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Trade Reform and the Evolution of Agglomeration in Vietnamese Manufacturing

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Abstract: *It is well-documented that agglomeration contributes to productivity growth. However, concentrations of workers could also lead to increasing regional income disparities. Therefore, understanding the evolution of agglomeration is relevant for the formulation of industrial policy and inclusive growth. This study documents the extent, pattern, and determinants of agglomeration in Vietnamese manufacturing during 2002–2016, a period when substantial economic reform took place. Our major findings are three-fold. First, agglomeration, as measured by the Ellison–Glaeser index, has declined since the mid-2000s. Second, there exists significant sectoral heterogeneity in the level and trend of agglomeration. Third, we do not find a significant impact of trade and foreign direct investment on agglomeration per se. However, foreign direct investment in port districts does contribute to disagglomeration.*

Keywords: agglomeration, trade liberalisation, transitioning economies
JEL codes: F13; F15; O18; P25

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1. Introduction

From a geographical point of view, firms in the manufacturing industries tend to be highly concentrated (Greenstone et al., 2010). Well-known examples include the United States' Silicon Valley, India's Bangalore, Thailand's Eastern Seaboard, and China's coastal areas, to name a few. Since agglomeration contributes to productivity growth while potentially resulting in increasing regional disparity, studying the evolution of agglomeration has important implications for industrial policies and regional development policies (Rosenthal and Strange, 2004; Combes et al., 2012; Francois and Nguyen, 2017). There is a vast literature on how and why these clusters emerge (e.g. Dumais, Ellison, and Glaeser, 2002; Combes and Gobillon, 2015; Hanlon and Miscio, 2017). However, due to data availability, these studies have mainly focused on developed countries so far.

This paper contributes to the empirical literature on the spatial distribution of industries in the case of Viet Nam, a transitioning economy. Our research objectives are threefold. First, we examine the pattern and evolution of geographical concentration in Vietnamese manufacturing during 2002–2016, a period marked by extraordinary structural change and increasing economic integration. We focus on the agglomeration of firms within an industry. Second, we explain the determinants of industrial agglomeration with augmented variables for trade reform. To achieve these goals, we utilise a comprehensive database of firms in Viet Nam including all four-digit manufacturing industries at the province, district, and commune levels. One advantage of our data set is that it includes the year 2007 when Viet Nam joined the World Trade Organization. The sharp reduction in tariffs and huge influx of foreign direct investment (FDI) following this event provide an interesting setting for our analysis.

To the best of our knowledge, our study is the first to examine the evolution of agglomeration in Viet Nam. Howard, Newman, and Tarp (2015) investigated the determinants of agglomeration by examining the pattern of agglomeration of firms in related industries, while we focus on the intra-industry concentration of firms. Furthermore, as they only utilised cross-sectional data, their study does not capture the dynamic nature of agglomeration across time. Gokan et al. (2016) also examined the spatial pattern of Vietnamese manufacturing but, similar to Howard et al. (2012), only

performed a cross-section analysis. Patterns of agglomeration may be expected to change over time to reflect changes in industrial structures. In particular, if different industries are at different stages of development, firm dynamics, including turnover and location choice, can significantly impact agglomeration (Devereux, Griffith, and Simpson, 2004). This observation may hold for Viet Nam given the substantial economic reforms that it has implemented. Improvements in the business environment and the deregulation and market liberalisation process following the country's WTO accession have had a remarkable impact on the industrialisation process (Nguyen, Luu, and Trinh, 2016). Therefore, it is worth exploring the influence of these movements on the evolution of agglomeration.

In addition, Howard, Newman, and Tarp (2015) and Gokan et al. (2016) all disregard the impact of trade and FDI reforms. Given Viet Nam's increasing integration into the global market and the significant contribution of trade and FDI to the country's economic growth, it would be interesting to see how globalisation affects industrial location. Several new economic geography models demonstrate that trade liberalisation reduces the geographic concentration of manufacturing. Krugman and Elizondo (1996), for example, argue that trade openness favours the internal dispersion of economic activities. By expanding foreign market access, international trade reduces the importance of proximity to local markets. In addition, enhanced access to imported inputs weakens domestic backward and forward linkages. Behrens et al. (2007) suggest the competition effect as another source of dispersion. Competition in regions with a high concentration of firms crowds out firms with low competitiveness. Nevertheless, some theoretical studies suggest a reverse result, where trade triggers density. Paluzie (2001) shows that liberalisation may not reduce regional inequalities if labour is mobile across regions, while Brülhart, Crozet, and Koenig (2004) find that trade liberalisation fosters agglomeration along border regions as producers and consumers seek better access to foreign markets and imported goods, respectively.

Turning to FDI, there are good reasons to conjecture that agglomeration increases with FDI. The vast literature on FDI spillover suggests that local firms benefit from FDI through knowledge diffusion, either through product imitation (Smeets, 2008), improvement of workers' skills (Gorg and Greenaway, 2004; Markusen and Trofimenko, 2009), or input–output linkages (Javorcik, 2004). In

addition, Keller (2002) shows that gains achieved through FDI erode with distance. These two observations suggest that local firms are motivated to be located in proximity to FDI firms, implying that FDI leads to agglomeration. However, a small number of studies have arrived at the opposite conclusion. First, if linkages between FDI and local firms are weak, and the absorptive capacity of local firms is limited, this spillover channel may not materialise. On the other hand, agglomeration may create costs. The concentration of a large number of firms within a dense region increases competition and consequently lowers product prices (Ottaviano, Tabuchi, and Thisse, 2002; Melitz and Ottaviano, 2008). If the costs exceed the benefits, dispersion may occur (Lu, Tao, and Yu, 2012; Hsu et al., 2018). Given the mixed findings, the correct answer remains to be determined empirically.

