Learning from yourself or learning from neighbours: knowledge spillovers, institutional context and firm upgrading

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ABSTRACT
Using a firm–product-level data set on China’s exports during the period 2000–11, we compare the impacts of intra- and inter-firm knowledge spillovers on the emergence of new, more sophisticated products at the firm level. Empirical results indicate that firm diversification is dependent on both intra- and inter-firm knowledge spillovers, though the effect of the former is much greater. More importantly, intra-firm knowledge spillovers are one key source of firm upgrading. In contrast, inter-firm knowledge spillovers even have some negative impacts on firm upgrading in the Chinese context, though it contributes to firm diversification. We further analyze how the roles of intra- and inter-firm knowledge spillovers in firm upgrading are contingent on regional institutional context.

KEYWORDS
knowledge spillover; technological relatedness; product sophistication; firm upgrading; institutional context

INTRODUCTION
Research on regional science and economic geography has argued that the regional economic environment may affect a firm’s competitiveness and tendency to innovate, via local knowledge spillovers (Audretsch & Feldman, 1996; Fritsch & Franke, 2004). This strand of literature can be traced back to Marshall’s (1920) and Jacobs’s (1969) work that laid the theoretical and empirical foundation for research on the key role of agglomeration economies derived from geographical proximity.

More recently, evolutionary economic geography (EEG) literature has, however, underscored that geographical proximity alone is not sufficient for knowledge spillovers to occur (Boschma & Capone, 2016; Boschma, Minondo, & Navarro, 2013; Hidalgo, Klinger, Barabási, & Hausmann, 2007; Rigby, 2015). For knowledge spillovers to take place between industries, the cognitive distance between them should be neither too great that they have nothing in common nor too small that there is nothing new to be learned. Technological relatedness between industries, which stems from cognitive proximity, needs to be in place (Neffke, Henning, & Boschma, 2011).

This strand of literature has also confirmed the importance of technological relatedness and cognitive proximity in regional industrial diversification, as regions often diversify into industrial sectors technologically related to their existing industrial profile (Boschma et al., 2013; Neffke et al., 2011; Zhu, He, & Zhou, 2017). The process of regional industrial diversification is therefore path dependent (Boschma et al., 2013).

Regional industrial dynamics at the macro-level can be seen as the result of the choices and behaviours of individual firms at the micro-level (Beugelsdijk, 2007). Hence, we need to acknowledge the role of technological relatedness in firm dynamics, and explore if firms are more likely to develop new products that are related to regional pre-existing productive structure (Lo Turco & Maggioni, 2016; Zhu, He, & Luo, 2018). Empirical evidence confirms that technological relatedness does play a key role not only at the national and regional levels (Bishop & Gripaios, 2010; Boschma et al., 2013; Broekel & Boschma, 2012; Neffke et al., 2011) but also in industrial dynamics at the firm level (Lo Turco & Maggioni, 2016; Neffke, Henning, & Boschma, 2012; Zhu et al., 2018).
Inspired by these studies, we aim to make three contributions. First, this is research at the micro-level. On the one hand, it is easy for firms to diversify into products related to local industrial profile by capitalizing on existing local capabilities and inter-firm knowledge spillovers. On the other hand, we anticipate that a firm also tends to develop new products closely related to its own productive structure due to intra-firm knowledge spillovers. The paper thus pays attention to the role of knowledge spillovers at the local level and also to that of intra-firm knowledge spillovers while analyzing how a firm diversifies into new products. Second, the existing EEG literature often focuses on the ways in which and the extents to which technological relatedness influences the emergence of new products/industries, whereas our research seeks to ask a new question: how does technological relatedness shape the emergence of new, more sophisticated products at the firm level? The key of this study is therefore to understand the role of technological relatedness in firms’ product upgrading. We thus bring two strands of literature – one on EEG and the other on firm upgrading – into the dialogue. Finally, the potential effect that institutional context can have over firm dynamics and upgrading is often underestimated (Boschma & Capone, 2015; Zhu et al., 2017). This may render our findings erroneous, especially when we focus on transitional economies such as China with graphically fragmented institutional contexts (Li, Meng, Wang, & Zhou, 2008; Zhu et al., 2018).

**KNOWLEDGE SPILLOVERS, INSTITUTIONAL CONTEXT AND FIRM UPGRADING**

Knowledge spillover is important for regional development because it shapes regional conditions for innovation (Fritsch & Franke, 2004; Giuliani, 2007; Kesidou & Romijn, 2008). Furthermore, it is often geographically localized (Jaffe, Trajtenberg, & Henderson, 1993). Geographical proximity thus matters, as a variety of localized mechanisms, such as labour mobility, entrepreneurial spin-offs, social networking and inter-firm synergies are important to induce local knowledge spillovers and result in localized capabilities (Kesidou & Romijn, 2008).

