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Industry Relatedness, Agglomeration Externalities and Firm Survival in China

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Abstract

The importance of agglomeration externalities for economic activities is widely recognized. Recent developments highlight the importance of industry relatedness to the performance of firms, industries and regions. This study explores the determinants of firm survival in China and tests the significance of industry relatedness using firm-level data over the period 1999-2007. Industry relatedness is developed from the co-occurrence analysis of paired industries. Results based on Cox regression models show that firms benefiting from industry relatedness and governmental supports are more likely to survive. However, the influence of relatedness varies across industries and provinces. This study highlights the significant influence of local forces on firm dynamics and enriches our understanding of regional industrial restructuring in China.

Key Words: Industry relatedness, Agglomeration Externalities, Firm Survival, China

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Introduction

An economy maintains its vitality through a continual process of firm entry, survival and exit. Firm survival is considered the ultimate criterion of business success. Strategic management theory in industrial organization links survival to firm age, size, ownership, innovation activities, to industrial and market structure (AUDRETSCH and MAHMOOD, 1995; GORG and STROBL, 2003; FONTANA and NESTA, 2009). Researchers within economic geography and industrial ecology have shifted their focus to external factors that impact firm performance, especially agglomeration economies (ACS *et al*., 2007; NEFFKE *et al*., 2012; DE SILVA and MCCOMB, 2012).

The links between agglomeration externalities and the performance of firms, industries and regions have been studied extensively. Both the clustering of firms within specialized sectors (MAR externalities) and clustering of firms across diverse activities (Jacobs externalities) are linked to growth, productivity gains, innovation and firm survival (GLAESER, 1992; HENDERSON, 1997).Empirical evidence of the relative significance of specialization and diversity to firm performance remains mixed (BEAUDRY and SCHIFFAUEROVA, 2009). More recent work has explored changes in the influence of agglomeration over industry life-cycles (POTTER and WATTS, 2014) and with respect to the characteristics of individual firms (RIGBY and BROWN, 2015). Dissatisfaction with simple measures of specialization and diversity such as the Herfindahl Index have also given rise to an emerging body of research focused on relatedness, on more precise measures of the similarities and differences between technologies, products, firms, industries and institutions, and on which kinds of relatedness matter most for competitive advantage and economic growth (FRENKEN *et al*., 2007; BOSCHMA *et al*., 2013).

The purpose of this study is to investigate the impact of industry relatedness on firm survival in China. With extensive institutional changes, transitional economies pose serious challenges to firm survival (MOCNIK, 2010). Many of these challenges are present in China where liberalization of markets and privatization of selected state-owned assets have caused significant price fluctuations and market adjustment. Decentralization within China has also triggered intensive inter-jurisdictional competition that is compounded by the pressures of global integration (HE *et al*., 2008). Within this environment of uncertainty, firms seek some respite in the economies that agglomeration provides (HE and PAN, 2010; ZHANG *et al*., 2014). Meanwhile, to sustain local revenues and economic growth, local governments provide subsidies to help firms to survive. However, we still know very little about the forms of agglomeration working across China and, in particular, how external economies induced by firm co-location operate across firms and regions bound by different levels of industry relatedness.

Using firm-level data for Chinese manufacturing industries over the period 1999-2007, we investigate the survival of newly created firms. Following HIDALGO *et al*. (2007), we develop a measure of industry relatedness based on co-occurrence of

all pairs of 4-digit industries across Chinese cities. We explore how industry relatedness, and government subsidies sustain Chinese manufacturing businesses. These different sets of factors vary in their influence on firm survival across industries and provinces. This study contributes to the literature in several ways. First, it identifies the factors influencing firm survival within China, a transitional economy. Second, it introduces a new measure of agglomeration economies for China, based on the concept of relatedness. Third, the paper reveals how different forms of agglomeration operate across different industries and regions, thus contributing to the emerging work on the heterogeneous impacts of firm co-location.

The rest of the paper is structured in the following manner. Section 2 provides an extended discussion of some of the key literature on agglomeration and relatedness. In Section 3, attention turns to the firm micro-data and a basic overview of the industrial and geographical variation in firm survival. Section 4 examines the role of firm characteristics, agglomeration variables and government supports on survival using a variant of the Cox hazard model. Section 5 concludes, summarizing our results and highlighting important remaining research questions.

Industry Relatedness, Agglomeration Externalities and Firm Survival

Agglomeration externalities are broadly understood as the benefits that arise from the geographical co-location of economic agents. It has become common in the literature to separate the different kinds of external economies into those that are restricted within particular sectors of the economy, localization externalities, and those that flow across sectors of the economy, urbanization externalities. In their dynamic form as motors of both city formation and growth these are often referred to Marshall-Arrow-Romer (MAR) externalities and Jacobs externalities, respectively.

Separation of the benefits of external economies into those flowing within and between industrial sectors is likely related to long-standing beliefs of orthodox economics and business that heterogeneity in firm performance was largely explained by industrial sector. For MARSHALL (1920), economies from specialization in industry towns derived from local input-output networks, from dense local labor pools and from knowledge spillovers. JACOBS (1969) was more generally concerned with the dynamics of cities. For her, cities were the font of all developments, emerging as centers of commerce and trade, built upon and around the diversity of ideas they collected. Jacobs imagines cities in a constant state of flux, distilling diverse cultures and experiences and perpetually seeding new possibilities rather than ossifying into the monolithic industrial towns of Marshall's day. These broad ideas underpin more theoretically sophisticated models of urbanization (STORPER and SCOTT, 2015), urban growth (GLAESER *et al*., 1992) and firm dynamics (DURANTON and PUGA, 2004).

