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ABSTRACT

Trade shocks, new industry entry and industry relatedness. *Regional Studies*. This paper examines the relationship between trade shocks and new industry entry at the regional level. Results show that US urban counties experiencing greater Chinese import penetration are more likely to develop new industries. From an evolutionary perspective, these trade shock-induced new industries may bring new growth opportunities to the local economy. It is also found that the positive impacts of trade shocks on industry entry are enhanced by industry relatedness. This suggests trade shock-induced industrial branching is also path dependent and can be influenced by the pre-existing industry structure of a region.

KEYWORDS

industry entry; trade shocks; industry relatedness; industrial branching; evolutionary economic geography

摘要

贸易冲击，新产业进入和产业关联性。区域研究。本文检视贸易冲击和新产业进入在区域层级的关联性。研究结果显示，在美国，中国进口渗透率越高的郡，更可能建立新的产业。从演化的观点来看，这些贸易冲击所带来的新兴产业，或许能为地方经济带来崭新的成长机会。本研究同时发现，产业关联性会增进贸易冲击对产业进入的正面影响。这表示贸易冲击所引发的产业扩展分支亦为路径依赖，并且可能受到一个区域的既有产业所影响。

关键词

产业进入; 贸易冲击; 产业关联性; 产业扩展分支; 演化经济地理

RÉSUMÉ

Les chocs commerciaux, l'entrée de la nouvelle industrie et la connexité industrielle. *Regional Studies*. Cet article examine le rapport entre les chocs commerciaux et l'entrée de la nouvelle industrie sur le plan régional. Les résultats montrent que les comtés urbains américains accusant une plus grande pénétration des importations en provenance de la Chine sont plus susceptibles de développer de nouvelles industries. D'un point de vue évolutionniste, ces nouvelles industries, provoquées par les chocs commerciaux, pourraient apporter de nouvelles possibilités de croissance à l'économie locale. Il s'avère aussi que les effets positifs des chocs commerciaux sur l'entrée de l'industrie sont améliorés par la connexité industrielle. Cela laisse supposer que la succursalisation industrielle provoquée par les chocs commerciaux présente aussi une dépendance du sentier et pourrait être influencé par la structure industrielle préexistante d'une région.

MOTS-CLÉS

entrée de l'industrie; chocs commerciaux; connexité industrielle; succursalisation industrielle; géographie économique évolutionniste

ZUSAMMENFASSUNG

Handelsschocks, Branchengründung und Branchenverwandtschaft. *Regional Studies*. In diesem Beitrag wird die Beziehung zwischen Handelsschocks und der Gründung von neuen Branchen auf regionaler Ebene untersucht. Aus den Ergebnissen geht hervor, dass in ländlichen Bezirken der USA, die stärker von chinesischen Importen betroffen sind, häufiger neue Branchen entstehen. Aus einer evolutionären Perspektive können diese durch Handelsschocks entstehenden neuen Branchen neue Wachstumschancen für die einheimische Wirtschaft bedeuten. Ebenso wird festgestellt, dass sich die positiven Auswirkungen von Handelsschocks auf die Branchengründung durch eine Verwandtschaft der Branchen

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verstärken. Dies lässt darauf schließen, dass eine durch Handelsschocks bedingte Branchenbildung auch pfadabhängig ist und von der bereits vorhandenen Branchenstruktur einer Region beeinflusst werden kann.

SCHLÜSSELWÖRTER
Branchengründung; Handelsschocks; Branchenverwandtschaft; Branchenbildung; evolutionäre Wirtschaftsgeografie

RESUMEN
Perturbaciones comerciales, creación de industrias nuevas y vínculos en la industria. *Regional Studies*. En este artículo se analiza la relación entre las perturbaciones comerciales y la creación de industrias nuevas a nivel regional. Los resultados muestran que las comarcas urbanas de los Estados Unidos en las que ocurre una mayor penetración de importaciones chinas presentan más probabilidades de desarrollar nuevas industrias. Desde una perspectiva evolutiva, estas nuevas industrias inducidas por las perturbaciones comerciales pueden aportar nuevas oportunidades de crecimiento en la economía local. También se observa que los efectos positivos de las perturbaciones comerciales en la creación de industrias mejoran debido a las relaciones entre las industrias. Esto indica que la creación de sectores industriales inducida por las perturbaciones comerciales también depende del camino que se siga y puede estar influenciada por la estructura industria ya existente de una región.

PALABRAS CLAVES
entrada de industria; perturbaciones comerciales; vínculos en la industria; creación de sectores industriales; geografía económica evolutiva

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INTRODUCTION

The impacts of globalization on regional economies have been widely studied in recent years. For high-income countries a notable transformation in the patterns of international trade during the past several decades has been the rapid growth of import competition from newly industrialized countries (Krugman, 2008). Import penetration from low-income countries has caused substantial influences on US local economies, and it has been found that regions specialized in industries heavily exposed to import competitions are more likely to experience adverse economic shocks in the short run (Autor, Dorn, & Hanson, 2013; Leichenko & Silva, 2004). How a regional economy responds to trade shocks has attracted increasing attention in researchers and policy practitioners.

While most previous studies on trade and regional economies use quantitative indicators such as employment, wage or poverty rate, this paper focuses on qualitative change in local economic structures. Specifically, it investigates how trade shocks stimulate creations of new industries in a region, and how this process is influenced by industry relatedness. Based on a factor reallocation effect caused by import competition, this paper develops a probability model of trade shock-induced industry entry. Although the direct impacts of trade shocks are adverse on the economy, they may help to unfreeze regional production factors from declining sectors and reallocate them to industries with better growth potential. Thus, it is expected that regions experiencing higher levels of import competition are more likely to develop new industries. This hypothesis is supported by data on the industrial structures of US urban counties and Chinese imports during 2000–07.

