1-1-2015

Essays on the Role of Knowledge in Recent Chinese Development

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Abstract
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Chapter 2: Intellectual property piracy is widely believed, by authorities in both U.S. industry and government, to be rampant in China. Because we lack evidence on the rate at which unpaid consumption displaces paid consumption, we know little about the size of the effect of pirate consumption on the volume of paid consumption. We provide direct evidence on both the volume of unpaid consumption and the rate of sales displacement for movies in China using two surveys administered in late 2008 and mid-2009. First, using a survey of Chinese college students' movie consumption and an empirical approach parallel to a similar recent study of U.S. college students, we find that three quarters of movie consumption is unpaid and that each instance of unpaid consumption displaces 0.14 paid consumption instances. Second, a survey of online Chinese consumers reveals similar patterns of paid and unpaid movie consumption but a displacement rate of roughly zero. We speculate on the small displacement rate finding relative to most of the piracy literature.

Degree Type
Dissertation

Degree Name
Doctor of Philosophy (PhD)

Graduate Group
Applied Economics

First Advisor
Howard Pack

Keywords
Automotive Industry, Backward Linkages, China, Foreign Direct Investment, Movie Piracy, Productivity Externalities

ESSAYS ON THE ROLE OF KNOWLEDGE IN RECENT CHINESE DEVELOPMENT

Jie Bai

A DISSERTATION

in

Applied Economics

For the Graduate Group in Managerial Science and Applied Economics

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2015

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ESSAYS ON THE ROLE OF KNOWLEDGE IN RECENT CHINESE DEVELOPMENT

To my husband,

Liang Wang,

who has been holding my hands through all the joys and tears.

To my parents,

Mandou Bai and Yali Wang,

who always believe in me and do their best to love me.

To my daughter,

Baiyi (Tutu) Wang,

who never fails to inspire me for each passing day.

献给我亲爱的爸爸白满斗，妈妈王亚利，

丈夫王亮和女儿王白衣.

To the One

who never stops pursuing me with His steadfast love.

ACKNOWLEDGEMENT

It is still like a dream for me now. I cannot believe that I did it! Without the generous support and continuous encouragement from Howard, my academic advisor, I could not have done it. I cannot thank him more! I am very grateful for his guidance and advice at every single step of the dissertation process. He has great interest in real-life questions and encouraged me to conduct my own field study in China to learn how things work in reality. It turned out to be a very fruitful and enjoyable experience. Howard is the most knowledgeable person I've ever met. His genuine interest in people and his ability to talk to everyone truly amazed me. Howard, as well as Janet (Howard's beautiful wife), treat me as a friend. They care not only about my academic performance, but also about me as a person. I appreciate it that he gave me enough time and space to make my own mistakes, allowing me to learn from my errors. On a side note, the most beautiful scene I had ever seen at Penn is Howard and Janet walking down the Locust Walk, holding each other's hands.

I am also grateful to two other faculty members on my committee, Dr. Anagol Santosh and Dr. Qiaowei Shen, for being interested in my work outside of their fields and for excellent comments that have substantially improved my thesis. Professor Joel Waldfogel, my co-author of the second paper, is very insightful and passionate about research. He has the "magic" to turn a casual topic into a paper. Our idea to study the movie piracy in China sprouted from a chat during a lunch break in a conference. He provided much practical advice and encouragement as I made my way from initial research questions to a paper.

I want to take this opportunity to give special thanks to Professor James Tybout at Penn State, where I did my graduate study. It was in his international trade class where I found my interest in the area of international industrial policy and decided to pursue the study at Wharton. Taking his class was one of my unforgettable memories. It was very challenging and equally rewarding. I had a tough start, but Jim bore with me by answering each question (sometimes very silly ones) with tremendous patience. I was deeply grateful for every bit of kindness he had shown

me. Professor Mark Roberts, for whom I had been a teaching assistant at Penn State, was one of the kindest persons I had ever met. I am greatly indebted to him for supporting my decision to leave for Penn so that I could live with my husband while continuing my graduate study.

My field trips to China were impossible without the tremendous support from many people in the China's automotive industry. Song Wei, Li Xin, Dong Ming, Sun Ping, and Gan Quan in Beijing, Li Yun, Wu Zhiping, and Wang Youzhao in Shanghai were all generous with their time. They patiently helped me understand the industry and provided me with the information that is the basis for the case study part of my dissertation. I was deeply humbled by their expertise and creativity in practice. My friends, Wang Gang, Liu Jia, Qiu Tian, and Lu Yan in China, never hesitated to lend a helping hand during my stay. My gratitude also goes to the wonderful staff team at Wharton BEPP, Diana, Jennifer, Beth, Louis. They welcomed me back as a family member and provided timely help anytime when I need. I also want to thank Maggie, Danielle, and Mallory, at the Wharton PhD office, for their excellent assistance.

I was surrounded with tons of love and prayers by many. I only wish I did not miss any of them. Thank you, my dear sisters and brothers: Chen Lihang, Cheng Xiao, Han Lining, He Andong, He Xia, Heng Junyao, Hu Jing, Hu Jinsheng, Huang Sijia, Irene, Jin Ye, Li Xuxiao, Liu Yiqin, Mao Rui, Rao Yunjie, Wang Min, Wang Xiaozhou, Yu Yuezhao, and Zhang Hui in Hawaii, and Chen Qi, Wang Fenfen, Wang Qian, Wang Xue, and Ying Mingjie in Philadelphia. My dear friends, Liu Yunxian, Su Shu, and Zhang Shijing, have me in their hearts and tireless prayers no matter how far we are apart. Thank you, Pastor Simon Lee, for your love and prayers for our family. Helen and Zhongjie Liang, Philip and Anya Siu are my spiritual mentors, in whom I always trust in times of troubles and confusion.

I am now writing this acknowledgement in the living room of my friends' home. Gong Bo and Xie Dawei, as well as Cao Kui and Huang Yijing, generously open their home to me during my brief stay in Philadelphia. They treat me like a family member. Indeed, we are a family! I would like to thank my dear sister Li Ning, who had warmly welcomed me to her office at the University of Hawaii. For two and a half years, she proved to be my faithful friend and passionate prayer

partner. I also want to thank Dr. Kwok Fai Cheung at the Ocean and Resources Engineering Department of UH-Manoa, for generously allowing me to share office with Li Ning at the HIG building.

Thank you, Baba and Mama! You are such wonderful parents! You walked through this long journey with me and never lost your faith in me. Your love sustains me and gives me courage to keep going. Thank you, my in-laws, for your constant support and prayers. You treat me like your own daughter and offer help whenever we need. Thank you, my dear daughter, Wang Baiyi (Tutu)! You have brought so much joy into my and daddy's life. Your smiles truly brightened many dark days. I cherish every moment with you! One of the reasons why I did not give up midway is that I wanted to learn how to overcome my deep-rooted fears so that one day I could teach you how to battle with your own fears. With each passing day, the most important thing of which I've become more and more certain is that I have the best husband—wise, insightful, eloquent, passionate, steadfast, trustworthy, responsible, supportive, gentle, humble, humorous, … and handsome! How wonderful that we could hold hands and grow into maturity together!

Three and a half years ago, it was the first time when I travelled from Hawaii back to Philadelphia, leaving my 8-month-old daughter at home. Without data, case study evidence, or any materials which could be used in my dissertation, I was completely hopeless. I did not know how to proceed. While I was weeping on the plane, this passage came into my sight, "those who sow in tears shall reap with shouts of joy! He, who goes out weeping, bearing the seed for sowing, shall come home with shouts of joy, bring his sheaves with him." At that moment, I burst into tears again, but tears of hope this time. For the next three and a half years, it was His faithfulness and mercy that sustained me until this very moment. This morning (on the day of my defense), when I woke up, instead of being fearful, I felt complete peace. I knew it was He who had caused my fear to fly. Thank you, my dear Lord, for never leaving me or forsaking me. If there is only one thing I've learnt throughout this long journey, it is this: **it is my strength to seek your face**.

ABSTRACT

ESSAYS ON THE ROLE OF KNOWLEDGE IN RECENT CHINESE DEVELOPMENT

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Chapter 1: Earlier studies have consistently found evidence for productivity externalities of FDI through backward linkages. However, most studies do not use direct measures of backward linkages, nor do they further investigate what exactly generates these productivity externalities. Using a unique dataset from the Chinese automotive industry, which provides direct supply linkage measures, this study shows that compared with suppliers that only sell to domestic brands, the total factor productivity premium is about 16.7 percent for auto parts suppliers that sell to at least one foreign brand. Employing difference-in-differences estimation, a causal link from backward linkages to the suppliers' productivity growth is also established. Specifically, auto parts suppliers' productivity grows by 25.5 percent in the first year after formal supply relationships are forged with foreign joint venture automakers, and productivity continues to grow at least over the next two years. The case study further identifies knowledge transfer from joint venture automakers as an important source of productivity gains in local suppliers. It also offers three caveats that need to be taken into account when interpreting the observed productivity externalities in the econometric analyses.

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1 Introduction

Many countries strive to attract foreign direct investment (FDI), which is taken as a catalyst for industrial development. Expecting FDI inflows to bring a package of capital, technology, and management skills, host countries tend to offer multinationals many favorable conditions, such as subsidies, tax holidays, policy loans, and so on. Extensive research efforts are devoted to examining FDI externalities and understanding its mechanisms in order to justify, or to provide guidance for, policy implementation. This study focuses on a specific kind of FDI externalities, the backward externalities, which take place when the domestic suppliers' productivity increases through their interaction with their downstream multinational customers and the value of these benefits are not fully internalized by multinationals.

The purpose of this study is twofold. First, it examines whether the productivity of local suppliers is enhanced by their *backward linkages*—partnerships with multinational affiliates in the host country. The analysis departs from the recent literature by using a direct measure of backward linkage—whether a local supplier sells to multinational customers—which is rarely observed in previous studies. This direct backward linkage measure makes it possible to conduct a causality test to investigate whether foreign investors in downstream sectors actually *bring about* the higher productivity levels of their local suppliers. However, economic policy intervention may not be warranted in these cases, since the elevated productivity levels associated with backward linkages may

not necessarily constitute evidence for pure externalities or knowledge spillovers. These suppliers' productivity may improve for reasons other than knowledge transfer, as Keller (2010) points out. Therefore, the second goal of this study is to explore the sources of the observed productivity externalities through backward linkages. Drawing upon fieldwork, this study first examines how backward linkages manifest themselves in the automotive industry and focus on various forms of technology transfers from multinational buyers to their local suppliers. Then concrete measures are provided for cost reduction and productivity increases in some auto parts suppliers as a direct consequence of knowledge transfer through backward linkages.

Unlike previous studies that have looked at entire manufacturing sectors,[1] this paper focuses on a particular industry—the Chinese automobile industry—broadly defined as also including automobile parts and components suppliers. This setting provides two main advantages for researchers. First, certain features of the automobile industry suggest it may be a major beneficiary of FDI's externalities through backward linkages. The flows of FDI in the automotive industry have been among the largest in the manufacturing sector, and the globalization of production has been most extensive. In the vertical direction, multinationals worked closely with suppliers in the host country to increase those suppliers' productivity (Moran 2005). Second, using the richer dataset of the Chinese automobile component industry, it is possible to overcome the significant data restrictions faced by earlier researchers. Previously, researchers have lacked detailed

[1] To name a few, Javorcik (2004) on Lithuanian manufacturing sectors, Blalock and Gertler (2008) on Indonesia's manufacturing establishments, and Du, Harrison, and Jefferson (2011) on Chinese manufacturing firms as well as firms that produce and supply electricity, gas, and water.

information on customer-supplier linkages, resorting to industry input-output tables to compute an industry-level proxy for the foreign presence in the industries that are being supplied by a particular industry. This conventional estimator is "best interpreted as the effect of an increase in the availability of technology on the average productivity of sellers in a particular industry in a particular region" (Blalock and Gertler 2008, 410). With firm-specific supply linkage information, it is possible to conduct a direct test as to whether suppliers selling to multinational car producers are more productive than those selling to indigenous carmakers. This is a more ideal measure of backward linkage, since it is based on the actual supply linkages of foreign buyers[2] to local suppliers and thus captures the extent of potential interactions between them.

Two results are presented in the econometric analyses. First, supplier firms' total factor productivity is positively correlated with their backward linkages with multinational buyers. Compared with suppliers that only sell to domestic brands, the total factor productivity premium is about 16.7 percent for auto parts suppliers that sell to at least one foreign brand. This productivity premium varies little after adding the control variables of firm age, agglomeration, and competition; it also remains positive in most cases across various groups of suppliers according to firm age, foreign ownership, product categories, and region. Second, a causal link from backward linkages to the growth of the suppliers' productivity is established in a productivity trajectory analysis of suppliers' productivity growth before and after selling to foreign brands. Employing difference-in-differences estimation, auto parts suppliers' productivity grows by 25.5

[2] In this paper, foreign buyers mean manufactures of foreign brands that are located within China.

percent in the first year after forging partnerships with foreign brands, and it continues to grow in the following few years.

Although suppliers' productivity improves if they are linked with multinational customers, the econometric analyses do not identify any particular sources of the observed productivity externalities. Case evidence from a joint venture automotive manufacturer and several local suppliers is used to supplement the econometric analysis by providing a real-life picture of knowledge transfer from joint venture automakers to local suppliers and how the transferred knowledge manifests itself in terms of enhanced productivity.

The case study identifies knowledge transfer from joint venture automakers as an important source of productivity gains in local suppliers. First, joint venture automakers have incentives to transfer technical knowledge and management practice to their suppliers in the rapid localization process. Second, the knowledge transfer is not a one-way diffusion from foreign investors to their suppliers; instead, it takes many forms both before and after actual production begins. Specifically, joint venture automakers provide a combination of direct knowledge transfer, inducement mechanisms for internal efforts, and platforms on which knowledge can be shared, or even created, through interactions among suppliers. Third, the examples of two suppliers provide evidence for the suppliers' enhanced productivity, quality improvement, and cost reduction as direct consequences of knowledge transfer from their joint venture automakers.

However, three caveats, revealed in the case study, need to be taken into consideration when interpreting the observed productivity externalities in the

econometric analyses. First, knowledge transfer from joint venture customers to their suppliers may be costly; thus knowledge transfer may not constitute externalities. Second, the case study also finds several other sources of observed productivity externalities related to backward linkages, which, unlike knowledge spillovers, are not necessarily true externalities. Third, an important feature about product launch in joint venture automakers' local suppliers—a one to two year lag between the procurement contract and the actual production—is identified in the case study. During this period of time, substantial knowledge diffusion and absorption could take place, but was not captured in the econometric analysis. For that reason, the aggregate productivity-enhancing effect of supplying joint venture automakers tends to be underestimated.

The rest of the paper is structured as follows. Section 2 reviews literature on FDI's productivity spillovers through backward linkages. Industry background is provided in Section 3 to explain why unique evidence from the Chinese automobile industry's experience with FDI helps in addressing the research questions. Section 4 describes the data and empirical specifications, followed by the econometric results. Section 5 is devoted to case evidence gathered from industry interviews to explore the sources of observed productivity externalities through backward linkages. Concluding remarks are in Section 6.

2 Literature Review

In the literature, researchers have identified multiple channels of productivity externalities of FDI through backward linkages, but econometric studies—at best—estimate a combined effect of these channels on local firms' productivity. Below is a

review of the multiple channels of productivity externalities of FDI through backward linkages that researchers have identified. After that, the common econometric method and proposed possible improvements are described.

2.1 Channels of Productivity Externalities through Backward Linkages

FDI can be a source of productivity externalities, including both pure and pecuniary externalities. Knowledge spillover is a form of pure externality that the market fails to take into account. Pecuniary externalities take place through market transactions. A few theoretical studies have explored the mechanisms of productivity externalities through backward linkages; some empirical work also has highlighted the importance of particular mechanisms.

Direct Knowledge Transfer

A number of scholars have argued that multinationals may transfer technology to suppliers as part of a strategy to build an efficient, high quality supply base in the host economy (to name a few, Javorcik 2004; Pack and Saggi 2001). However, if the benefits of knowledge transfer are internalized through input price reduction or direct consultant payment, the transferred knowledge does not generate productivity externalities. Thus, it is necessary to examine the features of knowledge transfer when relating it to pure externality. Pack and Saggi (2001) propose a mechanism through which knowledge transfer from multinationals may generate social benefits. They suggest that multinationals may have incentives to diffuse technology deliberately to upstream vendors besides their original suppliers. The wide diffusion of the technology would

encourage entry into the supplier market so that these multinationals may reap the benefits of increased competition and a reduced input price in the upstream sector.

Competitive pressure

Enhanced competition in the consumer good market forces suppliers to engage more in innovative activity and to improve productivity, but competitive effects differ among suppliers. Chung, Mitchell, and Yeung (2003) find that downstream FDI by Japanese auto manufacturers by and large has a positive effect on upstream suppliers in the US automotive components industry, but tie-in relationships did not particularly increase the productivity of supplier firms. Without systematic analysis, Chung et al. simply attribute competitive pressure as the primary cause of overall productivity growth.

Demand-scale effect

The entry of multinationals creates demands for domestic intermediate goods providers. Under an assumption of increasing returns to scale, the productivity of local firms would rise as they spread their fixed costs over a larger market, helping them move down their average cost curves (Markusen and Venables 1999). Javorcik (2004) estimates this scale effect by including the demand for intermediates calculated from information on sourcing patterns from the input and output matrix as well as the value of production in using sectors. She finds a positive correlation between demand in downstream sectors and firm productivity.

Input variety

Rodriguez-Clare (1996) proposes another mechanism through which the demand created by multinational may enhance local suppliers' productivity. He assumes that there

is love of variety for inputs in the production of final goods and that inputs are produced with increasing returns to scale. This increased demand for inputs allows a final-good firm to create a greater variety of specialized inputs, and this in turn leads to an increase in the productivity of domestic suppliers. Compared to local final-good firms, multinationals are more likely to generate a positive linkage effect because the products multinationals produce are more complex.

Quality Linkage

Javorcik (2004) mentions another channel of positive productivity externality from MNCs to suppliers. Multinationals impose more stringent quality requirements for process and product, providing incentives for domestic suppliers to improve their technologies or management. In their interviews, Rodriguez-Clare and Alfaro (2004) find that local firms had decided to upgrade the quality of their production processes in order to become MNC suppliers, even though these upgrades required significant investment. Presumably, the quality upgrading by suppliers would be reflected in an increase in their measured total factor productivity (TFP).

2.2 Review of Current Econometric Methodology

The general empirical model specified below is the most frequently encountered in econometric tests of FDI spillovers through backward linkages. The empirical strategy is to calculate a backward linkage measure and to examine the correlation between firm's productivity and the linkage measure. A positive coefficient on the backward linkage measure is interpreted as positive FDI spillovers through backward linkages.

For example, consider a foreign-invested automaker (the buyer) and a local bumper producer. Suppose that selling bumpers to the foreign-invested automaker improves the bumper producer's productivity. It could be the case when the automaker assists its bumper suppliers at a cost below market value, or when the pressure from the automaker elicits best efforts from its bumper supplier. Regardless of the mechanisms, the enhanced productivity due to customer relationships with foreign-invested producers is counted as positive FDI spillovers through backward linkages.

