The Rise and Fall of Regional Industries: The Roles of Inter-Industry Relatedness

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Abstract

This paper addresses one of lasting issues in regional development: how regions manage to develop new industries while others fail to do so. It focuses on regional knowledge that is arguably reflected by industry structures. Using inter-industry relatedness measure as a tool to analyse the evolution of industries at province level, this study finds that industries that are close to a province' portfolio have higher probability to emerge and thrive in that province, whereas industries that are less related to its provinces' portfolio tend to decline and exit. Therefore, regional industrial policies should focus on potential industries that are rather close to provinces' portfolio.

Keywords: *Regional Development, Regional Industries, Industry Structures*

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Khairul Rizal

I. Introduction

New industries are crucial in promoting economic growth of regions. However, how regions learn a new knowledge and use the knowledge to develop new industries are still under investigation. In this paper, we try to address this inquiry using a concept called relatedness.

The notion of relatedness is central in evolutionary studies particularly in evolutionary economic geography. It can be used to examine the evolutionary forces of variety, selection, and inheritance in shaping economic landscapes. The emergence of new varieties through diversification processes (path creation) can be traced back through its relatedness to the pre-existing industries on which it is built on (Boschma and Wenting, 2007). Moreover, relatedness can also demonstrate how the Schumpeterian process of creative destruction takes place (Boschma and Frenken, 2011; Essletzbichler, 2013). Existing industries that become less related to its regional industry structures might experience declining share of outputs and eventually winnowed out of the regions (path destruction). This can be interpreted as selection mechanism through which some industries are selected to enter and remain in a region while some others exit the region.

A considerable amount of works on the significance of relatedness has been carried out thus far, such as Frenken *et al.* (2007) for Netherland, Boschma and Minondo (2012) for Spain, Bishop and Gripaios (2010) for Great Britain, Brachert *et al.* (2013) for Germany, Boschma and Iammarino (2009) for Italy, Neffke *et al.* (2011) for Sweden, and Rigby (2013) and Essletzbichler (2013) for the US. Other work focuses on cross-country analysis such as Hidalgo *et al.* (2007) and Haussmann and Hidalgo (2010). While relatedness is measured in a variety of ways, those works focus exclusively on countries and regions of the Global North. No accessible records have shown similar works that have ever been conducted for developing countries, let alone for Indonesia. Hence, this paper offer one of the first accounts to use evolutionary economic geography approach within Indonesia context to explore the role of inter-industry relatedness in shaping the development path of regions.

Lack of empirical evidences and underrepresented in the literature has motivated this paper to adopt an evolutionary approach to seek understanding on how regions evolve toward different paths of development by focusing on the evolution of industries in Indonesian provinces. Specifically this paper aims to add some empirical works by countering the following interrelated questions: Do provinces really develop new industries in related industries? Do less related industries tend to leave out of provinces?

The flow of arguments in this paper is organised into five sections. Section 2 discusses relevant literature to provide theoretical groundwork and some operational concepts for this work. Section 3 elaborates the methods to measure some key concepts used in this paper, i.e. proximity, closeness and density. Section 4 discusses some key findings, and section 5 concludes.

II. Literature Review

How regions develop new varieties of economic activities, particularly new industries, is a crucial area of investigation in evolutionary economics (Witt, 2002; Hodgson, 2002; Essletzbichler and Rigby, 2007). Also, the creation of new knowledge as a result of recombination of prevalent knowledge has been widely discussed in the innovation literature (Henderson and Clark, 1990; Fleming, 2001; Frenken et al. 2012). Furthermore, the arguments of bounded rationality and local search (Simon, 1982; Cohen and Levinthal, 1990; Maskell and Malmberg, 2007) emphasize that innovation for new varieties often emerges from recombination of existing familiar components and it tends to occur locally. Distant search is also potential to invent a completely new breakthrough. However, less familiarity with the components increases uncertainties and risks of failure.

The tendency to search for new economic activities that are close to the existing ones arguably applies to regions as well. As argued by Hidalgo (2009), industries that are closely related to the existing industries are more likely to be developed by regions. Boschma and Wenting (2007) provide evidence of how the British automobile industry emerged in a region that was well endowed with related industries like coaches and bicycles. They argue that these related industries supplied the capabilities required to develop a new automobile industry in Birmingham. This evidence suggests two things. First, the more a region is endowed with related industries, the higher the chance for that region to develop new industries. Conversely, regions endowed with less related industries are likely to face enormous difficulties to develop new industries. Lacking for complementary capabilities expressed in low industry varieties means that there are fewer potential combinations for new industries to be promoted (Hausmann and Hidalgo, 2010). Second, the tendency of regions to develop new related industries displays path dependence in regional economic development.