This effect of trade shock-induced industry entry offers a new perspective to conceptualize regional economic resilience. Recent studies in evolutionary economic geography advocate an evolutionary approach to economic resilience, which emphasizes the capacity of an economy to reconfigure its economic structure and develop new growth pathways (e.g., Boschma, 2015; Christopherson, Michie, & Tyler, 2010; Hassink, 2010; Pike, Dawley, & Tomaney, 2010; Simmie & Martin, 2010). In this sense, trade shock-induced new industries may provide new economic opportunities for a region. If they can grow bigger and create persistent employment and sales, then they may become new growth pathways for the local economy and make the region more resistant to trade shocks.

Another widely discussed topic in the recent literature on evolutionary economic geography is the association between industry relatedness and industrial branching. It is suggested that industrial branching is path dependent, and the emergence of new industries in a region is strongly influenced by their relatedness with the pre-existing industrial structure of the local economy (Berger & Frey, 2015; Boschma, Eriksson, & Lindgren, 2014; Essletzbichler, 2015; Frenken & Boschma, 2007; Martin & Sunley, 2006; Neffke, Henning, & Boschma, 2011). This paper finds that the interaction effects between industry relatedness and trade shocks are positive in affecting industry entry, which means the positive impact of trade shocks on an industry entry is enhanced by this industry's relatedness with the pre-existing industrial structure of this region. This finding contributes to the literature by revealing that external shock-induced industrial branching may also be path dependent, and is likely to be influenced by industry relatedness.

This paper is organized as follows. A probability model of trade shock-induced industry entry is developed in the next section. In the third section, industry relatedness is incorporated to the model. Variables and data are described in the fourth section and empirical results are shown in the fifth section. The sixth section discusses regional resilience. The seventh section concludes.

TRADE SHOCK-INDUCED NEW INDUSTRY ENTRY

Factor reallocation effect

Theories indicate that trade liberalization increases competition and encourages countries to specialize in the industries in which they have comparative advantages. That means trade will result in a redistribution of resources among industries. In recent decades, researchers have studied this trade shock-induced reallocation effect at finer levels. Krugman (1980), Melitz (2003), and Melitz and Ottaviano (2008) find that the impacts of trade penetration vary across firms of different productivity levels, and firms' chances of survival depend on their relative efficiencies. This leads to an intra-industry (between-firm) reallocation of factors (see Tybout, 2003, for a review). More recent studies point out that this trade shock-induced reallocation effect exists not only at the intra-industry level but also at intra-firm level, i.e., multi-product firms confronted with trade shocks will reallocate resources to core products with the highest efficiencies (Bernard, Redding, & Schott, 2010; Chen, Imbs, & Scott, 2009; Eckel & Neary, 2010; Iacovone & Javorcik, 2010; Mion & Zhu, 2013).

In this literature, however, limited attention has been given to regional analysis. Few previous studies have investigated how trade shocks reallocate factors and resources within a region and reshape its industrial structure. Some studies discussed trade shock-induced structural change in employment, which are more relevant to this paper. These studies suggest sectors that are more exposed to import competition are at a disadvantage and suffer higher losses compared with sectors that are not (Kovak, 2013; Leichenko & Silva, 2004; Liang & Goetz, 2016; Topalova, 2010). Autor et al. (2013) use a general equilibrium model to investigate how the increasing Chinese import competition affects US commuting zones. Based on their model, an increase in imports incurs a reallocation of labour between traded and non-traded sectors as well as within traded sectors due to wage imbalance.

Therefore, in this research it is expected that although the direct impacts of import competition are generally negative on local economies, trade shocks can help unfreeze regional production factors, such as labour and land, from those declining sectors and make them available to new industries. This effect in turn offers favourable conditions for the emergence of new industries. This relationship leads to the basic hypothesis of this study:

> *Hypothesis: Trade shocks can increase the possibility of new industry entries in a regional economy.*

In other words, *ceteris paribus*, regions facing higher levels of import penetration are more likely to have industry entries. This hypothesis is formally developed with the following model.

A probability model

It is assumed that L_i is the total labour force in region i; there is no migration; and at time $t0$ the equilibrium wage in region r is W_r. Each industry i in region r (whether or not i exists in r's portfolio) has a 'breaking point' wage level $W^*_{i,r}$, which means if the actual wage is lower than this breaking point, then the industry is earning positive profit. Thus, if it is assumed that labour productivities are identical, then at time $t0$ sector i should exist in the industry portfolio of region r if $W_r < W^*_{i,r}$, i.e.:

$$\text{Portfolio}\,(i,\, r,\, t0) = 1 \quad \text{if} \;\; W^*_{i,r} - W_r + v_{i,r} > 0 \qquad (1)$$

where $v_{i,r}$ is a decision error term that represents all the non-wage factors that influence industry i's existence in region r. Notice that in this model one can also interpret labour L_i and wage W in a more general way, i.e., L_i refers to all the imperfectly mobile factors in a local economy, such as land, natural advantage and resources, and W is a composite rent of them. Thus, the decision error term represents all the influences other than L_i.

Trade shocks happen during $t0 \rightarrow t1$ and cause W_r and $W^*_{i,r}$ to change in the ratios of $\hat{W}_r$ and $\hat{W}^*_{i,r}$, respectively (where a 'hat' means percentage change). So at time $t1$, the portfolio condition is:

$$\begin{aligned}\text{Portfolio}\,(i,\, r,\, t1) = 1 \quad \text{if} \;\; & W^*_{i,r}(1 + \hat{W}^*_{i,r}) - W_r(1 + \hat{W}_r) \\ & + u_{i,r} > 0 \end{aligned} \qquad (2)$$

where $u_{i,r}$ is a new decision error term for this period. For observations with *Portfolio*$(i,r,t0) = 0$, rearranging (2) yields:

$$\begin{aligned}\text{Entry}_{i,r} = 1 \quad \text{if} \;\; & W^*_{i,r} * \hat{W}^*_{i,r} - W_r * \hat{W}_r \\ & + (W^*_{i,r} - W_r) + u_{i,r} > 0 \end{aligned} \qquad (3)$$