As Gorg and Strobl (2005) argue, such an empirical specification does not consider spillover channels explicitly. Any externalities from interactions between suppliers and their customers of foreign brands are accounted for in the production function estimation. The coefficient on the backward linkage measure picks up a net effect of FDI—a combined effect of knowledge transfer, competition, scale effect, and linkage effects, as reviewed above.[3]

$$\ln Y_{ijt} = \alpha + \beta_1 \text{Backward}_{jt} + \beta_2 \ln K_{ijt} + \beta_4 \ln L_{ijt} + \alpha_t + \alpha_j + \epsilon_{ijt} \qquad (1)$$

Y_{ijt} stands for the real output of firm i operating in sector j at time t, which is usually calculated by priced-adjusted production output or value added. K_{ijt} is defined as the value of fixed assets at the beginning of the year, deflated by investment price index. L_{ijt} is the total number of employees; it is also expressed in terms of efficiency units, which are computed by dividing the wage bill by the minimum wage (B. S. Javorcik 2004). In

[3] Some attempts are made to control competition effect and demand effect. For example, the Herfindahl index is included as a proxy for the level of industry concentration. The demand for intermediates is calculated based on information on sourcing patterns from the input-output matrix and the value of production in certain sectors (Javorcik 2004; Liu 2008).

some cases, M_{ijt} measures of materials are also included in the specifications. Backward linkage is measured by the share of the total output of an industry that is sold to downstream foreign buyers across all industries. Specifically, it is defined as in Blalock and Gertler (2008) and (B. S. Javorcik 2004):

$$\text{Backward}_{jt} = \sum_{k \text{ if } k \neq j} \alpha_{jk} \, \text{Horizontal}_{kt}$$

where Horizontal_{kt} is a proxy for horizontal spillovers, represents the proportion of the total output of a given industry in a given year[4] produced by all foreign affiliates. It is defined as below:

$$\text{Horizontal}_{jt} = \frac{\sum_{i \text{ for all } i \in j} \text{Foreign Share}_{it} \times Y_{it}}{\sum_{i \text{ for all } i \in j} Y_{it}}$$

This captures the extent of foreign presence in sector j at time t and assumes that technology spillovers from foreign firms to local rivals increase when there is an increase in either the output of foreign investment enterprises or the share of foreign equity in these firms.

α_{jk} is the proportion of sector j′s output supplied to sector k. The common approach to approximating α_{jk} is to use the input-output coefficients taken from the host country's input-output tables. These tables show the amount that firms in one industry purchase from each of the other industries. Together with the information on the share of output in

[4] Sometimes the horizontal spillover measure varies across regions as well. In that case, a local market is assumed, so that any technology spillover from foreign firms to local rivals most likely only occurs among firms that are geographically close. That assumption holds when regions are geographically isolated. It is true in the case of Indonesia, where poor inter-region transportation infrastructure is rather constrained by its vast island geography (Blalock and Gertler 2008).

industry j that is produced by foreign-owned firms (horizontal spillover measures), a measure of backward linkage can be constructed, which is the sum of the output shares purchased by other industries multiplied by the share of foreign output in each purchasing industry.

Instead of being a direct measure of potential spillovers through backward linkages, as Blalock and Gertler (2008) point out, this industry-level measure captures "the availability of buyers' foreign technology to sellers in a particular industry" (p. 410). This measurement choice, adopted by almost every prior paper in the literature, is largely driven by the data limitations because researchers rarely observe the specific supply relationship from local suppliers to foreign investors, not to mention the intensity of knowledge flow.

This industry-level linkage measure has some limitations which may result in measurement errors. First, the input-output tables are compiled for the entire national economy, usually every five years. Most studies use coefficients in one such table for computing backward linkage measures across years. Thus α_{jk} varies only across industries. In some cases, the backward linkage measures are defined at 20 NACE 2-digit industries (B. S. Javorcik 2004). The most disaggregated level can be up to 145 manufacturing industries (Lileeva 2010).

Second, this industry-level measure is built upon several strong assumptions that are very likely to be violated in reality. These assumptions include the following: 1) the share of firms' demand in a sector for a particular input is proportional to its output share. This assumption follows directly from using output as weight in the horizontal linkage

measure $Horizontal_{kt}$; 2) the input sourcing pattern is invariant across domestic firms and foreign multinationals of different nationalities. This assumption is the result of using input-output coefficients as demand measures of intermediate product (as in α_{jk}). Barrios, Görg, and Strobl (2011) argue against the validity of these assumptions. Rodriguez-Clare and Alfaro (2004) also provide evidence that multinationals' sourcing patterns are not the same as those of domestic firms. Biased linkage measure could potentially lead to biased estimates of the impact of backward linkages on productivity; moreover, there is no clear prior knowledge regarding the direction of the bias.

Recent studies find evidence for prominent productivity externalities through backward linkages from downstream foreign firms to upstream suppliers. Using panel data for Lithuania from 1996 through 2000, Javorcik (2004) finds evidence for the existence of productivity externalities from FDI taking place through contacts between foreign affiliates and their local suppliers in upstream sectors. Specifically, a one-standard-deviation increase in the foreign presence in the sourcing sectors is associated with a 15-percent rise in output of each domestic firm in the supplying industry. Blalock and Gertler (2008) find the evidence for positive backward externalities in Indonesian manufacturing establishments from 1988 through 1996. Firm output increases almost 9% as the share of foreign ownership downstream rises from zero to one. Two recent papers that investigate vertical FDI spillovers by Du, Harrison, and Jefferson (2011) and Lin, Liu, and Zhang (2009) focus particularly on Chinese manufacturing sectors. Using an empirical approach similar to Javorcik (2004), both of the studies find a positive and

much larger backward linkage spillover effect than was found in previous studies of other countries.

In contrast to studies using industry-level backward linkage measures, two papers stand out by employing direct measures of backward linkages. Javorcik and Spatareanu (2009) combine firm-level panel data on balance sheets with an enterprise survey that identifies the specific supplying relationships with MNCs. With direct measures, they are able to distinguish self-selection from learning effects. Using Probit and Linear Probability models, they find that more productive firms are more likely to supply MNCs. Using an IV approach, they find evidence for Czech suppliers learning from their relationships with multinational customers. Most specifications suggest that MNC suppliers are 12%-15% more productive than other firms.

Focusing on the US auto-component industry, Chung, Mitchell, and Yeung (2003) carefully identify firm-specific supply relationships between Japanese auto-transplants and their local US component suppliers, what they called "tie-in" relationships. Their findings stand in stark contrast to Javorcik and Spatareanu (2009) and the aforementioned studies using industry-level linkage measures. First, they find evidence for adverse selection: tie-in firms tended to be less productive than non-tie-in firms before tie-in relationships began, suggesting that transplants chose less productive local firms as suppliers. Second, they found no evidence for direct technology transfer. US firms that supplied Japanese manufacturers did not increase productivity more than suppliers that did not contract with Japanese buyers.

The different results probably arise from the fact that Chung, Mitchell, and Yeung (2003) study the US automotive industry, where the advanced state of physical technology reduces the potential for technology transfer, while Javorcik and Spatareanu (2009) study the manufacturing sectors in a developing country, where levels of both physical technology and production methods are relatively low compared to their foreign entrants.

3 FDI in the Chinese Automobile Sector and the Development of Local Suppliers

The Chinese automobile industry is an attractive setting for research on FDI's spillovers from backward linkages for two reasons. First, the Chinese automobile industry received a tremendous amount of foreign investment in past three decades, which played a crucial role for the sector development. Second, local supply linkages have become rather extensive, thanks to FDI and local efforts. Thus, it is more likely to generate productivity spillovers, if there are any, through backward linkages.

There are two developmental stages of auto industry. The first, beginning from early 1980s, is a combination of trade protection, openness to FDI, and local content requirements. Since a few years before access to WTO, it gradually moves away from the protectionist approach and invites competition, both domestic and international, to be the transforming force in the industry.

From 1982 to 2013, China accumulatively absorbed a total of $2557.1 billion in FDI. For many years in the 1990s, China claimed to be the world's second largest recipient of FDI; since 2009, China has surpassed the United States in terms of net FDI inflows

(World Development Indicators 2015). Reliance on foreign investment is the defining feature of the development path of the Chinese automobile sector. China opened the domestic market in exchange for technology and managerial skills embodied in foreign investment (Thun 2006, 63).

As China began to open itself to world trade in the late 1970s, multinational firms were lured by the China's population and market potential. A distinct feature of FDI in the Chinese auto sector is "market-seeking", as Thun (2006) puts it. As Chinese citizens' disposable income increased dramatically since early 1980s, they desired to have cars in their consumption bundle. Previously prohibited from using private vehicles, government officials began to enjoy the privilege to use cars. In addition, China then began to open itself to international tourism and foreign business. All these contributed to an increasing demand for taxis and other passenger cars (Harwit 2001).

Besides openness to foreign direct investment, the Chinese auto sector had initially been nurtured in a protectionist environment before entering the WTO. Foreign investors can produce automobiles in China only through partnership with state-owned enterprises; and foreign ownership is restricted to less than 50% (State Planning Committee 1994, art. 32). This gives the Chinese partners leverage to negotiate for technology transfer as part of any agreement. In addition, tariffs were as high as 200% in the 1980s and, with import quotas, only 30,000 vehicles were annually allowed from foreign carmakers. Foreign participation was also constrained in sales and distribution (Gao 2002, 148).

Believing that a rapidly rising local content rate was a key factor in the early success of joint venture automakers, the government began concerted efforts on localization.

Local content requirements (LCRs), one of such efforts, were embedded in China's approach to the automobile industry. The LCR policy was designed to create technological linkages to the component industries. It combined with a varied tariff rates according to the local content ratio of assembled vehicles. For passenger cars whose local contents exceeded 80%, the tariff rate on imported parts and components is 40%; for local contents of 60%-80% and below 60%, the tariff is 60% and 75%, respectively (Zhang 1997, 389).

It would be futile to pressure joint venture automakers to use local parts if local suppliers could not provide components of the desired quality. Some municipal governments made combined efforts to create local supply capabilities. In Shanghai, a Localization Office was formed directly underneath the mayor's office to deal with the local supply sector on a daily basis. The Office identified the most likely components to be replaced by local factories, selected potentially capable factories, and worked with managers of supply firms who hoped to form linkages with Shanghai Santana through upgrading their technical capabilities.[5] Moreover, it provided supply firms with access to investment funds at preferential rates to import foreign technology and equipment. The massive funds were collected through the so-called "localization tax," which was levied by the Shanghai government and was amounted to 16 percent of Santana's retail price at the time. Between 1988 and 1994, the localization tax in Shanghai reached over RMB 5 billion (Huang 2003, 266). The Localization Office was extremely effective in helping local suppliers manufacture components that met Santana's standards.

[5] For detailed description of the Localization Office, see Thun (2006, 110-117).

The technical standards of Chinese automobile component suppliers in mid-1980s were three decades behind international component suppliers. As the managing director of Shanghai Volkswagen claimed, "in the beginning there wasn't a single local parts supplier which could produce a part we could assemble into the Santana." (People's Daily Press 1988). Despite the low starting point, the manufacturing capability of the supply sectors increased sharply over the course of the next decade. As Table 1 shows, local content rates of various JV brands began to rise very quickly. Shanghai Santana achieved the highest possible local content rate, 92.9%, in 1997.[6] Thun (2006) points out that a virtuous circle links production volumes to the health of a supply network: "local suppliers made it possible to raise volumes (due to restrictions on foreign exchange) and high volumes created the economies of scale that made a components business viable."

Initially nurtured in a highly protective environment, the Chinese automotive industry was gradually exposed to increasing domestic competition as a result of a dramatic increase in FDI and impending accession to the WTO. By 2006, import tariffs were cut from 100% to 25% for passenger cars and from 24% to 10% for auto components. Quotas on automobile imports would be phased out by 2005 (UNCTAD 2000, 54). Although trade barriers were not lowered until 2005, an increase in the number of joint ventures raised the level of domestic competition. After Beijing Jeep and Shanghai Volkswagen became the first two joint-venture car producers in 1983, major global car producers followed their steps and set up production facilities in China in the following two decades (see Figure 1).

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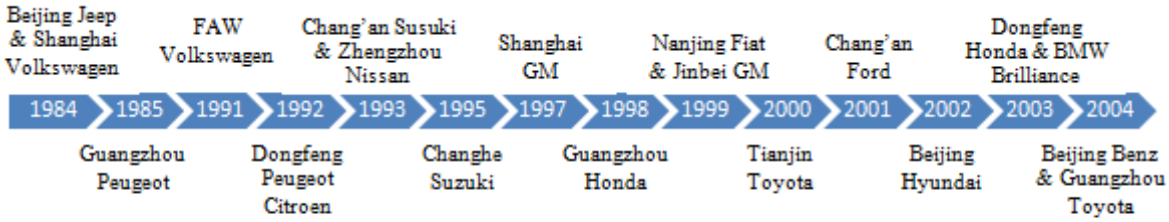
[6] The local content rate would not rise above this percentage because the remaining 7% consisted of parts that were used in volumes too small to be produced economically in China (Thun 2006, 105).



Source: CAIY (2009:43)

Figure 1: Entry Timeline of Joint Venture Brands: 1984-2004.

Increased domestic competition brought down the price of automobiles considerably in China. Nearly every car brand reduced its selling price (China Economic Information Network 2004, 48-50). The price of a Volkswagen Jetta, had fallen by one-third in the past three years since 2002, to 100,000 yuan ($12,000) in late 2004 (Economist 2005). Competitive forces became an impetus for supply firms to raise productivity and to reduce prices constantly. In the highly competitive environment, assembly plants were facing many alternatives which did not exist in the initial stage. If a supplier did not meet the quality, price, and service needs of a customer, the assembly could import the necessary components or turn to wholly foreign-owned suppliers. The data sample in the following analysis, ranging from 1998 to 2004, covers this competitive development period.

4 Econometric Analysis

4.1 Data Sources

The analysis here is based on data from the China Automotive Industry Yearbook (CAIY).[7] Since the early 1990s, the China Automotive Technology & Research Center (CATARC) has conducted an annual cross-industry survey of automotive manufactures, including automakers and their automobile parts suppliers. CAIY's last chapter is devoted to an enumeration of thousands of automotive manufacturers. Variables include output, value added, assets, and employment, which are ingredients to compute firms' total factor productivity. Most importantly, the data set contains unique information as to which brands each supplier made sales. It is the key to constructing direct backward linkage measures. In addition, the CAIY data set is supplemented with the China Annual Survey of Manufacturing Firms (CASMF) database, which covers firms' characteristics information, such as founding year, ownership (state-owned, joint venture, or foreign-owned, and so on), and industrial classifications. Additional characteristics information is available for about one half of the suppliers in the data sample. The analysis covers the years, 1998 to 2004, a period of time when these variables were recorded consistently.[8] The panel data set consists of 1,017 supplier firms in 3,450 firm-year combinations. A complete summary of variables can be found in Table A. 1.

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[7] CAIY is published by the China Automotive Technology & Research Center (CATARC) and the China Association of Automotive Manufacturers (CAAM).

[8] The analysis here focuses on the period between 1998 and 2004. The sample size jumps dramatically from year 1997 to 1998; since then, the number of respondents constantly remained at over 2,000. In addition, staring from 2005, only employment level, revenue, and supplying brands are listed. Lack of input (asset) and output (value added) information prohibits computing firms' productivity.

The CAIY data set does not specify whether a domestically manufactured automobile brand is produced by a joint venture automaker or a domestic one. Thus a mapping table was compiled, connecting hundreds of brands with their manufacturers and sorting these brands and automakers according to their characteristics.[9] Key information includes whether a brand is a foreign brand[10] or indigenous one and whether an automaker is domestic or a joint venture with a foreign car producer.

Although the automobile manufacturing industry is broadly defined as including passenger car producers, commercial car producers, motorcycles producers, and car remodeling companies, analysis is limited within a sample of suppliers of passenger cars. Given the fact that the majority of foreign direct investment takes place in the production of passenger cars, if there are productivity spillovers, firms supplying passenger car firms are most likely to be the beneficiaries. Therefore, when interpreting the spillover results, the estimate is an upper bound of backward productivity spillover effect.

4.2 Empirical Framework

In order to identify the effect of supplying a joint venture automaker on productivity, this study examines whether auto component suppliers which have a supplier relationship with joint venture automakers were more productive, *ceteris paribus*. This effect is estimated using log-linear production functions at the firm level with backward linkage measures and a few dummies. The production function controls for input levels and scale

[9] The information about brands and automakers are hand-collected from online public sources.

[10] Here, "foreign brand" is defined as a brand available outside China's domestic market.

effects. Fixed-effects models of the form are estimated on a sample of auto component and parts suppliers:

$$lnY_{it} = \alpha + \beta_1 lnK_{it} + \beta_2 lnL_{it} + \gamma SJV_{it} + \alpha_i + \tau_t + \varepsilon_{it} \quad (2)$$

where the dependent variable is log output of firm (i) at time (t), proxied by firms' value added. K_{it} and L_{it} indicate capital and labor of firm (i) at time (t), proxied by end-of-year total assets and end-of-year total employment. Value added and total assets are nominal values deflated to 1991 RMB.[11] In addition to backward linkage measures SJV_{it}, all estimates include a fixed effect α_i for firm i, that control for time-invariant unobservable firm characteristics, such as managerial ability, and year dummies τ_t, that control for changes common to all firms in a particular year. Most models also include linear province trends—the province-by-year dummy variables—to control for changes common to all supplier firms in a province at a particular time. These province-specific time trends take into account the uneven economic development across provinces. They control for any shocks that affect all firms in a given province equally. Standard errors are clustered at the firm level to correct within-firm serial correlation.

4.3 Direct Backward Linkage Measures

A unique feature of the CAIY dataset of the China's automobile industry is supplier-buyer linkage information. In each single year between 1998 and 2004, we observe that automobile parts and component suppliers sold certain intermediate products to some automobile brands or automakers. Thus it is possible to construct direct measures of backward linkage between part suppliers and the auto brands to which they sold. One of

[11] Total asset is deflated by the price index for investment in fixed assets, and value added is deflated by the producer price index for manufactured goods to the price level of 1991.

such linkage measures is the so-called *minimum linkage* of foreign brands, an indicator which equals one if the supplier sold to at least one domestically produced foreign brand in a particular year. Figure 2 shows that over half of suppliers sold to at least one foreign brand and over sixty percent sold to at least one joint venture automaker. The ratio remained rather stable during the period of 1998 and 2004.

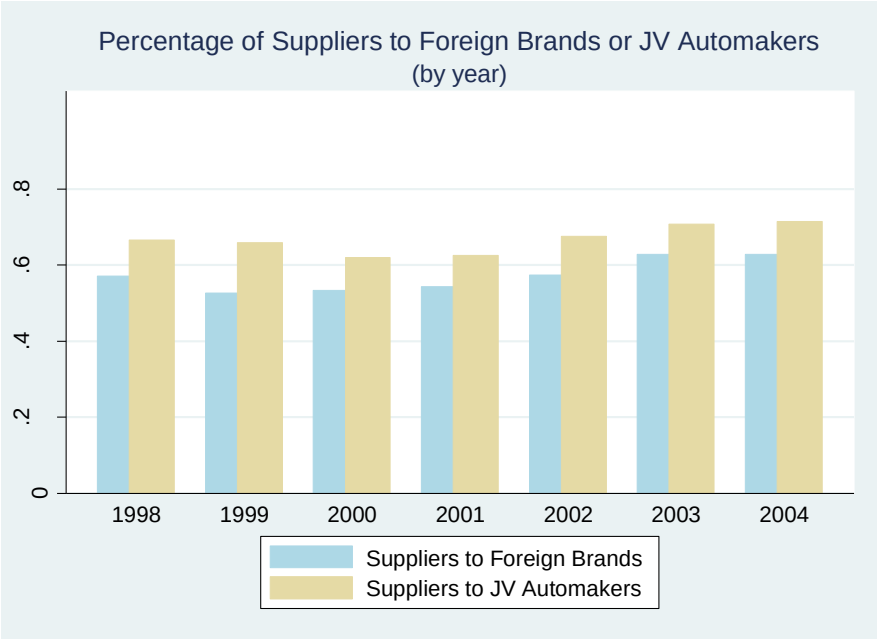

Figure 2: Changes of Minimum Linkage Measures over Years, 1998-2004

By using the minimum linkage measure, it is assumed that the effect of interacting with foreign auto brands is similar across auto component suppliers, no matter how many foreign brands to which they sold. This is apparently a very strong assumption. Presumably, the more frequent the interactions with foreign brands, the higher the benefits are (if there are any).

Linkage intensity, the second linkage measure, intends to capture the intensity of interactions between suppliers and its foreign customers. In the data, the interaction

intensity is measured by the number of foreign brands which a supplier sells to in a particular year.[12] This assumes the effect of foreign linkages is linear, while most benefits may occur during the initial cooperation experience with a foreign brand. The physical amount of sold auto products is not used because hundreds of components are not comparable without converting to monetary terms, and component prices are not available.