The rest of this paper is structured as follows. Section 2 presents a brief literature review. Section 3 documents the evolution of geographical concentration during the period studied. Section 4 examines the relationship between trade reform and agglomeration. Section 5 concludes.

2. Literature Review

Our study is related to two strands of literature. The first explores the pattern of agglomeration. Ellison and Glaeser (1997) propose a simple index to measure whether the observed magnitude of agglomeration would be greater if locations were randomly assigned. Using manufacturing data from the United States, they show various levels of industrial concentration that exceed random distribution. In other words, industries tend to agglomerate. Using another index for manufacturing in the United Kingdom, Duranton and Overman (2005) find that almost half of industries at the four-digit level are localised, and most are located within 50 kilometres of each other. The cutlery and textile sectors are the most concentrated, while resource-based industries and industries with high transport costs are more likely to disperse. Nakajima, Saito, and Uesugi et al. (2012) arrive at a similar conclusion in the case of Japan. About half of Japanese manufacturing industries are concentrated, mostly within 40 kilometres of each other. They find that the textile sector is also amongst the most localised, suggesting common cross-country factors at work. In addition, they observe no differences in agglomeration patterns across time. Combes and Overman (2004) report

the magnitude and location of industrial activities in European countries, while Holmes and Stevens (2004) conduct similar studies in North America. Despite various measures of agglomeration used and different countries of interest, a common observation is the prevalence of industrial concentration.

The second strand of literature investigates the driving forces of agglomeration. The study of sources of agglomeration economies can be dated back to Marshall and Marshall (1920), who postulated three drivers: input sharing, labour pooling, and knowledge spillovers. Recent research has added more determinants, globalisation being one of them. Since the theory suggests that both concentration and dispersion follow trade openness, empirical studies have been undertaken for the cases of various countries. For example, Ge (2009) shows that access to foreign trade and FDI is a driving force of industrial concentration in China. In particular, trade-intensive and FDI-liberalised industries tend to be located in places with better access to foreign markets. He, Wei, and Xie (2010) also find that more liberalised sectors have become more concentrated, and most are located in the coastal areas of China. Using trade volumes as a proxy for openness, Martincus (2010) reports that industries in Argentina tend to be located along the borders following the liberalisation of trade in the country. On the contrary, Sanguinetti and Martincus (2009) observe the dispersion of Argentinian manufacturing following tariff reductions. The authors argue that demand and cost linkages weakened with trade. Firms choose to disperse due to high commuting costs and land rents. Fernandes and Sharma (2012) link agglomeration in Indian manufacturing to policy changes, including industrial de-licensing, trade reforms, and FDI de-regulation. They also find evidence of weaker domestic input–output linkages and the increasing importance of access to imported inputs after reforms are implemented.

3. The Evolution of Agglomeration in Viet Nam

3.1. Data

3.1.1 Firm-Level Data

Our main data set for this analysis is the Vietnam Enterprise Survey (VES) compiled by the General Statistics Office of Vietnam (GSO) covering 2002–2015. The data cover registered firms in all sectors, including agriculture, industry, construction, and services. The survey information includes the type of ownership, assets and liabilities, number of employees, total wage bills, sales, capital stock, industry to which the firm belongs, and obligations to the government (e.g. taxes), amongst others, from January to December of each year. In addition, the data provide the location codes of each firm at the province, district, and commune levels. We use this information, together with employment data and industry codes, to compute the agglomeration measure. The unique firm identification code (ID) allows us to construct panel data. We only focus on manufacturing firms.

Another advantage of the VES is the comprehensive coverage of the data. To measure agglomeration and avoid a potentially biased estimation due to the exclusion of small firms, census data are essential. Although the GSO only collected census data for 2000–2002, 2006, and 2011, it provides researchers with a list of all registered firms for other years. Information on tax codes, employment, industry, and location for formal firms is available from the business registry of the tax bureau. Therefore, we can measure the annual agglomeration index. For unsurveyed firms,[1] other information, including wage bills, profits, and assets, is not collected. Instead, the GSO imputed these values by taking the average of surveyed firms' data within a given province's industrial clusters. In our empirical analysis we replace the imputed values with the missing values.

[1] All state-owned enterprises (SOEs) and foreign direct investors are surveyed. For domestic private firms, a size threshold has been applied since 2003. Domestic private firms below this threshold are chosen randomly within a given province's industrial clusters. The threshold varies across years, provinces, and sectors. For example, in 2015 the threshold increases to 100 in certain sectors for firms located in Hanoi and Ho Chi Minh City. On the other hand, the maximum threshold for 2008 is only 10. For the census years (2000–2002, 2006, and 2011), all formal firms were included.

The data have some drawbacks. As trade status and trade values are only available in certain years, we rely on international trade data at the industry level. In addition, the VES provides firm-level data, not the plant-level data typically used in the literature. Thus, the firm's address reflects the location of the headquarters only. When multi-plant firms operate across a wide geographical area, the agglomeration measure may be biased upwards. However, in the case of Viet Nam, the firm-level data may still be suitable for agglomeration analysis because the share of multi-plant firms is relatively small.[2]

From 2002 to 2006, industrial classification in the VES followed the 1993 version of the Vietnam Standard Industrial Classification (VSIC). In 2007, the VSIC 2007 was adopted. At the four-digit level for manufacturing, the VSIC 1993 and VSIC 2007 are fully compatible with the International Standard Industrial Classification (ISIC) revisions 3 and 4, respectively. To ensure that the industry codes are consistent, we converted all industry codes from VSIC 2007 to VSIC 1993 and linked them to the ISIC revision 3. For firms that switch industries, we assigned them to the industry to which the firm belonged for the majority of time in the data set. Otherwise, the latest industry code is used.