However, inspired by Boschma (2005), recent studies have increasingly acknowledged that geographical proximity alone is not enough for spurring knowledge diffusion between firms. Instead, Nooteboom (2000) has pointed out that cognitive proximity is often crucial for knowledge spillovers to occur. It may be difficult for co-located firms to benefit substantially from knowledge spillovers if their knowledge profiles overlap too much or are so different that they cannot communicate efficiently with one another. In this sense, technological relatedness, which derives from cognitive proximity or complementarity between firms, is necessary for knowledge spillovers to take place effectively (Boschma & Frenken, 2011).

Cognitive proximity is not only crucial for the growth of existing industries but also influences new path creation by providing potentials for regions to create new industrial sectors and setting limits to the process of regional industrial diversification as well (Boschma & Capone, 2016; Boschma et al., 2013). When most capabilities required by a new industry are already present in a region, it would be not difficult for the region to develop this new industry (Boschma et al., 2013). In other words, new industries do not originate in purely random events, but emerge out of existing industrial profiles via knowledge spillovers from technologically related industrial sectors in the locality (Boschma & Frenken, 2011; Boschma et al., 2013). The term ‘regional branching’ was coined by Boschma and Frenken (2011) to portray the process of regional industrial diversification where new industrial sectors derive from related ones or emerge from the recombination of localized capabilities from some related industrial sectors (Klepper & Simons, 2000; Tanner, 2016).

The role of technological relatedness, which derives from cognitive proximity among economic actors (Boschma et al., 2013; Frenken, Van Oort, & Verburg, 2007; Neffke et al., 2011), was first confirmed at the national level (Hidalgo et al., 2007). Furthermore, Boschma et al. (2013) have pointed out that the impact of technological relatedness and cognitive proximity on the emergence of new industries is much more evident at the regional level. Finally, technological relatedness also matters within a firm’s boundary and is found to shape industrial diversification at the firm level (Lo Turco & Maggioni, 2016). We expect that a firm tends to diversify into products closely related to local industrial profile, as it has access to more productive opportunities by taking advantage of inter-firm technologically related knowledge spillovers (Maskell & Malmberg, 1999). This hypothesis has already been testified in recent studies (Lo Turco & Maggioni, 2016).

More recently, EEG studies start to direct more attention to the role of some other factors that have been largely overlooked before, such as extra-regional linkages that may bring fresh knowledge and contribute to the formation of new growth paths (Batheit & Cohendet, 2014; Zhu et al., 2017). Here, we focus on another factor: intra-firm knowledge spillover. Although a firm’s diversification process is shaped by regional productive structure via inter-firm knowledge spillovers, the firm’s own pre-existing productive structure is also a key driver of its industrial diversification through intra-firm knowledge spillovers. Neffke and Henning (2013) calculated relatedness between industries by using data on labour mobility between industrial sectors and concluded that firms often diversify into industries related to their core activities in terms of labour skill. Some studies have even moved one step further, by comparing the impact of inter-firm knowledge spillovers within a region and intra-firm knowledge spillovers within a firm on the emergence of new products in a firm. For instance, Beugelsdijk (2007) and Sternberg and Arndt (2001) found that the importance of a firm’s regional environment is sometimes dwarfed by that of firm-specific resources in the firm’s product innovation. Lo Turco and Maggioni (2016) explored the ways in which firm and local product-specific capabilities have contributed to the
emergence of new products in Turkish firms, and showed that firms tend to introduce products related to their productive structures. This research builds on these firm-level studies and takes into account both technologically related knowledge spillovers between firms and firms’ internal product-specific capabilities.

While the impacts of technological relatedness on the reorganization of firms’ production activities are relatively well understood, one aspect that has been left largely underexplored is that how relatedness to local and firm productive structures affects the emergence of new, more sophisticated products at the firm level. In other words, the key question we seek to ask is how technological relatedness contributes to firm upgrading. Shedding a light on this issue first allows one to understand better the role of technological relatedness in industrial dynamics and economic development. It is also an opportunity to relate the EEG literature to another strand of literature on firm upgrading, which pays particular attention to the idea of product sophistication and what a region makes matters for its growth (Felipe, Kumar, Abdon, & Bacate, 2012; Hausmann, Hwang, & Rodrik, 2007).

Firms need constantly to upgrade their products to maintain and even increase their competitive advantages, for instance, by manufacturing higher end products and increasing the technology content of production activities (Humphrey & Schmitz, 2002). Firm upgrading will further alter the productive structure of the region and generate positive knowledge diffusion to the rest of economy, resulting in more sustainable economic growth. Recent studies even view regional economic development as a process where firms in the region jump from peripheral areas of the product space, consisting of low-end products, to core areas made up by more sophisticated products (Boschma & Capone, 2016; Felipe et al., 2012; Hausmann & Hidalgo, 2011; Hidalgo & Hausmann, 2009; Zhu et al., 2017). Nonetheless, firm upgrading is often costly and comes up with high levels of risks and uncertainties hand in hand (Jacovone & Javorcik, 2010). Production of a completely new product demands the exploration of brand new technologies and information. Even for the products manufactured with standard blueprints, massive investments may be still required with respect to firm absorption, local adaption and tinkering. Firms’ capabilities of absorbing new technologies and upgrading to more sophisticated products are likely to be dependent on firm and local product-specific capabilities. The natural question to ask is how inter-firm technologically related knowledge spillovers and firms’ internal product-specific capabilities influence firm upgrading.