Each automobile brand corresponds to a certain automaker. It should be noted that not every foreign brand is produced by a joint venture automaker. A couple of foreign brands are actually produced by domestic automakers under licensing agreements; thus the nature of the interaction is different from those with joint venture carmakers.[13] In order to check whether the linkage effects differ between joint venture automakers and foreign brands, another set of linkage measures are also included. The minimum linkage measure of joint venture automakers is an indicator of whether a supplier sold to a joint venture automaker, while the linkage intensity measure of joint venture automakers is the number of joint venture automakers to which a supplier sells.

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[12] It is almost impossible to measure precisely the interaction intensity in firm-level data, because it could be of many dimensions. In one case, an automaker may send a task-force team to a local component supplier to assist them to build up production capacity; in another case, suppliers are regularly summoned by their customer to keep up with up-to-date quality standard or operation practice. In both cases, a certain amount of technical knowledge is transferred to suppliers and potentially improves their productivity. But this level of detailed information can only exist in survey data or case study.

[13] For instance, the Daihatsu Terios was made in China under license by FVW-Huali, a domestic subsidiary of FVW. Another example is that Changfeng Motor, a Chinese state-owned automobile manufacturer, has produced license built the Mitsubishi Pajero, sold in China under the Mitsubishi brand.

4.4 Initial Estimates

Initial estimates of the equations are found in Table 2. Each column presents a regression of the log of supplier firms' output on inputs, firm and time dummies, province time trend (in even-numbered columns), and minimum linkage measures, which are equal to one if a given supplier firm is associated with at least one foreign brand or joint venture automaker in a given year, and zero otherwise. The first two columns contain the estimated impact of selling to at least one foreign brand on supplier firms' productivity level. The coefficient of 0.117 in column 1 indicates that after removing time-invariant firm fixed effect and common year effects, firm productivity grew by approximately 11.7 percent more in suppliers selling to at least one foreign brand. The second column adds 27[14] province-specific time trends to the model, increasing the point estimate slightly to 16.6 percent and reducing the SE. An F-test of the hypothesis that the province trends are jointly zero is strongly rejected by the data; hence these province trends are employed in most specifications.

Comparable models estimated with linkage measures of joint venture automakers are found in columns 3-4. The point estimates present similar patterns: firms selling to at least one joint venture automaker are approximately 7 percent more productive than suppliers to domestic automakers (col. 3). The premium increases to 18.5 percent when province trends are included (col. 4). Columns (5) and (6) of Table 2 estimate the impact of the two linkage measure simultaneously. The point estimate for linkage measure of

[14] There are 34 provincial level administrative divisions in China, including 22 provinces, 4 municipalities, 5 autonomous regions, and 2 special administrative regions. The data sample contains observations of 27 provincial divisions.

joint venture automaker is only minimally affected by the inclusion of the other linkage measure. Its coefficient of 14.3 remains robust after controlling province trends. By contrast, the linkage measure of foreign brands appears less important to supplier firms' productivity, even after including province trends. The last two columns of Table 2 show that merely having any of the two minimum linkage measures has a significant impact on supplier firms' productivity.

4.5 Estimates with a Varity of Linkage Measures

The results in Table 2 suggest that association with at least one foreign brand or JV automaker has a positive impact on supplier firms' productivity. Do suppliers associated with more foreign brands demonstrate higher productivity? Do automakers under technology licensing agreement with foreign brands generate backward linkage spillovers to their parts suppliers? These questions are addressed in this subsection, which begins with the specification from columns 2 and 4 of Table 2, and then introduces in Table 3 a variety of measures of backward linkages between automobile part suppliers and their joint venture customers. The second and fifth columns of Table 3 show that merely associating with more foreign brands or joint venture automakers does not necessarily improve suppliers' productivity. Indeed, the first relationship with either a foreign brand or a JV automaker improves auto parts suppliers' productivity (col.3 and col.6); the productivity effect is even more enhanced with connection to a second foreign brand. However, selling to three or more brands or JV automakers does not have a significant impact on suppliers' productivity. This diminishing feature of the backward linkage effect provides a glimpse of evidence that suppliers may learn through interactions with

their customers. If the self-selection hypothesis dominates, there would be a positive relationship between parts suppliers' productivity and the number of foreign brands or JV automakers to which they sold. Column 7 of Table 3 reveals that selling to a brand under technology licensing agreement has little impact on parts suppliers' productivity; merely having any of the three minimum linkages has no impact either (col.8). It appears that the linkage measure of brands and automakers—as opposed to the license linkage measure—matters.

4.6 Estimates by Supplier Firm's Ownership, Age, Region, and Intermediate Product Category

The robustness of the results was tested by estimating over a variety of subgroups according to supplier firms' ownership structure, firm age, region, and their product category. Estimates are found in table 4-6. A first specification check explores whether backward linkage spillover effects differ between domestic and foreign-invested parts suppliers.[15] Results of Table 4 show that domestic suppliers to foreign brands or JV automakers are more productive than other domestic suppliers (col.1 and 3); while in the group of foreign-invested parts suppliers, the correlation is higher, but insignificant (col.2 and 4). There is no strong evidence that foreign ownership matters for spillovers through backward linkages. Capital coefficients of foreign-owned suppliers is as high as 0.58, while it is only 33 percent in domestic suppliers. It is interesting that a wide range of capital intensity level is maintained among suppliers, regardless of the low wage rate in

[15] Foreign-funded companies include Sino-foreign equity joint ventures, Sino-foreign cooperative joint ventures, foreign wholly owned enterprises, and foreign investment companies limited by shares. In this analysis, Hong Kong-Macau-Taiwan-Invested (HKMT firm) companies are also included in this category.

China. As (Sutton 2005) points out, a low level of capital intensity makes it more difficult to reach acceptable quality standards. On the one hand, in order to make sales to foreign brands of higher quality requirements, suppliers need to attain some threshold level of capital intensity, however low the local wage level. On the other hand, for suppliers of domestic brands, they can take advantage of low wage rate, because domestic brands usually require a less demanding quality standard.

Do backward linkage spillovers exist in a particular age group of parts suppliers? Column 1 of Table 5 adds the supply firm's age[16] to the baseline specification. The point estimate of 0.513 indicates that older supplier firms are more productive than younger ones. By adding a quadratic age variable in column 2, it becomes clear that productivity grows at an increasing rate as supplier firms become older. In columns 3-5, separate production function estimations with backward linkage measures are made by three age groups. Old suppliers are those established before 1970, the middle-aged are between 1970 and 1995, and young suppliers are after 1995. 1970 and 1995 are the two cutoff points of firm age tertile. Results show that, in spite of being more productive than young suppliers (col.1), productivity spillovers through backward linkages in old suppliers are no greater than in young suppliers (col.3 and 5). The spillover effect is less by half in middle-aged suppliers than in young ones. In Table A. 2, another linkage measure of automakers shows a significantly positive coefficient only within the group of young suppliers, indicating that productivity of young suppliers associated with JV automakers are more productive than their counterparts only associated with domestic automakers.

[16] Firm age is calculated as one plus the number of years between the founding year and the year of observation.

Apparently young suppliers are major beneficiaries of backward linkage spillovers. They could adjust and learn faster from their multinational customers.

The data is subdivided to check the consistency of positive productivity spillovers through backward linkages. Two such tests are discussed here. The top panel of Table 6 presents estimates of the baseline model across subgroups of five intermediate product categories. The point estimates present a consistent picture: the coefficient of the backward linkage measure is positive in four out of five categories. In the lower panel of Table 6 are estimates of the base specification for each of the six geographic regions. Results show that in four of six regions, parts suppliers selling to at least one foreign brand are more productive than those selling only to domestic brands. In Table A. 3, the minimum linkage measure of JV automakers shows similar patterns across five intermediate product categories and seven regions.

4.7 Exploring the Agglomeration and Competition Effect

This subsection concentrates on two other factors which may influence parts suppliers' productivity, agglomeration and competition. Agglomeration economies are generally assumed to improve firms' productivity through economies that come from localization and urbanization. The former, proposed by Marshall (1920), focuses on the geographical concentration of an industry. The latter emphasizes the importance of urban diversity, which fosters cross fertilizations of different industries within a geographical area (Jacobs 1969). Localization is often proxied by the amount of employment in neighboring firms in the same industry and same area (Holmes 1999; Martin, Mayer, et al. 2011). Specifically,

- **Localization economies:** to deal with intra-industry externalities. It is defined as the number of other employees working in the same industry in the same area.

$$Loc_{ijrt} = \ln\left(employee_{jrt} - employee_{ijrt} + 1\right)$$

Index i, j, r, t, represents firm, sector, county, and time respectively.

- **Urbanization economies**: to capture the scale of economic activity outside own industry.

$$Urb_{jrt} = \ln\left(employees_{rt} - employees_{rjt} + 1\right)$$

Predictions of the theoretical literature on the impact of competition on productivity are ambiguous. Competition may force firms to innovate or fail (Porter 1990). In this view, competitive pressure improves productivity. On the other hand, competition may decrease productivity because of incomplete appropriation of the returns from innovation (Glaeser et al. 1992). The inverse of Herfindahl index measures the competition effect. The Herfindahl index of industry j, region r, time t is defined as below,

$$Competition_{jrt} = \ln\left(\frac{1}{Herf_{jrt}}\right), where\ Herf_{jrt} = \sum_{i \in j}\left(\frac{Sales_{ijrt}}{Sales_{jrt}}\right)^2$$

To construct agglomeration and competition variables, employment and sales information of firms are needed within the same industry and outside the industry of suppliers in the same geographical area. Thus, the original CAIY data was merged with the Chinese Manufacturing Firms Annual Survey data set according to firm names; the latter includes all state-owned enterprises and non-stated firms with annual sales of more than 5 million Yuan.[17] After merging, the sample size was reduced from 2,985 to 1,902,

[17] The number of firms per year varies from 162,033 in 1999 to 276,474 in 2004.

and the reduction is biased towards smaller firms[18] due to the sampling strategy of the manufacturing firm survey.

The baseline specification was considered over a matched subsample of parts suppliers. Coefficients of linkage measures (col.1 and 5 of Table 7) are slightly different from the full sample estimation in columns 2 and 6 of Table 2. Table 7 introduces the agglomeration and competition variables. Columns 2 and 6 show that increasing the number of other workers of the same industry-area by 10% (localization) and keeping the size of the other sectors in the area constant decreases supplier firms' productivity by 0.3%. Urbanization appears to have little impact on firms' productivity. Competition is added in columns 3 and 7. The coefficient of competition is positive and statistically significant, suggesting that more competition is associated with productivity improvement, consistent with Nickell (1996) that competition tends to increase total factor productivity growth. Furthermore, including a measure of competition in the estimation significantly reduces the importance of localization externalities. To test whether competition effect varies according to backward linkages, an interaction term between competition and backward linkage measures is added in columns 4 and 8. Interestingly, although it is possible that competitive pressure may extend beyond passenger car industry to its supply sectors, the insignificant coefficients on the interaction terms indicate that the productivity-enhancing impact of competition is no

[18] Comparing output, labor, asset and JV linkage between preserved and deleted observations due to sample merge, it is found that the unmatched firms tend to be smaller in terms of output and inputs and less likely to be a supplier of foreign brands.

greater among suppliers selling to foreign brands than those who only sold to domestic brands; rather, competition exerts positive influence on suppliers in general.

4.8 Inferring Causality via the Timing of Becoming Suppliers to Foreign Brands

The estimations above show that auto parts suppliers to foreign brands are more productive than their counterparts to domestic brands. But the positive correlation does not necessarily imply that becoming suppliers of foreign brands *causes* productivity gains. Plausible arguments can be made for reverse causality: relatively more productive parts suppliers are more likely to be selected by foreign brands which hold higher productivity and quality requirements for their local suppliers. To explore this possibility, a difference-in-differences model is estimated to compare a group of parts suppliers which only began to sell to foreign brands between 1998 and 2004 (new suppliers to foreign brands) with a group of suppliers which only sold to domestic brands, augmented with leads and lags of their supply status change. Specifically, indicator variables were added for 1, 2, and 3 years before they began to sell to foreign brands, years 0-2 after selling to foreign brands, and year 3 forward.

The first column of Table 8 presents the base specification, using foreign brand linkage measures, augmented with the leads and lags. Three interesting findings emerge. First, the coefficients on the entrance leads are significantly positive, showing evidence for selection; that is, foreign brands tend to select more productive suppliers of domestic brands. Second, in the year immediately before selling to foreign brands, suppliers' productivity drops close to zero, after which it increases substantially by 25.5%. Third,

over the subsequent 3 and more years after interacting with their multinational customers, these parts suppliers' productivity continues to grow by a rate between 42.9% and 68.6%. An F-test of the hypothesis that these entrance lags are jointly zero is strongly rejected by the data, indicating that these new suppliers of foreign brands improve in their productivity through interactions with their multinational customers. This pattern is depicted by Figure 3. The subsequent columns of Table 8 repeat the above estimates, using JV automaker linkage measures and over a subsample of domestic suppliers. The pattern of coefficients is comparable in each case, only not as statistically significant as using foreign brand linkage measures (column 1).

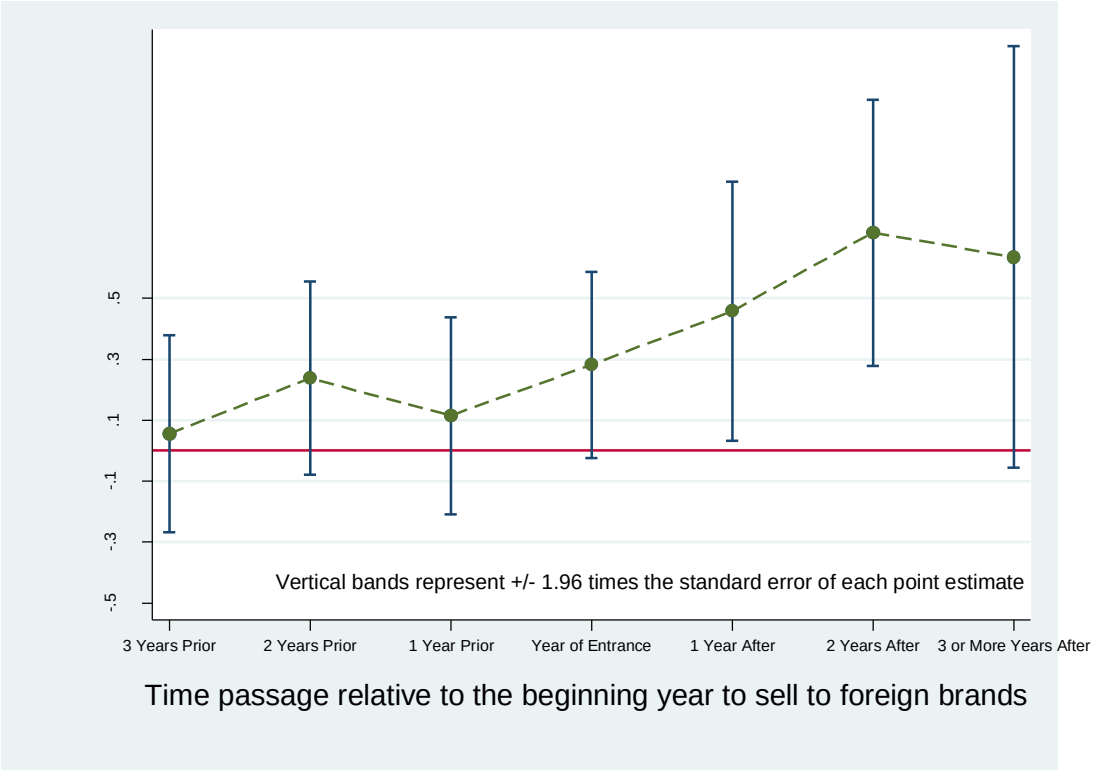

Figure 3: Estimated impact of backward linkages on supplier firms' productivity for years before, during, and after suppliers began to sell to foreign brands

In summary, the suppliers' total factor productivity is found to be positively correlated with their linkages with foreign investors. This positive correlation is robust across various age groups, foreign ownership groups, product categories, and regions. In the following productivity trajectory analysis, there is evidence of both selection and learning. On the one hand, foreign brands tend to select more productive suppliers as their local partners; on the other hand, suppliers' productivity is enhanced after they began selling to foreign brands.

Even though the firm-level backward linkage measures can capture a direct connection between local suppliers and foreign investors, the econometric analyses provide limited information about the sources of the observed productivity externalities. Moreover, the backward linkage measures at most indicate a potential for knowledge transfer; real knowledge transferred through interactions between suppliers and their foreign customers is rarely observable in data. Thus, the econometric analyses only offer indirect evidence for the knowledge transfer that may enhance suppliers' productivity.

5 Sources of the Observed Productivity Externalities through Backward Linkages: A Case Study

In the above econometric analyses, substantial productivity improvement is found in a group of local auto component suppliers to be related to their linkages with joint venture automakers. The next question is what exactly generates these productivity externalities suggested by the econometric analyses in here as well as earlier studies in the literature. Using a case study approach, this section aims to develop a more nuanced understanding of the sources of the observed productivity externalities through backward linkages.

It begins with a simple production function framework and demonstrates that the estimated productivity externalities in the common production estimation approach not only include knowledge spillovers, but several other factors as well. These are suppliers' internal efforts to improve productivity without their foreign customers' assistance, and the price and cost reduction of intermediate product sold to foreign customers. Therefore, the observed productivity externalities should not simply be attributed to knowledge spillovers without taking these other factors into account. Furthermore, knowledge spillover is not readily observable in the data. What we at best observe is whether a supplier is connected with a foreign customer and the result of such a connection in terms of enhanced productivity.

Drawing upon fieldwork at one joint venture automaker and several auto component and parts suppliers in China, this section establishes a concrete link between knowledge transfer through backward linkages and productivity improvement. Specifically, it addresses the following questions. First, do joint venture automakers transfer knowledge to their local suppliers? Second, what are the forms of these knowledge transfers? Third, do these knowledge transfers directly translate into local suppliers' productivity growth?

In addition, other sources of the observed productivity externalities are found to be important in the interactions between local component suppliers and their joint venture customers in the China's auto industry. To judiciously interpret the econometric results, these confounding factors need to be considered. Lastly, this section provides rich description to show how selection and learning occur through interactions between

multinational buyers and local suppliers and sheds light on the understanding of the productivity trajectory analyses in subsection 4.8.

5.1 A Simple Framework: What Generate the Observed Productivity Externalities?

The conventional method to measure productivity is subject to measurement errors, which may obscure true productivity externalities. It can be explained in the following simple framework. Using the Cobb-Douglas production function,

$$Q_i = A_i \cdot K_i^{\alpha} L_i^{1-\alpha} \tag{3}$$

In theory, output Q_i should be firm-specific physical output, or the quantity of total production; in data, we may observe firm-specific revenue ($P_i \cdot Q_i$) (Katayama, Lu, and Tybout 2009), or most of the time value added, VA_i.

Productivity is measured by using the production function on the logarithmic scale:

$$ln\widehat{A_i} = lnVA_i - \alpha \cdot lnK_i - (1-\alpha) \cdot lnL_i \tag{4}$$

Value added is defined as:

$$VA_i = P_i \cdot Q_i - AC_i \cdot Q_i = (P_i - AC_i) \cdot Q_i$$

Where AC_i is the share of gross output accounted for by intermediate inputs, which is defined as follows, $AC_i = \sum P_m Q_m$, P_m is the price of individual intermediate inputs such as metals and Q_m is the quantity of each intermediate input to produce one unit of final product.

Rewrite output $Q_i = \frac{VA_i}{P_i - AC_i}$. Plug this into production function (3) and rearrange it as:

$$VA_i = (P_i - AC_i) \cdot A_i \cdot K_i^{\alpha} L_i^{1-\alpha}$$

So, true productivity on the logarithmic scale is:

$$lnA_i = lnVA_i - \alpha \cdot lnK_i - (1-\alpha) \cdot lnL_i - \ln(P_i - AC_i) \quad (5)$$

Compare equations (4) and (5), observed productivity is true productivity plus a price-cost term:

$$ln\widehat{A_i} = lnA_i + \ln(P_i - AC_i)$$

Note that we often lack of price and cost information.