In a similar vein, Nooteboom (2000) elaborates it further by stressing that knowledge combination and interactive learning processes would effectively take place within a right cognitive distance, neither too far nor too close from existing knowledge base. Too much similarity may block learning from occurring as nothing can be learnt from. Likewise, too much dissimilarity may hamper knowledge spill over as nothing can be shared with. Therefore, the capacity of regions to generate new knowledge is not only dependent on the repertoire of existing knowledge contained by the regions; it also relies on the relatedness among that knowledge. Regions with larger existing knowledge repertoires, i.e. diverse knowledge bases, are likely to have better chances to generate new knowledge through more options of mixing and matching. However, having a large pool of knowledge does not necessarily guarantee that regions can learn something new and take advantage from it. If the existing knowledge base is too close or too distant then the sources of innovation would not be present, preventing regions from developing new products or industries. This argument highlights the importance of relatedness in learning and acquiring new regional knowledge.

Many studies use patent registration as a proximity for regional knowledge (Ponds et al. 2009; Rodriguez-Pose and Crescenzi, 2008; Feldman and Audretsch, 1999; Feldman and Florida, 1994; and Rigby, 2013). Following Hidalgo *et al.* (2007) this paper measures regional knowledge using output-based approach. That is, regions that host a certain industry must have all the knowledge and abilities necessary to support the industry. Therefore, the structure of regional industries arguably reflects the knowledge structure owned by the regions.

Relatedness concept. Neffke *et al.* (2011) identify three approaches that are commonly used to measure inter-industry relatedness. The first is based on the hierarchy of industry classifications such as International Standard Industrial Classification (ISIC) and Harmonised System (HS). Industries that locate under the same classes are considered to be related. Criteria that are used to define and delineate each class usually vary from one classification system to another. The second approach is based on similarity in upward and downward linkages such in input-output table (Fan and Lang, 2000), or similarity in the mixes of occupations (Farjoun, 1994). Principally two or more industries that use similar inputs, or employ similar mixes of occupation, or produce similar outputs are considered to be related. One major drawback of both approaches is that they also assume similarity in other broad conditions such as institutions, infrastructures, physical environments and climates. Ironically we often find two linked industries in conflicting institution as both have different interests. Murmann (2003) offers a good example of how two related industries of textiles and dyes have conflicting tax institutions in England at the beginning of twentieth centuries. Textile industrialists preferred to get cheaper synthetic dye from Germany and struggle for lower import taxes, which were desperately challenged by domestic producers of natural dye who lobbied for protection through higher taxes.

The third approach that recently gains popularity is co-occurrence analysis. The idea is that two related industries tend to be present altogether because they intuitively require not only the same inputs, factors of production, technologies required in production process, but also similar institutions, infrastructures, soil, climate, and other broad conditions embedded to the regions. Hidalgo *et al.* (2007) analyse co-occurrence at country level using international trade data while Neffke *et al.* (2011) analyse it at plant level using national manufacture data of Sweden. This paper follows Hidalgo as constructing relatedness based-on large international trade data could minimize the measurement bias particularly related to broad conditions as discussed just above.

III. Methods

3.1. Proximity and industry-space

In measuring inter-industry relatedness, this research adopted the proximity method introduced by Hidalgo *et al.* (2007). They developed proximity measure based on the co-occurrence concept of two industries being exported by a country in tandem. Formally, they defined proximity between industry 'i' and 'j' as 'the minimum of the pairwise conditional probability of a country exporting a good given that it exports another' (p.484). The formal representation is:

$$\Phi i,j = \min\{P(RCAxi|RCAxj), P(RCAxj|RCAxi)\} \quad (1)$$

where $\Phi i,j$ is the proximity between industry 'i' and 'j'; $RCAxi$ is Revealed Comparative Advantage of industry 'i' in country x; and $RCAxj$ is Revealed Comparative Advantage of industry 'j' in country x. $P(RCAxj|RCAxi)$ means the probability of country x to export industry 'j' in condition that country x also export industry 'i'. Similarly, $P(RCAxi|RCAxj)$ means the probability of country x to export industry 'i' in condition that country x also export industry 'j'. The lower value was assigned as the proximity between industry 'i' and 'j'. This paper used definition of RCA from Balassa (1986) which is given below. $x_{c,i}$ is the value of exports of country c in good i. This paper considered a country having dominant industries if it had RCA greater or equal to one

$$RCA_{c,i} = \left(x_{c,i}/\textstyle\sum_i x_{c,i}\right)/\left(\textstyle\sum_c x_{c,i}/\textstyle\sum_{c,i} x_{c,i}\right) \quad (2)$$

Using the industry proximity values, I then constructed what is called industry-space. The proximity matrix was translated into a network where industries and the values of proximity were referred as nodes and links respectively. The network builder software, Cytoscape, offers the edge-weighted spring-embedded layout that is considered to be the most suitable layout to reveal the industry-space structure. For its size, depicting all the nodes into the network representation of industry-space produced a very dense, crowded network which did not help the analysis at all. After experimentation with various cut-off values, it was decided that the best visual representation of the network structure emerged with a cut-off proximity value of 0.4. This means that only those links with proximity values greater or equal to 0.4 were included into the network.