Furthermore, we seek to examine if the relationship between intra/inter-firm knowledge spillovers and firm upgrading is further shaped by local institutional context. Boschma and Capone (2015) have stressed that some studies on technological relatedness tend to direct insufficient attention to the possible effect of institutional context, as these works are overwhelmingly conducted based on data or case studies in developed capitalist economies, in which factors move freely within and across regions and government intervention is limited. However, this may not be the case in transitional economies such as China (Binz, Truffer, & Coenen, 2016). A notable characteristic of China’s specific institutional context is that the state still plays a crucial role in shaping the country’s geographical and industrial dynamics (He, Wei, & Xie, 2008). This paper thus pays particular attention to the role of the state, rather than on every aspect of institutional context. The state has an important impact on the institutional context whereby firms operate, either directly through the issuance of government policies and laws or indirectly by conditioning the wider sets of norms, habits and values (Bathelt & Glückler, 2014).

One key aspect of China’s economic reform is decentralization, as more autonomy has been offered to local governments. This process has enabled the latter to intervene directly and indirectly in the development of the regional economy, giving rise to a geographically uneven institutional context (He et al., 2008). Although all local authorities attempt to adopt pro-business policies in order to catalyze firm upgrading and regional economic development, some in China’s wealthy coastal regions are often more capable at providing a variety of subsidies, tax credits, fiscal and administrative supports than their counterparts in less developed inland China. Such regional variations of institutional context have been named by Hu and Hassink (2017) as a ‘leadership of context’, and should be taken into consideration in order to understand better firm upgrading. Financial, political and technological supports provided by local governments could reduce firms’ cost of developing new, and even more sophisticated, products, triggering firm upgrading (Aghion et al., 2015; He & Yang, 2016).

**DATA AND RESEARCH DESIGN**

**Relatedness indicators**

To investigate the role of intra- and inter-firm knowledge spillovers in fostering a firm’s diversification into more sophisticated products, we need an index to measure the technological relatedness and cognitive proximity between products. It can be also seen as a proxy of the distance between new products and pre-existing firm/local productive structures, that is, the potential strength of intra- and inter-firm knowledge spillovers. It thus enables one to compare the impact of inter-firm knowledge spillovers within a region and intra-firm knowledge spillovers on firm upgrading. We adopt the relatedness indicator introduced by Hidalgo et al. (2007), which assumes that if regions often have a revealed comparative advantage (RCA) in two products, they can be seen as related to one another. This paper adjusts the indicator and defines two products as being related to each other if they are often co-exported by one firm. The relatedness indicator proposed by Hidalgo et al. calculates the co-occurrence of two products at the regional level, whereas our indicator computes the co-occurrence of two products at the firm level. The indicator is thus more accurate and can be

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calculated as:

\[ \phi_{ij} = \min \left\{ P(EV_{f,j} > 0 | EV_{f,i} > 0), P(EV_{f,j} > 0 | EV_{f,i} > 0) \right\} \]  

(1)

where \( EV_{f,i} \) is the export value of product \( i \) of firm \( f \). The relatedness between products \( i \) and \( j \) is the minimum between the conditional probability that product \( i \) is exported by firm \( f \) given that product \( j \) is exported by firm \( f \) and the conditional probability that product \( j \) is exported by firm \( f \) provided that product \( i \) is also exported by the same firm. The idea is that two related products probably require similar resources, input factors, localized capabilities and technologies, and thus tend to be produced and exported together.

Based on the relatedness indicator, we calculate the average relatedness between product \( i \) and the productive structure of city \( c \) (or firm \( f \)) as a proxy of the distance between a new product and local (or firm) pre-existing productive profile. The density index was designed by Hidalgo et al. to capture the extent to which product \( i \) is related to the existing productive structure of city \( c \) (or firm \( f \)). The idea is that if new product \( i \) is related to many products that city \( c \) already has an RCA in (or firm \( f \) already exports), the density of this new product is high, the strength of knowledge spillovers tends to be large, and the likelihood for firm \( f \) to diversify into product \( i \) will be also high. The indicators measuring how product \( i \) is related to the existing productive structure of firm \( f \) and city \( c \) are computed as follows:

\[ \text{density}_{f,i} = \frac{\sum_j x_{f,j} \phi_{ij}}{\sum_j \phi_{ij}} \]  

(2)

\[ \text{density}_{f,i} = \frac{\sum_j x_{f,i} \phi_{ij}}{\sum_j \phi_{ij}} \]  

(3)

where \( x_{f,j} \) is a dummy that takes the value of 1 if product \( j \) is exported by firm \( f \) and 0 otherwise; and \( x_{f,i} \) is also a dummy taking the value of 1 if city \( c \) has an RCA in product \( j \) (RCA\(_{c,j} \geq 1 \)), and 0 otherwise. RCA is defined as follows:

\[ \text{RCA}_f = \frac{(EV_{f}/\sum_j EV_{f,j})/\left(\sum_j EV_{f,j}/\sum_q EV_q\right)}{\text{RCA}_c} \]  

(4)

where \( EV_{f,q} \) represents the export value of product \( q \) in city \( c \).