Higher A_i means that output is greater with the same equipment and labor, or even less workers. Productivity may be raised by optimizing operating procedure, introducing incentive payment plan, and so on. These can be accomplished through knowledge transfer from external aids or by suppliers' own efforts. In reduced form estimation, these two distinctive sources of productivity enhancement are hardly distinguishable.

When P_i decreases, true productivity is underestimated. Price reduction due to market competition or pressure from downstream customers would make the estimated productivity lower than it should be. When AC_i decreases, measured productivity is greater than true productivity. Cost reduction due to management decision outside of the production process may reflect in elevated TFP. Thus, true productivity is hard to estimate without knowledge of price and cost; furthermore, direction of bias is still unknown if we don't know whether cost or price reduction weighs heavier.

This framework shows that besides knowledge transfer from foreign customers, there are at least three factors influencing the observed productivity externalities: internal efforts, price and cost factors. The following subsections present the case evidence to demonstrate the presence of these factors in the China's auto industry, which might

confound the interpretation of the substantial productivity externalities through backward linkages, which are found in the econometric analyses.

5.2 Case I: Knowledge Transfer before Selling to Downstream Foreign Customers in the Light of the Bidding Process

By describing joint venture automaker B's component localization process and its bidding process, the following two points are highlighted. First, the need to save costs and pressure from the Chinese partner of the joint ventures led to the joint venture automakers' decision to localize certain auto component and parts. To build up a local supply base in the localization process quickly, foreign investors are called to transfer technical knowledge and management practice to their supplier in various forms. Second, in some cases, the bidding process is more than a means for joint venture automakers to select qualified local suppliers; it also provides an inducement mechanism that stimulates suppliers' internal efforts.

Automotive manufacturing company B is a joint venture founded by a multinational automotive corporation in German and a Chinese state-owned automaker. As one of the largest joint venture manufacturers in China's passenger market, Automaker B assembles and manufactures in China its parent multinational's brands, which enjoy a reputation for high quality and popularity. As a late entrant, automaker B did not have to develop its supply base from scratch, but instead was able to take advantage of a rather mature local supply network, a fruit of its predecessors.

Foreign Investors' Incentives to Transfer Knowledge

Automaker B takes quality as its first priority and instills this value to its Chinese partners and local Chinese suppliers. However, fierce market competition has been pushing automaker B to strike a balance between the cost and quality of its components. Automaker B's long-term approach to maintaining its market competitiveness is to localize some of its auto parts and components. Components incurring high shipping costs are the first batch to be localized, which includes the following: 1) bulky, lightweight items—for instance, bumpers and the body in white[19]; 2) fragile components, such as safety glass; and 3) components which are easily deformed or damaged on the way of shipping, such as tubing, A & B pillars[20], pipelines, and exterior pieces. Because they were fostered by automaker B, some local suppliers of these sorts of intermediate products grow to be competent enough to be included in the global procurement system of automaker B's parent multinational company. Large oversea orders could bring prices further down through economies of scale, which in return lowers automaker B's input price.[21]

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[19] Body in white, or BIW, refers to the stage in automotive design or automobile manufacturing in which a car body's sheet metal components have been welded together — but before moving parts (doors, hoods, and deck lids as well as fenders) the motor, chassis sub-assemblies, or trim (glass, seats, upholstery, electronics, and so forth) have been added and before painting (*Free Dictionary*, s.v. "body in white" [accessed March 8, 2015, http://encyclopedia.thefreedictionary.com/Body+in+white]).

[20] Pillars are the vertical or near vertical supports of an automobile's window area or greenhouse—designat ed respectively as the A, B, C or D-pillar moving in profile view from the front to rear. The A pillar is the f rame of the front windshield that is between the windshield and the front doors. All cars with a windshield come with an A pillar. The B pillars are located behind the front doors. It is the frame between the front and rear doors (Wikipedia, s.v. "pillar (automobile)" [accessed March 8, 2015, http://en.wikipedia.org/wiki/Pill ar_(automobile)]).

[21] The interviewee in automaker B demonstrated this with an example. Company F, a Chinese automobile safety glass manufacturer, successfully became the global supplier of automaker B's parent multinational company through partnership with automaker B.

Local procurement of certain auto parts is also in line with automaker B's automotive sequencing requirements.[22] Automotive sequencing allows suppliers to deliver parts to the manufacturers' production line in the proper build sequence right in time as scheduled before they get assembled. It optimizes production efficiency while also reducing waste and parts storage space. Frequent coordination is required between the manufacturing line and the process area for adjustments and transportation. Components easily subject to sequencing include doors, seats, wheels, glass, and bumpers. Sequencing calls for suppliers' strong commitment to a long-term partnership with their customers. In order to meet pending sequencing requirements, suppliers need to increase investments in sequencing and the ability to locate where parts are to ensure timely delivery. In most cases, suppliers have to build up new production facility adjacent to[23] their customer's manufacturing complex.

Another force behind automaker B's component localization process is the Chinese parent company and China's local content requirements. Although since the July of 2008 the Local Content Requirement has become ineffective,[24] the provisions of the policy that require automobile producers to engage in a certain level of domestic parts production continue to be in effect (Stewart et al. 2012, 19-21). Parent companies of Chinese and foreign sides constantly negotiate over automaker B's localization agenda.

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[22] As Sturgeon, Biesebroeck, and Gereffi (2008) points out, lead firms in the automotive industry have the power to drive supplier co-location at the local levels for operational reasons, such as just-in-time production and design collaboration.

[23] In supplier M's case, it is 34.2 km away from automaker B's production base.

[24] The local content requirement had been effective until the July of 2008, when WTO had issued a decision that China had illegally imposed discriminatory tariffs on imported auto parts. (Bloomberg News 2008)

Automaker B represents many other joint venture automakers in China which are faced with both internal needs and external pressures to localize some of their components and parts. These firms use knowledge transfer to build up local supply bases in a rather short period of time. Below, the example of automaker B and its suppliers are used to describe the bidding process, through which this joint venture automaker transfers knowledge to local suppliers as to raise their productivity substantially and to improve product quality.

A Brief Description of the Bidding Process

Once automaker B decides to replace an imported component with a local substitute, it will select a few local producers of the component and invite them to submit bids. The bidding process is organized by a team, with members from the Department of Purchasing, the Department of Product Design, and the Department of R&D. Automaker B usually does not invite many bidders in order to save on cost, because bidding is a complicated review process, demanding a great deal of time and money from both automaker B and its potential suppliers. In some cases, when there is only one qualified local supplier, automaker B sends an invitation only to this supplier in addition to its foreign parent company's global supplier. The global supplier is more reliable in product quality and has established channels for cooperation; however, unless it already has production facility or is willing to set up new factory in China, automaker B will have to rely on imports from this global supplier. After potential suppliers submit their bids, the team evaluates their performance according to a grading system. The one with highest score wins the contract.

The bidding process not only guarantees what joint venture automakers eventually select is the most competent supplier on the upstream market, it is also an interactive learning experience for potential suppliers. In the process of preparing bidding documents, suppliers are constantly pushed to their limits and thus improve themselves to meet automaker B's standards. Even though they may fail in their bid to automaker B, some suppliers are still able to win another company's bid, which they would have never won if they had not prepared bids for automaker B's purchasing contracts. To ensure product quality, automaker B not only requires a finished component to meet certain standards, but the whole production process must pass Process Auditing as well. Each production step is reviewed, from purchasing proper materials, operating machinery, to organizing final products, and successfully delivering in certain sequence on time, and so on. Additionally, automaker B reviews its suppliers at each tier of supply chain in order to ensure its quality.[25] To this end, automaker B diffuses technical knowledge and management knowhow and spends tremendous amounts of resources, time, and money.

[25] For example, automaker B purchases car doors from a local supplier; however, it requires the door lock switch to be imported from a B's designated German supplier, because locally-produced switches failed to meet B's quality standards.

Various Forms of Knowledge Transfer before Actual Production Begins

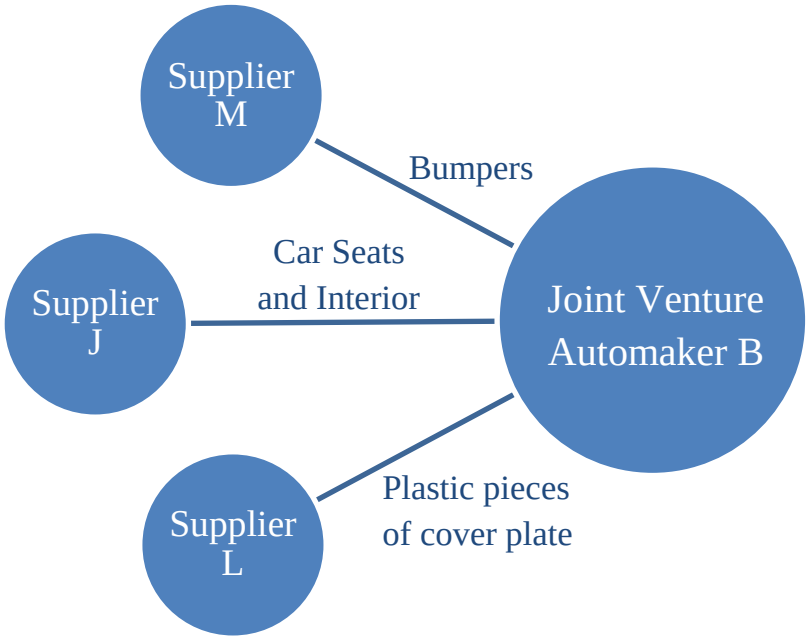

Figure 4: Joint Venture Automaker B and Its Local Suppliers

Knowledge transfer takes place in various forms before actual production begins. Some are identified in interviews with automaker B's suppliers (see Figure 4). First, technical knowledge is embedded in product design provided by foreign investors. Supplier J, automaker B's car seat and interior supplier for some car models, is barely involved in designing car seats or interiors, but automaker B provides the blueprints that were once used for outdated car models directly. Second, foreign investors help their local suppliers identify second-tier suppliers of critical input materials. Supplier L is automaker B's supplier of plastic pieces of cover plate. Supplier L was required to import the same plastic material from the second-tier material supplier that used to sell to the original plastic plate supplier of automaker B's foreign parent company. Automaker B

assisted in locating this plastic material supplier in Germany.[26] In some cases, joint venture automakers send a task force team to its suppliers' plants to assist them to build up production capacity. The third form of knowledge transfer, the direct on-site assistance, differs from above two cases in its importance in improving suppliers' productivity and product quality, as well as forging a long-term strategic supply relationship. Below, the example of automaker B's bumper supplier is delineated. Direct on-site assistance not only involves significant amount of knowledge diffusion, but also expedites knowledge adoption in local suppliers.

While automaker B was looking for a bumper supplier that would commit to a long term strategic partnership, supplier M stood out in the bidding process as a competent bumper supplier,[27] although it initially fell short of automaker B's standards. One particular challenge company M faced early on was that its traditional coating technology could no longer meet the European VOC emission requirements with which automaker B had been complying. Supplier M was forced to abandon the traditional solvent-borne coatings for waterborne coating technology. From 2007 to 2009, automaker B sent a task

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[26] Automaker B's assistance proved to be helpful but far from sufficient. The journey to identify this German material supplier was rather painstaking. As supplier L's project manager vividly recalled, automaker B only provided contact information of its German plastic plate supplier, which is supplier L's potential competitor, but was reluctant to offer further help to get L in touch with the material supplier in Germany. Supplier L had to make its own effort by asking this competitor directly. The not very friendly plastic plate supplier charged 50 euro for a PPAP document, which had already been paid by Daimler and presumably should not have been charged. Supplier L turned to automaker B's Chinese parent company for help, which had no upper hand over the issue. To its disappointment, company L had to pay for the document itself and finally identified the German material supplier.

[27] Supplier M is a subsidiary of a Mould and Plastic Technology Company, which boasts the largest bumper producer in the local market, with annual production of 1,600,000 sets of bumpers. As early as 1998, this company had become Shanghai Volkswagen Santana's exclusive bumper producer. Over years, it has established its reputation and has a partnership with many prominent brands, like Buick and BMW.

force team[28] from Germany to supplier M to set up its production facility. In the interviewee's words, a project manager and a specialist on coloring flew from Germany and "lived" at supplier M for over a year. Together with M's own engineers, they had successfully developed eleven colors for various car models. In addition, automaker B introduced to company M an up-to-date punching and piercing welding machine. As described by the M's project manager, the traditional way to install radar on a bumper is to punch and pierce the bumper first, and then to move it to the welding machine where the radar is welded onto the bumper. This way often results in a coarse edge and low accuracy. To achieve better accuracy, automaker B required supplier M to use the punching and piercing welding machine, which incorporates several additional steps.

Another major improvement took place in the delivery system, as indicated by the project manager. In the past, the degree of standardization and automation in logistics management had fallen behind common practice. Purchase orders were sent by fax one week earlier; the variety and amount of demand was rather limited, about 50 sets of bumpers per day, so it was comparably straightforward to manually manage orders. When supplier M became automaker B's supplier in 2007, demand increased and became more complicated (30 designs with 40 sets of each design), making it impossible to manage manually. Like other carmakers, automaker B desired to cut back its inventory costs, thus requiring supplier M to provide just-in-time delivery—reliably getting

[28] As indicated by the project manager, automaker B bore the cost of hiring the task force team. Daily wage of one expert is 900 euro; traveling and moving allowance are included as well. The cost of the whole team could easily amount to a million euros. Automaker B also shared part of the upfront cost; in return, it owns property rights to certain, if not all, technologies developed throughout this period.

products there just before the customer needs them. With orders being placed every four minutes through internet, supplier M had to turn to computerized order management.

Does Knowledge Transfer Translate into Productivity Growth or Quality Improvement?

The first two forms of knowledge transfer, knowledge embedded in product design and assistance with locating material suppliers, do not necessarily translate into productivity growth or product quality improvement. If automaker B had not provided supplier J with product blueprints, supplier J, as a leading car seat and interior supplier in the market, would still have the R&D capability to develop new designs or localize automaker B's existing designs. As for Supplier L, it was just a matter of time to locate its German material supplier. By contrast, in spite of lacking a concrete measure of productivity or quality, the project manager in supplier M pointed out that the direct assistance from automaker B eventually materialized into an elevated unit price. In the past, supplier M only focused on primary processing, that is, injection molding and painting. Because the primary processing market is competitive, the price remained at a rather low level. Supplier M used to sell bumpers at a unit price of RMB 150. After working with automaker B, supplier M's bumpers were embedded with state-of-the-art waterborne coating technology and with higher accuracy in welding. In addition, supplier M's value chain was extended by adding the assembly service and just-in-sequence (JIS) process.[29] The unit prices of bumpers sold to automaker B ranged from RMB 1000 to

[29] Just in sequence (JIS) is an inventory strategy that matches just in time (JIT) and complete fit in sequence with variation of assembly line production. Components and parts arrive at a production line right in time a s scheduled before they get assembled. Feedback from the manufacturing line is used to coordinate transpor

2500. Reluctant to provide specific profit data, the project manager admitted that profits of bumpers increase eventually, but with diminishing profit margins.

5.3 Case II: Knowledge Transfer through Interaction with Downstream Foreign Customers after Actual Production Begins

Company D is a Chinese joint venture with an American automotive air-conditioning system producer. In spite of being a supplier itself, company D's interactions with its local second-tier suppliers resemble those between automaker B and its first-tier suppliers. They both select some local suppliers as their long-term strategic suppliers and designate a Supplier Development Engineer team (called SDE) which specializes in assisting these suppliers to improve continuously their productivity and to reduce costs. The case of company D and its supplier S provide a rich description of various forms of knowledge transfer after actual production begins.

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tation to and from the process area. JIS is mainly implemented with automobile manufacturing (Free Dictio nary, s.v. "just in sequence" [accessed March 8, 2015, http://encyclopedia.thefreedictionary.com/Just+in+S equence]).

Forms of Knowledge Transfers after Actual Production Begins

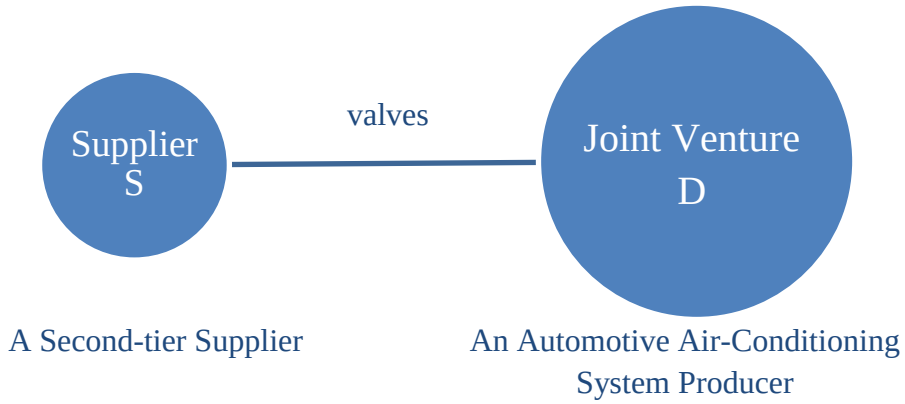


Figure 5: Joint Venture D and its Local Supplier S

Based on a document provided by the SDE in company D on Supplier Continuous Improvement and Lean Production, various forms of technology transfers from company D to their local suppliers[30] are summarized in Figure 6.

First, knowledge is directly transferred from company D to its suppliers through a training and supplier visit. During the supplier visit, the SDE team reviews the ongoing improvement projects with its supplier, makes sure the projects are being successfully implemented, and identifies potential improvement opportunities. Once in a while, suppliers are required to participate in training programs offered by the SDE team either at company D or at the suppliers' production sites. Training covers topics on EHS,[31]

[30] These forms of knowledge transfer are also mentioned by interviewees at automaker B, but not in an exhaustive manner.

[31] Environment, Health and Safety. EHS are guidelines created by the International Finance Corporation. company D is subject to EHS regulations and requires its suppliers to follow as well.

QRQC,[32] communication skills, and workshop visits are also included. The total training hours of suppliers amounted to 658 hours in 2011.

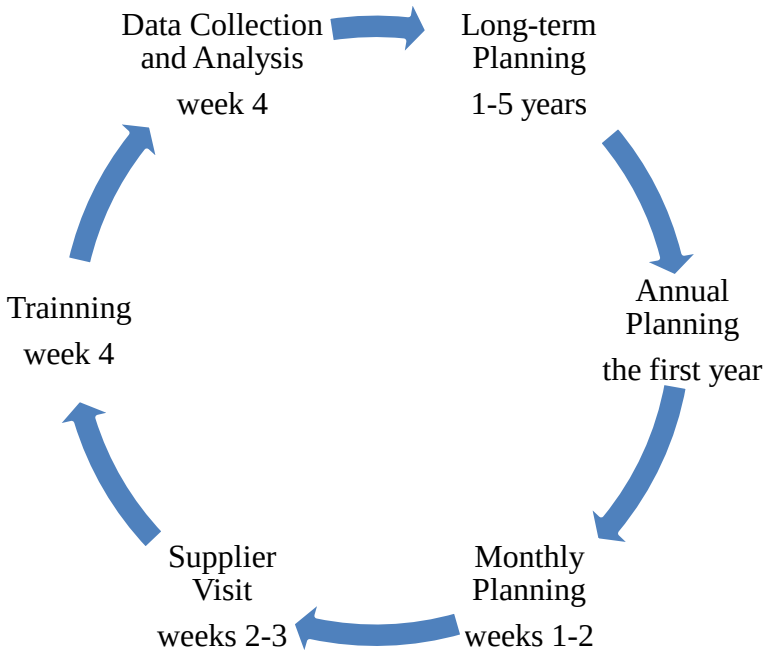


Figure 6: Company D's Standard Operating Mode of Supplier Continuous Improvement (Source: Company D's report)

Second, company D provides various incentives to elicit its suppliers' internal effort to constantly seek cost-saving and productivity-improving solutions. In the beginning of each year, SDE sets a monetary goal for cost reduction,[33] which is to be achieved by joint efforts of all strategic suppliers. For instance, six suppliers were expected to reduce cost by RMB 2,050 thousand in 2011. These suppliers were to come up with their own projects under the guidance of company D. At the end of the year, SDE ranked each

[32] Quick Response Quality Control.

