EVOLUTION OF THE PRODUCT SPACE AND A NEW PROPOSAL FOR TURKEY'S EXPORT INCENTIVE SYSTEM

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ABSTRACT

EVOLUTION OF THE PRODUCT SPACE AND

A NEW PROPOSAL FOR TURKEY'S EXPORT INCENTIVE SYSTEM

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What a country can produce and export says a lot about its development level. All countries are in a race toward producing most cutting edge products. Not all countries are so successful as can be deduced from limited quality of their export baskets. Products can be broadly organized as low-medium-high tech. But as researchers showed in the last decade, under closer scrutiny products shows an intricate network structure called Product Space. Each country only produces and exports a sub-network of Product Space and evolution of this sub-network says a lot about the development of the country. Many, if not all, countries have complicate export incentive schemes but none seems to have a broad and product-based incentive system in which a product is promoted so long as it helps the country reaching the cutting edge regions of Product Space. This thesis explores the idea that the evolution of Product Space for a country is predictable and that it is controllable by an appropriate incentive system.

Keywords: Product Space, Diffusion, Export Incentive System, Industrial Policy

ÖZET

ÜRÜN UZAYININ GELİŞİMİ VE

TÜRKİYE'NİN İHRACAT TEŞVİK SİSTEMİ İÇİN YENİ BİR ÖNERİ

Ata, Sezai

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Tez Yöneticisi: Prof. Dr. Mesut Murat ARSLAN

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Ürettiği ve ihraç ettiği ürünler bize bir ülkenin gelişmişlik seviyesi hakkında çok şey söyler. Tüm ülkeler, en gelişmiş ürünleri üretmeye yönelik bir yarış içindedirler. İhracat sepetlerindeki ürünlerden de görüleceği gibi tüm ülkeler bu konuda aynı derecede başarılı değildir. Ticarete konu ürünler kabaca düşük-orta-yüksek teknoloji olarak sınıflandırılabilirler. Ancak araştırmacıların son on yılda gösterdiği gibi, daha yakından incelendiğinde ürünler Ürün Uzayı denilen karmaşık bir ağ yapısı sergilemektedir. Her bir ülke bu Ürün Uzayı'nın sadece bir alt kümesini ihraç etmekte ve bu ağ aynı zamanda ülkenin kalkınma seviyesi hakkında çok şey söylemektedir. Ülkelerin hemen hemen tamamı karmaşık ihracat teşvik sistemlerine sahiptir. Ancak, hiçbiri ülkenin Ürün Uzayı'nın merkezi bölgelerine ulaşmasına yardımcı olacak Ürün Uzayı odaklı bir teşvik sistemine sahip değildir. Bu tez, bir ülke için Ürün Uzayı'nın gelişiminin öngörülebilir ve aynı zamanda uygun bir teşvik sistemi ile kontrol edilebilir olduğu fikrini savunmaktadır.

Anahtar Kelimeler: Ürün Uzayı, Difüzyon, İhracat Teşvik Sistemi, Sanayi Politikası

DEDICATION

In loving memories of

My brother, Recai ATA (1971-2016), and

My niece, Senanur ATA (2005-2016)

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Presidency for Strategy and Budget (successor organizaton to the Ministry of Development and State Planning Organization), where I have been working for more than a decade, and its managers have been supportive during all stages of my Ph.D. Indeed, I wrote the first draft of my thesis as a working paper and presented it my my managers and co-workers. In return, I received helpful reviews from them and their down to earth questions made my mind clearer on the specific pathways of the thesis. My special thanks goes to Strategy and Budget Associate Expert Hakan Terzi who coauthored the early working paper that we wrote on the subject.

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ABBREVIATIONS

AI	Artificial Intelligence
BMI	Brain-Machine Interface
CAD	Comparative-Advantage-Defying
CAF	Comparative-Advantage-Following
CGF	Credit Guarantee Fund
DPT	State Planning Organization (Turkey)
ECI	Economic Complexity Index
FTE	Full Time Equivalents
FVA	Foreign Value Added
GVC	Global Value Chain
ICT	Information and Communications Technologies
IoT	Internet of Things
IPR	Intellectual Property Disputes
ITN	International Trade Network
MIC	Middle Income Countries
MIT	Massachusetts Institute Of Technology (United States)
MITI	Ministry Of International Trade And Investment (Japan)
ML	Machine Learning
NIS	National Innovation System
OBM	Original Brand Manufacturing
ODM	Own Design Manufacturing
OEM	Original Equipment Manufacturing
PCI	Product Complexity Index
R&D	Research & Development
RCA	Revealed Comparative Advantage
SITC	Standard International Trade Classification

1. Introduction

1.1 Motivation

Economic developments of everyday life affect economists' thinking about the world and which in turn affects their theories on economics. Einstein once said "the whole of science is nothing more than a refinement of everyday thinking". This is also true for economics. If great depression had not happened maybe Keynes would not be a great economist and would just continue to be richer by speculating on stock exchange.

I liken complex network analysis to quantum physics. As quantum physics models the behavior of each single atom and electron, complex networks uses each agent's info. There is no aggregation at least until the effect of aggregation is fully understood. Quantum physics and general relativity are not compatible yet. Going from atoms to the movements of stars requires solving an immensely complex problem of aggregation. Similarly in economics, the most important problem in my opinion is aggregation.

After 2008 crisis economists understood that they need to make some progress in aggregation problem. Without fully understanding how to move from individual agents to macro structure it is impossible to have a true faith in macro analysis. Network analysis is just one strong candidate claiming that it can solve aggregation problem.

While I had these ideas, the March 2013 volume of the scientific journal Nature: Physics made my mind clearer. Because the title of that special issue was 'Complex networks in finance' and it included a paper by Nobel Winner economist Joseph Stiglitz (Stiglitz, et al., 2013). And then I encountered many recent papers of Daron Acemoglu many of which use the techniques of complex networks (Acemoglu & Ozdaglar, 2013; Acemoglu & Ozdaglar, 2013; Acemoglu & Ozdaglar, 2013; Acemoglu & Robinson, 2015). And lately, especially the writings of two scholar motivated me towards networks. First one is Cesar Hidalgo from MIT Macro Connections Lab. He has written various papers applying statistical physics ideas onto economics ranging from economic complexity of countries and network structure of economic output to Product Space and research space (Hidalgo, 2009; Hidalgo, 2015; Hidalgo & Hausmann, 2009; Hidalgo, et al., 2007). The second one Albert-Laszlo Barabasi from Northwestern University, Center for Complex Network Research. He is more interested in theoretical properties of networks such as observability, stability and controllability while

also introducing network structure of seemingly unrelated objects such as disease network, protein network, medicine network, language network, internet network etc. (Barabasi, 2016; Barabasi, 2002; Hidalgo, et al., 2007; Barabási, et al., 2017)

Like the ones I mentioned above, currently many leading economists are using complex network tools to solve seemingly intractable macro-economic problems (Wierzbicki, et al., 2016). Complex Systems are systems that have many interacting parts which displays a new quality of macroscopic behavior different from micro structure (Tarvid, 2016). So basically, in complex systems the whole is 'bigger' than the sum of parts. I believe that there is still a long way to get some major results in this area. A deep knowledge of mathematics, statistics and economics is needed for any major result.

Analysis of international trade is a hot topic among economists. From simple linear regression models to more developed gravity (Ata, 2012) or entropy (Mastrandrea, et al., 2014) models, there are various methods for analysis of trade. While analysis of aggregate level trade gives a general perspective, it may miss many important aspects of micro level structure of international trade network (ITN). Theory of complex networks was originally developed by physicists to study the dynamics of complex physical systems but lately it has become a method of choice for the analysis of dynamics for many economic systems such as credit network of banks and foreign direct investment network of countries.

In this thesis, we analyze network of international trade via Product Space. The Product Space is a network of all products which are traded globally. Mathematically, a network is just a simple graph. A network consists of nodes (called 'vertices' or simply 'points') and edges connecting some of these nodes. The nodes of Product Space are products themselves, one point for each product. The edges among various products can be created via a multiple of different methods. But in the standard method, two products are connected to each other if they are similar enough. Two products are similar if the exporter countries of one product also export the other one with a probability higher than some pre-defined threshold value, and vice versa.

A good way to visualize the Product Space is by analogy to a monkey living in a forest[1]. The

[1] This analogy was first used by Harvard economist Ricardo Hausmann: https://www.hks.harvard.edu/news-

monkey lives on the trees by eating different fruits from different trees. Some trees have more and delicious fruits while the others have less and not so tasty fruits. With time, the monkey explores the forest in search of fruits. Returning to real world analogy, country is the monkey and products are the fruits. A country must make a 'jump' from a tree to another if it wants to produce 'juicier' products.

With a homogeneous forest where trees and fruits are evenly distributed, our monkey has nothing to worry. It can make random jumps to neighbor trees and enjoy new fruits. But if the trees and fruits in the forest are not evenly distributed then the monkey must think about which way to go. Trees with juicier fruits may be concentrated in deep and faraway parts of the forest.

The Product Space of global trade is surely not homogeneous which has a complicated network structure with concentrated 'Amazon' regions, loose 'Sahara' regions and even scary blind alleys.

1.2 Background

Today, all countries that follow the export-oriented growth strategy are in a race to develop the most advanced technological products. Because, the growth of countries is usually possible only by diversifying the products they produce. Turkey has not shown sufficient improvement in this area. In 2016, the share of high-tech products in total merchandize exports was 24.4% worldwide, whereas it was as low as 3.5% in Turkey.

In order to increase exports in Turkey, various supports are given to exporting firms. Two common features of many of these supports are the equal treatment of all firms that meet the requirements and the support of process rather than the final product. While this system is positive in terms of improving the capacities of all companies a little, it does not generally cause the creation of new high-tech products.

Although it has been well understood by policy makers that incentive system is important for increasing the technology level of exports, finding the optimal structure of an incentive system was too elusive in the past and is still elusive currently. In this thesis, we address the problem of optimal incentive system. In this respect, the government can formulate policies

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events/publications/insight/markets/ricardo-hausmann

to raise average national productivity levels by encouraging latecomer firms to upgrade their products, processes and organizational practices. In our view, if these kind of diffusions are targeted to specific products and product chains, the upgrading process may be more effective.

In this thesis, before defining and using product space, we analyze some issues related with networks such as the usefulness of network representation, choosing the best network representation, and measuring the appropriateness of a network to answer our research question.

The questions that we ask include: What is a product? How we classify it? And which product is the best to produce for a country? To answer these questions, we rely on the latest developments in industrial policy literature. Within this literature, we analyze catch-up ccyles, cycle times, and windows of opportunities in detail.

We construct product space by using bilateral trade data of countries. In this study, we use 4 digit SITC Rev. 2 classification. According to this classification, worldwide merchandise trade consists of 775 different products. They are divided into 5 groups according to their technology level.

The product space is an example of networks. A network consists of nodes and edges. The nodes of the product space are 775 products. The edges are defined with the help of proximity index between two products.

$$P_{i,j} = min\{\Pr(RCA_i \geq 1 \mid \Pr(RCA_j \geq 1), \Pr(RCA_j \geq 1 \mid \Pr(RCA_i \geq 1)\}$$

According to this methodology, two product are similar if most of the countries which export product i also export product j, and most of the countries which export product j also export product i.

After constructing product space of world wide trade, we construct product space of Turkey which is a just a subset of whole product space. We then analyze product space of Turkey via various methods.

Our analysis shows that for Turkey there are many high-tech products that are similar to the products of the current export basket. That means these high-tech products are neigbors of Turkey's current product space and can be reached in 1 step, while the remaining 44 high-tech products are reachable in 2 or more steps.

Assuming that Turkey reached the products that can be reached in 1 step, we calculate the products that can be reached in 2 steps. With similar logic, we compute all the products that Turkey can reach with three, four or more steps. Our analysis indicates that there are no new connections after 4th iteration if we use 0.5 as our proximity threshold. This fact implies that these products, nonreachable with usual diffusion, can only be reached by making long-jumps.

Product space of Turkey includes many clues about the direction of development. Our analysis indicates that Turkey have huge diversity of products in low and medium-tech segments of products but not that much diversity in high-tech products.

We also analyze the evolution of product space for 60 countries in detail. Our results show that while most of the developed countries displays a decreasing trend after reaching their peaks in terms of diversity of products in their export baskets, most of the developing countries are still trying to get to their peaks.

The analysis of country group dynamics of product space shows that progress for countries happens in repeating cycles of jumps and diffusions. This is analogous to the theory of Thomas Kuhn about the structure of scientific revolutions (Kuhn, 1962). According to Kuhn, there are two kinds of change: normal and revolutionary. While normal change consists of incremental improvements, revolutionary changes creates discontinuity, uncertainty and turmoil in science. In this framework, jumps correspond to scientific revolutions and diffusions correspond to incremental change.

The jump vs diffusion dichotomy appears in many places of this work with different names. Explore vs exploit, revolutionary vs incremental, and jump vs diffusion dichotomies are all manifestations of the same idea.

The evolution of Turkish product space data indicates that Turkey made the first jump in 1980's, the second one in 1990's, and the last one in 2000's. International comparison implies that Turkey is ready for the next jump which will happen into high-tech machinery, chemicals and miscellaneous manufactured products. Policy makers should keep in mind that international comparisons also show that when a country makes a jump forward into a new technology, it generally makes a similar backward jump simultaneously in an old technology just to make room for the new one.

Evolotion of advanced countries' product spaces shows that there is no uniform trend in their product space expansion. Countries such as United States, Germany, and Japan made their last jumps into high-tech products long time ago and now they are in exploit stage. Other countries such as Italy, Spain, and Austria are still in exploring stage.

Our analyses has shown that most of medium income countries such as Turkey have not yet reached their peaks in diversification. This fact indicates that Turkey has not passed yet from exploration part to exploitation part of process. To accomplish that, we suggest various policies including increasing risk appetite of Turkish firms and supplying the necessary incentives to give the private sector the needed confidence.

The dependence of new products on existing capabilities means that a structural change left completely to the market is relatively slow. Because diffusion in the product space when left to itself primarily occurs in the neighborhood of similar products.

Information externalities and coordination externalities indicate that it is relatively much more difficult for diversification to take place without planned public action. The most important examples of product space diversity are the result of planned public action and public-private partnership.

Risk appetite of the firms is of big importance for the creation of new high-tech exporter firms. Turkish firms are not eager to take big risks in international arena. One of the reasons for not taking risk is the dire consequences of a failure. Especially in case of catch up cycles and windows of opportunities, risk appetite is crucial in taking advantage of suitable conditions for catching-up the leaders. In this study, we offer various incentives to increase the risk appetite of the firms.

Successful latecomers in general have a good learning system so that they efficiently learn from leaders and other successful examples. We analyze the properties of successful latecomers in detail.

FDI is an important tool to transfer some technology to developing countries. But, technology transfer has never been a priority for developed countries as their main criteria is low cost of land and labor, a big domestic market, low tax rates, and other incentives. So FDI is a necessary but not sufficient condition for successful upgrading of production technology.

The relation between industry, technology, and science is a complicated one. Studies show that some sectors need only technology and not much basic science and that some other sectors need more basic science and less technology. We give different country examples to highlight this phenomena.

In Turkey, government support for R&D activities began in the 1990s and the share of R&D in GDP rose from 0.32% to 0.53% in 2002 and to 1.06% in 2015. But there is still a long way to go to catch the top performers such as South Korea (4.29%), Israel (4.19%) or Japan (3.58%).

According to the proposed incentive system of this thesis, two criteria for government support in a given product are that the product must be a new product and that the product must have high potential. In our model, the potential of a new product is proportional to the average proximity of the new product to Turkish product space. This model is an improved version of the model developed in (Hidalgo, 2007).

Two main criteria for state support for a specific product i are;

i. The product i must be a new product ($RCA_i < 1$)
ii. The product i must have high potential $\prod_i$ as defined below

The potential for a new product can be defined as;

$$Potential = \ \prod_i = \frac{\sum_j RCA_j * (pci_i)^{\alpha} * (w_i)^{\beta} * (w_j)^{\gamma} * (P_{i,j})^{\delta}}{\sum_j (P_{i,j})^{\delta}}$$

Where;

pci_i : $product\ complexity\ index\ of\ product\ i$

w_i : $weight\ of\ product\ i\ in\ worldwide\ total\ merchandize\ trade$

RCA_i : $\begin{cases} 1\ if\ (Revealed\ Comparative\ Advantage\ of\ product\ i) \geq 1 \\ 0\ if\ (Revealed\ Comparative\ Advantage\ of\ product\ i) < 1 \end{cases}$

$P_{i,j}$: $Proximity\ between\ products\ i\ and\ j$

$\alpha, \beta, \gamma, \delta$: $parameters\ for\ the\ optimal\ decision\ about\ the\ products\ with\ highest\ potential$

So a product i with high potential have some of the following properties;

i. It is a high-tech and complicated product with high pci_i

ii. It is a widely traded product worldwide so has a large w_i
iii. Its neighbors in product space are widely traded products worldwide so have large w_j's
iv. The other products that i is similar to have current revealed comparative advantage
v. There are many products similar to product i

When we apply our model to Turkish product space, we see that all potential products in top 20 are high-tech or medium-high-tech products. When we analyze the sectoral distribution of these products we see that all of them are broadly categorized as either chemicals, machinery or misc. manufactured products.

In short, we argue that the government can set new policies to raise average national productivity levels by encouraging latecomer firms to upgrade their products, processes and organizational practices. If such diffusions are targeted to specific products and product chains in the product space, the upgrading process may be more effective. That is the main idea of this thesis.

2. What is Product Space

2.1 Networks

2.1.1 Why Networks

Before defining and using networks in economic analysis, it may be apt to ask three important questions (Brugere, et al., 2016);

i. Is network representation the best or most useful method to describe or to analyze our data?
ii. Which kind of network representation is best for our analysis?
iii. Can we measure appropriateness of a network to answer our research question?

The quality of these methodologies differ for various domains and we do not have a common best-method for evaluating the quality of networks inferred from data.

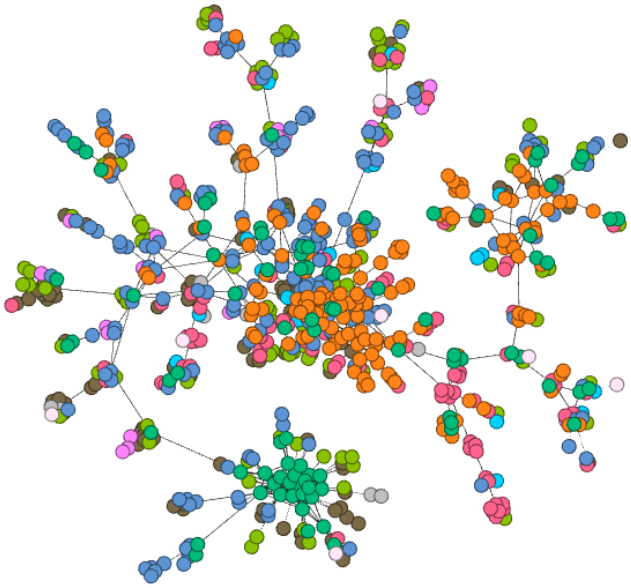
There are mainly two kinds of networks, natural networks and inferred networks. While natural networks have an obvious topology endowed upon them, inferred networks are not uniquely defined and can have very different properties depending on the parameters that were used to construct the inferred network.

Product Space structure fundamentally depends on proximity threshold between the products and this fact makes the product space an inferred network. As we can see from Figure 2.1 and Figure 2.2, the same underlying product data can be presented very differently. This user-defined feature of inferred networks make them also vulnerable for misguided analysis. The threshold we choose for proximity between the products affects almost all critical properties of network topology. A decrease in threshold will increase the number of edges and it will be more difficult to find the core regions and clusters in the product space. If we increase the threshold too much we may lose valuable information about dependencies between products. Product space literature usually use a threshold between 0.4-0.5. In this thesis, we will follow the common practice. The networks created in this study will all be inferred networks.

When we construct an inferred network, we must be careful on whether topological structures of the network is meaningful for our research problem. Sometimes the allure of nice visualizations (e.g Figure 2.9) can mislead the researcher to the idea that network is the

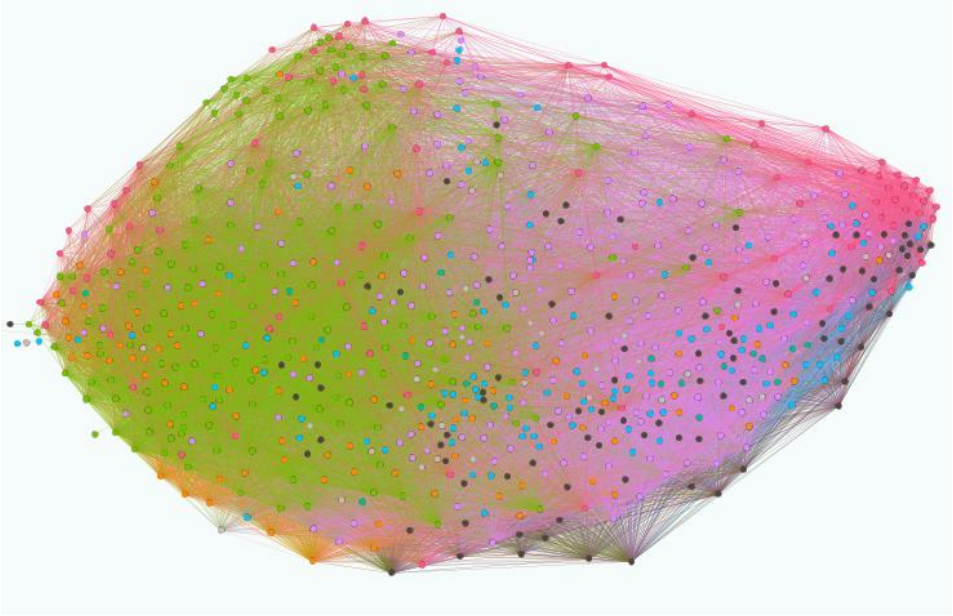
best method while other methods may be the best choice.

Figure 2.1 Product Space with Proximity Threshold 0.6



Source: Produced by the Author using Cytoscape

Figure 2.2 Product Space with Proximity Threshold 0.3



Source: Produced by the Author using Cytoscape

John Maynard Keynes describes economics as the "science of thinking in terms of models, joined to the art of choosing models which are relevant" (Harrod, 1938). In this respect, choosing the right network representation is more difficult than creating one.

A good criteria to decide whether to choose network as our research tool is to ask the questions; Does the network really matter for our problem? Can we understand different aspects of the problem without the underlying network? For example, it is difficult if not impossible to understand the spread of epidemic diseases without networks. The large scale energy grids are perfect examples of networks and again it is impossible to understand the power blackouts without them.

The networks are especially suitable for our problem if we are interested in relation prediction or structural properties of a complex system. Link prediction problems ask the question, given the initial structure of a network, can we predict where the new links will occur next time? This is crucial in many social science or computer science problems. For example, in a social network, we can ask which pairs of people are most probable to become new friends. There are many different algorithms to do link prediction. Social networks apply these methods to predict the people we may know (e.g. Facebook).

If we generalize these examples, it is possible to dissect network analysis problems into three broad categories;

i. Link prediction: all nodes and some of the edges are known and the problem is to predict the most probable new edges,
ii. Interaction networks: All nodes are known and the problem is predict the edges relationships,
iii. Network tomography: Some of nodes and edges are known and the problem is to predict the unobserved nodes and edges.

In this thesis, given the initial structure of product space for Turkey, we are trying to answer two questions. The first one is to guess the new products that Turkey can produce and the second one is to see how the Turkish product space evolve?

In this chapter, I will give important definition needed for network analysis and then also give the main metrics of networks used in the literature. First definitions.

2.1.2 Definitions

Graph: A graph G consists of a collection V of vertices and a collection edges E, shown as $G = (V, E)$. Each edge e in E joins two vertices and these are called end points of the edge.

If e joins u and v in V, it's written as $e = [u, v]$. In such a case, Vertex u and v are adjacent. Edge e is incident with vertices u and v.

Degree: The number of edges incident with a vertex v is called as the degree of v, and is denoted as $d(v)$. Loops are counted twice.

Adjacency Matrix: Adjacency matrix of a graph G with k vertices and n edges is matrix A with k rows and n columns with entry $A[u, v]$ denoting the number of edges joining vertices i and j.

Walk-trail-path-cycle:A (v_0, v_k) walk in G is an alternating sequence $[\boldsymbol{v_0}, \boldsymbol{e_1}, \boldsymbol{v_1}, \boldsymbol{e_2}, \boldsymbol{v_{k-1}}, \boldsymbol{e_k}, \boldsymbol{v_k}]$ of vertices and edges from G with $\boldsymbol{e_i} = [\boldsymbol{v_{i-1}}, \boldsymbol{v_i}]$, in a closed walk, $\boldsymbol{v_0} = \boldsymbol{v_k}$. A trail is a walk in which all edges are distinct; a path is a trail in which also all vertices are distinct. A cycle is a closed trail in which all vertices except $\boldsymbol{v_0}$ and $\boldsymbol{v_k}$ are distinct.

Connected: Two distinct vertices x and y in graph G are connected if there exists a (x, y) path in G. G is connected if all pairs of distinct vertices are connected.

Clique: A subset of vertices is called clique if every two vertices in the subset are connected by an edge.

2.1.3 Metrics

Vertex degree: The degree of a vertex v is the number of vertices that are neighbor to v.

Distance: Let G be a directed or undirected graph and u , v in V(G). The (geodesic) distance between u and v, denoted as $d(u, v)$ is the length of a shortest (u, v) path.

Clustering Coefficient: The local clustering coefficient C_i for a vertex v_i is given by the proportion of links between the vertices within its neighborhood divided by the number of all possible links between them. For a directed graph, e_{ij} is distinct from e_{ij}, and for each neighborhood N_i there are $K_i(K_i - 1)$ links that can exist among the vertices within the neighborhood (K_i is the number of neighbors of a vertex). So, the local clustering coefficient for directed graphs is defined as;

$$C_i = \frac{\left|\{e_{jk} : v_j \in N_i,\ e_{jk} \in E\}\right|}{K_i(K_i - 1)} \qquad \text{Eq. 2.1}$$

The local clustering coefficient of a vertex in a graph shows how similar its neighbors are to a clique.

The mean clustering coefficient for the whole network is then given by as the average of the local clustering coefficients of all the vertices;

$$\bar{C} = \frac{1}{n}\sum_{i=1}^{n} c_i \qquad \text{Eq. 2.2}$$

There is another way to compute the clustering coefficient of whole network. We call it the global clustering coefficient. The global clustering coefficient C_{GLOBAL} is the ratio of three times the number of triangles to the number of pairs of adjacent edges in the network.

$$C_{GLOBAL} = 3 * \frac{number\ of\ triangles}{number\ of\ wedges} \qquad \text{Eq. 2.3}$$

Centrality: Centrality is a measure that hows the relative importance of a vertex in a graph. There are many different kinds of centrality measures and many different applications. These include how influential a person is within a social network, how important a bank is within inter-bank system, and how critical a gene is in disease-gene network. The most important versions of centrality are degree, betweenness, closeness, and eigenvector centralities.

Degree Centrality: the number of links neighbor to a node.

Closeness Centrality: The farness of a node s is defined as the sum of its distances to all other nodes, and its closeness is defined as the inverse of the farness. Closeness measures how long it takes to send information from s to all other nodes.

Betweenness centrality: Betweenness centrality measures the number of times a node plays a role as a bridge along the shortest path between two other nodes. The betweenness centrality of a vertex v in a graph $G := (V, E)$ is computed as follows:

i. Compute the shortest paths for each pair of vertices (s, t)
ii. Determine the fraction of shortest paths that pass through the vertex v.

iii. Sum this fraction over all pairs of vertices (s, t).

Eigenvector centrality: Eigenvector centrality measures how influential a node is in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The PageRank algorithm that Google uses to classify webpages is slightly modified version of the the Eigenvector centrality.

For a given graph $G := (V, E)$ with $|V|$ number of vertices let $A = (a_{v,t})$ be the adjacency matrix, i.e. if $(a_{v,t}) = 1$ if vertex v is linked to vertex t, and $(a_{v,t}) = 0$ otherwise.

The centrality score of vertex v can be defined as:

$$x_v = \frac{1}{\lambda} \sum_{t \in M(v)}^{n} x_t = \frac{1}{\lambda} \sum_{t \in G}^{n} a_{v,t} x_t \qquad \text{Eq. 2.4}$$

where $M(v)$ is a set of the neighbors of v and λ is a constant. This can be rewritten in vector notation as an eigenvector equation;

$$Ax = \lambda x \qquad \text{Eq. 2.5}$$

We know from Linear Algebra that, in general, there are multiple solutions for the eigenvalues λ. But, if we require all the components of the eigenvector to be positive, then by the Perron–Frobenius theorem, there is a unique eigenvalue corresponding to that case. Thus, only the greatest eigenvalue gives the centrality measure. The v^{th} component of the eigenvector gives the centrality measure of the vertex v in the network.

2.1.4 Applications of Networks

Nobel laurate economist Robert Lucas once said "once you start thinking about growth it's hard to think about anything else." Nowadays, I believe many scientists from diverse areas think the same thing about networks. Personally, when I start to think about networks it is everywhere. Everything is a network!

Let me give a personal account of what I see when I look around.

Physically (in terms of classical physics) all matter is a bunch of particles and forces. Currently there are just 31 of them, namely, 24 fermions, 6 boson, and 1 famous Higgs boson. All the matter, light, electromagnetism and else is just a combination of these.

Then, there is chemistry. It consists of interactions between 98 kinds of naturally occurring elements. There is another group of 20 elements which does not exist in nature but only exists in labs for short periods of time.

Parts come together, a new structure appears, and we cannot see it coming from the behavior of parts. That is emergence. Ant hills, bee colonies, bird flocks making intricate dance over the sky are all emergence in flesh. In this respect chemistry is just emergent behavior of physical rules. Some mathematicians (Tegmark, 2014) claim that physics itself is an emergent phenomena rooting from mathematics and that the whole universe is no more than a mathematical function! But, for now, I will skip it.

With only physics and chemistry, you would not be reading this sentence right now. We need conscious intelligent beings to achieve this and only humans are capable for that for now. I believe (but will not prove in this thesis) biology is also an emergent phenomena. A few years back, in Google Keep I took a note for myself "Man is a state of matter that tries to understand itself". Nowadays, scientists are running algorithms to check the hypothesis that conscious beings are expected outcomes of complex dynamic systems and not just a coincidence from serendipity.

After biology, intelligence and consciousness come. Cognitive scientists say consciousness may be emergent behavior or it may even be non-existent. But to make a claim such as that is like chemistry is non-existent because physics sets all the rules and there is no room for chemistry. The claim is not ridiculous but in the usual sense of world, chemistry and consciousness exists notwithstanding the philosophical arguments of (Dennett, 1992) and the likes.

Then, one can ask why networks but not physics itself. Physical world itself is continuous but people, countries, products and trade between them are all discrete. Physical world is complicated but not complex. Because there are some simple rules that governs everything. The number of helium atoms in the universe is huge but every one of them behave the same. Economics is complex and complicated at the same time. There are less people, country or product than the number of atoms, but each person or country is unique and interactions between them is also not uniquely defined. That makes it complicated. When the territory and interactions are not homogeneous everywhere we need networks. So networks can be thought of simplified discrete models of real world. Why we need to simplify it. Because it

is very difficult to explain what will be the next sentence here if we start the logic from the big-bang and from the cloud of dust and gas.

Continents divide, mountains erupt, rivers flow, winds blow, humans think. If Hayek did live now instead of a century ago, he would be a much bigger hero. In his time, there was no computer power. His only tool was thought experiments (like Einstein). He heavily criticized the classical models for they depended on strong axioms on regularity. According to Hayek, the real economy was more complex and it was not describable by classical theory. I guess he would be more like Barabasi.

Human genome consists of about 25000 genes and each gene is responsible for a specific protein. Some proteins interact with some other. This creates a complex network structure which is responsible for many things from usual cell activities to rare genetic diseases.

Networks are also used in finance. For example, the algorithm DebtRank is an example of how network structure of financial system can be used in stress testing of banks. The algorithm uses network effects that were not included in previous studies in analyzing the propagation of distress and some central banks started to test the new algorithm (Stiglitz, et al., 2013).

As the above discussion shows network science gives us a suitable tool to analyze many different aspects of networks. In the next chapter, before going into the details of our network: the product space, we first analyze the nodes of this network which are products.

2.2 The Product

Before going into the world of the Product Space, it may be suitable to answer some questions; What is a product? How we classify it? And which product is the best to produce for a country?

We call an item a product if somebody sells it. It can be in various forms: physical, virtual or cyber. For each product, there is a cost and a selling price. The price depends on the quality of the product, the segment of targeted consumers and other general supply-demand conditions. Products are like animal species, each specific member of a product has an expected life duration after which it needs replacement and the product itself also have a life cycle after that the product must be reinvented.

The number of products subject to international trade varies from 10 to a few thousands depending on the number of digits we zoom in in SITC (Standard International Trade Classification). A passenger car is one of 775 SITC 4 digit products. But it still consists of about 30,000 pieces and about 3,000 different parts. So when answering an economics problem it is important to make it sure we are looking through the lenses with the correct amount of zooming for the problem.

In this thesis, we use SITC 4 digit classification that enables us to zoom enough to differentiate between every reasonable group of products without too much detail. This zooming gives us 775 different products which includes everything that is traded internationally.

2.2.1 Catch-Up Cycles

We have seen that each product has a life cycle. It is born, grows and then either it dies or is reinvented in a new form so that the product can continue to exist. For example, TV was born as black-white based on cathode-ray tube technology. Later, the initial form disappeared and color version took its place. Technology also changed many times black-white to color to LCD to LED but the TV itself continues to live. During life-cycles of a product, new technologies appears and disappears. In some products, the speed of change is fast and in some others it is slow.

The change in technologies of products offer risks and opportunities for the leader countries and followers in the production of these products. The process of changing leaders in a

product sector is called ‘catch-up cycles’. In some products, the change of leadership is frequent and fast, in others is long-term and slow. But almost every product experience change of leadership in its life-cycle. When this happens, the leader loses its superiority in technology, cost or marketing and the latecomers catch up. Later, this process continues and a new latecomer comes with better prospects.

There are different questions that we can ask about that dynamic catch-up process (Lee & Malerba, 2017).

i. How we model the catch-up process?
ii. What are the generic properties and dynamics in these catch-up cycles?
iii. Are there general rules that countries can follow to accomplish catch-up?

Successful latecomers in general have a good learning system so that they efficiently learn from leaders and other successful examples. Learning process happens in two ways. In the first one, latecomer visits the leader and analyze its system as Japanese and Chinese governments did when they sent thousands of student to United States to study abroad with the condition of return to home country after learning the top technologies. In the second one, the latecomer invites the leaders to the country for investment through various incentives such as tax cuts and special treatment in local market.

Learning from the leaders is a necessary but insufficient condition for the majority of catch-ups. Because by definition, learning can make a country a good follower. In some cases, if the follower has additional advantages over the leader such as lower labor costs and bigger domestic market, it can catch the leader. These cases cannot be counted as real catch-up cases. They are mostly temporary and when the leader develops a new technology, the latecomer cannot catch-up easily if it only uses learning methods.

The second condition of catch-up, additional to learning and more fundamental for success, is innovation. The successful latecomer must use its capabilities in learning, technology, and innovation to identify the suitable time and conditions for the implementation of a catch-up process in a specific product or sector.

If we think all the actors in a country which has an effect on catch-up process as a network, call it national innovation system (NIS), we see that different catch-up processes need different components of this network. National innovation network includes, among others,

legal and institutional structure, university, private and public research entities, human resources, suppliers, financial system etc. (Lee & Malerba, 2017).

It is said that climbing to the top is difficult but the real difficulty is to be able to stay at the top once you achieve it. We have a similar situation in catch-up cycles. When a country becomes leader in a product, it experiences some new problems not encountered when it was catching-up. One of them is 'innovators dilemma' in which the leader country is not sure about making new technological breakthroughs as it can be detrimental to its current leadership position. The leader must destruct its old technology for making room for new creative technologies. This is a classic case of 'explore or exploit' situation which is analyzed in more detail in Chapter 4.

A good example of decision problem for the leader is Motorola. Motorola developed the first widely used analog cell phone and was worldwide leader for a long period. When the digital technologies started to surface, Motorola decided to invest more on analog technologies where it had leadership advantage with huge patent list at hand. The company had assumed that the consumers would follow the technological path that the leader offered them. But history did not go in that way and Motorola lost the leadership to digital technology companies.

Table 2.1. Events of Leadership Change and Persistence in Six Sectors

Events/ Time	Mobile Phones	Memory	Camera	Jets	Steel	Wines
Event (I) Time Main actors	**1998** USA (Motorola) → Finland (Nokia)	**1982** USA → Japan	**Mid 1960s** Germany → Japan	**1995** Netherlands (Fokker) → Canada (Bombardier)	**1980** USA → Japan	**Mid 1990s** Old World (France, Italy, etc.) → New World (USA, Australia, etc.)
Event (II) Time Main actors	**2012** Finland (Nokia) → S Korea (Samsung)	**1993** Japan → S. Korea (Samsung)	**1980s – 2010s** No change (Japan persistent leader despite development of digital SLR camera))	**2005** Canada (Bombardier) → Brazil (Embraer)	**1998** Japan (Nippon Steel) → S. Korea (POSCO)	**Mid 2000s** Return of Old World
Event (III) Time Main actors		**1993- 2016** No Change (S. Korea persistent leader)	**Mid 2010s** Change likely with substantial rise of new entrants			
No. of EVENTS	2	3	3	2	2	2

Source: (Lee & Malerba, 2017)

We can see the leadership changes in Table 2.1. The leadership in cell phone changed two times. There was 14 years period between the changes. In 1998, Nokia introduced digital cell phones and quickly became the new leader. The next leadership change happened in 2012 when Samsung introduced smart phones. In both cases, new technology played the critical role and offered a window of opportunity.

In steel industry (see Table 2.1), before 1950s American firms controlled the production of steel but that has changed in 1970s when Japanese companies dominated the industry. After 1980s, Korean firms challenges the Japanese firms and lately Chinese firms has emerged as the biggest steel producers as their local demand for steel exceeds the demand of all other countries.

Shipbuilding is another industry in which repeated change in leadership occurred. During Second World War, American firms were dominant in worldwide shipbuilding but the British firms challenged them in 1950s. Japanese shipbuilders caught up in 1960s and they were dominant until 1990s, after which, Korean firms with the help of their highly developed steel industry dominated the shipbuilding industry.

Another example industry is telecommunication systems which was led by Swedish company Ericsson for a long period. A private Chinese company Huawei entered the telecommunication industry in a short time then grew quickly and became leader in 2012 surpassing Ericsson in total sales. (Joo, et al., 2016) analyzes this rare phenomena and offers possible explanations. Their first observation is that Huawei's main advantage over Ericsson was better technology instead of lower cost production. After this observation the paper models the process by using extensive data from European Patents Office. Analysis show that rapid expansion of Huawei is due to the new and different technologies developed by the firm itself instead of borrowing from other firms through patents. Main result of the study is that for a latecomer company it is not impossible to catch-up the leaders by developing its own technology (Joo, et al., 2016).

An important difference of Huawei from other big Chinese firms is that it is privately owned instead of owned by state. Although it is a private company, Huawei was supported by Chinese government by a special incentive for foreign terms. This important policy is called 'trading market for technology' and has been used extensively by Chinese government. The method allowed the foreign firms operate in China with the condition of bringing high tech to country. As an example, by this method, in 1980s the most developed telephone switching technologies was brought to China through foreign direct investment.

After its establishment in 1980s, Huawei continuously spent at least 10% of its budget on R&D and distributed its research departments throughout the world in countries such as United States, India, and Sweden. Starting from the year 2000, various alliances has been formed between Huawei and other renowned high tech firms such as IBM, Intel, and Sun Microsystems.

From these, we can see that establishment of a large R&D department, distributing it worldwide, and making alliances in strategic technologies with the leader firms allowed Huawei to catch-up the leaders become a world leader itself.

When confronted with production possibilities there may be many different paths for a country. There are mainly three types of new path creation;

i. Path-following
ii. Stage-skipping
iii. Path-creating

Sometimes, latecomer firms or countries try to catch-up the advanced leaders by learning the low-tech segments of advanced countries. That is called 'path-following'. According to (Lee & Lim, 2001; Lee, 2013), path-following is not the only possible method for latecomers to use in catching-up the leaders. Some steps that were taken by advanced countries when they established a sector or technology can be skipped by latecomers. This is called 'stage-skipping' and it allows the latecomers countries to save a lot of investment by skipping unnecessary or outdated parts of the technology. A still better method for latecomer is to create its own technology independent from advanced countries. That method is the most difficult one but it is also the one with the highest dividends. This last method is called 'path-creating'.

When we analyze Huawei experience from this view, we see that catch-up process of Huawei started with path-following, later followed by stage-skipping and finally completed with path-creation. Another term closely related with all of three versions of paths is leapfrogging (Perez & Soete, 1988). According to this view, a latecomer country or firm can leapfrog the outdated primitive technologies of advanced countries by bypassing large investments needed for old technologies and also by making big investments in new emerging areas before the advanced countries.

In simple terms, if a latecomer country or firm wants to catch-up or surpass the leaders, it either follows the same steps taken by the leaders or makes some short-cuts or finds an entirely new path. Following exactly same path with the leaders is seen the easiest way by developing countries and that is why they follow this method in their development process in general. But as we have already seen, there are some important pitfalls in this logic. First of all, some of the steps taken by the leaders may be outdated or unnecessary with the new improvements in the technology.

Stage-skipping and path-breaking have some advantages over path-following but these are not without costs. The foremost disadvantage is the risk taken in the process. As an example, if we consider the telephone switch industry from its start to its current technology we see many changes in leadership. Brazil, Korea, China and India, among others, invested heavily in this sector and all four countries was successful in initiating their own version of technology in telephone switches. The divergence of countries occurred when mobile phone took over the fixed line telephones. During this transition, China and Korea transformed

their old technology successfully but India and Brazil could not cope with the new technology (Malerba & R. Nelson, 2012).

The initial success of all four countries can be attributed to the fact that the telephone switch technology was mature and it was easy to get access to the know-how information from public literature or from licenses. As Tolstoy said "Happy families are all alike but every unhappy family is unhappy in its own way". So it is more difficult to explain failed countries than the successful ones. The innovation network of the country says a lot whether the country will make a successful transition. The first critical factor is the attitude of state. While the state provided coordination and protection for the private firms in China and Korea, it did not play such a role in India and Brazil. The second important difference was that while in China and Korea initial successful start caused more buildup of R&D and technology that did not happen in Brazil or India.

There is a discussion on the correct innovation system of a developing country. One view, Schumpeterian type, values domestic development of innovation system more and claims that the country itself must try to install the innovation system. Because, the developed countries put a wall between the developed and the developing world and kicked away the latter (Chang, 2002). So it is only in the hands of developing world to develop their own innovation system (Lee, et al., 2017). Some other development economists claim that global value chains and FDI are more important because it is difficult unless impossible for developing world to develop their own innovation system. So they depend on the developed world on that. The Korean case is a mixed one. Because it includes things from both side. So it is not clear which side is right.

OEM (Original Equipment Manufacturing) based growth strategy is flawed. Because, with it a firm can achieve catch-up in terms of sales or capital accumulation but not in terms of technology.

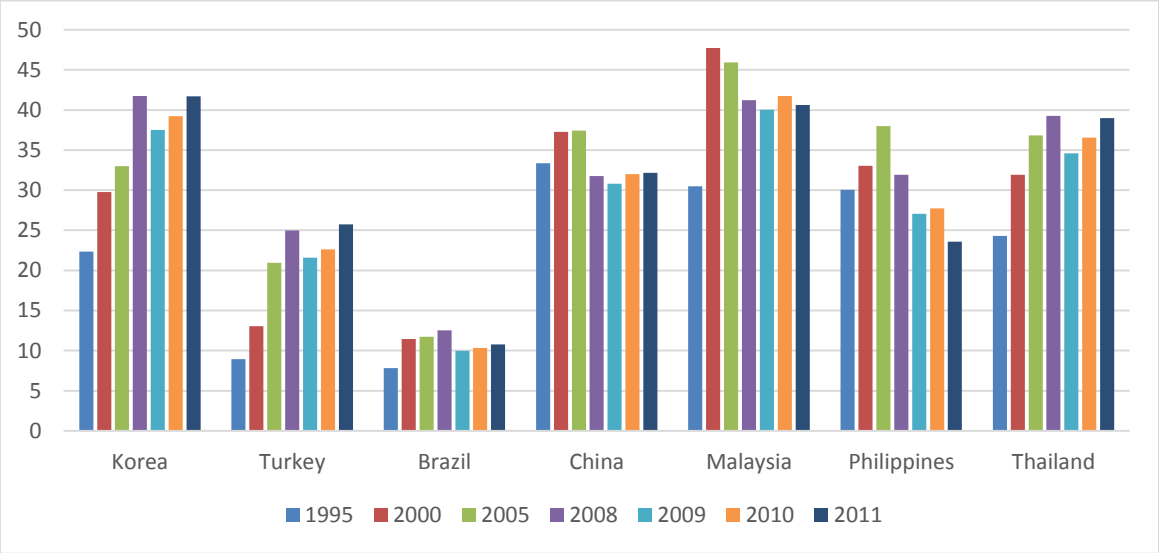
Another classic example of a successful catch-up process is Korean automobile industry and Hyundai Motors. This company started its business by making contract manufacturing agreement with American company Ford in 1968. In this agreement, the only role of Hyundai was assembling the parts that were produced by Ford. After a successful role played as an assembler, the founder of the firm, Chung Ju-Yung, wanted to produce a car with its own Korean brand. He ended the agreement with Ford and made a new one with Japanese

car manufacturer Mitsubishi. With the new agreement Mitsubishi had a 20% equity share in Hyundai Motors, and, in return, Hyundai used a Mitsubishi licensed engine in its production.

As a natural next step, Hyundai Motors wanted to develop its own engine and transmission mechanism. Mitsubishi did not help this time and ended its collaboration with Hyundai in engine technologies. This time, Hyundai Company was at a critical juncture and had to decide whether to make a new collaboration with other companies or to take risk and to try to produce its own engine and transmission. The company chose the second option and, in 1991, Hyundai successfully developed its own gasoline engine Alpha with 4 cylinders and with its own transmission mechanism (Lee, 2005).

As can be seen from the typical example above, when the latecomer firms starts to develop their own technology, the leader companies starts to worry that the transfer of technology to latecomer company can make a 'boomerang effect' and hit back the company. The leader countries or firms in general are reluctant to help the latecomer firms too much. This shows it is the latecomer's duty to want more and risk more for the prize of independence (Lee, et al., 2017).

Figure 2.3 Foreign value added share of gross exports



Source: OECD, Trade in Value Added (TiVA) (OECD, 2017)

In Figure 2.3, we see FVA (foreign value added) shares of gross exports for selected countries. While Turkey and Brazil have relatively low FVA ratios, the other countries have high FVA ratios. To have a higher FVA ratio in itself is not always good or bad for the

national economy. A hypothetical country A can have a very low FVA ratio with a big trade volume and surplus implying that the country produces almost all export products with local ingredients. Conversely, another country B can have a very high FVA ratio but still with a high trade volume and surplus implying that the country positions itself well in global value chains and possibly in higher value added parts of the chain.

(Lee, et al., 2017) claims that FVA trajectory of developing countries does not follow a linear path. Instead, FVA of developing countries increases at the initial stages of development during low income and lower middle income levels. Later, during middle income and upper middle income stages FVA ratio decreases and finally when the country reaches high income stage it increases again. The reason for this non-linear path is that while the country initially uses lots of foreign intermediate goods for production and import, in next stage the country begins to create more value added locally and this decreases FVA ratio. Finally, when the country can produce high tech and high value added segments of GVC (global value chain), the FVA ratio increases again implying that the country have the power to outsource low value added parts of production to other low income or developing countries.

These 3 stages of FVA is also called in-out-in strategy for the development of a developing country. In 'in' stages, the country uses intermediate imports heavily in its production but in 'out' stage the country concentrates on upgrading its NIS so that it can move to higher segments in GVC.

For a developing country to accomplish this, NIS must have 3 components. First of all, government must be supporting the firms which want to become independent in international markets. Secondly, government must promote private firm's R&D initiatives and public-private partnership in R&D. The last but not the least, in cases of international intellectual property disputes (IPR), the government must help the local firm.

2.2.2 Current vs Future Endowments

In the literature, sometimes we see papers named 'key sectors of country A', 'central elements in the network X' etc. One common misconception in some of this literature is that they all assume the current structure of country or network as given and exogenous. For example, a key sector analysis for a small banana-exporter Latin American country may very well results in bananas as the only key sector. These models does not take into account the

facts that the structure is dynamic and most of the variables are endogenous.

The other extreme version of literature sees every country as a potential developed country and offers the quickest way to reach that level by suggesting production of cutting edge technology.

We can criticize both point of view and argue that endowments of a country is not static and exogenous. A country can upgrade its endowments by growing and increasing its capital stock. Some endowments like land area and total population is fixed but others such as total capital and entrepreneurship are endogenous and improvable. According to Lin, the best way to accomplish high income status for a developing country is to aim the endowment structure of a country that has double the GDP per capita of developing country. After reaching that amount of endowment, the developing country must aim for long-established or leftover industries from the target countries (Lin, 2012).

Literature is divided on whether comparative-advantage-following (CAF) or comparative-advantage-defying (CAD) strategies are more successful (Siddique, 2016; Lin, 2012). CAD strategies argues that a developing country need not to follow the exact steps that a high income country followed. Instead, it can reach the level of developed country status faster by specializing in those areas with higher technological prospects. Because higher technology areas gives the country a bigger chance for growing faster. Technological level and the potential of a sector for growth can be calculated by the number of patents in a sector. The criticism against CAD strategies is that a robust relation of technological opportunity with GDP growth is not found (Radosevic, et al., 2017).

In our opinion both strategy are extreme and the best option is combination of two. The product space methodology will give us more insights about that in Chapter 2.3.

2.2.3 Cycle Time

All technology changes with time. Some changes fast and others change slowly. For example Moore Law says that the number transistors on a chip doubles every year. This law clearly shows chip industry is changing very fast. On the other hand, big investment sectors such as iron steel industry or food industry changes slower. Some researchers suggest that the high speed of change can be an advantage for developing countries.

We measure how fast a technology is with ‘cycle time’ of technology. It measures with what

speed the technology changes or becomes outdated with time. There are different methods for measuring the cycle time of a technology but the most widely used one uses the patent records of a technology. In the first page of a new patent, previous patents used are listed and technology cycle time is defined by computing the median age of patents cited in the new patent and then by taking average over all new patents. This methodology assumes that a longer cycle time implies slow technological change and a shorter cycle time implies a dynamic and fast changing technology.

According to Lee (Lee, 2017) "The technological development of South Korea over the last three decades reflects the increasing specialization of South Korean industries into short-cycle technologies during its catch-up period. South Korea began to specialize in labor-intensive (low-value-added long-cycle technology) industries, such as the apparel or shoe industries, in the 1960s. The economy then moved to the shorter- or medium-cycle sectors of low-end consumer electronics and automobile assembly in the 1970s and 1980s; to the shorter-cycle sectors of telecommunication equipment (telephone switches) in the late 1980s; and to memory chips, cellphones, and digital televisions in the 1990s. South Korean industries kept moving to shorter-cycle technologies to achieve technological diversification."

Lee also analyzes Korea, Taiwan and European G5 countries (Germany, France, United Kingdom, Italy, and Spain) and makes comparisons between them. According to this analysis, for Korea and Taiwan, the mean cycle time of technology is 8 years. That means the patents obtained by Korean and Taiwanese firms cite on overage 8 years old patents and older patents are deemed as outdated by technology firms. Analysis shows that starting from 1980s, the cycle time of Korean and Taiwanese technologies get shorter. The cycle time of European G5 countries is about 9-10 years and that is longer than cycle times of Korean and Taiwanese technologies. The reason for the difference is the success of European firms in those sectors which have longer cycle times and higher value added such as machine tools and pharmaceuticals (Lee, 2017).