Recent extensions to this theoretical literature have raised questions about the effects of agglomeration across industry life cycles (NEFFKE, 2009; POTTER and WATTS, 2014), and on whether geographical and industrial proximity are the only forms of proximity that impact firm performance. Since the important contribution of BOSCHMA (2005), there has been an increasing awareness that cognitive proximity is

more important than geographical proximity for information spillover. Research on relatedness questions the general relevance of the industrial and geographical divides employed in most studies of agglomeration, while also suggesting that social, cognitive and institutional forms of relatedness might be more relevant to processes of economic competition and uneven development (FRENKEN *et al*., 2007). Industry relatedness occurs when firms in a region operate within technologically related industries that have overlapping knowledge bases (BOSCHMA and FRENKEN, 2011). Relatedness emphasizes that not all types of diversities affect firm performance but that relations found within a range of industries could have such effects. Relatedness is an important driver of the birth and evolution of new technologies, new products, and even new industries and clusters (BOSCHMA and FRENKEN, 2006). Some of this work has recently been extended to focus on firm performance and particularly, survival (DE VAAN *et al*., 2013).

A few studies have explored the link between agglomeration externalities and firm survival. FRITSCH *et al*. (2006) show that new firms in Germany are less likely to exit if there are other new businesses in the same region and industry. Some find that industrial clusters help firm survival (DELGADO *et al*., 2010; WENNBERG and LINDQVIST, 2010) while others conclude that industrial clustering is associated with higher mortality of firms (ACS *et al*., 2007; DESILVA and MCCOMB, 2012). ACS *et al*. (2007) report negative impacts of both localization and urbanization economies on the survival of new service firms in US. STABER (2001) finds that locating in specialized clusters of firms increases business failure rates and locating in diversified clusters of firms operating in complementary industries reduces failure rates.

The impact of technological relatedness on firm survival still needs to be explored. There are only two studies having assessed the impact of technological relatedness and related variety on firm survival. Examining the evolution of the car industry in Britain during 1895 and 1968, BOSCHMA and WENTING (2007) find that the presence of previous related industries has a positive impact on the survival of automobile firms, but localization economies have a negative impact on survival of new entrants. Recently, NEFFKE *et al*. (2012) confirm that technological relatedness substantially increases survival rates of plants. Technological relatedness seems the key source of agglomeration externalities in firm survival.

Industry Relatedness and Firm Dynamics in China

Firm dynamics in China has been extremely underexplored. Much less is known about the processes underlying firm dynamics, let alone the influence of agglomeration externalities on such processes. MAO and SHENG (2013) and HE and YANG (2015) are two exceptions. Published in Chinese, MAO and SHENG (2013) find that both entry and exit rates of Chinese firms are fairly high. HE and YANG (2015) investigate the determinants of firm failureduring1998-2007in China and report that less productive and older firms are more likely to fail while firms with governmental supports have more chance to survive. Both studies have not touched the impact of agglomeration externalities on firm dynamics.

However, the role of agglomeration externalities for firm survival is highly anticipated in China. Since the economic reform, China has largely liberalized its economy. Chinese industries have been found to increasingly agglomerate in large cities and the coastal region (HE *et al*., 2008; LU, 2010). Access to market potential and industrial linkages underpin the formation of industrial clusters in China. Rich evidence shows that agglomeration externalities contribute to industrial productivity (LIN *et al*., 2011), urban productivity (FAN and ZHANG, 2002), urban industry growth (HE and PAN, 2010), and firm innovation (ZHANG *et al*., 2014).Nothing has been said about how agglomeration externalities influence firm survival in China.

Facing institutional uncertainties and intensive market competition, firms in China operate in a very tough business environment. Benefits from agglomeration externalities may help firms to excel and mitigate the negative influence of institutional uncertainties. Firms enjoying agglomeration externalities would have more chance to survive. However, industry relatedness is a key to putting agglomeration externalities into play in China. First, industry relatedness derived from the deep division of labor have been the underlying force of industrial clusters in China (YANG and LIAO, 2010). Second, fiscal decentralization has created conditions that encourage regionalism and inter-region competition, triggering local protectionism (ZHAO and ZHANG, 1999).This strategy has duplicated many industries in different localities, discouraging industrial linkages and relatedness (HE *et al*., 2008). Third, decentralization has not only triggered interregional competition for businesses, but also provide strong incentives for local governments to imitate successful industrial policies (THUN, 2004). The development strategy would weaken industry relatedness, downplaying agglomeration externalities. Technological relatedness based externalities are expected to play a larger role in sustaining Chinese firms.

Data Source

This study is based upon data from the Annual Survey of Industrial Firms (ASIFs), maintained by State Statistical Bureau in China. Analysis covers the period 1999 to 2007. The dataset includes all state-owned industrial enterprises and non-state-owned enterprises with sales revenues greater than 5 million Yuan. The dataset allows firms to be linked over time and provides useful information on start year, location, employment, exports and intermediate inputs. There is some inconsistency in reporting information about enterprises over the period studied. Following BRANDT *et al*. (2012), we use the legal person code (owner) as the basis to match industrial enterprises though years.

Enterprises with the same legal person code but different names are treated as different enterprises. We construct the data in the form of a panel by the following steps. Enterprises are matched for two consecutive years using legal person codes. The remaining enterprises are matched using firm names. If necessary, we combine the legal person code and county code or the combination of county code, telephone number and starting year to match business units. There are some enterprises with

missing information for one or more years. For example, enterprise A in the first year has no match with any enterprise in the second year, but a good match with enterprise C in the third year. In turn, enterprise C can be matched with enterprise B in the second year. Consequently, the business units A, B and C spanning three consecutive years can be treated as the same enterprise.