[33] Not all projects aim to reduce costs, but some improvement projects focus on quality improvement. For example, out of 28 projects carried out in supplier S in 2011, 18 ended up with cost reduction.

supplier's performance by their completion of a costing saving goal. The best suppliers were given the "Excellent Supplier" award. In addition, SDE encourages suppliers to submit Kaizen cases to Kaizen Expo 2011, a nationwide competition for best production process improvement. Company D and one of its suppliers S won prizes.

Third, interactions between company D and its suppliers are more than merely one-way knowledge diffusion. Instead, several information-sharing mechanisms are provided by company D to expedite learning among suppliers and to generate knowledge on performance improvement. Once a month, SDE releases a report including updates of ongoing improvement projects and summary statistics of cost reduction. The monthly report is circulated among all suppliers. The year-end supplier conference offers suppliers and company D with opportunities to share successful experiences in a more interactive way.

Does Knowledge Transfer Translate into Increased Productivity?

As company D's strategic supplier, supplier S, a valves producer for automobile air conditioning systems, receives company D's assistance in many forms, as mentioned above. Supplier S's award-winning Kaizen case provides a glimpse of the dynamics of productivity improvements unfolding in the production of product A. An English translation of this Kaizan case is provided in Appendix B with an elaborate description of efficiency improvement with some technical details.

Supplier S used to produce product A at an average rate of 12 seconds. Facing a demand surge for product A, supplier S's production capacity could no longer keep pace with the demand. Increased demand required supplier S to improve its production

capacity by reducing the cycle time to below 8 seconds. Supplier S's Kaizen team began by investigating each of the work stations along the production line and identified seven bottleneck stations whose cycle times were above 8 seconds and thus needed adjustment. Then the team measured productive time and idle time at some bottleneck stations and computed efficiency as a ratio of productive time to total time. The efficiency measure of both worker and machine turned out to be too low and thus had much room to improve. The worker efficiency was between 59 percent and 68 percent, which meant that workers remained idling at these bottleneck stations for at least one third of an entire production cycle. The machine efficiency was even lower at some stations.

The Kaizen team came up with the following straightforward solutions. First, three pairs of working stations were combined with proper rearrangements. As a result, the cycle time at these combined stations was reduced to between 6.47 and 7.56 seconds, and several operative positions were removed from the production line. In addition, each working station was equipped with hydraulic trolleys with a height-adjustable flat panel, facilitating operatives to stack and transport turnover boxes after each procedure, reducing 3 seconds on average by eliminating an inefficient walking around and bending movement. Overall, the cycle time after improvement was reduced to 7.56 seconds, below the required level. Capacity of the production line increased from 4,200 units per day to 6,300 units; and six working positions were removed from the line, yielding annual cost savings of RMB 240 thousand. Similar adjustments were adopted in other two production lines, raising production capacity by 50 percent.

5.4 Is Knowledge Transfer Also Knowledge Spillover?

While multinational affiliates may have incentives to transfer knowledge to their local suppliers, as this enables them to buy high-quality inputs from them, it is not clear that multinational affiliates will provide the knowledge free of charge. Knowledge spillovers arise only when there is a net benefit associated with knowledge transfer. Making a conceptual distinction between knowledge transfer and knowledge spillover is crucial for assessing the case for economic policy intervention. As pointed out by Smeets (2008), whereas the existence of knowledge spillovers clearly warrants intervention, the existence of knowledge transfer, which often takes place through market transaction, does not necessarily do so. However, empirical work too often ignores this important distinction. Due to the lack of information on the cost of knowledge transfer or learning, many of the estimated effects are more likely related to knowledge transfer than knowledge spillover. Keller (2010) highlights a dilemma that the more clearly identifiable the recipient of the multinational's knowledge transfer is, the less likely it is that any productivity effect is due to externalities or knowledge spillover.

Although data on the contractual payment for the knowledge transfer is rarely available, and thus it is hard to subtract the cost from the supplier's revenues before computing total factor productivity, the cost of knowledge transfer can be substantial. Interviews with company D and automaker B reveal that they constantly require their suppliers to reduce price over time[34]. In fact, it is written in the purchasing contract that

[34] Similarly, (B. Javorcik, Wolfgang, and Tybout 2008) also reports that the foreign investor, Wal-Mart in their case study, demands annual price reductions from its local suppliers in Mexico.

suppliers should commit to annual price reduction ranging from 3% to 5%. Not leaving their suppliers alone, as in the example of company D, it assists their suppliers in seeking cost-saving solutions, and the lower cost is further reflected in reduced intermediate product prices. If the local supplier agrees to reduce prices which it charges automakers, this suggests that the knowledge is actually costly to the local suppliers. To examine a net benefit associated with knowledge transfer, the extent of intermediate price reduction needs to be taken into account.

5.5 Other Sources of the Observed Productivity Externalities

As demonstrated in subsection 5.1, the observed productivity externalities associated with backward linkages with foreign customers are not necessarily the true productivity externalities. Two factors may also influence the observed productivity. One is suppliers' own effort to improve productivity independent of their foreign customers' assistance; the other is the reductions of price and cost of intermediate products sold to foreign customers. Case evidence reveals that both are possible in the China's auto sectors.

Internal Learning Independent of Foreign Customers' Assistance

Although suppliers may receive tremendous technical supports from their customers, suppliers are striving on their own efforts to constantly improve productivity. As mentioned earlier, automaker B's task force team assisted its supplier M to develop the state-of-are waterborne coating technology, which is the key to supplier M's success. Nevertheless, facing fierce market competition, supplier M is motivated to continuously

seek cost-saving and productivity-improving solutions. Introduction of incentive payment plan is one of such endeavors.

In the past, M's workers were paid hourly, giving them every reason to shirk. Now, workers are grouped into teams and compensated financially for the goals they meet as a collective group. The smaller a team is, the higher salary each team member receives. Thus workers have incentive to share more responsibility by reducing team size. Another benefit is that assignment of working loads is decentralized to a team. Within a team, working loads differ according to their position. Instead of assigning different salary, team members reach an agreement as how to rotate. With team-based incentive payment plan, three shifts of workers are reduced to two; and every production line almost triples its quantity, from 60 to 170.

Price and Average Cost Reduction of Auto Components

Both company D and automaker B indicate that they constantly require their local suppliers to reduce price over time. Similarly, Du, Harrison, and Jefferson (2011) finds that "price levels fell significantly in sectors where foreign firms exerted a significant downward pressure via backward linkages". Therefore, the estimated backward spillover effect may be underestimated if the input price reduction induced by downstream foreign firms is not taken into account.

Company D also provides an example of management decisions to reduce cost but not of technological learning that would easily show up in a production function. It shows

how readjustment of delivery methods saves one third of transportation cost.[35] First, ground transport of cargo was replaced by marine shipping, reducing the transportation cost up to RMB 1.78 million; second, rearrangements of items in the cargo brought down cost by RMB 1.05 million; third, capacity of each box was enlarged by repositioning items, reducing cost from RMB 2.19 to 1 per item. These management decisions outside of the actual production process can reduce the final unit cost of production. This could in principle be translated into a production function framework as the management decision would reduce the intermediate costs of production and thus increase value added for the firm. This would show up as an increase in TFP. But the true productivity does not increase accordingly, because these management decisions have no direct impact on its production process.

Therefore, in the production function estimation with the conventional measure of TFP, when we observe suppliers' measured TFP increase associated with connection with foreign customers, it may not always attribute to backward linkage spillovers.

5.6 A Discussion of the Econometric Results in the Light of Case Evidence

Automaker B's example has identified an important feature about product launch in joint venture automaker's local suppliers—a one to two years' time lag between the procurement contract and the actual production—which is hardly observable in the data. During this period of time, automakers and their suppliers interact to various degrees; sometimes substantial knowledge diffusion and absorption takes place. After being

[35] More details are provided in Appendix C.

selected as automaker B's supplier, it took supplier L more than one year to get its production line running. Another supplier, company M, spent almost two years to set up an entire operation process that met automaker B's requirements.

This time lag is also reflected in the literature. For instance, Kim (1997) finds there are long lags between technology transfer and successful production. Moreover, Pack (2013) highlights the fact that the interaction of transfer and internal effort during the preparation period is a very important component of the benefits from technology transfer and calls for case studies to focus on such interactions. Thus, understanding this one to two years' time lag is important in order to interpret the econometric findings judiciously.

First, the coefficients on the entrance leads (Table 8) are significantly positive, which seems to imply that foreign brands tend to select more productive suppliers of domestic brands. However, given the fact that supplier firms' interactions with their joint venture automakers begin two years before actual production, the purchase order provided an inducement mechanism that stimulates suppliers' internal effort in learning with automakers' external assistance. While it is not an easy task to disentangle the learning effect from selection, the impact of intensive learning occurring before actual production should not be disregarded. A similar inducement mechanism is highlighted in Pack (2013) when discussing the export-productivity link.

Second, some auto parts suppliers are founded for the exact reason to supply particular joint venture automakers; for example, supplier M was established to serve the purpose of joint venture automaker B, and thus had received technical assistance from B. However, the productivity data of these suppliers become available only after the actual

production begins, so the productivity growth associated with intensive learning during this project preparation period fails to be captured in the econometric analysis. For that reason, the aggregate productivity-enhancing effect of knowledge transfer from joint venture automakers tends to be underestimated.

6 Concluding Remarks

Previous studies find strong evidence for prominent productivity externalities through backward linkages from downstream foreign firms to upstream suppliers. This study confirms these findings by using a unique dataset from the Chinese automotive industry. This dataset can identify individual firms as suppliers to multinationals and thus a set of direct supply linkage measures are constructed accordingly. This is in contrast to the industry-level linkage measures used in earlier studies, which rely on input-output matrices and can only measure interactions between sectors. Compared with suppliers that only sell to domestic brands, the total factor productivity premium is about 16.7 percent for auto parts suppliers that sell to at least one foreign brand. Furthermore, by employing a difference-in-differences estimation, this study shows that auto parts suppliers' productivity grows by 25.5 percent in the first year after forging partnerships with foreign brands and continues to grow in the following few years.

While the econometric results do not suggest any particular source of the observed productivity externalities through backward linkages, the subsequent case study identifies knowledge transfer from multinationals to local suppliers as an important source of productivity gains. Interviews with a joint venture automotive producer and several local automotive component suppliers in China revealed two key findings: first, joint venture

automakers have incentives to transfer technical knowledge and management practice to some of their suppliers in various forms, and second, this transferred knowledge can translate into suppliers' enhanced productivity, quality improvement, and cost reduction.

The case study also identified three caveats that researchers should consider when interpreting the prevalent productivity externalities through backward linkages in the econometric analyses. First, joint venture customers transfer knowledge to some of their suppliers to improve their productivity. In return, these suppliers charge their joint venture customer lower prices. Thus, the knowledge is not necessarily free, and therefore knowledge transfer may not be an externality.

Second, the case study also finds several other sources of observed productivity externalities related to backward linkages, which, unlike knowledge spillovers, are not necessarily true externalities. One is suppliers' internal efforts independent of foreign automakers' assistance, but concurs with knowledge spillovers from foreign automakers. The other two are the reduction of price and cost of intermediate products sold to foreign customers. While price reduction may underestimate true productivity externalities, cost reduction would overestimate them. Direction of bias depends on whether cost or price reduction weighs more heavily.

Third, an important feature about product launch in joint venture automakers' local suppliers—a one to two year lag between the procurement contract and the actual production—is identified in the case study. During this period, substantial knowledge diffusion and absorption can take place. While the productivity data of these suppliers become available only after the actual production begins, the productivity growth

associated with intensive learning during this preparation period fails to be captured in the econometric analysis. For that reason, the aggregate productivity-enhancing effect of supplying joint venture automakers tends to be underestimated. Without a better understanding of these caveats, it will be difficult to assess the case for economic policy intervention.

Certainly, we need more research to fully understand the sources of the observed productivity externalities generated through backward linkages with multinationals and to identify the true productivity externalities of FDI. Specifically, it would be helpful to obtain the price and cost information of intermediate products sold to multinationals and to explore how much price reduction is associated with knowledge transfers from these multinationals. Moreover, it would be interesting to investigate the birth of new firms in response to multinationals' demands, which would be an important source of aggregate productivity gains.

Table 1: Local Content Rate[a] of Joint Venture: 1985-1997

	1985	1991	1994-1995	1996-1997
Beijing Jeep (Beijing Cherokee)	0%	43.51%		
Shanghai VW (Santana)	0%	60.09%	85.82%	92.9%[b]
Guangzhou Peugeot (Peugeot 505)	0%	19.05%		>80%
First-Auto VW (Audi)	-	13.66%		
Dongfeng-Citroen (Fukang/Citroen ZX)	-	-	25%	60%

[a] "Local content rate" officially refers to the percentage of a product that is manufactured within all of China.

[b] Thun(2006, Table 2.1)

Source: CAIY (multiple years).

Table 2: The Production Function Estimations with Direct Backward Linkage Measures, Initial Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Minimum linkage measure of foreign brands	0.117	0.166*			0.108	0.0683		
	(0.0950)	(0.0947)			(0.106)	(0.107)		
Minimum linkage measure of JV automakers			0.0720	0.185**	0.0141	0.143*		
			(0.0695)	(0.0765)	(0.0719)	(0.0806)		
Any of the two minimum linkage measures							0.105	0.195**
							(0.0703)	(0.0780)
Log(capital)	0.405***	0.399***	0.408***	0.399***	0.405***	0.398***	0.408***	0.400***
	(0.0718)	(0.0719)	(0.0711)	(0.0712)	(0.0718)	(0.0718)	(0.0712)	(0.0712)
Log(labor)	0.544***	0.492***	0.541***	0.488***	0.544***	0.489***	0.541***	0.488***
	(0.112)	(0.121)	(0.111)	(0.120)	(0.112)	(0.120)	(0.111)	(0.120)
Province × time trends	No	Yes	No	Yes	No	Yes	No	Yes
F test (p-value) province trends = 0	-	0.000	-	0.000	-	0.000	-	0.000
R-squared	0.217	0.307	0.216	0.308	0.217	0.308	0.217	0.309

Notes: Dependent variable: log value added. Minimum linkage measure equals one if a supplier firm sold to at least one foreign brand or JV automaker in a given year and zero otherwise. N=2,985. OLS estimates given. Supplier firm fixed-effects, year dummy variables, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table 3: The Production Function Estimations with a Variety of Direct Backward Linkage Measures

	Foreign Brands			JV Automakers			Tech. Licensing	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Minimum linkage measure of foreign brands	0.166*							
	(0.0947)							
Linkage intensity measure of foreign brands		0.0500						
		(0.0317)						
Indicator of selling to one foreign brand			0.158*					
			(0.0952)					
Indicator of selling to two foreign brands			0.244**					
			(0.114)					
Indicator of selling to three or more foreign brands			0.199					
			(0.122)					
Minimum linkage measure of JV automakers				0.185**				
				(0.0765)				
Linkage intensity measure of JV automakers					0.0378			
					(0.0355)			

Notes: Table continued in following page.

(*continued from previous page*)

Indicator of selling to one JV automaker						0.188**		
						(0.0764)		
Indicator of selling to two JV automakers						0.154		
						(0.0973)		
Indicator of selling to three or more JV automakers						0.177		
						(0.113)		
Minimum linkage measure of technology licensing							-0.00234	
							(0.0539)	
Any of the three minimum linkage measures								0.0584
								(0.0623)
R-squared	0.307	0.307	0.308	0.308	0.306	0.308	0.306	0.301

Notes: Dependent variable: log value added. The minimum linkage measure equals one if a supplier firm sold to at least one foreign brand or one JV automaker or under one technology licensing agreement in a given year and zero otherwise. The linkage intensity measure is the total number of foreign brands or JV automakers a supplier sold to. N=2,985. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation. Omitted reference group in col.3 and col.6 are suppliers which sold only to domestic brands and domestic automakers respectively.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table 4: The Production Function Estimations with Direct Backward Linkage Measures, by Supplier Firms' Ownership Type

	(1) Domestic	(2) Foreign	(3) Domestic	(4) Foreign
Minimum linkage measure of foreign brands	0.155	0.272		
	(0.100)	(0.193)		
Minimum linkage measure of JV automakers			0.114*	0.198
			(0.0681)	(0.202)
Log(capital)	0.328***	0.579***	0.332***	0.584***
	(0.0819)	(0.150)	(0.0808)	(0.150)
Log(labor)	0.405***	0.278	0.400***	0.276
	(0.136)	(0.302)	(0.135)	(0.302)
Observations	1,647	810	1,647	810
R-squared	0.339	0.504	0.338	0.502

Notes: Dependent variable: log value added. Column title 'Domestic' is short for domestic supplier firms; 'Foreign' is for foreign-invested suppliers, also including Hong Kong, Macao, Taiwan-invested suppliers (HKMT). The minimum linkage measure equals one if a supplier firm sold to at least one foreign brand or JV automaker in a given year and zero otherwise. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table 5: The Production Function Estimations with Backward Linkage Measures of Foreign Brands, by Supplier Firms' Age

			Estimations by Age Groups		
			Old Suppliers	Middle-Aged Suppliers	Young Suppliers
Minimum linkage measure of foreign brands	0.186*	0.182*	0.218	0.115	0.227
	(0.101)	(0.101)	(0.140)	(0.145)	(0.202)
Log(firm age)	0.513***	0.311			
	(0.113)	(0.196)			
Log(firm age)^2		0.128			
		(0.112)			
Log(capital)	0.380***	0.379***	0.259***	0.525***	0.410***
	(0.0736)	(0.0727)	(0.0797)	(0.127)	(0.123)
Log(labor)	0.436***	0.421***	0.524***	0.210	0.542**
	(0.129)	(0.132)	(0.129)	(0.248)	(0.235)
Observations	2,437	2,437	881	882	1,222
R-squared	0.342	0.343	0.448	0.370	0.402

Notes: Dependent variable: log value added. The minimum linkage measure of foreign brands equals one if a supplier firm sold to at least one foreign brand and zero otherwise. Firm age is calculated as one plus the number of years between the founding year and the year of observation. Old suppliers are those established before 1970, the middle-aged are between 1970 and 1995, and young suppliers are after 1995. 1970 and 1995 are the two cutoff points of firm age tertile. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table 6: The Production Function Estimations with Backward Linkage Measures of Foreign Brands, by Intermediate Product Category and Region

A. By Intermediate Product Category		
Body and Interior	Chassis	Electrical and Electronics
(n=543)	(n=971)	(n=345)
0.0151	0.136	-0.0880
(0.158)	(0.119)	(0.302)
Engine components and parts	Miscellaneous auto parts	
(n=835)	(n=291)	
0.124	0.162	
(0.247)	(0.195)	

B. By Region		
East China	South China	Central China
(n=979)	(n=187)	(n=220)
-0.00549	-1.100***	0.187
(0.173)	(0.237)	(0.143)
North China	Northwest China	Southwest China
(n=543)	(n=72)	(n=345)
0.0176	-	0.181
(0.164)		(0.122)
Northeast China		
(n=639)		
0.526		
(0.355)		

Notes: Dependent variable: log value added. The minimum linkage measure of foreign brands equals one if a supplier firm sold to at least one foreign brand and zero otherwise. Each coefficient is from separate production function estimation. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included in all specifications. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table 7: The Production Function Estimations with Backward Linkage Measures, Controlling for Agglomeration and Competition Effects