When we look at the trends of Korea and Taiwan, we see that there is a structural change around 1980s when both countries started to achieve a successful catch-up process and began to move in and out of the group of middle income countries. Korea and Taiwan attained 25% of US per capita GDP, whereas Turkish GDP per capita is around 20% of US per capita GDP

in 2016.

Cycle time methodology offers much insight especially for middle income countries in their development process. According to Lee, when these countries want to specialize on specific sectors, it is better to concentrate on sectors and technologies with shorter cycle times. Because in those technologies with shorter cycle time, investment requirements are lower in general and catch-up cycles are faster meaning that the country has a higher chance of success in the catch-up process.

According to cycle time methodology, not all middle income countries can apply it to choose technologies with shorter cycle time. The country must have fulfilled some pre-requirements such as a skilled labor force, a working NIS and a financial system suitable for long term technology investments. Middle income countries with these qualifications can have comparative advantages in technologies with shorter cycle time. Because, in technologies with short cycle, the control of leaders is partial and they cannot be display dominance as the technology changes quickly and outdated R&D does not mean much in these sectors.

The middle income countries which do not take cycle time methodology into account may face some problems. First of all, by trying to reach the level of advanced countries through concentrating on all high tech areas, the country becomes dependent on advanced countries in the long cycle technologies as in these technologies it is more difficult to make progress in a short time. On the other hand, middle income countries can progress faster by concentrating on short cycle technologies as in these sectors local firms can build up creative knowledge faster.

The comparison of Latin American countries such as Brazil with East Asian countries such as Korea and Taiwan clearly shows the differences in policies and outcomes. In this comparison, Latin American countries represent very long cycle technologies and East Asian countries represent the short cycle technologies. Latin American countries gave more importance to academic research in high tech areas and expected that this high level research will led to higher technology and innovation. Although, there are good cases such as Brazilian aircraft industry, the overall success rate is low due to the fact that concentrating solely on cutting edge science is not significantly associated with GDP growth (Radosevic, et al., 2017).

Despite all those advantages, short cycle time is not without caveats and risks. First rule is

that if you catch-up easily then you are caught-up easily. Higher chance of catch-up in short cycle technologies implies that the technology is changing quickly and once a country catches-up the leaders, it must continuously upgrade the ever changing technology. The ability of upgrading a technology dynamically is not easy and only a small subset of middle income countries can accomplish that. These countries have some common characteristics such as a minimum level of technological competence and a working national system of innovation. According to Lee, comparative advantage following strategy may help to achieve these minimums as it suggests learning and transferring mature technologies from advanced countries and these old industries increases the overall competence of country by creating a sample project to work on.

From this analysis, it follows that some degree of comparative advantage defying strategy is necessary but insufficient for the upgrading of overall technology level of the country. But rejecting the comparative advantage defying strategy altogether may mean that the middle income trap becomes destiny rather than a short period that a country must experience before reaching the level of advanced countries.

South Korea and Taiwan are two good example of countries which applied technology cycle time in their development process. But an interesting question is whether these countries explicitly planned these cycle time strategies beforehand or they just emerged as a result of best reply strategy of the countries against the development problems they encountered. The answer, according to (Lee, 2017), is apparently no. The countries did not plan the cycle time strategies beforehand. It appears only after an ex-post analysis is done.

This unplanned behavior implies that we must be cautious on offering cycle time strategies as proved methods for middle income countries. Because NIS is a complex structure and the overall behavior of a complex network in general cannot be determined by looking at just a small part of it. Economics science repeatedly (Lucas, 1976) showed that historical correlation or even historical causation relation between two variables does not mean that there is the same relationship now and it will be the same in future.

2.2.4 Windows of Opportunity

Frankly, when I read the modern literature on technology cycles, leapfrogging etc., it reminds me the legendary philosophy of science book that is Thomas Kuhn's The Structure of Scientific Revolutions. Before Kuhn, science was understood as a gradual increase in the

understanding of nature. In this old version, each discovery in science made it closer to truth. In his seminal book, Kuhn questioned this idea and claimed that scientific progress consists of 'normal' and 'revolutionary' periods in which 'paradigm changes' occurs.

According to Kuhn, there are two kinds of change, normal and revolutionary. Normal change consists of incremental improvements in the understanding of the standard scientific view of the day. It can be creation of new data, explanation of new data or some new interpretation of classical theory. Contrary to this, revolutionary changes creates uncertainty and turmoil in science. The old classical system and new revolutionary new system cannot be analyzed within a unique underlying model so they cannot be compared directly.

When viewed from this angle, technological change and scientific change, or even political change display similar structure and display long periods of 'normal' years, decades or centuries and then the sudden and short-period bursts of revolutions in between.

Technological changes that we analyze in this thesis shows exactly similar patterns. Incremental changes corresponds to comparative advantage following strategies which corresponds to path following strategies which will finally correspond to diffusion to close neighbors in product space terminology. Kuhn's revolutionary changes of science, on the other hand, corresponds to comparative advantage defying strategies which correspond to path breaking strategies and which will later correspond to long jumps in product space of a country. For me, the most striking projection of Kuhn's ideas to product space is 'paradigm shift' that corresponds to 'windows of opportunity'.

'Windows of opportunity' are discontinuities in the technological progress that resembles the 'creative destruction' of Hayek. The term was first used by (Perez & Soete, 1988) to explain the instances where a latecomers can have a more than usual chance of success in their struggle to catch-up the leaders. These windows of opportunity are of three kinds of paradigm shifts in technology, and corresponds to technological, demand, and institutional levels.

The change from analog technology to digital technology in mobile phones is a good example for a technological window of opportunity in which a latecomer firm has an advantage because it does not have any burden of old technology. The old technology always have some similarities with the new technology and one can think it must be an advantage over the latecomers. But history of changes in sector leaders of various technologies (see

Table 2.1) repeatedly showed that being a leader and having a big investment in old technologies can be big burden which reminds the story of David and Goliath where the extreme power and weight of Goliath becomes a liability and a fatal drawback while the small and fast stature of David becomes a game changing feature (Gladwell, 2013). With modern terminology, Goliath was the victim of 'incumbent trap'.

A second kind of window of opportunity is called 'demand window'. A demand window can be a new kind of demand which simply did not exist before, can be a peak of a business cycle with bigger opportunities for firms or can be a big shock to local demand. The huge demand increase in China's local market in recent years or previously nonexistent demand that Indian consumers show for cars with low cost are good examples of demand window. These situations offer big opportunities for latecomer countries and firms in catching up the leaders in those sectors with high demand. Even at the trough of business cycle creates chances for latecomers as incumbent firms face economic difficulties while latecomers can have low cost entry advantage to the market.

While the previous two windows are mostly exogenous to the firm or country, the third window of opportunity 'institutional window' is endogenous for the country and because of that it is the most critical one for a middle income country. Institutional windows are generally opened through public policy deliberately planned by the government. In many successful catch up cases, institutional windows were created by the corresponding governments. Korean and Taiwanese high-tech industries, Chinese telecommunications industry, and Indian pharmaceutical industry are good examples of successful institutional windows (Lee & Malerba, 2017).

Windows of opportunities happen for different technologies in different times and do not differentiate between countries. But to see an institutional window is no easy feat and countries need various capabilities even to do that. So important questions is to see it when an institutional window is opened and how to respond nationally in the best way. As we said before NIS is a complex network and best response against a window of opportunity is a must if a country want to catch up successfully. In most cases the various components of NIS works like a chain so the power of chain is measured by the weakest link. It is important for all components of NIS such as universities, research laboratories, education system, financial system, and public policy, to have the capability to respond to the window of

opportunity. Response of firms are not the same although they all share the same national response to a new window of opportunity. Some firms can interpret the risks and opportunities of local and global system and give a better response and become a global leader.

In our view, it is worth to analyze the China's responses to various windows of opportunities in more detail as they offer much insight for other middle income countries in their catch up experiences. China has one advantage that no other country has with the exception of India, and that is its sheer population with a big local market. China used this advantage cleverly in many cases of technological catch-up through the use of 'trading technology for market' strategy which is a very Chinese invention with its semi-free market semi-state controlled economic system. In this strategy, foreign firms were allowed to operate and sell within local markets in China with the condition that the firms also bring the latest technologies that do not exist in China.

The Chinese government understood the importance of this strategy early on in its development process. At least 80% of all FDI made in China since 1980s was based on this strategy especially in industries such as electronics, telecommunications, and chemicals. The essence of this strategy was first reflected in policy documents in 1979 by the 'Law of Sino-Foreign Equity Joint Ventures' in which it was explicitly stated that "the technology and equipment contributed by a foreign joint venture as its investment must be advanced technology and equipment that suit China's needs" (Mu & Lee, 2005).

In summary, because of the big domestic market which inferred a large bargaining power, China was able to require latest technologies to be transferred to China with the incentive of operating within local market.

2.2.5 Which Product is better?

Depending on the angle we look, there are many different lenses through which we can define which products are good for a country to produce? Some of the lenses are;

i. Contribution to current account balance,
ii. High-tech,
iii. High value-added,
iv. Similarity to current production structure,

v. Contribution to regional development,
vi. Contribution to employment,

This thesis mostly elaborates on the structure of the Product Space and its impact on development.

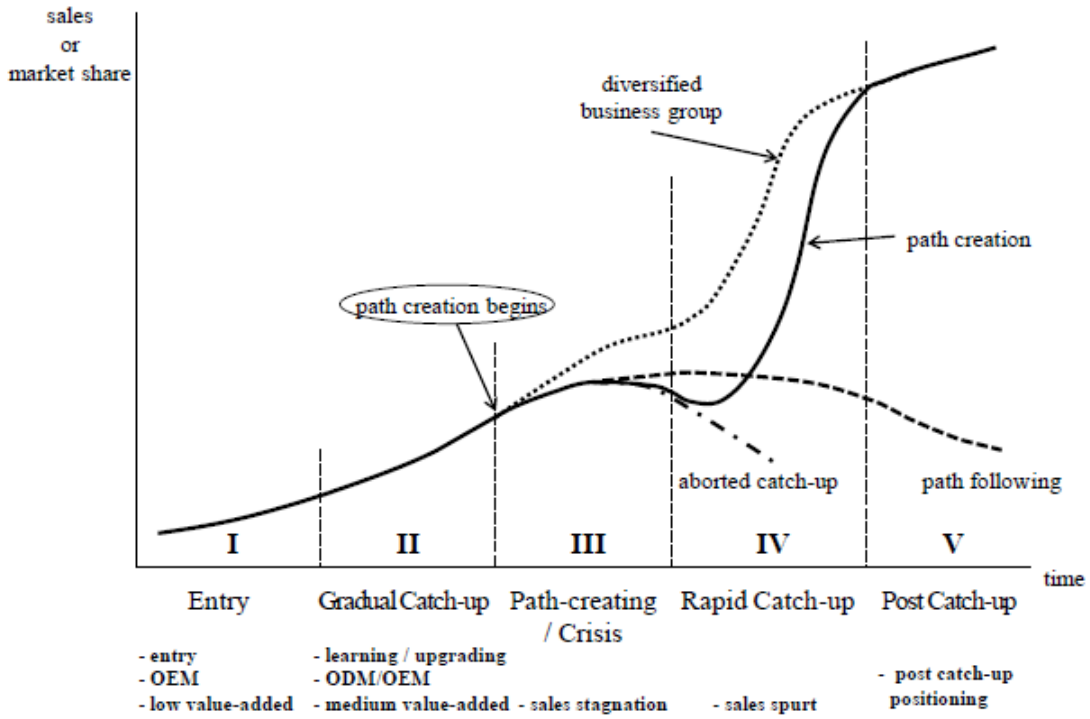
In risky endeavors of the firms, governments can help the firms in their catch-up process in international markets. Korean government is a good example in this respect as it helped those firms which took risks. Korean government implemented various policy measured targeted at risk taking latecomer firms. That was because most of the latecomer firms starting their own brand was confronted with harsh intellectual property right (IPR) lawsuits from their previous vendors.

International property disputes are important tools and are used extensively by developed countries or sector leader firms to preclude latecomer firms from entering international markets. The process goes as the following: when a latecomer company starts its own brand in international markets, the leader firms in international markets sue this firm on property rights ground. IPRs take a long time to resolve in general and this inflicts a serious financial burden on latecomer firms. If latecomer Company cannot display a good legal defense, it may be forbidden from international markets or may be obliged to pay large amounts of administrative fines.

Korea displayed a good example of state support in international IPR disputes by offering help in various areas such as by;

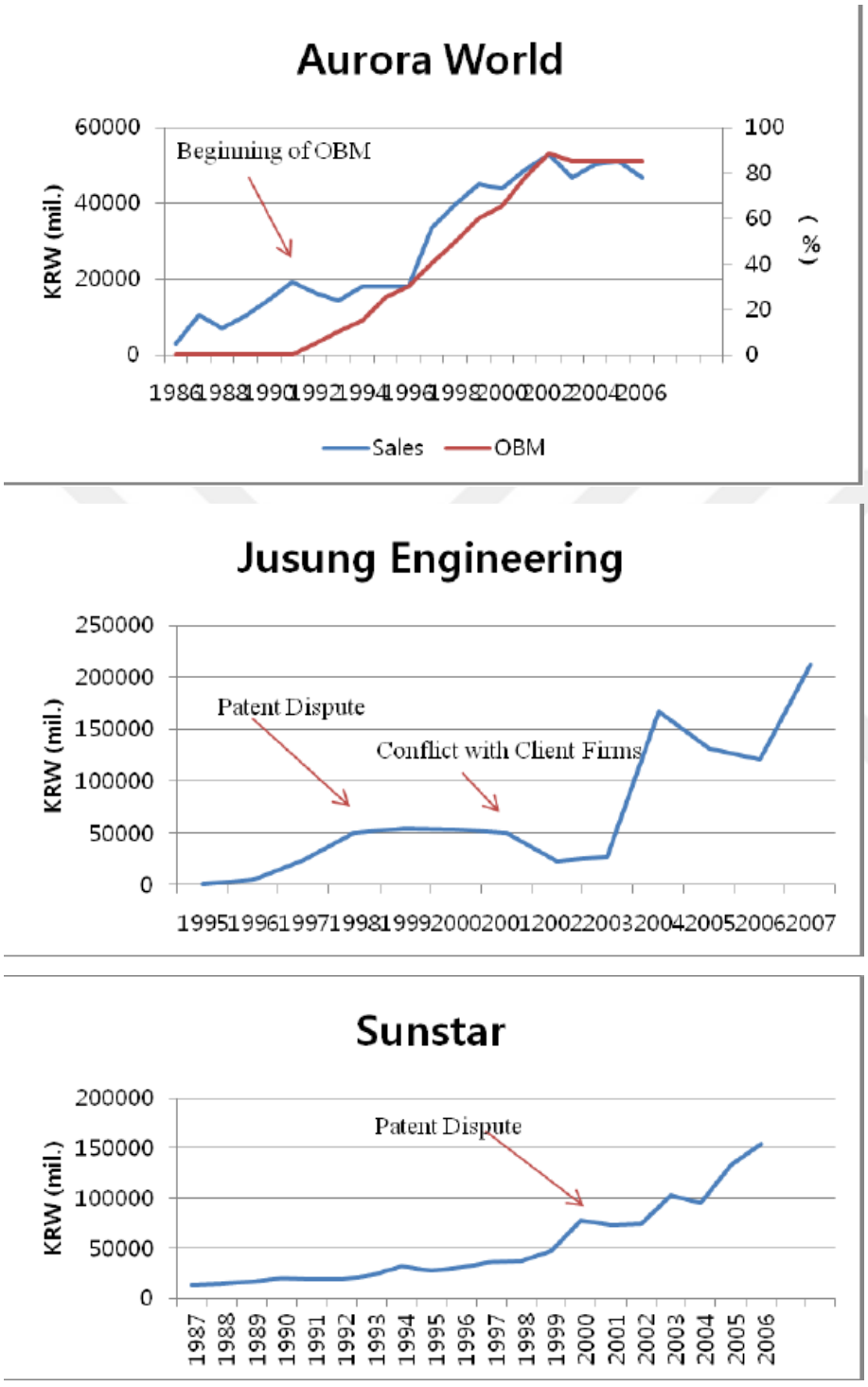
i. Providing low-cost insurance in case of a possible IPR litigations,
ii. Providing pre-marketing or export market analysis for possible litigations by other firms or countries,
iii. Creating special consulting packages for those small and medium sized enterprises which experiences IPR litigations with foreign firms.

Figure 2.4 Stages in Dynamics of Catch-Up



Source: (Lee, et al., 2015)

Figure 2.5 Catch-up Strategies of Korean Firms



Source: (Lee, et al., 2015)

The importance of FDI on development may even be higher than domestic investment. But, this only happens if the human capital level of host country is higher than a threshold value (Borensztein, et al., 1995).

2.2.6 Science vs Technology

When we compare Latin American and East Asian development experiences, one of the key differences we see is that while Latin American countries gave bigger emphasis to science in terms of academic research output, successful East Asian countries such as Korea and Taiwan preferred science stemming from technological research. These differences culminates in the end as invention in Latin America and as innovation in East Asia. Invention and innovation or academic research and technological research cannot be separated easily as they intermingled within the complex system of NIS. But, giving more importance and resource to one side expresses itself in the results. Because technological knowledge is more important for economic development as it is the source of high value added production. Furthermore, we see from country examples that a developed academic research system and generation of high quality scientific knowledge does not mean technological innovation directly.

To this end, (Kim & Lee, 2015) analyzed various country groups to see the roles that technological and scientific knowledge played in the development process of these countries. One observation is that in successful East Asian countries technological knowledge is mostly provided by corporate sector R&D initiatives which is lacking in most of Latin American countries. We see that especially in Korea and Taiwan, state favored technological policy over science policy by giving more importance to technological innovation of private sector.

Latin American countries gave bigger emphasis in academic research with the hope that the theoretical knowledge that academic research produces will culminate in the technological knowledge and innovation. Theory and practice are same in theory but different in practice[2]. So although the idea looks logical at first sight, in practice it is naïve to expect that the result will follow automatically. When the links between the academia and private sector are not well designed, the results attained in academic patents will not produce technological patents.

In contrast to Latin American case, East Asian governments encouraged the development of in-house R&D for private firms. As these industrial innovation activities increased, it also

[2] I looked for a source of this famous saying but apparently it's anonymous.

created a demand for academic research as some areas of industry have larger reliance on theoretical knowledge that can only be provided by long term research of academia. These demand and supply of technological knowledge created a healthy and productive interaction between university and industry (Nelson, 2017).

A country is locked by middle income trap simply when its technology is too little for high-tech production and its wage is too much for low-tech production. The only possible option looks like medium-tech production and that's what most of middle income countries does. As decreasing the wages is impossible socially, the only possible way is increasing the technology level to exit from the middle income trap.

The relation between industry, technology, and science is a complicated one. Studies show that some sectors need only technology and not much basic science and that some other sectors need more basic science. The machinery is an example to the first and biotechnology is an example to the second one.

If we look at country examples, we see a big variation in successes and failures of catch-up processes. For example, in pharmaceutical industries, India has been a success story but Brazil has not been so. In telecommunications industries, China has been successful but India was not. Brazil has been successful in agro-food industries but not in telecommunication industries (Lee & Malerba, 2017).

Another difference, other than scientific vs technological knowledge, is the scale of investment needed for production. In sectors with increasing return to scale, such as semiconductor or telecommunications, the private firms need to run big R&D departments and public policy must be designed to support the private sector's R&D initiatives.

On the other hand, in sectors where scale is not important and skills of researchers are more important, new and small firms generally dominates the sector by growing quickly and then losing the leadership to other newcomers. In these areas, government promotes education more as a high level of human capital is more important in these sectors. R&D initiatives of SMEs, low levels of corporate tax rates, and incentives for attracting more FDI is more critical for these areas.

In some sectors, it is difficult to apply big scale investments and in these sectors more dispersed and individualistic structures appear such as some crops in agro-food sectors. In

these sectors, it is more important to develop a science and technology infrastructure, public-private partnerships, and enable the diffusion of various market institutions. In this respect, China, Brazil, and Costa Rica are successful examples (Malerba & R. Nelson, 2012).

Furthermore, in other sectors, more theoretical scientific research is more important. In these sectors, a big portion of technological innovation stems from academic research rather than private sector R&D. Pharmaceuticals is an example to this kind of sectors and country comparisons shows that India has become quite successful in this sector by concentrating on university research. The collaboration of private firms with research universities led to the cutting-edge technological innovation in pharmaceuticals and India caught-up the leaders.

We can make a similar comparison between US and Japan in terms of fundamental vs technological innovation. In some industries, American firms are more interested in academic theoretical research, while the Japanese counterparts are more interested in commercialization of technologies in terms of developing new products and improving the production processes (Jang, et al., 2009).

From various types of innovation discussed above, one question becomes apparent. Can we copy the best innovation policies in one technology and apply it to another technology? Our intuition and various country studies clearly show that the answer in no. As we have seen, the structure of technologies are different and a policy that works best in one technology may not work in another technology. So before copying policies from technology to technology, it is important to make a comparative analysis that analyze the similarities and differences in terms of key structural properties.

There are successful and unsuccessful examples in terms of copying sectoral policies. One successful example is pharmaceuticals in India. Indian software industry caught up with the leaders by developing university research, improving the human capital, and creating a competitive market for firms with easy entry and exit. These successful policies were later applied in pharmaceuticals also with great success. One of the main reasons of success was the similarity between the structural features of software and pharmaceuticals industries. Another successful example is Korean policy that enabled the access of foreign knowledge via licenses, support to local firms, and protection of local market in initial period. These polices were first introduced in automobiles industry and led to a catch-up process in this industry. Later, these policies were copied and applied to telecommunications and semi-

conductors with great success.

Not all examples are successes. When the characteristic features of two sectors are different, a successful policy in one will not guarantee success in the other. For example, Taiwan tried to replicate its ICT policies in biotechnologies but it was a failure because of the characteristic differences between the two sectors.

Having argued about the various aspects of products and how to choose which product to export, in the next section we turn our attention to the relations between the products to answer questions such as how we quantify the relations between the products and what they mean for development strategies of a country.

2.3 The Product Space

Worldwide merchandise trade consists of 775 different products in 4 digit SITC Rev. 2 classification. They are divided into 5 groups according to their technology level. The comparative advantage index for product p of any country c is $RCA_{c,p}$ (Revealed Comparative Advantage Index) and defined as

$$RCA_{c,p} = \frac{\left(\frac{x_{c,p}}{x_{c,T}}\right)}{\left(\frac{x_{w,p}}{x_{w,T}}\right)}$$

Where;

$x_{c,p}$: export of country c in product p,

$x_{c,T}$: total export of country c,

$x_{w,p}$: Total world export in product p,

$x_{c,p}$: Total World Export

$RCA_{c,p} > 1$ implies that country c has a comparative advantage in product p. In other words, the share of product p in exports of country c is greater than the share of product c in world trade.

The products that Turkey has competitive advantage constitute a subset of whole Product Space. The table below shows the sectoral distributions of all products and also those products in which Turkey has competitive power.

Table 2.2 Sectoral Distribution of Products (SITC Rev. 2, 4 digit)

Sector	Technology Level	# of Products	# of products with $RCA_{TR}>1$
Commodities	1	148	39
Natural resource-based manufactures	2	196	53
Low-technology manufactures	3	154	90
Medium-technology manufactures	4	203	63
High-technology manufactures	5	61	3
other	0	13	1

Source: Prepared by the Author using Technological classification of exports by SITC

When similar products are connected to each other, Product Space is formed and represented by a 'Proximity Matrix' with size$775 * 775$. The similarity of any two products i and j is numerically defined as:

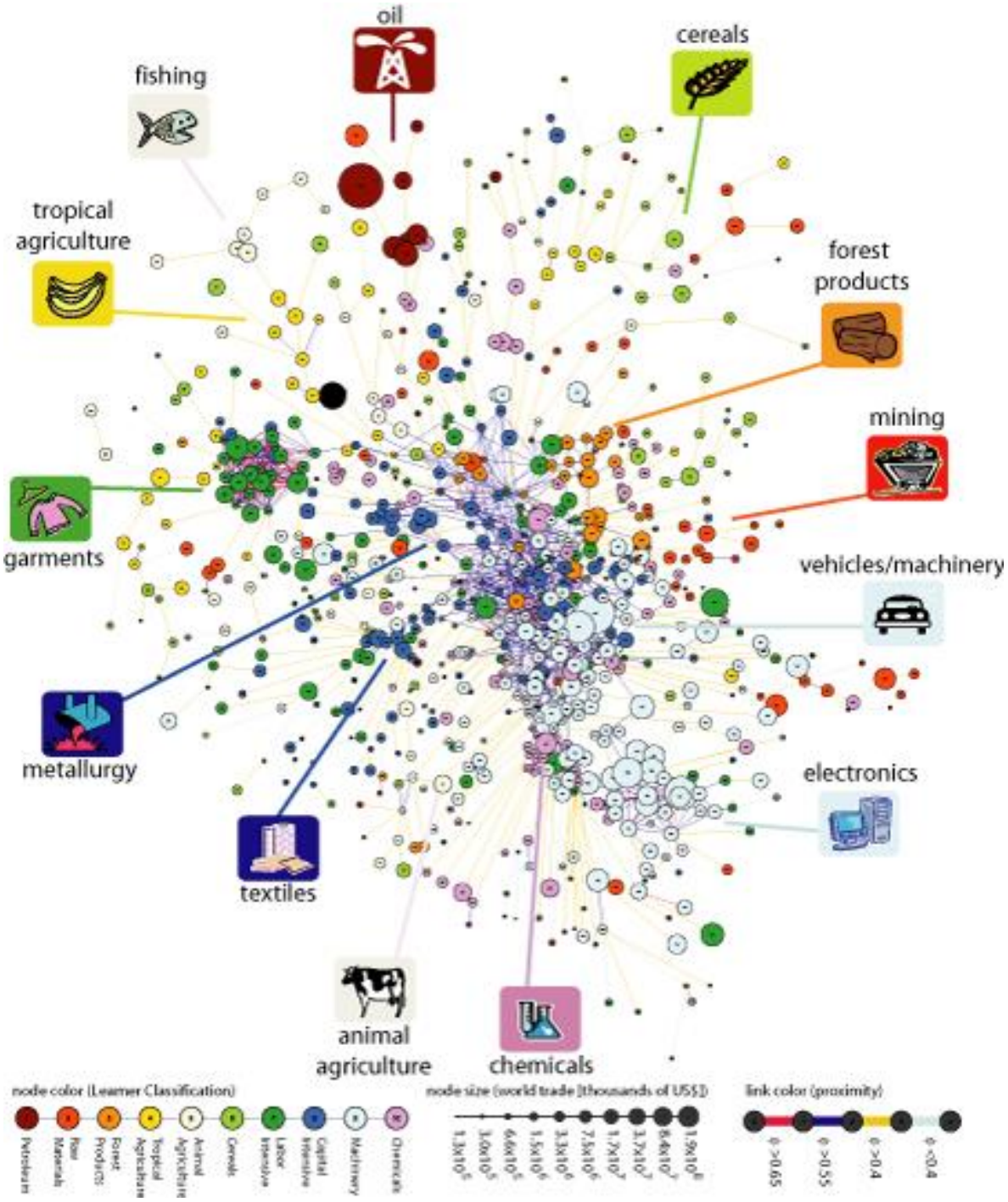
$$P_{i,j} = min\{\Pr(RCA_i \geq 1 \mid \Pr(RCA_j \geq 1), \Pr(RCA_j \geq 1 \mid \Pr(RCA_i \geq 1)\}$$

Here $\Pr(RCA_i \geq 1 \mid \Pr(RCA_j \geq 1)$ represents the conditional probability of exporting good i given that you export good j. By computing two conditional probabilities and then taking the minimum of these, we make it sure that an exporter of either of these products is most probably exporter of the other product also.

Afterwards, product pairs with similarities greater than 0.5 are connected in Product Space. Each row and column represents a specific good, and the entry $P_{i,j}$ off-diagonal measures the proximity between the products i and j.

Figure 2.6 gives a standard example of a product space. Colors represent sectors and node size is proportional to total export value of the product. We see that while low-tech sectors such as fishing, tropical agriculture, oil, and cereals are loosely connected with other parts of the network, high-tech sectors such as vehicles/machinery, chemicals, and electronics are strongly connected within themselves and with other sectors.

Figure 2.6 The Product Space



Source: (Hidalgo, 2007)

2.3.1 Product Complexity Index

The technology classification of 775 SITC Rev.2 products used in this study is based on a UN Trade Statistics study (UN Trade Statistics, 2016). It has only a rough 2 digit classification which was converted to 4 digit by the author. It has also disadvantage of classifying products solely by their SITC code. But in reality, two products with the same 2 digit SITC code can have different technology levels.

To overcome this problem, a new measure has been created by MIT Atlas (Hausmann, et al., 2014) called Product Complexity Index (PCI). It measures how complex a product is or how complex a country's export basket.

Complexity of a product c can be measured vaguely by counting the number of all countries c that can export the product c. If a big portion of countries export the product with $RCA_{cp} \geq 1$, then we call the product ubiquitous. If only a handful of countries export it, we may think of it as more complex.

Similarly, we can define complexity of a country's export basket by counting the number of products it has, and call the country's export basket diverse if it has many products.

Looking at just diversity and ubiquity may be misleading. A less diverse export basket may be preferred to more diverse one or a more ubiquitous product may be preferred to less ubiquitous one. For example, textile industry worldwide is more ubiquitous than banana industry and more countries export textile products than banana but it may still be preferable to have textile industry as it offers more options for going forward for a developing country. Similarly, a less diverse export basket of high-tech products may be preferred to more diverse products of low or medium-tech products. But, as we'll see the diversity of export baskets and complexity of overall export will in general have high correlation.

Diversity and ubiquity have a duality so that we can define each by linking it to the other in an infinite cycle. To do that, let M_{cp} be c by p matrix with entry 1 if country c produces product p with $RCA_{cp} \geq 1$, and 0 otherwise. We can define diversity of a country and ubiquity of a product as follows.

$$Diversity = d_{c,0} = \sum_{p} M_{cp} \quad \text{Eq. 2.6}$$

$$Ubiquity = d_{p,0} = \sum_{c} M_{cp} \quad \text{Eq. 2.7}$$

In the next step, we can compute a new kind of diversity of an export basket as weighted sum of ubiquities of all products in that basket (Eq. 2.8). Similarly, we can construct a new kind of ubiquity of a product as a weighted sum of diversities of all countries which produces that product (Eq. 2.9).

When we do this process recursively, we get:

$$d_{c,K} = \frac{1}{d_{c,0}} \sum_{p} M_{cp}\, d_{c,K-1} \quad \text{Eq. 2.8}$$

$$d_{p,K} = \frac{1}{d_{p,0}} \sum_{c} M_{cp}\, d_{c,K-1} \quad \text{Eq. 2.9}$$

If we plug Eq. 2.8 into Eq. 2.9, we get

$$d_{p,K} = \frac{1}{d_{p,0}} \sum_{c} M_{cp} \frac{1}{d_{c,0}} \sum_{p'} M_{cp'} \cdot d_{p',K-2} \quad \text{Eq. 2.10}$$

Rewriting this:

$$d_{p,K} = \sum_{p'} M_{cp'} \cdot d_{p',K-2} \sum_{c} \frac{M_{cp} M_{cp'}}{d_{p,0} d_{c,0}} \quad \text{Eq. 2.11}$$

We get:

$$d_{p,K} = \sum_{p\prime} \widetilde{M_{pp\prime}}\, d_{p\prime,K-2} \qquad \text{Eq. 2.12}$$

Where

$$\widetilde{M_{pp\prime}} = \sum_{c} \frac{M_{cp} M_{cp\prime}}{d_{p,0} d_{c,0}} \qquad \text{Eq. 2.13}$$

In Eq. 2.12, if we think $d_{p,K}$ and $d_{p\prime,K-2}$ as a vectors, the equation becomes a system of linear equations. In the limiting case where$d_{p,K} = d_{p\prime,K-2}$, one obvious solution is the vector $d_{p,K} = \vec{1}$. But this solution, corresponding to eigenvalue 1, does not give useful information. The useful information comes from the vector corresponding to the second largest eigenvalue (Hausmann, et al., 2014, p. 24).

So we define:

$$PCI = \frac{\vec{K} - \langle \vec{K} \rangle}{stdev(\vec{K})} \qquad \text{Eq. 2.14}$$

Where ⟨ ⟩ represents the mean value, stdev is standard deviation, and

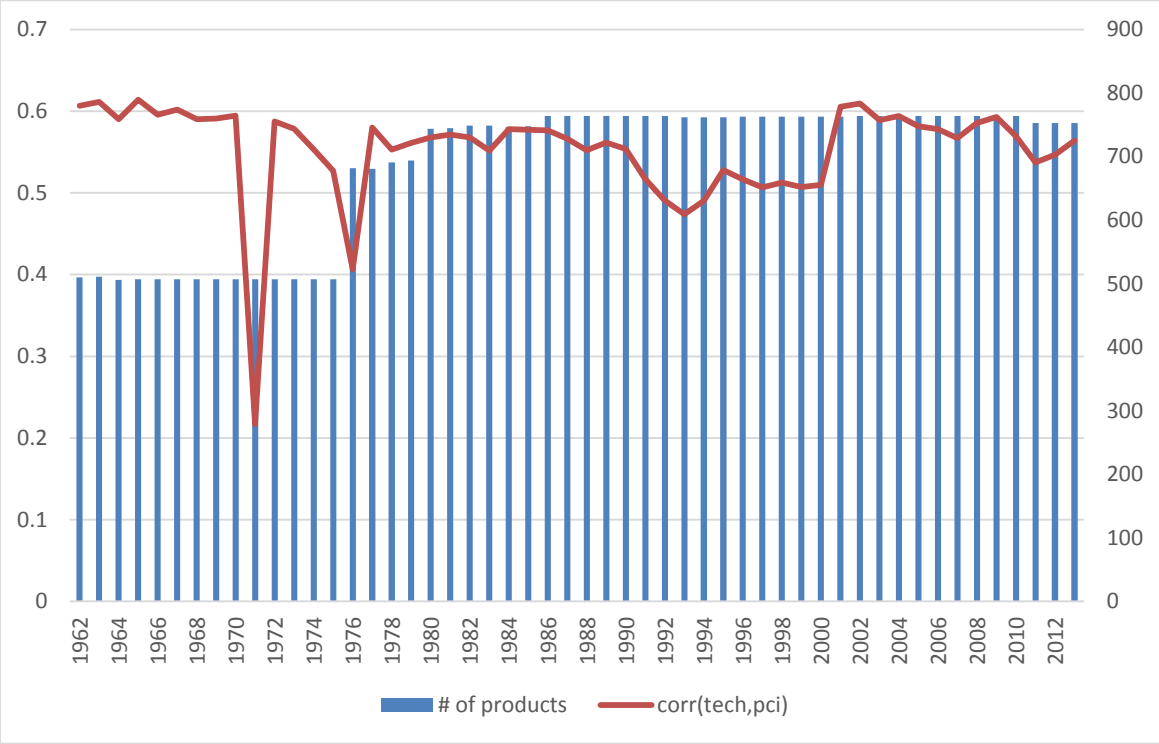
$\vec{K} = eigenvector\ of\ \widetilde{M_{pp\prime}}\ corresponding\ to\ the\ second\ largest\ eigenvalue.$

Actually, because of duality between c and k, we get Economic Complexity Index (ECI) of countries if we change the index p by c in all of the equations above. Hidalgo et al. analyzes PCI and ECI of all products and countries in detail in (Hausmann, et al., 2014).

2.3.2 PCI versus OECD Technology Classification

When we compare the Product Complexity Index and OECD defined technology levels of products, we see that although there is a wide overlap between the two, there are some differences especially for the year 1971.

Figure 2.7 Are PCI and OECD Classification consistent?



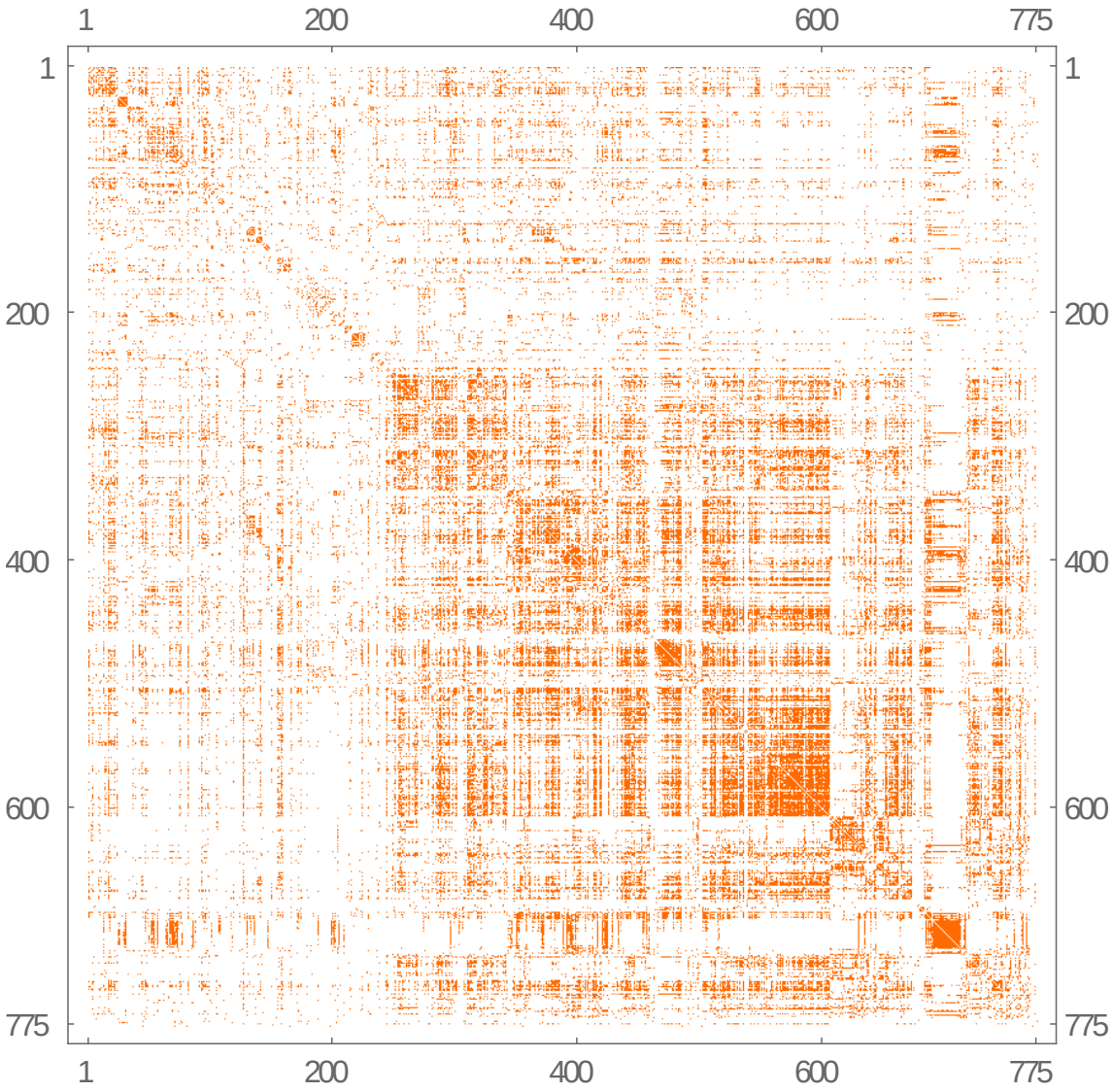
One thing missing from the figure above is the changing nature of PCI. While OECD defined technology levels are constant over the years or changing very slowly at best, PCI is dynamic and sensitive to yearly ebbs and flows in international trade of products.

We see from Figure 2.7 that after 2000 there is an increase in the correlation of OECD classification and PCI score. That is most probably because of better classification techniques used for OECD classification after 2000. What we did in this study is an example of anachronism. Because OECD classification of products are only true for a short period of time. By extending the current classification to historical data, we are making an error. PCI scores are computed and updated every year so it does not have that kind of error.

2.3.3 Visualizing the Product Space

A visual representation of the proximity matrix shows that the network is not homogeneous. While some of goods are highly connected, some other goods are disconnected from most of the network.

Figure 2.8 Matrix plot of Product Space



Dark colors represent stronger similarities.

Source: Created by the author using Mathematica.

When we compare the number of connections and the possible number of connections, they are very different. This implies the matrix is sparse. Approximately 32% of its 600625 (775*775) elements are less than 0.1, and 65% of the entries are less than 0.2. The sparseness of the proximity matrix shows that a network visualization is a good way to analyze the dataset.

The rule of thumb for a good visualization of a network is that the number of edges must be 3-4 times the number of nodes. By changing the threshold proximity between two products we can change the appearance of the Product Space network. In this study, threshold

proximity will vary between 0.3-0.6.

Color and size of nodes and edges represent various properties of the Product Space. It is possible to get many different kinds of visualizations by changing the color and size attributes.

When we draw the Product Space by using threshold 0.3, we get Figure 2.9. In the figure, the black color represents low-tech products and red color the high-tech ones. It is clearly seen that the Product Space of Turkey is divided into two regions. Turkey's successful products are mostly in low-tech southeastern part of the space. In northwest parts of the space where most high-tech products reside, Turkey does not have any significant product. The node size is proportional to Turkey's export of the product.

Figure 2.9 gives a striking example of Turkish product space. In this figure, the product space of Turkey looks like an island where most inhabitants are in poor south-east region. The other side of the island where mostly high-tech products reside is almost empty except a few products such as color TVs, Aircraft Parts and Accessories, and Electrical Transformers.

The peculiarity of Turkish product space can be seen more clearly when we make a comparison between Turkish and Japanese product spaces given in Appendix A. There, we see that Turkey mostly exports what Japan do not, and Japan mostly exports what Turkey do not. This clearly shows the main difference between a developed and developing country. The developed country is mostly done with exploring the product space and instead focus on exploiting the high-tech high-value-added products that it finds out. Explore-exploit process is one of the pillars of this thesis and will be analyzed in more detail in the next chapter.

When the same data is colored by PCI instead of classical SITC technology classification, we get Figure 2.12. In this figure, we can see the red nodes occupying the center of product space. These are the products with high PCI scores and they are in line with SITC technology classification.

Figure 2.10 gives a partition of product space using only binary proximity values in which two products are connected when proximity between them is higher than 0.5 threshold. We see that the partition is different from usual SITC classification with 10 groups. This is

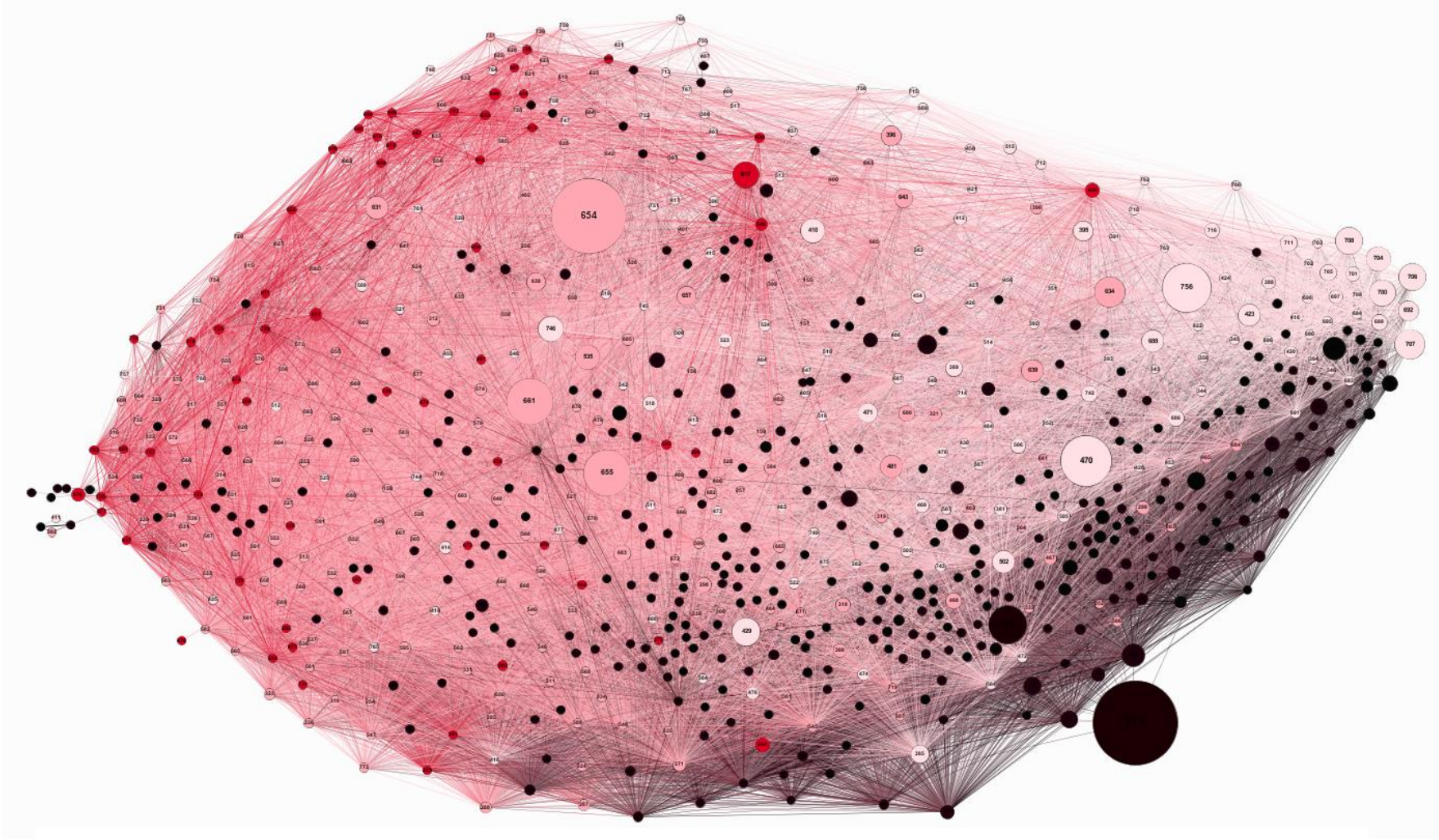
natural as different point of views give different classifications. Actually, according to (Hidalgo, 2007), the best classical classification that resembles the product space classification we see in Figure 2.10 is Leamer classification. In Leamer classification products are divided into 10 groups;

i. Petroleum
ii. Raw materials
iii. Forest products
iv. Agriculture
v. Animal products
vi. Cereals
vii. Labor intensive
viii. Capital intensive
ix. Machinery
x. Chemical

These groups gives higher in-group correlations than usual international classifications that depend on broad sectors (Hidalgo, 2007).

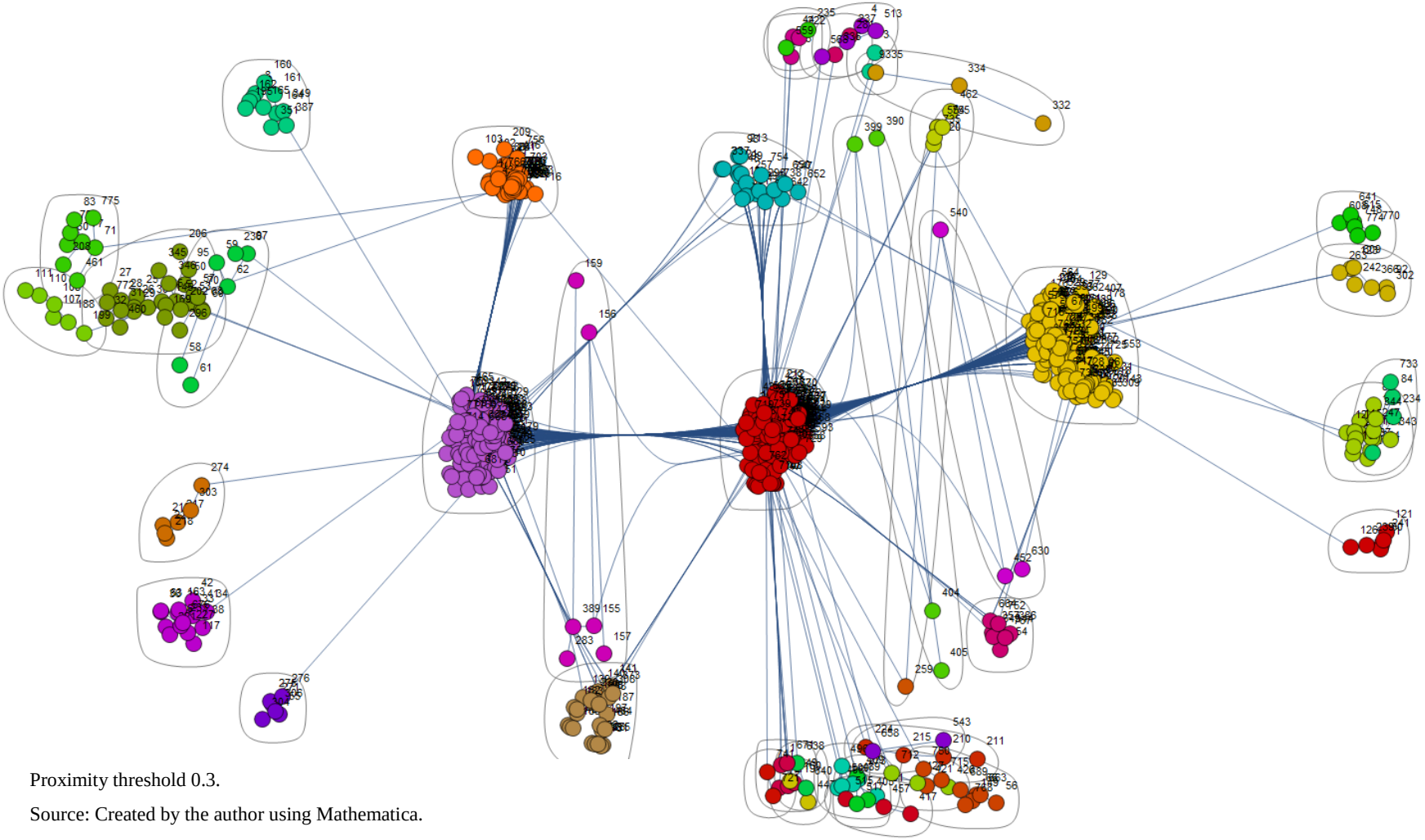
Figure 2.11 is similar to Figure 2.9 except that nodes are shaped in a way to differentiate the products that Turkey exports competitively (RCA>1) or not. The figure indicates that Turkey has competitive power in almost all its major export products except products such as Unclassified Transactions and Circuit Breakers and Panels.

Figure 2.9 Turkish Product Space



Source: Created by the author using Gephi. Proximity threshold 0.3. Black tones low tech, red tones high tech. Node size is proportional to Turkey's export values.

