuring and Explaining Management practices across firms and nations" *Quarterly Journal of Economics* (2007) 122(4), 1351–1408.

Bloom, Nick and John Van Reenen (2010) "Why do Management Practices Differ across Firms and Countries?" *Journal of Economic Perspectives* 24(1) 203-224

Burstein, Ariel and Alexander Monge-Naranjo (2008), "Foreign Know-How, Firm Control, and the Income of Developing Countries", *Quarterly Journal of Economics*, 124(1), 149-195.

Chandler, Alfred (1962) *Strategy and Structure: Chapters in the History of the Industrial Enterprise*, MIT Press.

Chuang, Y. and Hsu, P. (2004). "FDI, trade, and spillover efficiency: Evidence from China's manufacturing sector," *Applied Economics*, 36(10), 1103-15.

Djankov, A. and Hoekman, B.M. (2000). "Foreign investment and productivity growth in Czech enterprises," *World Bank Economic Review,* 14(1), 49-64.

Dougherty, S., Herd, R. and He, P. (2007). "Has a private sector emerged in China's industry? Evidence from a quarter of a million Chinese firms," *China Economic Review,* 18, 309-34.

Felmingham, B.S. and Zhang, Q. (2002). "The role of FDI, exports and spillover effects in the regional development of China," *Journal of Development Studies*, 38(4), 157-78.

Greenstone, Michael, Rick Hornbeck, and Enrico Moretti (2010) "Identifying Agglomeration Spillovers: Evidence from Million Dollar Plants" *Journal of Political Economy*, 118 (3): 536-598

Haddad, M. and Harrison, A.E. (1993). "Are there positive spillovers from direct foreign investment? Evidence from panel data for Morocco," *Journal of Development Economics*, 42, 51-74.

Helpman, Elhanan, Marc Melitz, and Stephen Yeaple (2004) "Export versus FDI with Heterogeneous Firms", *American Economic Review*, 94(1), 300-316.

Hu, A.G.Z., Jefferson, G.H. and Qian, J. (2005). "R&D and technology transfer: Firm-level evidence from Chinese industry," *The Review of Economics and Statistics,* 87(4), 780-86.

Javorick, B. (2004). "Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages," *American Economic Review*, 94(3), 605-27.

Jefferson, G.H. and Su, J. (2006). "Privatization and restructuring in China: Evidence from shareholding ownership, 1995-2001," *Journal of Comparative Economics*, 34, 146-166.

Konings, J. (2001). "The effects of foreign direct investment on domestic firms - Evidence from firm-level panel data in emerging economies," *Economics of Transition,* 9(3), 619-33.

Lall, S. (1978). "Transnationals, domestic enterprises, and industrial structure in host LDCs: A survey," *Oxford Economic Papers*, 30(2), 217-48.

Markusen, J.R. and Venables, A.J. (1999). "Foreign direct investment as a catalyst for economic development," *European Economic Review*, 43(2), 335-56.

Pawasutipaisit, Anan and Robert Townsend (2009), "Wealth Accumulation and Factors Accounting for Success", MIT mimeo.

Rodríguez-Clare, A. (1996). "Multinationals, linkages, and economic development," *American Economic Review*, 86(4), 852-73.

Song, Z., Storesletten, K., and Zilibott, F. (2011). "Growing Like China" *American Economic Review*, 101(1): 196–233

Van Reenen, J. (1996) "The Creation and Capture of Economic Rents: Wages and Innovation in a Panel of UK Companies" *Quarterly Journal of Economics* CXI, 443, 195-226

Young, A. (2003). "Gold into base metals: productivity growth in the People's Republic of China during the reform period," *Journal of Political Economy*, 111(6), 1220-61.

Table 1: Ownership types

Ownership Type	SOE (State Owned Enterprise)	Privatised SOE	Private Chinese	IJV (International Joint Venture) Greater	IJV Other	IJV TT (Technology Transfer)	WOFE (Wholly Owned Foreign	WOFE other	Total
Share	37.0%	13.8%	29.2%	5.0%	6.3%	2.3%	3.2%	3.2%	100%
Firms	470	175	370	63	80	29	41	41	1269

Note: Ownership type of each firm relates to initial ownership. Greater china includes Taiwan, Hong Kong and Macau.

Table 2 Descriptive Statistics

	Value Added	Number of workers	Capital Stock	Value added per worker	Capital stock per worker	% managers with higher education	Firm Age	Provincial FDI/total investment
	Y	L	K	Y/L	K/L	% college	Age	FDI
Mean	30241.433	687.813	72951.809	49.469	96.258	1.500	12.695	99.023
Median	6113.566	218.000	10974.416	28.187	52.852	1.000	8.000	78.456
s.d.	92487.605	1644.721	232877.325	67.568	208.248	0.773	14.373	88.156
Obs	4490	4491	4490	4346	4346	5405	5385	5231

Note: Monetary values are in 100 RMB.