	Foreign Brands				JV Automakers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Minimum linkage measure of foreign brands	0.220**	0.211**	0.207*	0.196				
	(0.107)	(0.107)	(0.107)	(0.125)				
Minimum linkage measure of JV automakers					0.132*	0.122*	0.128*	0.123
					(0.0730)	(0.0721)	(0.0717)	(0.0765)
Log(capital)	0.358***	0.360***	0.368***	0.367***	0.362***	0.363***	0.371***	0.371***
	(0.0838)	(0.0831)	(0.0829)	(0.0831)	(0.0837)	(0.0830)	(0.0827)	(0.0833)
Log(labor)	0.566***	0.566***	0.566***	0.567***	0.565***	0.564***	0.565***	0.566***
	(0.132)	(0.130)	(0.129)	(0.129)	(0.132)	(0.130)	(0.129)	(0.129)
Localization		-0.0288**	-0.0408***	-0.0410***		-0.0292**	-0.0416***	-0.0418***
		(0.0118)	(0.0150)	(0.0151)		(0.0118)	(0.0149)	(0.0150)
Urbanization		0.0178	0.0185	0.0186		0.0160	0.0168	0.0169
		(0.0159)	(0.0159)	(0.0158)		(0.0158)	(0.0159)	(0.0158)
Competition			0.0491*	0.0446			0.0512*	0.0483*
			(0.0276)	(0.0294)			(0.0273)	(0.0291)
Linkage × Comp.				0.0078				0.0046
				(0.0360)				(0.0291)
R-squared	0.361	0.367	0.369	0.369	0.359	0.365	0.368	0.368

Notes: Dependent variable: log value added. The minimum linkage measure of foreign brands equals one if a supplier firm

sold to at least one foreign brand and zero otherwise. N=1,902. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 8: The Production Function Estimations with Backward Linkage Measures with Leads and Lags

	New Suppliers to:		Domestic Suppliers to:	
	Foreign Brands	JV automakers	Domestic Brands	Non-JV automakers
Leads and Lags of becoming suppliers of foreign brands or JV automakers				
Supply status changet+3	0.0550	0.202	0.0835	0.192
	(0.165)	(0.160)	(0.198)	(0.160)
Supply status changet+2	0.238	0.209	0.155	0.132
	(0.162)	(0.131)	(0.222)	(0.202)
Supply status changet+1	0.115	0.0793	0.0786	-0.0596
	(0.165)	(0.152)	(0.195)	(0.187)
Supply status changet0	0.282*	0.325**	0.267	-0.00718
	(0.156)	(0.147)	(0.177)	(0.185)
Supply status changet-1	0.458**	0.394*	0.245	-0.127
	(0.217)	(0.203)	(0.317)	(0.296)
Supply status changet-2	0.716***	0.532**	0.473	-0.0180
	(0.223)	(0.218)	(0.315)	(0.310)
Supply status changet-3 forward	0.636*	0.599	0.261	-0.0784
	(0.353)	(0.371)	(0.328)	(0.303)
F test (p-value)				
Status change(t0-t3 forward) = 0	0.016	0.151	0.306	0.937
Observations	1,441	1,223	715	611
R-squared	0.349	0.365	0.482	0.529

Notes: Dependent variable: log value added. The minimum linkage measure equals one if a supplier firm sold to at least one foreign brand or JV automaker in a given year and zero otherwise. New suppliers of foreign brands or JV automakers are those which used to sell to domestic firms and only began to sell to foreign brands or JV automakers during the period between 1998 and 2004. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation. Status changet-3 forward dummy is equal to one in every year beginning with the third year after becoming suppliers of foreign brands or JV automakers. Reference group is suppliers to only domestic brands between 1998 and 2004.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Appendix A

Table A. 1: Summary of Variables

Numeric Variables	# of Obs.	Mean	Std.Dev.
Value added (1 million Yuan)	3282	1509.0	4380.9
Employment (persons)	3405	738.6	1171.7
Asset (1 million Yuan)	3401	11966.3	29349.5
Age (years)[36]	2203	28.93	17.02
Linkage Measures	# of Obs.	Mean	Std.Dev.
Minimum Linkage—Foreign Brands	3287	0.576	0.494
Minimum Linkage—Joint Venture Automaker	3287	0.669	0.471
Minimum Linkage—Tech. Licensing	3287	0.436	0.496
Linkage Intensity—Foreign Brands	3287	0.943	1.072
Linkage Intensity —Joint Venture Automaker	3287	0.916	0.857
Agglomeration Measures	# of Obs.	Mean	Std.Dev.
Localization Economies	2174	3.743	3.439
Urbanization Economies	2174	8.678	2.374
Competition (the inverse of Herfindahl Index)	2174	1.118	1.695
Other Variables			
Province	Suppliers in the sample are from 27 provinces.		
Zip code	Suppliers are scattered in 676 zip-code areas.		
Brand	Suppliers in the sample sell to 98 foreign and domestic auto brands, e.g., Buick, Alto.		
Automaker	Suppliers in the sample sell to 52 automakers, e.g., Shanghai VW, Tianjin Toyota, Chery.		
Foreign partner of brands	For all foreign brands, this variable indicates their producers, e.g., Toyota, GM; there are 15 foreign partners.		
Foreign partner of automakers	There are 17 foreign automakers in corporation with Chinese assemblers.		

[36] During the period of the Cultural Revolution, many firms still "existed", but closed for revolutionary violent class struggle. Some firms closed forever; the other firms resumed operation after 1976. The "old" firms in the data sample are those survived.

Automobile parts	Suppliers in the sample produce 333 kinds of automobile parts
Categories of Automobile parts	The 333 different kinds of auto parts can be grouped into 23 categories.
Large categories of Automobile parts	The 333 different kinds of auto parts can be further grouped into 5 large categories.
Ownership	

Table A. 2: The Production Function Estimations with Backward Linkage Measures of JV Automakers, by Supplier Firms' Age

			Estimations by Age Groups		
			Old Suppliers	Middle-Aged Suppliers	Young Suppliers
Minimum linkage measure of JV automakers	0.137*	0.133*	0.0743	0.177	0.337**
	(0.0773)	(0.0770)	(0.0903)	(0.155)	(0.167)
Log(firm age)	0.517***	0.312			
	(0.113)	(0.196)			
Log(firm age)^2		0.130			
		(0.112)			
Log(capital)	0.384***	0.383***	0.281***	0.521***	0.409***
	(0.0730)	(0.0721)	(0.0788)	(0.127)	(0.122)
Log(labor)	0.433***	0.418***	0.511***	0.211	0.530**
	(0.128)	(0.131)	(0.129)	(0.247)	(0.232)
Observations	2,437	2,437	881	882	1,222
R-squared	0.341	0.342	0.444	0.371	0.405

Notes: Dependent variable: log value added. The minimum linkage measure of JV automakers equals one if a supplier firm sold to at least one JV automaker and zero otherwise. Firm age is calculated as one plus the number of years between the founding year and the year of observation. Old suppliers are those established before 1970, the middle-aged are between 1970 and 1995, and young suppliers are after 1995. 1970 and 1995 are the two cutoff points of firm age tertile. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Table A. 3: The Production Function Estimations with Backward Linkage Measures of JV Automakers, by Intermediate Product Category and Region

A. By Intermediate Product Category		
Body and Interior	Chassis	Electrical and Electronics
(n=543)	(n=971)	(n=345)
0.126	0.179*	-0.0843
(0.172)	(0.0956)	(0.177)
Engine components and parts	Miscellaneous auto parts	
(n=835)	(n=291)	
0.252	0.241	
(0.226)	(0.189)	

B. By Region		
East China	South China	Central China
(n=979)	(n=187)	(n=220)
0.0192	0.176	0.0365
(0.146)	(0.196)	(0.184)
North China	Northwest China	Southwest China
(n=543)	(n=72)	(n=345)
0.325*	0.142	0.179
(0.167)	(0.702)	(0.115)
Northeast China		
(n=639)		
0.263		
(0.244)		

Notes: Dependent variable: log value added. The minimum linkage measure of JV automakers equals one if a supplier firm sold to at least one JV automaker and zero otherwise. Each coefficient is from separate production function estimation. OLS estimates given. Supplier firm fixed-effects, year dummy variables, province specific time trends, and a constant included in all specifications. Standard errors in parentheses are clustered at the firm level to correct within-firm serial correlation.

*** significant at 1%; ** significant at 5%;* significant at 10%.

Appendix B: Supplier S's Case of Improving Production Capacity of Product A

(*Below is an English translation of Supplier S's award-winning Kaizan case proposal.*)

Problem: As the demand for product A increased, production capacity then could no longer keep pace with the demand. Increased demand requires the Takt Time (TT)[37] to go down from 12 seconds to 8, thus the cycle time (CT) needs to decrease accordingly from 11.5s to below 8.

Goal: Developing an effective standard operating procedure (SOP) for the production line and bringing production's cycle time under 8s.

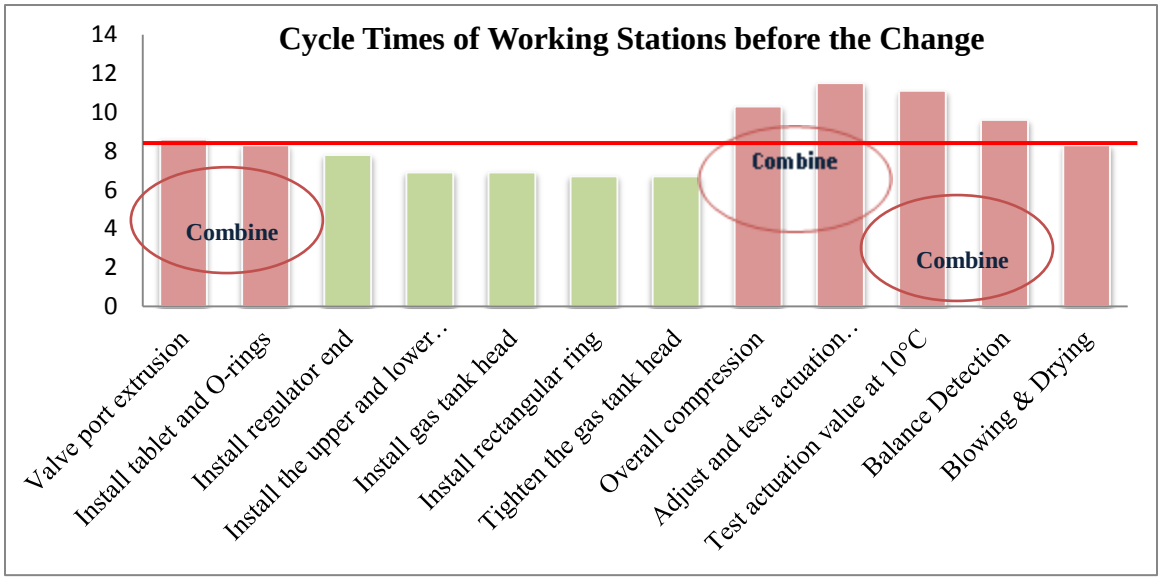


Figure B. 1: Cycle Times of Working Stations before the Kaizan Improvement

[37] Lean Production uses Takt Time as the rate that a completed product needs to be finished in order to meet customer demand.

Problem Analysis: The production line consists of twelve work stations. The Kaizen team began by investigating each of the work stations and identified seven bottleneck stations, whose CT were above 8 seconds. Cycle times of the twelve working stations are displayed in the chart below. These above the red line are bottleneck stations and needed adjustment.

At two bottleneck stations, Overall Compression and 0 ℃ Test, the team measured productive time and idle time, and computed efficiency as ratio of productive time to total time.

Overall Compression						
	worker		time		machine	
	install four valves		7.3s		idle	
	scan the next batch of valves to be tested		9.7s		compression	
	wait		17s			
	remove the four valves from the machine		7.4s		idle	
summary	cycle	Idle time		Productive time		Efficiency
worker	41.4s	17s		24.4s		**58.9%**
machine	41.4s	14.7		26.7s		**64.5%**
Adjust and test actuation value at 0 ℃						
	worker		time		machine	
	install two valves		9.1s		idle	
	wait		7.4s		test	
	Under tooling		6.4s		idle	
	On tooling		9.1s		idle	
	wait		7.4s		test	
	remove the two valves		6.4s		idle	
summary	cycle	Idle time		Productive time		Efficiency
worker	45.8s	14.8s		31s		**67.7%**
machine	45.8s	31s		14.8s		**32.3%**

Notes: Grey areas are productive times.

Similarly, at working stations 10℃ Test and Balance Detection, the team did the same analysis.

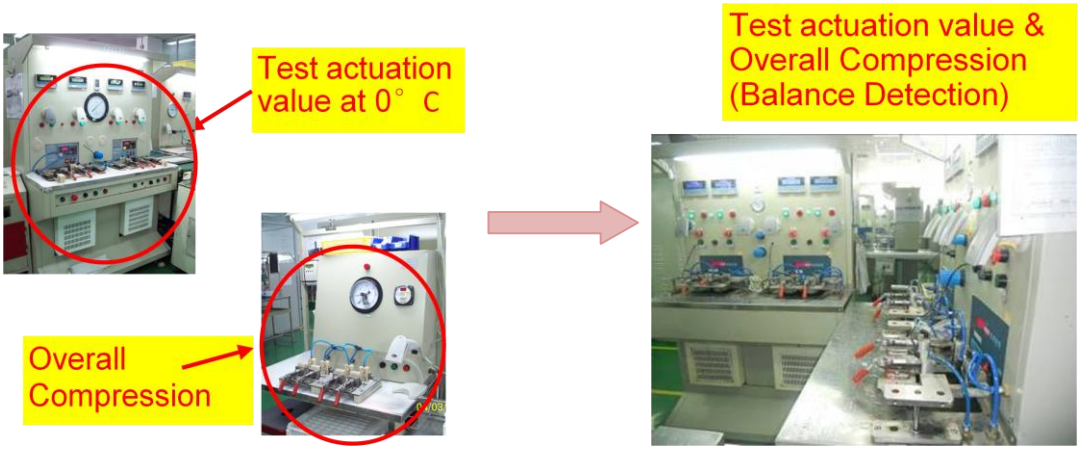
Test actuation value at 10℃						
	worker		time		machine	
	install two valves		8.5s		idle	
	wait		5.6s		test	
	Under tooling		6.4s		idle	
	On tooling		9.1s		idle	
	wait		5.6s		test	
	remove the two valves		9.2s		idle	
summary	cycle	Idle time		Productive time		Efficiency
worker	44.4s	11.2s		33.2s		**74.8%**
machine	44.4s	33.2s		11.2s		**25.2%**
Balance Detection						
	worker		time		machine	
	change valves		2.7s		idle	
	scan the next batch of valves to be tested		3s		detection	
	wait		3.9s			
summary	cycle	Idle time		Productive time		Efficiency
worker	9.6s	3.9		5.7s		**59.4%**
machine	9.6s	2.7s		6.9s		**71.9%**

Notes: Grey areas are productive times.

Statistics showed that efficiencies of both worker and machine were too low and had big room to improve.

Solutions and Results:

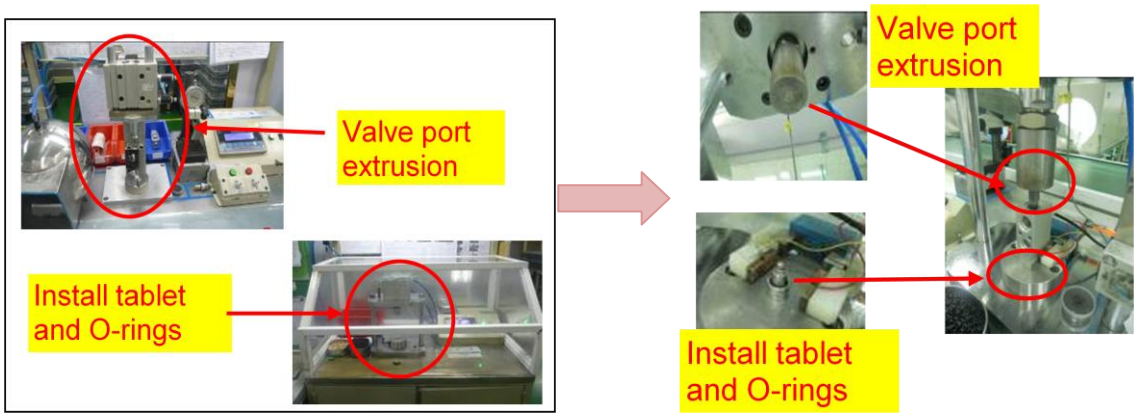
1. Combine two working stations, Overall Compression and 0℃ Test and add one testing position; as a result, cycle time was reduced to 7.56 seconds and two operative positions were removed. Similarly, working stations 10℃ Test and Balance Detection resulted in 7.25 seconds and saved two operative positions as well. Below are pictures of rearranging two stations.



In addition,

2. Two working stations, Valve Port Extrusion and Installing Tablet and O-rings, share similar pneumatic device. With fixture transformation and technical parameter adjustment, one air pressure machine could do both jobs. Therefore, cycle time after working station combination was reduced to 6.47 seconds, and

two operative positions were saved as well. Below are pictures showing how the two stations were combined.



3. Introduce to each working station hydraulic trolley with height-adjustable flat panel, which facilitates operatives to stack and transport turnover boxes after each procedure, reducing 3 seconds on average due to inefficient walking around and bending movement.

Overall, cycle time after improvement was reduced to 7.56 seconds, below TT of 8 seconds. Additionally, 6 working positions were removed, yielding annual cost savings of 240 thousand RMB.

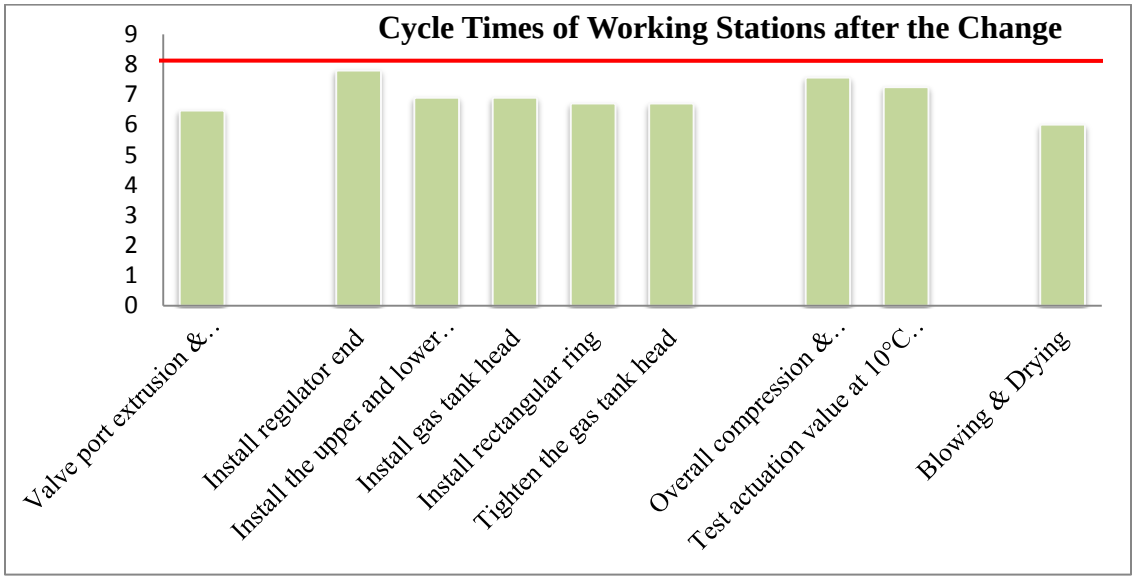


Figure B. 2: Cycle Times of Working Stations after the Kaizan Improvement

Appendix C: Company D's Transportation Cost Reduction

(*Below is an English translation of Company D's award-winning Kaizan case proposal of saving 1/3 of Transportation Cost*)

Shanghai Delphi provides automotive air-conditioning systems for many Chinese OEM[38] customers; thus transportation cost accounts for most of the selling costs. To maintain competitive cost structure, it is forced to reduce transportation cost and limit price increases. The Lean Supply Chain team proposed three approaches.

First, ground transport of cargo was replaced by marine shipping, reducing the transportation cost up to 1.78 million RMB.

[38] Original Equipment Manufacture

Second, rearrange items of different rate of weight to volume. Top left are light bulky boxes which wasted plenty of space; bottom left are heavy bags. By stacking bulky boxes on top of the heavy bags, the adjustment alone saves 1.05 million RMB.

Third, increase capacity of each box by repositioning items as shown in pictures below, reducing transportation cost from 2.19 RMB per item to 1 RMB, by 54%.