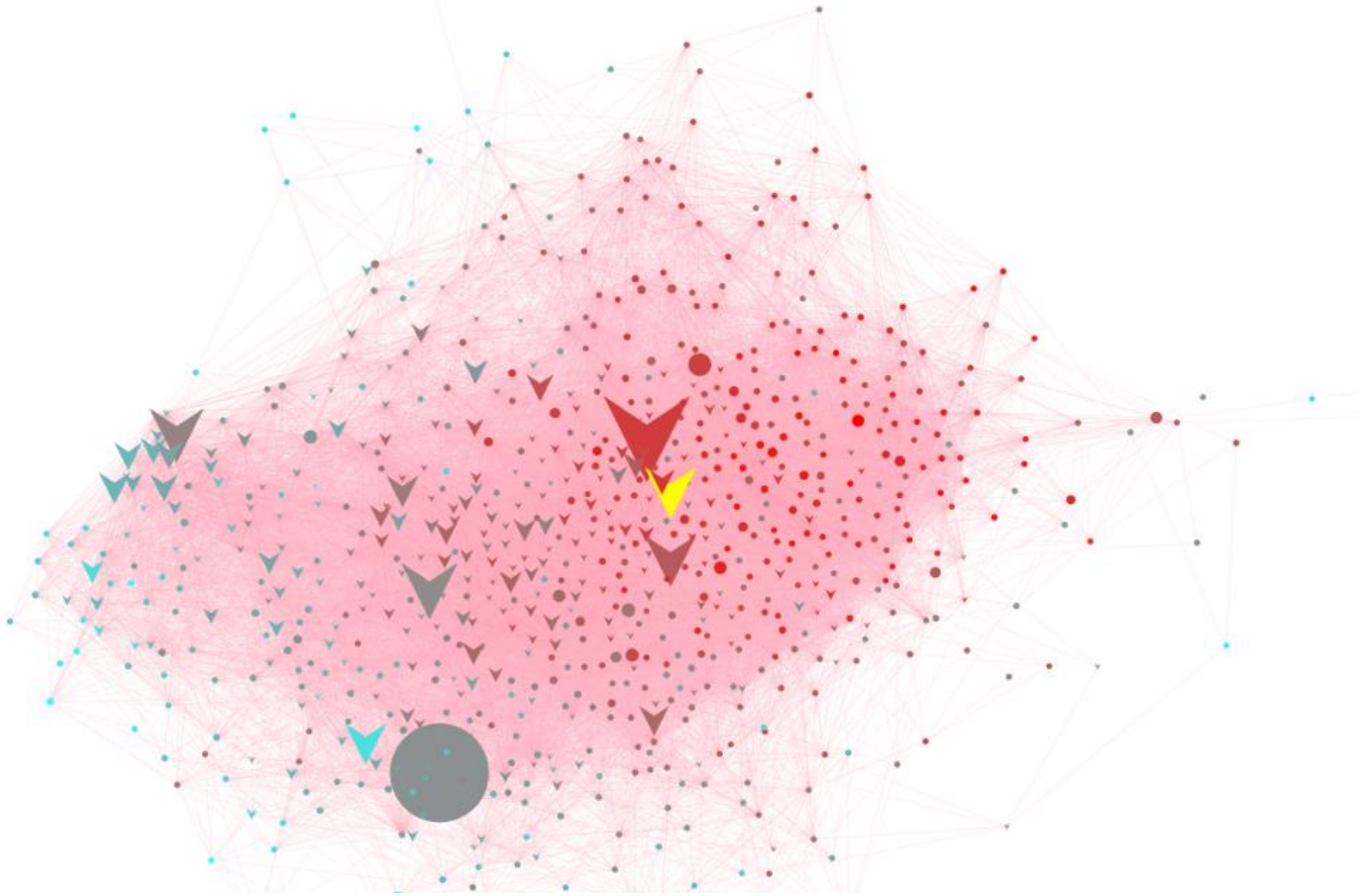
Figure 2.10 Product Space Partition



Proximity threshold 0.3.

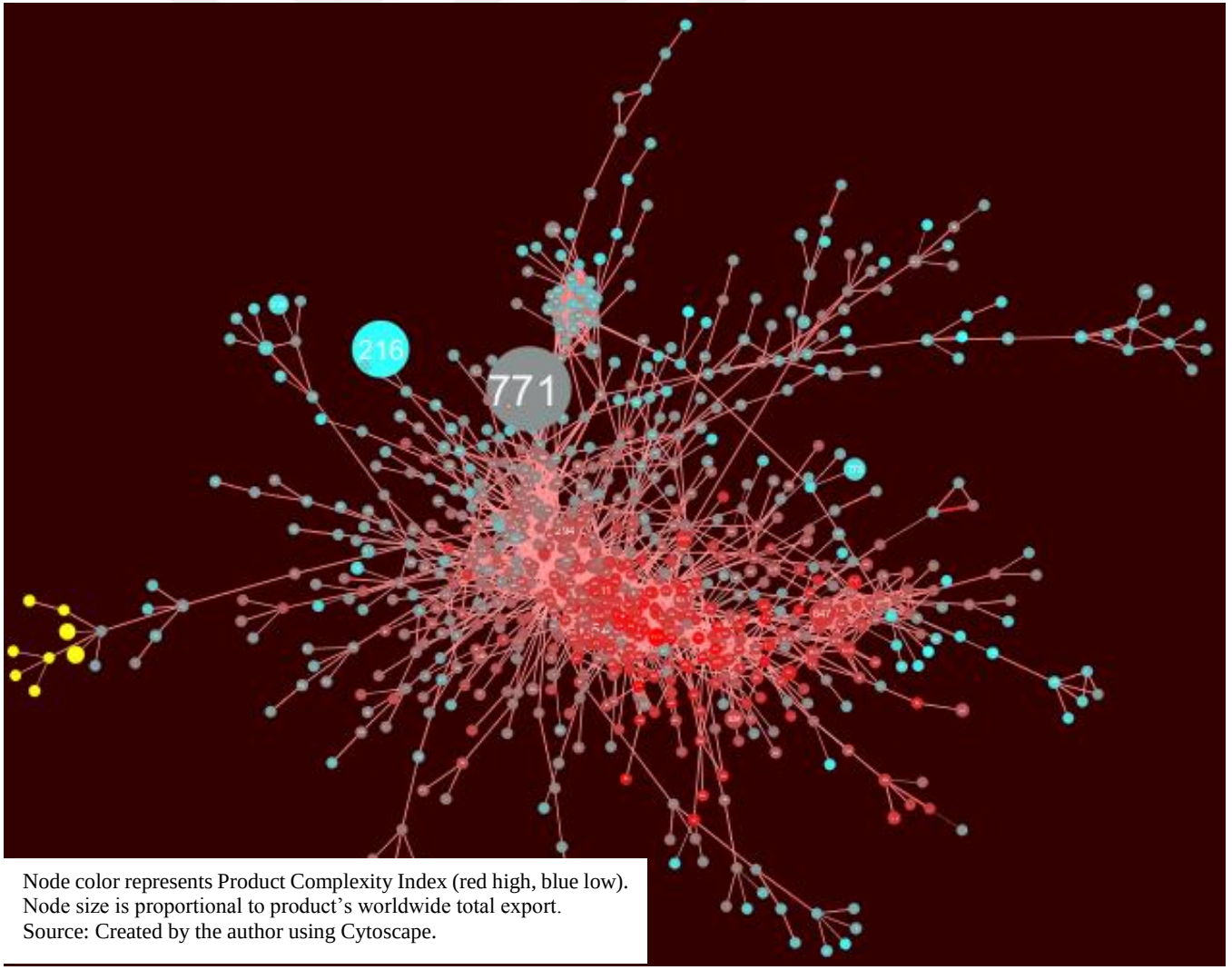
Source: Created by the author using Mathematica.

Figure 2.11 Turkish Product Space



Proximity threshold 0.3. Blue tones low tech, red tones high tech. Nodes proportional to Turkey's export values.
Node shape; disk: rca<1, v-shape: rca>=1.
Source: Created by the author using Cytoscape.

Figure 2.12 Turkish Product Space



Node color represents Product Complexity Index (red high, blue low).
Node size is proportional to product's worldwide total export.
Source: Created by the author using Cytoscape.

From the complex paths of Product Space jungle, an intriguing question lurks. A country is undeveloped or developing because whether;

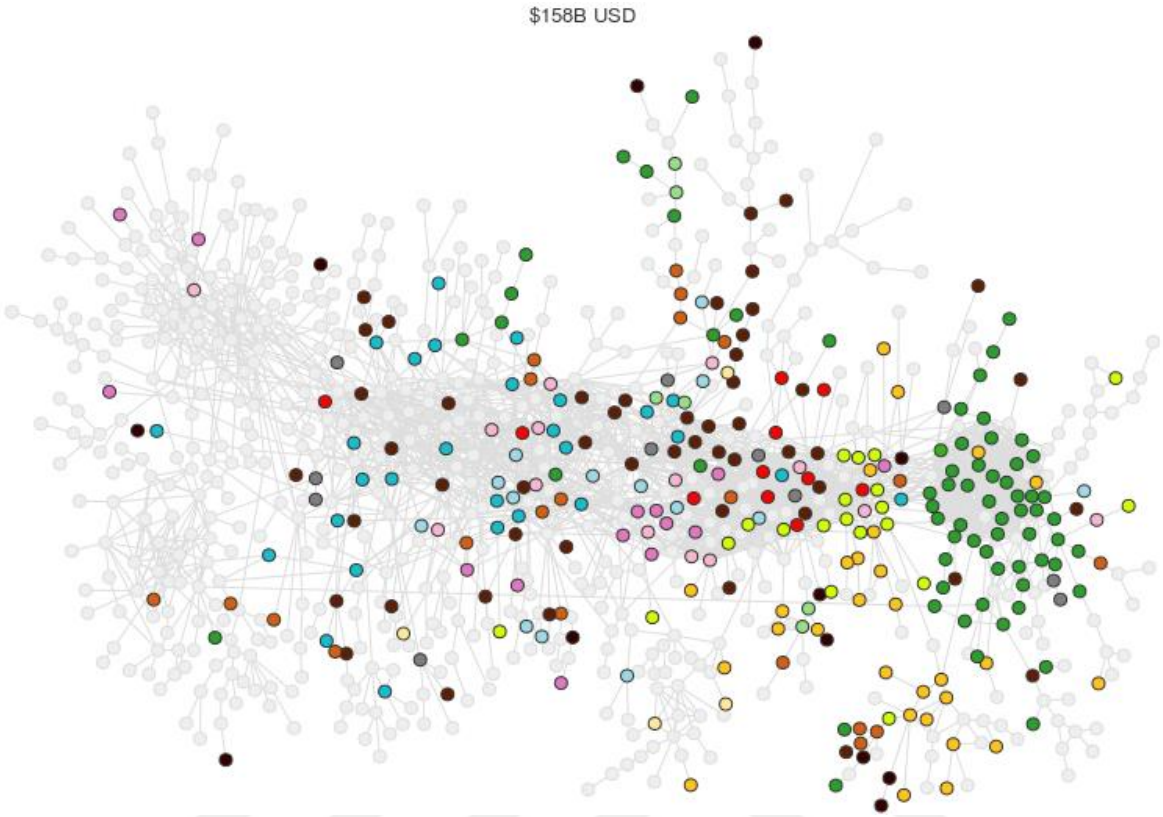
xi. They are all driving towards dead ends with full gas tanks so cannot move?
or
xii. Their roads have no dead ends but their car does not have fuel?

A car with full gas tank at a dead end of a road means a country have most of the ingredients (capabilities) to develop but its current production structure is not suitable to make a smooth transformation into being a high-tech producer. While a car on a superb highway with an empty gas tank means a country is on a good place of Product Space and many opportunities for transforming into being high-tech producer, but it does not have the environment for this to happen. In reality, of course, car's tank is half-empty and road is rough.

Products that Turkey has competitive advantage as of 2014 are shown in colored dots in Figure 2.13. Turkish exports are mostly concentrated in textiles (green), manufactured goods (yellow), and machinery& transport (blue). We see that there are vast empty areas that Turkey do not have any competitive power. These areas are mostly chemicals and related products, electronics, and high-tech machinery.

When Turkish and Japanese product spaces are analyzed visually, it is seen that Turkish product space for the year 2016 is very similar to Japanese product space through 1960s and 1970s. There is a sharp structural change in Japanese product space in which textile products suddenly lost competitive power and replaced by machinery, chemicals, and electronics.

Figure 2.13 Turkey's Place in Product Space



Source: (Hausmann, et al., 2014)

Once the data is compiled and Product Space is constructed, many interesting things can be done with it. For example;

Hidalgo tries to explain why some countries cannot produce more sophisticated export products and so fail to attain development level of more advanced countries. They think the problem is mostly related with the structure of the Product Space and claim that "most of the diffusion occurs through links with proximities of 0.6 or larger, thus the most popular strategy involves diffusing to nearby products, a strategy that is successful for richer countries located on the core of the space, and ineffective for poorer countries populating the periphery" (Hidalgo, et al., 2007).

The above paper shows one possible source of unbalances between developing and developed countries but does not offer any network based solution to this problem. One of the main claims of this thesis is that countries can have 'guided paths to the core' of the Product Space. With a guided path, a government tries to guide the industry into a specific path or direction so that arriving at the core will be faster for the country. This guidance can

be via giving financial incentives, providing know-how, etc.

There are also studies that try to find correlations between Gravity Model variables and Product Space variables. For example, Dany, et al. (2014) finds that "the probability that a product is added to a country's export basket is, on average, 65% larger if a neighboring country is a successful exporter of that same product". (Dany, et al., 2014) This is also in line with diffusion process of technology and shows that distance has an important role in the process.

2.3.4 Criticism against the Product Complexity Index

Although Product Space proponents give many useful applications of the method, there are also economists who are skeptical about that. For example, Lee claims that cycle time methodology is more helpful than product space methodology on the grounds that it offers a concrete transition path and higher value added GDP growth for middle income countries.

There are various criticisms against the Product Space methodology, and especially against Product Complexity and Economic Complexity Indices. The main criticism is that the Product Space is just numbers, matrices, inverses, and indices. It cannot offer anything for the value-added analysis, industrial upgrading or global value chains, because it does not encompass any data about the value-added to the country. They claim, for example, from the the $299 retail price of an Apple iPod, China gets only $4 (Radosevic, et al., 2017).

Nonetheless, there are many studies analyzing the high correlation of Economic Complexity Index with GDP.

Keun Lee says "However, this strategy does not consider the ability of a country to compete in the international market. Specifically, the strategy informs latecomer countries that they must try to produce those products being made by the incumbents, but do not inform them about how to compete with these incumbents in the same or similar sectors. Instead of avoiding direct collision with the incumbent countries, latecomer countries must find a niche for them to survive and compete effectively in the market." (Radosevic, et al., 2017)

This criticism does not take into account the insight that Product Space gives.

This thesis also can be read as a defense of Product Space view against criticism that it does not offer any real strategy other than offering some high-tech products. For example in (Radosevic, et al., 2017), Korean economist Keun Lee says;

“In sum, Hausmann et al. (2007) and Hidalgo et al. (2007) did not propose an effective way for MICs (Middle Income Countries) to reach the core structure, but merely argued that ‘countries can reach the core only by traversing ‘empirically infrequent’ (meaning long) distances,’ which is a very difficult task to achieve. However, Hausmann et al. (2007) and Hidalgo et al. (2007) do not discuss how these countries can traverse the long distance to reach the core space. This observation may help us understand why poor countries have trouble developing more competitive exports and fail to match the income levels of rich countries.”

In (Radosevic, et al., 2017), Lee also writes “Hausmann et al. (2007) and Hidalgo et al. (2007) also used income level as the weighting factor to calculate the degree of sophistication; in other words, those countries that produce the goods currently exported by high-income countries are considered highly sophisticated. This method makes such a measure tautological; in other words, a country can become rich by producing goods currently made by wealthier countries.” This is a big criticism against the Product Complexity Index and also against Economic Complexity Index. Because these two terms are defined recursively by using the other one repeatedly. These two indices are widely used in international comparisons and in my opinion Lee’s criticism is a little harsh. As the famous saying goes “All models are wrong but some are useful”. Although Product Space view offers no definitive final solution for the posed problems to the struggling country, it nonetheless offers valuable insights about the potential avenues that may be taken by the country.

The best way to go would be to combine two sets of potential products, the first one offered by the Product Space and the second one by the cycle structure of the product. In our opinion, instead of running the two algorithms in parallel, it is better to run the Product Space algorithm first and then running the algorithm on this subset of products. By this way, we make it sure that the unwanted products are eliminated from the second step.

In this respect, Product Space insights works exactly like the recommendation systems of machine learning algorithms. Recommendation systems are used extensively by almost all big tech companies. Amazon gives a list of books that you may like by using info from your previous purchases. Similarly, Facebook, Netflix, EBay lists potential friends, movies, and products that you may be interested in. Product Space, in the exactly same manner, offers

the country a list of products that it may like (produce). Though these recommendations are not definitive, they are still helpful. Applying additional filters to the recommendations is mandatory if these recommendations will be used by policy makers. Keun Lee's "Smart Specialization with Short-Cycle Technologies" is a helpful filter in this regard (Lee, 2017).

Keun Lee gives some possible filters that can be applied by developing countries to choose the sectors with the largest potentials.

Lee criticizes the strategy of choosing technologies solely based on the growth prospects. We have seen before that growth prospect and cycle time of a technology can be measured by the new patents and the patents cited in these new patents of the technology. At a first approximation, it may be appealing for a middle income country to choose technologies by looking at growth rate of the technology. Because a new and fast growing technology offers more opportunities for developing countries. But the studies made on this subject did not find a robust relation between economic growth and technological opportunity yet (Radosevic, et al., 2017).

A second criterion that a middle country may consider is the originality of a technology. Originality and creativity are similar terms and can be approximated from patent data as it is done when the cycle time of a technology is computed. In literature, a technology is considered highly original if the patents in this technology uses patents from a diverse pool of technologies. Similarly by averaging over all technologies that a country has, we can compute originality of a country's technology portfolio (Radosevic, et al., 2017).

Keun Lee says "Static or latent comparative advantages suggest that countries must enter a highly competitive market by inheriting those sectors left behind by forerunning economies because of their weak growth prospects. The sophistication of a country's trade structure along the product space is also oriented toward the same idea, but does not provide directions among many neighboring spaces. By contrast, technological opportunity or originality is biased toward growth prospects without considering the possibility of entry and survival." in (Lee, 2017).

Then, what kind of properties a good potential must have?

- entry/survival possibility
- growth prospect

Keun Lee offers the 'cycle time' of technologies as the best criteria for technological specialization (see Section 2.2.3 for details on cycle time).

In (Lee, 2017), Keun Lee criticizes product space as "… in contrast to Hausmann et al. (2007), who suggested that a developing country should become similar to a rich country, we propose that the transition strategy of a developing country must involve entering sectors that are based on short-cycle technologies instead of those that are dominated by rich countries, such as long-cycle technologies." and as "Lin criticizes the product space by saying "The criterion and an effective transition path to an upgraded mechanism of growth suggest that the cycle time of technologies is better than criteria based on product spaces and is complementary to the idea of latent comparative advantage of (Lin, 2012)". But, these criticisms is not correct as the ultimate aim of all development strategies is to attain the level of developed countries.

2.3.5 Static vs Dynamic Nature of Product Space

We can make one more criticism against Product Space that has not been encountered anywhere in literature. Let's explain with a thought experiment. Theoretically, we can have two countries A and B with exactly same RCAs and Product Space structures but with totally different GDPs and export values. How can that happen? It is simple. If we multiply country A's GDP and export value of each product with a nonzero constant λ, we see that RCAs does not change at all.

So country B can be a miniature of country A but with exactly same Product Space! We know, this looks scary for it can undermine the whole Product Space story. But, we do not need to be scared too much because of two reasons.

The first is that the main use of Product Space is to see the dynamics and evolution of production structure of a country. The static one-time picture does not say much about the potential of a country exactly like snapshot of a flying ball does not say anything about the direction and speed of ball.

The second reason is that in real world we never see a country A whose GDP and export of each product are an exact multiple of another country's. Because the weights of sectors and export products of a country does not change linearly as country develops. For example as Korea became competitive in electronics and machinery, the previous comparative

advantages in textile and agriculture were lost and as a result the weights and RCAs of products changed considerably.

2.3.6 Walk or Jump?

Technology, as one of the forces that drives regional economic development, not only affects the growth of current industries through externalities linked to the existing diversity, but is also important for the involvement of regions in new industries and the creation of new growth paths. (Zhu, et al., 2017)

Studies show that regional diversity is a path dependent process. Because the regions generally develop towards industries that are similar to themselves in technology and connected with existing industrial structures.

Such a path-dependent development can be explained by the fact that regions and countries may be jumping to limited distances in a heterogeneous and rough Product Space. This distance is determined by the technological link between the products.

Developed countries, which are trying to jump from the dense areas in the core of Product Space, have more opportunities than countries trying to jump from the isolated regions on the edge of the Product Space.

In some extreme situations, it is almost impossible for a developing country to penetrate into the core region. Because paths of developed countries and developing countries can diverge in the Product Space due to the path dependent diffusion process. This conclusion may be pessimistic, especially for developing countries / regions. This viewpoint accepts the assumption that regional diversity is affected or limited by industries, but overlooks the question of whether it is possible to develop the leaping capabilities of countries / regions.

The movements of countries in Product Space can be divided into two groups. The first one is path dependent short distance jumps in the form of diffusion to similar products that are the immediate continuation of the current structure of the country. The second one is path breaking jumps that bring great innovation to the existing structure.

According to Lin, government policies must ‘follow’ comparative advantage, instead of ‘defying’ it. Stiglitz adds that “The problem is that some of the most important elements of comparative advantage are endogenous. Switzerland’s comparative advantage in watchmaking has little to do with its geography”.

The examples below can be given in support of discontinuous jump methods (Altenburg, 2010);

i. Ship-building industry of Vietnam was mostly developed by a large SOEs. It targets simple and labor-intensive segments of the market. It can move into more high-tech segments but depends on considerable state subsidies currently.
ii. Ethiopia made a big investment in engineering by building 15-20 technical universities, and large national vocational training programs. There is no demand for this high level of skilled labor force. But it's expected that in 5-10 years situation may change.
iii. India's space program designed and produced satellites and the software to run them. This helped to increase the skilled labor force base that made India`s success in software exports possible. The satellites are used for agricultural projects but are not commercially profitable.
iv. The finnish company Nokia was a pulp and wood products company before becoming a leader in the telecommunication industry.

As the saying goes "the biggest risk is not taking one". We can add that a country must either take no risk or if it takes risk, it must go until the end. Maybe the worst case is to take the initial risk of starting a new technology but later not supporting it until it catches-up with the leaders.

A classic example is South Africa's national electric car project named 'Joule'. The firm Optimal Energy that was supposed to produce the electric car was established in 2005. The firm was start-up with the aim of "establishing and leading the Electric Vehicle industry in South Africa and expanding globally". The first part of the project was successful and 4 different prototypes were produced by the end of 2010. The electric vehicle Joule was an all-electric five-seat passenger car with a new design. The car's battery, motor, and software technologies were all developed in South Africa locally. Despite all this technological success and a wide web of partners, the firm closed in 2012 after the South African government decided to quit the financial support that was necessary for the start of big-scale production of the car. The uncertainties that surrounded the marketing success of the car in future prevented the government from taking the bold decision of large scale production.

In 2017, Turkish state announced the national electric car project with a few private firms.

The country case of South Africa and others must be analyzed deeply before starting large-scale production of the car as it is vital to plan all details from the design and input network to marketing network.

In this chapter, we have seen what product space is, what can do with it, and how to visualize it. We also have seen that product space methodology is not free of criticism. In the next chapter, we turn our attention to the various answers to the question: which policies must a country follow to develop as quickly as possible?

2.4 Analysis of Product Space

2.4.1 Complexity Theory View

How to find out the optimal speed of diffusion in product space? This is a complex problem and for that we need complexity theory. As an example of complexity theory, we can consider how the structure of communication networks between actors influences system level performance. The results in this area of research show that when agents are confronted with a complex problem, the more efficient the network is in spreading the information, the better the short-term performance, but the lower the performance of the system in the long-term.

An effective network positively affects the distribution of information that facilitates the dissemination of effective strategies, but at the same time adversely affects the diversity of information associated with positive performance (Lazer & Friedman, 2007).

Two frequently used terms with utmost importance are exploration and exploitation. These are two essential powers that shape the evolution of any complex behavior from a hunter-gatherer deciding whether to settle into a cave which looks promising to a firm deciding whether to expand the current factory or invest in new technology. While exploration tries to reach new knowledge or territory, exploitation stops the exploration and instead focus on implementation.

Using the jargon of optimization theory, in a solution space with many local optimums, we usually have to go through many sub-optimal points to reach the best option. So in real life with bounded knowledge and rationality, we are never sure when to explore and when to exploit. This simple thought experiment shows there is always the factor of risk. Without taking risk it's impossible to reach new highs.

2.4.2 Networks Science View

According to the network literature, the common feature of many successful high-performance networks in different areas is their 'small world' property with high cluster and short path length (Kali, et al., 2013).

Small world property has been made popular by famous Milgram experiment ((Milgram & Travers, 1969) in which a random person X in United States was asked to reach another random person Y via a chain of acquaintances P_1, P_2, P_3,… such that X knows P_1 who knows P_2 who knows P_3,… who knows Y.

Milgram computed average path length in this acquaintances network as 5.2. He even identified 3 persons as 'stars' because 48% of all paths passed through one of these 3 persons.

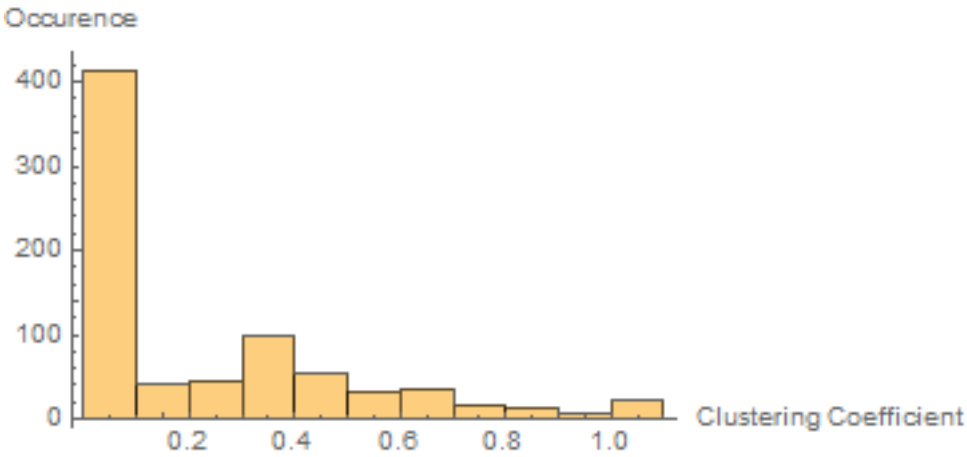
This small world feature also manifests itself in Product Space. Global and mean clustering coefficients[3] of Product Space (with threshold proximity 0.5) are 0.39 and 0.21 respectively. Global clustering coefficient is relatively higher indicating that products with higher number connections have smaller clustering coefficients.

From microdata we see that local clustering coefficients for Turkish product space are especially high in textile industries and relatively low in machine and chemical industries.

Figure 2.14 gives the distribution of local clustering coefficients of Turkish products. If we exclude the most common case of almost no connection with coefficient zero, we see that the neighborhood of a typical product includes about a third of all possible connections with each other. This is another proof of the fact that when the diffusion process is left to chance, the process will lead to products which are unrelated to each other.

[3] For definitions of global and mean clustering coefficients, see Section 2.1.2.

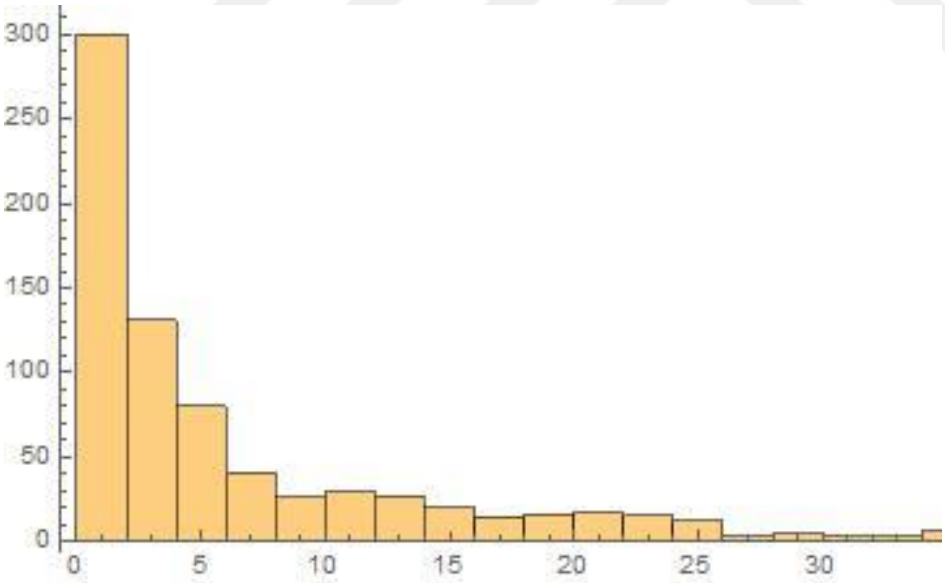
Figure 2.14 Histogram of Local Clustering Coefficients



Source: Created by the author using Mathematica.

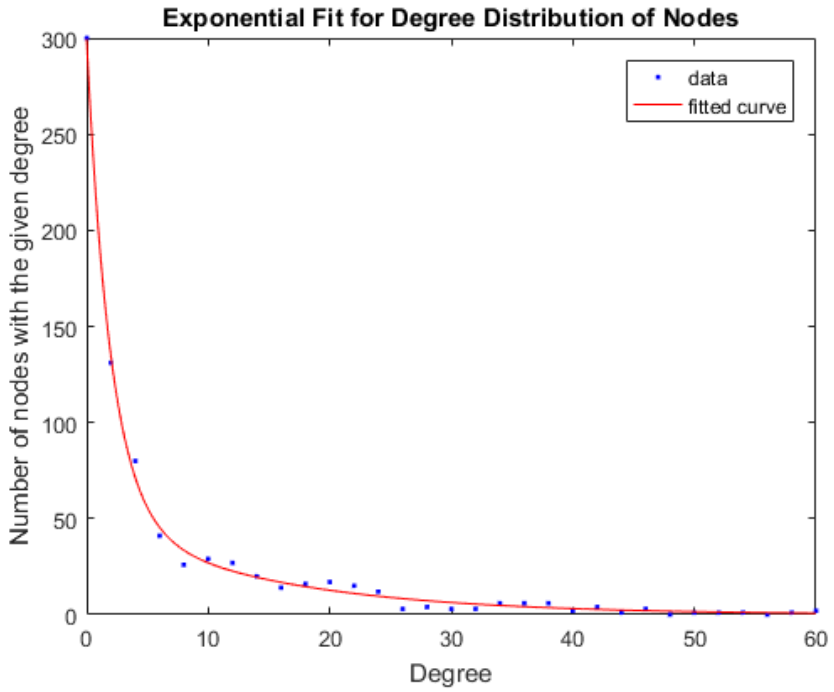
Figure 2.15 gives the distribution of node degrees which is the number of products that are connected to the original product. Figure 2.16 gives an exponential fit for degree distribution of nodes which is in line with the literature. In cases such as this, the distribution is called as a power law distribution (Barabasi, 2016).

Figure 2.15 Vertex Degree Histogram



Source: Created by the author using Mathematica.

Figure 2.16 Exponential Fit for Degree Distribution of Nodes



Source: Created by the author.

Table 2.3 gives network statistics of some of the classical networks that we encounter in literature frequently. We see that although number of nodes and number of links varies greatly, average degree of nodes, average distance between the nodes, and maximum distance between two nodes (diameter of the network) are comparable.

The average path length is 5.8, and compared to other classic real world networks, this is about the average.

Table 2.3 Reference Networks and Properties

NETWORK	N	L	$\langle k \rangle$	$\langle d \rangle$	d_{max}	$\frac{\ln N}{\ln\langle k \rangle}$
Internet	192,244	609,066	6.34	6.98	26	6.58
WWW	325,729	1,497,134	4.60	11.27	93	8.31
Power Grid	4,941	6,594	2.67	18.99	46	8.66
Mobile Phone Calls	36,595	91,826	2.51	11.72	39	11.42
Email	57,194	103,731	1.81	5.88	18	18.4
Science Collaboration	23,133	93,439	8.08	5.35	15	4.81
Actor Network	702,388	29,397,908	83.71	3.91	14	3.04
Citation Network	449,673	4,707,958	10.43	11.21	42	5.55
E. Coli Metabolism	1,039	5,802	5.58	2.98	8	4.04
Protein Interactions	2,018	2,930	2.90	5.61	14	7.14

Source: (Barabasi, 2016)

The explanation of variables in the above table and the values computed by the author for the network of Product Space are;

$N = \#\ of\ nodes = 775$

$L = \#\ of\ links = 2850$

$\langle k \rangle = average\ degree\ of\ nodes = 7.4$

$\langle d \rangle = average\ distance\ between\ two\ nodes = 5.8$

$d_{max} = maximum\ distance\ between\ two\ nodes = 18$

$$\frac{lnN}{ln\langle k \rangle} = 3.3$$

The last equation implies (after taking logarithm of both sides)

$N \cong \langle k \rangle^{3.3}$

In the light of Milgram's experiment and many other network examples, this equation means that we can reach from a product to any other product in 3.3 steps on average. This makes the product space a small world.

The small world feature creates a strong distribution among the products, bringing the potential for long-range jump across the network. Both of these properties of the 'small world' offer advantages to countries in terms of economic development. Because short

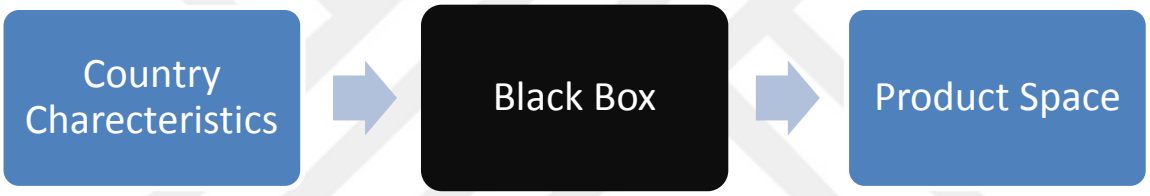
average path length in the Product Space makes it easier to leap from low-tech products to high-tech products.

Almost all known networks in the nature, such as the network of scientific collaborations, the US electric network and the wormhole neural network, are 'small world' networks. These findings support the claim that the 'small world' is a good topology in real world for successful networks. In the context of Product Space, this new perspective can be useful for creating a new development strategy for Turkey and for evaluating existing strategies with a fresh eye.

2.4.3 Unifying Theory

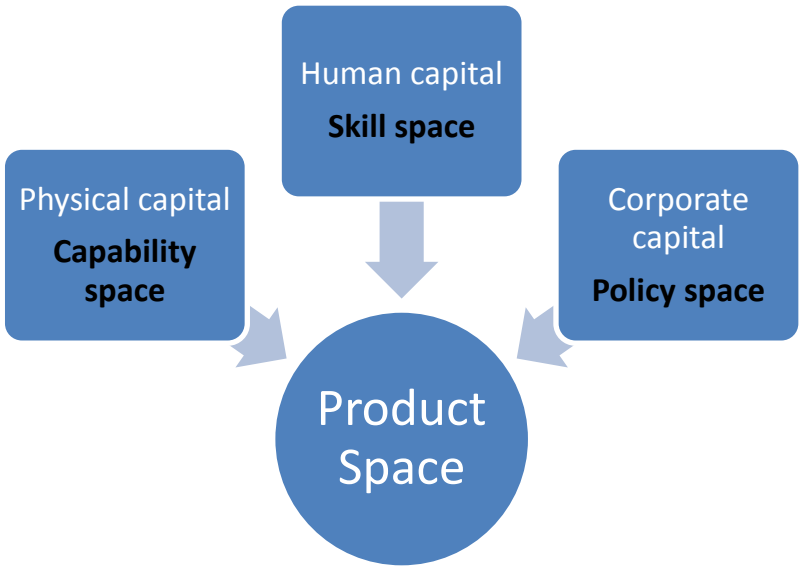
Actually, Product Space can be thought as the output of a black box system (Figure 2.17).

Figure 2.17 Black Box System of Product Space



Source: Created by the author.

Figure 2.18 Product Space Components



Source: Created by the author.

Until last decade, the black box was mostly a theoretical construct that included lots of theoretical literature and little data. Within the last decade, Product Space literature flourished with the advent of big data of international trade, fast computing power, and data visualization capability. Whether the beautiful visualizations and new analytical techniques which were not available before is enough for a new breakthrough in economics is not obvious. A really big breakthrough would be unravelling the black box with explicit construction of three components of production; human capital, physical capital, and corporate capital by defining the network structure of each and then constructing Product Space which is network of these networks (Figure 2.18).

Currently network structure of these can be done only manually. For example, to construct the policy space, we first need to know the nodes the basic building blocks of macro policies. We can manually make a long list of policies and try to extract the linkages via various techniques such as correlation, component analysis, and factor modelling. But the structure is most probably more complex than what these techniques can solve.

The best candidate to solve the system completely in future is ML (machine learning) which started to decipher systems in such a way that we, humans, can see the result but cannot comprehend what's going on in the black box of ML.

3. Industrial Policy of Turkey

Turkey's growth performance was particularly high in 2001-2007. In this period, high growth rates are because of;

i. Positive external conditions (world economy grew rapidly in the same period),
ii. Increased government spending (due to the rapid decline in interest payments),
iii. Financing a significant portion of the current account deficit with portfolio investments.

In the near future, the effects of these factors will be relatively small in the growth of Turkey and a new perspective is needed to reach high growth rates again.

The question of what this new perspective should be is being discussed by the political and academic circles in our country for many decades. In the 1960-80 period, an industrial policy based on import substitution was implemented along with the planned growth strategy. Despite the high growth rates in this period, our international competitiveness did not increase as in East Asian countries (e.g. South Korea) that passed from a similar process.

East Asian countries, after gaining competitiveness in international arena, have left protectionist policies that set the stage for import substitution policies and focused on free trade and export-oriented growth. However, Turkey, like the Latin American countries, continued its protectionist policy and adopted export-oriented growth strategy with the January 24 decisions (1980), before becoming competitive in international trade.

Acquiring technology based competitive power now is even tougher than before. This is mainly due to the fact that the Washington Consensus and the subsequent unconventional trade rules, which were implemented with the World Trade Organization channel at the request of the developed countries, made the import substitute production structure almost impossible. In any case, an import substitute structure that is not export-oriented will be lacking in competition power due to the economies of scale in today's interconnected world.

As a result, the most logical option in the future is a policy of protection and a system of incentives to be implemented in accordance with international rules. In fact, the decisions of January 24, 1980 were based on exactly that. Because these decisions have put many different incentives in support of export-oriented growth.

From the post-1980 fictitious export example, we see that the objectives and performance criteria of the incentives are vital. In this context, an output-driven incentive system instead of input-driven one can contribute more towards a high-tech export based growth.

Five key interrelated factors impede achieving high growth rates in Turkey;

i. Low savings levels,
ii. Low (productive) investment levels,
iii. Low productivity gains,
iv. Slow speed of structural change (in favor of manufacturing and in favor of more productive / high-tech products in manufacturing),
v. Low employment rates (closely related with women's low labor participation rates in urban areas).

Low savings levels lead to permanent current account deficits that increase financing needs (and therefore growth) for investment. This makes the economy fragile and makes it more vulnerable to external shocks.

The declining share of agriculture and the urbanization process helped to increase productivity in recent years. However, due to the decrease in agricultural employment, the potential to increase productivity with this kind of structural changes is limited in future. In addition, the share of manufacturing industry steadily declined in recent years, and this process is similar to what is called 'Premature Deindustrialization' by (Rodrik, 2015) which has been experienced especially in Latin American countries. The continuation of this trend in the future will limit the growth potential of the Turkish economy. In addition to the declining share of the industry, there was not enough success in transitioning to more productive / high-tech products in the manufacturing industry, and the share of high-tech products in exports remains at very low levels (~ 3% in 2016).

In order for our country to regain high growth rates,

i. increased productivity growth rate,
ii. shifts in the economy (more productive / advanced technology)
iii. establishing new jobs, especially for urban women,
iv. raising savings and investment rates as a necessary condition for all these changes

is required.

The government can provide technology extension services focused on dissemination of 'good practices' across the economy. Determination and implementation of product and

process standards can be used to disseminate 'good practices'. In other words, the government may create policies to raise average national productivity levels by encouraging and / or enforcing latecomers to upgrade their products, processes and organizational practices. If such diffusions are targeted to specific products and/or product chains, the upgrading process may be more effective. That is the main idea of this thesis.

R&D policies have long been used in our country to encourage technological innovation. In recent years, a large number of programs have begun to be implemented to support R&D. In order to make effective use of these programs, the legal framework of R&D policies should be simplified.

In order to increase productivity and wages, it is necessary to make structural changes for more productive / high value-added activities in production. Structural change in production will also facilitate structural change in services for more productive / high added value services such as commercial services.

3.1 The Literature on Industrial Policy

Even before the advent of fast computing power and big trade datasets, there was a big literature on network analysis of trade and its effect on growth and development. (Martin, 2010; Martin & Sunley, 2006; Martin, 2011) Especially evolutionary economic geography literature is full of jargon like inheritance, resilience, adaptive cycles, lock-in from fields as diverse as evolutionary biology, statistical physics, and complexity theory.

The closest classical field in economics to Product Space in terms of policy analysis and recommendations it offers is Development and especially Industrial Policy subfield. Industrial Policy is an already beaten path in this respect through questions like: Vertical or horizontal? Choosing winners or losers? Market failure of policy failure? Capital intensive of labor intensive? Comparative advantage or absolute advantage or latent comparative advantage? Etc.

For example, according to Hirschman, one of the founders of Development Economics, all kinds of development assumes some kind of priority-setting via policy-making (Kattel, et al., 2009, pp. 4-11).

Another founder, Nurkse, favors balanced growth path over unbalanced. But, this fact does not prevent him from thinking that by balanced growth, at best, a middle income country

can be created (Kattel, et al., 2009, p. 16).

According to Lin, "industrial upgrading and technological advances are best promoted by a facilitating state, i.e. a state that facilitates the private sector's ability to exploit the country's areas of comparative advantage". He also thinks that "the key is to make use of the country's current comparative advantages—not in the factors of production that it may have someday, but in the factors of production that it has now" (Lin & Chang, 2009, p. 491).

More up-to-date forms of 'industrial policy' include public policy instruments aimed at influencing resource allocation and accumulation, and the choice of technologies to provide them. One of the most important parts of the industrial policy set is the part that encourages learning and technological development. (Stiglitz & Akbar, 2016)

'New industrial policy' suggested by (Aghion, et al., 2011) claims that the interventions that the industrial policy offers targeting particular technologies or sectors can be more effective than previously assumed by neoclassicals. They claim that credit constraints and capital market imperfections are two important factors for sectoral policies. An efficiently working capital market system enables the allocation of new investments among the new sectors. On contrary, an immature or imperfect financial sector hinder efficient allocation and this in return makes state intervention necessary. They also argue contrary to traditional view that competition policy and industrial policy must be regarded as complementary rather than as substitutes.

In this respect, governments play a strategic coordinating role not only in the application of property rights and contracts, but also in ensuring macroeconomic stability and industrial policy. In developing countries, innovation is constrained by supply, not by demand. Because entrepreneurs see new products as risky and less profitable. (Hausmann & Rodrik, 2002)

The appeal of industrial policy as precursor of development surely has a high variability depending on which decade you are looking at. According to Rodrik (Rodrik, 2004), economic policies of the last two decades have been based on the view that the government has interfered too much with the marketplace. As a result of this view, governments especially in developing countries gave up regulation, trade restrictions, and public ownership. The reaction to failed import substitution policies of the past led the governments to ignore their failure to intervene when necessary.

As liberation and privatization do not seem to provide the expected benefits, governments tend towards a more balanced strategy. Well-formulated industrial policies are gaining importance as an important part of these strategies. But well formulated policy sets are in high demand and hard to find. According to (Taymaz & Voyvoda, 2015), one of the main obstacles for accomplishing inclusive and active industrial policies in Turkey is the absence of an 'active pro-active state' and 'effective policy design'.

When we look at the Turkey's export structure, we see that the transformation that Turkey has experienced in the export sector lately differs from that of other countries such as Korea. First of all, Turkey's transformation is slower. While exports of engineering products surpassed that of textiles in 1983 in Korea, Turkey accomplished this only in in 2004 (Taymaz & Voyvoda, 2015). Secondly, within the engineering products, while Turkey has gained competitive power in medium-technology products such as machinery and motor vehicles, the same success is not repeated yet in sectors based on information-intensive electrical and electronic engineering (Taymaz & Voyvoda, 2015). In addition to that, Turkey's net exports of metal goods and motor vehicles are less than 1% of total imports.

In Turkey, government support for R&D activities began in the 1990s and the share of R&D in GDP rose from 0.32% to 0.53% in 2002 and to 1.06% in 2015. But there is still a long way to go to catch the top performers such as South Korea (4.29%), Israel (4.19%) or Japan (3.58%).

Two of the most encountered market failures are information and coordination externalities. Information externalities are closely related with asymmetric information but they are different. In terms of domestic manufacturing firms, if some firms know how to produce a specific product and other firms do not, then there exists asymmetric information. But if none of the firms knows how to produce, then there exists an information externality. If a specific firm learns how to make a specific product and this knowledge becomes a positive information externality to other firms. Because, now they know that the product can be produced in domestic market without incurring any additional cost to the firm.

While coordination externalities are about systemic properties of the market, information externalities are related with the micro structure of the system. (Hausmann & Rodrik, 2002) emphasize the externalities that arise in self-discovery, which is defined as the process by which an economy finds the cost structure for the production of new goods.

According to this view, to encourage export of a new product, the first exporter of a high-tech product should receive the highest incentive. Because a company trying to produce a new field is actually trying to reveal the product cost structure of the country. In the event of failure of the company, all liability and damages are attributable to itself and if it is successful and profitable, this product will be copied by other companies and profit will be shared. (Hausmann & Rodrik, 2002)

For this reason, private returns from developing a new product are lower than total social benefits, and market incentives for self-discovery are often insufficient on their own. In such a case, the standard solution is to subsidize the state channel to make private revenues compatible with social revenues. Thus the negative externality of cost structure will be met by the state.

Coordination deficiencies and externalities are a particularly effective constraint for high-tech and new products. Developing a new product often requires a complex supply chain and it is difficult to develop a product for which the supplier is not available. In addition, it is difficult to find skilled and experienced workers for high-tech new products because nobody has produced this product in Turkey yet. So, is it possible for a structural transformation in such a case?

The dependence of new products on existing capabilities means that a structural change left completely to the market is relatively slow. Because diffusion in the Product Space when left to itself is relatively slow and primarily occurs in the neighborhood of similar products.

Instead of developing new talents, domestic firms usually use existing skills in production. The new capabilities in production often come about through new products.

Information externalities and coordination externalities indicate that it is relatively much more difficult for diversification to take place without planned public action.

The most important examples of Product Space diversity are the result of planned public action and public-private partnership.

Information externalities

Diversification of the product space requires the ‘exploration of the cost structure’ of an economy. That is discovering which products can be produced profitably. Entrepreneurs must first try new production processes. They have to connect with the technology of the

foreign manufacturers and adapt their technology to local conditions. This is a process called 'self discovery' (Rodrik, 2004).

The cost structure mentioned here should not be confused with innovation and R&D. Discovery here represents any kind of product that is not produced in the country with relative comparative advantage. So the discovery process here is applicable to all products that are produced by other countries but not yet by Turkey.

Countries with almost the same source and factor equipment are seen to specialize in very different products.

A good measure against information externalities which decrease self-discovery is to support investments made in non-traditional new products.

Carrot and Stick

Since self-discovery requires incentives for entrepreneurs, one side of policy must be using carrots. This could be in the form of subsidies, trade protection, or provision of venture capital.

For the system to function properly, incentives must be given to initial investors not to the imitators.

These incentives should be subject to performance criteria (e.g. export requirement) to ensure that bad projects are phased out and mistakes are not sustained.

Successful East Asian industrial policies possess both ingredients. The fact that Latin America generally had a lot of carrots and less sticks, in part, explains the inefficient and low added value production / export structure of this region.

The point to be emphasized here is that some of the investments encouraged even in the optimum incentive program will fail. The task of the policy maker is not to choose the winners but to determine the losers when they lose.

Coordination Externalities

Most of big investment projects require simultaneous, large-scale investment to be profitable. This is a classic coordination problem. It is a dilemma that profitable new industries may not develop unless they are established simultaneously with investments in forward and backward-connected sectors.

For example, in the big push model, the firm ties in its investment decision to other companies. This model assumes economies of scale with oligopolistic market structure and states that all firms must act at the same time for the industrialization to take place.

An implicit rescue guarantee may be useful in reducing negative coordination externalities. If the project is successful, no subsidy is paid to the investor. A good example is South Korea where Park regime Korea provided covered investment guarantees to leading companies (Chaebol) investing in new areas.

Appropriate policy interventions should focus not on industries or sectors but on factors and technologies that are the source of coordination failure.

Here, there is a similarity between policies that address coordination disruptions and policies that focus on information externalities. Both intervention groups should target activities (a new technology, a specific type of education, new goods or services) rather than sectors themselves.

However, policy makers must be careful about the limitations. The public sector is not fully aware of the private sector and may know no more than the private sector about the real causes market failures. It may be the case that the public sector have no idea about what they do not know (Rumsfeld style[4]).

Elements of institutional system;

i. Strong political leadership at the highest level
ii. Coordination and negotiating bodies
iii. Transparency and accountability instruments

General properties of industrial policy

[4] On June 7 2002, US Secretary of Defense, Donald Rumsfeld on a press conference on Iraq War said: "Now what is the message there? The message is that there are no "knowns." There are thing we know that we know. There are known unknowns. That is to say there are things that we now know we don't know. But there are also unknown unknowns. There are things we don't know we don't know. So when we do the best we can and we pull all this information together, and we then say well that's basically what we see as the situation, that is really only the known knowns and the known unknowns. And each year, we discover a few more of those unknown unknowns. It sounds like a riddle. It isn't a riddle. It is a very serious, important matter" In my opinion, this quote is applicable especially to public policy makers when making policy on private sector issues.

i. Incentives must only be given to new activities.
ii. Clear criteria have to be set for success and failure.
iii. When and under what conditions public support will be ended should be clearly indicated. (Sunset clause)
iv. State support should aim activities, not sectors.
v. The promoted activities must have a clear potential for spillovers to other activities
vi. The authority to conduct industrial policies must have sufficient experience and competence.
vii. Policy-making institutions should be closely monitored by the institution with the highest political authority.
viii. Organizations that promote policies should keep communication channels open to the private sector.
ix. In an optimal structure, errors that sometimes result in 'choosing failures' will occur. The goal should not be to block the discovery process by minimizing the likelihood of faults occurring, but rather to reduce the costs of these faults to the minimum.
x. Potential Product promotion activities should possess the capacity to renovate themselves so that the series of innovation becomes an enduring practice. (Schumpeter, creative destruction)

Possible incentive programs

i. Supporting 'self-discovery' costs
Criteria for the financing of such studies;
    a. They are interested in major new activities
    b. Other companies have the potential to supply learning externalities
    c. Open to surveillance and performance audits
ii. Development of high-risk financing mechanisms
Self-discovery efforts require long-term, high-risk financial intermediation products.
    a. Development banks
    b. Venture funds funded by the public,
    c. State guarantees for long-term commercial bank loans
    d. Special tools to direct some of the public pension fund assets to the high-risk investment portfolio
iii. Internalization of coordination externalities
iv. Public R&D,
v. Support for general technical training,
Innovative firms fear that on-the-job training increases labor turnover rate, thus, approach costly trainings very cautiously,
    a. Vocational

b. Technical
c. Language

vi. Making use of citizens abroad
Some of the tax incentives given to foreign investments can make a serious difference when targeting citizens abroad

As the poor countries become richer, sectoral output and labor force become less concentrated and more diverse. This continues until the country reaches advanced stages of development. However, after the countries have roughly reached the Irish income level, the production patterns begin to intensify (Imbs & Wacziarg, 2003). This process may be a consequence of optimal exploration-exploitation structure.

Role of the State in East Asian Miracle

In all cases of successful development in East Asia, the state plays a central role, and this key role has often been with the policies of the opposite direction of the Washington Consensus. The state has done more than merely fulfilling contracts, not just regulating, but also catalytic. (Stiglitz, 2016)

The success of China's export strategy cannot be explained only by comparative advantage and free trade. (Rodrik, 2006) The state played a critical role in the development of indigenous skills in consumer electronics and other sophisticated areas which could not develop without government policies.

