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Development of Product Space Theory for Systemic Analysis of Industries in Kermanshah Province

Shadi Ghiasi[1], Heirsh Soltanpanah[2*], Adel Fatemi[3], Abdolnaser Shojaei[4]

Abstract
Planning for economic sections and industrial activities at a regional level requires a proper understanding of a region's potentials. The present study applies product space theory, network science, and information on Iranian provincial production structure to outline a roadmap for industrial development of Kermanshah. Analysis of mean value added and population of Iranian provinces in 2014 to 2018 indicated that of the 32 activities examined, Kermanshah has a revealed comparative advantage in five areas (agriculture and horticulture, traditional husbandry, apiculture, sericulture, and hunting) and other agricultural areas, forestry, and chemicals, with latent comparative advantage in 11 areas, and no advantage in 16 areas. Next, greedy, majority, high degree, and low degree strategies were combined with Borda's and Copeland's approaches to identify 11 activities for activation prioritized as follows: poultry, fishing, food, base metal, machinery & equipment, wood industry, other non-metal minerals, pharmaceuticals, metals, appliances, and rubber and plastic products.

Keywords: Product Space, Regional Planning, Product Space, Revealed and Latent Comparative Advantage

Introduction

Iran is a vast country with a great cultural, social, and economic diversity, and given that Iranian provinces differ in terms of natural, geographical, and human opportunities available, it is essential to plan for each province based on its particular conditions. Development of any region requires a shift from a one-size-fits-all approach toward a systematic view that focuses on unique features of that region (European Commission, 2020).

Despite having access to many potentials for developments (including natural resources, being located at the country's border, *etc*.), Kermanshah still represents an underdeveloped province in terms of most development indicators, particularly in terms of industrial development. This underdevelopment may be attributed to the absence of a proper strategy, lack of a plan based on a systemic view and scientific principles, and ignoring potentials and features of the province. As a discipline, planning has experienced frequent highs and lows in terms of theoretical development and practical application; however, it has emphasized synergic interdisciplinary interactions with other disciplines to influence and improve social conditions. Economic, social, political,

1. PhD student, Department of Industrial Management, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran
2*. Department of Management, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran
(Corresponding author: heresh@iausdj.ac.ir)
3.4. Department of Statistics, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran

managerial, and futurological, and network sciences are among the disciplines closely linked to regional planning. Product space theory (PST) and network science have recently been applied to systemic analysis of industries and regional planning (Neffke *et al*., 2013; Akgungor & Mert, 2021; Wang & Turkina, 2021; Zaldívar & Pérez, 2020). PST states that a region is likely to produce new products which are consistent with the potentials available in that region (Alshamsi *et al*., 2018). Although an agreement exists on this view, there is still no proper understanding of strategies that can rightly balance development of related and nonrelated potentials. For this reason, it is essential to present a model that can form a basis for diversification of industrial productions consistent with regional potentials. Obviously, today's planners face the challenge of identifying products whose production not only aligns with regional potentials, but also results in sustainable economic development. To find the right strategy, it is essential to first identify the existing economic potentials of a region. To this end, a PST-based approach is used to identify actual and potential capabilities in Kermanshah. Only after identification of the potentials existing in different industrial sections and through focus on strengths and competitive advantages can one properly analyze the situation and outline a roadmap for industrial development of Kermanshah.

PST shows a region's capability in production of, and eventually exporting, "complex" goods based on the potentials of that region. A region with a complex economy will be able to produce a wide range of technological goods by combining a large amount of productive knowledge within extensive, complex networks. On the other hand, a region with a non-complex economy can only produce simple goods or, in other words, ubiquitous products. Production of these products does not require a great deal of knowledge and, even if it does, ubiquitous products can be produced by less complex regions; this is why these products provide a relatively smaller competitive advantage across a country. Economic complexity mainly focuses on creating a comprehensive map of product similarities in connection to required capabilities. This map depicts a road that facilitates capability accumulation. Hausmann *et al* (2015) call this map a "product space" and use it to identify a country's or a region's complexity status, demonstration of the existing production capabilities, and products that nearly match these capabilities and potentials. In addition, economic complexity can be thought of as a social learning process. A region can increase its potentials by developing its capacity to produce a wider range of products. This diversification process involves trial and error, where entrepreneurs, investors, and policymakers play a major role. As noted earlier, the primary objective of the present paper is to adopt a PTS approach to systemic analysis of Kerman industries following a data collection stage. A produce space network is charted after calculating diversity and ubiquity. The next step involves proper development of a network to classify Kermanshah industrial activities into three categories: (1) active (activities where Kermanshah acts as a competitive producers across the country), (2) potentially active (activities where Kermanshah has a potential to be actively involved), or (3) inactive (activities where Kermanshah is unlikely to attain competitiveness). Potentially active nodes in a product network can be activated using the five strategies proposed by Alshamsi *et al* (2018): (1) random (where nodes are randomly selected for activation), (2) high degree (where nodes with the highest degree are selected for activation), (3) low degree (where a node with the lowest degree at each stage is selected for activation), (4) greedy (where a node with the highest probability of activation and a shorter expected time of activation in a sequence is selected for activation), and (5) majority (where a node with the greatest number of links to active nodes is selected at each step), or a combination of these five strategies. A strategy is defined as an ordered sequence of activation goal over a network. The present study attempts to identify a sequence of objectives that minimizes the total time needed to activate all network nodes. In fact, our data analysis method combines network science with mathematics.