where the binary variable $Entry_{i,r}$ indicates whether industry i enters region r during this period. It is further assumed that at $t0$ (before the trade shock occurs), the whole country's labour market is in an equilibrium, so that there are no systematic variations in W_r and $W^*_{i,r}$ among different regions, and they are replaced by a constant and an industry-specific variable W^*_i, respectively. Trade shock comes from outside the country and is industry specific, so $\hat{W}^*_{i,r}$ is also substituted with an industry-specific variable $\hat{W}^*_i$. After these substitutions, rearranging model (3) yields the following probability model (the distribution function $\Phi(\bullet)$ on the right-hand side is omitted for brevity):

$$\begin{aligned}\text{Prob}\,(\text{Entry}_{i,r} = 1) & \\ & = C + \theta_1 * \hat{W}_r + \theta_2 * W^*_i(\hat{W}^*_i + 1) \\ & + \epsilon_{i,r} \end{aligned} \qquad (4)$$

where θ_1 and θ_2 are coefficients to be decided. In (4), $W^*_i(\hat{W}^*_i + 1)$ is an industry-specific fixed effect that can be simply substitute by a set of industry dummies α_i, so model (4) becomes:

$$\text{Prob}\,(\text{Entry}_{i,r} = 1) = C + \theta_1 * \hat{W}_r + \alpha_i + \epsilon_{i,r} \qquad (5)$$

Based on model (5) and its earlier form (3), the coefficient θ_1 is expected to be negative, which suggests a lowered wage level can increase the (potential) profit of an industry and thus enhance the possibility of industry entries. Given that $\hat{W}_r$ should be inversely correlated with regional trade shocks (Autor et al., 2013), (5) is further written as (6), where some control variables of local economic and demographic conditions, *controls$_r$*, are also included.

$$\mathrm{Prob}\,(\mathrm{Entry}_{i,r}) = C + \beta * \mathrm{Trade\ \ shock}_r + \alpha_i + \mathrm{controls}_r + \epsilon_{i,r} \tag{6}$$

If the above hypothesis is true, β in model (6) should be positive, meaning that a higher level of trade shock stimulates more industry entries in a region.[1] The computing of $Entry_{i,r}$ and Trade shock$_r$ in (6) will be described in the fourth section.

INDUSTRY RELATEDNESS AND EVOLUTIONARY ECONOMIC GEOGRAPHY

It has been widely believed that industry relatedness can influence regional economic development, as technology spillovers and industrial cross-fertilization are geographically bounded and are more likely to happen between related sectors (Ellison, Glaeser, & Kerr, 2010; Frenken, Cefis, & Stam, 2014; Glaeser, Kallal, Scheinkman, & Shleifer, 1992; Porter, 2003). Meanwhile, the relationship between industry relatedness and industrial branching is also attracting increasing attention. It has been found that at the country level the current state of industrial structure can shape its future evolution (Hausmann & Hidalgo, 2010; Hidalgo, Klinger, Barabási, & Hausmann, 2007). Many case studies at regional level have also shown that new economic activities do not start from scratch, but tend to emerge in regions that can offer related assets and/or intangible supports (e.g., Boschma & Wenting, 2007; Buerger & Cantner, 2011; Klepper, 2007). However, studies that systematically test the relationship between industry relatedness and industrial branching at the regional level had been scarce until very recently. Neffke et al. (2011) investigate how industry relatedness influences regional diversification in Swedish regions, and their results suggest industries with higher levels of technological proximity to the pre-existing sectors in a region have higher probabilities to enter that region. Boschma, Minondo, and Navarro (2013) distinguish between capabilities at the regional and national levels, and demonstrate that the former plays a larger role in affecting new industry entries. Essletzbichler (2015) finds technological relatedness is positively associated with industry entry and industrial portfolio membership in US metro areas. Berger and Frey's (2015) research about US cities suggests the emergence of new industries mainly occurs in cities dominated by industries that use similar skills.

Given these associations between industry relatedness and industry entry, variables of industry relatedness are included in the model of this study for two purposes. First, in order to estimate more accurately the impacts of trade shocks on industry entry in a region by model (6), the influences of industry relatedness should be properly controlled so as to avoid systematic estimation bias. Second, interaction effects between trade shocks and industry relatedness on new industry entries are also important. Existing studies in the literature mainly focus on the direct impacts of industry relatedness on industrial branching. In other words, what they have studied is usually the *spontaneous* evolution of regional industry structure. With the framework of trade shocks and industry entry developed in this research, it is possible to study further how relatedness influences industry entries that are *induced by trade shocks*. The method is to include cross-terms between trade shocks and variables of industry relatedness in model (6), which will be specified in the fifth section.

This study will use several variables to measure industry relatedness, including labour suitability, input–output linkages, industry clustering and related variety. They can cover the concept of relatedness from various angles. Their definitions and computing methods will be described in the next section.

VARIABLES AND DATA

Industry entry

The measure of industry entry used in this paper is developed from an industrial portfolio approach proposed by Neffke et al. (2011). If an industry i has non-zero employment at region r in year t, it is said that i exists in the industrial portfolio of region r at time t, or:

$$\mathrm{Portfolio}\,(i,\ r,\ t) = \begin{cases} 1, & \mathrm{Employment}_{i,r,t} > 0 \\ 0, & \mathrm{otherwise} \end{cases}$$

Then, if the employment of industry i in region r is null at time $t0$ ($Portfolio(i,r,t0) = 0$) and is non-zero at time $t1$ ($Portfolio(i,r,t1) = 1$), then there is an observed industry entry. However, a possible problem with this single-year portfolio measure is that the addition of a new industry between two time points might be arbitrary and is very likely to be affected by random disturbances in the start and end years. So in this study this method is modified and the portfolio membership is measured over three years,[2] i.e., for the initial and ending periods respectively:

$$\mathrm{Portfolio\_3year}\,(i,\ r,\ t0) = \begin{cases} 1, & \mathrm{Employment}_{i,r} > 0 \text{ for } 1998,\ 1999,\ 2000 \\ 0, & \mathrm{Employment}_{i,r} = 0 \text{ for } 1998,\ 1999,\ 2000 \end{cases}$$

$$\mathrm{Portfolio\_3year}\,(i,\ r,\ t1) = \begin{cases} 1, & \mathrm{Employment}_{i,r} > 0 \text{ for } 2005,\ 2006,\ 2007 \\ 0, & \mathrm{Employment}_{i,r} = 0 \text{ for } 2005,\ 2006,\ 2007 \end{cases}$$