3.1.2 Trade Data

Output tariff and trade values in the four-digit ISIC revision 3 are downloaded from the World Bank's World Integrated Trade Solutions database. We use the weighted average effectively applied tariff, which is the weighted average of the lowest applicable tariffs for each of Viet Nam's trade partners.

To measure trade openness, we utilise both tariff and trade values, the former being de jure and the latter de facto indicators of trade openness. Indeed, trade data are available at different levels of aggregation and forms.[3] De jure measures are constructed based on related trade policy tools. In other words, de jure indicators only represent instruments used to achieve a specific policy goal, be it tariffs, quotas, or trade prohibition. While interpretation is straightforward, de jure indicators may not capture certain aspects of trade reform such as the simplification of customs

[2] The authors' computation from 2011 census data shows that only 6% of manufacturing firms have multiple plants.
[3] Yanikkaya (2003) alone has listed over 20 indicators of trade openness.

procedures or the improvement of regulatory transparency. De facto measures, on the other hand, represent observed figures of trade volume. From this perspective, they capture the effectiveness of policy enforcement. This effectiveness can change over time even if the policy instruments remain unchanged (Kose et al., 2009). Therefore, de facto measures reflect the actual extent to which an economy is open.

3.2. Measuring Agglomeration

Ideally, the agglomeration indicator should be computed using a continuous-space approach, in which the distance between firms is measured precisely (Guillain and Le Gallo, 2010). Duranton and Overman (2005), for example, propose an agglomeration measure based on the Euclidean distance between firms and test for concentration patterns using various Kernel-density functions. Despite its appealing intuitiveness, the application of this method is limited due to its highly demanding data requirements. In the case of Viet Nam, detailed addresses for firms are not accessible. Instead, the VES only provides information down to the commune level, meaning that the distance between two firms is proxied by the distance between the communes in which they are located. Following this approach, if two firms operate in the same commune, their distance would be zero. Due to this aggregation problem, we employ a discrete spatial-unit approach to evaluate the extent of agglomeration in Viet Nam.

In particular, we follow Ellison and Glaeser (1997) to construct a within-industry agglomeration index (henceforth, the Ellison–Glaeser index) based on administrative boundaries. Construction of the Ellison–Glaeser index is grounded in the theory of firm location behaviour. In the model, N firms choose amongst M locations. A firm must choose whether to follow the prior firm's decision or to choose a location randomly by selecting a dot on a map. As such, the Ellison–Glaeser index measures the agglomeration level beyond what one would observe if a firm were to choose its location randomly. The original Ellison–Glaeser index for a specific industry *i* at location *d* is given by:

$$\gamma_{\mathrm{i}}^{\mathrm{EG}} = \frac{\sum_{\mathrm{d}=1}^{\mathrm{M}}(s_d - x_d)^2 - \left(1 - \sum_{\mathrm{d}=1}^{\mathrm{M}} \mathrm{x_d}^2\right)\sum_{\mathrm{j}=1}^{\mathrm{N}} \mathrm{z_j^2}}{\left(1 - \sum_{\mathrm{d}=1}^{\mathrm{M}} \mathrm{x_d}^2\right)\left(1 - \sum_{\mathrm{j}=1}^{\mathrm{N}} \mathrm{z_j^2}\right)} \quad (1)$$

where s_d is the share of area *d* in industry *i*'s employment, x_{d} is the share of total employment in area *d*, and z_j is the employment size of firm *j* in industry *i*. The Gini

index Gi is defined as the first term in the numerator, $\sum_{d=1}^{M}(s_d - x_d)^2$, whereas the Herfindahl index is defined as Hi = $\sum_{j=1}^{N} z_j^2$. Equation (1) can then be expressed as:

$$\gamma_i^{EG} = \frac{G_i - (1 - \sum_{d=1}^{M} x_d^2) H_i}{(1 - \sum_{d=1}^{M} x_d^2)(1 - H_i)} \quad (2)$$

The estimated γ_i^{EG} can be interpreted as the probability that two firms in the same industry choose to be located in the same region. A zero γ_i^{EG} implies that an industry is as concentrated as a random allocation. A positive γ_i^{EG} suggests concentration in excess of what would be observed if firms were to be located randomly. Conversely, a negative γ_i^{EG} is interpreted as an excess dispersion of employment.

Essentially, the γ_i^{EG}EG index is the difference between G_i, the index of raw geographical concentration, and H_i, industrial concentration. If the distribution of industry i's employment is uniform across regions, G_i equals zero. A greater value of G_i indicates a higher geographic concentration. On the other hand, the Herfindahl index is larger if the industry is dominated by a few large firms, implying greater industrial concentration. In the case of perfect competition where there are a large number of small firms, H_i approaches zero. γ_i^{EG} then approaches Gi/$\left(1 - \sum_{d=1}^{M} x_d^2\right)$.