As a result, China had a sophisticated export basket that would not be anticipated from a country with similar income level. This is one of the most important determinants of China's rapid growth. For China, sustaining high growth rates will depend not only on the volume of exports, but also on the capacity to produce new sophisticated products.

China, in 2000s, asked foreign producers such as Siemens and Kawasaki to supply locomotives for the high-speed rail network. In advance, Chinese companies became able to compete with Siemens and Kawasaki in international locomotive markets.

However, large-scale technological investments always have various risks. For example, after the invention of transistors in 1947, many countries made big investments to become world supply leader in semiconductors. Only the United States, Taiwan and South Korea have been successful (Table 3.1).

Table 3.1 State Support for Semiconductor Industries

Country	Date*	Estimated subsidies† $bn	Sustainable competitive edge?
United States	1976-80	12-36	✔
Japan	1980-82	19-54	✘
Taiwan	1990	15-43	✔
South Korea	1990	9-26	✔
Singapore	1995	5-16	✘
Germany	1996	2-7	✘
China	1999	6-17	✘
Malaysia	2001	1-3	✘

Source: McKinsey Global Institute

3.2 How to Make Industrial Policy Work: The Japanese Case

In this section, We will give a specific country examples in terms of the optimal overall government structure for the long-term strategic planning for the country as well as some examples for specific R&D support mechanisms. The country example will be Japan which used a government led development plan for the private sector.

In Turkey, we are currently arguing over how to increase the saving rate and how to design a good BES systems. We see that Japan and US argued over these more than a century before. Following passage clearly shows this.

After defeated by United States and its allies in World War II, Japan entered the period of occupation and rehabilitation during 1945-1952. To transform the political, economic, social and military structure of Japan, the occupying forces made many new reforms (United States Department of State, 2017).

Just after the occupation, saving rate of Japan was very high and one of the highest worldwide in that period. That was no coincident. Japanese system had various regulations some on purpose and some unknowingly to accomplish high savings rate such as;

i. An undeveloped social security system,
ii. a wage structure which twice a year makes big lump-sum payments,
iii. the decline of a worker's wage significantly when he/she becomes 60 years old,

iv. scarcity of land suitable for decent housing and high price of good quality university education, both of which made large savings mandatory,
v. a weak consumer credit structure,
vi. a postal savings system that was run by government and paid handsome interest on savings,
vii. an undeveloped capital market, and lack of any efficient saving mechanism

Although Japan was under US military control for 7 years and US economic advisers proposed various plans for Japan, it was deliberate Japanese planning that succeeded and this was at times against the US will. The most critical part for the Japanese to succeed in the international arena was the acquirement of latest technology.

For the big success of Japan in transforming from a defeated country of WWII into a miracle industrial state, (Johnson, 1982) credits almost completely MITI (Ministry of International Trade and Investment). (Johnson, 1982) is also one of the first in literature to give a definition of industrial policy. For him, industrial policy was a bundle of policies in order to improve the international competitiveness of a country[5].

The Japanese industrial planning policy was so strict that until the capital liberalization of 1960s and 1970s;

i. unless MITI approved no technology was imported,
ii. joint venture agreements were completed only after MITI's detailed analysis and most of the time terms of the rule were changed upon the request of MITI,
iii. there was no buy of foreign patents without MITI's intervention and as a result the cost of patents were reduced or it had become more advantageous for the whole Japanese economy,
iv. without MITI's or some of its advisory committees approval that it is the correct time for nurturing the relevant industry nobody could import foreign technology,

During the 1950-1980 period, the Japanese government controlled the whole technology transfer process. This process consisted of complex public-private interactions which is nowadays called industrial policy. The leading government agency in formulating and

[5] Korean industrial policy led by Economic Planning Board (EPB) is mostly a restatement of Japanese system.

executing this process was MITI.

3.2.1 Market-Rational vs Plan-Rational

If we go deep into the Japanese system we see that there are some major differences with other industrialized countries most notably United States. After some thought, we can see that the differences may be superfluous. Because the correct way of comparing would consider not the current US industrial policy but the policy it had applied when it was still an ‘underdog’ pre-industrialized country when compared with industrialized Great Britain during 18. and 19. century.

The most obvious difference of Japan with US is that while the first is a plan-rational state the latter is a regulatory market-rational state with some exceptions such as defense industry. Basically, a market-rational state likes to put the rules forward and control whether competition is working under these rules. To give an example, there are many very detailed antitrust regulations in the US that put limits on the maximal market size of firms but not as much regulation on which sectors must grow and which must be shrunk.

The plan-rational state on the other hand puts forward strict economic and social goals and organizes public and private resources to accomplish these goals. One implication of the difference is that while market-rational systems values lawyers more, plan-rational systems values the bureaucrats more.

In terms of their strategic goals the counterpart of MITI in US is not Department of Commerce but Department of Defense which behaves exactly like MITI with its goal-oriented long-term planning.

I believe, in this respect, Turkey is in a junction between defense oriented US style and development and strategic goal oriented Japan style. Both systems have some advantages and disadvantages. This is an explore-or-exploit problem that we analyze in detail in Section 4.2.2. Speaking broadly, we can state that in situations where the problem is clearly stated and the solution is roughly standard it is more reasonable to exploit the situation with a plan-rational outlook. But, in real world there is no free lunch and exploit period will come to an end. The surroundings will be unfamiliar and standard plan-rational solutions will not work. Now, time is ripe for distributing the resources to all possible paths and solutions. Because nobody knows the exact solution and future is full of surprises. Market-rational system where nothing is

forbidden and everything is possible becomes more reasonable. Resources are not directed at pre specified goals and instead are distributed in a game theoretical mixed-strategy perspective.

One of the differences between market-rational and plan-rational systems is that while the first one needs more lawyers, the second one needs more stable and powerful bureaucrats. We can see this clearly in numbers. While it is very difficult to change the position of a high-level bureaucrat in Japan, the Japanese prime minister can appoint only about 20 ministers, United States president appoints more than 1000 bureaucrats.

Market-rational systems involves more general principles of success, while plan-rational systems involves more specific and well defined goals. In evolutionary terms, in a newly explored area, being more robust and agile is more important and this implies that in a period characterized by fast change in an unchartered territory, market-rationality offers more chances of catching-up the leaders.

(Johnson, 1982) clearly states that;

> "Within the developmental state there is contention for power among many bureaucratic centers, including finance, economic planning, foreign affairs, and so forth. However, the center that exerts the greatest positive influence is the one that creates and executes industrial policy".

3.2.2 Industrial Policy

Robert Ozaki is one of the first to make it clear what industrial policy means (Ozaki, 1970). According to him industrial policy

> "is an indigenous Japanese term not to be found in the lexicon of Western economic terminology. A reading through the literature suggests a definition, however: it refers to a complex of those policies concerning protection of domestic industries, development of strategic industries, and adjustment of the economic structure in response to or in anticipation of internal and external changes which are formulated and pursued by MITI in the cause of the national interest, as the term 'national interest' is understood by MITI officials."

He states the ambitions of Japan in a poetic way also:

“It ain't right an' fair
To let a baby wrestle
With a Texas-tall giant
If your stature bothers you
Do your thing for bigness
Trust, combine an' merge
Merge, baby, merge
Till you dwarf USS
Bigness is goodness
'Cause you feel good with bigness.”

According to Ozaki “In Japan, competition is visibly ‘excessive’ and causes tremendous waste in resources and harmful instability of the market.”

Ozaki in 1970 wrote that “Liberalization, therefore, will proceed in gradual steps. We must distinguish between the ideal and the reality of the world economy today. Despite the propagated virtues of a free system we still live in a nationalistic world where each government does what it believes to be best for its country.” We see that after 50 years, the world may return to the same point again.

When a government wants to give incentives to private sector there is a dilemma that almost no government can escape. The dilemma is that it is very difficult to apply a serious industrial policy and to sustain the competition at the same time. MITI tried to accomplish exactly that in Japanese case by aiming to create a strong interest in private sector which favors a shift of energy and interest from old sectors towards new technologies and industries.

Old and established firms try to protect their market shares and their existing investments and know-how in general means there is no freedom for diversifying their investment portfolio.

The first truth to keep in mind about industrial policy is that no country did apply successful industrial policy intentionally. There is no Adam Smith or Marx of industrial policy.

Another implication of this difference is the distaste of Japans with American style capitalism which mainly depends on price competition and antitrust legislation. They like the mindset of Schumpeter more than other classical economists;

> "In other words the problem that is usually being visualized is how capitalism administers existing structures, whereas the relevant problem is how it creates and

> destroys them. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, that practically monopolizes attention. But in capitalist reality as distinguished from the textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization." (Schumpeter, 1943)

As we have seen in Korean case, the Japanese industrial policy also was not done intentionally and beforehand. Only after it had become successful that economists started to recognize the growth system of Japan. (Lee & Lim, 2001) says the same thing happened for Korea. Korean policy makers did not planned the national innovation system theoretically on paper. The system was like a living organism. It changed dynamically as it was born and developed.

In Japan economy bureaucracy had the total control over foreign exchange and any imports of technology. This enabled them to choose the sectors or technologies to nurture. In 21. Century, it's impossible to apply the same procedures in Turkey, but nonetheless it's possible to find some proxy policies with the same overall effect. The first suspect that is wrongly applied in Turkey for a long time is incentive system. The product space methodology asserts that a suitable incentive system can replace even a very strict plan-rational Japanese system.

Another set of powers that Japanese bureaucrats enjoyed are the abilities to disperse preferential financing, to give tax breaks, and to protect firms from foreign competition. These policies gave the power to the bureaucracy to lower the costs of the chosen industries mentioned above. The main difference of these policies from the preceding ones is that these policies are applicable and indeed are applied in Turkey. The crucial thing about the policies that are applied in Turkey is that they are mostly applied without a selection process. It may be even the case that preferences are given to the industries with lower total factor productivity. In many cases, short-term advantages of lower value-added sectors are preferred instead of long-term high-stake risky investments. One major exception is defense industry which reached a scalable level as a result of more than 30 years of planning.

The last set of powers that Japanese bureaucrats enjoyed included the ability to allow cartels to be created and the ability to create bank-led business conglomerates. This enabled the bureaucrats to set the competition level at the right level.

3.2.3 MITI bureaucrats

Industrial policy in Japan has been conducted so seriously that, in one incidence, MITI minister had to resign from office as he declared in a Parliament meeting that “"It makes no difference to me if five or ten small businessmen are forced to commit suicide".

Japan preferred loaning system to capital market. One of its main distinctive properties was that the whole system relied on a cascade of dependencies. In this system, a group of firms forms an agglomeration and borrows from a bank well beyond their capacity and in many cases beyond their net worth. The banks in turn over borrowed from the Bank of Japan. As the Bank of Japan was the guarantor of the whole banking system, it had a complete control over the lending criteria of private banks. As a whole around 80% of the capital for the postwar firms came from the Bank of Japan via the private banks. So we can say that Japan was more of a capitalist country after the WWII than before it.

One reason for the inclination of firms for loans instead of issuing equity shares was that equity shares paid dividends from profits only after taxes, while interest pain on bank loans was deductible for taxes. As banks also relied upon the health of their customer firms, the relation of firms and banks was of a kind of symbiosis. This system of symbiosis between firms and banks is reminiscent of old German banks such as Deutche or Dresdner banks in which there were cross-shareholding between the firms and the banks. This system of cross-shareholding is illegal in many countries, most notable example being United States.

Enterprises Rationalization Promotion Law of 1952 that MITI envisaged was a ‘completely epoch-making law’ according to MITI officials. It is complicated rules can be summarized as three important points.

First, with the Law, firms were able to get government subsidies for their new machine and equipment and they also got rapid amortization and immunity from domestic taxes for all R&D investments.

Secondly, some the cost of modern equipment installations in some industries were

depreciated 50 percent for the first year of installation.

Thirdly, by the Law, the central and local governments were required to build highways, ports, railroads, power generator units and industrial zones to be paid by government and the Law also made these investments available to chosen industries.

In short, it was joked that MITI would accept anything short of piracy if it is deemed necessary for Japan's rapid economic growth.

Japan thought that there is a disparity between competition and high-growth and the optimal level of competition is less than the then-current level. In this respect, MITI recommended a new law with the aim of providing 'coordination of investment' which would lead to mergers to solve the problem of 'excessive competition'.

3.2.4 The End of Comparative Advantage

MITI officials understood it very well that comparative advantage methodology would lead nowhere for Japan as the only advantageous endowment was the very cheap and large labor supply. If Japan ever wanted to break the heels of this vicious cycle, it had to go the sectors in which Japan had comparative disadvantage.

A final ingredient of the Japanese system was the promotion exports and domestic sales dynamically in such a way that the firms could produce at full capacity in all phases of business cycle. In that coherent structure, when balance of payments deteriorate, government would support the exports and restrict the domestic demand. Conversely, when import prices were suitable, domestic sales would be encouraged.

3.2.5 How to Create and Support a Sector

In its full-fledged form, MITI provided a full set of measures for nurturing (ikusei) a new baby industry. For example, in 1950's the following measures had been taken for petrochemicals (Johnson, 1982):

i. The first thing to do was an investigation and after that a basic policy report was prepared within the MITI such as 'Petrochemical Industry Nurturing Policy'.
ii. MITI authorized all foreign currency allocations and the Development Bank provided the necessary funding.
iii. The permits for the importation of the foreign technology were given by MITI. All

critical components of petrochemical technology was imported through licensing from abroad.

iv. The industry were treated as ‘strategic’ to give it distinctive and fast-tracked depreciation on its investments.

v. The industry were provided with suitable land free of charge or cheaply.

vi. Various tax breaks were given to the industry such as customs duties exemption on special machinery imports.

vii. MITI also set up an ‘administrative guidance cartel’ to control competition and manage investment between the firms within the industry. In petrochemical case the ‘Petrochemical Cooperation Discussion Group’ was established by MITI.

In situations where the establishment of new industry was too risky for the private sector to do alone, joint public-private corporations could be established. The first wave of chosen industries included steel, ship-building, chemical fertilizers, and electric power. The second wave included synthetic textiles, plastics, petrochemicals, automobiles, and electronics.

3.2.6 Capital Liberalization

Japan was very proud of their product competition in international markets. Their development strategy included competition in terms of quality, design, and price. In this respect, Japan imported the critical technology from United States and Europe, combined this technology with cheap Japanese labor. But when it comes to capital liberalization, it was a totally different story. The general tendency in Japanese economic bureaucracy was totally against capital liberalization.

Capital liberalization included technology, capital assets, management and many other things in addition to trade liberalization. Loan based system was preferred to capital market and as a result the low capitalization level of firms in Japanese bureaucrat’s eyes made them easy target for foreign acquisitions especially by Americans. According to Japanese, American firms already bought most of the assets in European capital markets and they were also eager to do the same thing in Japan.

IN 1960s and 1970s, Japan liberalized only a limited number of industries with so many caveats that it was almost impossible for foreigners to make big capital investments in Japan.

Some of these rules included (Johnson, 1982);

i. Only those industries in which competition with Japan was almost impossible were liberalized 100 percent. These sectors included industries like motorcycles, sake brewing etc.
ii. In all other industries only joint ventures with a minimum 50 percent Japanese participation were allowed.
iii. In case of capital investments in already established firms, the equity ownership to foreigners were limited to 20 percent.
iv. Even in seemingly liberalized industries, some segments were omitted from liberalization in such a way that competition by foreign firms was almost impossible. A striking example was television industry that were confirmed as liberalized except that integrated circuits and color sets were forbidden from production by foreign firms.
v. In all joint-ventures, a minimum of 50 percent of directors were required to be Japanese national.

It was interesting that when Japanese economy was fully liberalized in 1970s, the main investors in Japan were Arabs (Johnson, 1982).

3.3 Turkish Industrial Policy: The Past

Turkey used many different industrial policy tools since its inception.

8. Development Plan, Industry ÖİK (Specialization Commission) Report (2001) aimed at:

i. Transition to a high-tech industrial structure,
ii. Promoting science and technology policies and transferring more resources to R&D,
iii. Promoting arrangements to increase innovation capability,
iv. Introducing technology-intensive projects,
v. Dissemination of information access opportunities,
vi. Realization of the transformation, especially by the private sector,

The report has been criticized and described as a 'target and policy bundle' which does not discuss in detail the steps that must be taken and that requires a very intensive planning. While the structure of the economy is given, the report is incomplete on how to reach the targets laid out.

While the aim of the Industrial Strategy (2010) is to be the production base of Eurasia in medium and high-tech products, the aim of the Industrial Strategy (2014) is to be the design

and production base of Afro-Eurasia in medium-high and high-tech products.

When the development of the last 50 years is examined, it is seen that Turkey is a good follower that did not close the gap with the developed countries but also did not allow the widening of the gap even further.

Unlike countries like Korea, the main reason for this is that Turkey cannot demonstrate the will to implement policies aimed at changing its position in the world economy and constantly prefer passive adaptation to structural and macroeconomic conditions.

For example when the industrialists started to invest in the housing sector and its possible negative effects became visible, one of suggested strategies was to encourage smart manufacturing and similar sectors to encourage higher value-added manufacturing industries via the housing sector.

According to (Taymaz & Voyvoda, 2015), it did not differ in the post-2002 period, and despite the favorable national and international conjuncture, no industrial transformation occurred due to passive reactive policies. Their proposal for a new model includes;

- Labor market policies that encourage the development of human capital rather than pressure on labor costs
- Tax policies that provide equity in income distribution and do not punish productive investments

One takeaway in this thesis is that big Turkish firms are afraid of big fights against their western partners. This is true because while Korean and Chinese firms used catch-up strategies and followed OEM-ODM-OBM path, Turkish companies are stuck at ODM level at best. Fiat Egea of Koç Holding is a good example to that. Whether Turkish private sector companies or Turkish State are to blame is not clear. Because the firms did not get the needed back-up from the state in their upgrading process.

We know from catch-up literature, sometimes, firms need to step back in global value chains to get independence. This is in-out-in strategy and firms need courage themselves and support from government to do that. Product space view can help Turkey and its firms in their upgrading process.

3.4 Turkish Industrial Policy: The Current

In this section the recent developments that are related with industrial policy in Turkey will

be given.

3.4.1 Business and Investment Environment

In the Business Environment report prepared by the World Bank in 2014 and 2017, Turkey's place was 51 and 60, respectively. Compared to the first 20 countries in the overall standings, especially Company Liquidation, Tax Payment, Building Permits, Credit Supply and Recruitment have the potential to carry Turkey upward if improvements are made in these areas.

With the Law on the Amendment of Certain Laws for the Improvement of the Investment Environment No. 6728, significant amendments were made in 20 different laws. In this framework, procedures for investors have been simplified, permit and approval times have been shortened and investment costs have been reduced. There is a need to improve permits, approvals, licenses, investment location, legislation and legal processes in Turkey from the start of the investment until running of the operation.

Among the supports given to the investments with the law no 6745 aiming to support the investments on a project basis are;

i. corporation tax deduction or exception,
ii. income tax withholding incentive,
iii. customs duty exemption,
iv. VAT exception,
v. VAT refund,
vi. Allocating land for investment,
vii. employer's insurance contribution support,
viii. energy support,
ix. investment loan interest support,
x. wage support for qualified personnel,
xi. Contribution of capital, up to 49 percent,
xii. public procurement guarantee.

Project based incentive system, in line with the long-term targets of development plans and annual programs, supports highly innovative, R&D intensive and high added value investments each with a minimum total investment of 100 million $ that will meet the current

or future needs of Turkey, providing supply security, reducing external dependency, providing technological transformation. In addition to these, project-based support can be given by the Council of Ministers on legislative and administrative processes and infrastructure investments.

The first application of project-based support was realized in 2018 April. Incentive certificates were given to 23 projects with a total projected investment of 137.4 billion TL. These projects are estimated to create 35,000 direct employment and 138,000 indirect employment. Investments are expected to have a positive impact of $ 19 billion on the current account deficit through increasing exports by 6 billion $ and decreasing imports by 12 billion $. These 23 supported projects ranges from renewable energy, petro-chemical industry, and carbon fibers to furniture and agricultural sectors.

The State Support Information System has been established within the Undersecretariat of Treasury in order to provide data collection, reporting and monitoring from government granting organizations. In future, it is envisaged to carry out impact analysis studies by evaluating the data entered into the system. When this is done, it will be possible to evaluate and differentiate between good and bad incentives.

3.4.2 Public Private Partnership

Turkey made big investment in infrastructure in recent years and it is just not possible to finance all the investments with public resources. In this framework, the PPP model widely used in developed and developing countries in recent years is also applied in our country. During 2014-2017, the PPP model was applied especially in the transportation and health sectors, especially in the financing of mega projects.

3.4.3 Science, Technology and Innovation

The ratio of R&D expenditures to GDP increased from 0.86 percent in 2014 to 0.94 percent in 2016. In the same year, the EU-28 average was 2.03 percent. The number of full time equivalents (FTE) researchers and the number of FTE R&D personnel were realized as 100 thousand and 137 thousand respectively in 2016.

Within the scope of the legal arrangement for the R&D Reform Package 2016, which includes regulations for the improvement of the R&D and innovation ecosystem and the Law No. 7033 on the Development and Production Support of the Industry, the condition of

obtaining private sector R&D center certificate has been facilitated and the design centers have been included in the scope of support and basic sciences graduates incentives have been introduced for employment, arrangements have been made to improve university industry cooperation and to encourage post-doctoral research.

Approximately 6.1 billion TL has been allocated for the establishment and development of research infrastructures in public institutions and universities in 2002-2017 period. Within this scope, there are 131 completed and supported projects of 109 thematic research laboratories. These centers are mainly in life sciences, defense, information and communication technologies, aviation and space and energy fields. In addition, central research laboratories have been established at 58 universities to improve the research capacity of the universities, and installation is continuing at other 38 universities.

In order to ensure the more effective use and sustainability of research infrastructures, the Law on Supporting Research Infrastructures No. 6550 and the secondary legislation of this Law have entered into force in 2014 and 2015, respectively. With this Law, arrangements have been made regarding the management, financing, staff structure monitoring, evaluation and support of research infrastructures. By the end of 2017, four research infrastructures started to be supported under the Law.

3.4.4 Transformation in the Manufacturing Industry

Given the global developments in the manufacturing industry, it is observed that countries are moving towards more active industrial policies, consumer and customer demand and needs are reshaped, digitalization is more efficient, flexible and faster production opportunities are increasing, technological change is accelerating and sustainability is increasingly important.

The development of flexible production models based on new technology and automation, as well as information and communication technologies, such as artificial intelligence, robotics and joint manufacturing, enable consumer demands and needs to be met more personally, cost-effectively and quickly. Rapid dissemination of new technologies to substitute labor power is increasing the importance of selective technology policy in manufacturing industry competition power.

Although productivity per worker in the manufacturing industry has increased in the period

of 2014-2016, this issue remains important. When large-scale firms and small-scale firms are compared to EU member countries, there is a significant productivity gap against small-scale firms. In addition to capital and technology, human resources need to be used well in order to increase the productivity level of the manufacturing industry. In this direction, the need for qualified staff in the industry continues to increase. The value added per capita in manufacturing industry in Turkey was 1576 dollar and 1852 dollar in 2005 and 2016, respectively. While in terms of total value added of the manufacturing industry, Turkey is 16. in the world, in terms of manufacturing value added per capita Turkey ranks 46. This indicates a significant improvement potential in the manufacturing industry due to increased productivity.

In the distribution of manufacturing industry exports, the share of products above the medium-tech is observed to increase. The share of high technology sectors in the manufacturing industry exports, which was targeted at the Tenth Development Plan period as 5.5 percent, was 3.5 percent in 2016, following a stagnant course. However, in the Tenth Development Plan, the share of high-tech sectors in manufacturing industry exports was targeted at 32.1 percent, while this share was 33.1 percent in 2016. Compared with the world, the share of high technology sectors in exports remains low. The share of high technology sectors in world exports for the year 2016 is 24.4 percent.

In 2014-2017, changes and arrangements have been made to use public procurement as an effective tool to further support domestic, innovative and technological production. But effective implementation and infrastructure are still lacking.

In Turkey, it is observed that large industrial companies in the manufacturing industry are shifting their investment to other non-manufacturing sectors. In addition to that fact, the manufacturing industry is in need of large-scale investment. In order to make these investments, the improvement of Development Bank and other credit and guarantee facilities remains important.

Turkey Industry Strategy Document (2015-2018) has been put in place in 2015. Within the scope of 70 actions under three main strategic targets and eight priority policy areas, issues such as technological transformation, infrastructure, access to finance, green production, improvement of investment and business environment, increase of international trade and investment capacity, qualified labor force need and regional development, are discussed.

Law No. 7033, called Production Reform Package, was enacted in 2017 in order to improve the industry and to support the production. Important regulations have been made in the form of legal support and simplification of legislation. Work on secondary legislation on regulations is ongoing.

The production structure based on fashion design and export with branded products has continued to develop with preserving the production structure in textile, leather and garment industry. On the other hand, negativities related to the image of the country negatively affect the sector.

Establishment of chemical parks in the chemical sector by making appropriate logistics in areas such as petrochemical, plastic, composite and advanced materials will enable the sector to be transformed into a high added value structure and will give the sector advantages in terms of firms' competition power and new investments. Rubber and plastic products sector continues to be highly dependent on imported raw materials.

Imported high technology products are predominant in the medical device and pharmaceutical sector, which is mostly produced by traditional technologies in our country. Within the scope of the Domestic Drug Production Project, 80 percent of the drugs consumed in 2017 in terms of the number of boxes and 45 percent in terms of the expenditure were produced domestically.

In order to increase competition power in the steel sector, taking effective role in solving the global inert capacity problem, increasing the efficiency of implementing protective measures by taking into consideration the changing circumstances of customs and foreign trade regimes, and removing the burden on input costs are of great importance.

In the machinery sector, support for product-based product development, which makes a difference for order-based, high-quality and high-performance manufacturing, has increased and design and production capabilities have improved. Activities to increase product quality have gained importance in the sector. Supportive services such as after-sales services are becoming an integral part of the product.

It should be taken into account that while the automotive sector has set new targets for the future, the existing capacity has been adequately used and new targets can only be reached with new vehicle investments. In parallel with the development of the technological content

of the vehicles, the use of electronic parts has increased, and the competitiveness of our supply industry, which has a very limited competitive activity and accumulation in this area, is decreasing.

The increase in R&D expenditures in the electronics industry, the increase in the production of electronic components, and the emergence of domestic producers in sectors with intense competition, such as mobile phones, indicate that competition in the sector is increasing.

Defense industry development studies are underway within the scope of SSM Strategic Plan 2017-2021. Studies on increasing the locality rate and R&D share in the defense industry are continuing. Improvements have been made in the area of networking and clustering.

3.4.5 Entrepreneurship and SMEs

As of 2015, the level of labor productivity in enterprises with 1-19 employees is about 1/6 of those with more than 250 employees.

As of 2017, SMEs contribute 99.9 percent of total enterprises, 72.7 percent of employment, 53.5 percent of value added, 55 percent of investments, 56 percent of production, and 17.7 percent of R&D expenditures. SMEs use 25 percent of bank loans and make 55.3 percent of exports.

While the number of enterprises supported by the CGF (Credit Guarantee Fund) in 2013 is 1,200, in 2017, the number of enterprises reached 272 thousand and the volume of loans reached 192.2 billion TL from 882 million TL. While the number of enterprises that received early stage investment in 2013 was 78 and the investment amount was 65 million USD, in 2017, 167 enterprises received a total of $ 177 million worth of angel investment, venture capital and private capital investment. The investments and start-ups in Turkey is still very low compared with Western European countries.

Existing commercial banking services are inadequate for long-term and high-risk financing needs, especially for innovative business models and high technology entrepreneurs. There is a continuing need to support mechanisms to fund innovative entrepreneurship in this framework.

Policy interventions aimed at SMEs and entrepreneurs are not efficient enough to encourage the needed efficiency and innovation increases. The inclusive and egalitarian attitude towards all firms is not helpful in differentiating between which firms increase their

productivity as a result of the state support and which firms do not. There is a need to design special, unique and flexible support mechanisms for different initiatives in entrepreneurship and SME support. There is a continuing need to develop different approaches to the needs of different segments, such as newly established, innovative, fast-growing, steadily growing and productivity-enhancing export companies involved in global supply chains.

3.4.6 Intellectual Property Rights

In the field of industrial property rights there has been a significant acceleration in 2014-2017 period, as the number of trademark applications increased from 111,544 in 2014 to 118,354 in 2017, design applications from 42,844 to 46,500, and patent applications from 12,375 to 18,161.

3.4.7 Information and Communication Technologies

The size of Turkey's ICT sector in 2016 is 24.8 billion dollar. 60.5 percent of the ICT market consists of the electronic communication sector and 39.5 percent is the information technology sector.

Significant progress has been made towards the widespread use of broadband internet access services. Broadband subscriber density, which was 42.5 per cent in 2013, reached 85.1 per cent in September 2017. In terms of satellite system, Turksat 4B to be used for both data communication television broadcasting were taken into service in 2015. While TÜRKSAT 5A and 5B satellites are planned to enter service in 2020 and 2021, 6A is planned to be produced in Turkey and be blast off in 2020.

Especially new technologies, such as artificial intelligence (AI), machine learning (ML), quantum computing, internet of things (IoT), brain-machine interface (BMI), and big data create new products, services, markets, and important opportunities for the next big transformation.

The race of developed nations in some of these areas already took off and still in some other sectors they are just warming up. AI is a good study case. China announced its AI strategy in 2017 claiming that China would lead the world in AI technology by 2030. China's AI Strategy poses a credible threat to US leadership in technology.

The French AI strategy titled "For a Meaningful Artificial Intelligence" was written in 2018 by famous mathematician and French Parliament member Cédric Villani. President Macron

said that “I think artificial intelligence will disrupt all the different business models and it’s the next disruption to come. So I want to be part of it. Otherwise I will just be subjected to this disruption without creating jobs in this country.” (Delaney, 2018)

Even more prepared than France in AI is China. It is claimed that military and commercial AI ambitions of China creates the first serious danger to technological supremacy of United States since the Soviet Union. The main advantage of China is its focus and enormous funding (Allen, 2017).

European Union Vice-President Market Andrus Ansip said that "Just as the steam engine and electricity did in the past, AI is transforming our world. It presents new challenges that Europe should meet together in order for AI to succeed and work for everyone. We need to invest at least €20 billion by the end of 2020” (Middleton, 2018).

3.5 Turkish Industrial Policy: The Future

3.5.1 Public procurement

According to the Public Procurement Law No. 4734, it is obligatory for the Ministry of Science, Industry and Technology to provide a price advantage of 15% in favor of the tenderers who offer domestic products with medium or high technology approved by the Ministry.

Public procurement will contribute to R&D and innovation activities and will be used for investments to promote indigenization and technology transfer. In this scope;

i. Long-term procurement plans for public procurement will be prepared and joint purchasing facilities will be established between the institutions.
ii. Priority will be given to the fields of pharmaceutical and medical device industry, rail systems and air vehicles, defense systems, energy equipment, information and communication systems.
iii. Domestic products will be given priority in DMO (The State Supply Office) procurement and TOKI (Housing Development Administration of Turkey) projects.

So far, we have analyzed the structure of Product Space and looked at the literature on what it says about the development of a country.

Our detailed analysis showed that if we look at the development process of a country from

the viewpoint of Product Space, there are various models of development all competing with each other. In this thesis, we are comparing different views on how the product space evolves best for growth and development.

i. Comparative advantage
ii. Latent comparative advantage
iii. Long-jumping
iv. Extra-regional linkages
v. Catch-up cycle with windows of opportunity
vi. In-out-in strategy
vii. Smart Specialization With Short-Cycle Technologies
viii. Optimal Exploration-Exploitation

This study compares these different views on the optimal diffusion behavior on product space and finds the best one.

How to diversify best? Like Korea; two-staged, first quickly diversify and then concentrate on high-tech and machinery, forgetting textile and agriculture? Or like what; do not leave behind any sector like textile or construction but develop with them. Is this possible at all?

We see that the star products which occupies most of the avenues from Turkey's current products to Turkey's future products are similar in vein to Milgram's 'star' persons in his original experiment in 1960's (See Section 2.4.2).

As a result we can conclude that to be able to support industrial policy, an effective public procurement system must have the following properties;

i. Identification of strategic targets with which public procurement policy will be aligned
ii. Public procurement agency must have the capability to foreseen future technologies and must be to act pre-emptively with anticipative demand, and
iii. strong management

3.5.2 National Sovereign Funds

About 13 percent of the national sovereign wealth funds in the world are investing in new technology areas, and this rate has been increasing in recent years. For example, one of the largest investors of Apple, the largest US technology company, is the Norwegian sovereign

wealth fund, the world's largest one, with a portfolio size of 971 billion $.

One of the purposes of newly established Turkey Sovereign Wealth Fund Management Inc. (Türkiye Varlık Fonu) is "to participate in large-scale strategic investments". Investing in companies focused on production and export of high-tech products will accelerate the technological transformation in exports.

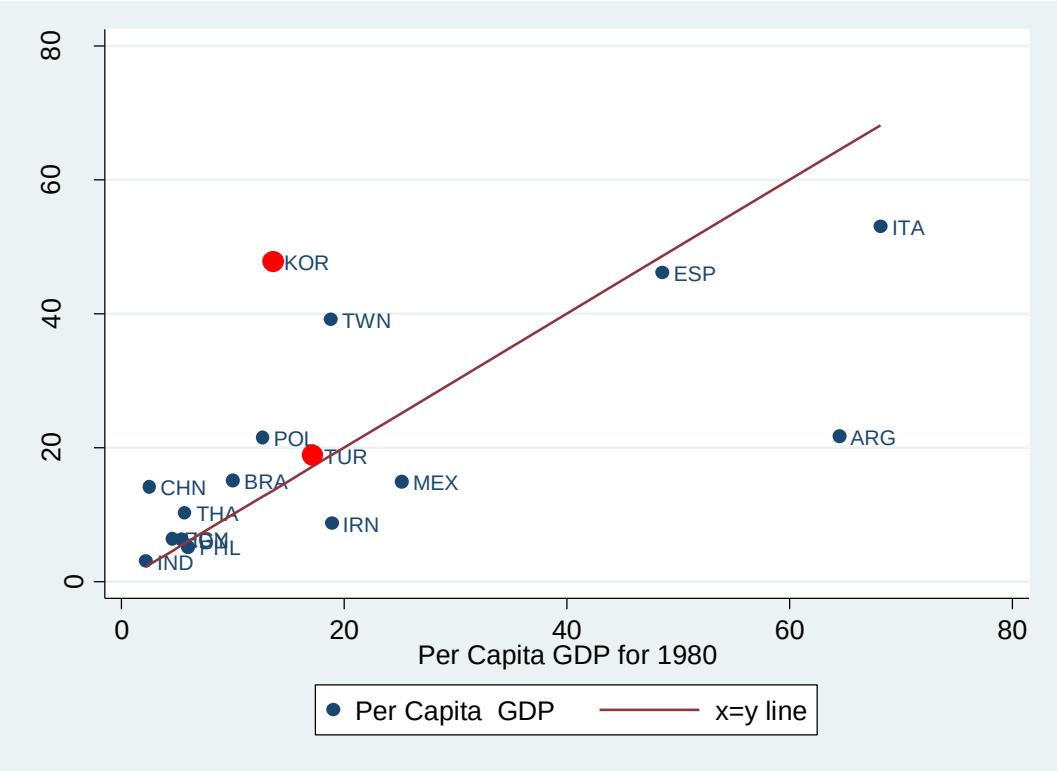
3.5.3 Jump Further

Private firms may well predict future products, but generally they may be uncertain about technological viability, risky financial products and marketing uncertainties. Because of that, to overcome that problem, it is best to create a process in which promising growth areas are asked to private sector firms and after that a public-private partnership is formed to overcome the financial and technological bottlenecks and uncertainties.

There are many examples to this kind of strategy. Taiwanese notebook sector is one of them. When Taiwanese technology firms decided to develop technology for laptops, their only proven technology was calculators! Taiwanese policy makers first established a public research institute that concentrated upon developing new technology and architecture for laptops. The acquired technologies later were transferred to private firms and this enabled sustainable development of electronic sector in Taiwan (Mathews, 2002).

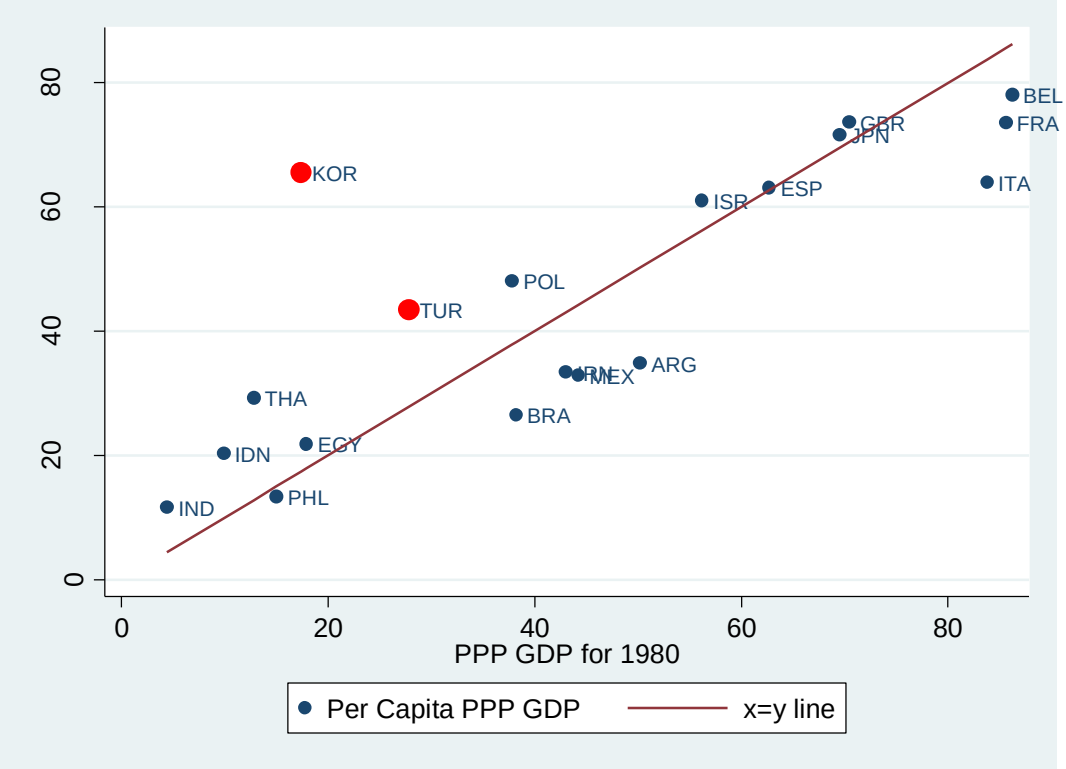
When we compare 1980 and 2016 GDP per capita levels for various countries as a ratio to corresponding US level, we see that while some countries improved their ratios, other countries deteriorated even more (Figure 3.1). Turkish per capita GDP as a ratio of US level did not improve much during 1980-2016 period and is about 20%. However, as can been seen in Figure 3.2, in terms of PPP per capita GDP, Turkey improved a lot and have a PPP per capita GDP of more than 40% of US level in 2016.

Figure 3.1 Per Capita GDP in 1980 and 2016 (as % of US Value)



Source: Generated by Author using Stata.

Figure 3.2 Per Capita PPP GDP in 1980 and 2016 (% of US Value)



Source: Generated by Author using Stata.

In Turkey, one of the basic problems is the lack of proper analysis of the situation, the deficiencies, the risks, and the opportunities about the future technologies. The low percentage of high-tech products in export basket imply that the private sector and public sector alike unable to see the future reminding unknown unknowns of Rumsfeld (See Footnote 4).

One strategy that is proposed here for Turkey is a new search process for future technologies that Turkey must go for in order to gain a first mover advantage. The proposed search process consists of;

i. A public-private joint force is established. This taskforce surveys the entrepreneurs, academics, and the firms extensively on the possible technologies that they see potential in medium-term and long-term and also on the bottlenecks and risks that accompany the opportunities.
ii. The most promising technologies or business ideas with highest future potential are decided by a dual process of i-identifying technological opportunities, and ii-identifying market opportunities. While technological opportunities are best predicted by academics, technology geeks, and bureaucrats, these guys are no good in assessing the market side opportunities and success chance of these technologies. Entrepreneurs and managers complete the missing link by assessing the odds of successful marketing of these new technologies.
iii. For the proper assessment of technological opportunities, financial, regulatory and other kinds of uncertainties and deficiencies are laid down precisely so that they can be dealt within a constrained maximization framework (See Box. 1).

3.5.4 Create More Value

When we analyze international markets we see that there are three kinds of firms.

i. Original Equipment Manufacturing (OEM) Firms,
ii. Own Design Manufacturing (ODM) Firms,
iii. Original Brand Manufacturing (OBM) Firms,

Original equipment manufacturing (OEM) firms does not need any R&D process or any marketing strategy because they produce according to the specifications of contracting firms. Many car spare part producers in Kocaeli, Turkey are good examples to OEM's.

Next step in hierarchy is own design manufacturing (ODM) firms. These firms are capable of most parts of the product design process. But, still, the customer firms of ODM companies do the marketing functions. Egea brand of automobile producer firm Fiat is a good example of an ODM. Although Fiat Egea is mostly designed and produced in Turkey under a Turkish-Italian collaboration, it is still under the umbrella of a foreign firm.

The final level is the original brand manufacturing (OBM). These firms does the design, R&D, and marketing themselves but may or may not channel the manufacturing processes to OEM's depending on the cost structure.

OEM-ODM-OBM is the standard order of steps that a developing country firm takes until it becomes competitive globally.

From the experience of Korean firms (see Section 2.2.3) we see that for the latecomer firms to reach OBM stage they need to reduce FVA ratio of their exports. This includes a risk of decline in sales for a prolonged period of time.

Some of the best examples in OEM-ODM-OBM transition comes from East Asian countries and especially from Korea. There are various Korean firms that successfully transformed from OEM to ODM without an industrial policy. Analysis of (Lee, et al., 2015) shows that the transition occurs only with a strategy concentrating on path creation which combines existing paths rather than creating completely new paths.

For example, the story of the Korean toy manufacturer firm Aurora is a classical case study. Inıtially, the firm was enjoying handsome growth rates and profits by contract manufacturing for leader firms in the 1985-1990 period. The firm decided to become an OBM in 1991 and

started to sell its products under its own brand. The vendor firms that previously purchased products from the firm canceled all OEM-ODM orders with the aim of preventing Aurora from becoming a new leader and competitor. In 1991-1996 period, the total sales of the company displayed a sharp drop from the previous period dues to the canceled orders. Such a period is named ‘OBM River’ meaning that it must be crossed over by latecomer firms if they want to catch-up and become an OBM firm.

We see strong similarities between Turkey and Mexico in terms of value added in exports. Mexico is neighbor to big advanced market economy of United States and export to US heavily especially in transportation vehicles sector. Mexicans call the subcontracted final assembly activities as ‘maquiladora’ and explains the decrease in their value added by it. The Maquiladora exports makes up more than 40% of total exports in 2007 compared to 10% in 1980. This fact imply that Mexico similar to Turkey is not successful in creating more value-added activities such as ODM and OBM.

4. Results

4.1 Analysis of the Turkish Product Space

Countries upgrades their export basket through diffusing in product space. We have seen that there is a never ending product cycle with newborn products on one end, dying products on the other end, and evolving products in between. Product spaces of high-income developed countries are relatively in equilibrium with small perturbations. These countries have passed most stages of exploration and are now in exploit stages. Low-income countries are on the other end of the spectrum but they share a property with high-income countries that both groups have stable trajectories of number of products in each technology level.

More interesting dynamics happens only in the product spaces of middle-income countries such as Turkey. Diversity of products are high and are mostly concentrated on medium and medium-high technologies. We have seen that while CAF strategies enables countries to move in the close neighborhood of existing products, CAD jumps allow for long jumps needed for quick access to the core regions of the product space.

In this section, we first apply the product space methodology to real data and find the potential high-tech products which are closest to the existing products of Turkey. For this, Turkish product space is analyzed using Matlab programming software. For each high-tech product, it is computed whether it's possible to reach that product in one-step. If it is possible, then all possible ways are counted from existing product space of Turkey to that high-tech product.

The product space is constructed using all bilateral trade data between all countries. So, in a way, it represents the statistical behavior of international trade. If we want to analyze the product space of a specific country, we first need to construct that country's product space by taking only the nodes with RCA>1. In this section, such an analysis is done for Turkey.

The analysis done in Matlab shows that for Turkey there are 14 high-tech products that are similar to the existing products (Table 4.1).

Table 4.1 High-Tech Products similar to Already Exporting Products

SITC	# of links	Tech level (0-5)	RCA	Product
5413	1	5	0.10	'Antibiotics'
5416	2	5	0.11	'Glycosides and Vaccines'
5417	5	5	0.21	'Medicaments'
5419	3	5	0.27	'Non-Medicinal Pharmaceutical Products'
7129	5	5	0.01	'Miscellaneous Parts of Steam Power Units'
7162	1	5	0.79	'Electric Motors and AC Generators'
7163	1	5	0.32	'Rotary Converters'
7169	9	5	0.66	'Miscellaneous Rotating Electric Plant Parts'
7188	17	5	0.33	'Miscellaneous Engines'
7741	3	5	0.07	'Electrical Medical Equipment'
7783	9	5	0.86	'Automotive Electrical Equipment'
7784	1	5	0.09	'Power Tools'
8743	1	5	0.31	'Control Instruments of Gas or Liquid'
8744	1	5	0.07	'Analog Instruments for Physical Analysis'

* The number of links indicates the number of products that we have competitive power similar to the product.
Note: A table containing detailed sector information is given in the appendices section.

These 14 products, similar to existing export products, can be reached in 1 step, while the remaining 44 high-tech products are reachable in 2 or more steps. Turkey does not have comparative advantage for any of 14 high-tech products in Table 4.1. But Turkey does have at least one similar product with comparative advantage for any of them. For example, for the product 'Miscellaneous Engines', Turkey does not have comparative advantage but does

have 17 products all of which are similar to 'Miscellaneous Engines'.

Assuming that Turkey reached the products that can be reached in 1 step, we can calculate the products that can be reached in 2 steps. When we do this analysis, we reach 15 new high-tech products (Table 4.2).

Table 4.2 High-Tech Products That Can Be Reached in Two Steps

SITC	# of links	Tech	RCA	Product
5411	2	5	0.07	Vitamins
5415	3	5	0.01	Hormones
7161	3	5	0.13	DC Motors
7522	4	5	0.03	Personal Computers
7523	1	5	0.04	CPUs
7524	1	5	0.00	Digital storage units
7528	1	5	0.07	Miscellaneous Data Processing Equipment
7712	1	5	0.23	Miscellaneous Power Machinery
7742	5	5	0.07	X-Ray Equipment
7763	1	5	0.02	Diodes, Transistors and Photocells
7764	1	5	0.01	Electronic Microcircuits
7768	1	5	0.02	Miscellaneous Electronic Circuit Parts
8742	3	5	0.18	Mathematical Calculation Instruments
8748	6	5	0.15	Miscellaneous Electrical Instruments
8749	3	5	0.19	Measuring Instrument Parts

Note: A table containing all linked sectors is given in the appendices section.

Table 4.3 gives a summary of the products that are in top 100 of both ‘world weight’ and ‘pci’ rankings. The list have 23 products and except three of them all products in the list are high-tech or medium-high-tech. Turkey has revealed comparative advantage only in 2 of them, namely ‘Vehicles Parts and Accessories’, and ‘Piston Engine Parts’. Almost all products in the list are from three sectors; machinery, chemicals, or miscellaneous manufactured products.

Table 4.3. The Products That Are in Top 100 of both 'World Weight' and 'PCI' Rankings

Name of the product	No	4 digit sitc rev. 2	Technology Level of the Product	Product Complexity Index (2001-2013 average)	Hidalgo RCA Index for Turkey 2014	Percent of World product in total World Export	Percent of Turkish product in total Turkish Export	Dummy=1 if RCA(TR)>= 1	Eigenvalue Centrality	Sector Names (SITC Rev 2, 1 digit)
Vehicles Parts and Accessories	661	7849	4	1.42	1.26	2.10	2.63	1	19275.5	machinery
Machinery for Specialized Industries	572	7284	4	2.12	0.39	0.96	0.34	0	3763.8	machinery
Glycosides and Vaccines	293	5416	5	1.33	0.11	0.85	0.08	0	1357.2	chemicals
Chemical Products	341	5989	4	1.43	0.36	0.73	0.26	0	918.7	chemicals
Valves	603	7492	4	1.51	0.75	0.55	0.38	0	17265.6	machinery
Optical Instruments	717	8710	5	1.54	0.03	0.50	0.01	0	6.5	misc manufactured
Heterocyclic Compounds	264	5156	2	1.63	0.02	0.45	0.01	0	21.5	chemicals
Motor Vehicles Piston Engines	532	7132	4	1.47	0.28	0.43	0.11	0	5071.9	machinery
Piston Engine Parts	535	7139	4	1.17	2.85	0.40	1.10	1	10282.5	machinery
Parts of Gas Turbines and Reaction Engines	538	7149	4	1.38	0.56	0.37	0.18	0	38.3	machinery
CPUs	611	7523	5	1.42	0.04	0.36	0.02	0	133.1	machinery
Miscellaneous Non-Electrical Machines	601	7452	4	1.61	0.59	0.35	0.17	0	5483.9	machinery

Name of the product	No	4 digit sitc rev. 2	Technology Level of the Product	Product Complexity Index (2001-2013 average)	Hidalgo RCA Index for Turkey 2014	Percent of World product in total World Export	Percent of Turkish product in total Turkish Export	Dummy=1 if RCA(TR)>=1	Eigenvalue Centrality	Sector Names (SITC Rev 2, 1 digit)
Pulley System Parts	604	7493	4	1.69	0.67	0.34	0.22	0	11125.1	machinery
Lifting and Loading Machinery	598	7442	4	1.25	0.57	0.33	0.17	0	12300.1	machinery
Orthopedic Devices	765	8996	3	1.37	0.17	0.31	0.05	0	939.9	misc manufactured
Filtering and Purifying Machinery	595	7436	4	1.24	0.80	0.27	0.20	0	8092.3	machinery
Control Instruments of Gas or Liquid	723	8743	5	1.62	0.31	0.27	0.08	0	1179.6	misc manufactured
Automotive Electrical Equipment	651	7783	5	1.27	0.86	0.26	0.23	0	7618.2	machinery
Optical Lenses	734	8841	4	1.18	0.16	0.26	0.04	0	155.9	misc manufactured
Air Pumps and Compressors	592	7431	4	1.40	0.34	0.25	0.08	0	1666.9	machinery
Miscellaneous Heating and Cooling Equipment	586	7416	4	1.74	0.49	0.23	0.10	0	5969.3	machinery
Fasteners	509	6940	3	1.26	0.98	0.23	0.22	0	6176.2	manufactured
Mathematical Calculation Instruments	722	8742	5	1.57	0.18	0.21	0.03	0	433.5	misc manufactured

Source: Prepared by the Author

What are the shortest paths to all of the high-tech products which are not in Turkey's Export Basket?

Analysis done with Matlab shows that there are no new connections after 4th iteration (Table 4.4). There are 61 high-tech products. Turkey produces only 3 of these with RCA>1, namely, 'Vegetable Alkaloids and Derivatives', 'Color TVs', and 'Electrical Transformers'. In one step Turkey can reach 14 more high-tech products. In two-step 15 more, in three-step 13 more, and finally in four-step 4 more high-tech products can be reached. After that no new products can be reached because proximity of these non-reachable 17 products are all smaller than our threshold 0.5.

So, Turkey or any other country trying to reach one of these products must make a long-jump. This impossibility of reaching these 17 high-tech products with diffusion also says something about the classical 'kicking-away the ladder' idea. It must be kept in mind that a few of these 17 products such as 'Black and White TV', 'TV Tubes and Cathode Rays', and 'Lightbulbs' are remnants from almost historical times and must be taken care of separately from our main analysis.