This paper uses the Chinese Customs Trade Statistics (CCTS) for the period 2000–11 to calculate the density indicators. The database includes all exports and imports passing through Chinese customs, and provides information on firm name and ownership, export/import value, eight-digit product code, the origin/destination of each export/import, etc. We exclude intermediary firms that do not directly engage in production, and firms conducting processing trade. This paper focuses on four-digit-level products at the firm level.

### Product sophistication indicator

To examine how relatedness to local and firm productive structures affects the emergence of new, more sophisticated products, we need a product sophistication indicator. Following Hidalgo and Hausmann (2009), we calculate product sophistication by using the UNComtrade data set. More sophisticated products often require many or exclusive capabilities. The more exclusive capabilities a product demands, the less ubiquitous is the product. Furthermore, it is expected that fewer countries are able to export more sophisticated products, and those countries should have many and diverse capabilities. We thus can jointly and iteratively calculate two indicators: the ubiquity of an export product and the diversity of a country’s export profile. Ubiquity (\( k_{i,0} \)) and diversity (\( k_{n,0} \)) are computed as follows:

\[ k_{i,0} = \sum_{i} M_{ni} \]  

(5)

where \( n \) denotes the country, and \( i \) represents the product. \( M_{ni} \) is 1 if country \( n \) has an RCA in export product \( i \), and 0 otherwise. RCA is the ratio of the share of a product in a country’s export profile to the same share worldwide:

\[ \text{RCA}_{n,i} = \frac{(EV_{n,i}/\sum_i EV_{n,i})/\left(\sum_i EV_{n,i}/\sum_j EV_j\right)}{\text{RCA}_n} \]  

(6)

where \( EV_{n,i} \) is the export value of product \( i \) in country \( n \). Therefore, \( k_{i,0} \) measures the ubiquity of product \( i \); and \( k_{n,0} \) measures the diversity of country \( n \)’s export basket.

However, a low level of ubiquity does not necessarily indicate a high level of sophistication of a product, since the sophistication of a product is also dependent on whether countries that export this product have high levels of capabilities, or in the present case, diverse export baskets. Similarly, a high level of diversity does not necessarily indicate a high level of sophistication of a country’s export profile, since the sophistication of a country’s export profile is also determined by the level of ubiquity of the products it exports (Poncet & Starosta de Waldemar, 2013). Taking this interdependent relationship into consideration, product sophistication and the sophistication of a country’s export profile are thus computed after \( m \) iterations as the following weighted average:

\[ k_{n,m} = \frac{1}{k_{n,0}} \sum_{i} M_{ni} k_{i,m-1} \]  

(7)

After \( m \) iterations, equation (7) measures the sophistication of product \( i \) and country \( n \)’s export basket, respectively. The number of iterations, \( m \), depends on whether there is additional information in the previous iteration. In other words, the iteration could stop when the relative rankings of the values estimated using equation (7) in the \( m \) + 1-th iteration remain the same as that in the \( m \)-th iteration. In this research, \( m \) is 15.

### Model specifications

To compare the impact of inter- and intra-firm knowledge spillovers on firm upgrading, this paper estimates the
following conditional linear model:

\[
Entry_{ij,t} = \alpha_0 + \alpha_1 \text{density}_{ij,t-1} + \alpha_2 \text{density}_{ij,t-1} \\
+ \alpha_4 \text{upgrading}_{ij,t-1} + \alpha_5 \text{upgrading}_{ij,t-1} + \gamma_1 \text{density}_{ij,t-1} \\n\times \text{upgrading}_{ij,t-1} + \gamma_2 \text{density}_{ij,t-1} \times \text{upgrading}_{ij,t-1} \\
+ \eta_t + \chi_t + \lambda_t + \epsilon_{ij,t-1}
\]  

(8)

where \(Entry_{ij,t}\) is a dummy variable that is 1 if firm \(f\) diversifies into new product \(i\) in year \(t\). Two density indicators, \(\text{density}_{ij,t-1}\) and \(\text{density}_{ij,t-1}\), which have been defined previously, reflect the extents to which product \(i\) is related to the existing productive structures of firm \(f\) and city \(c\) in year \(t-1\), respectively. A high level of \(\text{density}_{ij,t-1}\) (or \(\text{density}_{ij,t-1}\)) means that the distance between new product \(i\) and firm \(f\)’s (city \(c\)’s) existing productive profile is small. Hence, if the effect of density is positive, we can conclude that a firm tends to diversify into products related to the firm’s (city’s) existing productive structure. Our hypothesis is that higher levels of relatedness to firm (or local) productive structure may generate greater intra-firm (or inter-firm) knowledge spillovers, reducing the risks and uncertainties in the process of firm diversification in general and firm upgrading in particular. Equation (8) is estimated by the panel model.