The objective of this study is to explore the pattern and determinants of firm survival. We focus on the survival of newly created firms for different years. Using the start year of the firm, we compile a list of new firm entrants in each year. Assuming $firm_{it}$ is a new start-up, present in the survey in year t, for all future years $t+c$ (c=1, 3, 5, 7) for which we identify $firm_{it}$ in the survey, then the firm is regarded as a survivor. $Firm_{it}$ is considered to exit the economy if it cannot be identified in a future survey year. The firm survival rate is vintage specific and is the ratio of the number of surviving firms in year $t+c$ to the total number of newly created firms in the starting year$t$. We introduce a note of caution in that there are different forms of exit in our data. We capture firm failure in the sense of a business closing down, but firm failure might also result from a merger or acquisition and from a firm experiencing a decline in sales below the 5 million Yuan threshold.

Industrial and Spatial Pattern of Firm Survival in China

To examine the industrial and spatial variations in firm survival, we estimate a survival function S(t) using the KAPLAN and MEIER (1958) estimator. This is a frequently used non-parametric estimator that accounts for right censoring or truncation in time-series data, in our case, when the date of firm exit occurs after the last year of our study period. The Kaplan–Meier estimator is a good choice for exploratory analysis because of its non-parametric form. The estimator is given by

$$\widehat{S(t)} = \prod_{t_i \leq T} (1 - \frac{d_i}{n_i})$$

where S(t) is the survivor function,n_i denotes the number of firms in the risk set at time t_i while $d_i$denotes the number of exits at t_i. In order to examine the differences in firm survival rates across industries and cities, we aggregate the data to the two-digit industry level and explore the survival function by industry across cities.

There are substantial industrial variations in firm survival rate. Table 1 presents survival rates for different periods by two-digit manufacturing industries. For all industries, firm survival rates decrease as firms live longer. Survival rate for one year period is typically higher than that for seven year period. One year survival rate ranges from 86.60% for firms in the metal products sector to 92.13% for firms that manufacture chemical fibers. Relatively speaking, firms in labor and resource intensive industries are more likely to fail in the first year after establishment, while those in capital and technology intensive industries tend to have a survival rate of greater than 90%. Industrial variation in firm survival rate increases with age since birth. Thus, seven-year survival rate displays considerably more industrial variations than survival rates for a shorter term. The seven-year survival rate ranges from 51.35% in the chemical materials industry to 75.06% in the chemical fibers industry. Existing

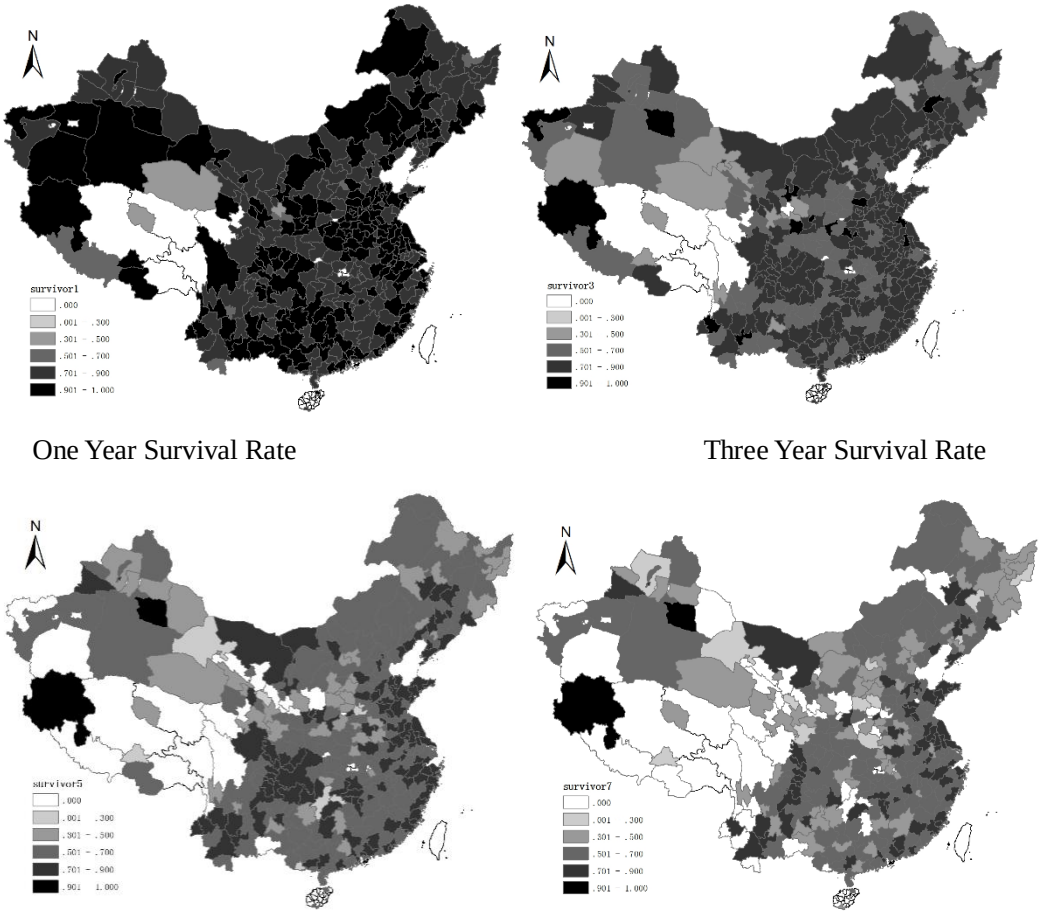
research explains industrial variations in survival rate with a number of industrial characteristics such as market size, growth rate, technology, market structure, scale economies and life cycle stage (AUDRETSCH and MAHMOOD, 1995; LOPEZ–GARCIA and PUENTE, 2007).