Although a few number of studies used an approach based on product space and economic complexity at regional or provincial level, the present study is the first of its kind to combine PST with different PS development strategies into a systemic analysis of regional industry and planning. Briefly, this paper particularly attempts to answer the following questions:

(a) In what areas of industrial activities does Kermanshah have a revealed comparative advantage (RCA)?
(b) In what areas of industrial activities is Kermanshah potentially capable of reaching comparative advantage?
(c) How does activation sequencing for potentially advantageous economic activities play out in Kermanshah based on different strategies or a combination of them?
(d) How are Kermanshah's active, potentially active, and inactive products situated within the countrywide and active product networks?

To answer these questions, we start with a literature review. This is followed by a description of research methodology, findings, discussion, and a conclusion.

Literature Review

The past few years have witnessed a significant development in regional planning science due to advancement in other sciences and emergence of new kinds of sciences which resulted in a new form of interdisciplinary network of these emerging sciences. Previous regional planning studies only focused on such indicators as comparative advantage, location quotient, or analysis and planning based on development indices. However, new studies of regional planning apply emerging sciences into theoretical and practical areas of development. A novel method used in this area is the application of network science and PST in regional planning.

Hausmann and Klinger (2007) emphasized the importance of product space. Using product space, it is possible to predict actual trends for regional comparative advantages. In fact, regions can identify products similar and closely related to their currently produced goods and lay the groundwork to facilitate production and export of these products. By similarity or proximity we mean that two sets of products that are similar in terms of required knowledge for production, physical capital, intermediate inputs, infrastructures, and institutional and legal requirements among other things needed to facilitate a shift toward comparative advantage of a country or a region.

According to PST, movement of regional economies toward technologies and industries related to their potentials is largely determined by knowledge structure and economic production of regions; and that is why countries and region tend to move toward related activities (Hidalgo *et al*., 2007; Neffke *et al*., 2013; Petralia *et al*., 2017; Pinheiro *et al*., 2018; Alshamsi *et al*., 2018; Hartmann *et al*., 2020).

Investigating the effect of competitive advantage strategies on customer loyalty with the mediating role of customers brand identification and brand awareness in the insurance industry, Falahatgar et al (2021) found that there is a relationship between differentiation and customer loyalty and also in the relationship between cost leadership and customer loyalty, but the relationship between cost leadership on customers loyalty and the mediating role of brand awareness in the relationship between differentiation on customer loyalty and cost leadership on customer loyalty were not confirmed. Munir (2020) explored the use of influence strategies and social mechanisms by the manufacturer to achieve supplier flexibility. Findings showed that using influence strategies has positive effects on supplier mix flexibility and the effects of trust on shared vision is meaningful on manufacturer flexibility. Karami et al (2020) studied the role of Internet in changing the transaction pattern of B2B markets. They stated that the factors contributing to the selection of B2B online market entry strategies in IT knowledge-based companies included entry time, external beneficiaries' characteristics and needs, corporate resources, corporate control strategy, corporate IT capabilities, external beneficiaries' IT knowledge and motivation, and product.

Evidently, development of economy in general, development of industrial section in particular, and launching activities completely unrelated to the existing activities and product portfolios can be difficult and risky (Zhu *et al*., 2017). In addition, complex industries or products often need a greater number of related activities to survive. Economic complexity theory states that economic growth happens when a nation accumulates its production capabilities and aligns them toward production and export of a wide range of complex products (Hausmann *et al*., 2015; Hidalgo & Hausmann, 2009).

Table 1 summarizes previous studies that used economic complexity and product space approach. A review of these studies shows that although a number of studies have applied PST at regional level (provinces or states) by plotting product networks, none of these studies proceeded to examine diffusion strategies over these networks. The present paper uses the model proposed by Alshams *et al* (2018) together with network science to prioritize RCA activities in Kermanshah based on an Iranian product space and by applying five diffusion strategies, namely random, high-degree, low-degree, greedy, and majority strategies as well as a combination of them.

Table 1.
A review of a number of related studies

Author(s)	Year	Method and findings
Khosravi *et al*.	2021	Using panel data econometrics, the authors demonstrated that economic complexity and product space indicators present Iranian export dynamicity in chemicals industry with 145 chemicals introduced by the authors for diversification of Iranian exports through an optimal strategy.
Chávez *et al*.	2017	In a study on 32 Mexican states using economic complexity theory and econometric models, the authors showed greater production complexity in northern states, with economic complexity acting as a major factor that can explain inequality between the states.
Shahmoradi *et al*.	2021	In a study on Iranian export products and a comparison with the global conditions, the authors used an approach based on economic complexity indicators to identify cutting edge technological products. They identified 86 products that can facilitate technological achievements, higher economic complexity, and diversification if the country focuses on producing these products.
Zaldívar & Pérez	2020	By applying economic complexity and PST to data collected for the period 1999 to 2014, the authors found that 5 southern Mexican states produce less complex products than other states, and eventually a number of products that are more complex than the existing ones were proposed by the authors to increase diversification in these five states.