Table 3: Total domestic and foreign direct investment in China, 1984-2007

	(1) Total investment (US$ bn)	(2) Domestic investment (US$ bn)	(3) FDI (US$ bn)	(4) IJVs (US$ bn)	(5) IJV share of FDI	(6) # IJVs	(7) # Foreign-firms	(8) FDI share of total investment	(9) JV share of total investment
1984	36.82	32.03	2.87	2.55	88.72%	n/a	n/a	7.81%	6.93%
1985	50.62	35.30	10.09	5.53	54.76%	n/a	n/a	19.94%	10.92%
1986	57.71	45.97	2.83	2.73	96.43%	n/a	n/a	4.91%	4.74%
1987	65.33	53.19	3.71	3.23	87.17%	n/a	n/a	5.68%	4.95%
1988	83.45	67.45	5.30	4.76	89.82%	n/a	n/a	6.35%	5.70%
1989	92.71	81.23	5.60	3.74	66.83%	n/a	n/a	6.04%	4.04%
1990	98.78	78.28	12.61	3.96	31.38%	n/a	n/a	12.77%	4.01%
1991	115.19	93.97	13.17	8.22	62.38%	n/a	n/a	11.44%	7.13%
1992	147.67	78.23	58.12	42.38	72.92%	n/a	n/a	39.36%	28.70%
1993	230.11	106.84	111.44	80.67	72.40%	n/a	20,058	48.43%	35.06%
1994	297.80	204.04	82.68	60.49	73.17%	n/a	29,101	27.76%	20.31%
1995	372.89	269.69	91.28	57.57	63.06%	39350	49,559	24.48%	15.44%
1996	421.42	339.81	73.28	46.17	63.01%	32816	43,412	17.39%	10.96%
1997	438.74	377.68	51.00	32.79	64.29%	31580	42,881	11.62%	7.47%
1998	458.45	399.89	45.46	28.07	61.74%	n/a	26,442	9.92%	6.12%
1999	482.42	429.76	40.32	24.06	59.68%	n/a	26,837	8.36%	4.99%
2000	510.11	450.75	40.71	20.94	51.43%	n/a	28,445	7.98%	4.10%
2001	582.24	532.56	46.88	21.95	46.83%	n/a	31,423	8.05%	3.77%
2002	667.09	612.07	52.74	20.05	38.01%	n/a	34,466	7.91%	3.01%
2003	819.32	763.18	53.51	19.23	35.94%	n/a	38,581	6.53%	2.35%
2004	1,012.65	948.57	60.63	19.50	32.16%	n/a	57,165	5.99%	1.93%
2005	1,180.69	1,116.88	60.33	16.45	27.26%	n/a	56,387	5.11%	1.39%
2006	1,377.70	1,310.62	63.02	16.32	25.89%	26604	60,872	4.57%	1.18%
2007	1,623.89	1,545.55	74.77	17.01	22.75%	28622	67,456	4.60%	1.05%

Source: China Statistical Yearbook, various years. **Note:** Domestic investment figures in RMB were converted using 1.00 CNY = 0.146403 USD. Column (5)=(4)/(3). Column (1) is not equal to (2) and (3) as there were other types of foreign investments, namely, loans.

Table 4: Production Functions, OLS

Dependent variable: ln(Value Added), ln(Y)	(1)	(2)	(3)	(4)	(5)	(6)
IJV (International Joint Venture)		0.203*** (0.074)	0.228*** (0.066)			
IJVTT (IJV with tech transfer agreement)				0.737*** (0.194)	0.759*** (0.195)	0.572*** (0.164)
IJV_Other (all Other IJVs)					0.125* (0.065)	0.072 (0.060)
Privatized SOE		0.037 (0.061)				
Private Chinese Firm		-0.043 (0.061)				
Foreign Firm (Great China)		-0.147 (0.115)				
Foreign Firm (other)		-0.114 (0.100)				
Omitted Base category: **SOE**						
ln(Labor)	0.607*** (0.028)	0.608*** (0.028)	0.606*** (0.028)	0.606*** (0.028)	0.606*** (0.028)	
ln(Capital)	0.278*** (0.018)	0.274*** (0.018)	0.272*** (0.018)	0.276*** (0.019)	0.273*** (0.019)	0.199*** (0.020)
% College Educated	0.281*** (0.034)	0.274*** (0.034)	0.270*** (0.033)	0.272*** (0.032)	0.267*** (0.032)	0.230*** (0.029)
ln(Wagebill)						0.342*** (0.017)
Firms	1,155	1,155	1,155	1,155	1,155	1,155
Observations	4,204	4,204	4,204	4,204	4,204	4,204
R-squared	0.740	0.743	0.743	0.745	0.746	0.782

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation by OLS in all columns with standard errors clustered by firm in parentheses below coefficients. All columns include firm age, a full set of three digit industry dummies (187), a multi-plant dummy, year dummies, year of entering sample dummies and province dummies. SOE is "state owned enterprise". "Great China" includes Taiwan, Hong Kong and Macao). % College Educated is the proportion of managers with a college degree.