Compared to a simple location Gini index (Krugman, 1991) or Hoover index (Hoover, 1936), the Ellison–Glaeser index offers several advantages. First, it is easy to compute with readily available data. Second, it controls for size differences across industries relative to the industry as a whole. Finally, in principle the index is not sensitive to geographical units and sectoral aggregation (Ellison and Glaeser, 1997).

3.3. Trends and Patterns of Agglomeration in Viet Nam

In this section we describe the evolution of agglomeration patterns in manufacturing in Viet Nam. To do so, we calculate the Ellison–Glaeser index at the four-digit and two-digit industry and district levels. Table 1 presents the summary statistics. Two features stand out from the table. First, the magnitude of agglomeration decreases as the industries progress from a more disaggregated to a broader classification. As pointed out by Rosenthal and Strange (2004), if more disaggregated industries are grouped together into broader and fewer sectors, the distribution of firms'

locations will converge with that of the entire economy. In other words, the Gini index and γ_i^{EG} approach zero.

Table 1: Average Agglomeration Index, by Year and by Sub-Industry

Year	4-digit	3-digit	2-digit
2002	-0.014	-0.030	-0.021
2003	-0.016	-0.049	-0.010
2004	0.019	0.010	0.017
2005	0.023	0.016	0.021
2006	0.024	0.023	0.022
2007	0.020	0.021	0.019
2008	0.015	0.016	0.013
2009	0.017	0.016	0.016
2010	0.017	0.017	0.016
2011	0.020	0.022	0.014
2012	0.018	0.021	0.013
2013	0.017	0.019	0.012
2014	0.018	0.019	0.011
2015	0.005	-0.008	0.011
2016	0.010	-0.003	0.012

Notes: The agglomeration index is calculated at the district level following Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927 (Equation 2). The average is the simple mean.
Source: Authors' calculation using the Vietnam Enterprise Survey (2002–2016).

Second, the γ_i^{EG} indices exhibit a declining trend, particularly after 2006. This suggests that the dispersion force is growing stronger as the structural economic reform continues.

To further understand the sources of dispersion, we examine the trend visible in the Ellison–Glaeser index sub-components: the Herfindahl index and Gini coefficient. Table 2 illustrates our results. Similar to the aggregate trend, both industrial concentration and geographical concentration show downward movement throughout the period under study. A smaller H_i suggests that there is an increasing number of new small firms. Indeed, the average number of employees per firm shrank from 154 in 2002 to 87 in 2016. The share of small enterprises with fewer than 100 employees increased from 73% to 88% in the corresponding period.

A smaller geographic concentration, G_i, suggests that regions that were once disconnected or underdeveloped are expanding, thus attracting more firms to disperse from the centres. Such expansion could be due to several different factors, including

the development of infrastructure, greater market access, and increasing price and wage premiums creating congestion effects in dense areas, amongst others.

Table 2: Geographic and Industrial Concentration at the District Level, by Year

Year	γ_i^{EG}	HHI_i	GI_i
2002	-0.014	0.168	0.145
2003	-0.016	0.165	0.144
2004	0.019	0.152	0.166
2005	0.023	0.141	0.158
2006	0.024	0.148	0.165
2007	0.020	0.136	0.151
2008	0.015	0.126	0.140
2009	0.017	0.114	0.128
2010	0.017	0.108	0.122
2011	0.020	0.094	0.110
2012	0.018	0.096	0.110
2013	0.017	0.095	0.109
2014	0.018	0.107	0.120
2015	0.005	0.108	0.121
2016	0.010	0.110	0.123

Note: The agglomeration index γiEG, industry concentration index HHIi, and GIi are calculated at the district level following Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927 (Equation 2).
Source: Authors' calculation using the Vietnam Enterprise Survey (2002–2016).

Despite possible common drivers at work, sector-specific characteristics imply that it is necessary to examine the extent and evolution of agglomeration across industries (Ellison and Glaeser, 1997; Rosenthal and Strange, 2001; Lu and Tao, 2009). Table 3 reports the agglomeration indices for 22 two-digit manufacturing industries at the commune level.

Table 3 demonstrates heterogeneity in the level and trend of agglomeration across industries. The most concentrated sectors can be divided into several groups. The first of these is high-technology sectors where the contribution of knowledge spillover can be important. In 2006, for example, this group includes office machinery (ISIC 30); medical, optical, and watches (ISIC 33); vehicles and trailers (ISIC 34); radio and television (ISIC 32); and electrical machinery (ISIC 31). In some resource-based sectors, such as basic metal (ISIC 27), coke and petroleum (ISIC 23), and furniture (ISIC 26), natural advantage can play a larger role.

Table 3: Agglomeration Index, by Two-Digit Industry at the District Level

2-digit	Industry	2006	2011	2016	Growth 2006–2016
23	Coke, petroleum, nuclear	0.084	0.006	0.013	-0.071
33	Medical, optical, watches	0.079	0.012	0.008	-0.071
30	Office machinery	0.138	0.142	0.094	-0.044
27	Basic metals	0.044	0.020	0.016	-0.028
31	Electrical machinery nec	0.014	0.004	-0.001	-0.015
22	Printing	0.017	0.013	0.010	-0.007
34	Vehicles, trailers	0.025	0.020	0.020	-0.004
26	Non-metallic mineral	0.008	0.007	0.005	-0.003
15	Food and beverages	0.009	0.007	0.006	-0.003
25	Rubber and plastics	0.006	0.003	0.004	-0.002
29	Machinery and equipment	0.004	0.002	0.002	-0.002
28	Fabricated metals	0.004	0.004	0.003	-0.001
18	Wearing apparel	0.003	0.003	0.002	-0.001
21	Paper	0.001	0.001	0.002	0.000
24	Chemicals	0.002	0.003	0.003	0.001
19	Leather	-0.003	-0.003	-0.002	0.001
20	Wood	0.007	0.006	0.008	0.002
36	Furniture	0.023	0.020	0.024	0.002
32	Radio, television	0.016	0.026	0.021	0.005
17	Textiles	0.008	0.011	0.013	0.005
35	Other transport	0.016	0.020	0.022	0.007
16	Tobacco	-0.014	-0.014	-0.005	0.010

nec = not elsewhere classified.
Note: The agglomeration index is calculated at the district level following Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927 (Equation 2).
Source: Authors' calculation using the Vietnam Enterprise Survey (2002–2016).