\(\text{Upgrading}_{ij,t-1}\) is calculated as the ratio of new product \(f\)’s sophistication to the average sophistication of a firm’s existing export basket in year \(t-1\) as a proxy of firm upgrading. The larger the upgrading indicator, the more sophisticated product the firm is jumping to relative to its existing export basket, the bigger step the firm is making, the more difficult firm upgrading is. Similarly, \(\text{Upgrading}_{ij,t-1}\) is the ratio of the sophistication of new product \(i\) to the average product sophistication of city \(c\)’s existing export basket in year \(t-1\). The larger the upgrading indicator, the more sophisticated product the firm is jumping to relative to its existing export basket. Firms are expected to face higher levels of risks and uncertainties while diversifying into more sophisticated products relative to the firm’s (or city’s) existing export profile. What is still unclear is if intra- and inter-firm knowledge spillovers can reduce those risks and uncertainties in the process of firm upgrading. We thus include several interaction terms between the upgrading indicators and the density indicators in equation (8). \(\gamma_1\) and \(\gamma_2\) capture the roles of intra- and inter-firm knowledge spillovers in the process of firm upgrading, respectively.

The relationship between firm upgrading and inter/ intra-firm knowledge spillovers may be also contingent on regional institutional context, particularly in transitional economies such as China. Four variables on institutional context are thus included, \(SUB1/2\) and \(TAX1/2\), in order to examine to what extent the incentives of local governments can affect firms’ capability of upgrading by providing subsidies and tax credits to certain firms. \(SUB1\) (or \(TAX1\)) is simply defined as the ratio of subsidies (or tax credits) to industrial output in sector \(f\), city \(c\) and year \(t\). During the study period, corporate tax rates in China ranged from 15% to 33%. We calculate tax credits as profits timing tax rate minus actual taxes paid and plus the exemptions to the value-added tax that is 17%. Furthermore, we follow Aghion et al. (2015) and calculate the sectoral dispersion of subsidies (\(SUB2\)) and tax credits (\(TAX2\)). First, we adopt the Herfindahl indicator to measure the concentration of subsidies and tax credits within sector \(j\) in city \(c\) and year \(t\):

\[
\text{Herf}_{\text{subsidy}_{ij,t}} = \frac{\sum_{ij} \left( \text{Subsidy}_{ij,t} \right)^2}{\sum_{ij} \text{Subsidy}_{ij,t}}
\]

\[
\text{Herf}_{\text{tax}_{ij,t}} = \frac{\sum_{ij} \left( \text{TaxCredit}_{ij,t} \right)^2}{\sum_{ij} \text{TaxCredit}_{ij,t}}
\]

(9)

where \(\text{Subsidy}_{ij,t}\) and \(\text{TaxCredit}_{ij,t}\) denote the amounts of subsidies and tax credits received by firm \(f\) in sector \(j\), city \(c\) and year \(t\) from governments, respectively. The greater the Herfindahl indicator, the lower degree of dispersion of subsidies or tax credits, the more uneven allocation of those across firms in an industrial sector. We then calculate the sectoral dispersion of subsidies and tax credits, \(SUB2\) and \(TAX2\), as follows:

\[
\text{SUB2}_{ij,t} = 1 - \text{Herf}_{\text{subsidy}_{ij,t}}
\]

\[
\text{TAX2}_{ij,t} = 1 - \text{Herf}_{\text{tax}_{ij,t}}
\]

(10)

The higher the sectoral dispersion of subsidies and tax credits, the more competitive business environment Chinese governments seek to formulate.

Data on subsidies and tax credits are obtained from China’s Annual Survey of Industrial Firms (ASIF) (1998–2007) compiled by the National Bureau of Statistics of China. The database records all state-owned enterprises (SOEs) and non-SOEs with annual sales of above 5 million yuan, and provides information on subsidies and tax credits at the firm level. We aggregate to prefectural city–industry level.

**FIRM UPGRAILING IN CHINA**

In this research, by ‘region’ we are referring to China’s prefectoral level city. Figure 1 shows the spatial distribution of Chinese exporters with new products in 2001 and 2011, respectively. China’s rapid economic growth has been driven largely by an export-oriented industrialization model and its integration into the global economy. Hence, the geographies of production were dramatically influenced by global sourcing for international markets. Exporters in China’s developed coastal regions of East and Southeast China were more likely to develop new products, particularly in 2001. However, cities in inland China started to catch up in 2011. As the costs of labour, land and other input factors in China’s coastal regions rose, production has been gradually relocated to inland China.

Empirical evidence also confirms that there has been a sharp rise in the complexity and sophistication of Chinese exports during the last few decades (Rodrik, 2006; Schott, 2008). Table 1 presents some preliminary evidence on the upgrading of Chinese exporting firms. Results in columns
Figure 1. Number of exporters with new products in Chinese cities (a) 2001 and (b) 2011.
2–4 show that the number of Chinese exporters has increased during 2000–11. Furthermore, they have become more active in diversifying into new products, especially more sophisticated products, which is in line with the findings of current literature on firm upgrading in China. In columns 5 and 6, we first compute the weighted average of the sophistication of products exported by a firm and a city, with the export share of each product as the weight, and then calculate the average sophistication of all Chinese firms and cities, respectively. The results indicate that, on average, Chinese firms and cities have upgraded their export baskets during 2000–11.