ARE 'WINDOWS OF OPPORTUNITY' GONE? MAYBE NOT YET!

Some claim that the good old days of Korea, Taiwan, and even China is gone. No new country can expect to succeed by copying their strategies. But, we know that China is copying Korea which copied Japan which copied United States which copied United Kingdom which copied … There is no starting point in copying the successful predecessors so no need to expect an end also. There will always be those countries successful and those countries not successful in industrial policy. So the question is to be or not to be in the race.

Table 4.4 Reachability of High-tech Products for Turkey

Already Exporting	Reachable in 1-step	Reachable in 2-step	Reachable in 3-step	Reachable in 4-step	Non-reachable
Vegetable Alkaloids and Derivatives	Antibiotics	Vitamins	Miscellaneous Office Equipment	Typewriters	Radioactive Chemicals
Color TVs	Glycosides and Vaccines	Hormones	Computer Peripherals	Calculating Machines	Miscellaneous Radioactive Materials
Electrical Transformers	Medicaments	DC Motors	Computer Parts and Accessories	Analog Computers	Steam Power Units
	Non-Medicinal Pharmaceutical Products	Personal Computers	Electronic Valves and Tubes	Parts of Office Machines	Nuclear Reactors
	Miscellaneous Parts of Steam Power Units	CPUs	Miscellaneous Electrical Machinery	Measuring Controlling Instruments	Black and White TV
	Electric Motors and AC Generators	Digital storage units	Optical Instruments		TV Tubes and Cathode Rays
	Rotary Converters	Miscellaneous Data Processing Equipment	Cameras		Batteries
	Miscellaneous Rotating Electric Plant Parts	Miscellaneous Power Machinery			Lightbulbs
	Miscellaneous Engines	X-Ray Equipment			Helicopters

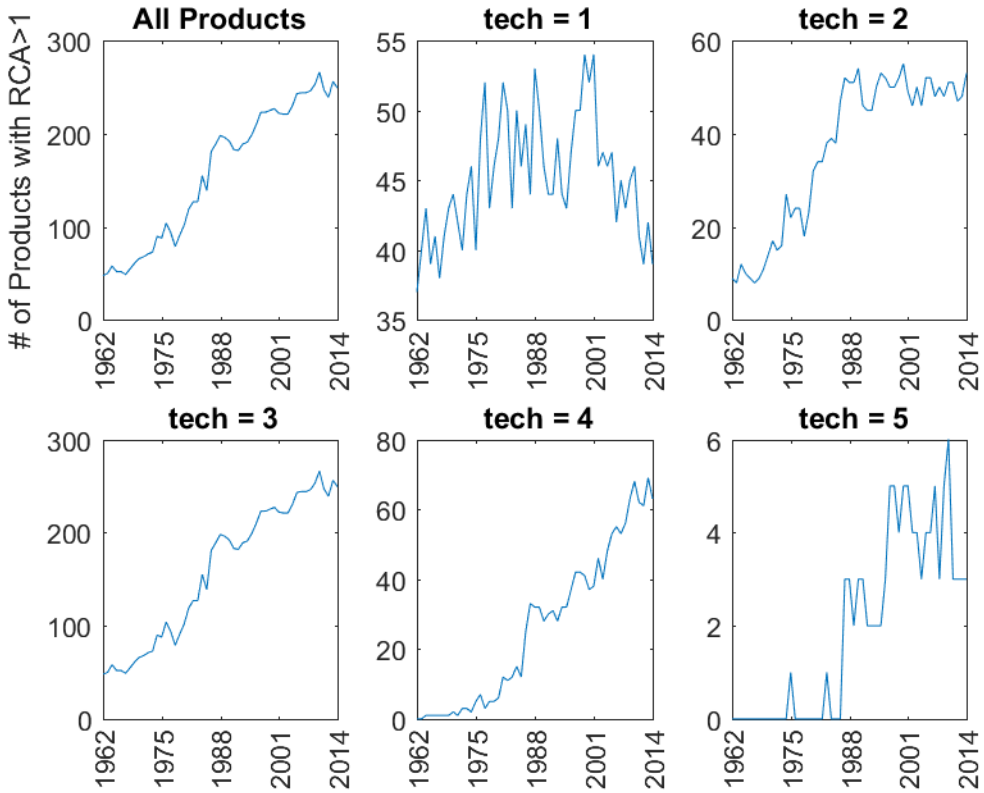
Already Exporting	Reachable in 1-step	Reachable in 2-step	Reachable in 3-step	Reachable in 4-step	Non-reachable
	Electrical Medical Equipment	Diodes, Transistors and Photocells			Small Aircraft
	Automotive Electrical Equipment	Electronic Microcircuits			Aircraft
	Power Tools	Miscellaneous Electronic Circuit Parts			Large Aircraft
	Control Instruments of Gas or Liquid	Mathematical Calculation Instruments			Miscellaneous Aircraft Equipment
	Analog Instruments for Physical Analysis	Miscellaneous Electrical Instruments			Aircraft Parts and Accessories
		Measuring Instrument Parts			Analog Navigation Devices
					Movie Cameras and Equipment
					Photo and Movie Equipment

Source: Created by the Author.

Table 4.5 gives the evolution of Turkish product space for the period 1970-2014. The most striking feature of the data is that although the number of new products in the product space of Turkey decreased in recent years when compared with 1980-1990 period, the percentage of diffusing products in all new products increases over time.

This observation indicates that the evolution of Turkish product space displays more diffusing behavior in recent period. Conversely, it was displaying more jumps in 1980-1990 period. We see in Figure 4.1 that 1980-1990 was a period of high growth in the number of technology level 2 products which are classified as natural resource-based manufactures.

Figure 4.1 Evolution of Technologies in Turkish Product Space



Source: Created by the author using data from (Feenstra, et al., 2005) and UN Comtrade.

The above analysis shows that Turkey was a better 'jumper' in preceding period as it was easier to jump from the bottom of product space. After 2000s, it become more difficult to make long jumps to higher technology products and Turkey instead opted for the easier option of diffusing to similar products.

This strategy made Turkish product space one of the most diversified in the developing world. Nonetheless, too much diversification caused the Turkish product space to lose the jumping capability.

Table 4.5 Evolution Turkish Product Space

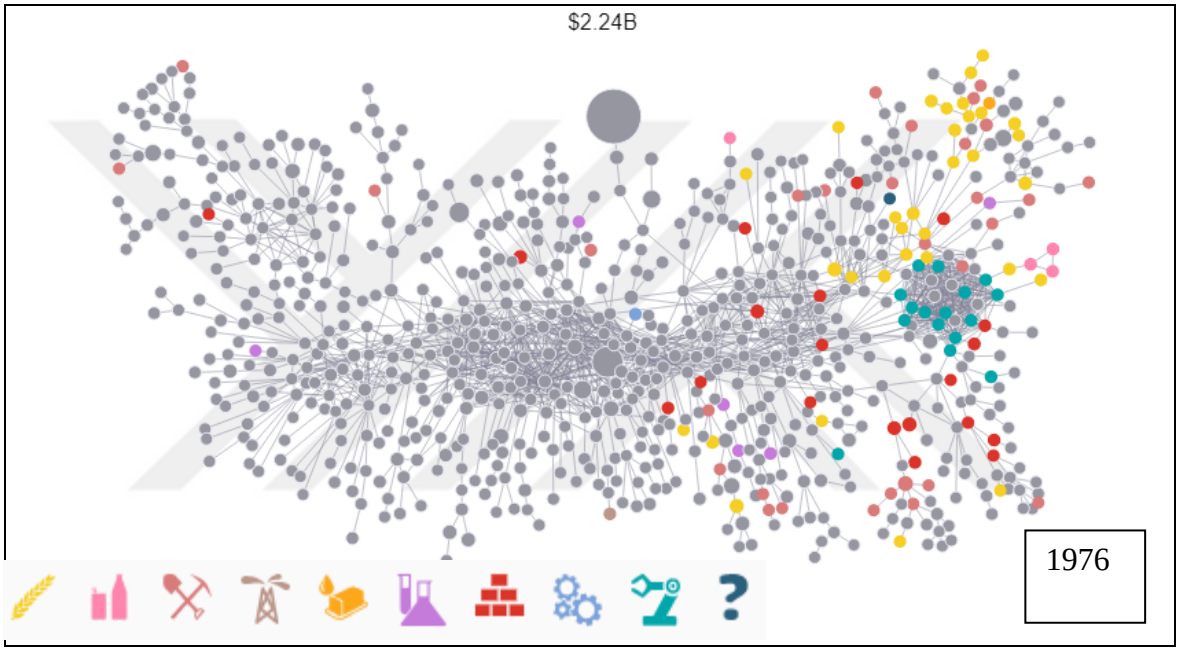
Year	Percentage of diffusing product in all new products	# of New Products	# of New Products with tech level 5	# of New Products with tech level 4 or 5	# of Diffusing Products	Lower Bound for Proximity	Minimum Tech Level
1970	14	7	0	1	1	0.5	4
1971	14	7	0	1	1	0.5	4
1972	0	14	0	3	0	0.5	4
1973	0	10	0	1	0	0.5	4
1974	0	29	0	1	0	0.5	4
1975	0	20	1	4	0	0.5	4
1976	0	34	0	6	0	0.5	4
1977	0	14	0	2	0	0.5	4
1978	0	7	0	3	0	0.5	4
1979	0	16	0	1	0	0.5	4
1980	11	19	0	3	2	0.5	4
1981	8	25	0	6	2	0.5	4
1982	3	33	0	4	1	0.5	4
1983	5	21	1	3	1	0.5	4
1984	8	66	0	9	5	0.5	4
1985	12	17	0	3	2	0.5	4
1986	7	56	0	14	4	0.5	4
1987	29	35	3	16	10	0.5	4
1988	13	46	3	12	6	0.5	4
1989	10	29	2	8	3	0.5	4
1990	8	24	2	4	2	0.5	4
1991	19	27	1	9	5	0.5	4
1992	0	16	0	3	0	0.5	4
1993	10	21	0	4	2	0.5	4

Year	Percentage of diffusing product in all new products	# of New Products	# of New Products with tech level 5	# of New Products with tech level 4 or 5	# of Diffusing Products	Lower Bound for Proximity	Minimum Tech Level
1994	27	22	0	8	6	0.5	4
1995	12	26	0	5	3	0.5	4
1996	3	31	1	7	1	0.5	4
1997	10	42	2	12	4	0.5	4
1998	0	0	0	0	0	0.5	4
1999	12	26	1	7	3	0.5	4
2000	12	25	1	5	3	0.5	4
2001	14	21	1	7	3	0.5	4
2002	25	20	1	9	5	0.5	4
2003	11	19	0	4	2	0.5	4
2004	30	23	0	11	7	0.5	4
2005	20	30	1	11	6	0.5	4
2006	15	20	1	8	3	0.5	4
2007	20	20	2	7	4	0.5	4
2008	13	15	0	5	2	0.5	4
2009	27	26	3	16	7	0.5	4
2010	26	27	2	11	7	0.5	4
2011	24	17	0	7	4	0.5	4
2012	42	12	0	5	5	0.5	4
2013	15	20	0	8	3	0.5	4
2014	7	14	0	3	1	0.5	4

Source: Created by the Author.

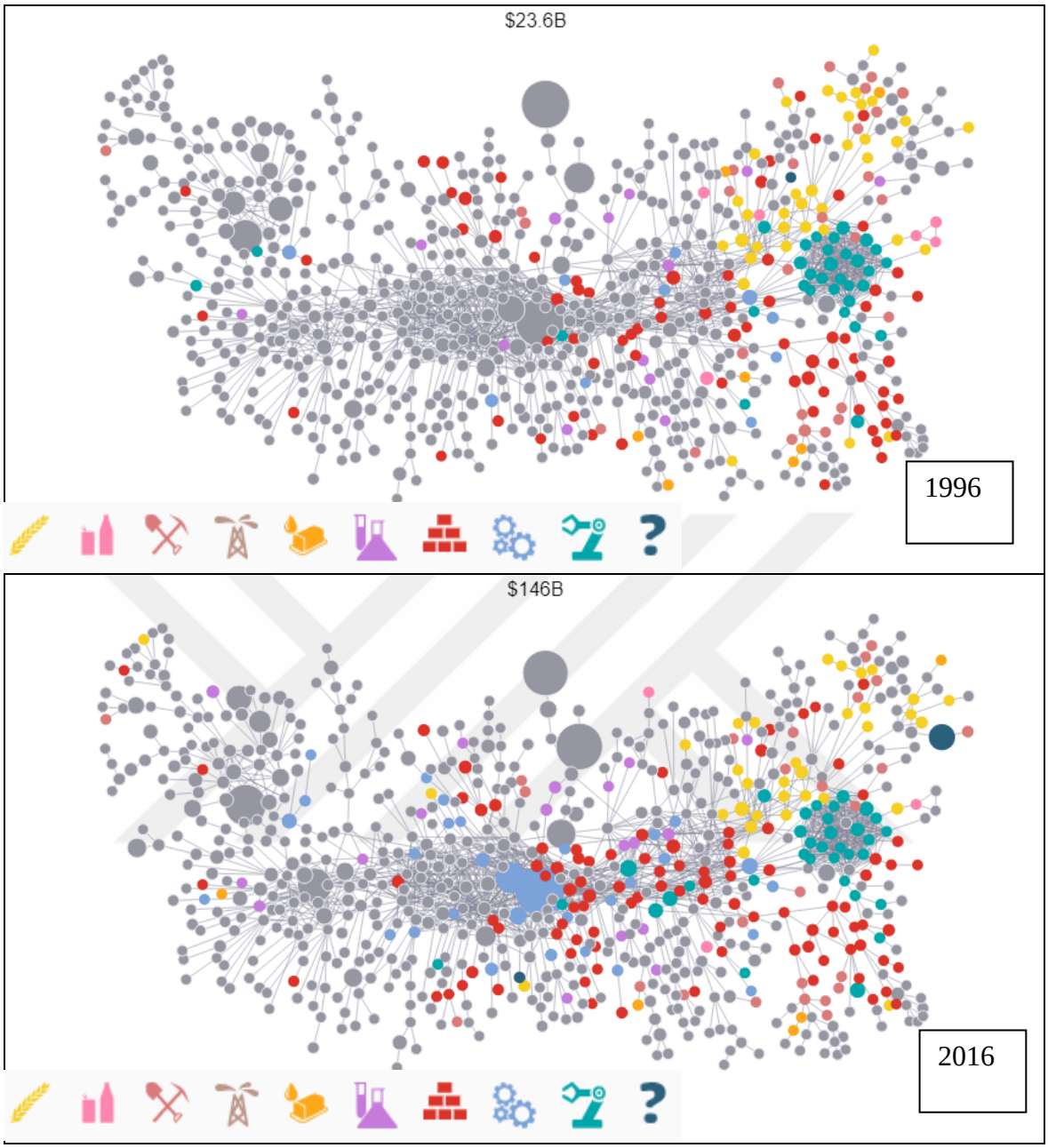
A visual evolution of Turkish product space is given in Figure 4.2. It gives the product space of Turkey for the years 1976, 1996, and 2016[6]. The colored nodes have RCA>1 and each color represents a different sector. The gray nodes represents those products in which Turkey do not have revealed comparative advantage. The increase in the number manufactured goods over the years is striking. In 2016, the machinery & transport products such as passenger motor vehicles (excluding buses) and other parts and accessories, for vehicles of headings become an important part of Turkish product space.

Figure 4.2 Evolution of Turkish Product Space



[6] A movie version of the product space of Turkey for all years can be found at:

http://atlas.cid.harvard.edu/explore/network/?country=224&partner=undefined&product=undefined&productClass=SITC&startYear=1995&target=Product&year=2016



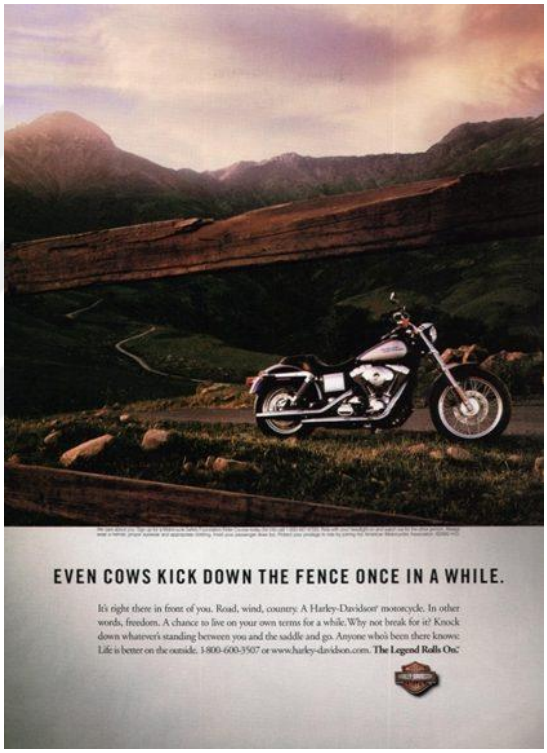
Source: (Hidalgo, 2016)

4.1.1 Choosing Worms

When an economist considers questions like "Should a bird eat only the biggest and best worms or should it eat every worm it finds? How long should a predator go on trying to get the remaining nourishment from one carcass before leaving it to look for other prey? Should a stag challenged by a rival fight or run away?" (Alexander, 1996), should he be inclined to think about the product space? The answer is yes. Because, the problems and cures looks too similar.

First let's make a comparison in which worms and carcasses are products and animals are countries. Until lately, Turkey was like the lazy chicken or the cow who is ok in his own turf and who is afraid of any adventure. Korea is like a falcon glooming from above forever in the look for a tasteful prey. One can argue that a tortoise and a falcon both stays alive but when one considers the tortoise in the unmerciful claws of a falcon flying over the cliffs, it is not something that tortoise is happy about. So, rule one is stay alive, and rule two is climb to the top of hierarchy.

Figure 4.3 Exploration or Exploitation?



Source: Harley Davidson Advertisement (2000)

4.1.2 Bandits Are One-armed, Two-armed or Multi-armed?

"How should animals choose between different feeding places when they do not know in advance how easily they will find food in them?" The answer in the animal kingdom reached after billions years of experience is clear. "They should search for a while in each place, see how well they do in each and then concentrate on the place that seems best." (Alexander, 1996).

The question above is surely from animal kingdom. But the answer above could easily be mistaken for a suggestion to a developing country that was derived from a Product Space analysis. This is a classical multi-armed bandit problem.

Hidalgo and Haussmann consider monkeys on the trees as an example of product space, but it is interesting that they missed a much better comparison, which is birds looking for fruits on the trees which is also a multi-armed bandit problem that mimics the developing country problem much better (Hidalgo, et al., 2007; Alexander, 1996).

(Alexander, 1996) only gives limited information and sources for multi-armed problem. But, since the publication of the book, there has been much research about different versions and aspects of multi-armed bandit problem. Especially Machine Learning (ML) algorithms exploit the power of different probabilistic methods for solving multi-armed bandit problems (Athey, 2017).

4.2 Evolution of Product Space for Country Groups

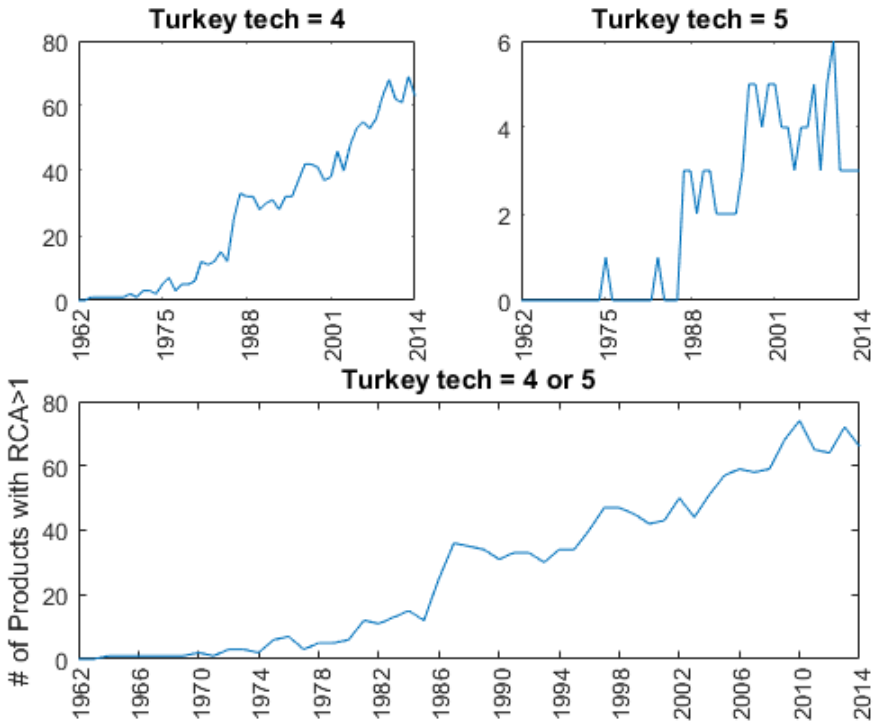
Product space of countries includes many clues about the direction of development for the specific country. In this section, we analyze the evolution of product space for 60 countries[7]. Of these, 25 are high income, 20 are medium income and 15 are low income countries.

[7] The countries included in this section are Angola, Argentina, Australia, Austria, Belgium, Bangladesh, Bulgaria, Bolivia, Brazil, Canada, Switzerland, Chile, China, Cameroon, Colombia, Czech Republic, Germany, Denmark, Algeria, Ecuador, Egypt, Spain, Ethiopia, Finland, France, United Kingdom, Ghana, Greece, Hungary, Indonesia, India, Ireland, Iran, Israel, Italy, Japan, Kenya, Korea, Morocco, Mexico, Malaysia, Netherlands, Norway, New Zealand, Pakistan, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Sudan, Sweden, Thailand, Turkey, Taiwan, Tanzania, United States, Vietnam, and South Africa.

Developing countries in general have huge diversity of products in low and medium-tech segments of products but they do not display that much diversity in high-tech products.

Figure 4.4 shows the evolution of medium-high and high-tech products for Turkish exports. It's clear that there are two different trends. While the number of medium-high-tech (level=4) products display a long term increasing trend, high-tech products are stuck at a low number.

Figure 4.4 Evolution of Medium-High and High Tech Products in Turkish Exports



Source: Created by the author using data from (Feenstra, et al., 2005) and UN Comtrade.

When we plot the same graphs for all countries in our sample, we see that different country groups display different trends. While trajectories of high-income countries mostly stabilized over the period, medium and low-income countries display chaotic trajectories (Figure 4.5, Figure 4.6, Figure 4.7).

Figure 4.5 High Income Countries, Number of High-Tech Products with RCA>1

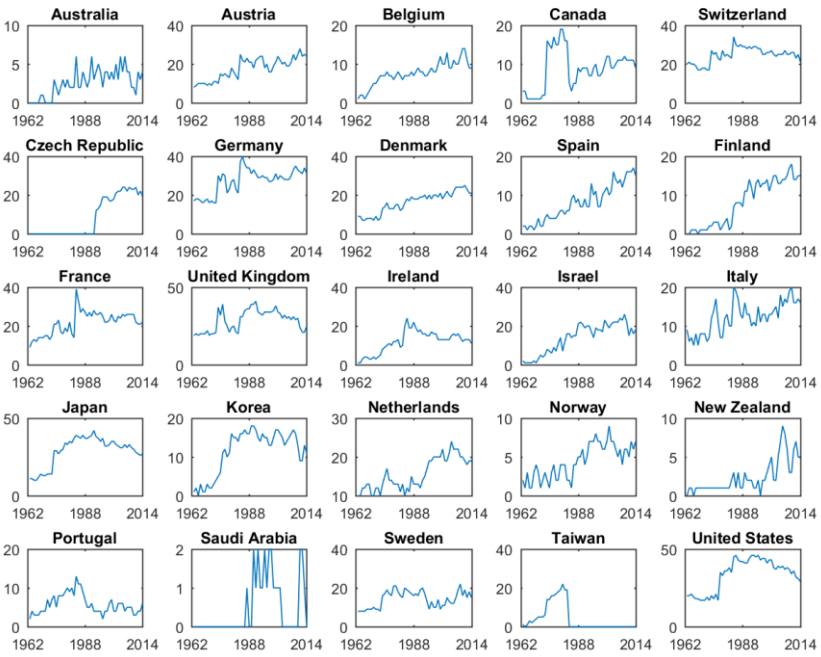


Figure 4.6 Medium Income Countries, Number of High-Tech Products with RCA>1

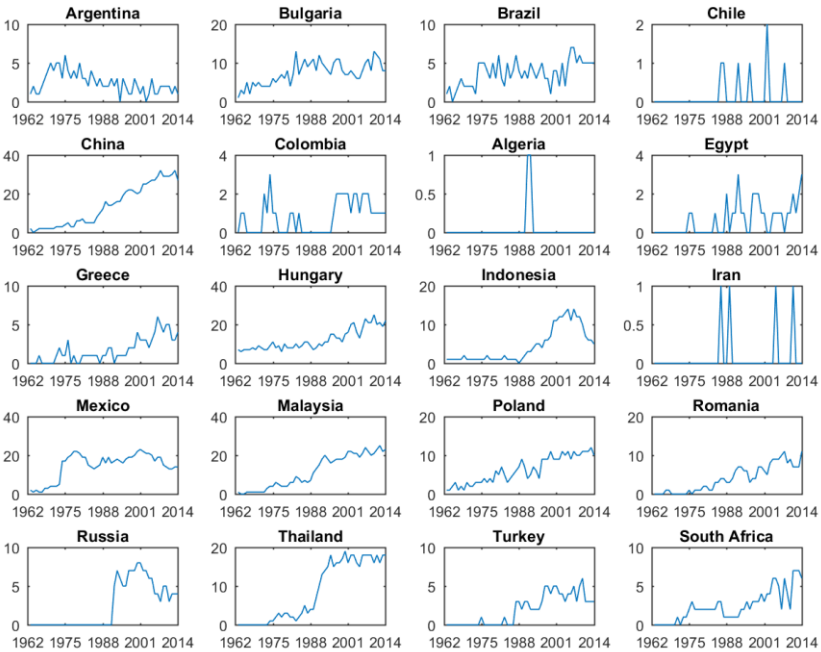
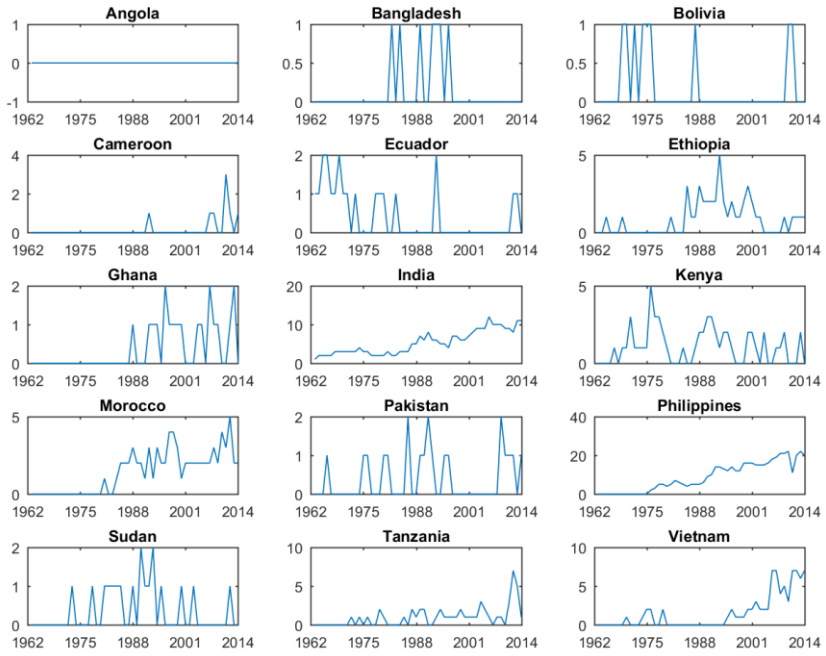


Figure 4.7 Low Income Countries, Number of High-Tech Products with RCA>1



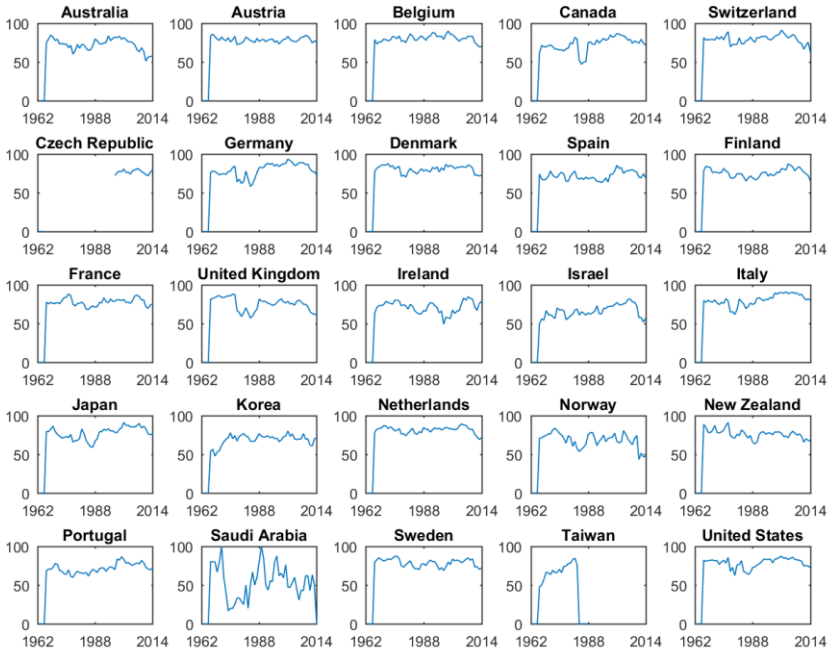
Source: Created by the author using data from (Feenstra, et al., 2005) and UN Comtrade.

4.2.1 The Effect of Natural Resources

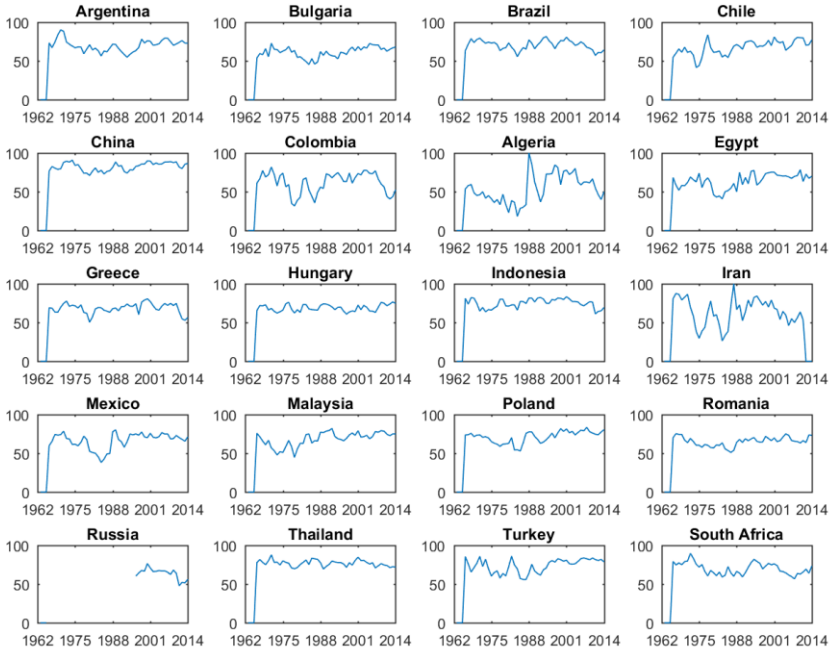
One of the general patterns we see in the graphs is that the countries whose exports heavily depend on natural sources have a quickly changing export basket. To see this fact, we have constructed a variable that measures the percentage of products that stayed in export basket with RCA>1 for the last 5 years successively (Figure 4.8). Saudi Arabia, Norway, and Algeria are clear examples of this sort of basket (Figure 4.9).

Figure 4.8 Percent of Products That Stayed In Export Basket with RCA>1 for the Last 5 Years

High-Income Countries



Medium-Income Countries



Low-Income Countries

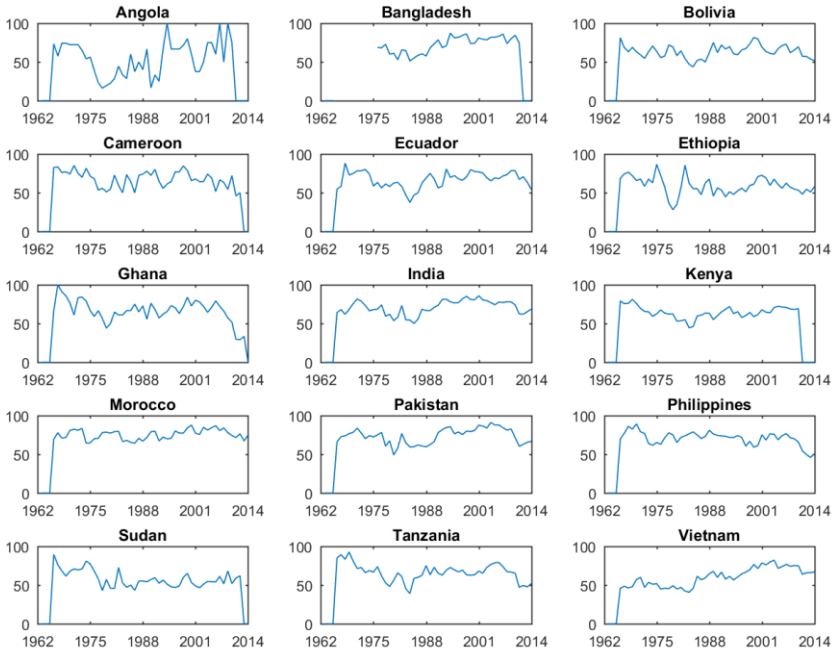
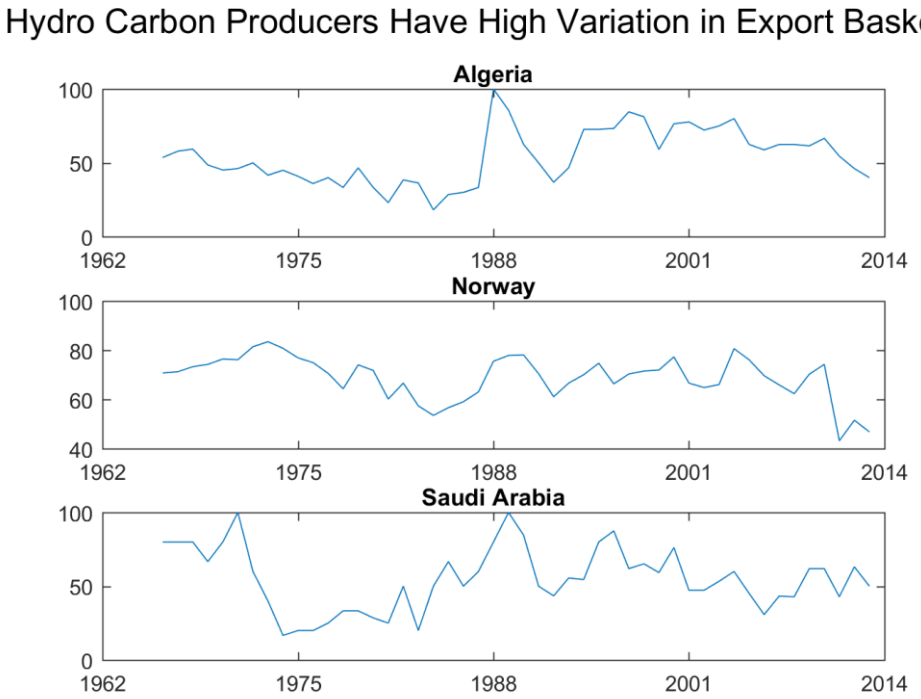


Figure 4.9 Percentage of Products That Stayed In Export Basket with RCA>1 for the Last 5 Years

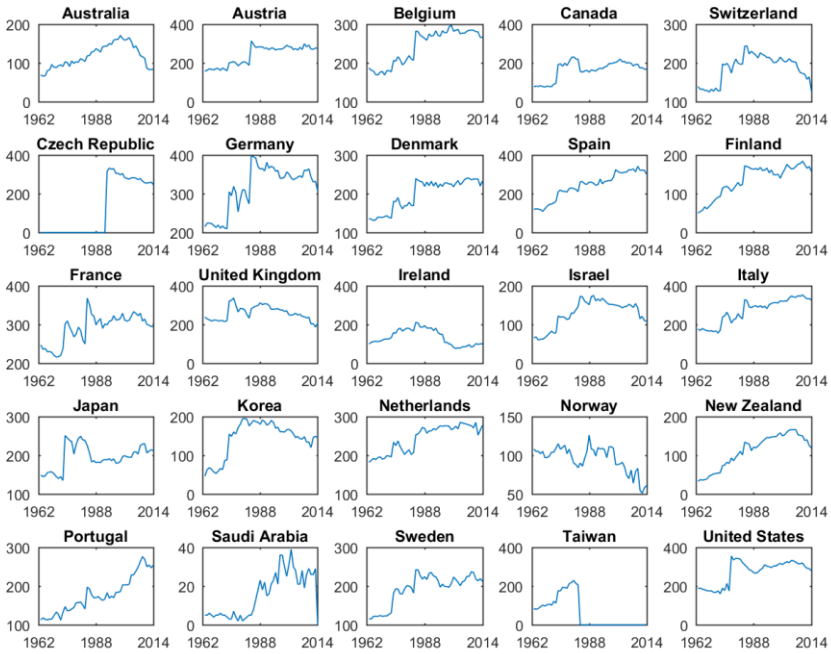


4.2.2 Explore or Exploit?

From Figure 4.10, we can see that in many of the developed countries such as Germany, Switzerland, United Kingdom, Korea, the number of products with RCA>1 increases first, reaches a peak and starts to decrease after that.

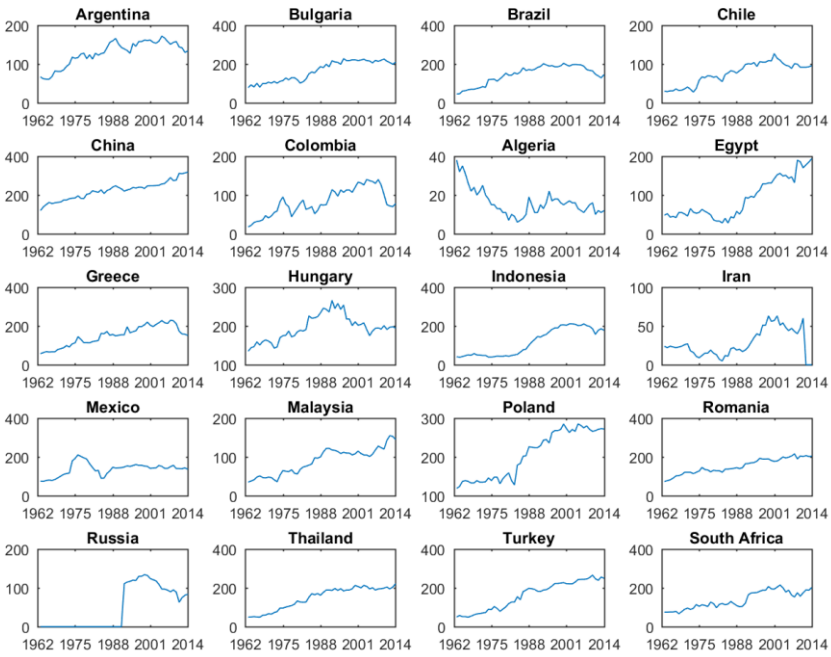
This behavior is a display of a general development trajectories of countries. In their development path, countries first try to increase their production capabilities as much as possible. We see this fact in the number of all products with RCA>1. After reaching maximum diversity of products, countries start to specialize in the products which offers the biggest growth prospects for the country. Because of that we see a decreasing trend in total number of products.

Figure 4.10 Number of all Products with RCA>1, High-Income Countries



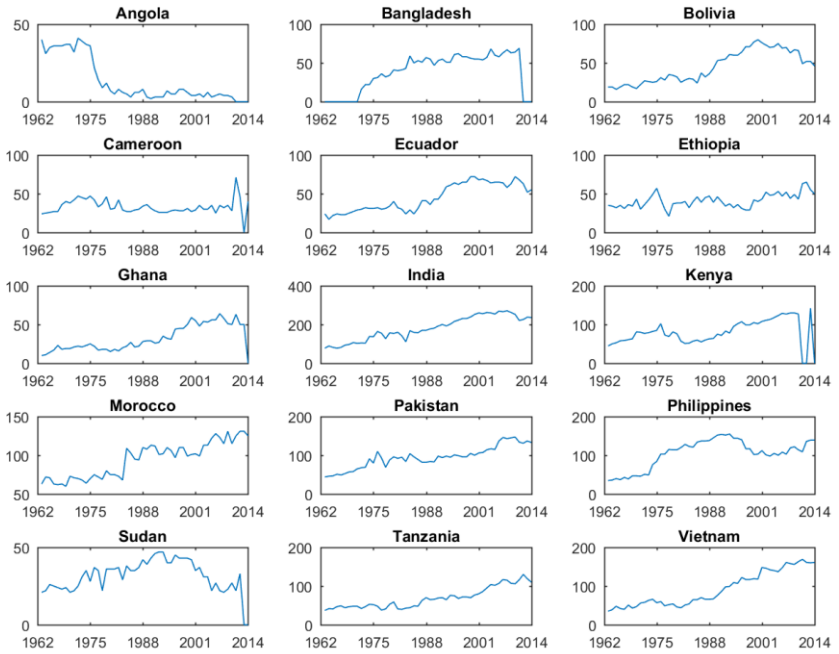
While most of the developed countries displays a decreasing trend after reaching their peaks, most of the developing countries are still trying to get to their peaks. From Figure 4.11, we can see that countries such as Turkey, Malaysia, Poland, and Thailand have not yet reached their peaks. The decreasing trend that we see in some of the developing countries are due to the 2008 financial crisis. We can see that, in that period, many countries lost some of the diversity in their export basket.

Figure 4.11 Number of all Products with RCA>1, Middle-Income Countries



Low-Income countries are still in their infancy in terms of the number of the products that they export competitively (Figure 4.12).

Figure 4.12 Number of all Products with RCA>1, Low-Income Countries

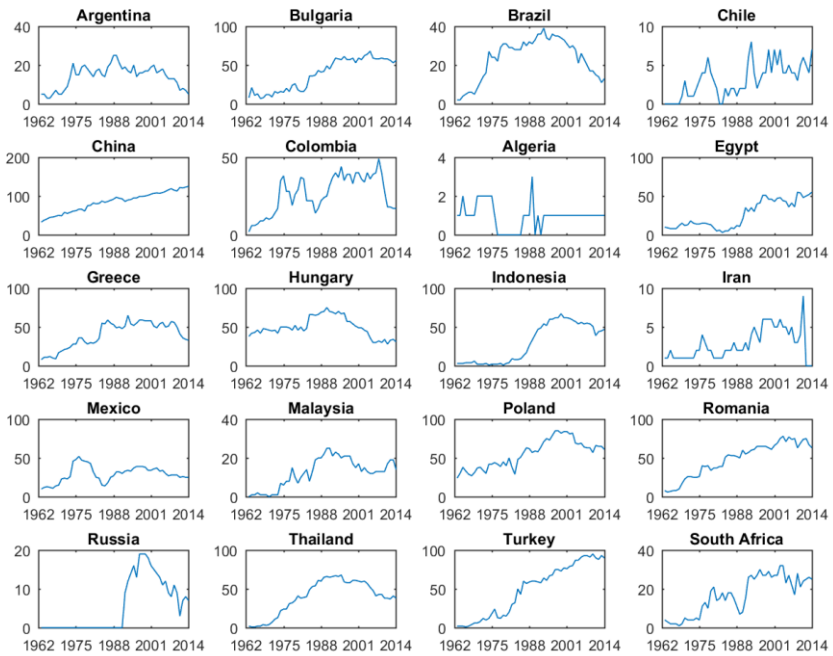


We see that while most of high-income countries reached their peaks in high-tech products (Figure 4.5), Middle-Income countries display a completely different picture.

We see from Figure 4.13 that most of the Middle Income countries reached their peaks in medium-tech products. We also see that these countries are in climbing part of their journey in medium-high-tech products (Figure 4.14). It is clear from the figure that these countries have no idea about what to do in high-tech products except a few countries such as China, Malaysia, and Thailand (Figure 4.6).

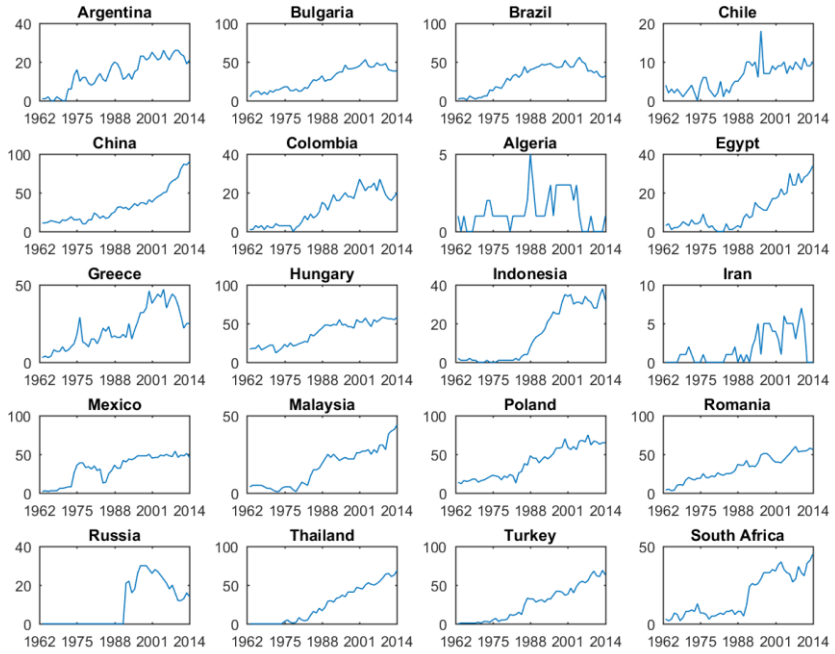
From product space perspective, these middle-income countries are in search of medium-high-tech products. They are already exploiting medium-tech products and diffusing towards medium-high-tech products.

Figure 4.13 Number of Medium-Tech Products with RCA>1, Middle-Income Countries



Source: Created by the author using data from (Feenstra, et al., 2005) and UN Comtrade.

Figure 4.14 Number of Medium-High-Tech Products with RCA>1, Middle-Income Countries



Source: Created by the author using data from (Feenstra, et al., 2005) and UN Comtrade.

4.3 A New Proposal for Turkey's Export Incentive System

In Turkey, export incentives are used by companies for roughly 3 purposes;

i. To continue to do what is currently being done,
ii. Expanding the existing structure,
iii. Move to new production structure

Although a substantial part of the incentives are used for the purposes i and ii, the main aim and the more difficult one is to increase the firms' ability to produce new products.

In order to increase the level and quality of Turkish exports, many kinds of supports are given to exporting firms through various state agencies[8]. Two common features of many of these supports are the equal treatment of all firms that meet the requirements and the support of process rather than the final product. While this system is effective in terms of improving

[8] A detailed list of export incentives given in Turkey are given in Appendix E.

the capacities of all companies a little, it does not generally cause the creation of new high-tech products.

In this section, we first construct a model to measure the potential of a product by extending the model of (Hidalgo, et al., 2007). Then, the high-potential for Turkey is discussed. Depending on the model, a new export incentive system is proposed for Turkey. The main scenarios of the offered system is given and then the optimal strategy for the implementation of the proposed incentive system is given.

4.3.1 The Model

In this section we propose a new model to measure the potential of a new product for the country. A simple version of this model is discussed in (Hidalgo, et al., 2007). They measure average proximity of a new product to current product space of a country which they call density.

Two main criteria for state support for a specific product i are;

iii. The product i must be a new product ($RCA_i < 1$)

iv. The product i must have high potential $\prod_i$ as defined below

The potential for a new product can be defined as;

$$Potential = \prod_i = \frac{\sum_j RCA_j * (pci_i)^{\alpha} * (w_i)^{\beta} * (w_j)^{\gamma} * (P_{i,j})^{\delta}}{\sum_j (P_{i,j})^{\delta}} \qquad \text{Eq. 4.1}$$

Where;

pci_i : $product\ complexity\ index\ of\ product\ i$

w_i : $weight\ of\ product\ i\ in\ worldwide\ total\ merchandize\ trade$

RCA_i : $\begin{cases} 1\ if\ (Revealed\ Comparative\ Advantage\ of\ product\ i) \geq 1 \\ 0\ if\ (Revealed\ Comparative\ Advantage\ of\ product\ i) < 1 \end{cases}$

$P_{i,j}$: $Proximity\ between\ products\ i\ and\ j$

$\alpha, \beta, \gamma, \delta$: $parameters\ for\ the\ optimal\ decision\ about\ the\ products\ with\ highest\ potential$

So a product i with high potential have some of the following properties;

vi. It is a high-tech and complicated product with high pci_i

vii. It is a widely traded product worldwide so has a large w_i

viii. Its neighbors in product space are widely traded products worldwide so have large w_j's

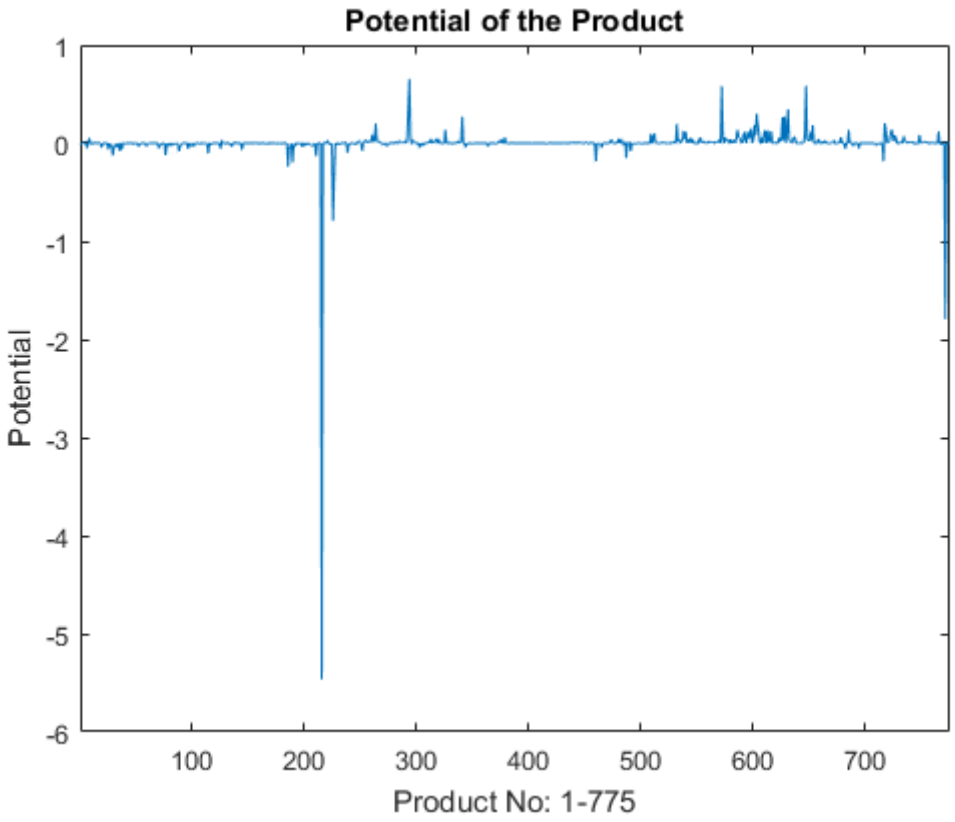
ix. The other products that i is similar to have current revealed comparative advantage

x. There are many products similar to product i

4.3.2 The Results

When we apply the formula given in Eq. 4.1 for product space of Turkey with the parameters alpha=1, beta=1, delta=1, gamma=1, we get the following results;

Figure 4.15 Products with Highest Potential



Source: Author calculations.