And industry entry is defined as:

$$\mathrm{Entry}\,(i,\ r,\ t0 \rightarrow t1) = \begin{cases} 1, & \mathrm{Portfolio\_3year}\,(i,r,t0) = 0 \text{ and } \mathrm{Portfolio\_3year}\,(i,r,t1) = 1 \\ 0, & \mathrm{Portfolio\_3year}\,(i,r,t0) = 0 \text{ and } \mathrm{Portfolio\_3year}\,(i,r,t1) = 0 \\ \mathrm{NA}, & \mathrm{Portfolio\_3year}\,(i,r,t0) = 1 \end{cases}$$

Table 1. Summaries of industry entry in urban counties (1998/1999/2000–2005/2006/2007).

All *r*–*i* combinations	Portfolio_3year (*i*,*r*,98/99/00)	Portfolio_3year (*i*,*r*,05/06/07)	Entry(*i*,*r*)	% of Entry(*i*,*r*)
$N = 200{,}008$	0; $N = 125{,}628$	1; $N = 6{,}070$	1	4.83
		0; $N = 119{,}558$	0	95.17
	Others; $N = 74{,}380$	n.a.		

Notes: *r* indicates an urban county; *i* indicates a five-digit North American Industry Classification System (NAICS) manufacturing industry.
n.a., Not applicable.

For brevity, the time argument ($t0 \rightarrow t1$) is omitted in the expression of *Entry* hereafter. Data for calculating *Portfolio* and *Entry* are drawn from the US Census County Business Patten (CBP) dataset, which provides annual county data of employment and establishment by detailed industry. In this study, industry is examined at five-digit North American Industry Classification System (NAICS) level of manufacturing sectors, which yields 184 industries. There are altogether 1087 urban counties in the dataset. Descriptives of *Entry* observations are shown in Table 1.

Regional trade shocks

Trade data in this study focus on the increase in Chinese imports from 2000 to 2007, a period with greater increase in Chinese imports than ever before, and before the financial crisis. Two reasons make this data ideal for the research here. First, the increase in Chinese imports accounted for most of the US import increases from low-income countries during this period; second, the trade advantage of Chinese manufacturers was largely due to increased productivity and/or lowered trade barriers, which were likely to be exogenous to local US economies at the county level (Liang & Goetz, 2016), allowing for greater estimation efficiency.

US county-level import statistics are not available from a public database. Thus, a measure of counties' trade exposure need to be indirectly derived based on local industry specialization, an approach widely used in recent studies (Edmonds, Pavcnik, & Topalova, 2010; Kandilov, 2009; Kovak, 2013; Topalova, 2010). Specifically, the exposure to trade shock in a region is measured by change in imports per worker (ΔIPW), calculated as:

$$\Delta \mathrm{IPW}_r = \frac{1}{L_r}\sum_i \frac{L_{i,r}}{L_{i,\mathrm{US}}}\Delta M_i \tag{7}$$

where ΔM_i is the change in Chinese imports (in thousands of US\$) in sector i for the whole United States during 2000–07; $L_{i,r}$ is employment of sector i in county r; $L_{i,\mathrm{US}}$ is employment of sector i in the United States; and L_r is total manufacturing employment in county r. Therefore, $\Delta \mathrm{IPW}_r$ measures the import shock per worker in county r during this period (in thousands of US\$/worker), and a greater value means higher import competition. $\Delta \mathrm{IPW}_r$ will be used as the measure of *Trade shocks* in model (6). In (7), data from Chinese imports M_i are from the International Trade Statistics database of the US Census Bureau; the three labour variables $L_{i,r}$, $L_{i,\mathrm{US}}$ and L_r for initial year come from CBP 2000.

Industry relatedness

Input–output linkage

The development of an industry depends on exchanges of tangible and intangible factors with other sectors. Support from related, pre-existing sectors in a region is essential for the emergence of new firms and new industries (Essletzbichler, 2015; Glaeser & Kerr, 2009). The intensity of input–output linkages between an industry and the incumbent sectors of a region provides a relevant measure for the closeness of the supply chain and technology similarity between this industry and the existing sectors.

The input (*IO_IN*) and output (*IO_OUT*) linkages of a focal industry i with the incumbent sectors in a region r are measured as (8) and (9), respectively. Subscript k refers to all incumbent industries in a region. $\mathrm{Input\_share}_{i \leftarrow k}$ in (8) is the share of intermediate input values that i obtains from k in the total intermediate input purchase values of i, and $\mathrm{Output\_share}_{i \rightarrow k}$ in (9) is the share of k's purchase from i in i's total output values. $\mathrm{ES}_{k,r}$ is sector k's employment share in region r. $IO\_IN_{i,r}$ and $IO\_OUT_{i,r}$ are calculated as the initial year 2000 values with employment data from CBP 2000; and $\mathrm{Input\_share}_{i \leftarrow k}$ and $\mathrm{Output\_share}_{i \rightarrow k}$ are calculated based on 1997 US Benchmark Input–Output Data obtained from the US Bureau of Economic Analysis (BEA).

$$IO\_IN_{i,r} = \sum_k \mathrm{ES}_{k,r} * \mathrm{Input\_share}_{i \leftarrow k} \tag{8}$$

$$IO\_OUT_{i,r} = \sum_k \mathrm{ES}_{k,r} * \mathrm{Output\_share}_{i \rightarrow k} \tag{9}$$

$IO\_IN_{i,r}$ ($IO\_OUT_{i,r}$) measures abundance of input suppliers (output markets) in region r for industry i. Geographical proximity to suppliers and demanders reduces shipping costs and makes a region more attractive to potential entrants (Fujita, Krugman, & Venables, 2001, 1999; Krugman, 1991). It is also suggests that geographical closeness to up- and downstream sectors can enhance innovation and productivity by increasing a firm's awareness of what products are preferred by customers and what novel inputs are available (Porter, 1990).