This can be also seen in Figure 2, which maps out the average sophistication of Chinese cities in 2000 and 2011, respectively. Most Chinese cities have managed to develop more sophisticated products during this period. The upgrading of Chinese firms has become more prevalent in both coastal and inland China.

### EMPIRICAL RESULTS

#### Baseline results

Correlation analysis suggests that there is no serious problem of multi-collinearity (see Table A1 in Appendix A in the supplemental data online). Firm and year dummies are added to control firm- and time-specific characteristics, respectively. Standard errors are clustered at the firm and four-digit product level. Empirical results are shown in Table 2.

| Year | Number of exporters | Number of exporters with new products | Average sophistication of new products | Average sophistication of Chinese exporters | Average sophistication of Chinese cities |
|------|---------------------|---------------------------------------|---------------------------------------|-------------------------------------------|----------------------------------------|
| 2000 | 50,092              | 19,327                                | 0.533                                 | 0.491                                      | 0.513                                   |
| 2001 | 54,520              | 23,327                                | 0.537                                 | 0.498                                      | 0.519                                   |
| 2002 | 62,423              | 24,067                                | 0.537                                 | 0.508                                      | 0.525                                   |
| 2003 | 74,923              | 32,195                                | 0.542                                 | 0.508                                      | 0.531                                   |
| 2004 | 91,545              | 41,434                                | 0.543                                 | 0.511                                      | 0.536                                   |
| 2005 | 106,946             | 41,749                                | 0.551                                 | 0.524                                      | 0.543                                   |
| 2006 | 121,957             | 67,974                                | 0.551                                 | 0.530                                      | 0.548                                   |
| 2007 | 134,625             | 56,697                                | 0.563                                 | 0.534                                      | 0.551                                   |
| 2008 | 144,267             | 48,853                                | 0.577                                 | 0.544                                      | 0.560                                   |
| 2009 | 149,567             | 71,583                                | 0.580                                 | 0.541                                      | 0.563                                   |
| 2010 | 159,937             | 97,877                                | 0.585                                 | 0.547                                      | 0.567                                   |
| 2011 | 172,458             | 102,799                               | 0.595                                 | 0.557                                      | 0.571                                   |

In model 5, the coefficient of density is much larger than that of density, implying that the impact of local productive structure is overshadowed by that of firm productive structure in the process of firm diversification. Lo Turco and Maggioni (2016) have also found that firms tend to bring in new products closely related to firm productive structure than to local productive structure in Turkey’s manufacturing industries.

The parameters of two upgrading indicators are both negative and significant (models 3 and 4). The greater those upgrading indicators are, the bigger step in upgrading firms need to make, the more difficult it is. Relatively speaking, firms tend to diversify into new, less sophisticated products due to lower levels of risks and uncertainties. These findings are also in line with current literature on how firms tend to develop new products based on their existing resources and organizational routines, and avoid actions with a high level of risks and uncertainties (Caves, 1998).

In models 6–8, we bring in two interactions terms between the density and upgrading indicators. The parameter of the interaction term between density and upgrading is positive and significant in models 6 and 8, confirming that intra-firm knowledge spillovers may reduce the risks and uncertainties in firm upgrading and allows firms to diversify into more sophisticated products relatively easily. By contrast, the parameter of density upgrading is negative and statistically significant. This implies that inter-firm knowledge spillovers within the locality do not help reduce the difficulty of firm upgrading to more sophisticated products; rather, the obstacle of firm upgrading has grown bigger in cities with higher levels of inter-firm knowledge spillovers. As pointed out by Zhu et al. (2018) and Poncelet and de Waldemar (2015), even though current EEG literature often takes positive knowledge spillovers among technologically related firms for granted, such effects are indeed highly contingent. In some cases, negative knowledge spillovers may be seen among technologically related firms in certain regions, and offset the positive ones. One possible explanation is that negative knowledge spillovers are indeed highly contingent.
Figure 2. Average sophistication of Chinese cities in (a) 2000 and (b) 2011.
### Table 2. Baseline results.

| Density & Upgrading | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Dependent variable: $Entry_{t,t}$ | | | | | | | | |
| $density_f$ | 1.020*** | 1.018*** | 0.969*** | 0.970*** | (0.021) | (0.026) | (0.028) | (0.033) |
| $density_c$ | 0.221*** | 0.072*** | 0.272*** | 0.104*** | (0.011) | (0.011) | (0.017) | (0.017) |
| $upgrading_f$ | $-0.015***$ | $-0.025***$ | $-0.009***$ | $-0.027***$ | (0.001) | (0.004) | (0.001) | (0.017) |
| $upgrading_c$ | $-0.011***$ | 0.023*** | $-0.003$ | 0.029*** | (0.001) | (0.005) | (0.003) | (0.005) |
| $density_f$*$upgrading_f$ | | | | | | | | |
| $density_c$*$upgrading_f$ | | | | | | | | |
| Constant | 0.073*** | 0.064*** | 0.131*** | 0.126*** | 0.060*** | 0.084*** | 0.068*** | 0.056*** | (0.002) | (0.003) | (0.003) | (0.004) | (0.003) | (0.005) | (0.005) |
| Firm dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,469,664 | 2,103,867 | 2,470,771 | 2,470,771 | 2,102,760 | 2,469,664 | 2,103,867 | 2,102,760 |
| $R^2$ | 0.031 | 0.016 | 0.011 | 0.011 | 0.032 | 0.031 | 0.016 | 0.032 |

Note: Standard errors are shown in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. 