Author(s)	Year	Method and findings
Lian *et al*.	2021	The authors applied economic complexity theory and econometric models to show that investments on infrastructures, education, research and development, and banking facilities contribute to economic diversification in South Asian countries.
Li *et al*.	2021	The authors examined the mechanism involved in development of product space in countries and applied PST and econometric models to the data collected from 186 countries and ISIC four-digit codes to demonstrate that diversity in exporting chemicals and machineries positively affect economic development of countries.
Sorensen *et al*.	2020	The author used data collected from 131 countries and four-digit ISIC codes for 1221 products to find that Mozambique should apply a short-term greedy strategy or low-hanging fruits strategy.
Hausmann *et al*.	2020	The authors examined new export diversification opportunities in Jordan and identify new products for production and export based on economic complexity theory.
Shahmoradi *et al*.	2021	In a study on Iranian export products and a comparison with the global conditions, the authors used an approach based on economic complexity indicators to identify cutting edge technological products. They identified 86 products that can facilitate technological achievements, higher economic complexity, and diversification if the country focuses on producing these products.
Akgungor & Abay	2021	The authors used PST, econometrics, and patent data for 2010 to 2017 in Turkish provinces to outline the overall knowledge space in Turkey. They showed that knowledge space in 2017 was denser than in 2010, with increased diversity and innovation density in Turkish provinces.
Tavakolinia *et al*.	2017	Using multicriteria decision making techniques and a set of 53 indicators, the authors showed that cities in Markazi Province of Iran do not have equal access to development resources, with a major inequality existing between these cities.
Falahati & Ahmadian	2011	Using factor analysis, the authors demonstrated that Kermanshah Province will benefit the most from non-metal mineral products, coke for oil refineries, and power-generating machineries. They also showed that food and beverage and chemical industries created the largest number of jobs in the province while Kermanshah mainly focuses its investment activities on non-metal products, manufacturing power-generating machineries, and paper products.
Wang & Turkina	2019	Using social network analysis and product space, the authors compared the products produced in Québec, Canada to other Canadian provinces in terms of economic complexity.

Research Methodology

Like many other academic studies of regional economies, the present paper uses location quotient (LQ) as a measure to identify activities with RCA in Kermanshah. LQ is defined in this study as

$$LQ_{s,a} = \frac{V_{sa}}{P_s} \Big/ \frac{\sum_s V_{sa}}{\sum_s P_s} \qquad (1)$$

Where V_{sa} denotes added value from activity a in province s in million Rials, Ps is the population of province s in the year being studied, $\Sigma_s V_{sa}$ denotes total added value for 32 Iranian provinces for activity a, and $\Sigma_s P_s$ is the population of 32 Iranian provinces in the year being studied. Once LQ is calculated, the method proposed by Hidalgo and Hausmann can be used to construct a province-activity matrix (M_{sa}). The matrix summarizes which activities have production competitiveness for each province. In other words, province s is a competitive supplier of activity a, if its corresponding M_{sa} value is above a certain threshold. A threshold equal to 1 was used in all studies. M_{sa} is constructed based on each province's LQ using the following equation:

$$M_{sa} = \begin{cases} 1 & if\ LQ_{s,a} \geq 1; \\ \cdot & otherwise \end{cases} \qquad (2)$$

Using this matrix, we can calculate product diversity and ubiquity as follows:

$$\text{diversity} = k_s = \sum_a M_{sa} \qquad (3)$$

$$\text{ubiquity} = k_a = \sum_s M_{sa} \qquad (4)$$

Diversity refers to the number of activities where a province has competitive advantage while ubiquity shows the number of competitive provinces involved in offering an activity.

Mapping Product Space

In the present study, product space refers to a network consisting of all activities supplied in Iranian provinces. Product proximity in a product space network is given by square proximity matrix.

Products are related if they are concurrently produced by a province or a number of provinces. Hidalgo *et al*. (2007) used similarities between the potentials needed in producing a pair of products to map product network. Since these potentials cannot be directly observed or measured, they used concurrent export probability (production probability in the present paper) for two products. Proximity index is given by:

$$Prox_{aa'} = \frac{\sum_s M_{sa} M_{sa'}}{\max(k_a ، k_{a'})} \qquad (5)$$

In mapping a product space it is essential to note a few important points. First, all products must be connected to each other; second, product density must not be excessively large or small. To this end, Hidalgo *et al*. (2007) used maximum spanning tree based on proximity index.

Next, to further highlight relatedness, products with maximum similarity are connected through the maximum spanning tree in addition to the existing network connection. In our proposed method for mapping the product space, all nodes with a similarity factor above 0.55 are connected to each other. It is important to note that Cytoscape 1 v. 3.6.1 was used to map the product space.

The Model Used to Identify LCA Products

To identify activities with latent comparative advantage, we used the model proposed by Alshamsi *et al*. (2018). Activation probability for each product in Kermanshah will be determined using the following model:

$$P_i = B\left(\frac{\sum_{j=1} a_{ij} M_j}{k_i}\right)^{\alpha} \qquad (6)$$

where a_{ij} indicates whether product i is connected to product j in the product space, M_j indicates whether product j is currently exported by the country being studied, k_j denotes the number of products related to product i in the network, B denotes activation probability of product i assuming that all related products are active (here we used B=1), and α is a coefficient to account for the significance of inter-product relations. For example, α=0 means that activation probability for a product node in a network is identical to all other nodes while α=1 means that activation probability of a node linearly increases with the number of active nodes related to that node. In addition, α>1 shows that activation probability of a node concavely increases with the number of related nodes.