Labour suitability

Another important driving force for the emergence of new economic activities is the availability of a suitable labour pool (Boschma et al., 2014; Combes & Duranton, 2006). A common occupation and skill pool reduces the costs of searching appropriate labour and promotes the entry and agglomeration of related industries. The approach to measure labour suitability between a new industry and a region is similar to Glaeser and Kerr (2009), which is based on the similarity of occupation requirements between industries. Data come from the Industry–Occupation Matrix (IOM) published by the US Bureau of Labor Statistics. The IOM provides industrial employments in different occupations at the national level. Labour suitability between a focal industry i and a region r is calculated as (10). $Corr_{i,k}$ is the correlation coefficient between industry i's and industry k's employment shares in the 22 top-level occupation categories. $\mathrm{ES}_{k,r}$ is sector k's employment share in region r. A greater value of $\mathrm{Labor}_{i,r}$ thus indicates a higher level of relatedness between industry i and the pre-existing sectors in region r in terms of labour suitability:

$$\mathrm{LABOR\_SUIT}_{i,r} = \sum_k \mathrm{ES}_{k,r} * \mathrm{Corr}_{i,k} \tag{10}$$

Related variety

The relationship between agglomeration and economic growth has been widely debated since the seminal work of Glaeser et al. (1992). Following Jacobs (1969), one perspective in agglomeration economies is that the variety or diversity of regional industries can contribute to local economic development. It is suggested that industrial variety can help firms to recombine different knowledge and ideas, leading to more innovations. Frenken, Van Oort, and Verburg (2007) propose the idea of *related variety*, which specifically measures the diversity of related industries. Since then, this concept has been widely applied in studies on regional development (Boschma, Minondo, & Navarro, 2012; Hartog, Boschma, & Sotarauta, 2012; Van Oort, De Geus, & Dogaru, 2014; Saviotti & Frenken, 2008; Wixe & Andersson, 2016).

Following Bishop and Gripaios (2010) and Frenken et al. (2007), related variety (RV) at a two-digit NAICS sector level in county r is calculated using the following entropy method:

$$\mathrm{RV}_{j,r} = \sum_{i \in I_j} \frac{\mathrm{emp}_{r,i}}{\mathrm{emp}_{r,j}} \log\left(\frac{\mathrm{emp}_{r,j}}{\mathrm{emp}_{r,i}}\right) \tag{11}$$

where emp is the number of employed; j refers to a two-digit NAICS sector; and I_j is the set of all the industries at a more disaggregated level (here are five-digit NAICS sectors, which are denoted with subscript i) that fall exclusively under this two-digit sector j. Industries that belong to the same broader (two-digit) industry category are deemed as 'related' to one another. For a two-digit industry j, if its employment is distributed more evenly in the sectors of its disaggregated level, it has a greater value of related variety according to (11).

In order to control for the scale effect of a two-digit industry j which may inflate the value of related variety, location quotients of employment (LQM) at the two-digit NAICS level are also included in the model. In fact, in this stream of literature LQM at a broader industrial level is usually used to measure clustering (CLU) effects of related sectors, as in (12). All the emp data in (11) and (12) are from CBP 2000:

$$\mathrm{CLU}_{j,r} = \frac{\mathrm{emp}_{r,j}/\mathrm{emp}_r}{\mathrm{emp}_{\mathrm{US},j}/\mathrm{emp}_{\mathrm{US}}} \tag{12}$$

Other control variables

The creation of new industries is also likely to be influenced by the level of entrepreneurship in a region. Entrepreneurial activities are associated with creative destruction and economic renovation (Schumpeter, 1934), and can bring about novel products or help a local economy better adapt to uncertain conditions in the market (Acs & Szerb, 2007; Acs & Varga, 2005). It is also suggested that entrepreneurs can accelerate an economy's structural evolution by introducing greater competitions to the market and absorbing the surplus labour force from shrinking sectors (Fritsch, 2013; Gries & Naudé, 2010).

The measure of entrepreneurship is based on industry-weighted firm entry rates (Fritsch, 1997; Johnson, 2004; Renski, 2012). Firm entry rate is defined as the number of entrants divided by the number of incumbent firms in an industry. Supposing that the average firm entry rate of industry i at the national level is $\bar{E}_i$, its actual entry rate in region r is $E_{i,r}$, and $s_{i,r}$ is the share of industry i in total firm numbers of region r, then the regional entrepreneurship level is calculated as:

$$\mathrm{ENT}_r = \frac{\sum_i s_{i,r} * E_{i,r}}{\sum_i s_{i,r} * \bar{E}_i} \tag{13}$$

where the nominator is the actual new firm formation rate of region r, and the denominator is an expected regional firm entry rate assuming every industry in the region resembles its national average entry rate. A higher level of ENT indicates greater regional entrepreneurial activity. Compared with other entrepreneurship measures, such as the actual firm entry rate, the advantage of (13) is that it accounts for the influence of regional industry mix. In order to avoid reverse causality, (13) is calculated with four-digit Standard Industrial Classification (SIC) manufacturing sector data averaged from 1990 to 1994, roughly 10 years' lag from the main study period (2000–07). Regional industry shares $s_{i,r}$ are drawn from CBP (1990–94), and sectoral firm entry data of counties are drawn from the US Census' Business Dynamics Statistics (BDS).[3]

Other regional control variables include demographic factors: population and age composition, which are from the US Census 2000 database. Regional fixed effects (regional dummies) are controlled at the combined statistical area (CSA) level. CSA is one of the statistical areas defined by the US Census. A CSA is composed of adjacent metropolitan and/or micropolitan statistical areas that have strong commuting linkages. The 1087 urban counties studied in this study are delineated into 197 CSAs.

Table 2. Statistics of independent variables.