Learning from yourself or learning from neighbours: knowledge spillovers, institutional context and firm upgrading.
spillovers may be common in China where the protection of intellectual property rights is weak and imitation is rampant (Fan, Gillan, & Yu, 2013). Labour poaching and hyper-competition could be also sources of negative knowledge spillovers. Furthermore, adverse knowledge spillovers could stem from the crowding-out effect and the lack of knowledge exchange between different kinds of firms in terms of size and ownership in China (see also Poncet & de Waldemar, 2015; and Zhu et al., 2018).

In short, the results echo the findings of Lo Turco and Maggioni (2016) by confirming that the role of inter-firm knowledge spillovers is dwarfed by that of intra-firm knowledge spillovers in firm diversification into new products. More importantly, the results further underline the importance of intra-firm knowledge spillovers in firm upgrading, whereas inter-firm knowledge spillovers may even have some negative impacts on firm upgrading in the Chinese context.

The role of institutional context

Tables 3 and 4 report the econometric results on whether the gains from relatedness with firm and regional productive profile as well as their impacts on firm upgrading are contingent on regional institutional context. Institution in each table represents SUB1, SUB2, TAX1, and TAX2 in models 1–4 respectively. The interaction terms between institution-specific variables, the density and upgrading indicators are included in the model. First, the coefficients of upgrading * density * Institution and upgrading * density * Institution are negative in first two models in both Tables 3 and 4. This implies that the positive impact of intra- and inter-firm knowledge spillovers on firm upgrading is likely to be even lower in certain sectors and regions with higher levels of subsidies and tax credits. However, the coefficients of those interaction terms are largely statistically insignificant, indicating the magnitude of subsidies and tax credits only has insignificant or weak effects in this process.

Instead, it is the distribution of subsidies and tax credits in a sector and a city that matters. In models 3 and 4 in Table 4, the parameter of upgrading * density * Institution is negative and statistically significant, and that of upgrading * density is negative and significant in models 7 and 8 in Table 2. It indicates that the negative effect of inter-firm knowledge spillovers on firm upgrading would be much greater in regions with higher levels of dispersion of subsidies and tax credits. The higher the sectoral dispersion of subsidies and tax credits, the more competitive business environment Chinese governments seek to formulate. One possible explanation is that in China, where the protection of intellectual property rights is weak, a too competitive business environment may encourage imitation rather than innovation, further enhancing negative knowledge spillovers and harming firm upgrading. Furthermore, in models 3 and 4 in Table 3,

### Table 3: Estimation results on the role of regional institutions (intra-firm knowledge spillovers)

| Institution | Dependent variable: Entry<sub>f,i,t</sub> |
|-------------|-----------------|
| SUB1 (1)    | TAX1 (2)        |
| upgrading<sup>f</sup> | −0.015*** (0.003) | −0.015*** (0.002) |
| density<sup>f</sup> | 0.980*** (0.056) | 0.883*** (0.041) |
| upgrading<sup>f</sup>*density<sup>f</sup> | 0.094** (0.036) | 0.063*** (0.024) |
| Institution | 0.006 (0.004) | −0.009*** (0.003) |
| upgrading<sup>f</sup>*Institution | 0.003 (0.003) | 0.005** (0.002) |
| density<sup>f</sup>*Institution | −0.040 (0.049) | 0.106*** (0.033) |
| upgrading<sup>f</sup>*density<sup>f</sup>*Institution | −0.067* (0.037) | −0.036 (0.027) |
| Constant | 0.083*** (0.005) | 0.093*** (0.004) |
| Firm dummies | Yes | Yes |
| Year dummies | Yes | Yes |
| Observations | 1,408,670 | 1,408,670 |
| R<sup>2</sup> | 0.038 | 0.038 |

Notes: Institution represents SUB1, SUB2, TAX1 and TAX2 in models 1–4, respectively. Standard errors are shown in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.
the coefficient of upgrading*density*Institution is negative and statistically significant, too, while that of upgrading*density is positive and statistically significant in models 6 and 8 in Table 2. This suggests that even the positive impact of intra-firm knowledge spillovers on firm upgrading could be weakened in regions with higher levels of dispersion of subsidies and tax credits. Without proper protection of intellectual property rights in place, high levels of competition could not only reinforce the role of negative inter-firm knowledge spillovers but also inhibit the positive impact of intra-firm knowledge spillovers. Additional resources and investments may be consumed by fierce competition, which reduces the probability of firm upgrading by capitalizing on firms’ internal product-specific capabilities and resources.