The most dispersed sectors include labour-intensive, low-technology industries, including wearing apparel (ISIC 18), food and beverages (ISIC 15), paper (ISIC 21), and leather (ISIC 19). This pattern differs from findings in other countries, where these sectors are often highly concentrated due to labour pooling (Devereux, Griffith, and Simpson, 2004; Duranton and Overman, 2005; Nakajima et al., 2015). One possible reason for this dispersion is the abundant availability of unskilled labour in Viet Nam in various locations. Another possible reason is the agglomeration diseconomies, including higher factor costs, higher land prices, and higher living costs, which encourage firms to be located away from dense areas. Interestingly, we also observe machinery and equipment (ISIC 29) in this category.

Second, patterns of change in agglomeration also vary across industries. Thirteen out of 22 sectors exhibit a declining trend, including the top five concentrated industries in 2006. Labour-intensive industries such as textiles and leather become more concentrated. Concentration in wearing apparel experienced a decline from 2012 to 2015 despite remaining unchanged until that point. It is worth noting that the sectors experiencing such decline are amongst the most liberalised sectors that witnessed large inflows of FDI. This suggests the competition effect mentioned earlier (Lu, Tao, and Yu, 2012; Hsu et al., 2018). If inter-firm linkages are weak, the expected knowledge spillover can be limited, while competition pressure from FDI could crowd out local firms.

Since the Ellison–Glaeser index allows comparison across countries, industries, and time, we summarise the findings of other studies as well as ours in Table 4. Following Ellison and Glaeser (1997), we report the percentage of four-digit industries within each two-digit industry that are either *not very concentrated*, *somewhat concentrated*, or *very concentrated*. For comparison, we also report findings from Ellison and Glaeser (1997); Devereux, Griffith, and Simpson (2004); and Lu and Tao (2009). For example, we found that industries were more concentrated in Viet Nam in 2016 than they were in China 10 years earlier (see Lu and Tao, 2009).

Table 4: Comparison of Agglomeration of Four-Digit Sub-Industries Within Two-Digit Industries

Study	Country	Year	Industry	Region	Percentage of industries which are		
					not very concentrated ($\gamma_i^{EG} < 0.02$)	somewhat concentrated ($0.02 \leq \gamma_i^{EG} \leq 0.05$)	very concentrated ($\gamma_i^{EG} > 0.05$)
Devereux et al. (2004)	United Kingdom	1992	211, four-digit	477 ZIP Codes	65%	19%	16%
Ellison and Glaeser (1997)	United States	1987	459, four-digit	3,000 counties	10%	65%	25%
Lu and Tao (2009)	China	2005	537, four-digit	2,862 counties	75%	16%	7.82%
This study	Viet Nam	2016	120, four-digit	64 provinces	62%	21%	17%

Note: The percentage used is that of four-digit industries within two-digit industries.
Source: Authors' calculation using the Vietnam Enterprise Survey (2016); Devereux, M.P., Griffith, R., and H. Simpson (2004). 'The Geographic Distribution of Production Activity in the UK', *Regional Science and Urban Economics*, 34(5), pp.533–64; Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927; Lu, J. and Z. Tao (2009), 'Trends and Determinants of China's Industrial Agglomeration', *Journal of Urban Economics*, 65(2), pp.167–80.

The heterogeneous patterns and trends of agglomeration observed at the industry level suggest different forces at work. In the next section we explore these drivers using a regression framework.

4. Determinants of Agglomeration in Vietnamese Manufacturing

4.1. Variables and Model

Following Rosenthal and Strange (2001) and Lu and Tao (2009), we regress the EG agglomeration index on a set of industry-level proxies as sources of concentration.

We divide these proxies into two groups. The first group consists of proxies for trade and FDI liberalisation. For trade, we use both tariffs and trade values, as discussed earlier. For FDI, we calculate the share of FDI firms at the industry level. Based on the discussion above, we hypothesise that FDI and trade liberalisation contribute to dispersion in Vietnamese manufacturing.

The second group is controls commonly used in the literature on determinants of agglomeration, including natural advantages, inter-industry linkages, economies of scale, and wage premiums. These can be outlined as follows:

(i) Natural advantages. For firms in resource-based industries such as coke and petroleum or basic metals, access to raw materials can play an important role in location choice. Although it is hard to capture natural resource endowment, we conjecture that firms that rely heavily on local raw inputs tend to agglomerate. It should be noted that this hypothesis assumes that these inputs are also concentrated in certain regions. In particular, we calculate the intensity of mining input (MINING) and agricultural input (AGRI) as the share over gross output by sector.