Table 5: Production Functions, Instrumental Variables

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	**Ln(Y)**	**IJV**	**Ln(Y)**	**Ln(Y)**	**IJVTT**	**Ln(Y)**
		1st Stage	**2nd Stage**	**1st Stage**	**2nd Stage**	**1st Stage**
Method	OLS	OLS	IV	OLS	IV	OLS
IJV (International Joint Venture)	0.228***		0.812***			
	(0.066)		(0.290)			
IJVTT (IJV with tech transfer agreement)				0.737***		2.620**
				(0.194)		(1.053)
Ln(FDI) in Province in year of birth		0.026**			0.011**	
		(0.011)			(0.004)	
Dummy - FDI=0 in province in year of birth		-0.275***			-0.065***	
		(0.058)			(0.024)	
ln(Labor)	0.606***	0.020	0.603***	0.606***	0.005	0.605***
	(0.028)	(0.015)	(0.030)	(0.028)	(0.008)	(0.032)
ln(Capital)	0.272***	0.024**	0.257***	0.276***	0.003	0.270***
	(0.018)	(0.011)	(0.021)	(0.019)	(0.005)	(0.022)
% College Educated	0.270***	0.039**	0.242***	0.272***	0.009	0.251***
	(0.033)	(0.017)	(0.033)	(0.032)	(0.010)	(0.035)
F-Stat of excluded IV		31.2			8.08	
Firms	1,155	1,155	1,155	1,155	1,155	1,155
Observations	4,204	4,204	4,204	4,204	4,204	4,204
R-squared	0.743	0.168	0.726	0.745	0.065	0.711

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation by OLS in all columns with standard errors clustered by firm in parentheses below coefficients. FDI is ln(investment in province at firm's year or birth/total investment in province). All columns include ln(investment in province at firm's year or birth), firm age, a full set of three digit industry dummies (187), a multi-plant dummy, year dummies, year of entering sample dummies and province dummies. % College Educated is the proportion of managers with a college degree.

DATA APPENDIX

To deflate norminal values we use price deflators from NBS (2006) "NBS Ex-Factory Price Index of Industrial Products" for value added and "NBS Price Index for Investment in Fixed Assets" for capital. To avoid influential observations due to reporting error, the production data is winsorised on the 1st and 99th percentiles. We only have incomplete data coverage on the firm's year of establishment: this information is available for nearly all of the foreign-invested enterprises and over three-quarters of the private Chinese firms, with data for SOEs and privatized SOEs mostly missing. Given the considerable institutional changes during the reform period from the late 1970s to the present time, whereby China transformed itself from a planned to a primarily market-driven economy, we argue that firm age for enterprises established prior to 1978 cannot be interpreted in the same way as in a Western market economy. We therefore uniformly code SOEs with missing data as established in 1978.

The survey data further contains information on manager (and worker) characteristics for 2005. These data include information on the share of managers with college education respectively and also the share of managers with tertiary education. For each of these variables the raw data is in categories (e.g. 1 = 0-20%, 2=20-40% etc.). We apply the median value for the reported category (in logs).

The distribution of firms across industrial sector is given in Table A1.

Table A1: Distribution of industrial sectors

Sector	Share of total (%)
Mining	1.06
Food, beverages & tobacco	13.17
Textiles, apparel & leather products	11.63
Wood, furniture & paper products	6.54
Crafts, other manufacturing & non-specified	1.15
Oil processing, coking & nuclear fuel processing	1.54
Chemicals & chemical products	13.75
Rubber & plastic products	3.75
Non-metallic mineral products	6.25
Metal processing & products	8.94
Machinery, equipment & instruments	7.02
Transportation equipment	11.73
Electrical machinery & equipment	7.12
Electric power & utilities	6.35

Note: The proportion of firms in each of the industrial sectors is reported. The 2-digit industrial codes have been grouped into 14 industrial sectors as follows: (1) Mining includes: Coal mining and cleaning; Black metal mining; Non-ferrous metal mining; Non-metallic mining; (2) Food, beverages & tobacco includes: Food processing; Food manufacturing; Beverages; Tobacco; (3) Textiles, apparel & leather products include: Textiles; Textiles and garments, shoes, hats manufacturing; Leather, fur, feathers, cashmere and its products; (4) Wood, furniture & paper products includes: Wood processing and timber, bamboo, rattan, brown grass products; Furniture manufacturers; Paper and paper products; (5) Crafts, other manufacturing & non-specified includes: Printing and recording media; Cultural sporting goods manufacturing; Crafts and other manufacturing industries; Not specified; (6) Oil processing, coking & nuclear fuel processing; (7) Chemicals & chemical products includes: Chemicals and chemical products; Chemical fibre manufacturing; (8) Rubber & plastic products includes: Rubber products; Plastic products; (9) Non-metallic mineral products; (10) Meta processing &products includes: Black metal smelting and pressing; Non-ferrous metal smelting and pressing; Fabricated metal products; (11) Machinery, equipment & instruments includes: General equipment; Special equipment; (12) Transportation equipment; (13) Electrical machinery & equipment includes: Electrical machinery and equipment; Communication equipment, computer and other electronic equipment; Instrumentation and culture, office machinery; (14) Electric power & utilities includes: Waste resources and recycling waste materials processing; Electricity, heat production and supply; Gas production and supply; Water production and supply.

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