Based on activation probabilities, products are classified into three categories: active products, potentially active products, and LCA products. Active products are related to those activities where Kermanshah currently has revealed comparative advantage while LCA products are associated with activities where Kermanshah does not currently have revealed comparative advantage but involve an activation probability greater than zero. Inactive products involve activities with activation probability of zero where Kermanshah does not have RCA.

Next, to activate LCA activities in the network, we use four diffusion strategies: greedy strategy, high degree strategy, low degree strategy, and majority strategy. In greedy strategy, a node with the highest probability of activation and a shorter expected time of activation in a sequence is selected for activation. In high degree strategy, nodes with the highest degree at each step are selected for activation. Low degree strategy selects nodes with lowest degree at each step for activation. And finally in majority strategy, a node with the greatest number of links to active nodes is selected at each step. It is important to note that here a node corresponds to a product and a node's degree denotes the number of products or nodes connected to that node.

Once the activation sequence for LCA products is determined based on high degree strategy, a combined strategy can be designed using the methods proposed by Borda and Copeland. In Borda's method, a pairwise comparison matrix is constructed to compare available options. The corresponding matrix element is set to 1 if, based on the four strategies, the number of cases where one strategy is preferred over the other three is greater than the number of cases where this strategy is dominated by the other three; otherwise, the corresponding matrix element will be set to zero. The number of elements in each row denotes the number of cases where the corresponding strategy is preferred over other strategies. In total, there are (m(m-1))/2 pairwise comparisons where m denotes the number of options. The criterion for preference here is the number of wins for each strategy in the majority of rows.

However, Copeland's method begins where Borda's method ends. In Copeland's method, the score assigned to each strategy is determined by subtracting the number of losses from the number of wins, and eventually the options are prioritized based on the differences between wins and losses.

Research Findings

After calculating LQ matrix using Eq. (1) and (2), it was found for Iranian provinces based on the mean added value and population data for 2014 to 2018 that Kermanshah attained an LQ over the threshold value 1 and thus a revealed comparative advantage in five areas of agriculture and horticulture, traditional husbandry, apiculture, sericulture, and hunting as well as other areas of activities in agriculture, forestry, and production of chemicals and chemical products as shown in Table 1.

Table 2.
LQs for Kermanshah economic activities

#	Activity	Activity Code	LQ
1	Agriculture and horticulture	A0110	1.202178
2	Industrial cattle farming	A012010	0.370245
3	Traditional husbandry	A012020	1.091577
4	Poultry farming	A012030	0.231218
5	Apiculture, sericulture, hunting, and other agricultural activities	A012040	1.59649
6	Forestry	A0130	1.542047
7	Fishing	A0140	0.768504
8	Mining for other minerals	B02	0.114574
9	Food production	C0310	0.536962
10	Beverage production	C0311	0.458938
11	Tobacco production	C0312	0
12	Textile production	C0313	0.236008
13	Garment production	C0314	0.514849
14	Production of leather and related products	C0315	0.055071

#	Activity	Activity Code	LQ
15	Production of wood and wooden products, except for furniture, matting, and straws	C0316	0.168981
16	Production of paper and paper products	C0317	0.506678
17	Publication and reproduction of recorded media	C0318	0.135005
18	Coke, oil refinery products	C0319	0.515926
19	Chemicals and chemical products	C0320	1.751743
20	Pharmaceuticals, chemical medicines and herbs	C0321	0.112926
21	Rubber and plastic products	C0322	0.396856
22	Other non-metal minerals	C0323	0.659475
23	Base metal production	C0324	0.051244
24	Fabricated metal products, except for machineries and equipment	C0325	0.176641
25	Computer, electronic, and optical products	C0326	0.030075
26	Electrical appliances	C0327	0.525245
27	Machineries and equipment not classified under other categories	C0328	0.042526
28	Vehicles, trailers, semitrailers	C0329	0.077553
29	Other transportation equipment	C0330	0.008574
30	Furniture	C0331	0.070211
31	Other synthetic products	C0332	0.145538
32	Machinery & equipment installation and maintenance	C0333	0.328749

Mapping the Product Space for Iranian Provinces

Product space is a geometrical representation of activities based on the concept of proximity between different goods. It is based on the idea that related activities need similar inputs, infrastructures, technologies, and institutions. Two activities are related if they are coproduced by a province or some provinces. To map this network, Hidalgo *et al*. (2007) used similarities between capabilities needed for producing a pair of products. A product space must be mapped based on a proximity matrix which is a 32×32 matrix here. In mapping a product space it is essential to note a few important points. First, all products must be connected to each other; second, product density must not be excessively large or small. To this end, Hidalgo *et al*. (2007) used maximum spanning tree based on proximity index. Figure 1 depicts the product space plotted for Iranian provinces in Cytoscape using the method proposed by Hidalgo *et al*. (2007). Node sizes are proportional to each product's contribution to the value added in total industrial activities (except for petroleum industry) across the country.