Table 1 Kaplan-Meier Survival Rates (%) for Manufacturing Industries (Two-Digit)

Industries	1-year	3-year	5-year	7-year
Processing of Food from Agricultural Products	91.17	80.55	71.31	65.83
Manufacture of Foods	87.15	75.80	66.12	60.74
Manufacture of Beverages	89.67	74.87	65.35	63.00
Manufacture of Textile	90.48	85.71	85.71	85.71
Manufacture of Textile, Apparel, Footwear and Caps	90.49	80.89	74.42	66.76
Manufacture of Leather, Fur, Feather and Related Products	88.46	74.17	67.35	60.67
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm and Straw Products	87.35	73.71	64.36	59.47
Manufacture of Furniture	90.63	78.86	69.87	61.56
Manufacture of Paper and Paper Products	90.76	78.73	71.51	65.81
Printing, Reproduction of Recording Media	89.03	76.47	67.33	60.81
Manufacture of Articles for Culture, Education and Sports	90.68	78.61	73.10	64.60
Processing of Petroleum and Nuclear Fuel	90.11	80.28	72.05	72.05
Manufacture of Chemical Materials and Chemical Products	89.72	68.94	60.85	51.35
Manufacture of Medicines	90.33	79.17	71.96	66.62
Manufacture of Chemical Fibers	92.42	82.95	78.25	75.06
Manufacture of Rubber	87.95	76.42	70.98	65.30
Manufacture of Plastics	90.74	81.64	77.44	66.78
Manufacture of Non-metallic Mineral Products	90.23	80.59	73.14	67.25
Smelting and Pressing of Ferrous Metals	90.10	79.54	72.43	65.71
Smelting and Pressing of Non-ferrous Metals	87.13	69.53	60.51	53.24
Manufacture of Metal Products	86.60	74.20	64.03	57.43
Manufacture of General Purpose Machinery	88.27	77.72	71.00	65.40
Manufacture of Special Purpose Machinery	91.93	82.84	77.63	73.55
Manufacture of Transport Equipment	90.38	80.03	73.28	68.15
Manufacture of Electrical Machinery and Equipment	90.96	80.65	74.17	70.35
Manufacture of Communication Equipment, Computers and Other Electronic Equipment	91.21	80.01	74.29	68.96
Manufacture of Measuring Instruments and Machinery for Cultural Activities and Office Works	89.72	77.18	68.99	61.78
Manufacture of Artworks and Other Manufacturing	88.55	75.06	67.41	63.20

Figure 1 maps spatial variations in firm survival rates over one year, three years, five years and seven years at the prefecture level. The divide between coastal and inland regions in firm survival is evident, with higher firm survival rates in the coast. Exploration of the data at a finer level of spatial aggregation suggests that entry rates also vary across prefectures within the same province. This suggests that local factors

such as market dynamics, policies and agglomeration externalities may play an important role in determining firm survival.



One Year Survival Rate

Three Year Survival Rate

Five Year Survival Rate

Seven Year Survival Rate

Figure 1 Kaplan-Meier Survival Estimates of Firms across Chinese Cities

Model Specification and Variables

Cox Proportional Hazard Model

To examine the effect of industry relatedness on firm survival, we estimate the semi-parametric Cox proportional hazard model which defines hazard rates as the probability that a firm exits the market at a certain time t conditional on its survival to that time and on a set of covariates X_{it}. Survival methods are appropriate to handle right-censoring in time-series data where the event of interest might not occur within the study period. In fixed-effect models of such events, observations for which the values of the dependent variable do not change are ignored. Such observations carry important information that researchers seek to exploit.

The basic cox PH model is defined as

$$h_i(t) = h_0(t)\exp(\boldsymbol{X_i\beta})$$

Where $h_0(t)$ is the baseline hazard function, $\boldsymbol{X}$ is a vector of independent variables, and $\boldsymbol{\beta}$ is a corresponding vector of coefficients. The subscript *i* denotes individual firm. This model is semi-parametric because the baseline hazard function $h_0(t)$can

be unspecified, the covariates enter the model linearly after taking the log form,

$$\log h_i(t) = \alpha(t) + \beta_1 \mathrm{x}_{i1} + \beta_2 \mathrm{x}_{i2} + \cdots + \beta_k \mathrm{x}_{ik}$$

Where $\alpha(t)$=log$h_0(t)$. The Cox model is estimated by the maximization of the partial likelihood function, developed by Cox (1972).

Explanatory Variables

A key variable is industry relatedness, a measure of technological proximity between a pair of industries. Industry relatedness provides a more accurate measure of specialization and diversity than the more widely used Herfindahl measures. Industry relatedness can be measured in different ways. Using a hierarchical structure of the standard industrial classification (NEFFKE *et al*., 2011) is probably the least appealing way because it does not overcome some of the basic problems with the Herfindahl index. To measure industry relatedness across Chinese industries we follow the co-occurrence analysis pioneered by HIDALGO *et al*. (2007). We exploit manufacturing employment data by 4-digit industries that are available at the city level. Thus, we build measures of relatedness between all pairs of 4-digit manufacturing industries based on the conditional probabilities that cities specialized in one industry are likely to specialize in another.

We follow the usual procedure of eliminating some noises in the data by examining only those industries that display revealed comparative advantage (RCA) within a set of cities, where RCA for an industry in a city is indicated by a location quotient greater than 0.5. Typically, RCA should take the value of 1 to indicate industrial specialization. This study uses 0.5 to imply the revealed comparative advantage. Chinese industries are less agglomerated than those in Europe and USA due to local protectionism and industrial duplication. Across the set of 287 prefecture-level cities, the relatedness between industries *i* and *j* is measured as the minimum conditional probabilities that cities specialized in employment in industry *j* are also specialized in industry *i* and vice versa:

$$\text{Relatedness}_{ij} = \min\left[P\left(\text{RCA}_i \middle| \text{RCA}_j\right) + P\left(\text{RCA}_j \middle| \text{RCA}_i\right)\right]$$

Based on this measure, we can visualize inter-industry relatedness in China as in Figures 2. In the figure, higher values of relatedness are indicated by the clustering of individual nodes that represent different 4-digit manufacturing industries. Only relatedness values >0.35 are mapped.