Variable	Mean	SD
Region-specific variables		
Trade shocks (Δ*IPW*) (thousand US$/worker)	11.5	15.0
Entrepreneurship (*ENT*)	1.11	0.48
Population density (thousand/square mile)	0.36	1.72
Percentage of the population aged < 18 (%)	25.8	3.10
Percentage of the population aged 40–64 (%)	31.0	3.10
Percentage of the population aged > 64 (%)	12.8	4.60
Industrial relatedness		
Output linkages (*IO_OUT*)	5.80E–4	4.99E–3
Input linkages (*IO_IN*)	9.20E–4	4.24E–3
Labour suitability (*LABOR_SUIT*)	8.49E–3	2.30E–3
Related variety (*RV*)	1.43	0.82
Clustering (*CLU*)	1.38	1.85

Note: Δ*IPW* is for 2000–07; *ENT* is computed based on data for 1990–94; all other variables are for 2000 data.

Descriptive statistics of all independent variables are shown in Table 2. For ease of interpretation, in following regressions the trade shock (Δ*IPW*), industry relatedness variables and entrepreneurship (*ENT*) are normalized with median values equal to 0 and standard deviations equal to 1.

EMPIRICAL RESULTS

Geography of trade shocks and new industry in US urban counties

This study focuses on US urban (metro) counties in the 48 contiguous states as defined by US Census. During the study period (2000–07), urban counties account for around one-third of the number of total counties but nearly 80% of total population. Figure 1 shows the geographical distributions of trade shocks and new industry entries in urban counties for 2000–07. Each coloured polygon in the maps represents an urban county; blank areas are rural counties not included in the data. The quantile rank of each county is indicated by different colours as specified in the legends. In Figure 1(A), trade shocks are measured by ΔIPW as defined with (7). In Figure 1(B), regional industry entry rate (in %) is calculated as the number of actual industry entries divided by the number of total possible industry entries in a county during this period; industry entry is defined as Entry $(i, r, t0 \rightarrow t1)$ in the fourth section.[4]

In Figure 1(A), as expected, those manufacturing-intensive areas are among the heavily trade-exposed counties, including many parts of the Northeast and South Central regions, and, to some extent, many West Coast counties. Analogously, Figure 1(B) shows the geographical distribution of industry entry rates. Counties with high entry rates are densely distributed in traditional economic centres in the Northeast area and in the high-tech belts of California and Seattle vicinity. Meanwhile, many counties in North Central and Southeast regions also have notable industry entries. By comparing Figures 1(A) and (B), the distribution of trade shocks is somewhat more geographically concentrated than that of industry entries. While both of them have substantial concentrations in Northeast and West Coast regions, counties with high entry rates are more evenly scattered in Southeast and the vast inland areas.

Furthermore, analysis suggests that trade shocks are much more dependent on regional industrial structure than are industry entry rates. Simple ordinary least squares (OLS) regressions find that employment shares of three-digit NAICS industries can explain 38% of the variations in trade shocks of urban counties, while only 12% of the variations in industry entry rates can be explained. Chinese imports mainly focus on labour-intensive products, such as apparel, footwear, furniture, toys and leather goods. So regions with high concentrations on these sectors are

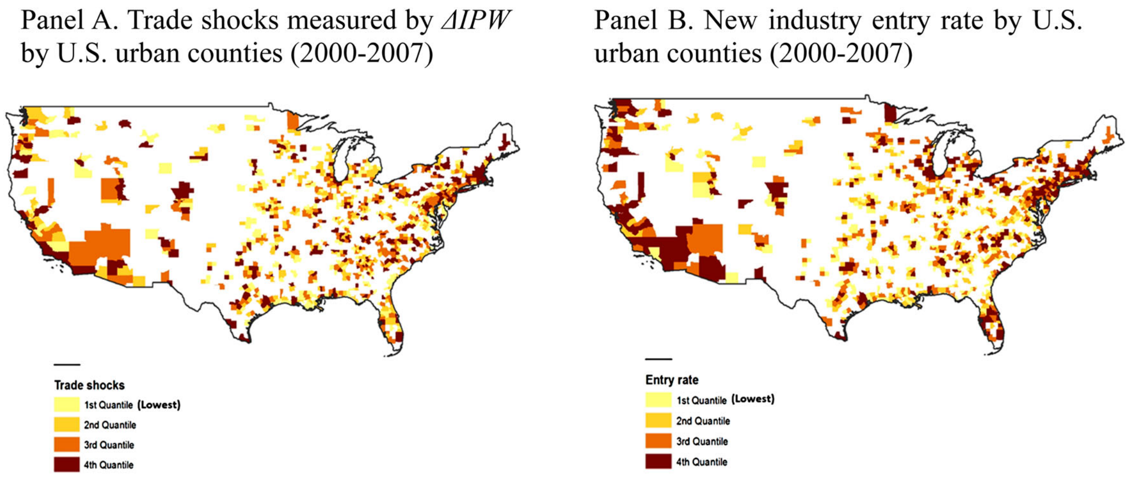

Figure 1. Trade shocks and industry entry rate by urban county.

more exposed to trade shocks. Because trade shocks are strongly dependent on regional industry structure while industry entries are not, it is not likely that the empirical association between trade shocks and industry entry is spuriously caused by common industry structures.

Methods and empirical results

First, all dependent variables are substituted into model (6), leading to:

$$\begin{aligned}\text{Probit (Entry)} = {} & C + \beta_1 \Delta\text{IPW} + \beta_2\text{IO\_OUT} \\ & + \beta_3\text{IO\_IN} \\ & + \beta_4\text{LABOR\_SUIT} + \beta_5\text{RV} \\ & + \beta_6\text{CLU} + \beta_7\text{ENT} \\ & + \text{Demographics} \end{aligned} \tag{14}$$

Model (14) is estimated with Probit method and results are reported in columns (a)–(c) of Table 3. The coefficients of trade shock ΔIPW are significantly positive in all columns, which confirms the prediction that the probability of a new industry entry in a region is positively associated with trade shocks that this region experienced. Coefficients of variables of industry relatedness are all positive and statistically significant (except Clustering), which means industry relatedness has positively impacts on industry entry. Further analysis of the marginal probability effects based on the results of column (c) suggests that compared with regions at the median value of trade shocks, a 1 standard deviation's difference in ΔIPW increases the possibility of a new industry entry by 0.3%. This is a noticeable increment considering that there are altogether 184 industries studied in the data.