**CONCLUSIONS**

Recent studies emphasize relatedness, which derives from some sort of cognitive proximity among firms, as a key factor underpinning regional industrial evolution, and point out that it contributes to regional economic development via inter-firm learning and knowledge diffusion. Empirical research has further tested the positive relationship between technological relatedness and regional economic performance at the national and regional levels. Here, we build on these studies and explores a new line of enquiry – industrial dynamics at the firm level. We examine if firm upgrading, defined as the emergence of new, more sophisticated products, is dependent on firm and local productive profile, by employing a firm-level database of China’s exports during the period 2000–11. Attention has been also directed to the role of regional institutional context in the process of firm upgrading.

This paper seeks to make three contributions. First, we stress that firms tend not only to diversify into products closely related to local productive structure due to inter-firm knowledge spillovers but also to capitalize on existing internal capabilities and intra-firm knowledge spillovers. More importantly, in the process of industrial diversification, firms rely more on firm productive structure than on the local set of available product-specific knowledge.

Second, one aspect that has been left largely underexplored is that how relatedness to local and firm productive structures affects the emergence of new, more sophisticated products at the firm level, that is, firm upgrading. Our results further highlight that intra-firm knowledge spillover is one key source of firm upgrading. In contrast, inter-firm knowledge spillover even has some negative impacts on firm upgrading in the Chinese context, though it contributes to firm diversification. It enriches the prevalent view in the existing EEG literature that often takes positive knowledge spillovers among technologically related firms for granted.

**Table 4.** Estimation results on the role of regional institutions (inter-firm knowledge spillovers).

| Institution                      | SUB1 (1)  | TAX1 (2)  | SUB2 (3)  | TAX2 (4)  |
|----------------------------------|-----------|-----------|-----------|-----------|
| **upgrading**                     | –0.015**  | 0.011**   | –0.023*** | –0.046*** |
|                                  | (0.006)   | (0.005)   | (0.008)   | (0.012)   |
| **density**                      | 0.287***  | 0.393***  | 0.170***  | –0.273*** |
|                                  | (0.042)   | (0.029)   | (0.042)   | (0.092)   |
| **upgrading***density**           | –0.037    | –0.091*** | 0.074**   | 0.366***  |
|                                  | (0.032)   | (0.022)   | (0.035)   | (0.073)   |
| **Institution**                   | –0.024*** | 0.034***  | –0.023    | –0.046**  |
|                                  | (0.009)   | (0.007)   | (0.016)   | (0.019)   |
| **upgrading***Institution**       | 0.020***  | –0.021*** | 0.040***  | 0.043***  |
|                                  | (0.007)   | (0.006)   | (0.013)   | (0.014)   |
| **density***Institution**         | 0.071*    | –0.086*** | 0.215***  | 0.611***  |
|                                  | (0.041)   | (0.029)   | (0.063)   | (0.100)   |
| **upgrading***density***Institution** | –0.055* | 0.024    | –0.238*** | –0.461*** |
|                                  | (0.033)   | (0.024)   | (0.053)   | (0.080)   |
| **Constant**                     | 0.072***  | 0.035***  | 0.076***  | 0.114***  |
|                                  | (0.009)   | (0.007)   | (0.010)   | (0.017)   |

Firm dummies: Yes
Year dummies: Yes
Observations: 1,260,815
R²: 0.027

Notes: Institution represents SUB1, SUB2, TAX1 and TAX2 in models 1–4, respectively. Standard errors are shown in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.
Third, note that the relationship between intra/inter-firm knowledge spillovers and firm upgrading is contingent on regional institutional context, especially in transitional economies such as China. Specifically, without proper protection of intellectual property rights in place, high levels of competition could reinforce the role of negative inter-firm knowledge spillovers and also inhibit the positive impact of intra-firm knowledge spillovers. Additional resources and investments may be consumed by fierce competition, which weakens firms’ capabilities of upgrading by capitalizing on firms’ internal product-specific resources and competences.

We can draw some policy implications from our empirical findings. First, local governments should seek to formulate a healthy business environment that encourages inter-firm learning rather than simple imitation, and protects firm innovation. On the contrary, an unhealthy environment may harm firm upgrading for several reasons. Second, Chinese central and local governments should rethink their ways in which to distribute subsidies and tax credits. In the context of China where inter-firm knowledge spillovers sometimes have negative impacts on firm upgrading, policies that seeks to create a competitive business environment may lead to some unwanted outcomes. For instance, it may result in rampant imitation, labour poaching and hyper-competition, which further reinforce adverse knowledge spillovers.

Future research could compare the roles of inter- and intra-firm knowledge spillovers with that of some other factors, such as extra-regional linkages. Second, this paper focuses only on regional institutional context. The interaction of multi-scale institutional contexts and their impacts over firm diversification and upgrading merit more attention. Finally, another key characteristic of institutional context is its contingency (Bathelt & Glückler, 2014). Studying the recursive processes of economic actions/interactions and institutionalization is thus of central importance and requires longitudinal research.

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