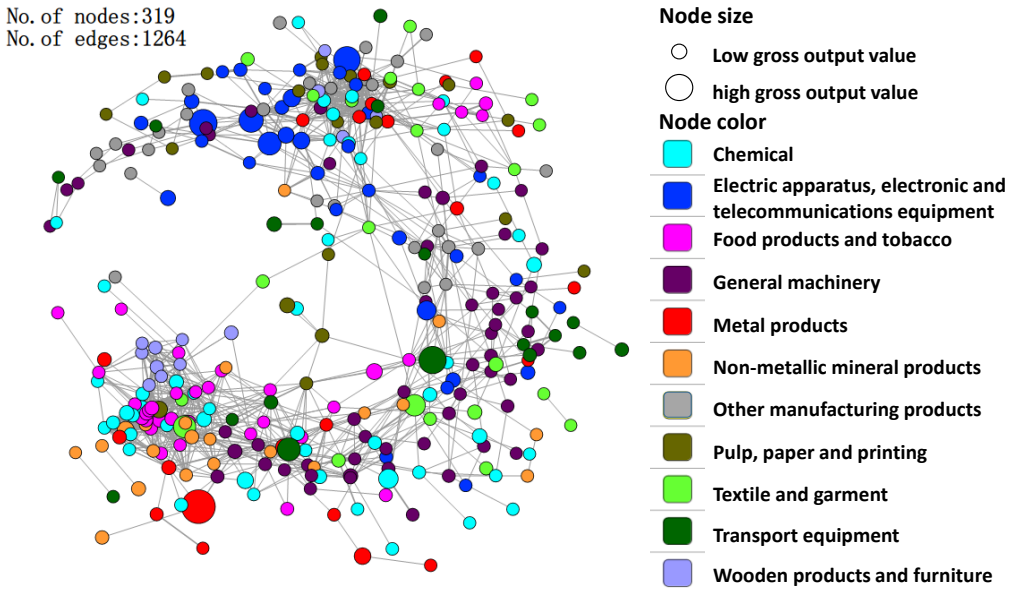


Figure 2 Industry Relatedness of Chinese Manufacturing Industries (2007)

The co-occurrence based measures of industry relatedness tell us which industries are more or less related to one another, but they don't indicate along which dimension any pair of industries are related, whether on the basis of technological similarity, similarity in demand for labor with specific skills, similarity in terms of the depth of input-output linkages or perhaps adjacency along a value chain. We examine the impact of industry relatedness on firm survival at the city level. The relatedness of four-digit industry *i* in city *r* is given as

$$IR_{ri} = \sum_{j} \text{Relatedness}_{ij} * E_{rj} / \sum_{j} E_{rj}$$

Where *r* represents the city, *i* denotes a four-digit industry to which a firm of interest belongs, *j* is another four-digit industry and *E* represents employment. A firm is hypothesized to have a greater chance of survival if it belongs to an industry which is strongly related to other sectors.

We further introduce two traditional measures of localization and urbanization economies. Localization economies are measured as the location quotient of total employment of the four-digit industry which a firm belongs to the city (LOC). Urban population density (URB) is applied to quantify urbanization economies.

Governmental supports are critical for firm survival in China. Local governments have strong incentives to support and protect state-owned enterprises (SOEs) under their administration. This protection however lessens the competitiveness of SOEs in the long run. Local governments often launch some programs to support entrepreneurship. It is a common practice for local governments to provide subsidies to firms, such as loans to encouraged industries from government owned banks, rebates of value added tax and cash payments to firms based on factors such as export performance (BARBIERI *et al.*, 2012). The supportive policies reduce costs and would help firms to survive at least in the short run. To test the impacts of

governmental supports on firm survival, we introduce three dummies for SOEs, firms with subsidies (SUBSIDY) and banking loans (LOAN).

Industrial organization studies typically consider firm size and age as key variables for firm survival. Larger and old firms are often found more likely to survive (ERICSON and PAKES, 1995; AUDRETSCH and MAHMOOD, 1995). Scale economies underline the role of firm size. Meanwhile, scope economies would improve a firm's capability to cope with market uncertainty. We apply the employment to measure firm size (SIZE). We introduce the product variety of a firm (PV) to measure scope economies at the firm level. PV is a dummy variable, 1 for firms producing two or more final products, 0 for those producing one type of final product. Firms producing more products have a better chance to survive due to scope economies.

Existing studies have reported controversial findings regarding the role of foreign ownership and exporting in firm survival (GÖRG and STROBL, 2003; BERNARD and SJOHOLM, 2003; GIOVANNETTI *et al.*, 2011). Foreign investors face disadvantages of alien status because they lack local knowledge of social, political and economic conditions (HE, 2002). However, foreign firms in China enjoy advantages to have more chance to survive. Foreign firms are more productive and competitive in the market and enjoy favorable policy supports such as tax holiday and waiver of importing tariffs (NG and YUAN, 2002). Exporters can learn from exporting (MARTINS and YANG, 2009) and benefit from comparative advantages and industrial clusters (YUE and HUA, 2002). We introduce two dummies at the firm level, including dummy variables for exporters (EXP) and foreign firms (FDI). All variables are summarized in Table 2.