Table 4.6 Products with Highest Potential

No	Product	Sector	Potential	RCA	Tech Level	PCI	Weight in World Trade (%)	Weight in Turkish Exports (%)
1	Medicaments	chemicals	0.66	0.21	5	0.74	2.29	0.40
2	Electronic Microcircuits	machinery	0.58	0.01	5	1.13	2.09	0.02
3	Machinery for Specialized Industries	machinery	0.58	0.39	4	2.12	0.96	0.34
4	Glycosides and Vaccines	chemicals	0.35	0.11	5	1.33	0.85	0.08
5	Circuit Breakers and Panels	machinery	0.35	0.86	4	0.96	1.11	0.96
6	Valves	machinery	0.30	0.75	4	1.51	0.55	0.38
7	Telecom Parts and Accessories	machinery	0.27	0.04	4	1.11	0.75	0.05
8	Chemical Products	chemicals	0.27	0.36	4	1.43	0.73	0.26
9	TV and Radio Transmitters	machinery	0.27	0.01	4	0.83	1.07	0.02
10	Optical Instruments	misc manufactured	0.20	0.03	5	1.54	0.50	0.01
11	Heterocyclic Compounds	chemicals	0.20	0.02	2	1.63	0.45	0.01
12	Motor Vehicles Piston Engines	machinery	0.20	0.28	4	1.47	0.43	0.11
13	Pulley System Parts	machinery	0.19	0.67	4	1.69	0.34	0.22
14	Miscellaneous Electrical Machinery	machinery	0.18	0.12	5	0.99	0.59	0.08
15	Miscellaneous Non-Electrical Machines	machinery	0.18	0.59	4	1.61	0.35	0.17
16	Lifting and Loading Machinery	machinery	0.15	0.57	4	1.25	0.33	0.17
17	Miscellaneous Power Machinery	machinery	0.15	0.23	5	1.13	0.36	0.10
18	Control Instruments of Gas or Liquid	misc manufactured	0.14	0.31	5	1.62	0.27	0.08
19	Medical Instruments	misc manufactured	0.14	0.20	4	0.77	0.58	0.11
20	Miscellaneous Heating and Cooling Equipment	machinery	0.14	0.49	4	1.74	0.23	0.10

Source: Author calculations

Figure 4.15 gives potential for each product in product space of Turkey. We see from Table 4.6 that all potential products in top 20 are high-tech or medium-high-tech products. These results are in line with the analysis done in Section 4.1 where it was shown that 14 high-tech products are within one-step reach of products that Turkey exports competitively.

When we analyze the sectoral distribution of top 20 potential products we see that all of them are broadly categorized as either chemicals, machinery or misc. manufactured products. 'Glycosides and Vaccines' and 'Medicaments' are in top three here and are also chosen in the previous analysis as they are similar to current Turkish export basket.

4.3.3 The Proposed Incentive System for Turkey

The national incentive or innovation system does heavily affects the success of latecomer country in jumping to the core of the product space. So it's important to design a national incentive system so that it is capable of offering different catch-up schemes for different sectors and products.

Diffusion in the Product Space depends heavily on the road ahead and the road ahead is different for each product. Sometimes there is a big scientific or technological breakthrough and sometimes it's just incremental change or upgrade. Depending on details, the country must enable the maximum use of catch-up schemes to gain competitive power in international markets.

Country specific properties are important in the success of catch-up policies. There are mainly three types of effects at country level:

i. information effect,
ii. complementarity/lock-in effect,
iii. learning effect

An 'information effect' refers to organizations and institutions specific to the country that have an effect on the local firm in terms of firm's capabilities for searching new technologies or methods. A complementarity/lock-in effect refers to the impact of the complex network of the interactions in the country's innovation system on the local firm that affects the capability of the local firm to recognize the technological discontinuities and windows of opportunities. Finally, a learning effect refers to national innovation system's impact on the local firms in accumulating capabilities at the firm level.

These country specific properties are the main determinants in countries' catch-up processes and depending on them different trajectories of catch-up dynamics can be observed. The level of technological disruption, the amount of lock-ins, the structure of technological structure, and latecomers' initial capabilities are determining factors in the catch-up process.

Most of the export incentive system of Turkey differentiates among companies depending on sector or region. But this leads to inefficient distribution of incentives. Mostly because these are the sectors with low technology production. High technology incentives are given in terms of the budget constraints of big investments.

According to proposed incentive system, to encourage export of a new product, the first exporter of a high-tech product should receive the highest incentive. Because a company trying to produce a new field is actually trying to reveal the product cost structure of the country. In the event of failure of the company, all liability and damages are attributable to itself and if it is successful and profitable, this product will be copied by other companies and profit will be shared. For this reason, private returns from developing a new product are lower than total social benefits, and market incentives for self-discovery are often insufficient on their own. In such a case, the standard solution is to subsidize the state channel to make private revenues compatible with social revenues. Thus the negative externality of cost structure will be met by the state.

Coordination deficiencies and externalities are a particularly effective constraint for high-tech and new products. Developing a new product often requires a complex supply chain and it is difficult to develop a product for which the supplier is not available. In addition, it is difficult to find skilled and experienced workers for high-tech new products because nobody has produced this product in Turkey yet. So, is it possible for a structural transformation in such a case?

The dependence of new products on existing capabilities means that a structural change left completely to the market is relatively slow. Because diffusion in the Product Space when left to itself is relatively slow and primarily occurs in the neighborhood of similar products.

Instead of developing new talents, domestic firms usually use existing skills in production. The new capabilities in production often come about through new products.

Information externalities and coordination externalities indicate that it is relatively much

more difficult for diversification to take place without planned public action. The most important examples of Product Space diversity are the result of planned public action and public-private partnership.

Success of these incentives should be measured by defining a criteria set to ensure that bad projects are phased out and mistakes are not sustained. We see that, the successful policies that East Asian countries applied possess these elements. The fact that Latin America generally had a lot of carrots and less sticks, in part, explains the inefficient and low added value export structure of this region. The point to be emphasized here is that some of the investments encouraged even in the optimum incentive program will fail. The task of the policy maker is not to choose the winners but to determine the losers when they lose.

Box. 1 Export Incentive System Proposal for Turkey

CONSTRAINED OPTIMIZATION PROBLEM

OBJECTIVE FUNCTION: Attain Competitive Power in Maximum Possible Number of High-Tech Products in Shortest Possible Time

CONSTRAINTS: Budget, Innovation System, Financial System, Infrastructure

POLICY VARIABLE: Incentive System

SOLUTION: Proposed Export Incentive System for Turkey

CRITERIA: The total state incentive given to product i is proportional to the potential of the product i.

Potential of a product is a combination of its technology level, proximity to current export basket, and weight in world trade.

Turkey can have 'guided paths to the core' of the Product Space. With a guided path, The State guides the industry into a specific path or direction so that arriving at the core will be faster for the country.

This incentive method is not unique as there may be multiple incentive methods with the same result. One option is improving infrastructure + giving financial incentives and tax benefits + providing know-how. Another option is a State interfering with free market in case of under-investment and lack-of-interest of private sector in critical areas.

In all options the common theme is the adoption of the common goal of reaching the core of product space in the shortest period of time by all actors.

Box. 1 gives a summary of the proposed export incentive system for Turkey. When we consider the properties that this incentive system must have, Section 3.1 is our main reference.

For an incentive system to be effective it must have various properties. When we try to get modified versions of those properties for Turkey, we find that an effective incentive system in Turkey must have the following properties;

The promoted activities should have a clear potential to provide spillovers and demonstration effects.

Our analysis in previous chapters demonstrates that spillover effects of new products diffuse mainly through the product space structure. In the proposed incentive system, spillover effects are maximized by choosing the paths that leads to the core regions of the product space.

There must be clear criteria for success and failure.

In Turkey's case the criteria is clear: give maximum support for the exporter of a high-tech product which is in neighborhood of current product space of Turkey. The tricky part is that the exporter will have a difficult time on choosing the new risky high-tech product. The main role of state is spreading the risk by giving incentives to risk-takers via tax benefits, long-term investment credits, risk insurances etc.

One opportunity for Turkey in this area is the newly established Turkey Sovereign Wealth Fund Management Inc. (Türkiye Varlık Fonu). One of the tasks of the Fund is 'to participate in large-scale strategic investments'. Investing in companies focused on production and export of high-tech products will accelerate the technological transformation in exports.

Prudence must be always the first property to have in case of state interfering in free market as there are more 'unknown unknowns' than 'known unknowns' (see Footnote 4).

When and under what conditions public support will be ended should be clearly indicated.

One may think that putting clear criteria for success and failure guarantees optimal distribution of incentives. This assertion is not true. Even successful activities may become mediocre after some time and if there is not clear sunset clause then it may be difficult to stop the incentive. So there must be clear rules for the start and end of incentives.

In an optimal structure, errors that sometimes result in 'choosing failures' will occur. The goal should not be to block the discovery process by minimizing the likelihood of faults occurring, but rather to reduce the costs of these faults to the minimum.

Measuring success or failure is comparatively easier than measuring genuine risk taking behavior. Because of that, governments in general use success or failure when giving incentives to firms. But more important criteria is risk taking behavior of the firms. When state only rewards success, the optimal behavior of firms is not taking risk but goes for easy successes. This partly explains the low number of high-tech product in export basket of Turkey.

The main aim of the state is to create an environment that encourages creativity and risk taking. Because innovation does not happen without risk. Some of these outcomes can be bad, and encouraging risk taking can help increase innovation.

Policy-making institutions should be closely related to or monitored by the institution with the highest political authority.

For a given incentive system, if we want to measure its quality, the first thing we look at must be whether the incentive system is a part of consistent long term industrial policy. Otherwise, an incentive system becomes a disoriented list of supports when the industrial policy is a wish list instead of a programmed list of the things to be done.

So it is important that industrial policy and incentive system is planned by the same authority. The higher the rank of authority the higher the chance of success. Because as (Rodrik, 2004) says industrial policy "requires a certain degree of autonomy for the bureaucratic agencies implementing it. But autonomy does not and should not mean lack of accountability. Close monitoring (and coordination) of the promotion activities by a cabinet-level politician, a principal who has internalized the agenda of economic restructuring and shoulders the main responsibility for it, is essential. Such monitoring guards not only against self-interested behavior on the part of the agencies, but also helps protect the agencies from capture by private interests".

4.3.4 Main Tools for the Proposed Incentive System

One way to think about exports is that if you do not export then you depend solely on one market, the domestic market, and this is extremely dangerous for a country. The aim of Turkey in promoting the exports is to get a system of strong and diversified exporters. There are many different ways to construct an incentive system for export and production.

We have seen that the problem of creating high-tech export products can be thought as a constrained optimization problem (see Box. 1). In constrained optimization problems, a constraint is defined as binding if changing the constraint also changes the optimal solution. So once an optimal solution is found the planner can improve the solution only by relaxing the binding constraints.

In our case, we argue that there are three main constraints and related sub-constraints;

i. Risk Appetite of Firms
    a. Coordination externalities
    b. Cost of self-discovery process
    c. Cost and availability of financial instruments for risky investments
ii. The Skill Set of Population
    a. Education system
    b. vocational, technical, and language training
iii. The Infrastructure
    a. Research
    b. Transportation
    c. Communication
    d. Electric, water, etc.

Increase Risk Appetite Of Firms

One of the main impediments of risk appetite is the dire consequences of a failure as explained in Section 2.2. Especially in case of catch up cycles (Section 2.2.1) and windows of opportunities (Section 2.2.4), risk appetite is crucial in taking advantage of suitable conditions for catching-up the leaders. State support for risk-takers enables the firms to go for the big game. The incentives to increase the risk appetite includes but is not limited to;

i. Increase the capacity of development banks substantially (see Japanese Development

Banks section).

ii. Public guarantees for long-term commercial bank loans

iii. Special tools to direct some of the public pension fund assets to the high-risk investment portfolio

Direct some of the fund of Turkey Sovereign Wealth Fund Management Inc. (Türkiye Varlık Fonu) to high-tech high-risk investments.

Broaden the Skill Set of Population

In sectors where scale is not important and skills of researchers are more important, new and small firms generally dominates the sector by growing quickly. In these areas, promoting the advancement of skill-sets of population is critical as high level of human capital is more important in these sectors.

Supplying the young with the indispensable skills of algorithmic reasoning, coding, and critical and creative thinking is utmost responsibility of the State. The PISA scores publicized by OECD indicates that Turkey needs a big restructuring in education system to obtain these goals for the majority of students.

Labor market innovations are important to increase the effectiveness of vocational, technical, and language training. Innovative firms fear that on-the-job training together with a labor turnover rate will reduce the benefit to the company and cautiously approach costly training.

Develop the Infrastructure

Sustainable development is impossible without a well-functioning infrastructure. Many countries do not have the institutional capacity and resources to develop big and critical infrastructure projects, and that fact deters potential investments in the country.

In some sectors, it is difficult to apply big scale investments and in these sectors it is more important to develop a science and technology infrastructure, public-private partnerships, and enable the diffusion of various market institutions (See Section 2.2.6).

In order to ensure the more effective use and sustainability of research infrastructures, the Law on Supporting Research Infrastructures No. 6550 and the secondary legislation of this Law have entered into force in 2014 and 2015, respectively. With this Law, arrangements have been made regarding the management, financing, staff structure monitoring, evaluation

and support of research infrastructures. By the end of 2017, four research infrastructures started to be supported under the Law (See Section 3.4.3).

4.3.5 The Will to Change

In economics and politics alike, it's widely believed that copying rules from other countries is easy but copying technology is not. Upon closer scrutiny, we see that that is not necessarily the case. Rules and incentives are impossible to copy perfectly. Even if we assume a perfect hypothetical copy of rules, it is impossible to apply these rules perfectly without copying the institutions, technology capabilities and productivity levels as well as the rules and incentives. If a country has a stable but not necessarily an efficient system of rules, it's very difficult to change the status quo as the cost of a consensus and coordination is high (Romer, 2010).

Macroeconomist Paul Romer claims that "Innovations in meta-rules, the rules for changing rules, would be particularly valuable if they made it easier for groups of people to transition from an existing set of rules to better ones that have been shown to work elsewhere" (Romer, 2010).

According to Romer, one very important meta-idea is the modern city where a large population of people live together in harmony. Another one is the market economy where market forces guide almost all decisions that people make in their interactions. These two meta-ideas allow large populations of people to cooperate by creating and sharing new ideas. According to Romer, the third important meta-idea is university. With the invention of the university, the creation of science became standart.

In this respect, we need to look beyond for the meta-ideas of the future. Because, only new meta-ideas can transform economies in a big scale and only the frontier countries can take the advantage of meta-ideas by being the first users of them. This is an example of 'Matthew effect' or simply 'the rich get richer' effect. In classical dynamic network models, the nodes with more links are likely to attract more links than the nodes with only a few connectons. This effect is also true for countries. For example, those countries having big patent pools create more patents by combining existing ones. So, the best way to catch-up the leader countries is to invest in meta-ideas of future.

5. Conclusion

In Turkey, a variety of supports are given to exporter firms for boosting exports. The two most common features of these supports are equal treatment of all firms which meet the criteria, and giving support to the processes rather than to the final products. While this system is good for improving the capacities of all companies to a certain degree, it does not usually lead to the creation of new high-tech products that Turkey needs in its catch-up process with the leading countries.

There may be various methods to increase the export level. One method is to increase the volume of exports without changing the tech level by either increasing intensive or extensive margin of Turkish exports. Most of the import substitution policies that Turkey applied in the past are of this kind. Creation of new high-tech export products has not been a priority of policy makers. Nowadays, we better understand the importance of high-tech and high value-added products. In this respect, it is important to find a new mechanism that enables the support of high-tech product export.

Although it has been well understood by policy makers that incentive system is important for increasing the technology level of exports, finding the optimal structure of an incentive system was too elusive in the past and is still elusive currently. In this thesis, we address the problem of optimal incentive system. In this respect, the government may create policies to raise average national productivity levels by encouraging latecomer firms to upgrade their products, processes and organizational practices. If such diffusions are targeted to specific products and product chains, the upgrading process may be more effective. That is the main idea of this thesis.

In the product space of Turkey, diversity of products are high and are mostly concentrated on medium and medium-high technologies. While CAF strategies enables countries to move in the close neighborhood of existing products, CAD jumps allow for long jumps needed for quick access to the core regions of the product space.

The analysis we have done shows that for Turkey there are 14 high-tech products that are similar to the products of the current export basket. These 14 products, similar to existing export products, can be reached in 1 step, while the remaining 44 high-tech products are reachable in 2 or more steps. Turkey does not have comparative advantage for any of these

14 high-tech products. But Turkey does have at least one similar product with comparative advantage for all of them.

Assuming that Turkey reached the products that can be reached in 1 step, we can calculate the products that can be reached in 2 steps. When we do this analysis, we reach 15 new high-tech products. Our analysis shows that there are no new connections after 4th iteration if we use 0.5 as our proximity threshold. Our analysis implies that these products, nonreachable with usual diffuson, can only be reached by making long-jumps.

Product space of Turkey includes many clues about the direction of development. Turkey have huge diversity of products in low and medium-tech segments of products but not that much diversity in high-tech products. In this respect, choosing the best feeding place is a classical problem for animals. They simply "search for a while in each place, see how well they do in each and then concentrate on the place that seems best." This can be also a good strategy for Turkey in deciding which products to export and which products to quit.

While most of the developed countries displays a decreasing trend after reaching their peaks in terms of diversity of products in their export baskets, most of the developing countries are still trying to get to their peaks. Our analyses has shown that countries such as Turkey have not yet reached their peaks. This fact indicates that Turkey has not passed yet from exploration part to exploitation part of process. To accomplish that, Turkish firms must take risks in quitting investment in low-tech products and starting to invest in risky high-tech products. The state must supply the necessary incentives to give the private sector the needed confidence in international arena.

When the development of the last 50 years is examined, it is seen that Turkey is a good follower that did not close the gap with the developed countries but also did not allow the widening of the gap even further. In this respect, Turkey is in a junction between defense oriented US style and development and strategic goal oriented Japan style. Both systems have some advantages and disadvantages. This is a classical problem of explore-or-exploit kind.

Our analysis shows that in situations where the problem is clearly stated and the solution is roughly standard it is more reasonable to exploit the situation with a plan-rational outlook. But, in real world there is no free lunch and exploit period will come to an end. The surroundings will be unfamiliar and standard plan-rational solutions will not work. In this situation, distributing the resources to all possible paths and solutions for a certain exploration

period is the optimal strategy. Because nobody knows the exact solution and future is full of surprises. In these cases, market-rational system where nothing is forbidden and everything is possible becomes more reasonable. Resources are not directed at pre specified goals and instead are distributed in a game theoretical mixed-strategy perspective.

In our proposed incentive system, the two criteria for state support for a specific product i are that the product must be a new product and that the product must have high potential. We have found out that all potential products in top 20 are high-tech or medium-high-tech products. All of these products are broadly categorized as either chemicals, machinery or miscellaneous manufactured products. 'Glycosides and Vaccines' and 'Medicaments' are in top three and they were also chosen in the first analysis we did.

The national incentive or innovation system does heavily affects the success of latecomer country in jumping to the core of the product space. So it's important to design a national incentive system so that it is capable of offering different catch-up schemes for different sectors and products.

Most of the export incentive system of Turkey differentiates among companies depending on sector or region. But this leads to inefficient distribution of incentives. Mostly because these are the sectors with low technology production. High technology incentives are given in terms of the budget constraints of big investments.

The dependence of new products on existing capabilities means that a structural change left completely to the market is relatively slow. Because diffusion in the Product Space when left to itself is relatively slow and primarily occurs in the neighborhood of similar products.

Information externalities and coordination externalities indicate that it is relatively much more difficult for diversification to take place without planned public action. The most important examples of Product Space diversity are the result of planned public action and public-private partnership.

The constrained optimization problem, its solution, and main incentive tools indicate that Turkey can have 'guided paths to the core' of the Product Space. With a guided path, The State guides the industry into a specific path or direction so that arriving at the core is faster for the country. This incentive method to guide the diffusion process is not unique as there may be multiple incentive methods with the same result. In all options the common theme

is the adoption of the common goal of reaching the core of product space in the shortest period of time by all actors.

Risk appetite of the firms is of big importance for the creation of new high-tech exporter firms. We have seen that Turkish firms are not eager to take big risks in international arena. One of the reasons for not taking risk is the dire consequences of a failure. Especially in case of catch up cycles and windows of opportunities, risk appetite is crucial in taking advantage of suitable conditions for catching-up the leaders. State support for risk-takers enables the firms to go for the big game. The incentives to increase the risk appetite includes but is not limited to increasing the capacity of development banks substantially, giving public guarantees for long-term commercial bank loans, offering special tools to direct some of the public pension fund assets to the high-risk investment portfolio, and directing some of the fund of Turkey Sovereign Wealth Fund Management Inc. (Türkiye Varlık Fonu) to high-tech high-risk investments.

Policy interventions aimed at SMEs and entrepreneurs are not efficient enough to encourage the needed efficiency and innovation increases. The inclusive and egalitarian attitude towards all firms is not helpful in differentiating between which firms increase their productivity as a result of the state support and which firms do not. There is a need to design special, unique and flexible support mechanisms for different initiatives in entrepreneurship and SME support.

There is also a continuing need to develop different approaches to the needs of different segments, such as newly established, innovative, fast-growing, steadily growing and productivity-enhancing export companies involved in global supply chains. As we have shown, product space perspective is a unifying framework bringing together different aspects of products.

Technologies, such AI, ML, quantum computing, IoT, BMI, and big data create new products, services, markets, and important opportunities for the next big transformation. The race of developed nations in some of these areas already took off and still in some other sectors they are just warming up.

Turkey’s good university education in computer sciences indicates that with good planning and investment Turkey can create its own ecosystem in high-tech areas, eduacate a new generation of scientists and engineers, and make it sure that the Turkish workforce will be

ready for the automated future.

A well-planned public procurement system is instrumental in supporting the industrial policy. If Turkey Sovereign Wealth Fund Management Inc. (Türkiye Varlık Fonu) invest in companies focused on production and export of high-tech products that will accelerate the technological transformation in export products.

For a proper analysis of the situation, the deficiencies, the risks, and the opportunities about the future technologies, creation of a new process has been proposed in which promising growth areas are asked to private sector firms and after that a public-private partnership is formed to overcome the financial and technological bottlenecks and uncertainties.

When we analyze international markets we see that there are three kinds of firms; OEM, ODM, and OBM. One of the claims in this thesis is that big Turkish firms are afraid of big fights against their more developed partners. This is true because while Korean and Chinese firms used catch-up strategies and followed OEM-ODM-OBM path, Turkish companies are stuck at ODM level at best. This is in-out-in strategy and firms need courage themselves and support from government to do that. Product space view can help Turkey and its firms in their upgrading process.

For big Turkish firms, collaboration with world leaders in high-tech areas is important. But the degree of collaboration must not deteriorate the chances of Turkish firms to become ODM or OBM instead of OEM. To accomplish that, it is important for big Turkish firms to establish large R&D departments, distributing it worldwide, and making alliances in strategic technologies with the leader firms. This structure allows a latecomer Turkish firm to catch-up the leaders and become a world leader itself.

Although FDI is an important tool to transfer some technology to developing countries, technology transfer has never been a priority for developed countries as their main criteria is low cost of land and labor, a big domestic market, low tax rates, and other incentives. So it is only in the hands of developing world to develop their own innovation system and to produce high-tech products.

FVA trajectory of developing countries does not follow a linear path. Instead, FVA of developing countries increases at the initial stages of development during low income and lower middle income levels. Later, during middle income and upper middle income stages

FVA ratio decreases and finally when the country reaches high income stage it increases again.

Turkish latecomer firms must not be afraid of temporary drops in their production or export levels if they want to catch-up the leaders. The most critical role in this area belongs to The Turkish State who must give the necessary confidence to private firms in their risk-taking international endeavors. Firstly, the state must be supporting the firms which want to become independent in international markets. Secondly, government must promote private firm's R&D initiatives and public-private partnership in R&D. The last but not the least, in cases of international intellectual property disputes (IPR), the government must help the local firm. Korean case offers valuable insights for the Turkish state and private firms alike.

Cycle time methodology offers much insight especially for middle income countries such as Turkey in their development process. When these countries want to specialize on specific sectors, it is better to concentrate on sectors and technologies with shorter cycle times. Because in those technologies with shorter cycle time, investment requirements are lower in general and catch-up cycles are faster meaning that the country has a higher chance of success in the catch-up process. In this respect, Turkish private firms and state alike must do firstly a breadth-first search and then a depth-first search for possible technologies which are suitable for Turkey and which have short cycle times.

Rejecting CAD strategy altogether may mean that the middle income trap becomes destiny rather than a short period that Turkey must experience before reaching the level of advanced countries.

Windows of opportunities happen for different technologies in different times and do not differentiate between countries. It is important when an institutional window is opened and how to respond nationally in the best way. NIS is a complex network and best response against a window of opportunity is a must if Turkey wants to catch up successfully.

In most cases the various components of NIS works like a chain so the power of chain is measured by the weakest link. It important for all components of NIS such as universities, research laboratories, education system, financial system, and public policy, to have the capability to respond to a new window of opportunity.

Invention and innovation or academic research and technological research cannot be

separated easily as they intermingled within the complex system of NIS. But, technological knowledge is more important for economic development as it is the source of high value added production.

Turkish State must encourage the development of in-house R&D for private firms. As these industrial innovation activities increase, it also creates a demand for academic research as some areas of industry have larger reliance on theoretical knowledge that can only be provided by long term research of academia. These demand and supply of technological knowledge creates a healthy and productive interaction between university and industry.

The relation between industry, technology, and science is a complicated one. Studies show that some sectors need only technology and not much basic science and that some other sectors need more basic science. The machinery is an example to the first and biotechnology is an example to the second one. In this respect, the regions in Turkey must take into account the expertise areas of their local universities and vice versa.

The government can provide technology extension services focused on dissemination of 'good practices' across the economy. Determination and implementation of product and process standards can be used to disseminate 'good practices'. In other words, the government can create policies to raise average national productivity levels by encouraging latecomers to upgrade their products, processes and organizational practices. If such diffusions are targeted to specific products and product chains, the upgrading process can be more effective.

R&D policies have long been used in our country to encourage technological innovation. In recent years, a large number of programs have begun to be implemented to support R&D. In order to make effective use of these programs, the legal framework of R&D policies should be simplified.

Contrary to traditional view that competition policy and industrial policy must be regarded as complementary rather than as substitutes. As the Japanese story indicates, high competition can co-exist with high level state incentives. The historical Turkish case shows that good intentions does not give good results. We claim that a well-planned incentive system can bring high-level of competition to the Turkish private sector. Giving same incentive to all firms or keeping the bar very high or low will not give the desired results (for a personal explanation see Appendix F)

In an automated future for the labor force, mental skills instead of physical skills will be more important. Supplying the young with the indispensable skills of algorithmic reasoning, coding, and critical and creative thinking is utmost responsibility of the State. Turkey needs a big restructuring in education system to obtain these goals for the majority of students.

Policy coordination, especially in the areas of education, infrastructure, innovation and financing, plays a critical role in supporting the simultaneous evolution of product space and framework conditions[9]. In this thesis, we offered product space as a new methodology to connect industrial policy and growth process of Turkey and a well-defined way to speed up the development process.

As a result, in order to attain export-oriented high growth rates required for the long-term development targets, Turkey needs a policy agenda aimed at continuously improving its product space and its physical, human and institutional capital dimensions.

[9] 'framework conditions' is English translation of German phrase "Rahmenbedingungen" and refers to the business and regulatory environment in which a company or economic actor is operating.

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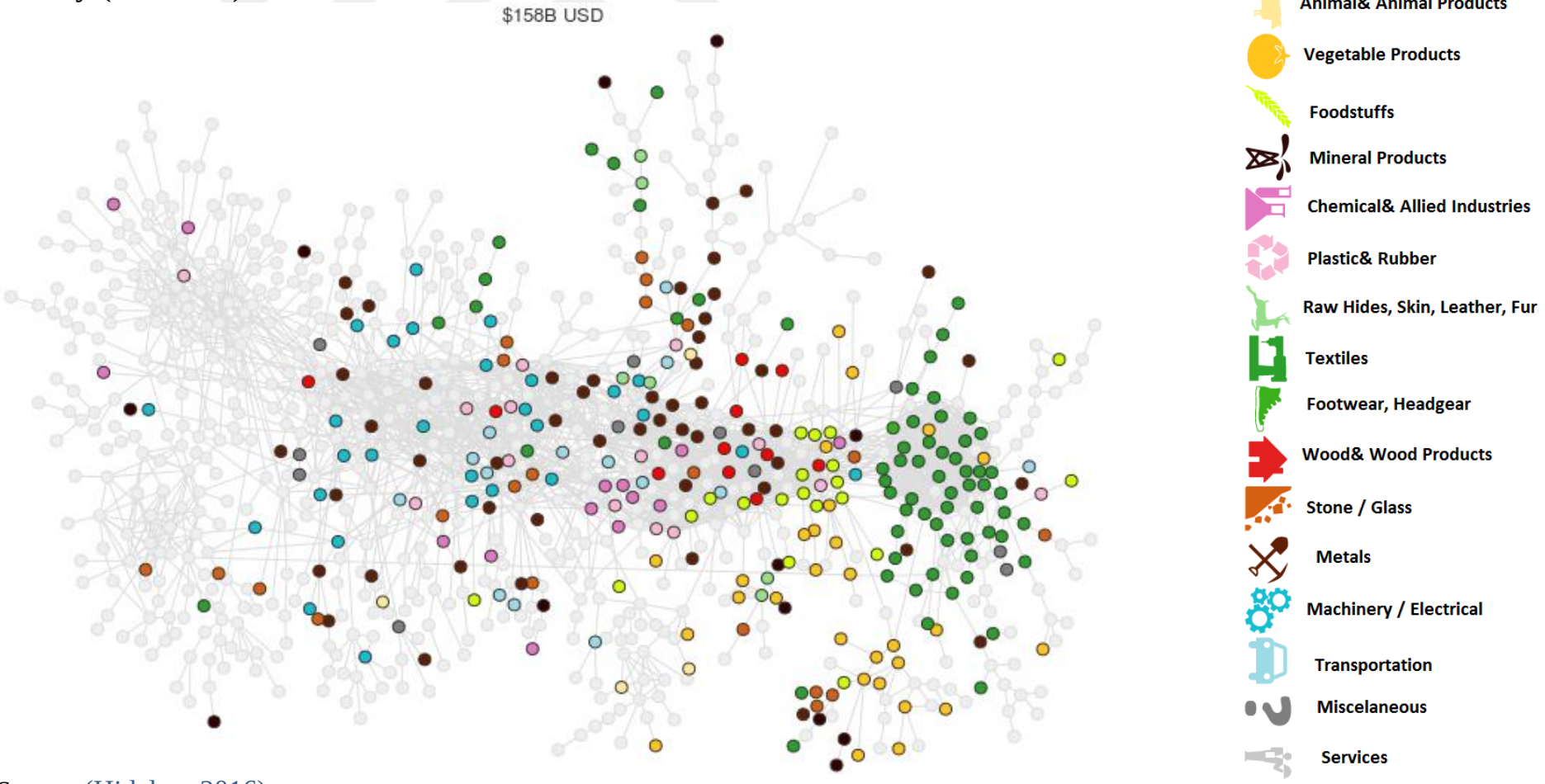
APPENDICES

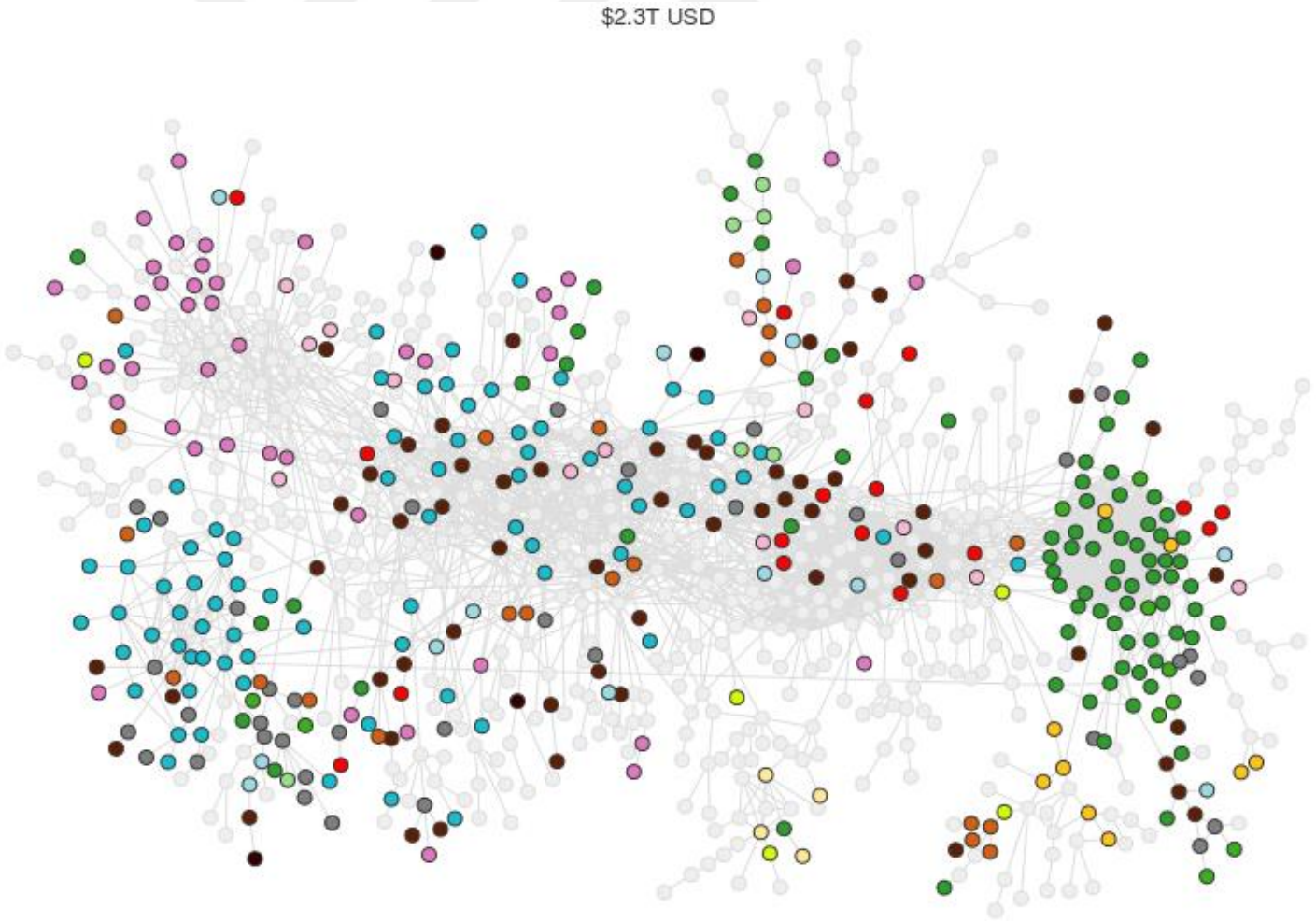
A. PRODUCT SPACES OF SELECTED COUNTRIES (GOODS&SERVICE EXPORTS / GDP %, HIGH-TECH EXPORTS / TOTAL GOODS EXPORTS %)

Turkey (22%, 2%)



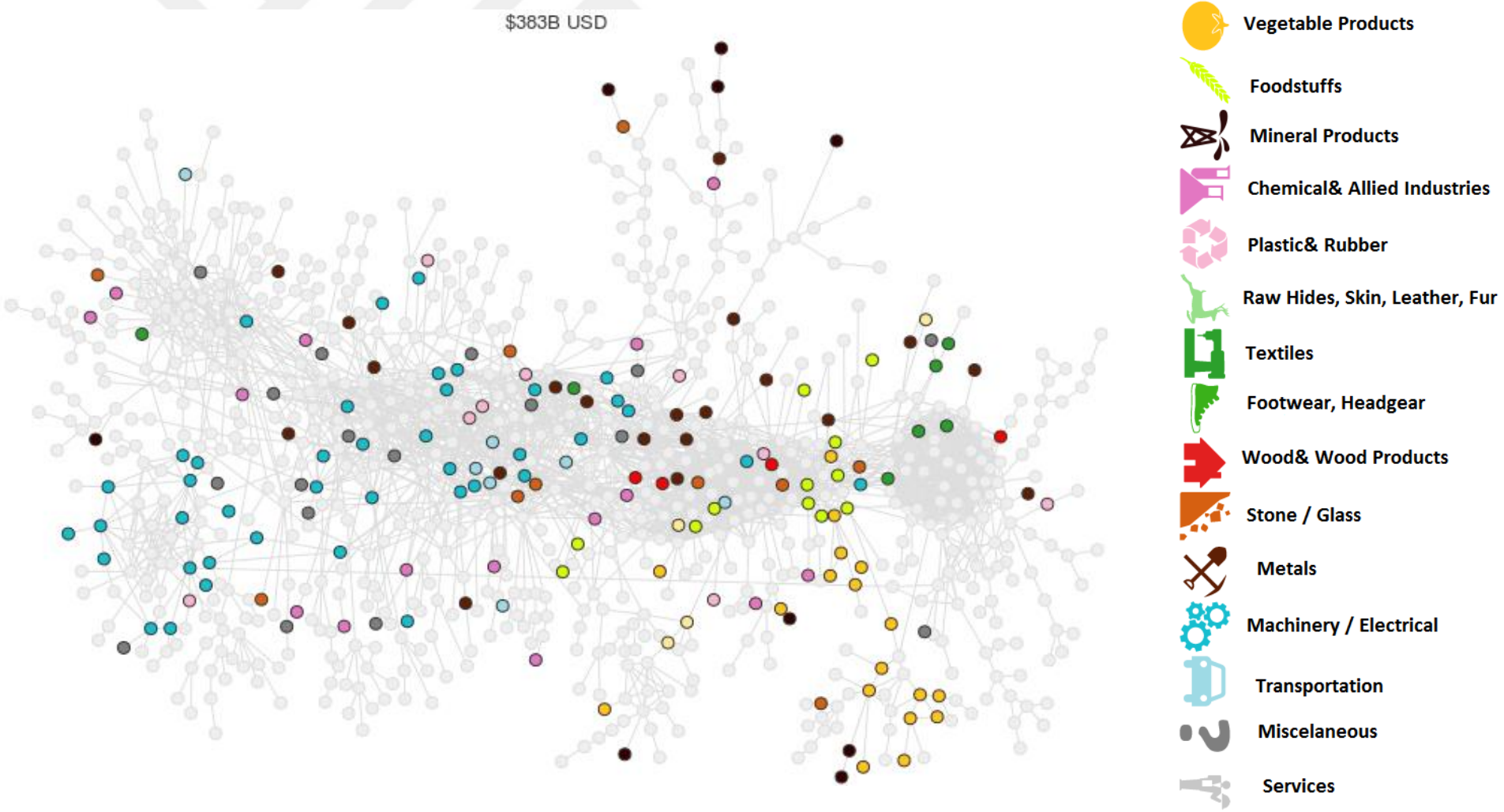
Source: (Hidalgo, 2016)

China (19.6%, 25.2%)

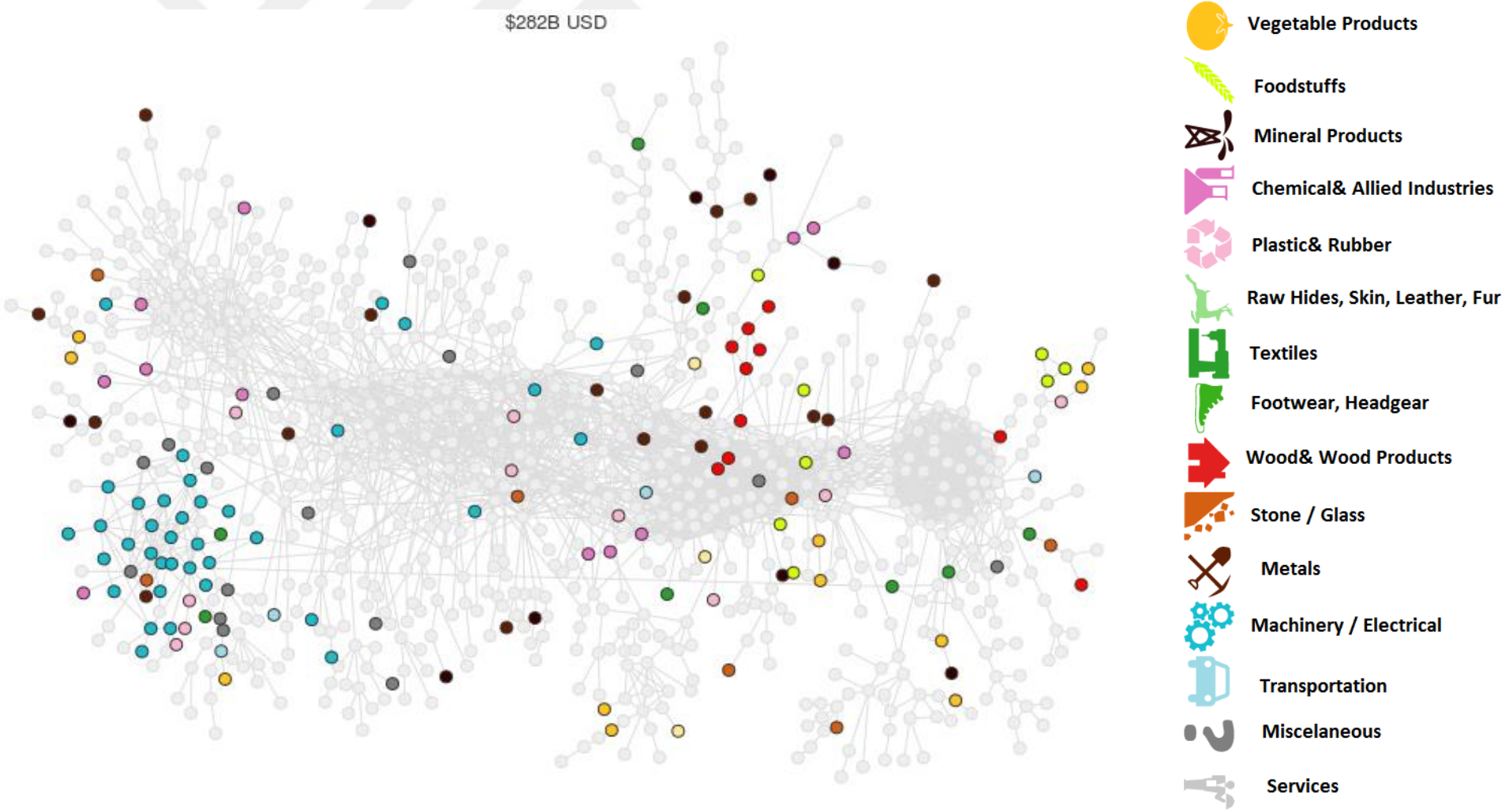


Animal& Animal Products
Vegetable Products
Foodstuffs
Mineral Products
Chemical& Allied Industries
Plastic& Rubber
Raw Hides, Skin, Leather, Fur
Textiles
Footwear, Headgear
Wood& Wood Products
Stone / Glass
Metals
Machinery / Electrical
Transportation
Miscelaneous
Services

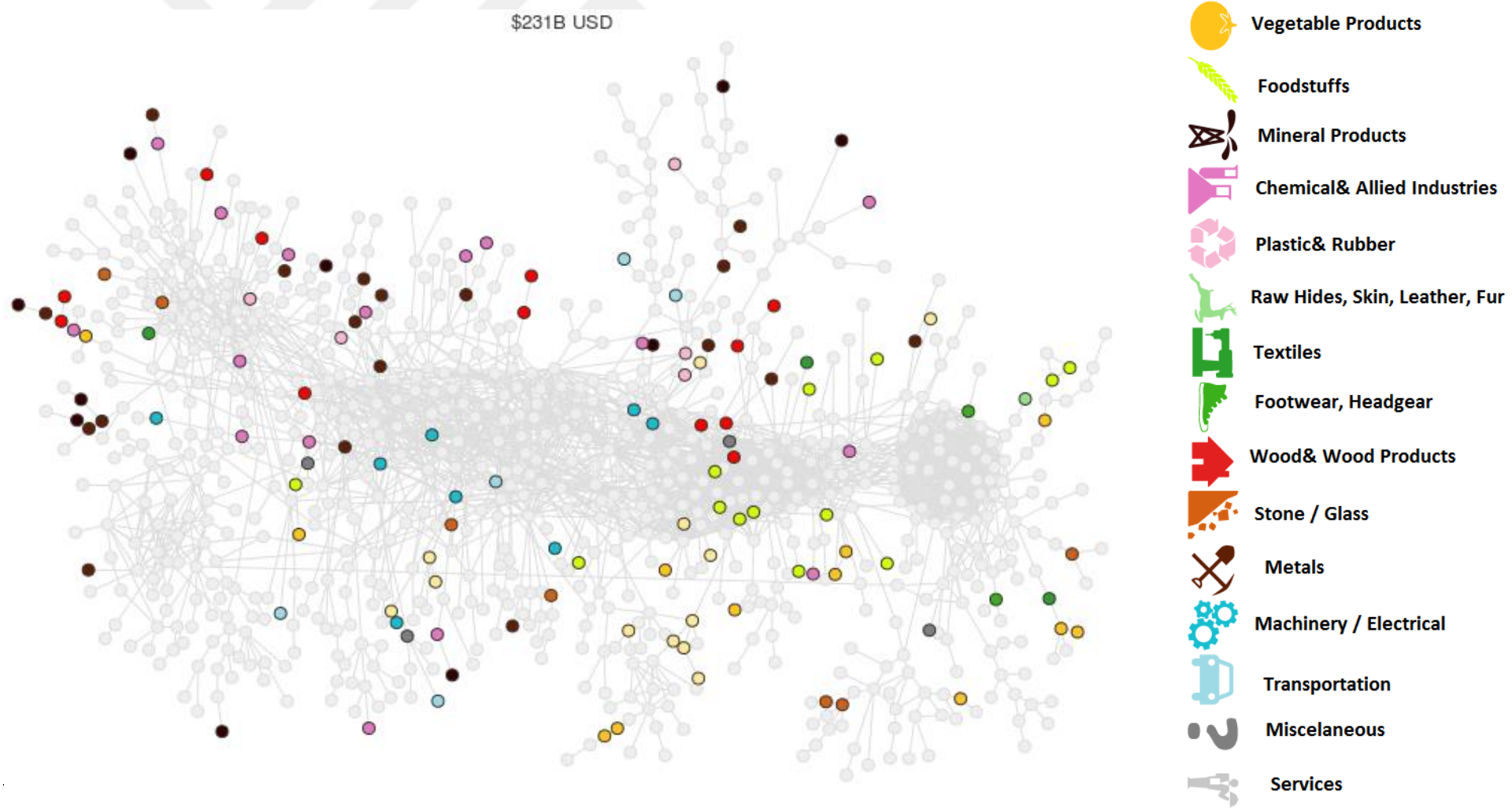
Mexico (38.2%, 15.3%)



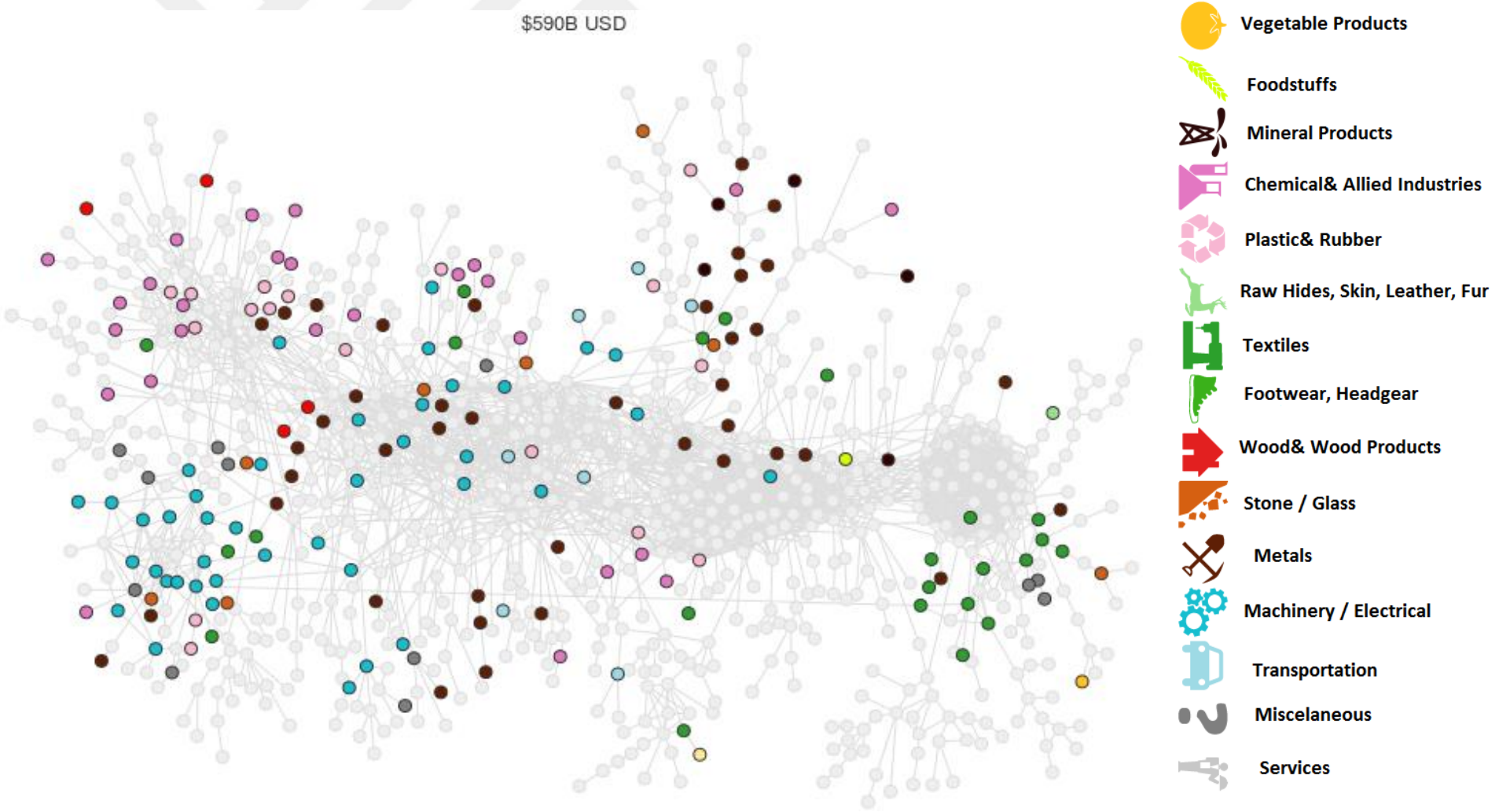
Malaysia (67.7%, 43.0%)