In order to enhance the eligibility of the graphs, information about the position of industries within the industry-space was added through colour coding different industry groups. Furthermore, I depicted the proximity information in the industry-space by the degree of transparency of the links. The rule is that darker links represent higher proximity (close industries). In addition, the total export values of the industries were represented by the size of the nodes. The larger the size of the nodes is the larger the global export value of those industries.

The proximity matrix could be used to perform some statistical analyses to evaluate whether regions really develop new industries that were cognitively close to the existing industry structures. The proximity matrix however, tells us only the cognitive distance between pairs of industries, or how close an industry to another is. The proximity value does not tell us how close an industry is to a region. We have to have this information to evaluate whether regions really do develop new industries that are cognitively close to the regions. One way to summarise this information is by adopting Neffke's *et al.* (2011) measure of closeness. The closeness measure calculates the cognitive distance between an industry to other industries residing inside provinces. This can be done by counting the number of links an industry has to other industries belong to provinces (called as portfolio). The links should reach a certain proximity value to be considered as 'close' to the portfolio. In our case, we arbitrarily chose the value of 0.1432 as this is the median of proximity values. Formally, closeness (θ) is defined in equation (3). 'I' is an indicator that takes value 1 if true or 0 otherwise.

$$\theta_{i.p} = \sum_{j \in PFp} I(\Phi_{i,j} > 0.143 \qquad (3)$$

Another way is by calculating the density of industries for each region (Hidalgo et al., 2007). The idea of density is that if a potential industry, i.e., industry that has not been developed yet, is surrounded by a lot of dominant industries (i.e., industry with RCA > 1) within a region, then that industry is considered having high density, and vice versa. They argue that regions endowed with a lot of dominant industries will be denser and have a higher chance to develop new industries. Formally, the density measure is given as follows:

[2] Neffke *et al.* (2011) choose 0.25 as threshold while and Essletzbichler (2013) adopt 0.237. Neffke *et al.* (2011) and author experimented different cutting values (0.02, 0.58. 0.125) but the results show similar patterns.

$$\omega_j^k = \sum_i x_i \Phi_{i,j} / \sum_i \Phi_{i,j} \quad (4)$$

where ω_j^k is the density around industry 'j', given the export basket of region 'k'; and x_i = 1 if $RCA_{k,i}$>1, or 0 otherwise.

3.2. Data

The analysis used trade data both at international and provincial levels from 2000 to 2012. International trade data were downloaded from the United Nations website http://data.un.org/ while provincial trade data were provided by BPS Statistic Indonesia. The trade data use the classification of the Harmonized System 2002 at four digit industry level (HS4 2002).

The HS4 2002 consists of 1,241 industry classifications. Our unit of analysis was at provincial level and included 33 provinces. Thus, we had 40,953 entries of province-industry combinations. We performed the analysis from the year 2000 to 2012 with three-year gaps: 2000, 2003, 2006, 2009 and 2012. The reason was mainly based on the assumption that provinces need at least three years to set up a new industry. So, in total, we have 204,765 entries of data that comprise five three-year datasets with 40,953 entries in each. This provided us enough ammunition to decipher evolutionary patterns of industry development at provincial level in Indonesia.

IV. Results and Discussion

4.1. Proximity matrix and industry-space

A 1,241 x 1,241 proximity matrix is calculated by applying equation (1). The main diagonal of the proximity matrix equals one, meaning countries which export industry A must also export industry A. Proximity matrix is symmetric, meaning the proximity between industry A and B is exactly the same as the proximity between industry B and A. Figure 1A colour codes the pairwise proximity values. Figure 1B depicts the distribution of proximity value cumulatively, and by its frequencies in 1C. Sample of proximity values of some agriculture industries is displayed in Table 1. The proximity matrix reveals that most industries are basically unrelated with very low or zero proximity. Around ninety per cent of industry pairs have proximity values less than 0.3 (dark blue colour), around seven per cent of industry pairs have proximity values between 0.3 and 0.4 (light blue) and less than three per cent have proximity values greater than 0.4 (yellow).

This finding is somewhat similar to what were developed by Hidalgo *et al.* (2007) for proximity matrix based on trade data in 1998. The burning question is whether the proximity matrix changes over time? The proximity matrix did change over time but the structure (proximity values between different industries) remains stable. This means that the proximity values for links might change but strong links keep strong and the weak links stay weak. To check this stability, correlation coefficients between the proximity matrices in 2000, 2006, and 2012 are calculated and the results are compared with Hidalgo's (2007) calculation for the earlier periods (1985, 1990, and 1998) in Table 2. Nevertheless, changes in proximity matrix over time offer an interesting topic for future research.