Table 3. Trade shock-induced new industry entry in urban counties, 2000–07

	(a)	(b)	(c)	(d)
Trade shocks (Δ*IPW*)	0.017***	0.015**	0.015**	0.024***
	(0.006)	(0.007)	(0.007)	(0.009)
Output linkages (*IO_OUT*)			0.021***	0.021***
			(0.007)	(0.008)
Input linkages (*IO_IN*)			0.022***	0.023***
			(0.007)	(0.007)
Labour suitability (*LABOR_SUIT*)			0.013*	0.011
			(0.008)	(0.008)
Related variety (*RV*)			0.465***	0.459***
			(0.011)	(0.012)
Clustering (*CLU*)			0.011	0.010
			(0.009)	(0.009)
Entrepreneurship (*ENT*)			−0.010	−0.028***
			(0.010)	(0.009)
Interaction terms				
*IO_OUT*ΔIPW*				0.004
				(0.019)
*IO_IN*ΔIPW*				0.010
				(0.004)
*LABOR_SUIT*ΔIPW*				0.009~
				(0.007)
*RV*ΔIPW*				0.027**
				(0.011)
*CLU*ΔIPW*				0.005
				(0.010)
*ENT*ΔIPW*				0.028***
				(0.008)
Demographic controls		Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Regional fixed effects (CSA)	Yes	Yes	Yes	Yes

Notes: $N = 140{,}396$ region-industries. Δ*IPW*, *ENT* and industry relatedness variables are normalized with medians = 0 and SD = 1.
Level of statistical significance: ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$; ~$p < 0.20$.
CSA, combined statistical area.

Next, cross-terms between trade shock (Δ*IPW*) and variables of industry relatedness are incorporated to the model, which yields (15):

$$\begin{aligned}\text{Probit}\,(\text{Entry}) = {} & C + \beta_1\Delta\text{IPW} + \beta_2\text{IO\_OUT} \\ & + \beta_3\text{IO\_IN} + \beta_4\text{LABOR\_SUIT} \\ & + \beta_5\text{RV} + \beta_6\text{CLU} + \beta_7\text{ENT} \\ & + \gamma_1\text{IO\_OUT}*\Delta\text{IPW} + \gamma_2\text{IO\_IN}*\Delta\text{IPW} \\ & + \gamma_3\text{LABOR\_SUIT}*\Delta\text{IPW} \\ & + \gamma_4\text{RV}*\Delta\text{IPW} + \gamma_5\text{CLU}*\Delta\text{IPW} \\ & + \gamma_6\text{ENT}*\Delta\text{IPW} + \text{Demographics} \qquad (15)\end{aligned}$$

Based on (15), the actual coefficient of Δ*IPW* on the probability of industry entry is:

$$\begin{aligned}\beta_{\text{actual}} = {} & \beta_1 + \gamma_1\text{IO\_OUT} + \gamma_2\text{IO\_IN} \\ & + \gamma_3\text{LABOR\_SUIT} + \gamma_4\text{RV} + \gamma_5\text{CLU} \\ & + \gamma_6\text{ENT}\end{aligned}$$

so the coefficients of the cross-terms will show how the actual effects of trade shock-induced industry entry are influenced by these variables. Estimation results of (15) are shown in column (d) of Table 3. For variables of industry relatedness, coefficients of their cross-terms with Δ*IPW* are all positive. The cross-term of related variety (*RV**Δ*IPW*) is significantly different from zero, and the cross-term of labour suitability (*LABOR_SUIT**Δ*IPW*) has a weak trend towards significance. These results suggest the positive impacts of trade shocks on industry entry are strengthened by relatedness between a potential industry and the pre-existing industry structure of a region. In particular, related variety and labour suitability are more significant than other factors in enhancing the effect of trade shock-induced industry entry. From a regional perspective, this means industrial branching caused by Chinese import competition is path dependent, and a region is more likely to diversify into industries that are related with the local economy. Besides that, results in Table 3(d) also show the moderation effect of entrepreneurship (*ENT**Δ*IPW*) is significantly positive, which means entrepreneurship can also promote trade shock-induced industry entry.

DISCUSSIONS: REGIONAL RESILIENCE FROM AN EVOLUTIONARY PERSPECTIVE

Regional resilience against trade shocks has been widely debated recently. Traditionally, the idea of resilience is based on an engineering or equilibrium concept in which resilience is reckoned to be a passive response to external shocks or as a recovery to the original status. Recent studies on evolutionary economic geography, however, advocate an evolutionary approach to regional resilience, which emphasizes the capacity of an economy to reconfigure its economic structure and develop new growth pathways (Christopherson et al., 2010; Hassink, 2010; Simmie & Martin, 2010). And it is suggested that this new approach can help one better understand how regional economies renovate and adapt themselves when confronting external shocks (Boschma, 2015; Pike et al., 2010).

In this sense, this study provides a possible method to analyze systematically regional resilience from this evolutionary perspective. The results of this paper suggest that although the direct impacts of import penetration are adverse, trade shocks may also stimulate a regional economy to develop more new industries. Then if these new industries can endure and offer increasing employment, they will become new growth pathways and make the regional economy more resilient to trade shocks. Recent studies suggest that when facing import competitions, entries of new industries, technologies and entrepreneurial activities are associated with actual growth and can promote economic resilience (Bloom, Melitz, Ossa, Schott, & Veugelers, 2011; Hanson & Slaughter, 2002; Liang & Goetz, 2016). Regional diversification caused by industry entries can also increase economic resilience, as a diversified industrial portfolio helps to spread out sector-specific shocks and protect the local economy (Dissart, 2003; Liang, 2016; Pede, 2013). Therefore, the ability of a regional economy to create new industries when facing trade shocks is likely to be associated with economic resilience, as these shock-induced industry entries can offer new growth opportunities that may counteract the losses caused by import penetration.