(ii) Inter-industry linkages. The availability of specialised inputs could encourage firms in downstream sectors to agglomerate (Marshall, 1920). Following Lu and Tao (2009), we measure vertical linkages by the ratio of inputs from upstream sectors over gross output (INPUTSHARE). Similar to natural advantages, to the extent that these inputs are localised, we expect a positive correlation between INPUTSHARE and agglomeration.

(iii) Economies of scale. In principle, studies on agglomeration using the Ellison–Glaeser index need not control explicitly for economies of scale in the regression, since the index includes (through Herfindahl) controls for industrial structure.

However, Alecke et al. (2006) argued for the need to control for firm size as the Ellison–Glaeser index cannot fully control for this factor. Therefore, following Alecke et al. (2006) and Lu and Tao (2009), we compute average firm size (FIRM SIZE) as a proxy.

(iv) Wage premium. We use the wage premium as a proxy for the congestion cost in agglomerated areas. Firm concentration drives up labour costs and generates more competition pressure amongst firms for workers. Given Viet Nam's comparative advantage in labour-intensive sectors and the abundance of low-skilled workers in various regions, we expect that increasing labour costs discourage firms from locating in dense areas. We construct wage premium (W_PREMIUM) by multiplying the wage premium of a region over the country's average wage with the employment share of an industry in a region.

Table 5 reports the summary statistics of our key variables.

Table 5: Descriptive Statistics

Variable	Number of observations	Mean	Standard Deviation	Min	Max	Unit
Agglomeration index (district, four-digit industry)	1,638	0.01	0.12	-1.82	1.09	
Export value	1,747	11.09	2.37	-3.30	17.22	Log
Export tariff	1,747	3.94	4.85	0.00	51.02	%
Import value	1,743	11.89	1.98	5.61	16.30	Log
Import tariff	1,743	10.87	13.54	0.00	106.31	%
Port	1,677	0.02	0.10	0.00	1.00	Log
Wage premium	1,678	0.10	0.19	0.01	1.69	Log
Firm size	1,678	4.39	0.92	1.10	7.26	Log
SOEs	1,678	3.70	6.57	11.86	11.75	Log
FDI share	1,610	0.16	0.16	0.00	1.00	Log
Mining inputs	1,604	16.40	3.20	4.32	27.89	Log
Agricultural inputs	1,604	15.36	5.41	0.00	28.88	Log
Input share	1,604	21.93	2.58	12.74	29.70	Log

FDI = foreign direct investment, Max = maximum, Min = minimum, SOE = state-owned enterprise.
Notes: Agglomeration is calculated at the district level, and by four-digit industry following Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927 (Equation 2). The measurement of variables is in the Appendix.
Source: Authors' calculation using the Vietnam Enterprise Survey (2002–2016), and trade data from the UN Comtrade Database. www.comtrade.un.org (accessed 2 March 2020).

4.2. Ports

Transportation infrastructure can impact location choice by affecting firms' transaction costs. Especially for more globalised firms, access to ports could enhance trading activities. Therefore, we include in our analysis a variable to distinguish between inland and port districts. In particular, for each industry we measure the share of industrial output in port districts (PORT). To the extent that firms located in port districts enjoy the benefits of better market access, we expect a positive PORT coefficient.

Finally, given the special role of state-owned enterprises (SOEs) in Viet Nam, we include SOEs' (RATE_S) share in total output as a control for the potential impact of local protectionism on agglomeration. SOEs tend to enjoy more benefits from local governments, receiving more favourable treatment in local industries. Thus, the nurturing of SOEs in a region may negatively impact agglomeration, as distortionary policies in favour of SOEs could drive away private firms.

The estimation results are presented in Tables 6–9. The major findings are as follows. First, we find weak evidence of the impact of trade, particularly import value, on agglomeration. In most cases the coefficients of exports and imports are not significant. As agglomerated regions may have developed prior to liberalisation, further openness does not play a significant role in changing this landscape. Second, firm size exhibits a positive and significant impact on agglomeration, suggesting the role of scale economies. Third, the impact of access to a port is positive but not significant, while the interaction term between access to a port and FDI share is negative and significant. The presence of FDI in port districts seems to heighten competition for local firms, thus reducing agglomeration. Finally, we observe non-significant impacts of SOEs, wage premiums, and access to inputs, except for mining. This observation suggests an abundant labour supply and relatively evenly distributed inputs across regions.

Table 6: Agglomeration and Export Value (Log)

	(1) EG4d	(2) EG4d	(3) EG4d	(4) EG4d	(5) EG4d	(6) EG4d
Export value	0.00608	0.00668	0.00691	0.00470	0.00488	0.00494
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
WTO#Export value	0.00153	0.00005	0.00007	-0.00057	-0.00070	0.00015
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Wage premium		0.09846	0.09683	0.25012	0.25052	
		(0.312)	(0.312)	(0.286)	(0.285)	
Mining input		-0.01486*	-0.01148+	-0.01043		-0.01159*
		(0.006)	(0.007)	(0.006)		(0.006)
FDIshare		-0.09291	-0.08071			0.15231
		(0.080)	(0.094)			(0.101)
Mining#FDIshare		0.00968				
		(0.007)				
Agricultural input		0.01320*	0.00989	0.00976		0.01121*
		(0.006)	(0.007)	(0.007)		(0.006)
Agri#FDIshare			0.00945			
			(0.007)			
SOEs				0.00707	0.00709	
				(0.005)	(0.005)	
Firm size				0.05057*	0.05079*	
				(0.022)	(0.022)	
SOEs#Firm size				-0.00160	-0.00161	
				(0.001)	(0.001)	
Input share					-0.00085	
					(0.001)	
Port						0.29390
						(0.266)
Port#FDIshare						-2.15351**
						(0.715)
N	1637	1447	1447	1564	1564	1447

Notes: EG4d is the agglomeration index at the district level. See Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927. Year fixed effects, four-digit industry fixed effects. Standard errors are in parentheses, and clustered at year#2digit industry.
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.
Source: Authors, using data from the Vietnam Enterprise Survey (2002–2016).