Table 1. Sample of proximity values of some agriculture industries

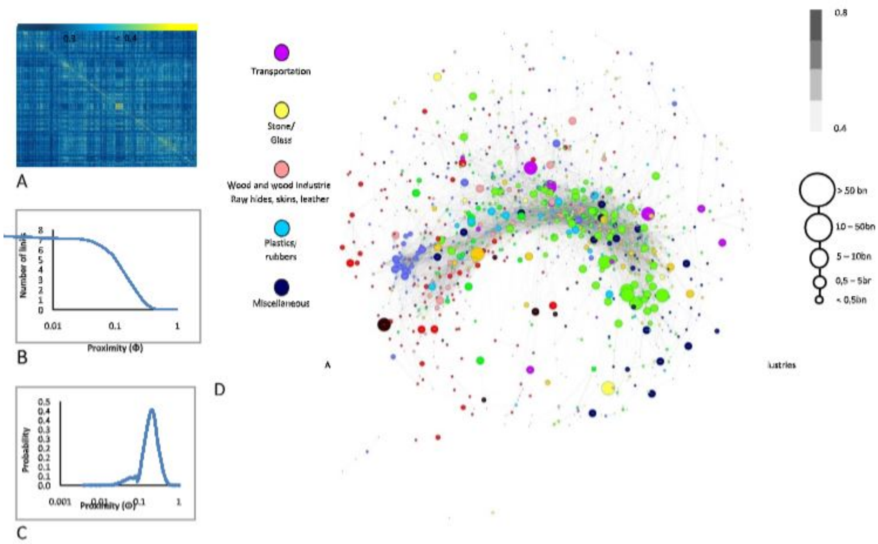
Industries (HS4 1992)	101	102	103	104	105
101					
102	0,41				
103	0,10	0,26			
104	0,36	0,52	0,16		
105	0,19	0,22	0,19	0,31	

Table 2. Correlation between proximity matrixes

This Research			Hidalgo et al. 2007		
2000	2006	2012	1985	1990	1998
1	0,71	0,59	1	0,701	0,696
	1	0,68		1	0,616
		1			1

To visualize the industry-space, we represent the proximity matrix as a network. Using network builder software and after some adjustments, the complete industry-space representation is displayed in Figure 1D. As we can see, the industry-space reveals somewhat a core-periphery pattern. The core of the industry-space shows a denser and darker network whereas the periphery consists of a sparser and transparent network. As expected, advance industries such as transportation, electrical, machineries, chemical and metal industries are mostly concentrated at or near the core of industry-space, whereas natural resources such as vegetable, food and oil industries are located further away of the core. Some exceptions do occur. For example, although they are considered as resource-based industries, many wood industries are found near or at the core of the industry-space. We can find many of these industries across the industry-space. Textile industries are concentrated at the edge of the industry-space core, but we can also find some of them at the core and some other at the outer sections of the industry-space.

Figure 1. Proximity Matrix and Industry-Space. A. Proximity matrix in colour representation; B. Cumulative distribution of proximity values; C. Density distribution of proximity values; D. Industry-Space. Source: author's calculation.



It is interesting to explore the industry-space by looking at some more examples. The large dark brown node at the left side of industry-space is oil. The large size of the node shows that oil is a valuable industry in international trade. However, its relative position at the edge of industry-space tells us that oil is not closely related to many other industries. Countries or regions endowed with oil industries have a strong incentive to stay with this industry for two reasons. First, oil is a valuable product in the global market, thus there is no reason to turn away from it. Second, it is difficult to develop other industries, as they are not close enough to 'jump to'. One may ask why oil is located rather close to the periphery of industry-space even though it is a crucial input in production process[3]. Within the input-output perspective, it is true that oil is an important input for almost all production process. Thus, within this view, one would expect oil to be located in the middle of industry-space.

Nonetheless, the co-occurrence measure has different logic to the input-output measure. The co-occurrence measure asks whether provinces endowed with the oil industry are cognitively capable of making other industries which are very likely to be produced by using oil as one of the inputs. According to the co-occurrence measure the answer would be 'no'. From the co-occurrence perspective, oil industry has, on average, low proximity to other

[3] This question was actually raised by a participant in a conference attended by the author. The participant argued that oil product should be located at the core of industry-space, given its crucial roles in production process.

industries, suggesting countries or regions exporting this industry are unlikely capable of developing other industries.

A similar case is demonstrated by diamond industry - the large yellow node at the bottom of the industry-space. The large size, showing the value in the international market, does not necessarily locate an industry at the core of industry-space. Diamond and oil are good examples of resource curse in action. The high value of these industries tempts countries to focus their energy on these non-renewable resources neglecting other major and usually advance industries. In the end, they become highly dependent on these industries and highly vulnerable to the price shocks of commodity in the global market.

In the following, we construct some countries and provinces' industry-space by depicting countries and provinces' industries onto the network. In order to reveal their evolutionary changes, countries and provinces' industry-spaces are constructed at two points in time: years 2000 and 2012. Limited space has forced us to focus on four countries and three provinces[4].