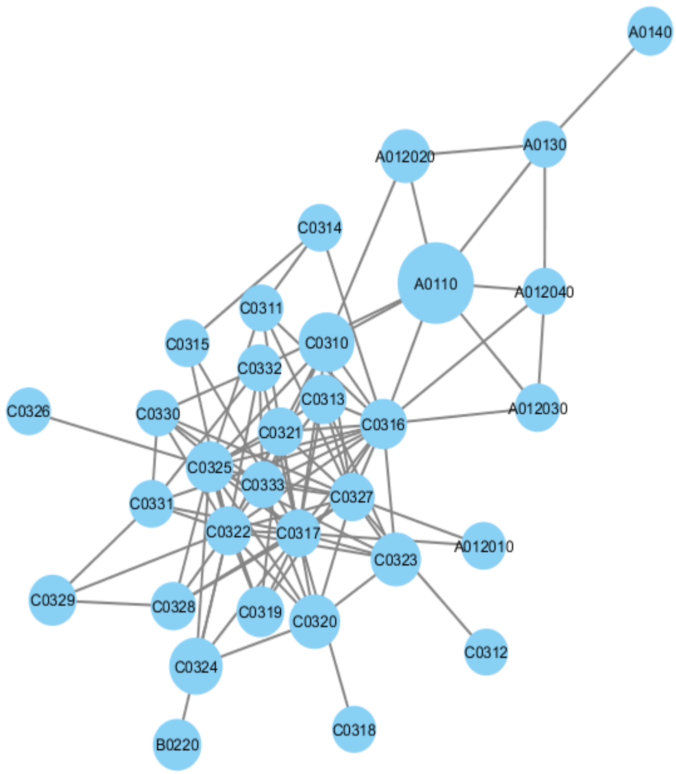

Figure 1: Product space for Iranian provinces
Source: findings of the study

So far, we know that of the 32 activities studied, five products give Kermanshah a revealed comparative advantage. However, to determine LCA activities or activities lacking comparative advantage in Kermanshah we used the model proposed by Alshamsi *et al*. (2018) to calculate activation probability for the remaining 27 activities. The results indicated that eleven activities have potential comparative advantages while the remaining 16 activities have no potential for comparative advantage with zero probability of activation. Table 2 lists LCA products for Kermanshah. The greatest activation probability (50%) was found for poultry and fishing. Ubiquity for poultry farming in Iran is 11, meaning that 11 provinces have RCA for poultry farming. The activity is connected to 4 nodes in the product space and network with two nodes (activities), covering agriculture & horticulture, apiculture, sericulture, hunting, and other agricultural activities, showing RCA for Kermanshah. Fishing has a ubiquity of 8 and is only connected to forestry. These two activities are followed by base metal production with an activation probability of 20%. Its ubiquity stands at 8 and the activity is connected to 5 products with only one of them being active.

Table 3.
LCA activities and their activation probabilities in Kermanshah

Activity Code	Activity	Activation probability	Ubiquity	Number of connected nodes	Number of active connected nodes
A012030	Poultry farming	0.5	11	4	2
A0140	Fishing	0.5	8	2	1
C0310	Food production	0.25	13	8	2

Activity Code	Activity	Activation probability	Ubiquity	Number of connected nodes	Number of active connected nodes
C0316	Production of wood and wooden products, except for furniture, matting, and straws	0.125	12	16	2
C0321	Pharmaceuticals, chemical medicines and herbs	0.11111	7	9	1
C0322	Rubber and plastic products	0.05555	11	18	1
C0323	Other non-metal minerals	0.125	11	8	1
C0324	Base metal production	0.2	8	5	1
C0325	Fabricated metal products, except for machineries and equipment	0.07142	9	14	1
C0327	Electrical appliances	0.06666	13	15	1
C0333	Machinery & equipment installation and maintenance	0.125	9	8	1

Source: Findings of the study

Figure 2 illustrates the product space for 32 activities with Kermanshah conditions across this network. Based on our calculations, Kermanshah has RCA in five activities (blue), LCA in 11 activities (green), and no RCA or LCA in 16 activities (red).