Table 2 Definitions of Independent Variables

Variable	Definition
IR	Industry relatedness at the four digit level in the city a firm is located in
LQ	Location quotient of employment of four-digit industry a firm belongs to in the city
LnURB	Natural log of population density in the city a firm is located
SOE	Dummy variable for SOEs
SUBSIDY	Dummy variable for firms with subsidies
LOAN	Dummy variable for firms with banking loan
PV	Dummy variable, 1 for firms with more than one type of product, otherwise, 0.
LnSIZE	Natural log of firm employments
FDI	Dummy variable for foreign-owned firms
EXP	Dummy variable for exporters

Empirical Results

The correlation analysis indicates that explanatory variables are not strongly correlated. The largest correlation coefficient is 0.65, implying that there is no serious collinearity. The Cox PH model assumes that the hazard ratio for any two specifications of variables is proportional over time. If the assumption is violated, we should estimate the stratified cox model rather than the basic cox model. We apply the

Schoenfeld residuals to test the proportionality. The results show that LOC, lnSIZE, FDI, some dummies of industries and provinces are significant (Table 3), implying that the variables are not satisfied with the assumption of proportional hazards and we should estimate the cox model by stratifying these variables.

Table 3 The Results of Schoenfeld Residuals Tests

Variables	Prob>chi2
IR	0.223
LQ	0.055
LnURB	0.337
SOE	0.405
SUBSIDY	0.740
LOAN	0.311
PV	0.194
LnSIZE	0.000
FDI	0.066
EXP	0.825
Industry_dummy	20/28, insignificant
Province_dummy	22/29, insignificant
Global	0.000

Moreover, this feature of the stratified Cox model is called the "no-interaction" assumption, which means that β does not vary across the strata. But there may exist systematic difference in β across the stratas. If it is true, we would obtain different coefficients for each of the strata. Likelihood ratio tests are carried out to test the "no-interaction" assumption for the stratified variables (SIZE, SOE, Industry Dummy, and Province Dummy), showing that there is statistically significant difference and thus we should estimate the cox models across different sizes, ownership, industries, and provinces, respectively.

The regression results for the full sample are reported in Table 4. Model 1 includes both dummies of industries and provinces; Model 2 only includes industrial dummies while Model 3 does not include those dummies. There is strong evidence that industry relatedness does increase the likelihood of firm survival in China. IR has a significant and negative coefficient even after controlling for industrial dummies. That means that a firm in a four-digit industry which enjoys stronger relatedness with other four-digit industries in a city has more chance to survive. Local competence and localized business networks derived from strong inter-industry relatedness generate externalities for related firms (YANG and LIAO, 2010). In these localized networks, firms are able to build business linkages with fellow firms. Managers and labor are also easy to shift from one firm to another. Industry knowledge and market information are transmitted easily across firms. Agglomeration externalities improve firm survival. The findings agree with NEFFKE *et al.* (2012) which finds that the local presence of technologically related industries substantially increase the survival rates of plants in the developed economies.

To further test the effect of localization economies, we introduce the location quotient of industrial employment at the four-digit industry level (LOC) in the models. With the inclusion of IR, LOC has a negative coefficient but is not significant, indicating that traditional sources of localization economies may not play a crucial role in helping firm survival. Localization economies are mainly derived from industry relatedness. Urban population density (LnURB) is included to test the importance of urbanization economies. Evidently, urbanization economies have created favorable business climates for firms. LnURB has significant coefficients even after controlling industrial dummies, implying urbanization economies reduce the hazard rate of firm failure. Firms located in large cities have more chance to survive, suggesting that urbanization externalities help firm survival. China is still urbanizing. Densely populated large cities do enjoy a large number of advantages, including good access to market, favorable institutional supports, large market of intermediate goods, well connected with outside and readable availability of infrastructure and public facilities (ZHAO *et al*., 2003).

Table 4 The Regression Results from Cox PH Models

VARIABLES	MODEL1	MODEL2	MODEL3
IR	-1.245***	-1.197***	-1.160***
LOC	-0.001	-0.000	-0.000
lnURB	-0.143***	-0.120***	-0.125***
SOE	0.763***	0.871***	0.839***
SUBSIDY	-0.122***	-0.104**	-0.119***
LOAN	-0.062***	-0.109***	-0.123***
PV	-0.099***	-0.101***	-0.127***
lnSIZE	-0.172***	-0.160***	-0.145***
FDI	-0.244***	-0.229***	-0.205***
EXP	-0.053*	-0.085***	-0.038
Industry Dummy	YES	YES	NO
Province Dummy	YES	NO	NO
Observations	49,491	49,491	49,491
LR Chi2	1928	1314	1041
Prob> Chi2	0	0	0

Note: *** significant at 1% level, ** significant at 5% and * significant at 10% level.

Industry relatedness and urbanization economies represent market based forces. Governmental supports seem to generate mixed impacts on firm survival. Although with strong supports from governments, SOEs in China are still more likely to fail. SOEs make profits based on their institutional advantages. Governmental supports and protections discourage SOEs to invest in innovation and improve their efficiencies. SOEs are difficult to survive in the competitive market. In addition, during the studying time period some SOEs may be privatized or changed into other ownerships such as foreign owned or privately owned or mixed ownership (NOLAND and WANG, 1999).

Financial supports however help firm survival, which is shown by the significant coefficients on SUBSIDY and LOAN. Local governments often provide a variety of subsidies to local business, reducing production costs and improving firms' profitability and enhancing the chance of firm survival. Loans from banks can also sustain firms to live longer. Positive impacts of bank loans on firm survival have been observed in South Korea and France (OH *et al*., 2009; CRÉPON and DUGUET, 2003). In China, small and medium firms and privately owned firms are often difficult to borrow from state-owned banks (ZHOU, 2009) since they typically favor the larger firms and SOEs. This has made bank loans more critical for firm survival.