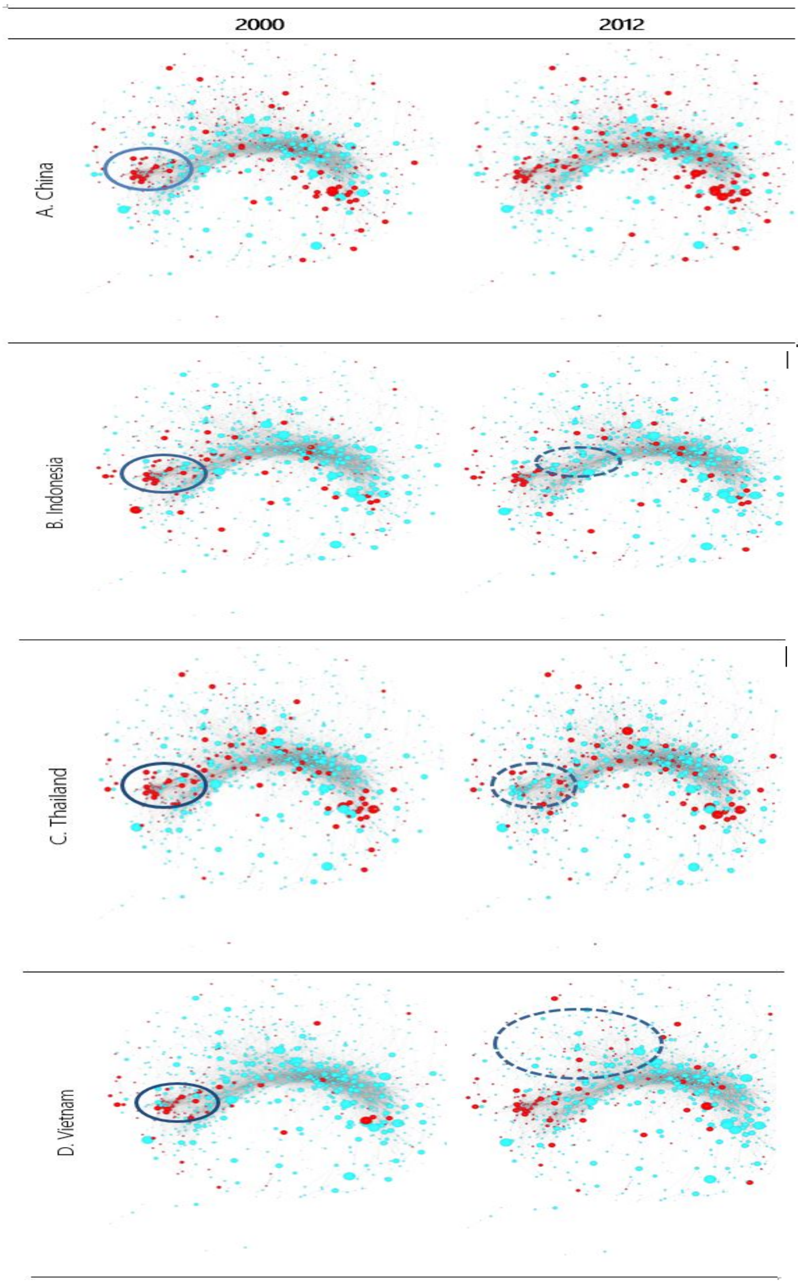
4.2. Comparative industry-space of selected countries

Using the industry-space as a template, four countries' industry-space are constructed for comparison purpose. we purposively focus on four countries, i.e. China, Indonesia, Thailand, and Vietnam because of their similarities in terms of level of industrialisation. We reapply equation (2) to calculate the RCA for each industry in those countries, and depict them onto the network of industry-space. The results are displayed in Figure 2.

One thing that the four countries share in common in year 2000 is that the structures of each country's industry-space is populated by textile industries (solid circle in Figure 2). The landscapes did not change much in 2012 except for China and Thailand. China's industry-space looked much denser, particularly at its core, suggesting a successful industrial transformation took place in the country. Similarly, Thailand's industry-space became fairly denser at its core, populated mostly by electrical and machinery industries, but it started losing its textile industry in 2012 (dashed circle). Meanwhile, Indonesia barely managed to diversify toward the core of the industry-space, at the same time lost its comparative advantage in some wood and rubber industries (dashed circle). Similar to Indonesia, although Vietnam managed to develop few new industries at the core of its industry-space, the trajectory of its industrial transformation seemed to embark to the direction of food and miscellaneous industries (dashed circle).

[4] For the complete collection of industry-spaces and more colorful images of Figure 2-4 can be viewed at:
https://regionalknowledge.wordpress.com/product-space/

Figure 2. Industry-Space of Selected Countries in the Global South. The red dots represent regional industries with an RCA greater than unity, which populate the industry-space. Source: Author's analysis.