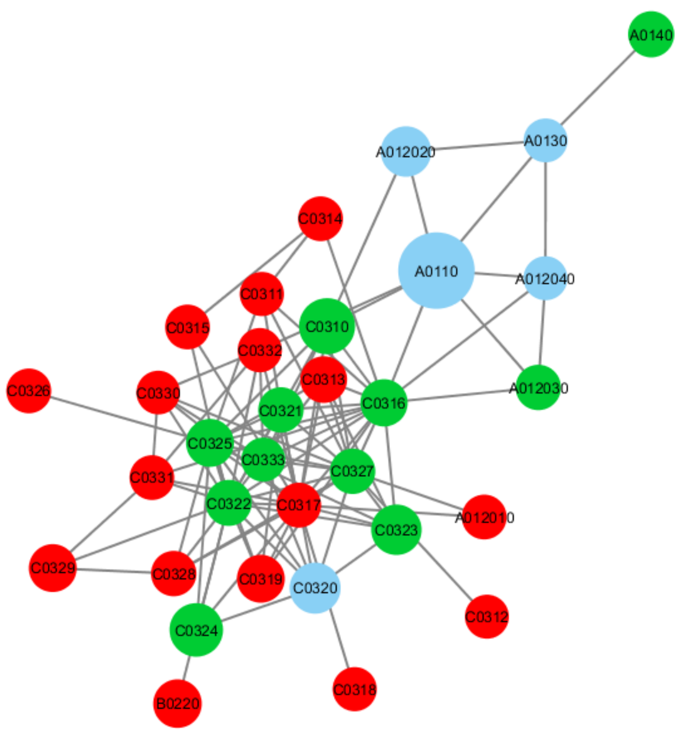

Figure 2: Product space for 12 activities in Kermanshah

The next question involves how to determine activation sequence for the 11 LCA activities. To this end, a variety of strategies can be chosen. Here, we used majority, greedy, high degree, and low degree strategies to activate 11 LCA products to increase production diversity in Kermanshah as indicated in Table 3. In majority strategy, a product with the greatest number of connections to active products is selected at each step. Since food production, poultry farming, and production of wood and wooden products, except for furniture, matting, and straws are connected to two active nodes each, these three activities are ranked the highest based on majority strategy, with the remaining 8 products placed at the lower ranks. In greedy strategy, a node with the highest probability of activation and a shorter expected time of activation in a sequence is selected for activation. Since both poultry farming and fishing have activation probability of 50%, these two activities are given the highest rank based on greedy strategy, with base metal production ranked second with an activation probability of 20%. . In high degree strategy, nodes with the highest degree (greatest number of links to other products) at each step are selected for activation. Here, rubber and plastic products, wood and wooden products except for matting, and electrical appliances are ranked highest, respectively. Low degree strategy selects nodes with lowest degree at each step for activation. Based on this strategy, fishing, poultry farming, and base metal production are the top three activities. Finally, we used Borda's and Copeland's methods to combine the four strategies and determine the activation sequence for these 11 LCA activities in Kermanshah.

Table 4.

Activation sequence for LCA activities based on the four strategies

Activity	Majority	High degree	Low degree	Greedy	Combination
Poultry	1	10	2	1	1
Fishing	2	11	1	2	2
Food production	1	6	6	4	3
Production of wood and wooden products, except for furniture, matting, and straws	1	2	10	7	6
Pharmaceuticals, chemical medicines and herbs	2	5	7	8	8
Rubber and plastic products	2	1	11	11	11
Other non-metal minerals	2	7	5	6	7
Base metal production	2	9	3	3	4
Fabricated metal products, except for machineries and equipment	2	4	8	9	9
Electrical appliances	2	3	9	10	10
Machinery & equipment installation and maintenance	2	8	4	5	5

Source: Findings of the study

Conclusion and Recommendations

Decision makers and planners can greatly benefit from product space theory and network science in regional planning and making right planning decisions. The present paper was an attempt to apply PST, network science, value added data for economic activities, and Iranian provincial population data to provide proper clues for development of Kermanshah Province. Results from implementing the model on the data collected from Kermanshah indicated that of the 32 activities examined here, Kermanshah has a location quotient greater than a certain threshold (=1) and therefore revealed comparative advantage in five activities, namely agriculture and horticulture, apiculture, sericulture, hunting and other agricultural activities, forestry, and chemical production. In addition, activation probabilities found for the remaining 27 products showed that the probability values for 11 products were greater than zero, indicating a latent comparative advantage. Furthermore, 16 products have an activation probability of zero. Moreover, we mapped the network for 32 products in Iran to identify where Kermanshah stands in the product network across the country. Given the high costs of investments in new products and the limited resources available for activating 11 LCA products, it is essential to determine an activation sequence for these products. Here, we used five strategies (*i.e.* greedy, high degree, low degree, and majority strategy and a combination of them) to identify this sequence of activation. It is easier to achieve objectives through greedy strategy and therefore it is referred to as a low-hanging fruit strategy. However, high degree and majority strategies activate products that potentially facilitate further activation of future products. These strategies target products that are more difficult to activate in earlier stages but can facilitate activation of other products in later stages while greedy and low degree strategies are less likely to enable activation of future products. A major finding of the present study is identification of a combined strategy using Borda's and Copeland's methods. We employed this combined strategy to identify activation sequence for LCA products in Kermanshah and outline a road map for diversification of LCA products based on the combined strategy. In this strategy, poultry farming was ranked as the top activity. Poultry industry is among the Iranian industries with a significant added value. The value added by this industry has grown from 13,197 billion Rials in 2011 to 78,149 billion Rials in 2018, representing a 492% growth. In addition, the value added by poultry industry in Kermanshah has increased from 117 billion Rials in 2011 to 349 billion Rials in 2018, showing a 199% growth over this period. It has a ubiquity of 11 across the country, meaning that 11 Iranian provinces have a revealed comparative advantage in this activity. Activation probability for poultry farming in Kermanshah was 50%, ranking the industry at the top of the table among the 11 products studied here. The product is connected to 4 other products in the network, two of which are active products. The same procedure can be used to identify and analyze other LCA products.

References

Agosin, M. R. (2007). *Export diversification and growth in emerging economies* (Vol. 233, pp. 559-562). Working paper. DOI: 10.18356/27e5d46c-en

AKGÜNGÖR, S., & Mert, A. B. A. Y. (2021). Knowledge Space, Relatedness and Complexity: A Regional Analysis in Turkey. *Yildiz Social Science Review*, *7*(2), 123-136. DOI: 10.51803/yssr.869824

Alshamsi, A., Pinheiro, F. L., & Hidalgo, C. A. (2018). Optimal diversification strategies in the networks of related products and of related research areas. *Nature communications*, *9*(1), 1-7. DOI:https://doi.org/10.1038/s41467-018-03740-9

Arthur, W. A. (2017). *Complexity and the economy* (Translated to Persian by Mahjub), Tehran: Ney Publishing.