In addition, both PV and LnSIZE have significant coefficients, indicating that larger firms are more likely to survive and firms producing multiple products have more chance to survive. Larger firms enjoy scale economies while multiple products firms possess scope economies. Firms with scale and scope economies are more productive and consequently more likely to survive. This is largely consistent with industrial organization literature (SIEGFRIED and BETHEVANS, 1994). Size effect is often explained by the learning model of industrial dynamics in the existing literature. However, larger firms in China are typically favored by both central and local governments and can gain substantial governmental supports such as subsided electricity, cheap land and market channels. The governmental supports for large firms are additional advantage to help them survive in the harsh business environment.

Finally, both FDI and EXP have significant coefficients, showing that foreign firms and exporters are less likely to fail. The positively determined effect of exporting on firm survival is also reported in the literature (PEREZ *et al*., 2004; KIMURA and KIYOTA, 2006). GORG and STROBL (2003) and BERNARD and SJOHOLM (2003) find that being foreign owned is correlated with firm survival. In China, foreign firms enjoy ownership advantages from their parent companies and institutional advantages. Exporters can learn from exporting and can be sustained by international market. Exporters in China benefit from the deep division of labor and industrial clustering in the coast region.

We further look at the differences across firm size and ownership. We divide firms into large (employment greater than 200 persons), medium (employment between 50-200 persons) and small size firms (employment smaller than 50 persons). We classify firms into SOEs and non-SOEs. The Cox PH model results are presented in Table 5. There are several interesting observations. First, industry relatedness seems more important for small and medium sized firms and non-SOEs. Large firms and SOEs lack incentives to exploit industry relatedness since they enjoy scale economies and institutional advantages. Second, with the inclusion of IR, small firms and non-SOEs do not benefit from other sources of localization economies. Large firms and SOEs however are hard to survive in clusters. Large firms also do not appreciate urbanization economies. Third, subsidies can only help the survival of small firms and non-SOEs. Banking loan is critical to the survival of firms except small firms. In fact, small firms are often difficult to gain loan from banks.

Table 5 Regression Results by Sizes and Ownership (SOE) from Cox PH Model

	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5
VARIABLES	SIZE=large	SIZE=medium	SIZE=small	SOE=1	SOE=0
IR	-0.197	-1.330***	-1.607***	-0.895	-1.285***
LOC	0.002*	-0.002**	-0.001	0.001	-0.001
lnURB	-0.077	-0.173***	-0.130***	-0.242**	-0.138***
SOE	0.601***	0.770***	0.790***		
SUBSIDY	-0.136	-0.062	-0.260***	-0.041	-0.124***
LOAN	-0.118***	-0.053*	-0.030	-0.167*	-0.059***
PV	-0.165***	-0.064*	-0.138***	-0.127	-0.097***
lnSIZE	-0.031	-0.204***	-0.180***	-0.179***	-0.172***
FDI	-0.348***	-0.219***	-0.187***		-0.249***
EXP	-0.072	-0.053	-0.045	-0.257	-0.051*
INDUSTRY	YES	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES	YES
Observations	9,209	24,194	16,088	839	48,652
LR Chi2	250.5	812.2	864.2	168.6	1599
Prob> Chi2	0	0	0	0	0

Note: *** significant at 1% level, ** significant at 5% and * significant at 10% level.

Role of Industry Relatedness: Industrial and Provincial Differences

We expect industrial and provincial differences of the role of industry relatedness in firm survival. Table 6 reports the cox regression results for two-digit manufacturing industries and selected provinces. To save space, we report the coefficients of key variables. It is evident that industry relatedness (IR) only affects firm survival for some industries. Among 28 industries, IR has a significant coefficient in 15 industries, ranging from -0.753 for textiles to -5.946 for manufacture of wood, bamboo, straw products. Other industries include food processing and manufacturing, manufacturer of leather and fur and related products, chemical materials and products, medicine, rubber, plastics, nonmetal mineral products, metal mineral products, transport equipment, electrical machinery and equipment, communication equipment and computers and other electronic equipment, smelting and pressing of nonferrous metals. Firms in these industries are more likely to survive because industries are well linked with other industries. The co-location of upstream and downstream sub-industries in resource intensive industries such as food process and manufacturing, manufacturers of chemical materials and products, metal products, plastics and medicine would generate externalities, increasing firm survival. Manufacturers of all types of equipment are industries demanding a large number of suppliers of components and parts and share institutions and knowledge bases. Strong industry relatedness would help the survival of firms in those industries.

Industry relatedness does not significantly affect firm survival in 13 industries. They include manufacturers of beverage, textile, apparel, footwear and caps, furniture, paper and paper products, printing and reproduction of media, articles for culture, education and sports, chemical fibers, general and special purpose machinery,

measuring instruments and machinery for cultural activities and office works, and artworks, and smelting and pressing of ferrous metals. This is not consistent with studies using selected industries, which report positive impact of externalities on firm performance such as productivity (FAN and SCOTT, 2003; ZHANG *et al*., 2014). Externalities may work differently for firm survival in these industries. Relatedness has different impacts on the survival of firms in different sectors, indicating that industrial characteristics exert influence on the way that relatedness plays its role in firm performance. The influence of industrial characteristics deserves further investigation.