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Movie Piracy and Sales Displacement in Two Samples of Chinese Consumers

(Article is co-authored with Joel Waldfogel)

1 Introduction

It is widely believed that intellectual property piracy is widespread in China and elsewhere in Asia. This has caused great consternation among the countries exporting commercial intellectual property, chiefly the U.S. Especially as it grows wealthy, China could become an important export market for intellectual property. U.S. film studios in particular are concerned about piracy. The Motion Picture Association of America (MPAA) claims that its members lost $6.1 billion to piracy in 2005, $4.8 billion internationally, and the MPAA estimates that 90 percent of movies sold in China are pirated copies, stating that the "countries where movie piracy is occurring most prominently are China, Russia, UK, France, Spain, Brazil, Italy, Poland and Mexico." The U.S. government shares Hollywood's concern about piracy in China.[39]

Even if intellectual property piracy is widespread in China, it does not follow that paid consumption would have been higher in the absence of unpaid pirate consumption.

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[39] "The Administration's top priorities this year continue to be addressing weak IPR protection and enforcement, particularly in China and Russia. Although this year's Special 301 Report shows positive progress in many countries, rampant counterfeiting and piracy problems have continued to plague China and Russia, indicating a need for stronger IPR regimes and enforcement in those countries." Under Special 301, the United States Trade Representative "must identify those countries that deny adequate and effective protection for IPR or deny fair and equitable market access for persons that rely on intellectual property protection." And: "China remains a top intellectual property enforcement and TRIPS compliance priority for the United States. China will remain on the Priority Watch List, and remain subject to Section 306 monitoring."

The amount of paid activity that stealing displaces depends on both the volume of unpaid activity and the rate of displacement of paid for unpaid consumption. A growing body of literature provides estimates of displacement rates for a variety of media (music, movies, video), and available evidence provides a range of displacement rates that vary across media. The smallest displacement rates arise in television, where access to clips on YouTube appears not to cannibalize conventional television viewing.[40] Music provides intermediate displacement estimates, with estimates around a quarter (although some as low as zero).[41] Estimates for movies provide the highest displacement rates: Rob and Waldfogel (2007) find that unpaid movie consumption displaces paid consumption roughly 1:1 in a sample of U.S. college students. They speculate that the high displacement rate arises because movie consumption, even when unpaid, requires hours of undivided attention.

The existing literature has focused largely on developed countries, particularly the U.S. It is not clear whether findings in these contexts are relevant to China, a developing country context with large-scale piracy. This paper seeks to answer that question with a study of the effects of unpaid movie consumption on paid movie consumption among two Chinese populations in 2009. First, we survey a sample of college students analogous to the US student population examined in Rob and Waldfogel (2007, which we refer to as RW below). Second, we survey a larger sample of Chinese Internet users.

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[40] See Waldfogel (2010).

[41] See, for example, Oberholzer-Gee and Strumpf (2007), Rob and Waldfogel (2006), Liebowitz (2006), Zentner (2006), and Hong (2007), among others.

The paper proceeds in five sections following the introduction. Section two provides background on the movie industry and piracy in China. Section three provides some theoretical discussion on the effects of piracy on paid consumption. Section four describes our two sources of data. Section five presents empirical results on the sales-displacing effects of unpaid on paid consumption among our samples of Chinese consumers. We speculate on the reasons for our small displacement estimates and conclude in the last section.

We find large amounts of unpaid movie consumption in both of our samples: nearly three quarters of movie consumption is unpaid, compared with under a tenth in a US college-student sample. We find mixed but, at most, modest evidence of sales displacement in China. Among the college students we find a statistically significant but small rate of sales displacement. Longitudinal estimates suggest roughly 1:7 displacement, or that each instance of unpaid consumption reduces paid consumption by a seventh. We find no evidence of sales displacement in the general online population surveyed. Both estimates are far smaller than the comparable result for a US college student sample, roughly 1:1 displacement.

2 Industry Background and Piracy Issue in China

The Chinese Movie Industry

Since 1949 China's cultural market has been closed; for five decades the film industry was financed, owned, and controlled by the government. Under government

control, filmmakers were not burdened by the need to secure finance or recover production costs at the box office. Since early 1992, as China has undergone economic reform, the government-sanctioned film industry has faced competition from new sources such as video parlors, Karaoke bars, and video piracy. Unable to withstand private competition, the existing industry has withered, and filmmakers have turned to other sources of finance. Privately – and jointly – owned production companies have appeared.[42]

Since 1995, China has engaged in "box office split" (i.e. revenue-sharing) deals on up to ten foreign films, usually 'blockbusters'. Prior to 1995, foreign films were bought into Chinese market for flat fees of $30,000 to $50,000 per film.[43] These were typically outdated and low-grade but inexpensive foreign movies.[44] With China's entry into the WTO, the number of foreign films allowed in on a revenue-sharing basis rose from 10 to 20. This number is expected to increase to 40 in the coming years.[45] Most of the foreign films are Hollywood films, followed by films from Hong Kong. The effective quota need not be filled if China determines that films have "improper content."

In 2007, box office revenue in China totaled RMB 3.33 billion (approximately US $438 million), or $0.35 per capita, while in the U.S. the box office revenue is $9.63

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[42] For detailed introduction of the history of the Chinese film industry, please refer to *www.dfat.gov.au/geo/china/fta/submissions/cfta_submission_6se05.pdf*

[43] The copyright is completely bought-out by the film distributor in China for a flat fee.

[44] Supra note 4, page 10.

[45] According to the 2008 Research Report on Chinese Film Industry, in 2007 10 films were actually allowed into on a revenue-sharing basis, and 12 on a flat-fee basis; in 2006, 16 on a revenue-sharing basis, and 13 the latter.

billion, or $32 per capita.[46] Although the scale of the Chinese film industry is rather small compared with U.S., revenue is growing. The box office revenue in 2005 and 2006 totaled U.S. $250 million and U.S. $325 million respectively.[47] In total, more than five hundred domestic films were produced in 2007. Among 188 films released in theaters, 140 were domestic films, accounting for only 54.1 percent of total box office revenue; 48 foreign films earned the other 45.9 percent.[48] In 2005, there were 1,216 theaters and 2,530 movie screens in China[49], while U.S. had 6,114 cinema cites and 37,740 movie screens.

Piracy in China

Piracy, both physical and on the Internet, is considered an important threat to the film industry. According to some observers, no country contributes more to the piracy problem, or will play a more critical role in shaping the future of international piracy, than China (Priest, 2006). Physical piracy has flourished in China and has grown quickly since the early nineties. According to industry estimates, more than 90 percent of all music CDs, movies DVDs and software sold in China are pirated. In 2004, industry estimates of U.S. losses due to piracy in China range from about $1.85 to $2.54 billion annually in displaced sales of CDs, DVDs, VCDs and software.[50]

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[46] See http://www.natoonline.org

[47] See http://www.reuters.com/article/pressRelease/idUS159860+28-Feb-2008+PRN20080228 (in Chinese)

[48] See http://www.medialeader.com.cn/media/200806/20080624091808_19137.html (in Chinese)

[49] See http://www.china.com.cn/chinese/zhuanti/whbg06/1120913.htm (in Chinese)

[50] See footnote 5 of Priest (2006).

Concern about Internet-based piracy has been heightened as China has grown to account for the world's second-highest number of Internet users. Thousands of websites and numerous peer-to-peer file-sharing networks or FTP services make copyrighted works available for free to Internet users in China.[51] As in the U.S., use of these sites is prominent on college campus, with a large proportion of low-income students and high-speed Internet access. While Chinese consumers do not have officially sanctioned access to many foreign films, they are nevertheless able to view pirated versions online. Many U.S. television programs, such as *Prison Break* and *Lost*, are not officially available in China; but Chinese audiences are able to view episodes at the same time as U.S. audiences through file-sharing networks.

While the West has blamed China's central government for its failure to eliminate the problem, the Chinese government believes it is not obligated to protect the interests of private parties with the same urgency with which it protect its own interests. China has employed gradual reforms, while performing occasional campaigns against infringers in response to pressure from foreign and domestic copyright owners (Priest, 2006).

The Chinese government recently ordered a crackdown on online video and audio content which does not have an individual license. Internet companies must edit or erase such content.[52] While the longer-term effects of the crackdown are not yet clear, a brief

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[51] See footnote 21 of Priest (2006).

[52] See http://www.ft.com/cms/s/0/d2452e5a-1fa6-11de-a1df-00144feabdc0.html on the April 2009 crackdown.

look at the most popular video-sharing websites, like Tudou.com and Youku.com, shows that TV series such as *X-Files*, *24 hours*, etc. had been removed.

Many foreign and domestic film companies have responded to China's IP protection climate with new business strategies. Recently, Warner Bros. announced an experimental online service offering "DRM-protected copies of various Warner Bros. films (including some that have never been released theatrically in China) for a fraction of the rental cost, compared to other parts of the world…. The studio's movies will reportedly be available for rent for a mere 4 to 7 yuan, roughly 60¢ to $1.03. … Warner Bros. is trying to compete with street pirates who hawk burned movies on the cheap."[53] In music – and also as a response to piracy - Google has made music available on a fully ad-supported basis.[54]

3 Theory

The static effects of intellectual property piracy on both legal sales and welfare can be described with a simple demand model (Figure 1). First consider a context in which the product has a zero marginal cost and a positive price, but piracy is not possible. Then the area under the demand curve is divided into revenue, consumer surplus, and deadweight loss (Figure 1.1).

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[53] See http://arstechnica.com/old/content/2008/11/warner-bros-to-fight-china-movie-piracy-with-60-downloads.ars

[54] See Barboza, David. "Google and Music Labels Bet on Downloads in China." New York Times, April 6, 2009.

When piracy is feasible, the demand for legal products changes. However, the nature of the change depends on whether the instances of demand manifesting themselves as pirate consumption would otherwise have manifested themselves as legal purchases. For example, if the low-valuation demanders – formerly resulting in deadweight loss – now consume pirated products, then piracy raises welfare without reducing revenue (Figure 1.2). On the other hand, if consumers with high valuations of the product – who would formerly have purchased legally – now consume pirated copies, then revenue falls (Figure 1.3).

For the static problem, piracy increases welfare. Either valuations that were formerly shared between consumer surplus and revenue now become simply consumer surplus. Or (low) valuations that were formerly deadweight loss become consumer surplus.[55]

Piracy can, in principle, also stimulate the demand for paid consumption. Shapiro and Varian (1999) emphasize the possible effect of sampling on paid demand. Bakos, Brynjolffson, and Lichtman (1999) and Varian (2000) articulate theories in which file-sharing does not necessarily reduce paid demand but may increase it, particularly if sharing remains small in scale. Another consideration is that there are several sources to generate revenue for movie industry, such as rentals, box office sales, royalties for showing the movie on television, and DVD sales. Some consumers watch the same movies several times. Therefore, it is possible that unpaid consumption may stimulate

[55] A dynamic analysis – outside the scope of this study – would be different. If revenue does not cover the cost of production, then the product won't come into existence in the first place.

further paid consumption; on the contrary, an instance of unpaid consumption may displace several instances of paid consumption as well (Rob and Waldfogel, 2007).

The key point that this analysis highlights, however, is that piracy can cause anywhere between a 1:1 displacement of revenue and have no effect (and, possibly, even a stimulating effect). Put another way, the effect of piracy is an empirical question that we seek to address.

4 Data

The data for this study come from two surveys administered in China. The first survey was administered to students at a Chinese university in late 2008. The second survey was administered to a sample of Chinese Internet users in July 2009. We describe these data sources in turn.

College Student Sample

The college student sample comes from a paper survey administered on the campus of a Chinese university in December of 2008. The survey was given to 372 students in two classes. The basic data set resulting from the survey is an individual-level panel on legal and illegal movie consumption of movies released from 2006 to 2008.

In the survey, each student was shown lists of 50 movies from each of the past three years for a total of 150 movies. For each movie, respondents were asked to indicate whether they had seen it, whether they had seen it in paid or unpaid modes or both

(theater, rented DVD, downloaded,…), and in what order they had viewed the films.[56] For example, if they first saw the movie in a theater, then later watched a pirated DVD, they would indicate "1" under theater and "2" under pirated DVD for that movie. The list of 50 movies from each year included the 20 foreign movies allowed into China per year, as well as 20[57] domestic (Chinese) movies, and 10 additional foreign movies not legally allowed in Chinese theaters, which we refer to as "unauthorized films" below.[58]

In addition to movie consumption, the survey asked the students to report their interest in movies on a scale of 1 to 5 (whether their interest in movies was "a lot less", "a little less", "about the same", "a little more", or "a lot more" than their peers) and to indicate how often they go to a theater. The survey also asks about family income, gender, age, and Internet access (over the past three years).

The first column of Table 1 summarizes the college student respondents' characteristic data. Respondents average 20.2 years of age, and 50 percent are between 19.75 and 21. Just over half (52 percent) are female. Nineteen percent report annual family income of less than $2,930, 32 percent report $2,930 to $7,320, 29 percent report $7,320 to $14,640, $14,640 to $29,280, and 5 percent report a higher income.[59] Only

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[56] Although respondents are presented a list of movies, rather than being asked to generate a list of movies they have viewed, it remains possible that respondents will forget some of the movies the have seen.

[57] In the 2006 sample, there are 19 foreign authorized films, 15 domestic movies and 16 unauthorized movies; while in 2007, there are 21 foreign authorized films, 19 domestic films and 10 unauthozied.

[58] A few unauthorized films are allowed into Chinese markets in the form of DVD, VCD, or even Blu-ray, usually several months after theatrical release in China.

[59] While these income levels seem low by developed country standards, it is important to keep in mind that per-capita income in China was $4,620 in 2010 (see http://www.worldbank.org/en/country/china/overview).

seven percent report below-typical levels of interest in movies, while 44 percent report typical, 36 percent report more than typical, and 14 percent report far more than typical. Over half (55 percent) report never going to the theater, while 39 percent report going once a month or less, and 6 percent report going more often. High-speed Internet access is nearly ubiquitous: 99 percent report having had it in 2008, 96 percent in 2007, and 80 percent in 2006.

Table 2 summarizes movie consumption among the college student respondents. As the first ("all viewings") column indicates, respondents had viewed movies among the 150 in the survey a total of 31 times. (These are listed as viewings rather than movies, since some of the respondents view some of the movies multiple times.) Of these viewings, three quarters (23 of 31) were unpaid. The vast majority of viewings – 96 percent – are first-time viewings. That is, these respondents do not typically see movies a second or third time, while in the U.S. sample analyzed in RW, first viewings make up only 78 percent.

The vast majority of the unpaid viewings are obtained via downloading; downloaded movies make up three quarters of unpaid consumption and over half of consumption overall. Theatrical consumption makes up a fifth of overall consumption and over 80 percent of legal consumption.

Internet User Sample

Our Internet user sample was collected through a major online paid survey community in China. While our data license prevents us from disclosing the identity of

the company (which we term "community C"), community C has one million registered users. These users are compensated for survey participation, providing them with an incentive to stay online and respond regularly to surveys. We posted our survey during a two-week period in July of 2009 and obtained data on 3,852 individuals.

Our sample is fairly representative of the registered participants in community C. According to company reports on community C, males account for 66 percent of registered users and 63 percent of our sample. The majority of registered users – just over 60 percent - at community C are between 18 and 30. A similar percentage of our online sample falls into the same age range. Our Internet users are also at least roughly representative of Chinese Internet users overall. According to a report issued by China Internet Network Information Center (CNNIC), males accounted for 57 and 53 percent of Internet users in 2007 and 2008, respectively, somewhat below their share in our sample (63 percent). Our respondents are somewhat younger than typical Chinese Internet users; nearly 90 percent of our respondents are between 20 and 40 years old, compared with just over half of the Chinese Internet-connected population. Finally, our sample has a somewhat higher income level than typical Internet users; nearly 60 percent of Internet-connected individuals have a lower monthly income (below $220), compared with only 15 percent of our online sample.

While our student sample covers respondents in a narrow age range, our Internet user sample covers a much wider range. Half of our online survey respondents are between 25 and 33 (compared with an inter-quartile range of 19.8-21 for the students).

Because college students may report either their own or their parents' incomes as "family income", it is difficult to compare their reported income with the reported income of the Internet user sample. Nevertheless, as Table 1 shows, the distribution of income is fairly similar between our two populations.

Compared to the student sample, the online sample is less likely to have broadband. While nearly all of the students (99 percent) had broadband in 2008, only 87 percent of the online sample had broadband in 2008. Of the online population, 82 percent report owning a DVD burner, compared with 64 percent of the students. Reported interest in movies is higher in the online sample than among the students; 78 percent report above-average interest in movies, compared with 49 percent among students. Finally, online respondents report going to the theater more frequently; nearly half report going to theaters more than twice a month, compared with only 6 percent of the students.

Paid and unpaid movie consumption is broadly similar for our college students and online samples, and both differ substantially from the US college students in RW. While our college student respondents had an average (median) of 8 (5) movie viewings by paid means and 23 (18) by unpaid means, our online respondents had an average of 12 paid viewings among an average of 33 overall viewings. Unpaid viewings make up the majority of movie viewings among both populations. This is starkly at odds with survey results based on US college students in Rob and Waldfogel (2007). First, US college students watch far more movies than Chinese students. Given a list of 150 movies – the top 50 in each of the preceding three years – respondents had viewed movies 57 times.

Second, the vast majority of US consumption was legal: of the 57 viewings, 54 of these were legal.

According to Table 3, which describes the college students, of the 23 unpaid consumption episodes, 10.7 were Chinese movies, 9.3 were legal foreign movies, and 3 were illegal foreign movies. Of the 8 paid movies, 4.4 were legal domestic movies, 3.4 were legal foreign movies, and 0.2 were illegal foreign movies. Table 4 describes the online sample. This population has similar patterns. Domestic authorized movies occupy the largest share, followed by foreign authorized movies. Unpaid consumption of foreign unauthorized movies accounts for roughly a tenth of movie viewings in these samples.

5 Empirical Strategy and Results

We ask two broad questions. First, descriptively, what are the determinants of paid and unpaid movie consumption? Part of the motivation is to find plausible sources of exogenous variation in unpaid movie consumption that can be used to identify the sales displacement effect of unpaid on paid consumption. Second, we seek to measure the displacement rate: how much does an instance of unpaid movie consumption displace paid movie consumption in China? We pose the latter displacement question using both cross sectional and longitudinal approaches, applied to the two data sets.

Determinants of Movie Consumption

We create simple cross-section datasets indicating the total number of movies watched – by each of the paid and unpaid means – by each individual, along with the

individual's characteristics. Table 5 uses regressions to describe how paid and unpaid movie consumption varies across respondents in the two samples. The first two columns report regressions on the student sample. Both paid and unpaid consumption rise sharply in self-reported interest in movies: those reporting the highest level of interest watch 9 more paid and 34 more unpaid movies than those reporting the lowest level of interest. Paid consumption rises with family income, and unpaid consumption falls – although not statistically significantly – with income. Men watch substantially more – 11 more – unpaid movies, while women watch 2 more paid movies.

The latter two columns of Table 5 report regression results for the Internet user sample. Here too paid consumption rises systematically with interest in movies and with income. Unpaid consumption rises sharply in movie interest and falls sharply in income. As with the college students, men watch less paid movies and more unpaid movies than women.

Displacement

The most basic way to measure sales displacement is simply by asking whether respondents who have more unpaid instances of movie consumption have fewer paid instances. An immediate problem with this approach is that people who like movies may like them in both paid and unpaid modes, which would give rise to a positive correlation, even if no complementary relationship exists. What is needed, in principle, is a measure of interest in movies. Conditional on a respondent's level of interest in movies, the question is whether those who do more unpaid viewing do less paid viewing.

The first 5 columns of Table 6 report cross sectional regressions of paid consumptions on unpaid consumption and controls for the college student sample. In column (1), a regression of paid viewing on unpaid consumption yields a coefficient of -0.015, which is insignificantly different from zero. Including dummies for a self-reported level of interest in movies and income levels changes the displacement coefficient to -0.066, which is three times the absolute value of its standard error. This estimate implies sales displacement of 15:1. These results are robust to the inclusion of other covariates, or interaction terms with interest (column 4 and 5). However, because our measure of interest in movies is likely imperfect, the true level of displacement is probably higher.