Table 7: Agglomeration and Weighted Export Tariff

	(1) EG4d	(2) EG4d	(3) EG4d	(4) EG4d	(5) EG4d	(6) EG4d
Export tariff	-0.00125	-0.00128	-0.00126	-0.00151	-0.00148	-0.00117
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
WTO#Export tariff	0.00108	0.00151^{+}	0.00148^{+}	0.00069	0.00066	0.00124
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Wage premium		0.10183	0.10017	0.25329	0.25357	
		(0.318)	(0.317)	(0.289)	(0.289)	
Mining input		-0.01619*	-0.01280^{+}	-0.01122		-0.01258*
		(0.006)	(0.007)	(0.007)		(0.006)
FDIshare		-0.07982	-0.05902			0.16653^{+}
		(0.079)	(0.090)			(0.097)
Mining#FDIshare		0.00986				
		(0.007)				
Agricultural input		0.01443*	0.01121	0.01049		0.01215*
		(0.006)	(0.008)	(0.007)		(0.006)
Agri#FDIshare			0.00910			
			(0.007)			
SOEs				0.00666	0.00667	
				(0.006)	(0.006)	
Firm size				0.05370*	0.05398*	
				(0.022)	(0.022)	
SOEs#Firm size				-0.00154	-0.00155	
				(0.001)	(0.001)	
Input share					-0.00091	
					(0.001)	
Port						0.32264
						(0.255)
Port#FDIshare						-2.21924**
						(0.694)
N	1637	1447	1447	1564	1564	1447

Notes: EG4d is the agglomeration index at the district level. See Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927. Year fixed effects, four-digit industry fixed effects. Standard errors in parentheses, and clustered at year#2digit industry.

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.

Source: Authors, using data from the Vietnam Enterprise Survey (2002–2016).

Table 8: Agglomeration and Import Value (Log)

	(1) EG4d	(2) EG4d	(3) EG4d	(4) EG4d	(5) EG4d	(6) EG4d
Import value	0.01326	-0.01516*	-0.01463*	-0.01199+	-0.01172	-0.01668*
	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)
WTO#Import value	0.0076*	0.00563+	0.00538+	0.00510+	0.00496+	0.00587+
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Wage premium		0.07430	0.07357	0.23188	0.23263	
		(0.320)	(0.320)	(0.291)	(0.291)	
Mining input		-0.01633*	-0.01311+	-0.01155+		-0.01298*
		(0.007)	(0.007)	(0.007)		(0.006)
FDIshare		-0.08539	-0.05276			0.15589
		(0.078)	(0.089)			(0.097)
Mining#FDIshare		0.00948				
		(0.007)				
Agricultural input		0.01488*	0.01196	0.01101		0.01277*
		(0.006)	(0.008)	(0.007)		(0.006)
Agri#FDIshare			0.00793			
			(0.007)			
SOEs				0.00517	0.00522	
				(0.005)	(0.005)	
Firm size				0.05108*	0.05142*	
				(0.021)	(0.021)	
SOEs#Firm size				-0.00118	-0.00119	
				(0.001)	(0.001)	
Input share					-0.00074	
					(0.001)	
Port						0.28923
						(0.261)
Port#FDIshare						-2.18490**
						(0.690)
N	1637	1447	1447	1564	1564	1447

Notes: EG4d is the agglomeration index at the district level. See Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927. Year fixed effect, four-digit industry fixed effect. Standard errors are in parentheses, and clustered at year#2digit industry.

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Source: Authors, using data from the Vietnam Enterprise Survey (2002–2016).

Table 9: Agglomeration and Weighted Import Tariff

	(1) EG4d	(2) EG4d	(3) EG4d	(4) EG4d	(5) EG4d	(6) EG4d
Import tariff	0.00052	0.00058*	0.00055+	0.00038	0.00036	0.00054+
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
WTO#Import tariff	-0.00030	-0.00014	-0.00013	-0.00034	-0.00035	-0.00018
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wage premium		0.10247	0.10070	0.25306	0.25337	
		(0.319)	(0.318)	(0.290)	(0.290)	
Mining input		-0.01600**	-0.01262+	-0.01103+		-0.01241*
		(0.006)	(0.007)	(0.007)		(0.006)
FDIshare		-0.09298	-0.06972			0.15427
		(0.080)	(0.090)			(0.094)
Mining#FDIshare		0.00985				
		(0.007)				
Agricultural input		0.01431*	0.01112	0.01032		0.01201*
		(0.006)	(0.007)	(0.007)		(0.006)
Agri#FDIshare			0.00896			
			(0.007)			
SOEs				0.00731	0.00732	
				(0.006)	(0.006)	
Firm size				0.05175*	0.05209*	
				(0.021)	(0.021)	
SOEs#Firm size				-0.00168	-0.00168	
				(0.001)	(0.001)	
Input share					-0.00089	
					(0.001)	
Port						0.29637
						(0.255)
Port#FDIshare						-2.19494**
						(0.696)
N	1637	1447	1447	1564	1564	1447

Notes: EG4d is the agglomeration index at the district level. See Ellison, G. and E.L. Glaeser (1997), 'Geographic Concentration in US Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp.889–927. Year fixed effect, four-digit industry fixed effect. Standard errors are in parentheses, and clustered at year#2digit industry.