It is worth to note that although Indonesia and China has equal level of industrialisation in terms of its share to GDP, both have contrast structure of industry-space. While China rapidly diversifies to more advance industries at the core of industry-space, the structure of Indonesia's industry-space seems to be stagnant. Moreover, even though countries with similar profile in terms of level of development and level of industrialisation, each of them has unique trajectories of industrial development. Regardless the path those country chose to travel toward industrialisation, it seems that they started the journey from the some light industries such as textile.

4.3. Industry-space of three provinces

Three provinces' industry-spaces in Figure 3 offer an overview about different paths of industrial development. The choice of the three provinces is mainly based on their comparability in terms of level of industrialisation. Bear in mind that the analysis will not discuss industry by industry in detail. Rather it outlines the structural transformation taking place in the provinces by comparing their industry-spaces. Nevertheless, some industries will still be highlighted to emphasize some significant changes along the transformation process.

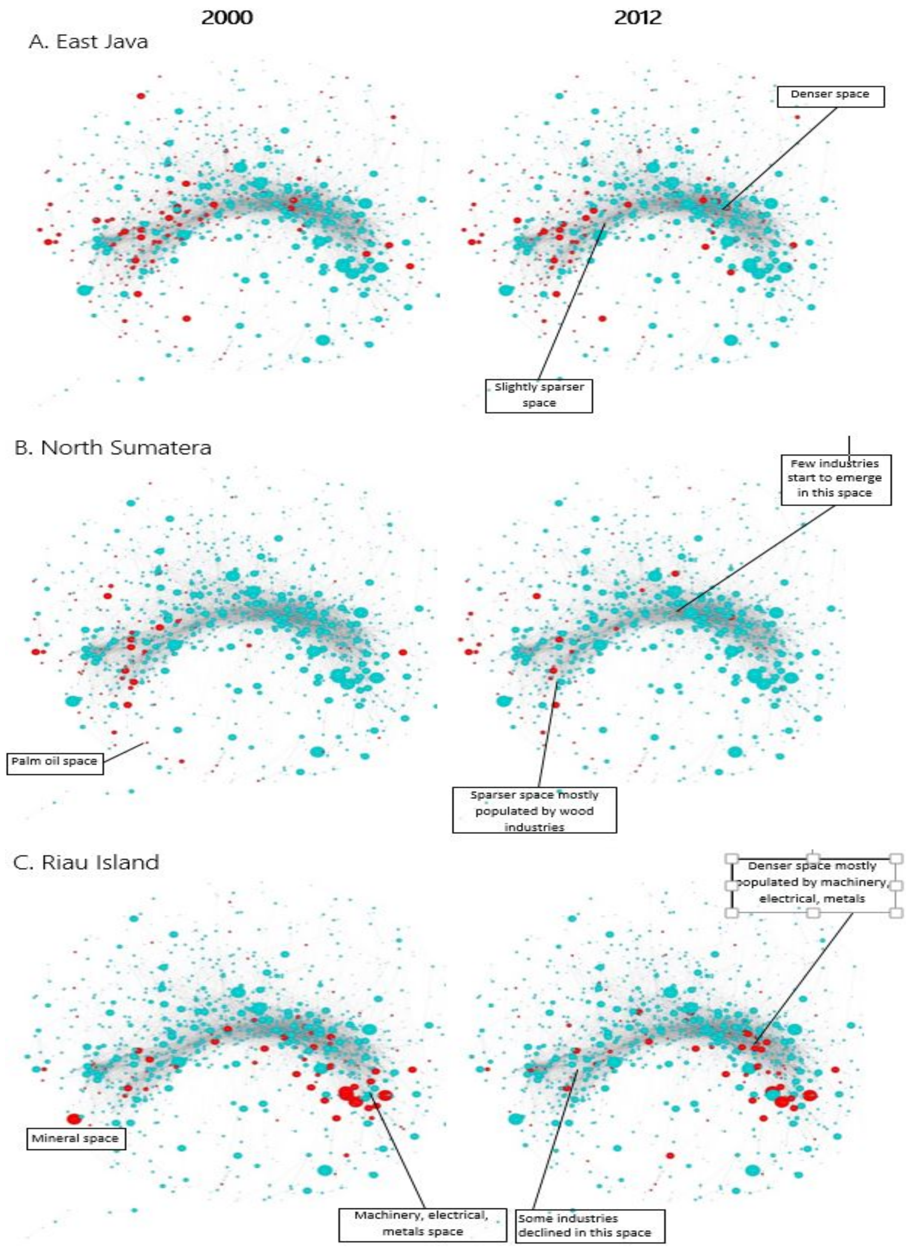
The three provinces' industry-spaces reveal a different composition. For instance, North Sumatera's industries mostly reside on the left-hand side area of industry-space, while Riau Islands' industries concentrate on the right-hand side area of industry-space. East Java somehow demonstrates a rather distributed industry-space compared to the two others. Apart from the differences, the three provinces share one thing in common that they do not have specialisation in textile industry.