Bahar, D., Hausmann, R., & Hidalgo, C. A. (2014). Neighbors and the evolution of the comparative advantage of nations: Evidence of international knowledge diffusion?. *Journal of International Economics*, *92*(1), 111-123. DOI: 10.1016/j.jinteco.2013.11.001

Bogetic, Z., Pejovic, I., & Osorio-Rodarte, I. (2013). Expanding and diversifying Montenegro's exports: A product space analysis. *Available at SSRN 2288087*. RePEc:cbk:journl:v:2:y:2013:i:2:p:19-34

Chenery, H. B., & Elkington, H. (1979). *Structural change and development policy*. Baltimore, MD, USA: Johns Hopkins University Press.

Ricardo, David, 1772-1823. (1911). *The principles* *of political economy & taxation. London : New York :J.M. Dent; E.P. Dutton,*

Dunning, T. (2005). Resource dependence, economic performance, and political stability. *Journal of conflict resolution*, *49*(4), 451-482. doi.org/10.1177/0022002705277521

European Commission. (2020b). Smart Specialization:
Strengthening Innovation in Europe’s Regions. Factsheet,
Smart Specialization Platform, Regional and Urban Policy. https://ec.europa.eu/regional_policy/sources/docgener/guides/smart_spec/strength_innov_regions_en.pdf

Falahati, A., Ahmadian, T. (2011). Economic Examination and Determination of Industrial Investment Priorities in Kermanshah Province.. *Journal Of Economics and Regional Development*, 18(2),100-125. http://dx.doi.org/10.22067/erd.v18i2.13737

Falahatgar, S., Chamanzamin, M. R., & Taleghani, M. (2021). The Effect of Competitive Advantage Strategies on Customer Loyalty: Mediated role of Brand Identification and Brand Awareness (Case study: Parsian Insurance customers). *Journal of System Management*, *7*(4), 229-252. doi: 10.30495/jsm.2021.1943132.1550

Fortunato, P., Razo, C., & Vrolijk, K. (2015). *Operationalizing the product space: A road map to export diversification* (No. 219). United Nations Conference on Trade and Development. Handle: *RePEc:unc:dispap:219*

Ghosh, A. R., & Ostry, J. D. (1994). Export instability and the external balance in developing countries. *Staff Papers*, *41*(2), 214-235. https://doi.org/10.2307/3867507

González, A., Ortigoza, E., Llamosas, C., Blanco, G., & Amarilla, R. (2019). Multi-criteria analysis of economic complexity transition in emerging economies: The case of Paraguay. *Socio-Economic Planning Sciences*, *68*, 100617. DOI: 10.1016/j.seps.2018.02.004

Grossman, G. M., & Helpman, E. (2018). Growth, trade, and inequality. *Econometrica*, *86*(1), 37-83. https://doi.org/10.3982/ECTA14518

Guevara, M. R., Hartmann, D., Aristarán, M., Mendoza, M., & Hidalgo, C. A. (2016). The research space: using career paths to predict the evolution of the research output of individuals, institutions, and nations. *Scientometrics*, *109*(3), 1695-1709. DOI: 10.1007/s11192-016-2125-9

Hakala T. (2020). E*xport Diversification as a Contributor to Economic Growth*. (Unpublished Master’s thesis). Alto University, Finland

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., & Hidalgo, C. A. (2017). Linking economic complexity, institutions, and income inequality. *World development*, *93*, 75-93. DOI: 10.1016/j.worlddev.2016.12.020

Hartmann, D., Bezerra, M., Lodolo, B., & Pinheiro, F. L. (2020). International trade, development traps, and the core-periphery structure of income inequality. *EconomiA*, *21*(2), 255-278. https://doi.org/10.1016/j.econ.2019.09.001

Hausmann, R., & Chauvin, J. (2015). Moving to the adjacent possible: Discovering paths for export diversification in Rwanda. *CID Working Paper Series*. http://www.tinyurl.com/y5xbtsp7

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. Mit Press.

Hausmann, R., Goldstein, P., Grisanti, A., O'Brien, T., Tapia, J. A., & Santos, M. A. (2020). A roadmap for investment promotion and export diversification: The case for Jordan. *CID Working Paper Series*. https://growthlab.cid.harvard.edu/files/growthlab/files/2020-01-cid-wp-374-roadmap-jordan-revised.pdf

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the national academy of sciences*, *106*(26), 10570-10575. https://doi.org/10.1073/pnas.0900943106

Guevara, M. R., Hartmann, D., Aristarán, M., Mendoza, M., & Hidalgo, C. A. (2016). The research space: using career paths to predict the evolution of the research output of individuals, institutions, and nations. *Scientometrics*, *109*(3), 1695-1709. DOI: 10.1007/s11192-016-2125-9

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482-487. Handle: *RePEc:arx:papers:0708.2090*

Karami, M., Rastgar, A. A., Azar, A., Feiz, D., & Esfidani, M. R. (2020). Identifying the Factors

Affecting the Selection of B2B Online Market Entry Strategies Using Soft System Methodology (Case Study: IT Industry knowledge-based companies). *Journal of System Management*, *6*(2), 55-80. doi: 10.30495/jsm.2020.677236