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Source: Authors, using data from the Vietnam Enterprise Survey (2002–2016).

5. Conclusion and Policy Implications

This paper analyses the trend and determinants of agglomeration in Vietnamese manufacturing with an emphasis on trade and FDI openness. There are four major findings. First, agglomeration, as measured by the Ellison–Glaeser index, has declined since the mid-2000s. Both industrial concentration and geographical concentration show downward movement throughout the period. A smaller industrial concentration index suggests that the number of new small firms is increasing. On the other hand, a smaller geographic concentration suggests that once disconnected or underdeveloped regions are expanding, and thus encouraging more firms to disperse from the centres. This expansion could be due to several different factors, including the development of infrastructure, greater market access, increasing prices, and wage premiums creating congestion effects in dense areas, amongst others.

Second, there exists significant sectoral heterogeneity in the level and trend of agglomeration. The most concentrated sectors can be divided into several groups. The first is high-technology sectors where the contribution of knowledge spillover can be important. In 2006, for example, this group included office machinery (ISIC 30); medical, optical, and watches (ISIC 33); vehicles and trailers (ISIC 34); radio and television (ISIC 32); and electrical machinery (ISIC 31). In some resource-based sectors, such as basic metal (ISIC 27), coke and petroleum (ISIC 23), and furniture (ISIC 26), natural advantage can play a larger role. The most dispersed sectors include labour-intensive, low-technology industries, including wearing apparel (ISIC 18), food and beverages (ISIC 15), paper (ISIC 21), and leather (ISIC 19).

Third, the impact of trade and FDI per se are not clear. However, FDI located in port districts contributes to disagglomeration. The presence of FDI in port districts could heighten competition for local firms, thus reducing agglomeration. Agglomeration is considered a source of productivity improvement. Given the dispersion observed in Viet Nam, policies necessary to facilitate the process of agglomeration should be considered.

It is worth noting several aspects that can be investigated further. First, as our study only focuses on within-industry agglomeration, we are unable to capture the vertical clustering of firms. This analysis is particularly relevant for Viet Nam, where participation in global value chains suggests the importance of upstream–downstream linkages. Second, we do not examine firm turnover as a channel related to the agglomeration process. In particular, an analysis of firms' entries and exits and the impact of agglomeration patterns would facilitate understanding of the dynamics of agglomeration.

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Appendix

Table: Variable Measurement

Variables	Measurement	Note	Source
Agglomeration index	$GI_{id,t}$	*4-digit industry i by year t* *District-level d (or province-level p, or commune-level c)*	The Vietnam Enterprise Survey (2002–2016).
Export value (import value)	$EV_{i,t}$	*4-digit industry i* *Log value by year t*	www.wits.org
Weighted export (import) tariff	*Weighted by trade value*	*4-digit industry i* *By year t*	www.wits.org
Wage premium	$\frac{1}{N_{i,t}}\sum^{i}\frac{E_{id,t}}{E_{i,t}} * \frac{W_{d,t}}{W_t}$	$W_{d,t}$: *average wage by district* W_t: *average wage*	The Vietnam Enterprise Survey (2002–2016).
Firm size	$Log\frac{E_{i,t}}{N_{i,t}}$	*4-digit industry i* $N_{i,t}$*: number of firms at year t* $E_{i,t}$*:Employment at year t*	The Vietnam Enterprise Survey (2002–2016).
SOE	$Log\frac{E_{soe,t}+1}{E_{i,t}}$	$E\_SOE_{i,t}$: *Employment of SOE firms*	The Vietnam Enterprise Survey (2002–2016).
FDI share	$Log\frac{E_{fdi,t}+1}{E_{i,t}}$	*4-digit industry i* $E_{FDI\,i,t}$: *Employment of FDI firms*	The Vietnam Enterprise Survey (2002–2016).
Mining input	$Log(\alpha_{2digit,2005} * GO_{4digit,t}+1)$	$\alpha_{2digit,2005}$: *Mining input share* $GO_{4digit,t}$: *Gross output*	Domestic Input–Output Table 2005
Agricultural input	$Log(\alpha_{2digit,2005} * GO_{4digit,t}+1)$	$\alpha_{2digit,2005}$: *Agricultural input share* $GO_{4digit,t}$: *Gross output*	Domestic Input–Output Table 2005
Input share	$Log(\mu_{2digit,2005} * GO_{4digit,t})$	$\mu_{2digit,2005}$: *Input share* $GO_{4digit,t}$: *Gross output*	Domestic Input–Output Table 2005
Port	$\frac{GO_{d,i,t}}{GO_{i,t}}\#\#D_d$	$GO_{d,i,t}$ share of output industry i in district d in total output of industry i. D_d =1 if district with port, = 0 otherwise.	The Vietnam Enterprise Survey (2002–2016). Map of ports in Viet Nam.

FDI = foreign direct investment, SOE = state-owned enterprise.
Source: The Vietnam Enterprise Survey (2002–2016) and the General Statistics Office of Vietnam Domestic Input–Output Table 2005. A list of ports and their locations in Viet Nam was derived from Decision 70/2013/QD-TTg. http://congbao.chinhphu.vn/tai-ve-van-ban-so-70-2013-qd-ttg-10242-6128?format=pdf (accessed 18 February 2019).

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