In order to fully justify this link between industry entry and economic resilience, however, more empirical evidence is needed to demonstrate how these new industries can persist and increase employment. The theoretical framework built in the second section is a probability model about decision-making of industry entry, and it is not developed to analyze quantitative employment growth. In addition, the time span of the data used here (2000–07) also limits further analysis on the long-term development of new industries, as the influences of the financial crisis started from 2007/08 make data for the several years subsequent to this period inappropriate for trade shock analysis. Thus, an important topic for future research is to study the long-term actual growths, such as employment or sales, of these trade shock-induced new industries when data permit. This will help one better understand what factors can promote a region's ability to adjust its industrial structure and develop new growth pathways.

CONCLUSIONS

This paper has examined the relationship between trade shocks and new industry entries at regional level. A probability model of trade shock-induced new industry entry was developed. The model suggests that although the direct impact of import competition is adverse, trade shocks also lead to a factor reallocation effect that offers opportunities for the creation of new industries. This model was empirically analyzed with data on industrial structure of US urban counties and Chinese import for 2000–07, and the findings were as follows.

First, regions subject to higher levels of import penetration are more likely to develop new industry entries. Trade shocks reduce prices of local factors, and then the lowered input prices increase the potential profits of new industries and promote their probabilities of entry. This process suggests a new approach to conceptualize regional economic resilience, which is based on an evolutionary perspective and is advocated by recent literature about evolutionary economic geography. Specifically, if these trade shock-induced new industries can continue to grow and provide increasing employment, then they may offer new growth pathways for the local economy. So regions capable of creating new industries when facing import competition may better adapt their economic structures and have higher economic resilience. As a future research question, when data for longer periods are available, long-term growth of these trade shock-induced new industries should be investigated. This will help to fully connect industry entry with regional resilience, and may further reveal how this process of industry adaptation is influenced by local economic factors.

Second, interaction effects between trade shocks and variables of industry relatedness are positive in the model, which means the positive impacts of import competition on industry entries are strengthened by industry relatedness. It has been found in recent studies that sectors related to the pre-existing economic structure are more likely to enter a region (Berger & Frey, 2015; Boschma et al., 2014; Essletzbichler, 2015; Frenken & Boschma, 2007; Martin & Sunley, 2006; Neffke et al., 2011). This research contributes to this literature by revealing that industry relatedness not only influences *spontaneous* industry creation, but also affects industry entries *stimulated* by trade shocks. From a regional perspective, this means trade shock-induced industrial branching is also path dependent. Industries more related to the pre-existing industrial structure can better benefit from the factor reallocation effect caused by import competition at the regional level, and thus they are more likely to enter the local economy.

It is also found that among the variables of industry relatedness studied in the model, related variety has the most significant impacts on industry entry. That may suggest compared with bilateral industry linkages per se, a variety of related industries have greater contributions to the creation of new industries. Many scholars believe that a diversified economic structure where the cognitive distance between different sectors is not too large or too small can more effectively promote the recombination of ideas and technologies, and thus new industries are more likely to be incubated in related variety than in an economic structure dominated by a few large sectors (e.g., Asheim, Boschma, & Cooke, 2011; Boschma & Iammarino, 2009; Castaldi, Frenken, & Los, 2015; Frenken et al., 2007). This paper provides further evidence for this literature, i.e., when facing trade shocks, a region's ability to develop new industries is also enhanced by related variety.

Given that this research is based on a framework of Chinese import competition, one should be cautious when applying the above conclusions to other types of external shocks. Trade shock from developing counties is a special case of external shocks, which mostly involves competition from low-wage manufacturers in particular. Therefore, one question for future research is whether other kinds of external shocks can also trigger the factor reallocation effect within a local economy and stimulate new industry entries. Similarly, the relationship between industry relatedness and industry entries induced by external shocks other than trade is not yet investigated, which might be accomplished by future research as well.

This study provides extensive policy implications for regional trade-related policies and regional diversification strategies. As a result of significant local economic impacts that resulted from increasing trade penetration from developing countries, policies such as the Trade Adjustment Assistant programme have been enacted to address trade-related economic loss in the United States. The results of this paper suggest import competition can also help incubate industry entries. So if a region can make good use of these opportunities to create new industries that meet local comparative advantages and support these new industries to grow fully, then the local economy will have more growth pathways and the region will be more resilient to trade shocks. In addition, regional diversification is path dependent, so industry relatedness should be considered in industrial branching strategies so as to achieve higher policy efficiency. Specifically, industries in harmony with local cohesion of labour pool, input–output linkages and related varieties can better benefit from local spillovers, and thus they are more likely to enter this region and create new growth opportunities. Finally, it is also found that entrepreneurial regions are more capable of adjusting their economic structures, allowing them to adapt effectively to external shocks. This result is consistent with a growing literature about the roles of entrepreneurship in regional adaptation and evolution (e.g., Glaeser, Rosenthal, & Strange, 2010; Liang & Goetz, 2016), and it suggests policy instruments for entrepreneurship can also be used to promote a region's industry branching and adaptation.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

NOTES

1. These new industries may either come from outside the region (*attracted* from outside) or be *produced* locally (e.g., spinoffs of incumbent firms). This study does not distinguish between these two types of entries and assumes they both follow the same decision-making pattern specified in the model. The author is grateful to an anonymous reviewer for pointing this out.
2. The author is grateful to an anonymous reviewer for this suggestion.

3. BDS data at county level are obtained by special request. The BDS provides two types of firm birth statistics: multi- and single establishment. The former refers to a new branch establishment of an existing firm, the latter to a new start-up. Firm entry in (13) is based on single-establishment data, as small start-ups are more related with entrepreneurial activities than large firms (Glaeser et al., 2014).

4. Regional industry entry rate is aggregated to county level and is used in Figure 1 only; the binary variable Entry $(i, r, t0 \rightarrow t1)$ at region-industry level is used for model estimations below.

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