The latter half of Table 6 (columns 6-10) repeats the exercise of the first half using the Internet user survey. Most variables enter with similar signs and magnitudes in the online sample. The coefficients on the movie interest dummies are monotonically increasing, as are the movie attendance coefficients. However, with these data, the displacement coefficient is precisely estimated to be near zero.

Although we have direct measures of the respondents' interest in movies among the variables in the data (interest in movies, frequency of theater attendance, etc.), there is still a possibility that unobserved determinants of movie consumption will contaminate the cross sectional approach. If the approach is biased toward producing positive coefficients – or, equivalently, biased toward producing evidence against sales displacement – then findings of negative and zero displacement have rather different interpretations. A negative estimated coefficient in a context biased toward positive findings is informative, suggesting that the true rate of displacement is even more

negative. A positive estimated coefficient, while on its face suggestive of a stimulating relationship between unpaid and paid consumption, is less informative; it simply means that the true relationship is less positive than the estimated relationship.

A second approach to measuring sales displacement exploits the panel nature of the data to deal with fixed unobserved heterogeneity. Define P_{iv} as the number of movies from vintage *v* that person *i* consumes via paid means, and define U_{iv} analogously. Then:

$$P_{iv} = \alpha U_{iv} + X_{iv}\beta + \mu_i + \mu_v + \varepsilon_{iv},$$

where μ_i is an individual fixed effect and μ_v is a vintage effect. The coefficient α measures displacement by asking whether a person has more or less paid consumption from vintages in which they have more unpaid consumption, after accounting for the average vintage effect (movies released that year are more popular) and the individual's fixed effect (reflecting his time-constant taste for movies). The vector *X* contains time-varying individual characteristics, such as class year and age. Column (1) in Table 7 reports the results of the college student sample. Note that an observation in this setup is an individual-vintage pair. That is, the dependent variable is, for example, the individual's number of paid viewings of movies released in 2006. Using all of the college student data, the displacement rate is -0.135, meaning that one instance of unpaid consumption displaces one seventh of paid consumption.

Pooling all movies is potentially misleading, since illegal movies are not available for paid consumption. Therefore, we further look at the displacement rate within legal foreign and legal domestic movies separately in columns (2) and (4). The displacement

rate for legal foreign movies is slightly smaller than the rate overall, about 1:7.4. The displacement rate for domestic movies is higher, at 1:5.6.

The above specification assumes there are no displacement effects across movie types. To relax this assumption, in columns (3) and (5), we examine how the unpaid consumption of three types of movies affects the paid consumptions of legal foreign and legal domestic movies. These two types of movies exhibit opposite patterns. Unpaid foreign legal consumption displaces paid foreign legal consumption at a rate of -0.124, while unpaid domestic consumption displaces paid foreign legal consumption at about -0.043. Similarly, the within-type displacement rate of paid domestic consumption is -0.197, while the across-type displacement rate is positive, 0.063. Taken literally, the positive coefficient implies that unpaid consumption of foreign movies stimulates paid consumption of domestic movies, although the coefficient is small in magnitude.

The latter half of Table 7 repeats the longitudinal estimation exercise with the Internet user sample. The overall displacement estimate, which was -0.14 in the college student sample, is 0.005 (and insignificantly different from zero, in column 6) for the Internet users. Other estimates vary between 0.05 and -0.07, and while some are statistically discernible from zero, none are far from zero. These estimates stand in fairly sharp contrast with the US estimates in RW. The longitudinal approach yields an estimate of 1:1 displacement, compared with the estimates here that lie between zero and -0.14.

6 Concluding Discussion

While an analogous study including a comparable US population finds a large sales displacement rate, we find rather different results for Chinese consumers. First, the Chinese respondents view fewer movies (30 vs 50 from a comparable list). Second, unpaid consumption makes up a far larger share of consumption for the Chinese respondents (roughly three quarters rather than about 5 percent). Third, econometric estimates of sales displacement are far smaller for the Chinese samples. While the US estimates based on the longitudinal approach employed above indicate roughly 1:1 displacement, the estimates on the Chinese data in this study are between 0 and -0.14.

These results, on their face, suggest small damages from movie piracy in China despite large volumes of unpaid consumption. Before drawing this conclusion, however, it is important to understand the reason for the reason for the stark difference between results for the US and China. We can offer some speculation along these lines.

One possible explanation for the low Chinese displacement rate – suggested by lower overall movie consumption in China – is that Chinese students' time budgets are not as strained as the U.S. students'. A relaxed time budget could accommodate additional unpaid consumption without reducing paid consumption. Related, those spending additional time with unpaid movies may be scaling back the time they spend with other non-moviegoing activities, such as television or reading.

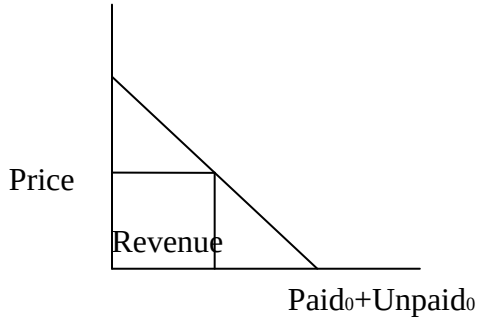
A second possible explanation is that unpaid consumption of movies released between 2006 and 2008 does not come at the expense of a pre-existing tendency for

consumers to pay for movies in China. That is, US audiences have generally paid for their movies, and recent opportunities for unpaid consumption represent a change. The response to this change in the US sample has been a replacement of paid by unpaid consumption. It is possible that in China, by contrast, unpaid consumption has a longer history, and the period under study may not contain a change in unpaid consumption opportunities. Rather than substituting unpaid for paid consumption, Chinese respondents may simply be substituting one form of digital unpaid consumption for physical unpaid consumption, which would show up as zero sales displacement.

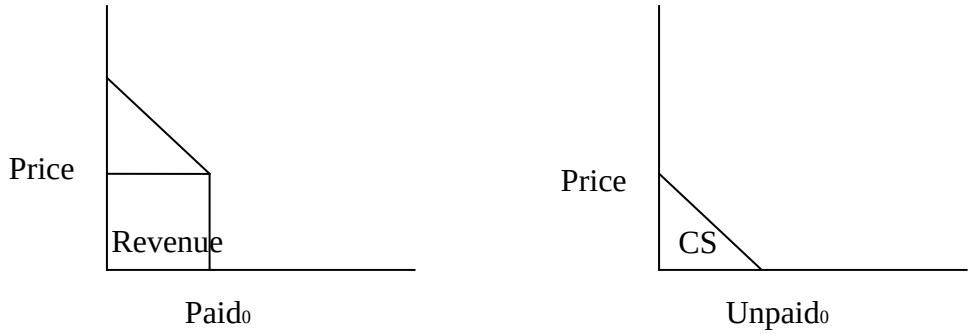
Additional studies of sales displacement from piracy will be useful for determining whether the differing displacement patterns for the US and China withstand additional scrutiny. If so, then determining which of these explanations, if any, explains the conflicting results is an important topic for future research.

Figure 1: A Simple Demand Model

1.1: No unpaid consumption



1.2: Paid and unpaid consumptions: low valuation



1.3: Paid and unpaid consumptions: high valuation

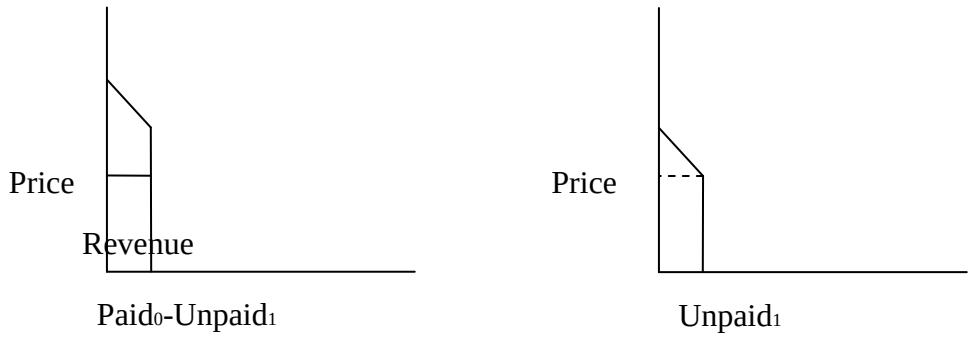


Table 1: Summary of Respondents' Characteristics

Background Characteristics	Student Sample (obs=372)	Online Sample (obs=3852)
Gender		
Female	51.6%	37.0%
Male	48.4%	63.0%
Age	(17--30)	(11--68)
Mean	20.23	29.56
25 percentile	19.75	25
Median	20	28
75 percentile	21	33
College Year		
Freshman	0.54%	-
Sophomore	43.1%	-
College junior	46.1%	-
College Senior	9.8%	-
Annual Family Income/ Monthly Income*		
Below $2930/below $220	18.8%	14.8%
$2930-7320/$220-440	31.8%	35.3%
$7320-14640/$440-730	29.2%	28.2%
$14640-29280/$730-1020	15.6%	10.4%
Above $29280/above $1020	4.6%	11.2%
Computer		
Have no computer or regular access	0%	0.18%
Own computer or have regular access	100%	99.82%
Internet Access in 2008		
No internet access	0.27%	0.88%
Dial-up	0.82%	12.5%
Broadband	98.9%	86.6%
Internet Access in 2007		
No internet access	0.28%	2.88%
Dial-up	3.64%	14.7%
Broadband	96.1%	82.5%
Internet Access in 2006		
No internet access	12.0%	7.53%
Dial-up	7.45%	16.7%
Broadband	80.5%	75.8%
DVD/VCD Burner		
Yes	63.6%	81.7%
No	36.4%	18.3%
Interest in Movies**		
A lot less	1.62%	0.23%
A bit less	5.39%	0.47%
Average	43.7%	21.6%
A bit more	35.6%	51.6%
A lot more	13.8%	26.2%

Notes: Table continued in following page.

(*continued from previous page*)

Frequency to Movie Theaters		
Never	55.3%	16.1%
Once a month or less	38.5%	37.1%
Two or three times a month	6.2%	34.5%
More than three times a month	0%	12.4%

Notes: * Student sample is asked about annual family income, and online sample monthly income; Chinese currency is converted to US dollars.

** the questions is phrased as 'Compared to other people you know, how big a movie fan are you?'.

Table 2: Respondent Movie Viewings, by Mode (Student sample)

	All viewings	First	Second	Third
Paid	**8.0**	**7.7**	**0.2**	**0.0**
Theater	6.7	6.5	0.1	0.0
Legally purchase	0.1	0.1	0.0	0.0
TV	0.8	0.8	0.1	0.0
Rental	0.4	0.3	0.0	0.0
Unpaid	**23.1**	**22.2**	**0.8**	**0.1**
Download	17.8	17.3	0.5	0.0
Online/burned DVD	3.9	3.7	0.3	0.0
Borrow	0.5	0.5	0.0	0.0
Illegally purchase	0.8	0.7	0.1	0.0
Total	**31.1**	**29.9**	**1.0**	**0.1**

Table 3: Respondent Movie Viewings, by Movie Type
Student Sample

	Total	Foreign Authorized Movies	Domestic Authorized Movies	Unauthorized Movies
Paid	**8.0**	**3.37**	**4.41**	**0.21**
Theater	6.7	2.98	3.61	0.10
Legally purchase	0.1	0.07	0.05	0.01
TV	0.8	0.19	0.59	0.04
Rental	0.4	0.13	0.17	0.05
Unpaid	**23.1**	**9.32**	**10.73**	**3.02**
Download	17.8	7.19	8.34	2.30
Online/burned DVD	3.9	1.56	1.87	0.52
Borrow	0.5	0.21	0.21	0.07
Illegally purchase	0.8	0.37	0.31	0.13
Total	**31.1**	**12.69**	**15.15**	**3.23**

Table 4: Respondent Movie Viewings, by Movie Type
Online Sample

	Total	Foreign Authorized Movies	Domestic Authorized Movies	Unauthorized Movies
Paid	**11.52**	**3.98**	**6.42**	**1.11**
Theater	5.99	2.31	3.15	0.54
Legally purchase	1.67	0.63	0.82	0.22
TV	2.80	0.64	1.95	0.20
Rental	1.06	0.40	0.50	0.16
Unpaid	**21.88**	**7.88**	**10.99**	**3.01**
Download	10.33	3.70	5.20	1.43
Online/burned DVD	9.78	3.54	4.91	1.33
Borrow	0.82	0.28	0.43	0.11
Illegally purchase	0.94	0.36	0.45	0.13
Total	**33.40**	**11.86**	**17.42**	**4.13**

Table 5: Paid and Unpaid Movie Consumption

	Student Sample		Online Sample	
	Paid	Unpaid	Paid	Unpaid
	(1)	(2)	(3)	(4)
Movie Interest Category 2	2.368	7.369	-1.291	1.891
	(3.967)	(7.221)	(5.641)	(8.111)
Interest Category 3	3.834	19.23	2.935	9.690
	(3.555)	(6.472)**	(4.632)	(6.660)
Interest Category 4	7.204	26.20	7.757	18.423
	(3.582)*	(6.520)**	(4.620)	(6.644)**
Interest Category 5	9.558	34.06	11.584	22.247
	(3.704)*	(6.742)**	(4.634)*	(6.664)**
Female	2.359	-11.22	1.174	-5.898
	(0.993)*	(1.807)**	(0.464)*	(0.667)**
Have DVD burner	0.745	-0.182	1.958	2.254
	(1.009)	(1.836)	(0.593)**	(0.853)**
Income Category 2	-0.251	0.790	1.753	-2.569
	(1.3560)	(2.468)	(0.692)*	(0.995)**
Income Category 3	1.848	-1.577	4.113	-5.981
	(1.405)	(2.557)	(0.721)**	(1.037)**
Income Category 4	2.639	-4.261	5.973	-8.722
	(1.638)	(2.982)	(0.914)**	(1.314)**
Income Category 5	5.990	4.683	4.425	-14.290
	(2.477)*	(4.509)	(0.898)**	(1.292)**
College Sophomore	4.462	-1.788	-	-
	(6.101)	(11.10)		
College Junior	5.195	1.520	-	-
	(6.087)	(11.079)		
College Senior	4.569	-3.407	-	-
	(6.227)	(11.33)		
Beyond College	6.392	-10.42	-	-
	(8.583)	(15.62)		
Constant	-5.071	7.459	-1.070	9.908
	(6.963)	(12.67)	(4.626)	(6.653)
Observations	335	335	3852	3852
R-squared	0.15	0.27	0.08	0.10

Note: Standard errors in parentheses. * significant at 5%; ** significant at 1%

Table 6: Cross Sectional Regressions with Different Observables

	Paid Consumption									
	Student Sample					Online Sample				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Unpaid Consumptions	-0.015	-0.060	-0.066	-0.052	-0.051	0.003	0.006	0.006	0.009	0.009
	(0.024)	(0.021)**	(0.022)**	(0.025)*	(0.025)*	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)
Movie Interest Category 2		2.287	2.465	2.430	3.904		-1.045	-0.978	-0.970	-2.944
		(3.261)	(3.189)	(3.238)	(3.912)		(4.751)	(4.743)	(4.741)	(5.819)
Interest Category 3		2.494	2.881	2.559	2.744		1.526	1.447	1.389	0.605
		(2.947)	(2.895)	(2.951)	(3.627)		(3.907)	(3.900)	(3.899)	(4.783)
Interest Category 4		4.827	5.181	4.642	5.321		3.803	3.684	3.635	2.627
		(2.993)	(2.944)	(3.013)	(3.743)		(3.906)	(3.898)	(3.897)	(4.776)
Interest Category 5		7.318	7.855	7.404	8.945		5.153	5.052	5.042	0.000
		(3.147)*	(3.099)*	(3.164)*	(3.951)*		(3.922)	(3.915)	(3.914)	(0.000)
Once per month		6.366	6.505	6.383	6.420		3.247	3.121	3.054	3.084
		(0.794)**	(0.817)**	(0.849)**	(0.852)**		(0.565)**	(0.568)**	(0.569)**	(0.570)**
2-3 times per month		16.019	16.418	16.349	16.265		9.460	9.193	9.127	9.161
		(1.566)**	(1.612)**	(1.637)**	(1.645)**		(0.593)**	(0.608)**	(0.608)**	(0.610)**
Above 3 times per month	-	-	-	-	-		12.957	12.943	12.860	12.912
							(0.757)**	(0.791)**	(0.792)**	(0.794)**
Income Category 2			0.294	0.247	0.123			0.283	0.353	0.358
			(1.075)	(1.102)	(1.109)			(0.584)	(0.585)	(0.586)
Income Category 3			1.291	1.277	1.215			1.585	1.678	1.670
			(1.106)	(1.141)	(1.151)			(0.613)**	(0.615)**	(0.616)**
Income Category 4			0.899	0.723	0.796			1.971	2.090	2.085
			(1.300)	(1.332)	(1.340)			(0.781)*	(0.783)**	(0.784)**
Income Category 5			4.459	4.687	4.372			-0.540	-0.456	-0.479
			(1.939)*	(2.037)*	(2.056)*			(0.791)	(0.792)	(0.793)
College Sophomore				2.371	2.621	-	-	-	-	-
				(4.963)	(4.999)					
College Junior				2.690	2.954	-	-	-	-	-
				(4.959)	(4.998)					
College Senior				1.824	2.025	-	-	-	-	-
				(5.079)	(5.122)					
Beyond College				5.640	5.880	-	-	-	-	-
				(7.015)	(7.042)					
Female				0.807	2.721				0.710	-1.885
				(0.851)	(6.028)				(0.394)	(8.222)

Constant	8.120	1.806	0.912	-1.813	-2.640	10.353	0.573	0.122	-0.165	0.693
	(0.719)**	(2.856)	(2.910)	(5.701)	(6.080)	(0.295)**	(3.879)	(3.888)	(3.890)	(4.761)
With Interaction Terms	No	No	No	No	Yes	No	No	No	No	Yes
Observations	372	370	344	338	338	3852	3852	3852	3852	3852
R-squared	0.00	0.35	0.39	0.40	0.40	0.00	0.15	0.16	0.16	0.16

Note: Standard errors in parentheses. * significant at 5%; ** significant at 1%. In column (5) and (10), we include interest and gender interaction terms. Including other interaction terms with interest gives very similar results, which are not shown in this table.

Table 7: Longitudinal Displacement Estimates

	Student Sample					Online Sample				
	Paid Consumption	Paid Consumption (Foreign Films)		Paid Consumption (Domestic Films)		Paid Consumption	Paid Consumption (Foreign Films)		Paid Consumption (Domestic Films)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Unpaid Consumption	-0.135 (0.024)**					0.005 (0.008)				
Unpaid Consumption (Foreign Authorized Films)		-0.135 (0.025)**	-0.124 (0.026)**		0.068 (0.027)*		0.018 (0.009)*	0.011 (0.009)		0.049 (0.011)**
Unpaid Consumption (Domestic Authorized Films)			-0.043 (0.025)	-0.179 (0.026)**	-0.197 (0.026)**			0.004 (0.008)	-0.057 (0.010)**	-0.069 (0.010)**
Unpaid Consumption (Unauthorized Films)			-0.066 (0.049)		0.056 (0.052)			0.057 (0.015)**		0.018 (0.019)
2007 Vintage	0.085 (0.584)	0.437 (0.356)	0.365 (0.357)	-0.301 (0.376)	-0.306 (0.376)	-0.245 (0.131)	0.206 (0.073)**	0.219 (0.073)**	-0.454 (0.092)**	-0.460 (0.092)**
2008 Vintage	-0.235 (1.133)	0.040 (0.690)	-0.113 (0.692)	-0.311 (0.731)	-0.322 (0.728)	0.883 (0.245)**	0.303 (0.136)*	0.305 (0.136)*	0.639 (0.171)**	0.628 (0.171)**
Observations	1071	1071	1071	1071	1071	11556	11556	11556	11556	11556
R-squared	0.005	0.008	0.008	0.025	0.041	0.11	0.05	0.05	0.13	0.14

Note: All regressions include individual fixed effects and age dummies; column (1)-(5) include grade dummy as well. Standard errors in parentheses. * significant at 5%; ** significant at 1%.

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