It is obvious that East Java (Figure 3A) has the most populated industry-space among the three. East Java seems to manage promoting some industries at the core of industry-space, such as machinery, electrical, metal, chemicals industries. Although some industries declined, mostly wood industries and some glass, stone, plastics and rubbers industries, most existing industries in East Java stay in the space to where they belong. Furthermore, the industry-space of East Java in 2012 indicates that the new emerging industries seem to be rather close to the existing ones. In other words, the industry-space of East Java gradually evolves toward the related industries.

Meanwhile, North Sumatera (Figure 3B) displays a different trajectory from its counterpart East Java. The wood industry-space of North Sumatera seems less sparse in 2012 than in 2000, suggesting a decline of those industries in the province. Detailed scrutiny of the dataset revealed that the province lost comparative advantage in some vegetable and food industries, wood industries, and some miscellaneous and metal industries. Moreover, the oil palm industry that is one of North Sumatera's primary export only has a tiny share in the global market and its position in the industry-space is rather close to the periphery. Focus too much on this industry would be less promising for the province's long term industrial development. Nevertheless, the industry-space in 2012 suggests that North Sumatera has managed to develop a few new industries in the centre of the industry-space, particularly chemical industries and plastics and rubbers industries. However, in terms of their cognitive position in the industry-space, those industries seem to be quite far from its industry structure in 2000, suggesting a leap in industrial development. The specific reasons for the fall and the leap are beyond the scope of this analysis. Nevertheless, the case of North Sumatera is worth serious attention for future research.

Riau Islands' industry-space is arguably the most sophisticated one among the three (see Figure 3C). The province hosts many sophisticated industries such as chemicals, machineries, electricals, and metal. Apparently the province's industry-space is shaped by the presence of special economic zone in Batam that has been long promoted by the government back to early 1970s. Some machinery industries did fall along with some wood industries. However, some other machinery industries do grow even more along with chemicals and metal industries. Those emerging industries are visually not far from the structure in 2000 (concentrate at the right-hand side of its industry-space). Conversely, those which were declining previously resided at the other side of its industry-space. It seems that Riau Islands starts to specialising its industry toward machinery, electrical, metal, and chemicals industries occupying the right-hand side of its industry-space. Riau Islands has also been known as oil-producer province. Its industry-space in 2000 confirmed the status as shown by the big red node on the left-hand side of the industry-space. The status, however, has changed in 2012 that also occurred at the national level. Since 2004 Indonesia has become a net importer country of oil.

Figure 3. Regional Industry-Space. A. East Java's industry-space in 2000 and 2012; B. North Sumatera's industry-space in 2000 and 2012; and C. Riau Islands' industry-space in 2000 and 2012. The red dots represent regional industries with RCA greater than unity that populate industry-space. Source: Author's analysis.