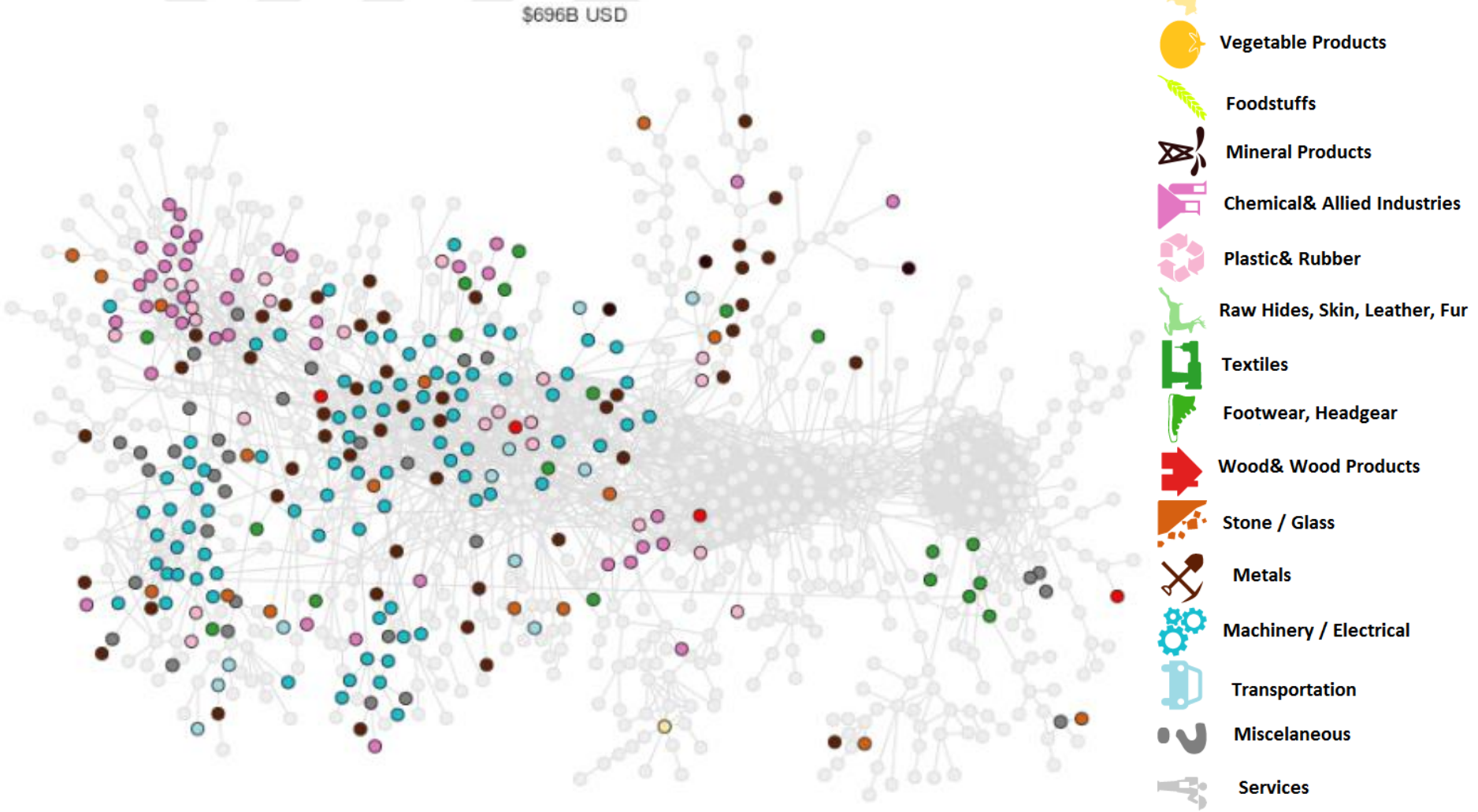
Brazil (12.5%, 13.4%)



South Korea (42.2%, 26.6%)



Japan (16.1%, 16.2%)



B. HIGH-TECH PRODUCTS REACHABLE IN ONE STEP

SITC	Already Exporting Product	RCA	Tech	Proximity	SITC	Similar Potential Product	RCA	Tech
6996	'Miscellaneous Articles of Base Metals'	2.1	3	**0.51**	5413	'Antibiotics'	0.1	5
5169	'Organic Chemicals'	1.3	2	**0.64**	5416	'Glycosides and Vaccines'	0.1	5
7219	'Miscellaneous Agricultural Machinery'	1.1	4	**0.53**	5416	'Glycosides and Vaccines'	0.1	5
5334	'Varnishes and Lacquers'	1.3	4	**0.59**	5417	'Medicaments'	0.2	5
5543	'Polishes for Floors, Footwear and Metals'	2.8	4	**0.60**	5417	'Medicaments'	0.2	5
6428	'Miscellaneous Articles of Paper'	3.8	3	**0.51**	5417	'Medicaments'	0.2	5
6996	'Miscellaneous Articles of Base Metals'	2.1	3	**0.65**	5417	'Medicaments'	0.2	5
7449	'Miscellaneous Parts of Lifting Machinery'	1.2	4	**0.52**	5417	'Medicaments'	0.2	5
5169	'Organic Chemicals'	1.3	2	**0.56**	5419	'Non-Medicinal Pharmaceutical Products'	0.3	5

5334	'Varnishes and Lacquers'	1.3	4	**0.51**	5419	'Non-Medicinal Pharmaceutical Products'	0.3	5
5335	'Glazes'	2.1	4	**0.56**	5419	'Non-Medicinal Pharmaceutical Products'	0.3	5
6637	'Miscellaneous Refractory Goods'	1.1	2	**0.52**	7129	'Miscellaneous Parts of Steam Power Units'	0.0	5
6997	'Miscellaneous Articles of Iron'	1.6	3	**0.53**	7129	'Miscellaneous Parts of Steam Power Units'	0.0	5
7139	'Piston Engine Parts'	2.9	4	**0.54**	7129	'Miscellaneous Parts of Steam Power Units'	0.0	5
7449	'Miscellaneous Parts of Lifting Machinery'	1.2	4	**0.53**	7129	'Miscellaneous Parts of Steam Power Units'	0.0	5
7868	'Non-Mechanically Propelled Vehicles'	1.2	4	**0.51**	7129	'Miscellaneous Parts of Steam Power Units'	0.0	5
6649	'Miscellaneous Glass'	1.3	2	**0.52**	7162	'Electric Motors and AC Generators'	0.8	5
5837	'Polyvinyl Acetate'	2.7	4	**0.51**	7163	'Rotary Converters'	0.3	5
8121	'Central Heating Equipment'	9.2	4	**0.50**	7163	'Rotary Converters'	0.3	5

6649	'Miscellaneous Glass'	1.3	2	**0.54**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
6991	'Locksmith Hardware'	1.7	3	**0.50**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
6997	'Miscellaneous Articles of Iron'	1.6	3	**0.64**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
6998	'Miscellaneous Metal Articles'	1.3	3	**0.51**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
7449	'Miscellaneous Parts of Lifting Machinery'	1.2	4	**0.62**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
7849	'Vehicles Parts and Accessories'	1.3	4	**0.54**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
7861	'Transportation Containers'	1.3	4	**0.57**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
7868	'Non-Mechanically Propelled Vehicles'	1.2	4	**0.63**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
8121	'Central Heating Equipment'	9.2	4	**0.54**	7169	'Miscellaneous Rotating Electric	0.7	5

						Plant Parts'		
8212	'Medical Furniture'	1.0	3	**0.6**	7169	'Miscellaneous Rotating Electric Plant Parts'	0.7	5
5334	'Varnishes and Lacquers'	1.3	4	**0.52**	7188	'Miscellaneous Engines'	0.3	5
5335	'Glazes'	2.1	4	**0.54**	7188	'Miscellaneous Engines'	0.3	5
5837	'Polyvinyl Acetate'	2.7	4	**0.50**	7188	'Miscellaneous Engines'	0.3	5
6210	'Rubber Materials'	2.8	2	**0.52**	7188	'Miscellaneous Engines'	0.3	5
6282	'Transmission Belts'	1.0	2	**0.54**	7188	'Miscellaneous Engines'	0.3	5
6632	'Abrasive Powder'	1.2	2	**0.50**	7188	'Miscellaneous Engines'	0.3	5
6996	'Miscellaneous Articles of Base Metals'	2.1	3	**0.54**	7188	'Miscellaneous Engines'	0.3	5
6997	'Miscellaneous Articles of Iron'	1.6	3	**0.52**	7188	'Miscellaneous Engines'	0.3	5
7211	'Soil Preparation Machinery'	1.3	4	**0.55**	7188	'Miscellaneous Engines'	0.3	5
7283	'Miscellaneous Mineral Working Tools'	2.6	4	**0.57**	7188	'Miscellaneous Engines'	0.3	5
7372	'Rolling Mills'	2.5	4	**0.54**	7188	'Miscellaneous Engines'	0.3	5

7449	'Miscellaneous Parts of Lifting Machinery'	1.2	4	**0.70**	7188	'Miscellaneous Engines'	0.3	5
7822	'Special Purpose Trucks and Vans'	1.4	4	**0.51**	7188	'Miscellaneous Engines'	0.3	5
7849	'Vehicles Parts and Accessories'	1.3	4	**0.52**	7188	'Miscellaneous Engines'	0.3	5
7868	'Non-Mechanically Propelled Vehicles'	1.2	4	**0.58**	7188	'Miscellaneous Engines'	0.3	5
8212	'Medical Furniture'	1.0	3	**0.5**	7188	'Miscellaneous Engines'	0.3	5
8946	'Non-Military Arms'	8.3	3	**0.5**	7188	'Miscellaneous Engines'	0.3	5
5169	'Organic Chemicals'	1.3	2	**0.58**	7741	'Electrical Medical Equipment'	0.1	5
5836	'Acrylic Polymers'	1.5	4	**0.50**	7741	'Electrical Medical Equipment'	0.1	5
7219	'Miscellaneous Agricultural Machinery'	1.1	4	**0.51**	7741	'Electrical Medical Equipment'	0.1	5
6210	'Rubber Materials'	2.8	2	**0.51**	7783	'Automotive Electrical Equipment'	0.9	5
6571	'Felt'	4.8	3	**0.54**	7783	'Automotive Electrical Equipment'	0.9	5
6632	'Abrasive Powder'	1.2	2	**0.50**	7783	'Automotive Electrical Equipment'	0.9	5
6637	'Miscellaneous Refractory Goods'	1.1	2	**0.66**	7783	'Automotive Electrical Equipment'	0.9	5

6994	'Metal Springs'	1.9	3	**0.56**	7783	'Automotive Electrical Equipment'	0.9	5
7139	'Piston Engine Parts'	2.9	4	**0.54**	7783	'Automotive Electrical Equipment'	0.9	5
7372	'Rolling Mills'	2.5	4	**0.52**	7783	'Automotive Electrical Equipment'	0.9	5
7428	'Miscellaneous Pumps'	1.4	4	**0.64**	7783	'Automotive Electrical Equipment'	0.9	5
7810	'Cars'	1.2	4	**0.54**	7783	'Automotive Electrical Equipment'	0.9	5
7849	'Vehicles Parts and Accessories'	1.3	4	**0.60**	7783	'Automotive Electrical Equipment'	0.9	5
7757	'Home Electrical Appliances'	1.0	4	**0.50**	7784	'Power Tools'	0.1	5
6994	'Metal Springs'	1.9	3	**0.64**	8743	'Control Instruments of Gas or Liquid'	0.3	5
5836	'Acrylic Polymers'	1.5	4	**0.52**	8744	'Analog Instruments for Physical Analysis'	0.1	5

C. HIGH-TECH PRODUCTS THAT CAN BE REACHED IN TWO STEPS*

SITC	1. Step Product	RCA	Tech	Proximity	SITC	2. Step Product	RCA	Tech
268	Inorganic Esters	1	2	0.58	289	Vitamins	0.1	5
724	Analog Instruments for Physical Analysis	1	5	0.54	289	Vitamins	0.1	5
565	Miscellaneous Printing Machines	1	4	0.53	292	Hormones	0.0	5
567	Printing Machine Parts	1	4	0.53	292	Hormones	0.0	5
724	Analog Instruments for Physical Analysis	1	5	0.56	292	Hormones	0.0	5
542	Miscellaneous Rotating Electric Plant Parts	1	5	0.55	539	DC Motors	0.1	5
603	Valves	1	4	0.50	539	DC Motors	0.1	5
651	Automotive Electrical Equipment	1	5	0.56	539	DC Motors	0.1	5
286	Printing Ink	1	4	0.52	610	Personal Computers	0.0	5
724	Analog Instruments for Physical Analysis	1	5	0.57	610	Personal Computers	0.0	5

753	Miscellaneous Office and Stationary Supplies	1	3	0.55	610	Personal Computers	0.0	5
760	Sound Recording Media	1	3	0.71	610	Personal Computers	0.0	5
760	Sound Recording Media	1	3	0.53	611	CPUs	0.0	5
315	Epoxide Resins	1	4	0.57	612	Digital storage units	0.0	5
760	Sound Recording Media	1	3	0.56	614	Miscellaneous Data Processing Equipment	0.1	5
540	Electric Motors and AC generators	1	5	0.52	630	Miscellaneous Power Machinery	0.2	5
268	Inorganic Esters	1	2	0.62	637	X-Ray Equipment	0.1	5
286	Printing Ink	1	4	0.57	637	X-Ray Equipment	0.1	5
565	Miscellaneous Printing Machines	1	4	0.53	637	X-Ray Equipment	0.1	5
636	Electrical Medical Equipment	1	5	0.55	637	X-Ray Equipment	0.1	5
724	Analog Instruments for Physical Analysis	1	5	0.54	637	X-Ray Equipment	0.1	5
315	Epoxide Resins	1	4	0.59	646	Diodes, Transistors and Photocells	0.0	5
315	Epoxide Resins	1	4	0.56	647	Electronic Microcircuits	0.0	5

315	Epoxide Resins	1	4	0.55	648	Miscellaneous Electronic Circuit Parts	0.0	5
268	Inorganic Esters	1	2	0.52	722	Mathematical Calculation Instruments	0.2	5
286	Printing Ink	1	4	0.58	722	Mathematical Calculation Instruments	0.2	5
565	Miscellaneous Printing Machines	1	4	0.50	722	Mathematical Calculation Instruments	0.2	5
262	Organo-Sulphur Compounds	1	2	0.50	726	Miscellaneous Electrical Instruments	0.1	5
268	Inorganic Esters	1	2	0.62	726	Miscellaneous Electrical Instruments	0.1	5
286	Printing Ink	1	4	0.56	726	Miscellaneous Electrical Instruments	0.1	5
565	Miscellaneous Printing Machines	1	4	0.56	726	Miscellaneous Electrical Instruments	0.1	5
582	Furnaces	1	4	0.50	726	Miscellaneous Electrical Instruments	0.1	5
724	Analog Instruments for Physical Analysis	1	5	0.57	726	Miscellaneous Electrical Instruments	0.1	5
262	Organo-Sulphur Compounds	1	2	0.52	727	Measuring Instrument Parts	0.2	5
636	Electrical Medical Equipment	1	5	0.52	727	Measuring Instrument Parts	0.2	5

723	Control Instruments of Gas or Liquid	1	5	0.54	727	Measuring Instrument Parts	0.2	5

*RCA of all the products that can be reached in one step are assumed to be 1 and then based on this assumption, the products that are reachable in two steps are computed.

D. MATLAB CODES FOR THE COUNTRY ANALYSIS OF PRODUCT SPACE DATA

Part 1: Evolution of Turkish Product Space

```
%Copyright. Sezai ATA, Ph.D., Yildirim Beyazit University, Ankara, Turkey
% This code checks what is more important in evolution of a country's
product
% space, i-diffusion (new products are similar to already exporting
% products or ii-jump (new products not similar to already exporting
% products)

% First load the needed data from alldata.dat which includes;
% l; 1x775; converts 1-775 code of product to 1x9710 sitc 4digit code of
product,
% name; 1x775; names of products,
% p; 775x775; proximity matrix of all product pairs,
% rca, 1x775; revealed comparative advantage index for all products,
% t; 1x9710; inverse of l, so converts 1x9710 sitc 4digit code of product
to 1-775 code of product,
% sitc; ?x1, all sitcs rev2 4 digit product codes for 1962-2014
% year; ?x1, all sitcs rev2 4 digit products years for 1962-2014
% rca; ?x1, all sitcs rev2 4 digit products rca for 1962-2014

clear all; clc; load alldata.mat; format shortg;
plim=0.5; %lower limit of proximity data so that 2 products with higher
proximity is assumed to be similar
mintech=0; % minimum tech level that a new product must have to be counted
as diffusing from last year
d=zeros(60,52,22); %all resulting data for 60 countries 52 years and 22
variables (to be defined in the code) will be stored in this 3 dimensional
array.

for id=1:60;

rca=rca_([cstart(id) : cend(id)]);
sitc=sitc_([cstart(id) : cend(id)]);
year=year_([cstart(id) : cend(id)]);

for yearno=1963:2014;
str1=num2str(plim);
str1=str1([1 3]);
sheetname=strcat(str1,'-',num2str(mintech));
text1 = iso_weo(id);
text1=text1{1};
text2='_';
text3=origin(id);
text3=text3{1};
text4='.xlsx';
filename=strcat(text1,text2,text3,text4);

newpros=[]; % new product diffusing from last year

if yearno<=1965
intersectpercent=0;
end

if yearno>1965
```

```
y4pre1=sitc(find(year==yearno-4 & rca>=1))'; % all products 4 years ago
with rca>=1
y4pre2=intersect(y4pre1,l); % all standart products 4 years ago with rca>=1
end
if yearno>1964
y3pre1=sitc(find(year==yearno-3 & rca>=1))'; % all products 3 years ago
with rca>=1
y3pre2=intersect(y3pre1,l); % all standart products 3 years ago with rca>=1
end
if yearno>1963
y2pre1=sitc(find(year==yearno-2 & rca>=1))'; % all products 2 years ago
with rca>=1
y2pre2=intersect(y2pre1,l); % all standart products 2 years ago with rca>=1
end

ypre1=sitc(find(year==yearno-1 & rca>=1))'; % all products in previour year
with rca>=1
ypre2=intersect(ypre1,l); % all standart products in previour year with
rca>=1
ypre3=setdiff(ypre1,l); % the products which were not in the standart list
in the previous year

ynow1=sitc(find(year==yearno & rca>=1))'; % all products with rca>=1
ynow2=intersect(ynow1,l); % all standart products with rca>=1
ynow3=setdiff(ynow1,l); % the products which are not in the standart list
ynew=setdiff(ynow2,ypre2); %new products with rca>=1
new=length(ynew); % number of new products
arca=length(ynow2); % # of all product with rca>=1

% intersection of last 5 years products
% This stat measures the continuity level of the product space of a country
if yearno>1965
  intersect1=intersect(y4pre2,y3pre2);
  intersect2=intersect(intersect1,y2pre2);
  intersect3=intersect(intersect2,ypre2);
  intersect4=intersect(intersect3,ynow2);
  intersectpercent=100*length(intersect4)/length(y4pre2);
end


lostpros=setdiff(ypre2,ynow2); % the products which were in the standart
list in the previous year but not this year
lostpercent=100*length(lostpros)/length(ypre2); % percent ratio of lost
products to last year products

newpercent=100*length(ynew)/length(ypre2); % percent ratio of new products
to last year products

alltech0pros=name(t(ynow2(find(tech(t(ynow2))==0)))); % list of all
products with rca>=1 and tech level=0 'all tech'
alltech1pros=name(t(ynow2(find(tech(t(ynow2))==1))));
alltech2pros=name(t(ynow2(find(tech(t(ynow2))==2))));
alltech3pros=name(t(ynow2(find(tech(t(ynow2))==3))));
alltech4pros=name(t(ynow2(find(tech(t(ynow2))==4))));
alltech5pros=name(t(ynow2(find(tech(t(ynow2))==5))));

at0=length(alltech0pros); % # all products with rca>=1 and tech level=0
'all tech'
at1=length(alltech1pros); % # all products with rca>=1 and tech level=1
at2=length(alltech2pros); % # all products with rca>=1 and tech level=2
```

```
at3=length(alltech3pros); % # all products with rca>=1 and tech level=3
at4=length(alltech4pros); % # all products with rca>=1 and tech level=4
at5=length(alltech5pros); % # all products with rca>=1 and tech level=5

k=0;
ypre2=ypre2';
ynew=ynew';
for i=ypre2;
  for j=ynew;
     if p(t(i),t(j))>=plim && tech(t(j))>=mintech;
     k=k+1;
     newpros(k)=t(j); %new product diffusing from last year
     end
  end
end

newpros=unique(newpros); % new product diffusing from last year
diffuser=length(newpros); %number of new products diffusing from last year
difpercent=diffuser/new*100; %portion of diffusing products in all new
products

nt0=length(ynew(tech(t(ynew))==0)); % # of new products with rca>=1 and
tech level=0
nt1=length(ynew(tech(t(ynew))==1)); % # of new products with rca>=1 and
tech level=1
nt2=length(ynew(tech(t(ynew))==2)); % # of new products with rca>=1 and
tech level=2
nt3=length(ynew(tech(t(ynew))==3)); % # of new products with rca>=1 and
tech level=3
nt4=length(ynew(tech(t(ynew))==4)); % # of new products with rca>=1 and
tech level=4
nt5=length(ynew(tech(t(ynew))==5)); % # of new products with rca>=1 and
tech level=5

d(id,yearno-1962,:)=[yearno arca new diffuser difpercent lostpercent
newpercent intersectpercent plim mintech at0 at1 at2 at3 at4 at5 nt0 nt1
nt2 nt3 nt4 nt5];
data(yearno-1962,:)=[yearno arca new diffuser difpercent lostpercent
newpercent intersectpercent plim mintech at0 at1 at2 at3 at4 at5 nt0 nt1
nt2 nt3 nt4 nt5];
end

end

 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  PLOTTING
% This part plots all countries' and all variables by dividing countries
% into three group 1-high-income, 2-midlle-income, 3-low-income
header={'Year','Number of All Products','Number of All New
Products','Number of Diffusers','Percent of Diffusers','Percent of Lost
Products','Percent of New Products','Percent of Commons in Last 5
Years','Lower Bound for Proximity','Minimum Tech Level','at0', 'at1',
'at2', 'at3', 'at4', 'at5', 'nt0', 'nt1', 'nt2', 'nt3', 'nt4', 'nt5'};
headers={'Year','NumAllPro','NumAllNewPro','NumDiffusers','PercentDiffuser'
,'PercentLostPro','PercentNewPro','PercentCommon5Year','ProxLowBound','MinT
echLevel','AllTech0', 'AllTech1', 'AllTech2', 'AllTech3', 'AllTech4',
'AllTech5', 'NewTech0', 'NewTech1', 'NewTech2', 'NewTech3', 'NewTech4',
'NewTech5'};
% 'Year'1,'Number of All Products'2,'Number of All New Products'3,'Number
of Diffusers'4,'Percent of Diffusers'5,'Percent of Lost Products'6,'Percent
of New Products'7,
```

```
%'Percent of Commons in Last 5 Years'8,%'Lower Bound for
Proximity'9,'Minimum Tech Level'10
%'at0'11, 'at1'12, 'at2'13, 'at3'14, 'at4'15, 'at5'16, 'nt0'17, 'nt1'18,
'nt2'19, 'nt3'20, 'nt4'21, 'nt5'22};

for varid=1:22;
filename1=strcat('Low--',headers(varid),'.png');
filename2=strcat('Mid--',headers(varid),'.png');
filename3=strcat('Hig--',headers(varid),'.png');

q=0;
figure
for i=1:60;
  if income(i)==1;
    q=q+1;
  subplot(5,3,q);
plot(d(i,:,1),d(i,:,varid));
xlim([1962 2014]);
title(origin(i));
ax = gca;
ax.XTick = [1962:13:2014];
set(gca,'fontsize',6)
  end
end
print('-dpng', filename1{1}, '-r250')
close(gcf)

q=0;
figure
for i=1:60;
  if income(i)==2;
    q=q+1;
  subplot(5,4,q);
plot(d(i,:,1),d(i,:,varid));
xlim([1962 2014]);
title(origin(i));
ax = gca;
ax.XTick = [1962:13:2014];
set(gca,'fontsize',6)
  end
end
print('-dpng', filename2{1}, '-r250')
close(gcf)

q=0;
figure
for i=1:60;
  if income(i)==3;
    q=q+1;
  subplot(5,5,q);
plot(d(i,:,1),d(i,:,varid));
xlim([1962 2014]);
title(origin(i));
ax = gca;
ax.XTick = [1962:26:2014];
set(gca,'fontsize',6)
  end
end
```

```
print('-dpng', filename3{1}, '-r250')
close(gcf)

end
```

Part 2: Products Reachable in 1-Step

```
% THIS CODE FINDS ALL HIGH-TECH PRODUCTS REACHABLE IN ONE STEP
% load necessary data which is the following;
% l; 1x775; converts 1-775 code of product to 1x9710 sitc 4digit code of
product,
% name; 1x775; names of products,
% p; 775x775; proximity matrix of all product pairs,
% rca, 1x775; revealed comparative advantage index for all products,
% t; 1x9710; inverse of l, so converts 1x9710 sitc 4digit code of product
to 1-775 code of product,

clc; clear all; format shortg; load data.mat;
% define lower and upper bounds for proximity and rca
proximity_low_limit=0.5;
rca_low_limit=0.0;
rca_up_limit=1;

onestep=[]; % will give all high-tech products similar to each rca>1
product
for i=1:775;
  count=0;
   if rca(i)>1
    for j=1:775;
      if
(p(i,j)>=proximity_low_limit)&&(rca(j)<rca_up_limit)&(rca(j)>=rca_low_limit
)&((tech(j)==5)|(tech(j)==5));
        count=count+1;
        onestep(i,count)=j;
      end
    end
  end
end

onestep(775,:)=0; % fill in blanks with zero until 775 to make it sure size
is 775
allhightech=[];

 for i=1:775;
   if onestep(i,1)>0
     allhightech=[allhightech onestep(i,:)];
   end
 end
 allhightech=allhightech(allhightech~=0); % delete zeros
 list=unique(allhightech); % delete repeating values
 out1=[list; l(list); histc(allhightech,list); tech(list); rca(list)]';
%product code,name, # of similar products


[row,column] = size(onestep);
table=[];
for i=1:row;
  for j=1:column;
    if onestep(i,j)~=0;
      table=[table; l(i) name(i) rca(i) tech(i) p(i,onestep(i,j))
l(onestep(i,j)) name(onestep(i,j)) rca(onestep(i,j)) tech(onestep(i,j))];
    end
```

```
  end
end
% write the table to excel file
filename = 'onestep_tech5.xlsx';
col_header={'No','sitc','Frequency','Tech', 'RCA'};
xlswrite(filename,col_header,'shortlist','A1');   %Write column header
xlswrite(filename,out1,'shortlist','A2');   %Write data

col_header2={'sitc','Name','RCA','Tech',
'Proximity','sitc','Name','RCA','Tech'};
xlswrite(filename,col_header2,'longlist','A1');   %Write column header
xlswrite(filename,table,'longlist','A2');     %Write data
%}
```

Part 3: Products Reachable in 2-Step

```
% ASSUME THE COUNTRY REACHED ALL ONE-STEP PRODUCTS
% FIND ALL HIGH-TECH PRODUCTS REACHABLE IN 2 STEP
%  FIRST RUN analysis2.m
format shortg; load data.mat;

proximity_alt_limit=0.5;
rca_alt_limit=0.0;
rca_ust_limit=1;
c3=[];
for i=1:775;
    count=0;
     if rca2(i)>1
        for j=1:775;
            if
(p(i,j)>proximity_alt_limit)&(rca2(j)<rca_ust_limit)&(rca2(j)>=rca_alt_limi
t)&((tech(j)==5)|(tech(j)==5));
                count=count+1;
                c3(i,count)=j;
            end
        end
    end
end
c3(775,:)=0;
all3=[];
 for i=1:775;
     if c3(i,1)>0
         all3=[all3 c3(i,:)];
     end
 end
 all3=all3(all3~=0);
 a3=unique(all3);
 out3=[l(a3); histc(all3,a3); tech(a3); rca(a3)]';
 namethis3=name(a3)';

[satir,sutun] = size(c3);
ikili3=[];
for i=1:satir;
    for j=1:sutun;
        if c3(i,j)~=0;
           ikili3=[ikili3; i name(i) rca2(i) tech(i) p(i,c3(i,j)) c3(i,j)
name(c3(i,j)) rca2(c3(i,j)) tech(c3(i,j))];
        end
    end
end
filename = 'twostep_tech5.xlsx';

col_header={'sitc','# of Similar Products','Tech', 'RCA', 'Product'};
xlswrite(filename,col_header,'shortlist','A1');     %Write column header
xlswrite(filename,out3,'shortlist','A2');     %Write data
xlswrite(filename,name(a3)','shortlist','E2');     %Write data

col_header2={'sitc','Name','RCA','Tech',
'Proximity','sitc','Name','RCA','Tech'};
xlswrite(filename,col_header2,'longlist','A1');     %Write column header
xlswrite(filename,ikili3,'longlist','A2');     %Write data
```

Part 4: Shortest Paths

```
%This Code answer the question:
%What are the shortest paths to the products which are not in Turkey's
Export Basket?
%Analysis shows that there are no new connections after 4th iteration
load data.mat
plimit=0.5;
p1=p;
p1(p1<plimit)=0;
p1(p1>plimit)=1;
p1(p1==plimit)=1;
%%%%%%%%%%%%%%%%%%%%
s=p1;
step1=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step1=[step1; i j];

        end
end
end
list1=unique(step1(:,2))';
%%%%%%%%%%%%%%%%%%%%
s=p1^2;
step2=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step2=[step2; i j];

        end
end
end
list2=unique(step2(:,2))';
%%%%%%%%%%%%%%%%%%%%
s=p1^3;
step3=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step3=[step3; i j];

        end
end
end
list3=unique(step3(:,2))';
%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%
s=p1^4;
step4=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0
```

```
            step4=[step4; i j];

        end
end
end
list4=unique(step4(:,2))';
%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%
s=p1^5;
step5=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step5=[step5; i j];

        end
end
end
list5=unique(step5(:,2))';
%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%
s=p1^6;
step6=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step6=[step6; i j];

        end
end
end
list6=unique(step6(:,2))';
%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%
s=p1^7;
step7=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step7=[step7; i j];

        end
end
end
list7=unique(step7(:,2))';
%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%
s=p1^8;
step8=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step8=[step8; i j];
```

```
        end
end
end
list8=unique(step8(:,2))';
%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%
s=p1^9;
step9=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step9=[step9; i j];

        end
end
end
list9=unique(step9(:,2))';
%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%
s=p1^10;
step10=[];
for i=1:775;
for j=1:775;
        if rca(i)>1 && rca(j)<1 && tech(j)==5 && s(i,j)>0

            step10=[step10; i j];

        end
end
end
list10=unique(step10(:,2))';
%%%%%%%%%%%%%%%%%%%%%%%%
u1=list1;
union1=list1;
u2=setdiff(list2,list1);
union2=union(union1,list2);
u3=setdiff(list3,union2);
union3=union(union2,list3);
u4=setdiff(list4,union3);
union4=union(union3,list4);
u5=setdiff(list5,union4);
union5=union(union4,list5);
u6=setdiff(list6,union5);
union6=union(union5,list6);
u7=setdiff(list7,union6);
union7=union(union6,list7);
u8=setdiff(list8,union7);
union8=union(union7,list8);
u9=setdiff(list9,union8);
union9=union(union8,list9);
u10=setdiff(list10,union9);

% 21 products are not connected to the Turkey's products
% if we do not relax proximity lower threshold=0.5
```

E. STATE SUPPORTS IN IMPLEMENTATION

State support in practice is monitored by the Undersecretariat of Treasury General Directorate of State Supports and a list of legislation that constitutes the basis for support applications is published. Below is a list of state subsidies directly related to the manufacturing industry.

MINISTRY OF SCIENCE, INDUSTRY AND TECHNOLOGY

- Supporting Industrial Thesis Projects
- Supporting Research, Development and Design Activities
- Promotion and Marketing of Technological Products
- Technological Product Investment Support Program
- Technology Development Zones
- Organized Industrial Zones
- Cluster Support Program

MINISTRY OF ECONOMY

- State Aids in Investments
- Project-Based Government Assistance to Investments
- Attraction Centers Program
- State Aids for Exports
    - Employment assistance
    - Branding of Turkish Products Abroad,
    - Enhancement of Turkish Product Image and TURQUALITY Design Support
    - Support for Brand and Promotion Activities Abroad
    - Supporting the Development of International Competitiveness
    - Market Research and Market Entry Support
    - Supporting Sectoral Qualified International Fairs in Turkey
- Supporting Market Entry Documents
- Supporting Fair Participations Abroad
- State Aids for Technical Consultancy Services
- Supporting Foreign Exchange Earning Service Trade
- Foreign Exchange Earning Service Sectors Branding Supports
- Inward processing regime
- Free Zones

MINISTRY OF ENERGY AND NATURAL RESOURCES

- Supporting Energy Efficiency Enhancement Projects in Industrial Firms
- Energy Sector Research and Development Projects Support Program (ENAR)

MINISTRY OF DEVELOPMENT

- Development Agencies Project and Activity Supports
    - Interest Support
    - Interest-Free Credit Support
    - Direct Financing Support

MINISTRY OF TRANSPORT, MARITIME AND COMMUNICATIONS

- Supporting Research and Development Projects

CREDIT GUARANTEE FUND

- Credit Guarantee Support

TECHNOLOGY DEVELOPMENT FOUNDATION OF TURKEY

- Environmental Project Supports
- Support for Advanced Technology Projects
- Support for Technology Development Projects
- Support for Commercialization Projects

TUBITAK TECHNOLOGY AND INNOVATION SUPPORT PROGRAMS

- Industry Research Technology Development and Innovation Projects Support Program
- Project Markets Support Program
- University-Industry Cooperation Support Program
- SME R&D Start Support Program
- International Industrial R&D Projects Support Program
- Priority Areas Research Technology
- Development and Innovation Support Program
- Entrepreneurship Progressive Support Program
- Technology Transfer Offices Support Program
- Venture Capital Support Program
- Preliminary R&D Laboratories Support Program

- Support for Capacity Building in Innovation Entrepreneurship Areas
- TÜBİTAK Patent Support Program

SMALL AND MEDIUM ENTERPRISES DEVELOPMENT ORGANIZATION (KOSGEB)

- KOSGEB Support Programs
    - General Support Program
    - Entrepreneurship Support Program
    - SME Project Support Program
    - Thematic Support Program
    - Collaboration- Union of Force Support Program
    - Research-Development Innovation and Industrial Application Support Program
    - Developing Business Market SME Support Program
    - International Incubator Center and Accelerator Support Program
    - KOBIGEL SME Development Support Program
    - Technological Product Promotion and Marketing (Teknopazar) Support Program
    - SME Technological Product Investment (SME Teknoyatırım) Support Program
    - Strategic Product Support Program
- KOSGEB SME Loan Interest Support

EXPORT CREDIT BANK OF TURKEY

- Export Credits, Buyer Referrals and Receivable Insurance

CENTRAL FINANCE AND CONTRACTS UNIT

- Instrument for Pre-Accession Assistance (IPA) Supports

Source: Undersecretariat of Treasury, General Directorate of State Aids, https://www.treasury.gov.tr/state-aids-about-us?type=icon

F. BEHAVIORAL ROOTS OF INCENTIVES: MICRO ANALYSIS OF PRIMARY SCHOOL PUPILS

My older son Ahmet Turan is in 4th grade. His school is close to my workplace, and once or twice a week I visit his class and ask questions with small rewards for the winner. At the beginning I was making a pairwise elimination tournament and asking a classical guessing game for each pair in which a random number generator (downloaded to my smart phone) produces a number between 1-100 and two players make guesses simultaneously at each round. I respond by declaring that their guesses are above or below the chosen random number until one of the students find the number. All students go crazy for this game as it requires no knowledge or strategy[10] and their winning chances are almost equal.

Other kinds of problems includes mathematical ones such as 'How many squares are there in a chess board?', or 'What is the least nonnegative integer which requires 20 letters to write in Turkish?'[11] Student behavior for these questions depends on

i. the mood of the student on the day,
ii. the reward of the problem, and
iii. perceived probability of winning

Most acute problems I encounter are;

i. If I ask difficult questions, even the most talented students do not participate.
ii. If I always ask mathematical problems, a few talented students win all the rewards and other students are pissed off and quit participating after some time.
iii. If I ask questions such that winners are decided by chance most of the time, participation is very high but there is no progress in the problem solving skills of students.

To solve these problems, in the next rounds of competitions, I plan to ask individualized questions suitable for the level of each student.

[10] Actually there is a stochastic strategy for maximizing the winning chance but large number of students makes it almost obsolete and most of the time winner is decided by chance alone.

[11] Try it yourself! Check out https://oeis.org/A305100 for the answer!

G. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Ata, Sezai

Nationality: Turkish (TC)

Date of Birth: 1 January 1978

Place of Birth: Aksaray /Turkey

sata@dpt.gov.tr

EDUCATION

Degree	Institution	Year of Graduation
Ph.D.	AnkaraYıldırım Beyazıt University, Economics	2018 (Expected)
MS	University of Minnesota, Mathematics	2004
BS	Koç University, Mathematics	2000

PROFESSIONONAL EXPERIENCE

Year	Place	Title
2018-	Presidency of the Republic of Turkey, Directorate of Strategy and Budget	Strategy and Budget Expert
2010-2018	Ministry of Development	Planning Expert
2005-2010	State Planning Organization	Associate Planning Expert
2003-2004	University of Minnesota	Research Assistant
2000-2003	University of Minnesota	Teaching Assistant

FOREIGN LANGUAGES

Turkish (Native), English (Fluent), German (Intermediate)

AWARDS AND HONORS

Winner of Mental Game Competition 2008 (Soru Maratonu) organized by Turkish Intelligence Foundation (Türkiye Zeka Vakfı)

Koç University, Full Scholarship, 1995-2000

Koç University, Recepient of Vehbi Koc Honors Medal, 1998

PUBLICATIONS AND CONFERENCE PAPERS

Ata, Sezai, "The Macroeconomic Effects of Credit Regulations", International Conference on Eurasian Economies in Tashkent, UZBEKISTAN, 18-20 June 2018

Ata, Sezai, "Turkey's Trade with Neighbor Countries: A Gravity Model Analysis", International Conference on Eurasian Economies in St. Petersburg, RUSSIA, 17-18 September 2013

Ata, Sezai, "Turkey's Export Potential: A Gravity Model Analysis", International Conference on Eurasian Economies in Almaty, KAZAKSTAN, 11-13 October 2012

Ata, Sezai, "Symmetric Interval Orders and Signed Posets", Master Thesis, University of Minnesota, School of Mathematics, 2004

H. TURKISH SUMMARY

Uluslararası ticaret analizi, ekonomistler arasında sıcak bir konudur. Basit doğrusal regresyon modellerinden daha gelişmiş çekim (Ata, 2012) veya entropi (Mastrandrea, et al., 2014) modellerine kadar çeşitli yöntemler uluslararası ticaret analizi için kullanılmaktadır. Ülkelerin toplam ticaret seviyelerinin analizi genel bir bakış açısı sunmasına rağmen, uluslararası ticaret ağının (ITN) mikro düzeydeki yapısının birçok önemli yönünü gözden kaçırabilmektedir. Karmaşık ağlar (complex networks) teorisi, ilk olarak fizikçiler tarafından fiziksel sistemlerin dinamiklerini incelemek için geliştirilmiş, sonrasında ve özellikle son dönemde ise bankalar arası kredi ağı ve ülkeler arası doğrudan yabancı yatırım ağı gibi birçok alanda sistem dinamiklerini analiz etmek için tercih edilen bir yöntem haline gelmiştir.

Bu tez uluslararası ticaret ağını ürün uzayı metodu kullanarak analiz etmektedir. Ürün uzayı, küresel olarak ticareti yapılan tüm ürünlerden oluşan bir yapıdır. Matematiksel olarak, bir ağ sadece basit bir grafiktir. Bir ağ, düğümler ("köşe" veya basitçe "nokta" olarak adlandırılır) ve bu düğümlerin bazılarını birbirine bağlayan kenarlardan oluşur. Ürün uzayı düğümleri, ürünlerin kendileridir. Ürünler arasındaki kenarlar, farklı yöntemlerle tanımlanabilirler. Ancak standart olan yöntemde, birbirlerine yeterince benzer iki ürün birbirine bağlanır. İki ürünü benzer olarak tanımlayabilmek için ürünlerden birini rekabetçi olarak ihraç eden ülkelerin belli bir orandan fazlasının diğer ürünü de rekabetçi olarak ihraç edebilmesi gerekmektedir. Literatürde bu sınır oran genellikle 50% olarak kabul edilmektedir.

Ürün uzayını anlamanın iyi bir yolu, ürün uzayını bir ormana, her bir ürünü bir ağaca ve ülkeleri de bu ormanda yaşayan maymunlara benzetmektir. Maymun, farklı ağaçlardan farklı meyveler yiyerek ağaçların üzerinde yaşamaktadır. Bazı ağaçlar daha fazla ve lezzetli meyvelere sahipken, diğerleri daha az ve çok lezzetli olmayan meyvelere sahiptir. Zamanla maymun, daha iyi meyveleri bulmak için ormanı araştırmaya başlar. Benzetmeden yola çıkarak, bir ülkenin "daha tatlı" meyvelerin bulunduğu orman bölgelerini bulabilmesi için ağaçtan ağaca sıçrama yaparak ilerlemesi gerekmektedir.

Ağaçların ve meyvelerin eşit dağıldığı homojen bir ormanda, maymunun endişelenecek bir şeyi yoktur. Komşu ağaçlara rastgele atlama yapabilir ve yeni meyvelerin tadını çıkarabilir. Fakat ormandaki ağaçlar ve meyveler eşit dağılmadığı durumda maymun hangi yöne gideceğine karar vermek zorundadır. Daha tatlı meyveleri olan ağaçlar, ormanın derin ve uzak kısımlarında yoğunlaşabilir.

Uluslararası ticaret verileri incelendiğinde, ürün uzayının homojen bir yapıda olmadığı, ıssız

Sahra çöllerinden sık Amazon ormanlarına hatta korkutucu çıkmaz sokaklara kadar çok farklı karmaşık ağ yapılarına sahip olduğunu görmekteyiz.

İhracat seviyesini artırmak için çeşitli yöntemler bulunmaktadır. Bu yöntemlerin birisi ihracatın hacmini artırmaya odaklanmak ve ihracat ürünlerinin yoğunluğunu veya çeşitliliğini ikinci planda tutmaktır. Türkiye'nin geçmişte uyguladığı ithal ikame politikalarının çoğu bu türdendir. Günümüzde, yüksek teknolojili ve katma değerli ürünlerin önemini daha iyi anlaşılmaktadır. Bu bakımdan, yüksek teknolojili ürün ihracatını destekleyen yeni bir ihracat teşvik mekanizmanın geliştirilmesi ülkemiz için büyük öneme sahiptir.

Son yirmi yılın ekonomi politikaları, hükümetin piyasaya çok fazla müdahale ettiği görüşüne dayanmaktadır. Bu görüşün bir sonucu olarak, hükümetler özellikle gelişmekte olan ülkelerde piyasa düzenlemeleri, ticareti kısıtlayıcı uygulamalar ve kamu mülkiyetinden büyük oranda vazgeçmişlerdir. Yakın geçmişteki başarısız ithal ikame politikalarına gösterilen tepki, hükümetlerin gerektiğinde ekonomik sisteme müdahale etme becerilerini zayıflatmıştır.

Liberalizasyon ve özelleştirme uygulamaları beklenen faydayı sağlamadığından dolayı, hükümetler özellikle küresel finansal kriz sonrası daha dengeli bir stratejiye yönelmeye başlamışlardır. İyi formüle edilmiş sanayi politikaları, bu stratejilerin önemli bir parçası olarak önem kazanmaktadır. Ancak iyi formüle edilmiş politika setleri, yüksek talep görmelerine rağmen geliştirilmeleri oldukça zordur.

Teşvik sisteminin ihracatın teknoloji seviyesinin yükseltilmesi için önemli olduğu geçmişte politika yapıcılar tarafından iyi şekilde anlaşılmış olmasına rağmen, iyi bir ihracat teşvik sisteminin en uygun yapısının bulunması geçmişte zor olduğu ve günümüzde de zordur. Bu tezde, optimal ihracat teşvik sisteminde olması gereken bazı özellikler ele alınmıştır. Bu bakış açısıyla, devlet geç kalmış firmaları ürünlerini, süreçlerini ve kurumsal uygulamalarını iyileştirmeye teşvik ederek ortalama ulusal verimlilik seviyelerini yükseltmek için politikalar oluşturabilir. Bu tür difüzyonlar belirli ürünlere ve ürün zincirlerine odaklanmışsa, ürün uzayının yüksek teknolojili merkez ürünlerine ulaşma süreci daha hızlı olmaktadır. Bu bakış açısı tezin ana fikrini oluşturmaktadır.

Literatüre

Özellikle, yakalama döngüleri ve fırsat pencereleri söz konusu olduğunda, risk iştahı, liderleri yakalamak için uygun koşullardan yararlanılmasında çok önemlidir. Riske giren firmalar için devlet desteği sağlanması firmaların riske girme iştahlarının artmasını sağlamaktadır. Risk

iştahını artırmaya yönelik teşvikler, kalkınma bankalarının kapasitesinin önemli ölçüde artırılması, uzun vadeli ticari banka kredileri için kamu garantisi verilmesi, bazı kamu emeklilik fonu varlıklarının yüksek riskli yatırımlara yönlendirilmesi gibi ihracatçı firmalara özelleştirilmiş bazı araçlar sunmayı gerektirmektedir. Türkiye Varlık Fonu A.Ş.'nin fonunun bir kısmını yüksek riskli yüksek teknolojili ürün yatırımlarına yönlendirmesi önerimiz bu bağlamda değerlendirilmelidir.

Uluslararası pazarlar incelendiğinde üç çeşit firmanın olduğunu görmekteyiz: OEM, ODM ve OBM. Bu tezin iddialarından biri, büyük Türk firmalarının, daha gelişmiş rakiplerine karşı büyük mücadelelerden kaçınmalarıdır. Koreli ve Çinli firmalar yakalama stratejileri kullanırken ve OEM-ODM-OBM yolunu takip ederken, Türk firmaları ODM veya daha alt seviyede kalmışlardır. Ürün uzayı metodolojisi, yerli firmaların rakiplerini yakalama sürecinde yardımcı olacak bir bakış açısı sunmaktadır.

Döngü süresi (cycle time) metodolojisi, özellikle Türkiye gibi gelişmekte olan ülkelere büyük fırsatlar sunmaktadır. Bu ülkelerin gelişmiş ülkelere ait lider firmaları yakalama konusunda daha kısa çevrim sürelerine sahip sektörlere ve teknolojilere yoğunlaşmaları daha faydalıdır. Çünkü daha kısa döngü süresine sahip olan teknolojilerde, yatırım gereksinimleri genel olarak daha düşüktür ve yakalama döngüleri daha hızlıdır ve bu da ülkenin yakalama sürecinde daha yüksek bir başarı şansına sahip olduğu anlamına gelmektedir. Bu bağlamda, Türk özel firmaları ve devlet, öncelikle geniş kapsamlı bir araştırma yapmalı ve daha sonra Türkiye'ye uygun ve kısa döngü süreleri olan olası teknolojiler için derinlemesine bir araştırma yapmalıdırlar.

Endüstri, teknoloji ve bilim arasındaki ilişki oldukça karmaşıktır. Araştırmalar bazı sektörlerin yüksek derecede teknolojiye ihtiyaç duyarken temel bilimlere çok fazla ihtiyaç duymadığını, bazı sektörlerde ise bu durumun tam tersinin varolduğunu göstermektedir. Makine teçhizat birinci kategoriye, biyoteknoloji ise ikinci kategoriye iyi birer örnektirler.

Bu noktada devlet ekonomi genelinde iyi uygulamaların yayılmasına odaklanan teknoloji genişletme hizmetleri sağlayabilir. Ürün ve süreç standartlarının belirlenmesi ve uygulanması iyi uygulamaların yaygınlaştırılması için kullanılabilir. Diğer bir deyişle, hükümet, müşterilerini ürünlerini, süreçlerini ve örgütsel uygulamalarını yükseltmeye teşvik ederek ortalama ulusal verimlilik seviyelerini yükseltmek için politikalar oluşturabilir. Bu tür difüzyonlar belirli ürünlere ve ürün zincirlerine odaklandığında yakalama süreci daha hızlı işleyecektir.

Geleneksel görüşün aksine, rekabet politikası ve sanayi politikası, ikame yerine tamamlayıcı olarak görülmelidir. Tezimizde anlatıldığı şekliyle Japon hikâyesinin belirttiği gibi, yüksek rekabet devlet düzeyindeki teşviklerle birlikte var olabilir.

Türkiye'de ihracatçı firmalara ihracatı artırmaya yönelik çeşitli destekler verilmektedir. Bu desteklerin en yaygın iki özelliği, kriterleri karşılayan tüm firmaların eşit muamele görmesi ve nihai ürünlere değil süreçlere destek verilmesidir. Bu sistem, tüm şirketlerin kapasitelerini belirli bir seviyeye yükseltmek için iyi olsa da, Türkiye'nin lider ülkeleri yakalama sürecinde ihtiyaç duyduğu yüksek teknolojili ürünlere ulaşmasında yetersiz kalmaktadır.

Türkiye'de, Ar-Ge faaliyetlerine devlet desteği 1990'lı yıllarda başlamış ve Ar-Ge'nin GSYİH içindeki payı 2002'de% 0.32'den% 0.53'e, 2015'te ise% 1.06'ya yükselmiştir. Ancak, Güney Kore (% 4,29), İsrail (% 4,19) veya Japonya (% 3,58) gibi iyi performans gösteren ülkeleri yakalamak için önümüzde hala uzun bir yol bulunmaktadır.

Ülkemiz son dönemde orta teknolojiye sahip ürünlerde ihracat miktarını yüksek oranda artırmasına rağmen yüksek teknolojiye sahip ürünlerin ihracat miktarlarında ciddi bir ilerleme kaydedememiştir. Yüksek teknolojili ürünlerin toplam mal ihracatı içerisindeki oranının 2014 yılında dünya ortalaması yüzde 17,1 iken Türkiye'de bu oran yüzde 1,9 gibi oldukça düşük bir seviyededir.

SITC sınıflamasına göre uluslararası ticaret konu 775 ürünün içerisinde 203 adet orta teknolojili 61 adet ise yüksek teknolojili ürün bulunmaktadır. Bitkisel alkoloid ve türevleri, renkli TV ve elektrik trafoları olmak üzere, Türkiye yüksek teknolojili ürünlerin sadece 3 tanesinde rekabet gücüne sahiptir.

Ülkelerin uluslararası ticarette rekabet gücünü ölçmek için literatürde kullanılan dört temel faktör bulunmaktadır:

- Ürünün pazar payını artırmayı hedefleyen yoğun ticaret;
- Ürün ve pazar çeşitliliğini artıran yaygın ticaret;
- Ürünlerin teknoloji seviyesine odaklanan kaliteli ticaret ve
- Firmaların eski pazarlarda devamlılığını ön plana çıkaran sürdürülebilir ticaret.

Türkiye'nin ihracatında büyümenin kaynakları incelendiğinde (The World Bank, 2014),

- Mevcut ürünlerin mevcut pazarlardaki artışı 65%,
- Yeni pazarlar yüzde 15,

- Yeni ürünler yüzde 9,
- Yeni firmalar yüzde 11,

pay almakta ve bu dağılım bize ihracat artışlarının büyük çoğunluğunun varolan şirketlerin varolan ürün ihracatındaki artışlardan kaynaklandığını göstermektedir. Türkiye'nin ihracat pazarlarını ve ürün yelpazesini çeşitlendirdiği durumlarda ise genellikle yüksek teknolojili segmentlere giriş yapılamadığı görülmektedir.

Bu sonuç literatür kısmında ayrıntılı anlatılan öz-keşif süreciyle ilgili görünmektedir. Bir ekonominin 'maliyet yapısının keşfedilmesi'ni, yani hangi faaliyetlerin kârlı şekilde üretilebileceğinin belirlenmesi Hausmann ve Rodrik tarafından öz-keşif (self-discovery) olarak adlandırılmaktadır (Hausmann & Rodrik, 2002).

Öz-keşif sürecinin iyi çalışmadığı durumlarda üreticiler yeni ürünler üretmeyi deneyip risk almak yerine klasik üretim ve ihracat yapılarını devam ettirmektedirler. Bu yapının nasıl değişebileceğine dair öneriler literatür kısmında sunulmaktadır.

İthalatın Teknoloji Yapısı

İthalatın teknoloji yapısı üzerinde çok detaylı durulmayan ancak hem ihracat yapısını hem de yurtiçi tüketim kalıplarını etkilemesi bakımından önem arz eden bir konudur.