Table 6 Regression Results by Two Digit Industries from Cox PH Model

Industries	IR	Province	IR
Processing of Food from Agricultural Products	-1.639***	Beijing	-3.243*
Manufacture of Foods	-1.812*	Tianjin	0.047
Manufacture of Beverages	-0.831	Hebei	-1.660**
Manufacture of Textile	-0.753**	Shanxi	0.125
Manufacture of Textile, Apparel, Footwear and Caps	-0.470	Neimeng	-0.970
Manufacture of Leather, Fur, Feather and Related Products	-3.005***	Liaoning	-2.554***
Processing of Timber, Manufacture of Wood, Bamboo, Palm and Straw Products	-5.946***	Jilin	-3.580***
Manufacture of Furniture	-0.992	HLJ	-0.152
Manufacture of Paper and Paper Products	0.291	Shanghai	-0.261
Printing, Reproduction of Recording Media	0.787	Jiangsu	-3.145***
Manufacture of Articles For Culture, Education and Sport Activities	-0.576	Zhejiang	-1.318**
Processing of Petroleum, Coking, Processing of Nuclear Fuel	-1.428	Anhui	-0.187
Manufacture of Raw Chemical Materials and Chemical Products	-2.771***	Fujian	-1.355*
Manufacture of Medicines	-2.962*	Jiangxi	-2.428***
Manufacture of Chemical Fibers	1.647	Shandong	-1.376***
Manufacture of Rubber	-5.621**	Henan	-1.621*
Manufacture of Plastics	-1.567*	Hubei	-1.573***
Manufacture of Non-metallic Mineral Products	-1.029**	Hunan	-2.948***
Smelting and Pressing of Ferrous Metals	-0.996	Guangdong	-0.065
Smelting and Pressing of Non-ferrous Metals	-2.809***	Guangxi	0.210
Manufacture of Metal Products	-1.961**	Chongqing	-0.685
Manufacture of General Purpose Machinery	-0.575	Sichuan	-1.797**
Manufacture of Special Purpose Machinery	-0.921	Guizhou	-2.765
Manufacture of Transport Equipment	-2.440***	Yunnan	-3.851
Manufacture of Electrical Machinery and Equipment	-2.417***	Shaanxi	-2.109
Manufacture of Communication Equipment, Computers and Other Electronic Equipment	-2.384***	Gansu	-1.539
Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work	-2.330		
Manufacture of Artwork and Other Manufacturing	-0.325		

Note: (1) *** significant at 1% level, ** significant at 5% and * significant at 10% level; (2) To save space, only coefficients for industry relatedness are listed here.

(3) There are very few newly created firms in Tibet, Ningxia and Xinjiang. We excluded them in this

analysis.

Chinese provinces differ in many aspects, including economic development, industrial structure, governance, infrastructure linkages and locations. Firm success may be determined by a different set of factors in provinces. Industry relatedness which is market based force shall play a significant role in liberalized and globalized regions. Table 6 presents the cox regression results for firms located in Chinese provinces. There are several interesting observations. First, many inland provinces, particularly those in the west, do not show evidence of relatedness externalities. Relatedness is not significant in Guangxi, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Shanxi, Inner Mongolia, Heilongjiang, and Anhui. Marketization is lagged behind and market based industry relatedness is not well developed in inland provinces. It is reasonable that relatedness is not conducive to firm survival in inland provinces, which are lagged behind in marketization and globalization. Firm specific factors may be more important determinants of firm survival.

Second, relatedness is often found significant in the coastal provinces. IR has a significant coefficient in models of Beijing, Hebei, Liaoning, Jiangsu, Shandong, Zhejiang, and Fujian. With the first-mover advantages, the coastal region is more economically liberalized and globalized. Firms are able to and have strong incentives to exploit industry relatedness to improve their competitiveness. The finding is consistent with HE and PAN (2010) which report that economic transition has created conditions to allow a larger role of dynamic externalities in liberalized and globalized regions.

Third, several central provinces such as Jilin, Jiangxi, Henan, Hubei and Hunan observe a positive and significant role of industry relatedness in firm survival. Those central provinces have rather strong industrial sectors, including transportation equipment, machinery equipment and general and special purpose machinery. Strong local competence and localized business networks are important factors for firms to survive in those industries. Surprisingly, industry relatedness does not affect firm survival in Tianjin, Shanghai, Guangdong and Chongqing. Those highly urbanized regions and municipalities are more diversified in industries. Firms mainly benefit from urbanization externalities rather than industry relatedness.

Summary and Implications

Externalities have long been reported to underpin firm performance. Recent development has highlighted the role of industry relatedness in growth, employment, productivity and innovation of regions and firms. This study made a special effort to explore the importance of industry relatedness on firm survival in China. Unlike in mature market economies, firms in China often encounter changing industrial policies, institutional uncertainties and market imperfection meanwhile facing strong domestic and international competition. To curb the institutional risks and intensive market competition, Chinese firms are likely to take advantage of agglomeration externalities, particularly relatedness externalities.

This study has investigated the survival of newly created firms during 1998-2007.

Based on the co-occurrence analysis, we develop a new measure of industry relatedness, which can be measured at the four digit industry level and at the city level. Applying the commonly used Cox regression models, we found that industry relatedness does help firms to survive in China. Firms enjoying scale and scope economies have more chance to survive. Governmental financial supports are also conducive to firm survival. The impact of industry relatedness however varies substantially across provinces and industries. Industrial characteristics and province attributes are additional factors to affect firm survival. Further research can explore the crucial industrial and provincial factors to enrich the understanding of firm survival in China.

Traditional understanding of externalities stresses the importance of size and diversity. Our findings indicate that internal structure of local economies is critical. It is relatedness that matters for the performance of firms. This finding has important policy implication for regional development in China. As mentioned, local governments are engaged into intensive inter-jurisdictional competition in economic development. Local protectionism and imitation of industrial policies often duplicate industries in many localities, which has caused the distortion of regional production away from patterns of comparative advantages and local competence (PONCET, 2005; HE *et al*., 2008). This has also sacrificed industrial competitiveness and efficiencies due to lack of scale economies. Furthermore, local governments have strong incentives to attract new industries to upgrade industrial structure or restructure local economies.

Under regional competition, it is likely to introduce industries which are not technologically related to local industrial portfolios, which will challenge the sustainable development of local industries. The empirical findings suggest that Chinese regions should take the locally inherited knowledge and skills into account when attracting new industries and restructuring their industrial structures. Industrial upgrading is more likely to succeed when new industries are to some extent related to those already in places.

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