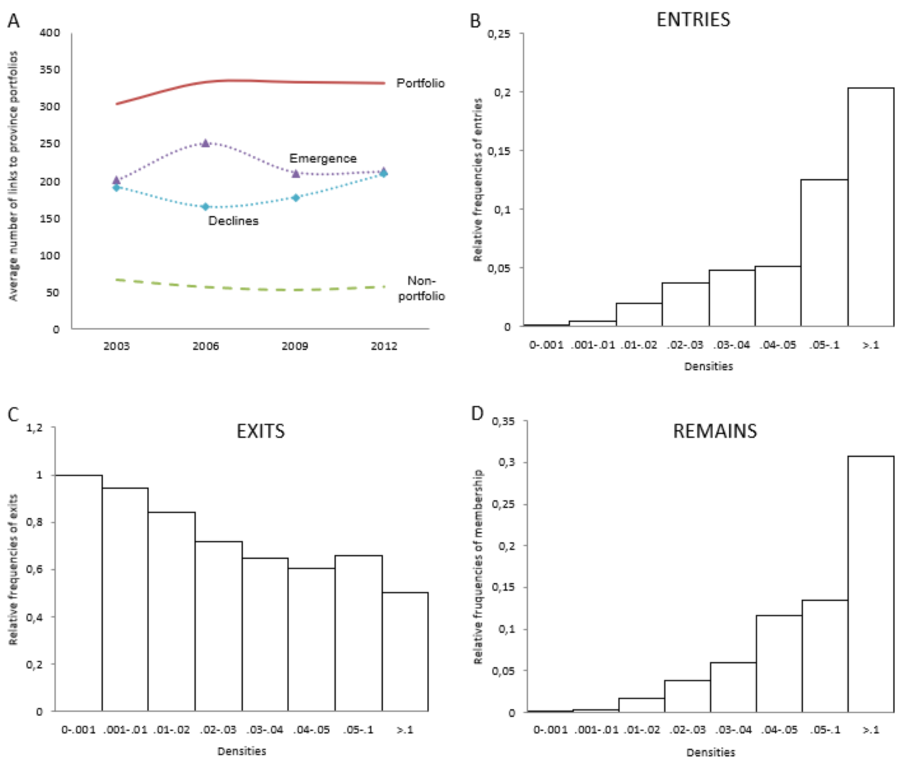
4.4. Statistical analysis

Beyond the visual analysis, do provinces really develop industries that are close to the existing industries? I used statistical analysis to further investigate this question. First, I looked at the relation between the probabilities of new industries to emerge as a function of its closeness to provinces' portfolio. To do this, I calculated the closeness of every industry outside the provinces' portfolio (called as non-portfolio industries) to the provinces' portfolio by applying equation (3). Here portfolio industries are defined as industries that have non-zero value at time t in province p, whereas non-portfolio industries are otherwise. As comparison, I also calculated the closeness among portfolio industries as depicted in Figure 4A. Averaged across industry-province combinations for each three-year period, the closeness among portfolio industries (bold line) is always above the closeness of non-portfolio to portfolio industries (dash line). This means that provinces' portfolio industries are always more cohesive. In other words, portfolio industries are more related one to each other relative to their counterparts of non-portfolio industries. Moreover, the rather flat and smooth line of portfolio line tells us that the cohesiveness (averaged closeness) of region portfolios tend to be stable over time.

I also add average closeness of emergence and decline into the graph. The dotted line with upward triangles plots the averaged closeness of emerged industries and the one with diamonds plots declined industries. The emergence line is always closer to portfolio line compared to the decline line, suggesting emerging industries tend to be closer to province portfolio than those which are declining industries. The similarity of required infrastructures, labours and raw materials, physical environments, climates, institutions and other things that constitutes the closeness of industries to its provinces' portfolio is believed supporting those industries to thrive in provinces where they are close to. In contrast, declined industries might perceive that those of required conditions became less and less supporting for their productive activities over time and increasingly pushing them down, and even out of the provinces.

Then I identified the emerging industries which are defined as industries that did not belong to provinces' portfolio three years ago but present in the provinces' portfolio three years later. The calculations are applied for 1,241 industries of four-digit HS codes in 33 Indonesia provinces pooled across five three-year periods between 2000 and 2012, resulting 204,765 observations of combination region-industry. In total, there were 6,816 events of emerging industries. As emergence can only be occurred only for industries that were initially outside of regions' portfolio, the potential industries that had such chances would be the non-portfolio industries at the beginning of the given period. Summed up across region-industry combinations and years, I found 151,679 possibilities of emergence. Thus, the probability of emergence would be 6,816/151,679 = 4.5 per cents. If we calculated this probability separately for each value of density defined in equation (4), we could analyse the relation between the probability of industries to emerge and its density values, as revealed by Figure 4B. The graph evidently suggests that new industries tend to emerge if they are closer to provinces' portfolio. Reading horizontally from the right to the left, the probabilities of industries with the largest density values (greater than 0.1) are 200 times higher than industries with the smallest density values (less than 0.001) to emerge as dominant industries in the near future.

Figure 4. The Rise and the Fall of Industries in Provinces. A. Portfolio industries are more cohesive than non-portfolio industries; B. Industries closer to provinces' portfolio tend to enter/emerge; C. Industries that are relatively distant tend to exit/decline; D. Closeness to provinces' portfolio also keeps industries staying. Source: author's calculation based on province trade data from 2000-2012.



With similar calculation, one can also investigate the other way around. Do less related industries to regions' portfolio tend to decline? Here declining industries are defined as industries that part of provinces' portfolio in the beginning of periods but have left the portfolio three years later. I estimated 7,101 events of region-industry decline out of total 12,133 potential declines. In other words, the overall probability of decline is 58.5 per cents. Elaborating the probability of decline by its density values, I came out with somewhat a contrast graph to the previous one (Figure 4C). Smaller values of density (below 0.001) display very high probability to decline. The probabilities drop into half of it for larger density values (greater than 0.1). This evidently suggests that low relatedness to provinces' portfolio increase the probability of industries to decline.

Apart of emerged and declined industries, some industries did stay as member of provinces' portfolio over a certain period of time. They were part of provinces' portfolio at the beginning of periods and still so by the end of periods. In total, there were 13,606 events out of 204,765 potential stays. Plotted by its density values in Figure 4D, probabilities of staying follow the probability of emergence, that is closer industries tend to stay within the provinces to where they belong. In order to maintain the accuracy of analysis, I also apply the same analysis but with a different measure, i.e., closeness as formulated in equation (3). The analysis, although the results are not displayed here, produced highly similar graph to those with density measure.

V. Conclusion

The proximity matrix not only tells us that many industries are cognitively close to each other, but it also tells us that most of industries are not really related. It is also evident that the proximity between industries tends to be stable. That is, close industries tend to stay close to each other and vice versa. The analysis also confirms the claim of path dependence theory that new industries are more likely to emerge in a region if they are close to existing industry structures and tend to decline if they are not. This calls for regional policies that focus on promoting potential industries that are close to the provinces' portfolio rather than on old, distant and declining industries.

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