Klinger, B., & Lederman, D. (2004). *Discovery and development: an empirical exploration of" new" products* (Vol. 3450). World Bank Publications. https://doi.org/10.1596/1813-9450-3450

Lall, S. (2000). The Technological structure and performance of developing country manufactured exports, 1985-98. *Oxford development studies*, *28*(3), 337-369. DOI: 10.1080/713688318

Lall, S., Weiss, J., & Zhang, J. (2006). The "sophistication" of exports: A new trade measure. *World development*, *34*(2), 222-237. https://doi.org/10.1016/j.worlddev.2005.09.002

Li, S., Li, X., Lang, W., Chen, H., & Huang, X. (2021). The Spatial and Mechanism Difference in the Export Evolution of Product Space in Global Countries. *Sustainability*, *13*(4), 2255. https://doi.org/10.3390/su13042255

Lin, J. Y., & Monga, C. (2011). Growth identification and facilitation: the role of the state in the dynamics of structural change. *World Bank policy research working paper*, (5313). https://doi.org/10.1596/1813-9450-5313

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. *Journal of economic theory*, *58*(2), 317-334. https://doi.org/10.1016/0022-0531(92)90057-O

McMillan, M., Rodrik, D., & Verduzco-Gallo, Í. (2014). Globalization, structural change, and productivity growth, with an update on Africa. *World development*, *63*, 11-32.https://doi.org/10.1016/j.worlddev.2013.10.012.

Moiseev, A.K., Bondarenko, P.A. (2020). Application of the Economic Complexity Index in Macro-Financial Models. Stud. Russ. Econ. Dev. 31, 318–326 https://doi.org/10.1134/S1075700720030120

Munir, Y. (2020). Influence Strategies and Social Mechanisms in Promoting Manufacturer Flexibility. *Journal of System Management*, *6*(2), 1-25. doi: 10.30495/jsm.2020.677234

Neffke, F., & Henning, M. (2013). Skill relatedness and firm diversification. *Strategic Management Journal*, *34*(3), 297-316. https://doi.org/10.1002/smj.2014

Petralia, S., Balland, P. A., & Morrison, A. (2017). Climbing the ladder of technological development. *Research Policy*, *46*(5), 956-969. DOI: 10.1016/j.respol.2017.03.012

Pinheiro, F. L., Alshamsi, A., Hartmann, D., Boschma, R., & Hidalgo, C. A. (2018). Shooting high or low: Do countries benefit from entering unrelated activities?. *arXiv preprint arXiv:1801.05352*. https://doi.org/10.48550/arXiv.1801.05352

Pitigala, N., & Lopez-Calix, J. (2021). Trade policy options for export diversification: The case of Mali, Chad, Niger, and Guinea. *Journal of Infrastructure, Policy and Development*, *4*(2), 261-286. DOI: 10.24294/jipd.v4i2.1200

Rodrik, D. (2006). What's so special about China's exports?. *China & World Economy*, *14*(5), 1-19. https://doi.org/10.1111/j.1749-124X.2006.00038.x

Santoalha, A. (2016). *New Indicators of Smart Specialization: A related diversification approach applied to European Regions* (No. 20161220). Centre for Technology, Innovation and Culture, University of Oslo. Handle: *RePEc:tik:inowpp:20161220*

Scott, T. J., Scott, J. T., & Link, A. N. (2017). Commercial complexity and entrepreneurial finance. *Economics of Innovation and New Technology*, *26*(5), 489-500. https://doi.org/10.1080/10438599.2016.1236474

Sezai, A. (2020). Evolution of the product space and a new proposal for Turkeys export incentive system. *Turkey: Presidency of Strategy and Budget*. https://www.researchgate.net/publication/330089293_data-and-code-for-the-thesisrar

Shahmoradi, B., Samandarali Eshtehardi, M. (2018). Investigating the Status of Iran's Technological Competitiveness in the Region, Based on the Economic Complexity Approach. *Journal of Science and Technology Policy*, 11(1), 29-38. doi: 10.22034/jstp.2018.10.1.539421

Sørensen, B. B., Estmann, C., Sarmento, E. F., & Rand, J. (2020). *Economic complexity and* *structural transformation: the case of Mozambique* (No. 2020/141). WIDER Working Paper. doi:10.35188/UNU-WIDER/2020/898-6

Tavakoli Niya, J., Goudarzi, V., & Samadi, R. (2017). On the Analysis of the Regional Development of Markazi Province Using Multi-Criteria Techniques to Achieve Balanced Development. *Journal of Studies of Human Settlements Planning*, *12*(2), 285-299. https://jshsp.rasht.iau.ir/article_532879.html?lang=fa

Wang, Y., & Turkina, E. (2020). Economic complexity, product space network and Quebec's global competitiveness. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration*, *37*(3), 334-349. https://doi.org/10.1002/cjas.1555

Gómez-Zaldívar, F., & Molina-Perez, E. (2021). Evolution of the Productive Capabilities of Mexico: Economic Complexity Analysis for the Development of Special Economic Zones (SEZ). *The International Trade Journal*, *35*(1), 4-18. https://doi.org/10.1080/08853908.2020.1851328

Zhu, S., He, C., & Zhou, Y. (2017). How to jump further and catch up? Path-breaking in an uneven industry space. *Journal of Economic Geography*, *17*(3), 521-545. https://doi.org/10.1093/jeg/lbw047