Örneğin 10. Kalkınma Planı, 'İthalata olan Bağımlılığın Azaltılması Öncelikli Dönüşüm Programı'nda ihracatta orta-yüksek ve yüksek teknolojili ürünlerin payının artırılması hedeflenirken ithalatta tam tersi bu oranın düşürülmesi hedeflenmektedir. 2017 yılı 'Katılım Öncesi Ulusal Reform Programı'nda ise ihracatta ve ithalatta orta-yüksek ve yüksek teknolojili ürünlerin payının artırılması hedeflenmektedir.

Bu iki örnek, ithalatın teknolojik yapısı konusunda ülkemizin net bir duruşunun olmadığını ortaya koymaktadır. Çünkü ithalatın teknolojik yapısının yüksek olmasının hem olumlu hem de olumsuz yanları bulunmaktadır. Yüksek teknolojili ithalat bir yandan yurtiçi yüksek teknolojili üretimle rekabet ederek onun gelişimini zayıflatırken, bir yandan da doğru kullanıldığı durumlarda ülkemizde yüksek teknolojili üretimi teşvik etmektedir. İlk bakışta tüketim ve aramalı ithalatında düşük teknoloji, sermaye malı ithalatında ise ileri teknoloji tercih edilebilir ancak ithal girdi kullanılarak ne kadar katma değer yaratıldığı daha büyük öneme sahiptir.

Bu noktada ithalat politikamız yüksek teknolojili ithalatı yurtiçi üretimin teknoloji seviyesini

artırmak amacıyla kullanmak olmalıdır. Özellikle Japonya ve Çin hızlı kalkınmalarının ilk dönemlerinde yurtdışı yüksek teknolojiyi çeşitli kanallarla ülkeye getirip sonrasında ilgili alanlarda rekabet gücü kazanmışlardır.

Örneğin, Çin 2000'li yılların ortalarında, Almanya'nın Siemens ve Japonya'nın Kawasaki gibi yabancı üreticileri, yüksek hızlı demiryolu ağı için lokomotif tedariki için davet etmiş, sonrasında ise Çinli firmalar Siemens ve Kawasaki ile dış pazarlarda rekabet edebilir hale gelmişlerdir.

Son dönemde özellikle savunma ve ulaştırma başta olmak üzere birçok sektörde ülkemiz yurtdışından teknoloji transferi yerine teknolojiyi ortak geliştirme vizyonunu uygulamaya koymuştur. Önümüzdeki dönemde, bu bakış açısının hem kamu hem özel sektör olmak üzere tüm sektörlere yerleşmesiyle beraber ülkemiz yeni teknoloji ve ürün geliştirme konusunda daha üst seviyeye çıkacaktır.

Küresel Değer Zinciri

Uzun vadeli ihracat hedeflerinin gerçekleşmesi için, Türkiye'nin küresel değer zincirinde (KDZ) sınıf atlaması gerekmektedir. Ülkemizin farklı sektör KDZ'lerinde yükselmesi konusunda avantaj sağlayabilecek üç faktör bulunmaktadır (The World Bank, 2014);

- Ortalamadan daha uzun değer zincirlerine sahip ekonomik faaliyetlere sahip olması,
- Ticaret maliyetlerin düşüklüğü,
- Lojistik altyapısının iyi bir performansa sahip olması

KDZ'ler açısından incelendiğinde KDZ'lerin özellikle orta yani emek yoğun segmentlerinde uzmanlaştığımız görülmektedir. Genel olarak bakıldığında ise, ülkemiz KDZ'lerin düşük katma değerli segmentlerinde uzmanlaşmaktadır. Buna rağmen, ülkemizin KDZ'de üst seviyelere çıkması için benzer ülkelere göre bazı avantajları vardır. Öncelikle, KDZ'deki yerimiz incelendiğinde, Brezilya ve Meksika gibi benzer bir yapıda olan ülkelere göre daha güçlü bir yapıda olduğumuz görülmektedir. Ülkemiz KDZ'nin daha çok düşük katma değerli segmentlerinde yoğunlaşmasına rağmen, KDZ'lerin segment uzunlukları incelendiğinde Türkiye'nin ortalamadan daha uzun zincirlerde daha güçlü varlık gösterdiği görülmektedir (The World Bank, 2014).

Bu bağlamda, rekabet gücümüzün yüksek olduğu makine sanayiinde yerli firmaların küresel değer zincirindeki konumlarını özellikle tasarım aşamasına geçerek daha da yükseltmeleri için

teşvik ve destek mekanizmaları geliştirilmelidir. Son dönemde tartışılan "yerli otomobil" örneğinde olduğu gibi, üretim lokasyonu istihdam için önem arz etmekte ancak asıl katma değer tasarım ve markalaşma aşamalarında oluşmaktadır.

Dış Ticaret Politikası

Günümüzde büyük ekonomiler arasında yaşanan ticaret savaşları da göz önüne alındığında, geçici ticaret kısıtlamalarını ülkemizin rekabet gücünü korumak ve geliştirmek amacıyla kullanmak büyük önem arzetmektedir.

Ülkemizin AB'nin karar alma süreçlerinde yeterince yer almaması, AB'nin üçüncü ülkelerle yaptığı Serbest Ticaret Anlaşmalarının üstlenilmesinde yaşanan güçlükler gibi problemlerden dolayı tarım, hizmetler ve kamu alımları konularının AB-Türkiye Gümrük Birliğine dahil edilmesi ülkemiz ihracatına büyük yararlar sağlayacaktır. Anlaşmanın güncellenmesi durumunda hem Avrupa Birliği ülkeleri ile ticaretimizde hem de AB'nin STA imzaladığı üçüncü ülkelerle olan ticaretimizde ciddi artışlar olacağı hesaplanmaktadır (Ülgen & Dilek, 2015).

Dünya genelinde yapılan hizmet ticaretinin mal ticaretine oranı 2004 yılında yüzde 24,2 iken günümüze kadar geçen dönemde artış trendini korumuş ve 2016 yılında yüzde 30 seviyesine ulaşmıştır. Bu açıdan bakıldığında, Gümrük Birliğinin kapsamının hizmetler sektörlerini de içerecek şekilde genişletilmesi büyük önem arzetmektedir. Bunun gerçekleşmemesi durumunda, tarım ve hizmet sektörlerine ilişkin AB ile yapılacak Gümrük Birliğini tamamlayan bir serbest ticaret anlaşması (STA) ülkemiz dış ticareti açısından büyük önem arz etmektedir.

İhracatın büyümeye katkısını artırabilmek için ihracatçılarımızın, uluslararası piyasalarda satış hacimleri ortalamanın üzerinde büyüyen ürünlere odaklanması ve ürünlerin teknoloji seviyeleri artırarak fiyat üzerinden değilde kalite üzerinden rekabet edebilir bir ihracat yapısına kavuşması gerekmektedir.

Çünkü piyasaların işleyişini yatay politikalarla iyileştirmek ne kadar önemli ise, bu politikaların düşük oranlı büyüme ve düşük katma değerli teknolojilere kilitlenmesini (lock-in) engellemek de o kadar önemlidir (Martin, 2010). Özellikle gelişmekte olan ülkelerdeki maliyet kısıtından dolayı en etkili çözüm yatay ve dikey politikalar arasında optimal bir dengenin kurulması olacaktır.

Bu optimal yapıda, kamu, geç kalmış firmaları ürünlerini, süreçlerini ve örgütsel

uygulamalarını yükseltmeye teşvik ederek ve/veya zorlayarak ortalama ulusal verimlilik düzeyini yükseltmek için politikalar oluşturabilir. Buna ek olarak, ürün uzayındaki difüzyon yapısına uygun olarak belirlenmiş üretim zincirleri (specific production chains) hedeflenirse, yükseltme süreci daha etkili olabilecektir.

İhracata Yönelik Devlet Yardımları

İhracatımızı hem seviye hem de teknoloji seviyesi olarak artırmayı amaçlayan devlet desteği uygulamaları, prensip olarak 1994 yılındaki İhracata Yönelik Devlet Yardımları Kararıyla başlatılmış ve gelişmiş ülkelerdeki uygulamalara benzer şekilde "bir faaliyetin yapılması" önşartına göre yapılmaktadır. İhracata Yönelik Devlet Yardımları kapsamında uygulanmakta olan desteklerin başlıcaları şunlardır;

- Uluslararası Nitelikteki Yurt İçi İhtisas Fuarları
- Çevre Maliyetleri
- Araştırma-Geliştirme (AR-GE)
- İstihdam
- Yurt Dışında Gerçekleştirilen Fuar Katılımları
- Yurt Dışı Birim, Marka ve Tanıtım Faaliyetleri
- Türk Ürünlerinin Yurtdışında Markalaşması, Türk Malı İmajının Yerleştirilmesi ve TURQUALITY
- Pazar Araştırması ve Pazarlama
- Uluslararası Rekabetçiliğin Geliştirilmesi
- Tasarım

Bu destekleri Ekonomi Bakanlığı bazı kuruluşlar eliyle yürütmektedir.

Ülkemizde ihracat teşvikleri firmalar tarafından kabaca 3 amaç için kullanılmaktadır;

1. Mevcut yapıyı devam ettirebilmek,
2. Mevcut yapıyı büyütmek,
3. Yeni üretim yapısına geçmek

Teşviklerin önemli bir kısmı 1. ve 2. amaçlar için kullanılmasına rağmen teşviklerin asıl amacı ve daha zor olanı firmaların yeni ürün üretme yeteneklerinin artırılmasıdır.

Türkiye'de ihracatı artırmak amacıyla ihracatçı firmalara verilen desteklerin çoğunluğunun

ortak özelliği şartları sağlayan tüm firmalara eşit davranılması ve nihai üründen çok süreçlerin desteklenmesidir. Bu sistem tüm firmaların kapasitelerini bir miktar geliştirmeleri açısından olumlu olsa da teknoloji seviyesi yüksek ürünlerin üretilmeye başlanıp ihraç edilmesi kriterini genellikle sağlamamaktadır.

Genel bir destekleme sistemi yerine hedeflenen teknoloji seviyesinde ürün üretmeyi başaran firmaları ödüllendiren bir sistemin orta ve uzun vadede ihracat yapısını değiştirmede daha etkili olacağı düşünülmektedir.

İhracat desteklerinde asıl amaç katma değeri ve teknoloji seviyesi yüksek ürünleri teşvik olmalıdır. Böyle bir yapının işlerlik kazanabilmesi için, yüksek teknolojili bir ürünü ilk ihraç eden firmanın en yüksek teşviki alması gerekir. Çünkü yeni bir alanda üretim yapmaya çalışan bir şirket aslında ülkenin ürün maliyet yapısını ortaya koymaya çalışmaktadır. Şirketin başarısız olması durumunda tüm sorumluluk ve zarar kendisine ait olurken, başarılı ve karlı olması durumunda bu ürün diğer firmalar tarafından kopyalanacak ve böylelikle kar da paylaşılacaktır. Bu nedenle, yeni bir ürün geliştirmekten kaynaklanan özel getiriler toplam sosyal getiriden daha düşüktür ve öz keşif için piyasa teşvikleri kendi başlarına genellikle yetersizdir. Böyle bir durumda standart çözüm özel getirileri sosyal getirilerle uyumlu hale getirmek için devlet kanalıyla sübvansiyon sağlanmasıdır. Böylelikle maliyet yapısını keşifteki negatif dışsallık devlet tarafından karşılanmış olacaktır.

Yeni ürünlerin önceden var olan yeteneklere bağımlı olması piyasaya bırakılan bir yapısal dönüşümün göreceli olarak yavaş gerçekleşmesi anlamına gelmektedir. Çünkü tüm ihraç ürünlerinin oluşturduğu ürün uzayındaki difüzyon kendi başına bırakıldığında oldukça yavaş ve öncelikli olarak komşu ve benzer ürünler yönünde gerçekleşmektedir. Yurtiçi firmalar yeni yetenekler geliştirmek yerine genellikle üretim yapısındaki mevcut yetenekleri kullanma yoluna gitmektedir. Üretim yapısındaki yeni yetenekler ise çoğunlukla yeni ürünler vasıtasıyla ortaya çıkmaktadır (Rodrik, 2004).

Rodrik'in sanayi politikası için belirlediği on tasarım ilkesinin bazıları aynı zamanda ihracatta yüksek teknolojili bir yapıya geçiş için de uygun görünmektedir (Hausmann & Rodrik, 2002);

1. Teşvikler yalnızca "yeni" faaliyetlere verilmelidir.
2. Başarı ve başarısızlık için net kriterler / ölçütler olmalıdır.
3. Kamu desteğinin ne zaman ve hangi şartlarda biteceği açıkça belirtilmelidir. (sunset clause)

4. Teşvik edilen faaliyetlerin, difüzyon etkileri (spillovers and demonstration effects) sağlayacak açık bir potansiyele sahip olması gerekir.
5. Optimal bir yapıda, bazen "başarısızları seçmek" ile sonuçlanan hatalar ortaya çıkacaktır. Hedef, hataların ortaya çıkma ihtimalini en aza indirerek keşif sürecini tıkamak değil, hataların ortaya çıktığı anda bu hataların maliyetlerini en aza indirgemek olmalıdır.
6. Potansiyel ürün bulma sürecinin kendisini yenileme kapasitesine sahip olması gerekir; böylece keşif döngüsü devam eden bir süreç haline gelir (Shumpeter, creative destruction).

Bu bağlamda ülkemizin ihracat teknoloji yapısını değiştirebilmek için dikkate alınması gereken bazı temel kriterler ve faydalanılabilecek bazı araçlar bulunmaktadır (Rodrik, 2004):

- "Öz keşif" maliyetlerinin desteklenmesi
  Bu tür çalışmaların finansmanı;
  a. Büyük ölçüde yeni faaliyetlerle ilgilenmeli,
  b. Desteklenen firmalar dışındaki diğer şirketlere öğrenme dışsallıkları sağlama potansiyeline sahip olmalıdır.
- Yüksek riskli finansman mekanizmalarının geliştirilmesi
  Öz keşif çalışmaları uzun vadeli ve riski yüksek finansal aracılık ürünleri gerektirir. Bu çerçevede kullanılabilecek araç ve kurumlar aşağıda sıralanmaktadır:
  a. Kalkınma bankaları,
  b. Kamu tarafından finanse edilen (ancak profesyonel olarak yönetilen) girişim fonları,
  c. Uzun vadeli ticari banka kredileri için kamu garantileri,
  d. Kamu emeklilik fon varlıklarının bir kısmını yüksek riskli yatırım portföyüne yönlendiren özel araçlar

Bu çerçevede, dünyadaki ulusal varlık fonlarının yaklaşık yüzde 13'ü yeni teknoloji alanlarına yatırım yapmakta ve bu oran son yıllarda giderek artmaktadır. Örneğin ABD'nin en büyük teknoloji firması Apple'ın büyük yatırımcılarından birisi 865 milyar dolar portföy büyüklüğü

ile dünyanın en büyük ulusal varlık fonu olan Norveç Ulusal Varlık Fonu'dur[12]. Ülkemizde yeni kurulmuş ve amaçlarından birisi "stratejik, büyük ölçekli yatırımlara iştirak etmek" olan Türkiye Varlık Fonu Yönetimi A.Ş. (Varlık Fonu)'nin yüksek teknolojili ürün üretimi ve ihracatına odaklanan şirketlere yatırım yapması ihracatta teknolojik dönüşümü hızlandıracaktır.

Ancak büyük çaplı teknolojik yatırımlar her zaman içerisinde çeşitli riskler barındırmaktadır. Örneğin 1947 yılında transistorun bulunmasıyla başlayan yarı iletken teknolojilerindeki uluslararası yarışta birçok ülke milyarlarca dolar harcamış olmalarına rağmen başarısızlığa uğramışlardır. Sadece ABD, Taiwan ve Güney Kore başarılı olmuşlardır.

Son olarak, geçmişte ve günümüzde uygulanan ihracat desteklerinin ihracata olumlu etkilerinin ne düzeyde olduğu ve hangi destek türlerinin daha etkili oldukları görmek ancak üzerinde araştırma yapılabilecek bir veri seti ile mümkündür. Bu sebeple, politikaların etki değerlendirmelerini yapabilmek için, ihracat destek programlarına ait bir veri setinin oluşturması önem arz etmektedir.

Ürün Uzayı ve Teşvik Sistemi

Günümüzde ihracat odaklı büyüme stratejisi izleyen tüm ülkeler en ileri teknolojili ürünleri geliştirmek için bir yarış içerisindedirler. Çünkü ülkelerin büyümeleri genellikle ürettikleri ürünleri çeşitlendirmeleriyle mümkündür. Diğer taraftan Türkiye, bu alanda yeterli atılımı gösterememiştir. Yüksek teknolojili ürünlerin toplam mal ihracatı içerisindeki oranının 2016 yılında dünya ortalaması yüzde 24,4 iken Türkiye'de bu oran yüzde 3,5 gibi oldukça düşük bir seviyededir.

İhraç edilen ürünler basitçe düşük-orta-ileri teknolojili olarak isimlendirilseler de son on yılda yapılan ampirik çalışmalar ticarete konu ürünlerin karmaşık ve homojen olmayan bir network yapısına sahip olduklarını göstermiştir. Bu süreci analizde Harvard ve MIT Üniversitelerinden bir grubun geliştirdiği fizik ve bilgisayar alanlarından ilhamla ortaya çıkan kompleksite ve Ürün Uzayı metotları detaylı sektör ve ürün seviyesinde değerlendirmeye imkân vermektedir (Hidalgo & Hausmann, 2009).

Türkiye'de ihracatı artırmak amacıyla ihracatçı firmalara çeşitli destekler verilmektedir. Bu desteklerin çoğunluğunun ortak özelliği şartları sağlayan tüm firmalara eşit davranılması ve

[12] Kaynak: http://fortune.com/2016/06/07/sovereign-funding-tech-investments/

nihai üründen çok süreçlerin desteklenmesidir. Bu sistem tüm firmaların kapasitelerini bir miktar geliştirmeleri açısından olumlu olsa da teknoloji seviyesi yüksek ürünlerin üretilmeye başlanıp ihraç edilmesi kriterini genellikle sağlamamaktadır.

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Bu bağlamda literatüre son on yılda giren Ürün Uzayı metodu ile birçok teorik ve ampirik çalışma yapılmıştır. Türkiye'nin ihracat Ürün Uzayı dünya ihracat Ürün Uzayının bir alt kümesidir. Yıldan yıla ürünler arasında difüzyon gerçekleşmekte ve Ürün Uzayımız genişlemektedir. Türkiye özelinde bu genişleme genellikle rastsal sektörler ve rastsal ürünler üzerinden olmaktadır. Ürün Uzayı tekniklerini kullanan ürün ve/veya sektör bazında uygun bir teşvik sistemi ile Türkiye'nin Ürün Uzayı gelişimi yönlendirilebilecek (controllability) ve böylelikle ihraç ürünlerimizin dünya Ürün Uzayının yüksek teknolojili ürünlerden oluşan çekirdeğine daha hızlı ulaşması mümkün olacaktır.

Analiz Sonuçları

Literatürde yapılan çalışmalarda ülkelerin ihracat ürün sepetlerini geliştirirken mevcut ürünlerden öncelikle benzer ürünlere geçtikleri tespit edilmiştir (Hidalgo, et al., 2007). Türkiye için Matlab programı kullanılarak benzer bir analiz yapıldığında mevcut ürünlere benzeyen ileri teknoloji grubunda 14 ürün tespit edilmiştir (Tablo 1).

Tablo 1. Mevcut İhracat Ürünlerine Benzeyen Yüksek Teknolojili Ürünler

SITC	Bağlantı Sayısı*	Teknoloji Seviyesi (0-5)	RCA	Ürün
5413	1	5	0.10	'Antibiyotikler'
5416	2	5	0.11	'Glikozitler ve Aşılar'
5417	5	5	0.21	'İlaçlar'
5419	3	5	0.27	'Tıbbi olmayan İlaç Ürünleri'
7129	5	5	0.01	'Buharlı Güç Ünitesi Muhtelif Parçaları'
7162	1	5	0.79	'Elektrik Motorları ve AC Jeneratörler'
7163	1	5	0.32	'Döner Çeviriciler'
7169	9	5	0.66	'Muhtelif Döner Elektrikli Tesis Parçaları'
7188	17	5	0.33	'Muhtelif Motorlar'
7741	3	5	0.07	'Elektrikli Tıbbi Ekipmanlar'
7783	9	5	0.86	'Otomotiv Elektrikli Ekipmanlar'
7784	1	5	0.09	'Elektrikli El Aletleri'
8743	1	5	0.31	'Gaz veya Sıvı Kontrol Aletleri'
8744	1	5	0.07	'Fiziksel Analiz için Analog Araçlar'

Kaynak: Yazar Hesaplamaları

* Bağlantı sayısı ilgili ürüne benzeyen rekabet gücüne sahip olduğumuz ürün sayısını göstermektedir.

Mevcut ihracat ürünlerine benzeyen bu 14 ürüne 1 adımda ulaşabilecekken geriye kalan 44 yüksek teknolojili ürüne 2 veya daha fazla adımda ulaşılmaktadır. 1 adımda ulaşılabilecek ürünlere ulaştığımızı varsayarak 2 adımda ulaşılabilecek ürünleri hesaplayabiliriz. Bu analizi yaptığımızda 15 yeni yüksek teknolojili ürüne ulaşmaktayız. (**Tablo 2**).

Türkiye, hâlihazırda, **Tablo 1**'deki 14 yüksek teknolojili ürünün her birine benzer en az bir üründe rekabet gücüne sahiptir. Bu da Türkiye'nin yüksek teknolojili bu ürünlere geçmek için gerekli potansiyele sahip olduğuna işaret etmektedir. Söz konusu sektörlerin sektörel dinamikleri incelenerek ihracatımızı arttırmanın önündeki engellerin tespit edilmesi ve bu

sektörlerin gerekli teşvik ve düzenlemelerle desteklenmesi önem arz etmektedir. Böylelikle Türkiye daha yüksek teknolojili ürünler ihraç eden bir yapıya kavuşabilecektir.

Tablo 2. İki Adımda Ulaşılabilecek Yüksek Teknolojili Ürünler

SITC	Bağlantı Sayısı	Tech	RCA	Ürün
5411	2	5	0.07	Vitaminler
5415	3	5	0.01	Hormonlar
7161	3	5	0.13	DC Motorlar
7522	4	5	0.03	Kişisel bilgisayarlar
7523	1	5	0.04	CPU'lar
7524	1	5	0.00	Dijital depolama birimleri
7528	1	5	0.07	Çeşitli Veri İşleme Ekipmanları
7712	1	5	0.23	Çeşitli Güç Makineleri
7742	5	5	0.07	X-Ray Ekipmanları
7763	1	5	0.02	Diyotlar, Transistörler ve Fotoseller
7764	1	5	0.01	Elektronik Mikro Devreler
7768	1	5	0.02	Çeşitli Elektronik Devre Parçaları
8742	3	5	0.18	Matematiksel Hesaplama Araçları
8748	6	5	0.15	Çeşitli Elektrikli Aletler
8749	3	5	0.19	Ölçüm Cihazı Parçaları

Kaynak: Yazar Hesaplamaları

Yüksek Teknolojili Üretim ve İhracat için Neler Yapılabilir?

Türkiye'nin büyüme performansı özellikle 2001-2007 döneminde yüksek olmuştur. Bunun gerçekleşmesine katkı yapan unsurlar arasında olumlu dış koşullar (dünya ekonomisi aynı dönemde hızla büyüdü), devlet harcamalarının artması (faiz ödemelerinin hızla azalması sayesinde) ve cari açığın önemli bir bölümünün portföy yatırımları ile finanse edilmesi sayılabilir. Önümüzdeki dönemde Türkiye'nin büyümesinde bu faktörlerin etkisinin görece az olacağını varsayımıyla, yüksek büyüme oranlarına tekrar ulaşabilmek için yeni bir perspektife ihtiyaç vardır.

Ülkemizde 1960-80 döneminde planlı büyüme stratejisi ile birlikte ithal ikameci bir sanayi politikası uygulanmıştır. Bu dönemde yüksek büyüme oranları yakalanmasına rağmen uluslararası alanda rekabet gücümüz benzer bir süreçten geçen Doğu Asya ülkeleri (Örn. Güney Kore) kadar artmamıştır.

Zaten Doğu Asya ülkeleri uluslararası arenada rekabet gücü kazanmalarından itibaren ithal ikameci politikalara zemin hazırlayan korumacı politikaları bırakmışlar ve serbest ticaret ve ihracat odaklı büyümeye odaklanmışlardır. Ülkemiz ise, Latin Amerika ülkelerine benzer şekilde korumacı politikalara devam etmiş ve uluslararası ticarette rekabet gücü kazan(a)madan 24 Ocak kararlarıyla beraber ihracat odaklı büyüme stratejisi uygulamaya başlamıştır.

Batılı gelişmiş ülkeler ve Japonya'nın ilk olarak ve Doğu Asya ülkelerinin sonradan kazandıkları teknolojiye dayalı rekabet gücünü günümüz dünyasında kazanmak önceye göre daha zordur. Bunun başlıca sebebi Washington Uzlaşısı ve sonrasında gelişmiş ülkelerin isteğiyle Dünya Ticaret Örgütü kanalıyla uygulanan engelsiz ticaret kurallarının ithal ikameci bir üretim yapısını neredeyse imkânsız hale getirmiş olmasıdır. Ayrıca; ihracat odaklı olmayan ithal ikameci bir yapı günümüz dünyasında ölçek ekonomisi ve sınırları aşan değer ve üretim zincirleri nedenleriyle rekabet gücünden yoksun olacaktır.

Böyle bir durumda önümüzdeki en mantıklı seçenek uluslararası kuralları çiğnemeyecek derecede korumacı politika ve beraberinde uygulanacak bir teşvik sistemidir. Aslında 24 Ocak 1980 kararları tam da bunun üzerine kurulmuştur. Çünkü bu kararlar ihracat odaklı büyümeyi destekleyen birçok farklı teşviki de uygulamaya koymuştur.

Ancak, 1980 sonrası dönemdeki hayali ihracat örneklerinden hareketle, teşviklerin amaçları ve performans kriterleri hayati öneme sahiptir. Ülkemiz için, girdi ve süreç odaklı bir teşvik

sistemi yerine ürün uzayına dayalı çıktı odaklı teşvik sisteminin faydalı olabileceği düşünülmektedir.

Imbs ve Wacziarg (Imbs & Wacziarg, 2003)'a göre yoksul ülkeler zenginleştikçe, sektörel üretim ve istihdam daha az konsantre ve daha çeşitli hale gelmektedir. Bu süreç gelişimin nispeten ileri aşamalarına kadar devam etmekte, ancak, ülkeler kabaca İrlanda gelir düzeyine ulaştıktan sonra üretim kalıpları daha yoğunlaşmaya başlamaktadır. Bu yorum Nurkse'nin dengeli bir büyümeyle, en iyi ihtimalle, orta gelirli bir ülke yaratılabileceği fikrini desteklemektedir (Kattel, et al., 2009).

Bu sonuç ürün uzayı metodolojisi ile de uyumludur. Çünkü bir ülkenin ürün uzayından en iyi verimi alabilmesi öncelikle ürün uzayını keşfe (self-discovery, Hausmann (Hausmann & Rodrik, 2002) ve sonrasında en iyi sonuçları aldığı ürünlerde ölçek ekonomisine (exploitation) geçmekle mümkündür.

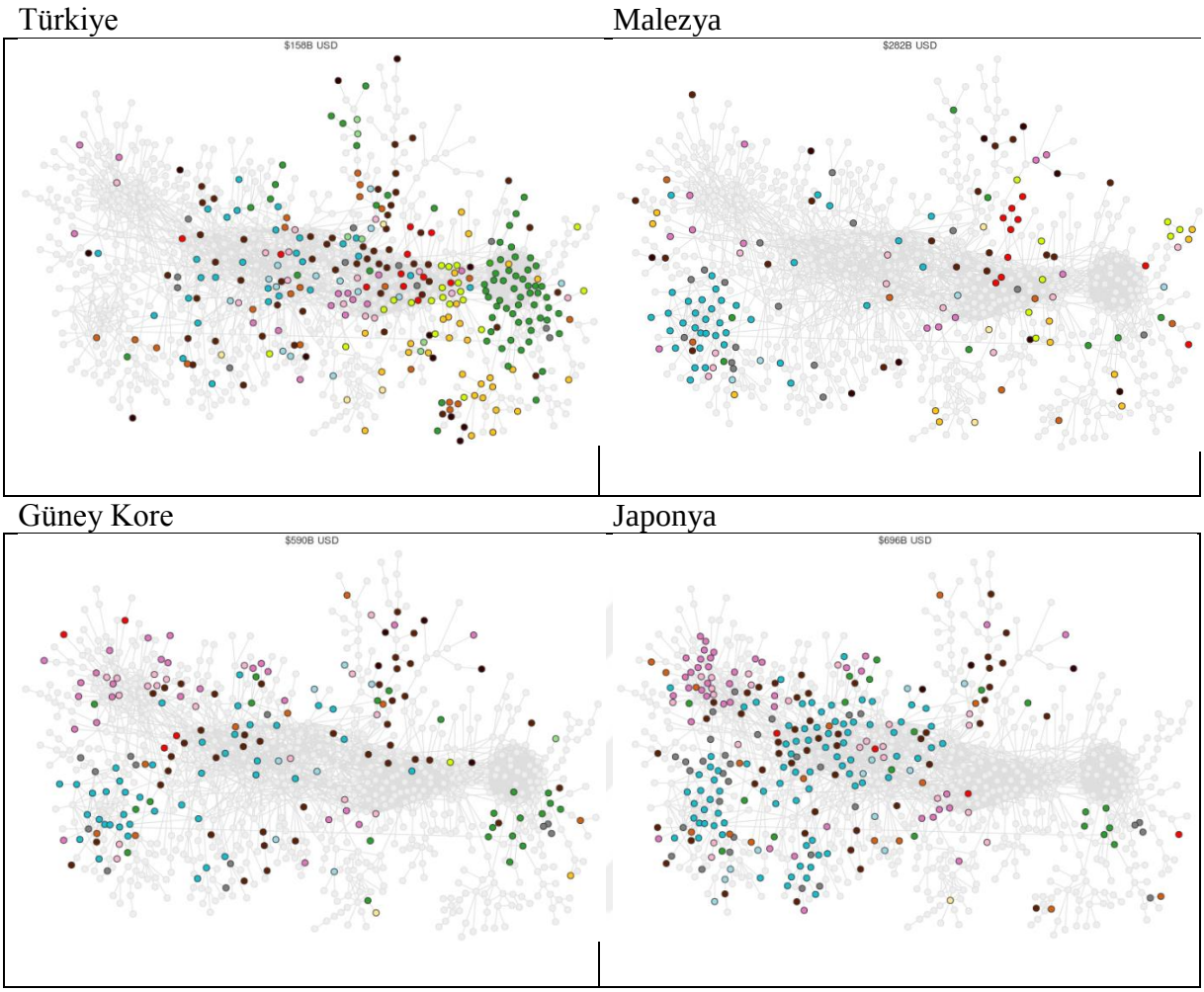
Türkiye ile Doğu Asya ülkelerinin ürün uzaylarındaki gelişim karşılaştırıldığında, Malezya gibi ülkelerin elektronik sektöründe ölçek ekonomisine geçtikleri ve ürün uzaylarının Türkiye'ye göre az ürün çeşidine sahip oldukları görülmektedir. Ülkemizin ve Japonya'nın ürün uzayları birbirine göre simetrik bir yapıdadır. Yani, Japonya'nın ihraç edemediklerini Türkiye, Türkiye'nin ihraç edemediklerini Japonya ihraç etmektedir. (Şekil 1).

Stiglitz'e göre Doğu Asya'daki başarılı kalkınma örneklerinin hepsinde devlet merkezi bir rol oynamıştır ve bu kilit rol genellikle Washington Mutabakatının aksi istikametindeki politikalarla olmuştur. Devlet sadece sözleşmeleri yerine getirmekten fazlasını yapmış, sadece düzenleyici bir rol oynamamış, aynı zamanda katalitik bir rol oynamıştır (Stiglitz, 2016).

Bölgesel ekonomik gelişmenin kilit itici gücü olan teknoloji, yalnızca mevcut çeşitliliğe bağlı dışsallıklar yoluyla mevcut endüstrilerin büyümesini etkilemekle kalmaz, aynı zamanda bölgelerin yeni sanayilere girmesi ve yeni büyüme yollarının oluşumuna da imkan sağlar.

Son zamanlarda yapılan çalışmalar, bölgesel çeşitliliğin patikaya bağımlı bir süreç olduğunu vurgulamaktadırlar. Çünkü bölgeler genellikle teknolojik açıdan kendilerine benzer olan ve mevcut endüstriyel yapılarıyla bağlantılı endüstrilere doğru gelişmektedir.

Şekil 1. Seçilmiş Ülkelerin Ürün Uzayları (2014)



Kaynak: MIT Atlas (Hausmann, et al., 2014)

Böyle bir patikaya bağımlı bölgesel çeşitlilik, bölge ve ülkelerin heterojen ve pürüzlü bir endüstri uzayında sınırlı mesafelere sıçrama yapıyor olabilmeleriyle açıklanabilir. Bu mesafe, endüstriler arasındaki teknolojik bağlantıyla belirlenmektedir.

Bundan dolayı, ürün uzayındaki çekirdek ve yoğun alanlardan sıçrama yapmaya çalışan gelişmiş ülkeler, ürün uzayının ıssız ve kenar bölgelerinden sıçrama yapmaya çalışan ülkelere göre daha fazla fırsat ve olanaklara sahiptirler.

Difüzyona dayalı olan patikaya bağımlı gelişme bakış açısına göre; bazı durumlarda, gelişmekte olan ülkelerin çekirdek bölgeye girmesi olanaksızdır ve gelişmiş ülkelerle gelişmekte olan ülkelerin ürün uzayında izledikleri yol, patikaya bağlı difüzyon nedeniyle ayrışmaktadır. Özellikle gelişmekte olan ülkeler / bölgeler için böyle bir sonuç oldukça kötümserdir. Çünkü bu bakış açısı bölgesel çeşitliliğin endüstriler arasında ilişkiden etkilendiği

veya sınırlandığı varsayımını kabul eder ancak ülkelerin / bölgelerin sıçrama yeteneklerini geliştirmesinin mümkün olup olmadığı problemini göz ardı eder.

Zu'ya göre ülkelerin ürün uzayındaki hareketleri iki gruba ayrılabilir. Birincisi ülkenin mevcut yapısının devamı niteliğinde olan ve benzer ürünlere difüzyon şeklindeki "patikaya bağımlı" sıçramalar, ikincisi ise mevcut yapıya büyük yenilik getiren "çığır açan" sıçramalardır (Zhu, et al., 2017).

Rodrik'e göre Çin'in ihracat başarısını şekillendirmede karşılaştırmalı üstünlük ve serbest pazardan daha fazlası vardır. Devlet politikaları olmadan gelişemeyecek tüketici elektroniğinde ve diğer gelişmiş alanlarda yerli yeteneklerin geliştirilmesinde devletin önemli rolü olmuştur. Bunun sonucu olarak Çin, kendi gelir düzeyindeki bir ülkeden beklenmeyecek derecede sofistike bir ihracat sepetine sahip olmuştur. Bu, Çin'in hızlı büyümesinin en önemli belirleyicilerinden biridir. Çin'in yüksek oranlı büyümeye devam edebilmesi ihracat hacmine değil, yeni çıkacak sofistike ürünleri üretebilme kapasitesine bağlı olacaktır (Rodrik, 2006).

Bilgi ve Koordinasyon Dışsallıkları

Rodrik'e göre gelişmekte olan ülkelerde yüksek ve sürdürülebilir büyümenin önündeki önemli engellerden iki tanesi bilgi ve koordinasyon dışsallıklarıdır (Rodrik, 2004).

Koordinasyon eksiklikleri ve dışsallıklar özellikle yüksek teknolojili ve yeni ürünler için daha etkin bir kısıttır. Yeni bir ürün geliştirmek için genellikle karmaşık bir tedarik zincirine ihtiyaç vardır ve tedarikçilerin mevcut olmadığı bir ürünü geliştirmek zordur. Ayrıca, yüksek teknolojili yeni ürünler için kalifiye ve tecrübeli işçi bulmak zordur çünkü henüz yurtiçinde bu ürünü hiç kimse üretmemiştir. O zaman, böyle bir durumda yapısal bir dönüşüm mümkün müdür?

Bilgi Dışsallıkları

Pazar aksaklıklarının kaynaklarından birisi bilgi dışsallıklarıdır. Hausmann ve Rodrik (Hausmann & Rodrik, 2002), bir ekonominin yeni malların üretimi için maliyet yapısını bulma süreci olarak tanımlanan öz keşifte (self-discovery) ortaya çıkan dışsallıkları vurgulamaktadır.

Üretken yapının çeşitlendirilmesi, bir ekonominin "maliyet yapısının keşfedilmesi"ni, yani hangi faaliyetlerin kârlı şekilde üretilebileceğinin belirlenmesini gerektirmektedir. Buna göre, girişimciler öncelikle yeni üretim süreçlerini denemeli, yurtdışındaki üreticilerin teknolojileri

ile bağlantı kurmalı ve yerel koşullara uyarlamalıdırlar. Bu "maliyet yapısını keşif" veya "öz keşif" olarak adlandırılan süreçtir.

Burada bahsedilen maliyet yapısını keşfi yenilik ve Ar-Ge ile karıştırmamak gerekir. Burada anlatılmak istenen, yeni ürünler veya süreçler ortaya çıkarmanın yanında, dünya pazarlarında zaten iyi kurulmuş belirli iyi ürünlerin yurtiçinde düşük maliyetle üretilebileceğini "keşfetmek" demektir.

Neredeyse aynı kaynak ve faktör donanımı olan ülkelerin çok farklı ürünler konusunda uzmanlaştıkları görülmektedir. Öz keşfi kısıtlayan bilgi dışsallıklarına karşı alınabilecek iyi bir önlem, geleneksel olmayan yeni ürünlere yapılan yatırımları sübvanse etmektir.

Öz keşif girişimcilere teşviklerin sağlanmasını gerektirdiğinden, politikanın bir tarafı havuç (ödüllendirme) biçiminde olmalıdır. Bu, bir çeşit sübvansiyon, ticari korumanın sağlanması veya girişim sermayesinin sağlanması şeklinde olabilir. Sistemin işleyebilmesi için teşvikin taklitçilere değil başlangıçtaki yatırımcılara verilmesi gerekmektedir.

Hataların devam ettirilmemesi ve kötü projelerin aşamalı olarak çıkarılmasını sağlamak için, bu teşvikler performans kriterlerine (örneğin, ihraç zorunluluğu) tabi tutulmalıdır. Doğu Asya endüstriyel politikalarında her iki unsur da vardır. Latin Amerika'da tipik olarak havucun çok fazla ve sopanın çok az kullanılması, bu bölgenin genellikle verimsiz ve düşük katma değerli üretim/ihracat yapısını kısmen açıklamaktadır.

Burada üzerinde durulması gereken nokta, optimum teşvik programında bile teşvik edilen bazı yatırımların başarısızlıkla sonuçlanacağıdır. Kamunun görevi kazananları seçmek değil, kaybedenleri kaybettikleri anda belirleyebilmek olmalıdır.

Son dönemde, ülkemizde özellikle savunma sanayii ve uzay teknolojileri projelerinde dünyaca tanınan uluslararası firmalar yerine risk alarak yerli firmalarla çalışılmaktadır. Bu uygulamanın artarak devam etmesi ülkemiz üretim ve ihracat yapısının yüksek teknolojiye uygun hale gelmesi açısından önem arz etmektedir.

Koordinasyon Dışsallıkları

Birçok projenin karlı hale gelebilmesi için eş zamanlı, büyük çaplı yatırımların yapılması gerekmektedir. Bu klasik bir koordinasyon problemidir. Kârlı yeni sanayiler, ileri ve geri bağlantılı sektörlerdeki yatırımlarla eşzamanlı kurulmadıkça gelişemeyebilirler.

Örneğin, Büyük İtme Modelinde (big push model), firma sanayileşip büyümeye karar vermesini diğer firmaların kararına bağlar. Ölçek ekonomilerini ve oligopolistik piyasa yapısını varsayar ve sanayileşmenin gerçekleşmesi için tüm firmaların aynı anda harekete geçmesi gerektiğini söyler.

Bu koordinasyon dışsallığını bertaraf etmek için örtülü bir kurtarma garantisi iyi kurgulandığında oldukça etkili olmaktadır. Proje başarılı olursa, yatırımcıya herhangi bir sübvansiyon ödenmemekte ancak firma dışı koordinasyon problemlerinden dolayı başarısızlık durumunda zarar devlet tarafından ödenmektedir. Kore'de Park rejiminin yeni alanlara yatırım yapan önde gelen şirketlere (Chaebol) örtülü yatırım garantileri vermesi buna iyi bir örnektir.

Burada, koordinasyon aksaklıklarını gideren politikalar ile bilgi dışsallıklarına odaklanan politikalar arasında bir benzerlik vardır. Her iki müdahale grubu da, kendi başına sektörlerden ziyade, faaliyetleri (yeni bir teknoloji, belirli bir eğitim türü vb.) hedeflemelidir.

Burada dikkat edilmesi gereken bir nokta kamunun özel sektörü tam olarak bilmemesidir. Çünkü kamu piyasa aksaklıklarının yeri ve doğası hakkında özel sektörden daha az bilgiye sahip olabilmektedir. Kamu bilmediğinin ne olduğunu bile bilmiyor olabilir (Rumsfeld tarzı).

Kalkınma Ekonomisinin kurucularından Hirschman'a göre, her türlü kalkınma, politika üretme yoluyla birtakım öncelikleri belirleme dayanır. Bir başka kurucu Nurkse, dengeli büyümeyi (balanced growth)dengesiz büyümeye tercih etmekte, fakat aynı zamanda dengeli bir büyümeyle, en iyi ihtimalle, orta gelirli bir ülke yaratılabileceğini düşünmektedir (Kattel, et al., 2009).

Çünkü piyasaların işleyişini yatay politikalarla iyileştirmek ne kadar önemli ise, bu politikaların düşük oranlı büyüme ve düşük katma değerli teknolojilere kilitlenmesini (lock-in) engellemek de o kadar önemlidir. Özellikle gelişmekte olan ülkelerdeki maliyet kısıtından dolayı en etkili çözüm yatay ve dikey politikalar arasında optimal bir dengenin kurulması olacaktır.

Bu optimal yapıda, kamu, geç kalmış firmaları ürünlerini, süreçlerini ve örgütsel uygulamalarını yükseltmeye teşvik ederek ve/veya zorlayarak ortalama ulusal verimlilik düzeyini yükseltmek için politikalar oluşturabilir. Buna ek olarak, ürün uzayındaki difüzyon yapısına uygun olarak belirlenmiş üretim zincirleri (specific production chains) hedeflenirse, yükseltme süreci daha etkili olabilecektir.

Taymaz ve Voyvoda (Taymaz & Voyvoda, 2015)'ya göre Türkiye'nin son dönemde ihracat sektörlerinde yaşadığı dönüşüm Kore gibi dönüşüm geçiren diğer ülkelerden 2 şekilde farklılaşmaktadır.

1. Türkiye'nin dönüşümü daha yavaş ve geç gerçekleşmektedir. İhracat içinde mühendislik ürünlerinin tekstili yakalaması Güney Kore'de 1983 yılında gerçekleşirken ülkemizde 2004 yılında gerçekleşmiştir. İhracat yerine net ticaret rakamlarını kullandığımızda bu görünüm daha da kötüleşmektedir.
2. Mühendislik ürünleri içerisinde Türkiye makine ve motorlu taşıt gibi orta teknolojili ürünlerde rekabet gücü kazanırken bilgi yoğun elektrik ve elektronik mühendisliğine dayanan sektörlerde aynı başarıyı tekrarlayamamıştır.

Model

Bu tezde önerilen teşvik sistemine göre, belirli bir üründe devlet desteği için iki kriter, ürünün yeni bir ürün olması ve ürünün yüksek potansiyele sahip olmasıdır. Yeni bir ürünün potansiyeli ölçmek için oluşturduğumuz modele göre bir ürünün potansiyeli ürünün Türkiye'nin ürün uzayına ortalama yakınlığı ile orantılıdır. Bu model (Hidalgo, 2007) çalışmasında geliştirilen modelin gelişmiş bir versiyonudur.

Yeni bir ürünün potansiyeli şu denklemle ölçülmektedir;

$$Potansiyel = \Pi_i = \frac{\sum_j RCA_j * (pci_i)^{\alpha} * (w_i)^{\beta} * (w_j)^{\gamma} * (P_{i,j})^{\delta}}{\sum_j (P_{i,j})^{\delta}}$$

Burada;

pci_i : i ürününün $komleksite\ endeksi$

w_i : i ürününün $küresel\ mal\ ticaret\ içerisindeki\ ağırlığı$

RCA_i : $\begin{cases} 1\ eğer\ (i\ ürününün\ Açıklanmış\ Karşılaştırmalı\ Üstünlük\ Endeksi) \geq 1 \\ 0\ eğer\ (i\ ürününün\ Açıklanmış\ Karşılaştırmalı\ Üstünlük\ Endeksi) < 1 \end{cases}$

$P_{i,j}$: $i\ ve\ j$ ürünleri $arasındaki\ benzerlik$

$\alpha, \beta, \gamma, \delta$: $model\ parametreleri$

Bu modele göre, yüksel potansiyele sahip yeni bir ürün şu özelliklere sahiptir;

i. Yüksek pci_i değerine sahip yüksek teknolojili bir ürün olması,
ii. Yüksek w_i değeri ile küresel ticarette yüksek bir paya sahip olması

iii. Yüksek w_j değeri ile küresel ticarette ciddi ağırlığı olan ürünlere benzer olması,

iv. Benzeri olduğu ürünlerin Türkiye ürün uzayında Açıklanmış Karşılaştırmalı Üstünlüğe sahip olmaları

v. Benzeri olan çok sayıda ürün bulunması

Yukarıdaki denklemde verilen model $\alpha = 1,\ \beta = 1,\ \gamma = 1,\ \delta = 1$ varsayımları ile Türkiye ürün uzayına uygulandığında Figure 4.15 elde edilmektedir. Table 4.6 en yüksek potansiyele sahip ürünlerin bir listesini vermektedir.

Türkiye'nin ihracatında en yüksek potansiyele sahip ilk 20 ürünün büyük çoğunluğu yüksek veya orta-yüksek teknoloji ürünlerdir. Bu ürünlerin çoğunluğu kimyasallar, makineler veya çeşitli imal edilmiş ürünler olarak sınıflandırılmaktadır. 'Glikozidler ve Aşılar' ve 'İlaçlar' ürünleri, bu çalışmada yapılan iki analizde de yüksek potansiyele sahip ilk üç ürün arasında yer almaktadırlar.

Yüksek teknolojili ürün ihracatı yapan yeni firmaların oluşturulması konusunda firmaların risk iştahı büyük önem taşımaktadır. Çalışmamız, Türk firmalarının uluslararası alanda büyük riskler almaya istekli olmadıklarını göstermektedir. Riske girmeme nedenlerinden biri başarısızlığın kötü sonuçlarıdır.

Türkiye'nin ürün uzayı yüksek derecede çeşitliliğe sahiptir ve çoğunlukla orta ve orta yüksek teknolojilere yoğunlaşmaktadır. Karşılaştırmalı üstünlük yanlısı politikalar ülkelerin mevcut ürünlerin yakın çevresinde hareket etmelerini sağlarken, karşılaştırmalı üstünlük karşıtı politikalar ülkelerin ürün alanının çekirdek bölgelerine hızlı erişim için gerekli olan uzun sıçrama yapmalarına izin verir.

Gelişmiş ülkelerin büyük bir kısmı ihracat sepetlerindeki ürünlerin çeşitliliği açısından zirveye ulaştıktan sonra azalan bir eğilim gösterirken, gelişmekte olan ülkelerin çoğunluğu henüz bu aşamaya gelememiştir. Analizlerimiz, Türkiye'nin de henüz zirveye ulaşmadığını ve ürün çeşitliliğini artırma sürecinde olduğunu göstermektedir. Bu bulgu, Türkiye'nin henüz keşif bölümünden odaklanma sürecine geçmediğini göstermektedir. Bunu başarmaları için, Türk firmaları düşük teknolojili ürünlere yatırım yerine riskli yüksek teknolojili ürünlere yatırım yapmaya başlamalıdır. Devlet, özel sektöre uluslararası alanda ihtiyaç duyulan güveni vermek için gerekli teşvikleri sağlamalıdır.

Sonuç

Ülkeler, ürettikleri ve ihraç ettiği ürünleri geliştirerek büyümektedirler. Yeni ürünleri üretmek

için gerekli teknoloji, sermaye, kurumlar ve beceriler üründen ürüne farklılık göstermektedir. Bazı ürünler daha az sofistike bir sistem gerektirirken bazıları ise her alanda son derece gelişmiş bir yapı gerektirmektedir. Bu çalışmada, daha sofistike ürünlerin birbirine sıkı şekilde bağlı halde bir çekirdekte yer aldığını, daha az karmaşık ürünlerin ise bağların daha zayıf olduğu çevre bölgeleri işgal ettiğini Ürün Uzayı ve bunun ihracat ürün yapısını değiştirmede olası etkileri incelenmiştir.

Türkiye'nin ihracat Ürün Uzayı dünya ihracat Ürün Uzayının bir alt kümesidir her yıl ürünler arasında difüzyon gerçekleşmekte ve Ürün Uzayımız genişlemektedir. Türkiye özelinde bu genişleme genellikle rastsal sektörler ve rastsal ürünler üzerinden olmaktadır. Ürün Uzayı tekniklerini kullanan ürün ve/veya sektör bazında uygun bir teşvik sistemi ile Türkiye'nin Ürün Uzayı gelişimi yönlendirilebilecek (controllability) ve böylelikle ihraç ürünlerimizin dünya Ürün Uzayının yüksek teknolojili ürünlerden oluşan çekirdeğine daha hızlı ulaşması mümkün olacaktır.

Türkiye, hâlihazırda 14 yüksek teknolojili ürünün her birine benzer en az bir üründe rekabet gücüne sahiptir. Bu da Türkiye'nin yüksek teknolojili bu ürünlere geçmek için gerekli potansiyele sahip olduğuna işaret etmektedir. Söz konusu sektörlerin sektörel dinamikleri incelenerek ihracatımızı arttırmanın önündeki engellerin tespit edilmesi ve bu sektörlerin gerekli teşvik ve düzenlemelerle desteklenmesi önem arz etmektedir. Böylelikle Türkiye daha yüksek teknolojili ürünler ihraç eden bir yapıya kavuşabilecektir.

Politika koordinasyonu, özellikle eğitim, altyapı, inovasyon ve finansman alanlarında, ürün uzayı ve çerçeve koşullarının eşzamanlı gelişimini desteklemede kritik bir rol oynamaktadır. Bu çalışmada, ülkemizin sanayi politikası ile büyüme sürecini birbirine bağlayan ve kalkınma sürecini hızlandıracak bir strateji olarak ürün uzayı metodolojisine dayanan bir ihracat teşvik sistemi önerilmiştir.

Sonuç olarak, ihracat odaklı yüksek oranlı büyümeyi kalkınma hedeflerini karşılayacak şekilde gerçekleştirmek için ürün uzayımızı ve bunun bileşenleri olan fiziki, beşeri ve kurumsal sermayemizi sürekli olarak iyileştirmeyi hedefleyen bir politika gündemi gerekmektedir.

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü [ ]

Sosyal Bilimler Enstitüsü [X]

YAZARIN

Soyadı: Adı: ATA, SEZAİ

Bölümü: İKTİSAT

TEZİN ADI (İngilizce): EVOLUTION OF THE PRODUCT SPACE AND A NEW PROPOSAL FOR TURKEY'S EXPORT INCENTIVE SYSTEM

TEZİN TÜRÜ: Yüksek Lisans [ ] Doktora [X]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. [ ]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: