

ECONOMIC COMPLEXITY, HUMAN DEVELOPMENT, AND INNOVATION
CAPABILITY

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ABSTRACT

ECONOMIC COMPLEXITY, HUMAN DEVELOPMENT, AND INNOVATION CAPABILITY

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This thesis theorises innovation capability within the Human Development and Capability Approach (HDCA) scope. Today, development thinking has increasingly focused on human beings and their freedoms. People need to expand their capabilities and utilise them to bring valued change. However, HDCA literature heavily concentrated on basic capabilities that limit its power to address complex challenges. We aim to extend the discussion towards complexity. We hypothesise that development is a 'continuous process of building and sophisticating capabilities' and economies need to pass certain complexity thresholds. Therefore, our research question is 'what are the threshold patterns for different country clusters?' The purpose is to discover thresholds that can inform our thinking regarding how one economy can deal with thresholds through innovation policies. We also propose a policy design framework (Four-P Model) as an analytical approach to structure the relationship between the capability space and innovation policy. Methodologically, we have developed a two-stage process that utilises machine learning algorithms. First, we search for the patterns of thresholds.

Then, we concentrate on innovation capability to construct policy level recommendations. In this final stage, we also performed a case study by evaluating Turkey's innovation policy evolution. The case methodology is descriptive policy analyses built upon our quantitative analysis and serves as a sensitivity analysis of our analytical results. The main contribution of this thesis to the existing realm of knowledge is that: while innovation is an essential driver of development, economies face various degrees of complexity thresholds in transforming innovation capabilities into economic complexity.

Keywords: Human development, capability approach, economic complexity, innovation capability, innovation policy

ÖZ

EKONOMİK KARMAŞIKLIK, BEŞERİ KALKINMA VE İNOVASYON KABİLİYETİ

KARA, Okan

Doktora, Bilim ve Teknoloji Politikası Çalışmaları Bölümü

Tez Yöneticisi: Prof. Dr. M. Teoman PAMUKÇU

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Bu tez, Beşeri Kalkınma ve Yetenek Yaklaşımı kapsamında 'inovasyon kabiliyetini' kuramlaştırmayı amaçlamaktadır. Günümüzde kalkınma düşüncesi, insanlara ve çeşitli derecelerde ve türlerdeki eşitsizliklerin üstesinden gelme özgürlüklerine giderek daha fazla odaklanmaktadır. Özgür olmak için, insanların yeteneklerini genişletmeleri ve takiben bu yetenekleri kendi yaşamlarına değer atadıkları bir değişim getirmek için kullanmaları gerekmektedir. Bununla birlikte, söz konusu literatür, karmaşık ekonomik zorlukları ele alma gücünü sınırlayan temel bireysel yeteneklere yoğunlaşmıştır. Bu tez, Yetenek Yaklaşımı konusundaki tartışmaları karmaşıklığa doğru genişletmeyi amaçlamaktadır. Kalkınmanın 'sürekli bir yetenek oluşturma ve karmaşıklştırma süreci' olduğunu ve ekonomilerin çeşitli karmaşıklık eşikleri ile karşı karşıya kalırken belirli aşamalardan geçmeleri gerektiğini varsayıyoruz. Bu nedenle, araştırma sorumuz 'farklı ülke kümelenmeleri için eşik değerler nelerdir?' Bu tez kapsamında kullanılan metodoloji keşifsel araştırmadır. Çalışmanın amacı, bir ekonominin inovasyon politikaları aracılığıyla bu tür eşiklerle nasıl başa çıkabileceğini ortaya çıkartmaktır.

Tez aynı zamanda, yetenek alanı ile inovasyon politikası araçları arasındaki ilişkiyi yapılandırmak için analitik bir yaklaşım olarak Dört-P Modeli olarak adlandırılan bir politika tasarımı ve değerlendirme çerçevesi önermektedir. Metodolojik olarak, ülke düzeyindeki verilerde çeşitli makine öğrenimi algoritmalarını kullanan iki aşamalı bir yaklaşım geliştirdik. İlk olarak, eşik modellerini araştırıyoruz. Ardından, politika düzeyinde öneriler oluşturmak için Dört-P modeli üzerine kurgulanmış inovasyon yetkinliğine odaklanıyoruz. Bu son aşamada, Türkiye'nin inovasyon politikası gelişimini değerlendirerek bir vaka çalışması da gerçekleştirdik. Vaka çalışmasının metodolojisi, kantitatif analiz sonuçlarımıza dayanan tanımlayıcı politika analizleridir ve analitik sonuçlarımızın duyarlılık analizi olarak değerlendirilmelidir.

Anahtar Kelimeler: Beşeri kalkınma, yetenek yaklaşımı, ekonomik karmaşıklık, inovasyon yeteneği, inovasyon politikası

This dissertation is dedicated to my wife Yıldız Tuğba and our son Kaan whose love, support and encouragement have motivated me to pursue and complete this research. I also dedicate it to my brother and my mother, who unexpectedly passed away on the 21st of July 2021.

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LIST OF ABBREVIATIONS

BHN	: Basic Human Needs
CA	: Capability Approach
ECI	: Economic Complexity Index
GERD	: Gross domestic expenditure on Research and Development
GDP	: Gross Domestic Product
PPP	: Purchasing Power Parity
HDCA	: Human Development and Capability Approach
HDI	: Human Development Index
IHDI	: Inequality-adjusted Human Development Index
INQ	: Inequality
IPR	: Intellectual Property Rights
OECD	: Organisation for Economic Co-operation and Development
R&D	: Research and Development
SCST	: Supreme Council of Science and Technology
STI	: Science, Technology and Innovation
TRA	: Turkish Research Area
TRIPS	: Trade-Related Aspects of Intellectual Property Rights
TUBITAK	: The Scientific and Technological Research Council of Turkey
UNCTAD	: United Nations Conference on Trade and Development
UNDP	: United Nations Development Programme
UNRISD	: United Nations Research Institute for Social Development
WB	: World Bank
WTO	: World Trade Organisation

CHAPTER 1

INTRODUCTION

This chapter describes the thesis's objectives and briefly outlines its research question and hypothesis. The chapter also briefly summarises the data sets, methods, and explanatory variables used for the empirical analysis.

1.1. The Context and the Aim of the Thesis

Development is all about empowering individuals and social groups to live a life they have valued. However, human beings' potentialities far exceed what they manage to do. Inadequate access to high-quality education and healthcare services, limited economic opportunities, the absence of political rights, and many others might prevent human beings from performing their potential of beings or doings. The roles of policies are to create the right environment, expand the opportunity space, and influence society's values. People can then develop their full potentials through free choices – named real freedom by Nobel Laureate economist Amartya Sen under his Capability Approach theory.

Amartya Sen defined development as a process where the ultimate aim is to remove unfreedoms that leave people with limited choice (Sen, 1999). His approach focuses on individuals, their abilities, and their freedoms.

He defined functionings as achievements that people value, reached by transforming available resources by grounding skills and abilities. Then, a capability is a person's freedom to enjoy various possible functionings (Frediani, 2010).

In human development and capability approach (HDCA) literature, some scholars claimed that society should guarantee every member a minimum number of central capabilities at minimum socially acceptable levels – marked as social thresholds (Nussbaum, 2013). Social minimum is the bundle of capabilities necessary for individuals or social groups to live a decent life in their societies – one that includes our being able to enjoy self-respect (Nussbaum, 2000). Despite critics over categorising central human capabilities, we believe that every society implicitly agrees that some freedoms be intrinsic to its social contract that defines the boundaries of inequality within that society.

Despite its essential contribution to development thinking, however, HDCA has been criticised for its overemphasis on basic and individual capabilities (Ibrahim, 2006) and the undervalued role of more complex ones and their potential impact on economic development. This thesis aims to overcome this theoretical limitation by expanding the HDCA from basic capabilities to more complex ones.

We assume that development is a moving target. Therefore, each capability's social minimum thresholds shall shift upward over stages of development or downward in the case of nondevelopment. So, the merits of development affect societies' social valuation, which tends to enjoy more complex capabilities as per freedoms. In this regard, we define development as a continuous process of enlarging individuals' choices by expanding their capability space towards complexity and allowing them to freely utilise those capabilities to bring valued change to their own lives.

While the explicit policy objective of HDCA is the expansion of capabilities, the implicit one is to catalyse agency. Real freedom is the power to determine action without restrictions, so-called the agency (Sen, 2000).

People will be free (be an agent) when they bring change to their own lives through their capabilities (Alkire and Deneulin, 2009). Therefore, we claim that the direction of the change valued by the agent(s) should be a vital policy concern.

In economics, the direction of change could be either quantitative or qualitative. While growth is associated almost entirely with the former, development is allied mainly with the latter. Innovation economists acknowledge that qualitative transformations result from introducing novelties that are new to the context (Atkinson and Audretsch, 2010). Hence, there is a need to bridge the theoretical gap between the Capability Approach and Economics of Innovation. In this regard, within this thesis's scope, we aim to define and then assess innovation capability as a complex one to stimulate qualitative change.

Sen also defined the Capability Approach as a policy evaluation and designing toolkit (Sen, 1999). However, the Capability Approach literature is not ready to provide an appropriate framework for policy development. So, we decide to employ it with its original purpose. We further aim to construct a policy framework (we named it as Four-P Model) and then apply it more specifically for innovation.

1.2. The Originality of the Thesis

This thesis extends the original Human Development and Capability Approach to address three main theoretical limitations:

1. The Capability Approach is not a theory but rather an approach for the evaluation of effective freedoms. Hence, it necessitates an explanatory theory for the capability that is under consideration. In this thesis, we employ Economics of Innovation as the explanatory theory for our analysis on innovation capability.

2. The approach has been criticized for being excessively individualistic – which means overemphasis on basic human capabilities. This thesis extends the current literature from basic to complex capabilities.
3. Despite its ultimate aim of being a policy evaluation and design toolkit, there is no clear methodology to apply the Capability Approach. This thesis provides a policy design and evaluation framework, namely Four-P Model.

Such theoretical extensions allow us to test our central hypothesis. Development is a moving target. Therefore, the social minimum thresholds for each capability shall shift upward over stages of development or downward in the case of nondevelopment. Since capabilities are the means of other capabilities, there should be various capability thresholds over complexity increase. Overall, ‘what are the threshold patterns for different country clusters?’ is the main research question for our hypothesis.

Empirically, we shall apply various machine learning techniques (such as regression, random forest, confirmatory factor analysis, clustering, and decision trees) to country-level data to address our research question of identifying patterns of thresholds.

Our particular focus is on innovation, which is a complex capability. As our Four-P Model postulates, each capability has components (such as resources and capacities). Understanding the inner mechanism of such components is vital to design and evaluate innovation policies. Again, we shall apply machine learning techniques at country-level data to compare innovation capability components of various country clusters. We will draw out policy recommendations accordingly. We acknowledge that no model is perfect. But our model provides us with a way to explore the mechanism behind the complex capabilities and their fundamental role in development.

1.3. The Organization of the Thesis

There are five chapters in this thesis. Chapter 1 is the introductory chapter that summarizes the content of the thesis.

Chapter 2 contains the literature review. First, we outline the current literature on human development and the capability approach. Then, we focus on economic complexity, which is the dependent variable in our empirical analyses. Finally, we examine the contemporary discussions on innovation, innovation capability and innovation policy.

Chapter 3 theorises complex capabilities for development and addresses extending the literature from basic to complex capabilities. We performed an initial empirical analysis (through a group of unsupervised machine learning techniques) to achieve country-level clusters so that we could identify complexity thresholds for each cluster.

Chapter 4 is on innovation capability, and the Four-P Model framework for policy design and evaluation is formalised in this chapter. We will exercise our second empirical analysis in this chapter—an analysis of the policy-level assessment of Turkey’s innovation policy change as a descriptive study and built upon the results of our machine learning algorithms. The final chapter concludes with policy recommendations.

1.4. Brief Summary of Findings

Here are the key findings of this thesis:

- The HDCA has been mainly applied for basic human needs and related capabilities. In this study, we demonstrated the potentiality of HDCA for addressing complex capabilities (and the underlying) inequalities that exceed basic human needs.

- Development is a continuous process of enlarging individuals' choices by expanding their capability space towards more complex capabilities and allowing them to freely utilise those capabilities to bring valued change to their own lives.
- Governments' roles are to define the direction of change and socially construct competitive assets that accurately fit the new direction. Overall, we name these roles as the sophistication of the capability space, while the ultimate aim is to remove unfreedoms and inequalities that leave people with the limited choice to exercise their agency.
- In this study, our hypothesis is that there are complexity thresholds over the stages of development, and our research aim was to identify these threshold patterns for different country clusters. As a method, we used various machine learning algorithms that feed each other to test our hypothesis. Our study reveals that the level of a country's science, technology, and innovation capability (STI) is vital to determine its potentiality for complex capabilities. Therefore, STI is a critical threshold for development, independent of cluster belonging.
- However, STI alone cannot explain countries' economic performances (where the dependent variable is the economic complexity index) since there are other thresholds over development and economic complexity. For the top performers' inequality (INQ) is an absolute threshold. STI is the only threshold for the lowest performers, but when they enhance their STI levels, they have faced INQ and (basic human needs) BHN as additional thresholds. For the emerging economies, lower STI performers need to surpass certain BHN thresholds, while higher STI performers should tackle INQ as a threshold.

- We conclude that, while investments in STI capability should boost the economic performance, over the development process, many other factors limit full utilisation of STI investments and call for crossing some different thresholds for complexity enhancement.
- Our cross-country analysis reveals that economies should extend their STI capabilities while overcoming non-STI thresholds that they would face according to their cluster belongings for achieving economic complexity.
- The Capability Approach literature is highly immature to provide an appropriate framework for policy development. Therefore, we constructed a policy framework (namely Four-P Model).
- In Four-P Model, each P stands for complementary roles within the overall capability space. P1 aims to maximize a systems' exposure to resources where lack of such resources generates inequalities. For innovation capability, P1 aims to generate or acquire new-to-the-system knowledge. P2 involves policies for enhancing the actors' resource-related capacities – an actor specific conversion factor to transform resources into functionings. In our analysis, absorption capacity plays this role under P2 category policies. Socio-environmental conversion factors (i.e., institutions) stand for the P3 category, and innovation policy literature has a broad perspective on system-related institutions that allow capability enhancement and resource-capability match. Finally, P4 defines the social valuation (a choice mechanism) of the politically targeted functioning.
- Therefore, the components of innovation policy are as follows: (P1) accessing and developing new knowledge; (P2) sophisticating absorptive capacity; (P3) developing appropriate institutions for innovation capability; and (P4) social valuation of agents to operationalize innovation capability, i.e., attitude change.

- Once again, we used multiple machine learning algorithms to assess the Four-P Model empirically. A consensus within society is that innovation is vital for prosperity (UNCTAD, 2010). For the most developed economies, the critical variable of importance is Knowledge. Countries in this group have set their institutional infrastructure and strengthened their capacities. Therefore, the fundamental issue is to access state-of-the-art knowledge to sustain welfare and catalyse its transformation to innovations.
- Catching up economies are generally in a position to adopt institutions of developed economies, enhancing their absorptive capacity to benefit from global circulation of knowledge and influence their change agents' choice decisions towards innovation.
- Finally, the developing economies generally have systemic failures that need good governance and continuous improvement of institutions. Accordingly, we have witnessed that institutions have a dominant score in our analysis of variable importance.
- As a sensitivity analysis, we performed a case study based on the research findings of the previous step's variable importance analysis. The case study was a descriptive innovation policy analysis applied to Turkey and its innovation policy change pattern.
- Our descriptive analysis revealed that Turkey followed the right approach and invested in P3 and P1 to develop its innovation capability during the 1990s and 2000s, which – as we outlined – was a reflection of Turkey's political integration to Europe, including integration at Science and Research domain.

- The increased STI capability improvement efforts weighted on P3 and P1 policies resulted in moving up a new cluster. However, Turkey has been locked into former cluster's institutions with limited diversification.
- Overall, our analysis revealed that the Four-P model and our cluster analysis could provide a valuable policy design and assessment tool to operationalize.



CHAPTER 2

LITERATURE REVIEW

2.1. Human Development and Capability Approach

In his influential approach, Amartya Sen defined development “*as a process of removing unfreedoms (or expanding freedoms) that leave people with limited choice or opportunity to exercise their agency*”, which refers to the capacity of individuals to act independently and make their free choices (Sen, 1999, p.18). With this regard, an individual could be an agent when s/he develops her capabilities (freedoms) to change her own life.

The definition of development from Sen's perspective structures it as a moving target. The necessary capabilities and the change process that people value evolve due to personal or group dynamics. Overall, the capability approach focuses on individuals, their abilities (to be and to do), and their freedoms. This description discloses the two main features of the approach for further discussion: (a) valuation: attribute value to any activity or personal statement, and (b) the central role of the capabilities.

The attribution of value to an activity (doing) or a situation (being) and exercising the capability set is 'functioning' in Sen's original approach (Sen, 1999). Within functioning, available resources are transformed into value(s) by grounding skills and abilities. A capability is, then, a person's freedom – within a given opportunity space – to enjoy various possible functionings. While functionings refers to real achievements, a capability indicates the opportunity space (Frediani, 2010).

It is an essential distinction between 'doing X' and 'choosing to do X'. One can define the choice mechanism only with the attributed value of it. It reflects the freedom reference of Sen. Figure 1 illustrates the simple sequence of the human agency based on the Capability Approach theorization.



Figure 1: Human Agency

Source: Author's illustration, based on (Clark, 2005; Frediani, 2010; Sen, 1999)

The approach also highlights the difference between means and ends. Only the ends have central importance; however, some ends are simultaneously also meant to other ends (e.g., the capability of being in good health is an end in itself, but also a means to the capability to work) (Robeyns, 2005). One needs to follow two primary processes to exercise agency: (a) first, need to access the necessary resources; and (b) be able to and willing to transform these resources into desired value(s).

The following example adapted from Alkire and Deneulin (2009) may better introduce the key concepts. *“Assume that a girl owns a bicycle (resource) and can ride it (capacity). She rides around the town and values this mobility (functioning). However, if she cannot do so, for instance, due to cultural restrictions on women's mobility alone, owning a bicycle would not result in this functioning. Therefore, her agency shall only be realised with the appropriate opportunities”* Alkire and Deneulin, 2009, p.41).

As a further example, political freedom is a powerful capability to exercise human agency. Under such freedom, a well-known capacity is to determine who should govern society. The possibility of complaining about authorities, having the freedom of political expression, and enjoying the freedom to choose between different political parties are all components of broader political freedom (Sen, 2011).

The perspective of freedom is where capacity and capability terms differentiate, even though they are unintentionally used interchangeably in several studies. As Frediani, (2008, p1) highlighted, *"capacity is related to enhancing skills and abilities, whereas capability is tied with reaching appropriate resources, improving capacities and expanding opportunities"*.

Therefore, capabilities are the potential of the proper combination of resources and associated capacities. The realisation – transforming capabilities into achievements (functionings) – is the choice mechanism. In reality, two people with identical capability sets are likely to end up with different types and levels of achieved functionings due to their diverse ideas of the good life (Robeyns, 2005).

The choice mechanism significantly departs from the mainstream development discourse in which homogenous agents are assumed to perform similar functionings (the representative agent). However, the Capability Approach attaches great importance to individuals' heterogeneity - in the form of capabilities, valuation, and availability of opportunities.

The availability of appropriate opportunities allows the transformation of capabilities into functionings by (1) expanding resources, (2) enhancing capacities and (3) catalysing the matching of the resource-capacity pair. The Capability Approach's underlying assumption is that in the absence of fitting opportunities, capacity building programs – aiming to enhance new skills and abilities – will not be sufficient to enable people to achieve their well-being (Sen, 1999). Palliative interventions to tackle development challenges – i.e., poverty mitigation programs, by concentrating on capacities or resources only, might not be sufficient (Frediani, 2010) to overcome the "systemic reproduction of inequalities" (Hartmann, 2012). In brief, Sen has focused on functioning, capabilities and resources. Together, they constitute the three building blocks of the capability approach, as illustrated in Figure 2.

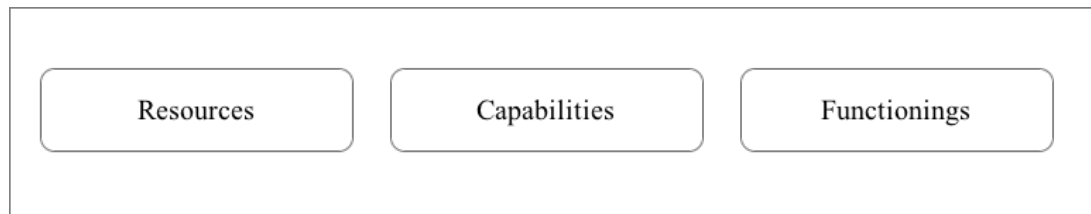


Figure 2: Building Blocks of the Capability Approach

Source: Author's illustration, based on (Sen, 1999)

Many scholars who practised the capability approach are primarily focused on linking functionings and capabilities. They wonder whether individuals who want to live a certain way have the capability to do it or not; alternatively, whether they have the choice to realize their capabilities or not. Few others concentrated instead on the linkage between resources and capabilities. In both cases, real freedom is the aim of their analyses. Resources consist of goods and services distributed through the political, economic, and social systems. Nonetheless, equal resources may correspond to wholly unequal capabilities (Berthet et al., 2009), and transforming such resources into the functionings is influenced by some factors, either internal or external. Sen labelled them as the conversion factors (Sen, 1999).

As (Robeyns, 2005) defined, there are two main conversion factors: personal and socio-environmental. While the former is associated with capacities, the latter is linked with institutions and other environmental factors. Both types of conversion factors influence how an individual can convert a resource's characteristics into real achievement. Knowing the resources an individual owns is not sufficient to understand which functionings s/he can achieve. Therefore, we can claim that, unlike the mainstream development discourse, the capability approach considers both personal and socio-environmental diversity for policy-level actions. Recalling back the previous bicycle example, in the absence of adequate personal conversion factors – i.e., ability to ride, and socio-environmental conversion factors – such as social norms permitting riding – the transformation of resource (bicycle) into real achievement (functioning) is not possible. Figure 3 illustrates the linkages among components of the capability approach.

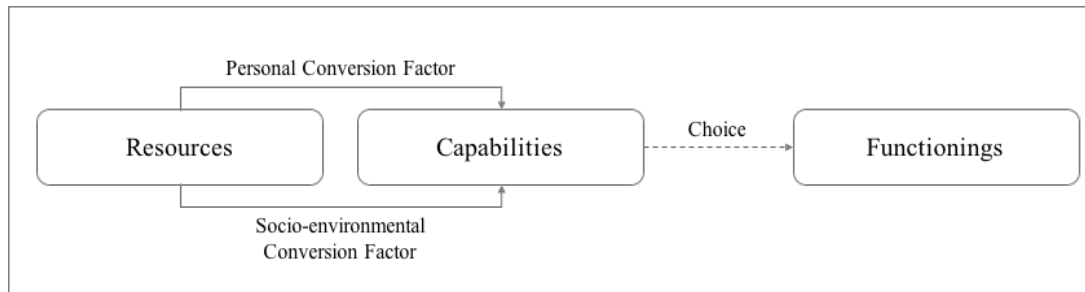


Figure 3: Components of the Capability Approach

Source: Author's illustration, based on (Berthet et al., 2009) and (Robeyns, 2005)

As the capability approach gained popularity, several social sciences branches attempted to complete it by generating lists of several capabilities and augmenting the original framework. The most well-known attempt belonged to the feminist philosopher Martha Nussbaum, who aimed to build a list of central human capabilities. Nussbaum's list of central human capabilities includes life, bodily health, bodily integrity, the senses, imagination and thought, emotions, play, other species (being able to live with concern for and with animals, plants, and the world of nature), and control (political and material) over one's environment (Nussbaum, 2013). Although Nussbaum by no means claims her list as definite and unchanging, she does strongly advocate for the advantages of outlining a list of central human capabilities.

According to her, this list isolates those human capabilities that can be convincingly argued to be of central importance in any human life, whatever else the person pursues or chooses (Nussbaum, 2013). However, Sen is critical to such efforts. For him, the problem is not with listing essential capabilities but with insisting on one predetermined canonical list (Sen, 2011). An exact list and weights would be problematic to establish primarily due to the appropriate specification of the context of their use, the diversified choices of various societies and their understanding of the decent standard of living (Clark, 2005).

The Capability Approach is not a social justice theory (Sen, 1999). It does not provide a clear path on which capabilities to concentrate on and how much we should extend these capabilities (Nielsen and Axelsen, 2017).

Nussbaum defined her list as a benchmark for setting a 'social minimum' (Nussbaum, 2013), a threshold that every society should guarantee to ensure human dignity. However, concentrating on a relatively low threshold of basic human needs limits the capability approach's potentiality in more complex capabilities and undermines the inequalities above such minimal thresholds. Otherwise, we can only apply the approach to underdeveloped societies and social groups since the perspective does not answer inequalities above the social minimum or inequalities beyond basic needs. One recent issue of the Human Development Report (UNDP, 2010) highlights the rise of a new generation of inequalities since opportunities once considered luxuries are evolving as critical needs for experiencing human capabilities, such as accessing broadband for education.

From our point of view, the capability approach has the potentiality to provide solutions for more complex inequalities. The development community's efforts should be concentrated on the components of any targeted capability and the relevant conversion factors while working on extending the theoretical understanding towards complex capabilities as a response to inequalities that exceed the basic human needs.

2.2. Economic Complexity

Approaching economic policy from a complexity perspective (rather than from mechanical equilibrium) enhances our understanding of complex capabilities. The core mechanism of complexity is evolution. From an evolutionary perspective, an economy is an organism that is constantly developing new industries, technologies, organizations, and capabilities while at the same time shedding older ones - making them redundant (Atkinson, 2016).

This rate of evolutionary change within the economy's composition differs over time and space, depending on various factors, including technological advancement, entrepreneurial effort, domestic policies, and the international competitive environment.

Complexity theory emphasizes the crucial role of history in shaping the future. Past interactions and decisions have significant impacts on the economy - a characteristic known as path dependence.

Complexity theory sees the economy as a complex adaptive system that evolves (Scott, 2008). The evolutionary process of diversification, selection, and retention provides the system with novelty and is responsible for the growth in order and complexity over time. Out of this process of evolution, we get an increase in the gross throughput to the system in terms of its qualitative structural transformation. Such change differentiates and integrates to exhibit greater complexity (OECD, 2019).

A complex adaptive system allows for a broad set of interactions between individuals and recognizes that an economic actor's preferences are diverse (Beinhocker, 2007). Agents do not just respond to market signals, such as the price; they also interact with other agents, influencing their subsequent choices and actions (Arthur, 1999). The system is adaptive because agents learn from experience and the experience of others and so gain the knowledge they would otherwise have lacked. In contrast, in traditional economic theory, the economy is populated by representative agents operating in isolation. Rational economic man presents a "pitiful portrait of humanity: he stands alone, with money in his hand, a calculator in his head, ego in his heart, and nature at his feet" (Raworth, 2017). In models derived from a complexity perspective, however, people are not assumed to be rational agents: they factor in the ability of agents to learn and adapt based on experience and allow for trial and error and flexible behaviour (Nelson and Winter, 2002).

Historically, economics deals with two essential questions: allocation (how quantities of goods and services and their prices are determined within and across the market) and formation (how an economy emerges in the first place and grows and changes structurally over time) (Arthur, 2015).

The formation is fundamentally about innovations, institutions, qualitative change, and economic development. Economic development is associated with structural transformation and increased complexity of production and exports from the perspective of complexity.

The literature on the economic complexity (Anand et al., 2012; Felipe et al., 2012) has found that diversification towards more complex products (those exported by fewer countries with a more diversified production base) can be vital contributors to economic development.

These theoretical studies stimulated several country-studies that identify potential new economic sectors for diversification that can contribute to the economic development (Felipe and Hidalgo, 2015; Hausmann et al., 2013; Hausmann and Klinger, 2008). This process is a strongly path-dependent (Gerschenkron, 1979). The industries that are more likely to be emulated require a set of capabilities that might overlap with the set required by the existing industries in the economy (Rodrik and Hausmann, 2006).

Eric D. Beinhocker, in his influential book of "The Origins of Wealth", defined the key factors of complex economies as follows (Beinhocker, 2007, p.97):

- *Dynamics: The complex economy is open, dynamic, non-linear, and generally far from equilibrium, whereas mainstream economics defines the economy as closed, static, and linear.*
- *Agents: In the complex economy, agents have limited information and face high costs of information processing. In the Neoclassical economy, by contrast, agents have perfect information and can optimize free of charge.*

- *Networks: Agents in the complex economy participate in sophisticated networks that compensate for having limited information and facing formidable information processing costs.*
- *Emergence: In the complex economy, macroeconomic patterns are emergent properties of micro-level interactions and behaviours. In such cases, we cannot analytically derive the properties of the macro system from those of its components.*
- *Evolution: In the complex economy, the evolutionary process of differentiation, selection, and amplification provides the system with novelty and is responsible for the growth in order and complexity.*

(Hidalgo and Hausmann, 2008) presented ECI (Economic Complexity Index) as a measure of the number of capabilities and know-how that goes into producing any given product. Economic complexity approaches are grounded on the trade data collected into a bipartite network, defining exporters and products and detailing whether and how much (in monetary value) a country exports a given product (Sciarra et al., 2020). More precisely, based on HDCA, ECI is measuring realized capabilities - i.e., functionings. Products are presented as the vehicles for knowledge. Product Space is a theoretical concept in which the distance between any two products is related to the distance in the capabilities required to make them.

Therefore, the complexity of an economy is related to the diversity of valuable knowledge embedded in it. Because individuals are limited in what they know, societies can expand their knowledge base by facilitating the interaction of individuals in increasingly complex networks to make complex products. As a tool, it can help us determine which products require productive know-how like the know-how a country already possesses.

Using network science algorithms, the ‘Product Space’ details nearly 800 products into 34 colour-coded communities, visualises the ‘capability distance’ between products (Hausmann et al., 2013).

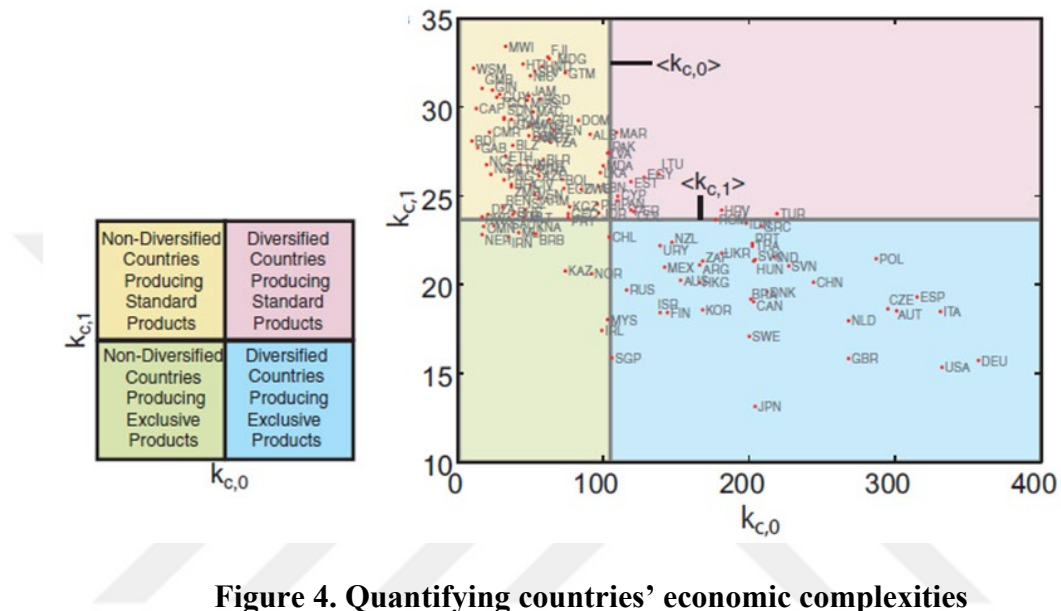


Figure 4. Quantifying countries' economic complexities

Source: (C. A. Hidalgo and Hausmann, 2009)

Figure 4 plots the observed diversification of a country (calculated by the number of products exported by that country) against the ubiquity of its exports. ($k_{c,0}$ – $k_{c,1}$) the diagram on the right is divided into four quadrants defined by the empirically observed averages ($k_{c,0}$): the observed levels of diversification of a country (the number of products exported by that country) and ($k_{c,1}$): generalized measures of the ubiquity of their exports. The two quadrants (‘non-diversified countries producing exclusive products’ and ‘diversified countries producing standard products’) are almost unoccupied as expected. In contrast, the remaining quadrants (‘non-diversified countries producing standard products’ and ‘diversified countries producing exclusive products’) are highly crowded.

Therefore, the economic complexity of a country is calculated based on the diversity of exports a country produces and their ubiquity, or the number of the countries able to produce them¹. ECI, therefore, is the rank of countries based on how diversified and complex their export basket is (Hidalgo and Hausmann, 2009).

Empirical evidence on economic complexity resulted in the perspective having the potential to provide insight into cross-country differences for long-term GDP changes. A recent study (Mealy et al., 2019) found that countries with high (low) ECI tend to specialize in high complexity (low complexity) products, meaning technologically sophisticated. A country with a high complex economic system can cope with the economic crisis, generate high-quality jobs, and prevent social problems arising due to economic inequalities.

The ECI has attracted significant attention from researchers and policymakers because it can explain more variation in-country income per capita and economic growth than other variables commonly employed in growth regressions such as governance, institutional quality, education, and competitiveness (Mealy and Teytelboym, 2020).

The complexity of a country's exports is found to predict current income levels highly, or where complexity exceeds expectations for a country's income level, the country is expected to experience more rapid growth in the future². ECI, therefore, provides a useful measure of economic development. In this thesis, ECI values of a broad group of countries are used for the empirical analysis as a proxy for complex capabilities.

¹ <https://atlas.cid.harvard.edu/glossary>

² <https://atlas.cid.harvard.edu/glossary>

2.3. Innovation Policy

The notion of innovation is prevalent among decision-makers. There is a consensus among academia, international organisations, and national and local governments that innovation is vital to generating prosperity and overcoming challenges (UNCTAD, 2010). Innovation is also one of the fundamental economic complexity processes. Increasing economic complexity necessitates a long-term commitment to innovation efforts guided by an integrated policy attempt.

However, innovation policies remain "skewed, unfocused, and limited" on various occasions; mainly due to innovation's complex and evolutionary nature that requires a holistic approach covering science, technology, and industry policies (Borrás and Edquist, 2019). Moreover, social embeddedness and path-dependent characteristics necessitate specialised experience for different agents, domains, and geographies. There is no one-size-fits-all type of policy solution package, and policy construction is all about the decision-maker's choices.

In this regard, any policy attempt requires straightforward questions to begin with. What is the purpose of the policy? What are the shortcomings that we intend to overcome? Which theoretical framework fits well in our case? Which instrument (or combination of instruments) shall serve our targets? Which agents should be induced to initiate search activities? How to allocate resources? Etc.

Historically, innovation policy's fundamental role was mainly industrial competitiveness and economic catch-up. Nevertheless, today, policymakers also expect innovation policies to be active in defeating inequalities, fighting global challenges, and transforming economies. Contemporary innovation policies target complex and collective societal problems. SPRU School (The Science Policy Research Unit of the University of Sussex) analysed this evolving role of innovation policy under the heading of 'three frames of innovation policy' (Schot and Steinmueller, 2018).

The first frame governed from the 1960s to the 1980s, and the core responsibility was fixing the market failures as advocated by the neoclassical economy perspective. The linear model dominated the conceptualisation of innovation during the period, and policy attempts primarily focused on knowledge generation and IPR protection. Therefore, government resources are mainly allocated for R&D expenditures to fix the market. The second frame, which has been the dominant discourse since the late 1980s, is structured around the "systems of innovation" conceptualisation. This second frame's core policy intervention justification is fixing systemic structural failures such as linkage problems among actors, stimulating demand for innovation, enhancing absorptive capacity, and circulating knowledge to simulate different learning modes.

In the first frame, science (and scientific discovery) is the basis of economic growth, and innovation mainly consists of the commercialisation of such discoveries. In the second frame, however, knowledge utilisation and knowledge generation have gained interest. The scope of innovation policy has extended to cover process and organisational innovations in addition to product innovation.

Today, contemporary challenges driven from economic, environmental and societal roots gave birth to a new frame – the so-called transformative change (Diercks et al., 2019). Transformation refers to the “*socio-technical system-wide changes that exceed geographical, economic, social and technological boundaries*” (Schot and Steinmueller, 2019, p.1554). Neither the first nor the second frames necessarily solve grand challenges, necessitating collective learning of many scientific disciplines, research and industry groups, end-users, and governments.

In this third frame, the innovation policy does not solely target technological leap forward but also changes in capabilities, institutions, industry structures, regulations, and social choices. In many cases, fundamental institutional reforms that affect the direction and rate of innovation will need to stimulate targeted creative destructions – for instance, forcing the usage and accelerating market penetration of electric vehicles to cope with climate change. Therefore, under this new frame, designing and executing innovation policies necessitate new practices.

Scholars argue that mission orientation is the ideal policy practice under this third frame (Mazzucato, 2018). In this context, a mission is *"a concrete target, achievable step towards a grand challenge that contextualises projects"*, and a grand challenge is *"a difficult but important, systemic and society-wide problem with no silver bullet solution"* (Mazzucato and Dibb, 2019, p.17). Naturally, a mission is a complex system of diversified technologies and sectors. Therefore, missions are subsets of grand challenges and proposed as an ideal object of innovation policies - focussing less on individual technologies or sectors but more on problems that matter to all of us (Mazzucato, 2018).

The role of innovation policy is to orchestrate innovations of such technologies and sectors in a harmonised way to a direction. Therefore, missions transform a challenge into concrete problems requiring many change agents to collaborate and innovate, accompanied by behavioural changes, new institutions, and good governance. In a nutshell, missions focus on issues — not sectors, technologies, or companies (Mazzucato, 2011).

Overall, the third frame of innovation policy is not eliminating policy interventions and instruments of the first and second frames. Instead, it is a new manifest to reorganise tested and untested tools for the sake of new and emerging challenges that our societies face.

Especially in the developed world, there is an increasing tendency to experience the third frame through various programs to tackle emerging challenges (OECD, 2019) – such as inequalities, climate change, pandemics, etc. The second frame was a radical departure from neoclassical economy policies and instruments, but the third frame is an alignment of innovation policy studies with the emerging economic complexity phenomenon. Complexity economics relaxes many assumptions of neoclassical economics, considers economic agents as heterogeneous interacting within networks, and defines the economic development process as self-creating and in a perpetual novelty (Arthur, 2021). Hence the third frame defines innovation policy according to this understanding.

The oligopolistic structure of high technology sectors and their increasing knowledge intensity force decision-makers to search for a new way of policymaking. Despite the diversification of policy aims and programs, a recent study outlined that, countries have still allocated resources through the instruments they best knew. National strategies and plans, grants for public research projects, grants for corporate innovation, and clusters and collaborative platforms are still the top policy instruments (OECD, 2019).

After market failures (resulting in sub-optimal investment in research and innovation) and system failures (bottlenecks in the system's functions), the innovation policy systems are now facing transition failures. Under the third frame of innovation policy literature, addressing transition failures are defined as governments attempts to drive socio-technical transitions that are vectors of societal transformation and contribute directly to resolving societal challenges (Schot and Steinmueller, 2018). A socio-technical system is a “*configuration of actors (their knowledge, skills), technologies (products, infrastructures), and institutions (regulations, cultural symbols, markets) for fulfilling a certain societal function (mobility; or inland mobility; urban mobility)*” (Kanger et al., 2019, p.2). The transition of a socio-technical system is a complex and long-term process resulting from a co-creative journey between several STI actors (Molas-Gallart et al., 2021). They are centred on creating novelty and building niches. The outcome is not only a change of the socio-technical system, “*but also about changing the underlying rules that actors use to build, optimise, and maintain the system*” (Ghosh et al., 2021, p.741).

This paradigm observes the fusion of innovation policies with more traditional policies that aim at national competitiveness and productivity; and mission-oriented policies. Such mission-oriented policies have the following features: (a) they are top-down initiatives with solid political support; (b) they are multidisciplinary concerning technologies but concentrated on a unique theme; (c) along with the development of technologies, their diffusion and adoption are central concerns; and (d) from the design phase to implementation, inclusiveness and representation of relevant actors in the society is vital (Mazzucato and Dibb, 2020).

2.4. Conclusion

This thesis gains its theoretical foundation from three categories of literature: The Human Development and Capability Approach, Economic Complexity, and contemporary innovation policy studies (as illustrated in Figure 5).

This chapter summarised them briefly and defined the fundamental terminologies that we will use in the following two chapters.

In his seminal study, Thomas Kuhn, defined paradigm shifts. He stated that they happen when a critical mass emerges in the number or importance of anomalies that contradict the dominant paradigm and that catalysis the emergence of an alternative theory that better explains such anomalies (Kuhn and Hacking, 2012). The financial crash in 2008, followed by a slow recovery, the widening of economic and social inequalities, environmental crises, emerging societal challenges, political instabilities, and power shifts in the global world, are both the reasons for the modification within the current neoliberal paradigm in economics and the signals of a new emerging one. The three foundational pieces of literature (capability approach, economic complexity, and contemporary innovation policy) that we have analysed in this chapter has contributed to the modifications within the current paradigm from different vectors. Theorising a foundation for the new paradigm is not an issue of this thesis. We aim to utilise these three literature pieces to define hybrid approaches and practical tools while fulfilling the gaps for enhancing interoperability.

The HDCA is the backbone of our study, under which development necessities a positive change in human lives by removing unfreedoms and expanding the opportunity space for all. However, this literature is underdeveloped to cover complex capabilities since the primary debate has been on basic human capabilities. So, we decided to benefit from complexity theory literature to understand economic complexity dynamics. The heterogeneity of individuals, capabilities, and choices structure our extension efforts of the capability approach. A complex adaptive

economic system can confirm the importance of diversification and qualitative change as a human development source. We defined development as a moving target that each stage of development necessitates overcoming certain thresholds. By analysing historical data, knowing these thresholds is vital to develop appropriate policies towards complexity. Qualitative change in an economy results from the deliberative innovation efforts and policies.

As a policy design and evaluation tool, capability approach and innovation policy can feed each other to provide a new way of policy design. The contemporary innovation policy literature prioritizes not only the rate of innovation but also its direction – together with the central role of change agents. Economic Complexity literature defines capability extension as a significant activity within an economy to enhance the product mix. Altogether, these three pieces of literature will define complex capabilities for economic development and then the innovation capability more specifically in the following two chapters.

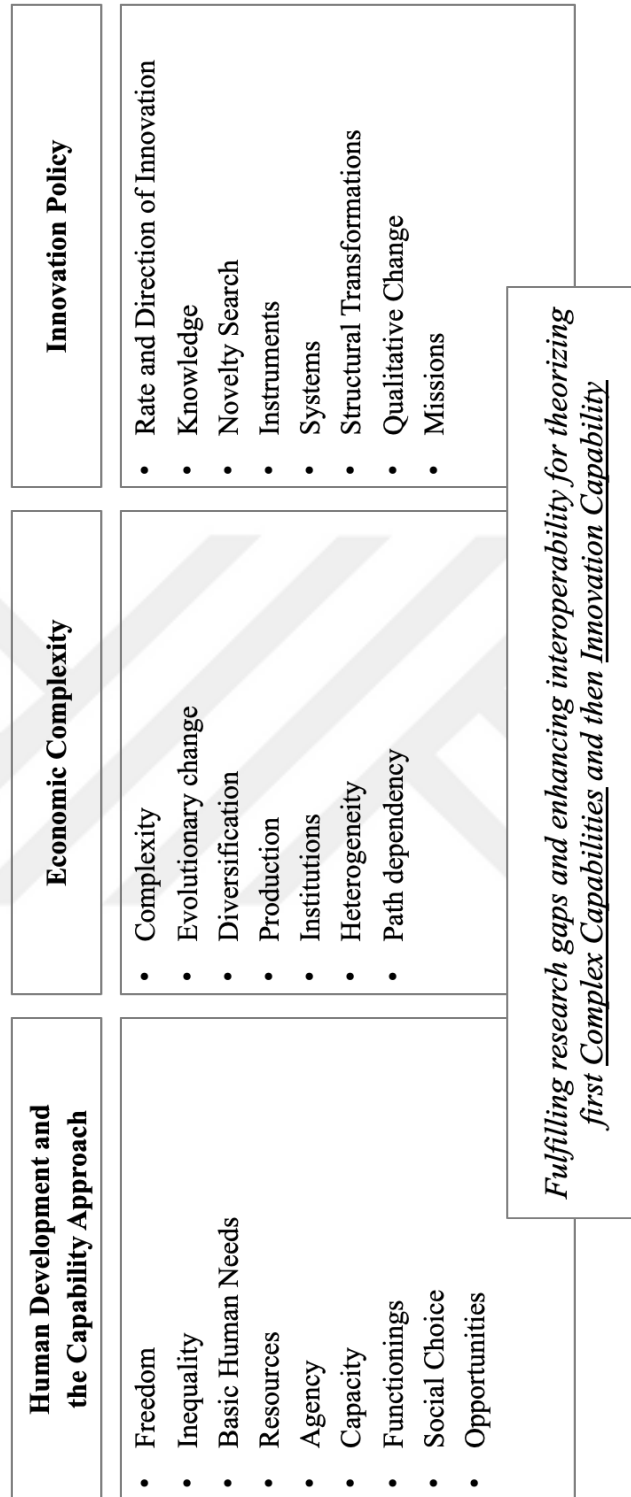


Figure 5. Theoretical Synthesis

Source: Author's illustration

CHAPTER 3

COMPLEX CAPABILITIES FOR DEVELOPMENT

3.1. Introduction

Human beings' potentialities far exceed what they manage to do (Sen, 1999). Lack of education, healthcare problems, limited economic opportunities, the absence of political rights and many other challenges might prevent human beings from performing their potential of 'to be' or 'to do'. Therefore, development is about creating the right environment to develop their full potential. It could be a process of empowering people to live a life that they value. The intellectual interest in development has been increasingly focusing on the one hand, on how human life can go much better ("where to go"), and on the other hand, on how this betterment can be brought by human agency ("how to go there") (Sen, 1985). According to Sen, those two aspects could be labelled respectively as 'the evaluative aspect' and 'the agency aspect' (Sen, 2011). Scholars crystallized such theoretical curiosity under the heading of Capability Approach. The ultimate aim is to remove unfreedoms and inequalities that leave people limited choices to exercise their agency (Sen, 1999).

However, despite its substantial contribution to development thinking, the overemphasis on the supply of basic individual capabilities has been criticized (Amsden, 2010). Development is a moving target, and new challenges necessitate new and more complex capabilities over time, extending the limits of basic individual capabilities.

Moreover, the efficient supply of these better capabilities does not automatically lead to better economic opportunities if the demand for such capabilities is missing. Therefore, the balance between the supply of and demand for such capabilities is a key policy challenge.

Accordingly, one may claim that a successful economic development process necessitates the co-evolution of complex capabilities on the supply side and appropriate economic opportunities on the demand side (i.e., formal jobs). Those are the main discussion points of this Chapter, which has six sections.

Section two explores basic capabilities and defines the human development index as a proxy for them. Section three theorizes complex capabilities. Section four describes the central hypothesis of this thesis, the research question, the research methodology, and finally describes the dataset. Section five explores our research results. The final section concludes.

We hypothesised that "There are complexity thresholds over the stages of development", and the research question was "What are the threshold patterns for different country clusters?". Our research results confirmed the existence of thresholds – mainly STI (science, technology, and innovation) and INQ (inequalities) and BHN (basic human needs) for sub-clusters. We have defined these thresholds for each cluster and their magnitude. Our conclusion for this chapter is that economies should extend their STI capabilities while solving non-STI thresholds that they would face according to their cluster belongings for achieving economic complexity.

3.2. Basic Capabilities

In the 1980s, Amartya Sen began to develop capability-based human well-being understanding. A few years later, economist Mahbub ul Haq put the idea into practice by introducing the Human Development Index (HDI) with the United Nations Development Programme (UNDP, 1990).

Since its first introduction in 1990, HDI has been the most successful effort to supplant GDP. It extends the traditional approach of the mainstream development discourse's commodity-based evaluations of life to health, education and freedom (UNDP, 2010). In this thesis, HDI and its sub-components are utilized as proxies for basic capabilities.

The HDI was created to emphasize that people and their capabilities should be the ultimate criteria for assessing development, not economic growth alone. The HDI can also question national policy choices, asking how two countries with the same level of GNI per capita can end up with different human development outcomes. These contrasts can stimulate debate about government policy priorities. The Human Development Index (HDI) is a summary measure of average achievement in human development's key dimensions: a long and healthy life, being knowledgeable and having a decent standard of living (see Figure 6). The HDI is the geometric mean of normalized indices for each of the three dimensions (UNDP, 2011).

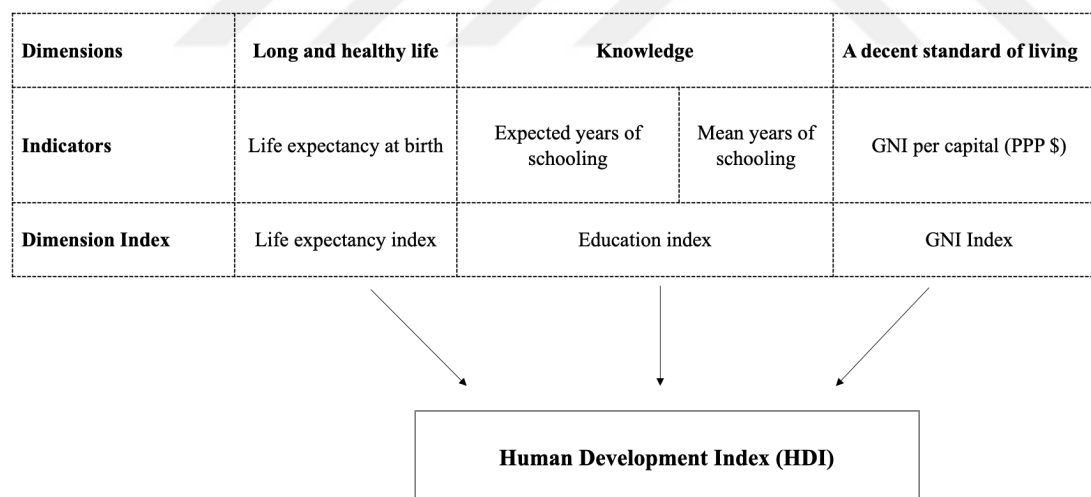


Figure 6: Dimensions and the Indicators of HDI

Source: 2019 Human Development Report (UNDP, 2019)

Unlike HDI, GDP addresses the economy's scale and concerns increase in its output. It is only one of several necessary ingredients for promoting human well-being but fails to measure human development for two main reasons. At first, income is an insufficient measure of well-being.

GDP cannot fully capture many valuable things in life since GDP cannot distinguish between economic activities that increase a nation's wealth and ones that eat into its natural endowments and result in future costs (Fox, 2012).

Further on, the second limitation of income to measure human well-being is that income levels alone mask inequality in the level of distribution and material consumption (Spence, 2010; UNDP, 1990). If income distribution is unequal, human development cannot be improved much. Reducing inequality has clear benefits over time: it strengthens people's sense that society is fair, improves social cohesion and mobility, and broadens support for growth initiatives (Hasanov and Izraeli, 2012).

Since 2010, UNDP has also provided an 'Inequality-adjusted HDI (IHDI)' measure that accounts for inequality. The IHDI combines a country's average achievements in health, education and income with how those achievements are distributed among the country's population by "discounting" each dimension's average value according to its level of inequality (UNDP, 2011). Two countries with different distributions of achievements can have the same average HDI value while diversifying by the level of IHDI.

The IHDI is equal to the HDI but falls below the HDI when inequality rises. In this sense, as shown in Figure 7, the IHDI is the actual human development level (i.e., functioning). Simultaneously, the HDI can be viewed as an index of potential human development (i.e., capability) achieved under perfect equality (UNDP, 2019).

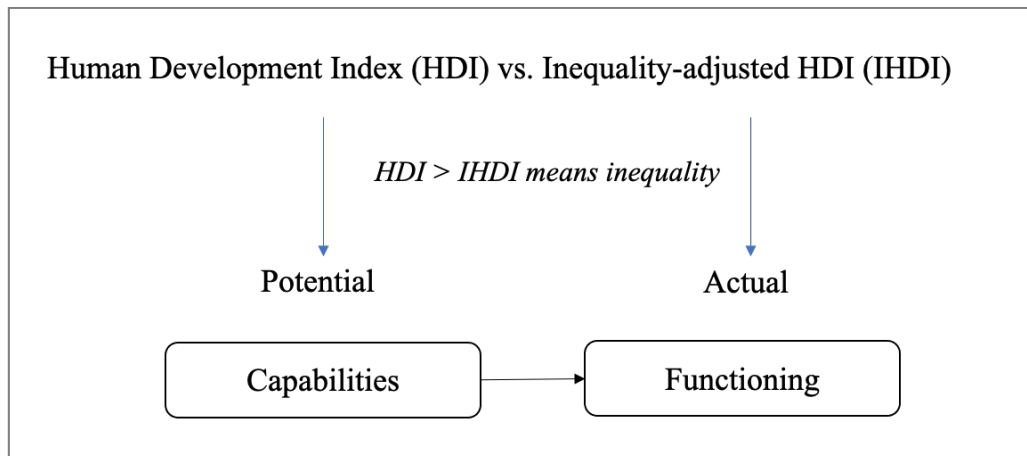


Figure 7: HDI vs. IHDI under Capability Approach

Source: Author's illustration

HDI is an ideal representation of potential basic capabilities. The distance between potential capabilities and actual functionings (HDI-IHDI) provides valuable insights into many societal challenges. Through the Capability Approach perspective, the distance (HDI-IHDI) might be the result of a subset of the following points:

- agency (the change agents may not prefer to realize their capabilities),
- choice mechanism (some institutions prevent the agents from initiating the change process),
- mismatch among capabilities and available institutions, and finally
- inequality in resource allocation limits the realization of functionings for some social groups within a society.

The difference between the HDI and IHDI expressed as a percentage of the HDI indicates human development loss due to inequality (UNDP, 2019). When we plot (see Figure 8) the HDI and the percentage change of the inequality effect, we can observe that for high HDI countries, the distance is relatively lower for the majority of the countries. However, inequality is significant for almost all the countries in the low HDI category.

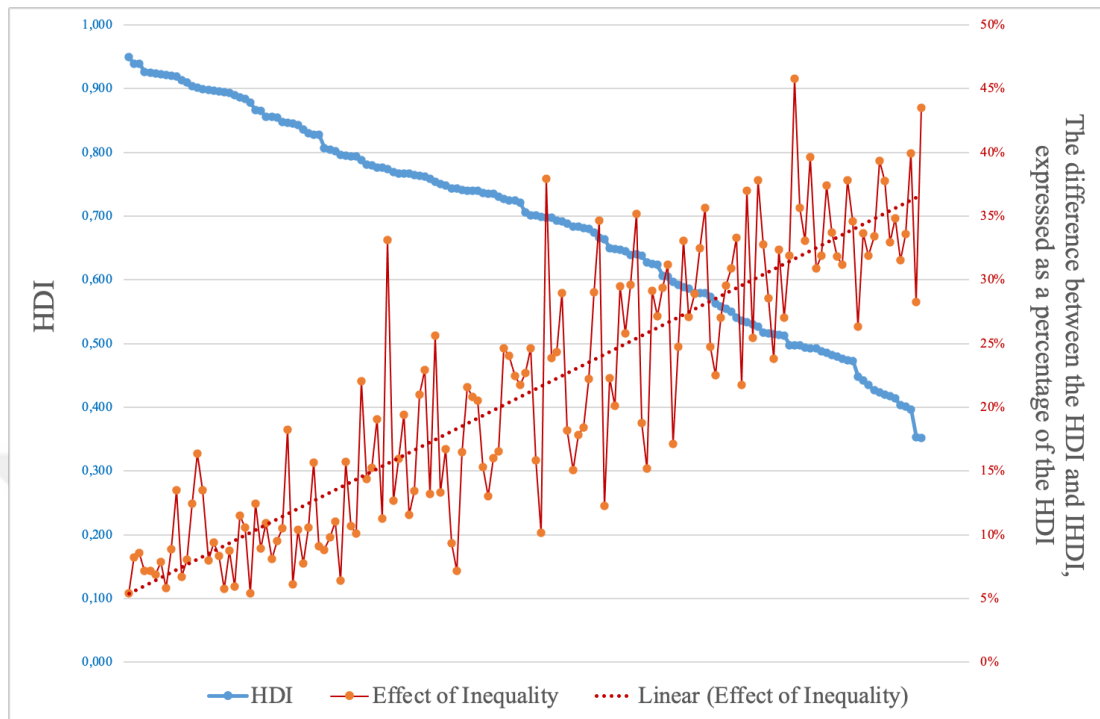


Figure 8: HDI vs. IHD for Selected Countries

Source: Author's illustration

Data: <http://hdr.undp.org/en/data>

As illustrated in Figure 9, a society can fully realise its capabilities in high HDI and lower inequality, which is the desired condition. Norway, Switzerland, Sweden, and Canada are examples of this group. For a few high HDI countries (like the USA, Japan, and Korea), we can observe relatively higher inequality – meaning that not all the members of their societies equally benefit from the available opportunities. When both HDI with inequality are low, such as Moldova and Kyrgyzstan, the available stock of basic capabilities prevents kick-start development. We name this situation as equality at the bottom. Finally, dozens of countries fit into low HDI but high inequality categories - mainly in sub-Saharan Africa or conflict zones.

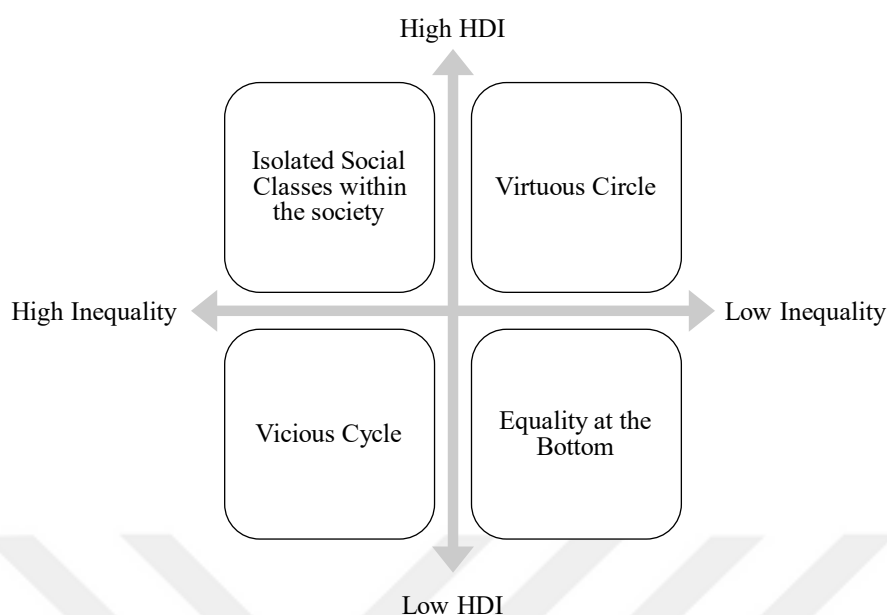


Figure 9. HDI vs. Inequality

Source: Author's illustration

HDI is a well-structured proxy for basic human capabilities. Although the capability approach literature heavily concentrated on such basic capabilities, development necessitates complexity – as we have outlined above while dealing with economic complexity.

Therefore, there is a clear need for extending the theoretical discussions of the capability approach towards more complex capabilities to better equip us for unfreedoms that exceed basic needs.

3.3. Theorizing Complex Capabilities

Development is a continuous process. In each, stage beings and doings (functionings) a person (or a group) values evolve, together with the set of necessary human capabilities. Individual freedoms that members of a society value do not exist independently.

They are path-dependent, contains backwards and forward linkages with other capabilities and the product composition of the economy play a constitutive role for valued capabilities (Amsden, 2007).

Human capabilities are hardly separable from production capabilities (Andreoni and Chang, 2017). From the perspective of economics, a change in the production structure, the sophistication of capabilities, and social valuation (choices of individuals and their understanding of freedoms) are co-evolving. Therefore, a static perspective for HDCA that is narrowed to basic human needs limits its potential application in economic complexity. One can claim that the social minimum is embedded deeply in the production structures, norms, and relationships within a society. Figure 10 illustrates the theoretical linkages of production structure, capabilities, and ideas of freedom.

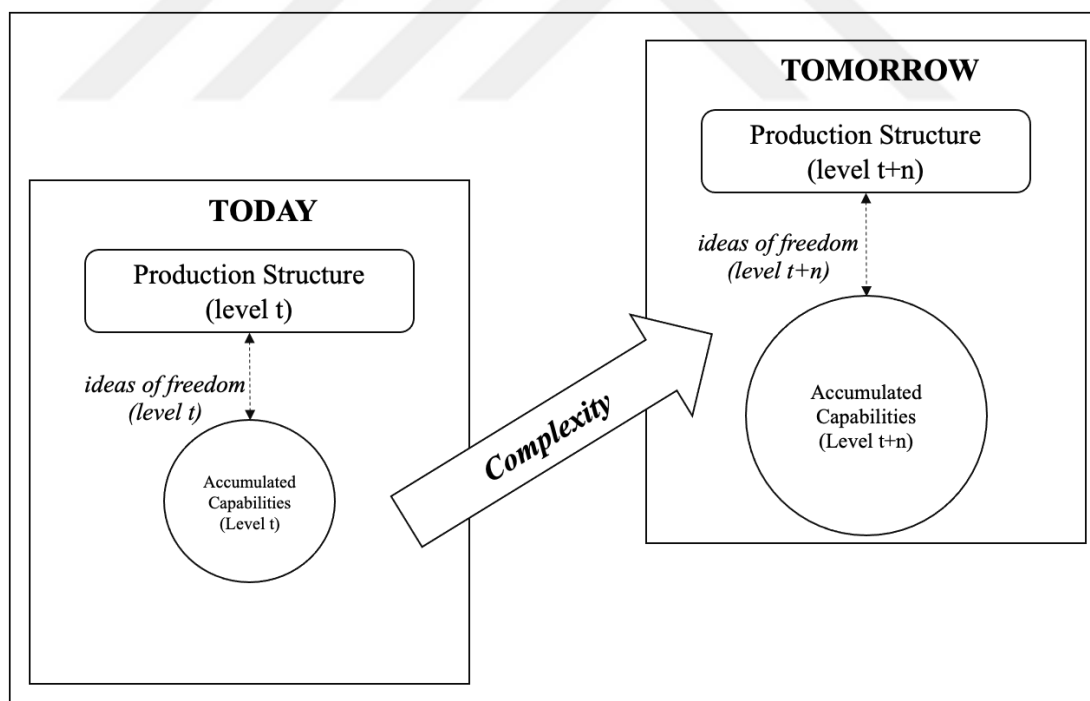


Figure 10: Changes of Ideas of Freedom

Source: Author's illustration

The roles of government (see Figure 11), under this theoretical understanding, are twofold: (i) to define the direction of change (Atkinson, 2015), by understanding what drives people's current choices and by influencing them toward a new direction; and (ii) to socially construct competitive assets (productive capabilities) that accurately fit the new direction (Amsden, 2010). Overall, we name such roles as the 'sophistication of the capability space'.

The competitive assets define the composition of the current production structure, which bundles the production capabilities of several products. Therefore, it is the starting point for an economy to improve its complexity. It could provide insight on how a country can diversify – the limits of its opportunity space.

From the capability approach perspective, building up a new capability is not an end in itself but a means for achieving the desired change. The direction of change is the pre-defined path that an economy aims to shift from one production structure to a new one – diversifying to produce higher complexity products.

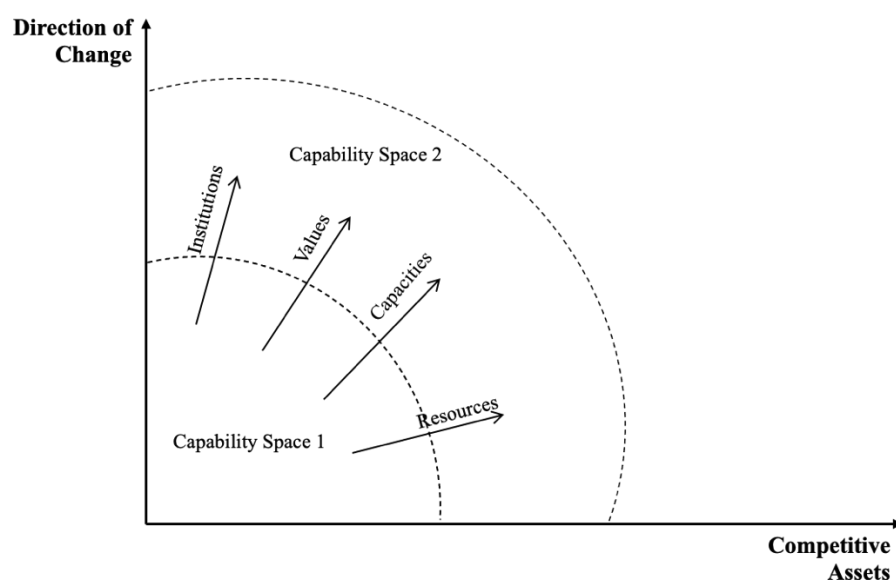


Figure 11: Role of Governments

Source: Author's illustration

In economics, the terms growth and development are both associated with change. While the former is entirely quantitative, the latter is mainly qualitative. In this thesis, the term "qualitative change" refers to a broader range of changes in the economic system's composition by introducing innovations (Saviotti and Pyka, 2004a, 2004b). The Commission on Growth and Development Report (World Bank, 2008b, p.31) stated that “economic growth is not an end in itself, but a means to human development, equity, security, and empowerment”. While the ultimate goal of the human-based development approach is building the capability of individuals and groups, the capacities of systems and institutions, economic growth can provide valuable opportunities to catalyse such goals. However, there is no natural link between economic growth and human flourishing. Countries with high GDP growth do not necessarily exhibit high human development achievement. Amartya Sen named this phenomenon "growth without development" (Sen, 2011). To better evaluate, we will use the following classification, as shown in Figure 12, developed by (Ranis et al., 2000).

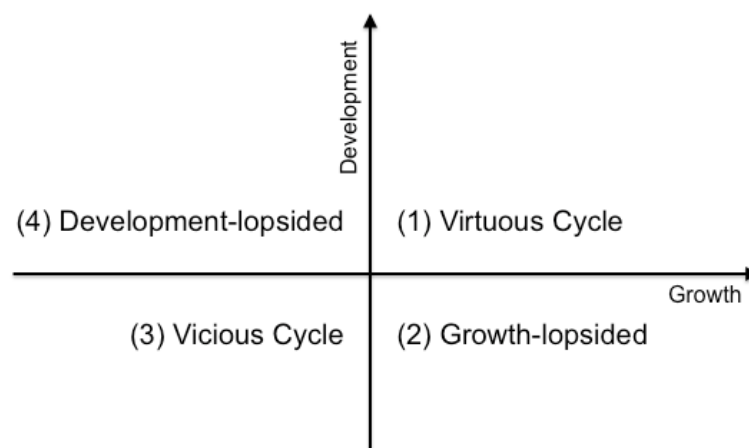


Figure 12: Growth vs. Development

Source: (Ranis et al., 2000)

In the virtuous cycle (Category 1), development enhances growth which promotes development. In the vicious cycle (Category 3), poor performance on development tends to lead to poor growth performance, which depresses the development's potentiality. Category 4 may happen when good human development performance cannot generate positive economic growth due to various reasons such as shortage of complementary resources or mismatch of developmental capabilities and growth-inducing institutions. However, this scenario does not persist in the long-term; either quantitative changes pave the way for institutional changes (and growth shall be cultivated), or lack of quantitative changes will erode qualitative changes. Category 2 is the so-called 'growth without development' phenomenon where high inequality depresses agents' exposure to economy-wide opportunities. This phenomenon generally occurs when economic convergence forces are powerfully push emerging economies to grow and reach their limits. This growth is typically generated by quantitative change – that means efficiency increase in the economy's production structure and the lack of sophistication efforts of the capability space that do not lead to complexity increase in production structure.

Sustaining development over the long term presents significant challenges. Latecomers can follow the path of the rich, skip some steps along the way, and narrow the gap (Gerschenkron, 1979). Nevertheless, this process of economic catch-up has not consistently been reproduced. Some poor fail to get going. Others make quick progress, then lose their momentum.

Countries in the first group are the victims of a poverty trap, while the others are in the middle-income trap (The Economist, 2013). A developing country can be said to get into a middle-income trap when it loses its growth dynamism after a successful transition from low-income to middle-income status and is unable to continue developing to become a high-income country (Gore, 2017). On the other hand, a growing number of researchers view the concept of the middle-income trap as a myth and name it as a statistical phenomenon (Robertson and Ye, 2013).

Instead of analysing the trap from a statistical perspective, this thesis understands it “in terms of structural and technological dynamics” and puts the capability approach at the centre of the analysis (Vivarelli, 2014).

In the long run, countries in a vicious cycle became poor due to the poverty trap. On the other hand, the growth-loop sided countries cannot escape from the middle-income trap in growth without development. It is a situation where a country, which attains a level of income due to given advantages, will get stuck at that level (Felipe, 2012). The problem usually arises when developing countries cannot compete with advanced economies in high-skill innovations or with low income, low wage economies in the cheap production of manufactured goods (Kharas and Kohli, 2011). The converge principles (catching up) are more applicable for the countries in the lower income levels (Gill et al., 2007).

Economic growth is essential to human development. However, development depends on growth type and the strength of existing mechanisms for building appropriate capabilities and translating them into real achievements (functionings). The virtuous cycle necessitates decades of cumulative progress and qualitative change, which entails transforming the economy’s structure without getting stuck in the middle (Gore, 2017).

The current literature on human development driven policies strongly emphasises the supply of new capabilities and does not pay enough attention to the demand side (Amsden, 2010). Nonetheless, expanding capabilities will have a limited transformational effect unless demand for these new capabilities has been established (Bangura, 2010).

Accordingly, in this thesis, we claim that a healthy economic development process necessitates the co-evolution of (supply of) human capabilities towards complexity and the appropriate economic opportunities that generate demand for them. In a steady state, unless there are no constraints, there is an equilibrium point (the social optimum) where supply and demand of capabilities would match (Figure 13).

The social optimum reflects the full utilisation of society's potential (transforming capabilities into functionings). Recalling back to the discussion of the basic capabilities (proxied by HDI vs IHDI), we might witness a lower level of utilisations due to some limitation constraints (Figure 14). Typically, conversion factors, such as inappropriate institutional settings or limited capacities, act as constraints. Such limitation results in reduced social gain (or social cost of nonoptimal supply and demand).

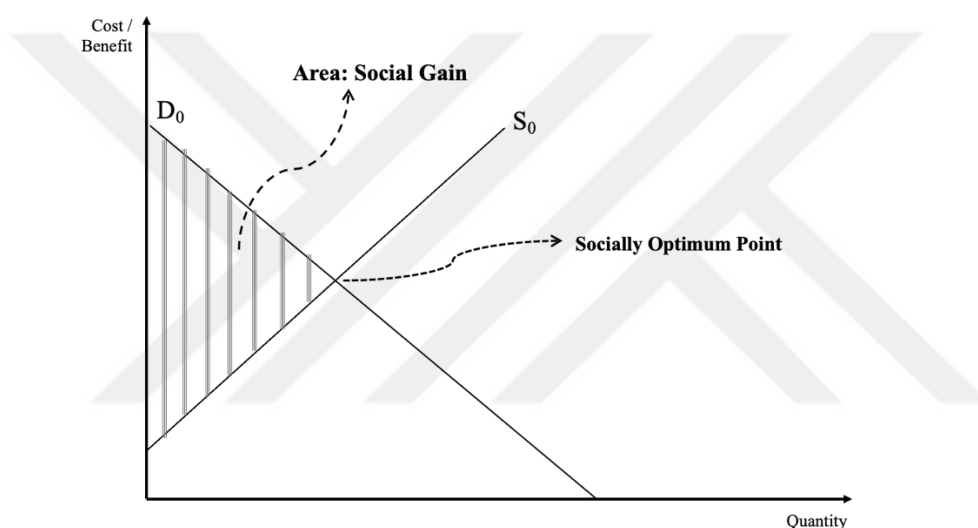


Figure 13: Social Optimum of Demand and Supply

Source: Author's illustration

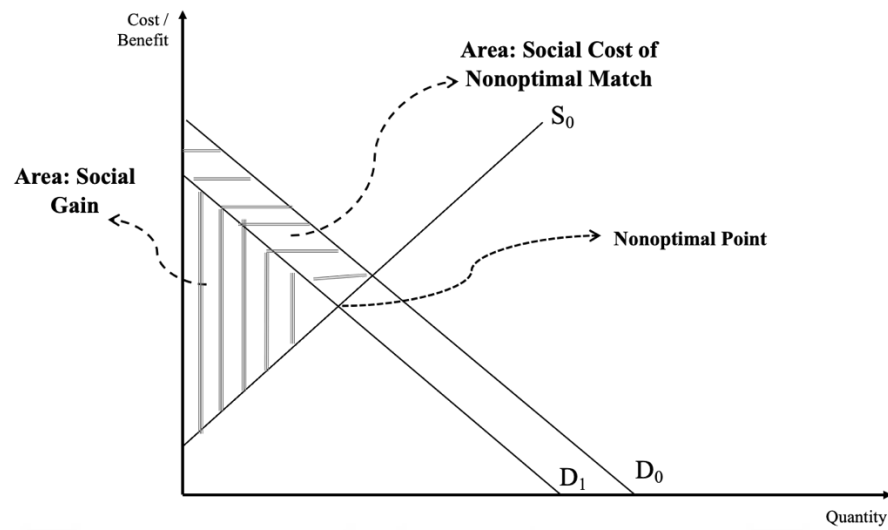


Figure 14: Nonoptimal Supply-Demand Match

Source: Author's illustration

In healthy economic conditions, the supply of capabilities and the demand for them co-evolve in a way that increases social gain for the whole society within the process of economic complexity (Figure 15).

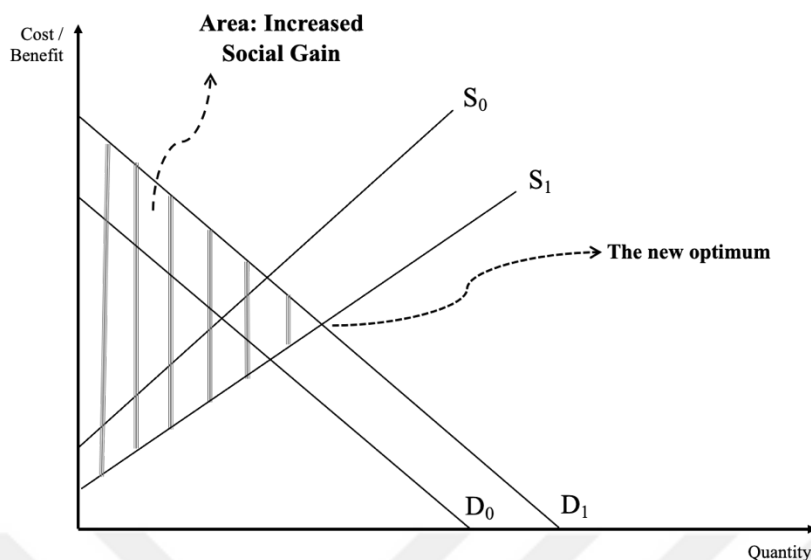


Figure 15: Co-evolution of Supply and Demand

Source: Author's illustration

Despite its importance, Sen's approach has always been criticized for "being too individualistic" as it is mainly concerned with individual capabilities (Stewart, 2005). It is useful to distinguish three kinds of individualism (Robeyns, 2005) in order to understand the approach's individualistic nature:

- Ontological individualism holds that society is built up from only individuals, and it is nothing more than the sum of individuals and their properties.
- Methodological individualism presumes that all social phenomena can be explained in terms of individuals and their properties.
- Ethical individualism postulates that only individuals are the ultimate units of moral concern. It implies that structures and institutions will be evaluated because of the causal importance that they have for individual well-being.

The capability approach takes the normative position of ethical individualism, the view that “*what ultimately matters is what happens to every single individual in a society*” (Sen, 1999, p.54). Sen supports ethical individualism because “*if the smallest unit of moral concern is any group, then analyses may systematically overlook any existing or potential inequalities within these units*” (Alkire and Deneulin, 2009, p.35). Since Sen positioned the capability approach as a policy design and evaluation tool, such ethical individualism as a moral concern is reasonable.

However, critics have questioned whether a rejection of ontological individualism is consistent with a commitment to ethical individualism (Robeyns, 2005). When human beings live together, they generate something truly collective, which is more than the total of their individual lives and cannot be reduced to individual characteristics. Sen regards individuals as “socially embedded agents” but deals with such social structures only to the extent they influence an individual’s capabilities (Sen, 1999). This insufficiency has been addressed, and the scholars introduced the term collective (or group) capabilities.

Collective capabilities are defined as “*the newly generated capabilities achieved by individuals’ engagement in a collective action or their membership in a social network that helps them to achieve the lives they value*” (Ibrahim, 2006, p.404). Collectivity here does not refer neither merely to the sum of individual capabilities nor “*the average of the capabilities of all the individuals in the selected groups*” (Stewart, 2005, p.199), but rather to new capabilities that individuals alone could not achieve unless being part of a network (Comim and Kuklys, 2002). Collective capabilities can only be achieved through social interactions (Ibrahim, 2006). Therefore, the agency should also be defined collectively. Collective agency necessitates an appreciation of the organizational context. They can only be realized either by integrating into a change-driven organization or by setting up a new organization –i.e., the enterprise. In this regard, the collective nature of the production process recalls the desired capabilities’ collectivist nature – together with the collective agency. We will further utilize such a collective manner while dealing with the innovation capability, which is collective by all means.

3.4. Research Methodology and Data

In the previous chapter, we have defined development as a continuous process of enlarging individuals' choices by expanding their capability space towards complexity and allowing them to utilise those capabilities freely to bring valued change to their own lives. We have also defined that; complex capabilities are collective and are generally the means of other capabilities.

Non-optimised backward linkages (where some capabilities are means of others) might limit the full utilisation of any given complex capability. In this regard, this thesis's central hypothesis is that development is a moving target, throughout which there are complexity thresholds.

Ho: There are complexity thresholds over the stages of development.

Perhaps an essential aspect to note about the method used here is that it is exploratory research. The purpose of that exploration is to discover threshold patterns that can inform our strategic thinking regarding how an economy can deal with such thresholds at the policy level. To allow benchmarks, we will cluster economies through various clustering algorithms.

Research Question: What are the threshold patterns for different country clusters?

Methodologically, we will use various machine learning algorithms that feed each other to test our hypothesis. The dependent variable in our analyses is ECI (Economic Complexity Index), a proxy for complex capabilities for economic development.

To identify the independent variables that we would use in our empirical study, we reviewed all articles published in ‘Journal of Human Development and Capabilities’ and selected 52 papers published between 2010 and 2019), listed in section 7.4 (Annex). Accordingly, we have identified eight potential explanatory factors (Table 1) and 39 independent variables (Table 2).

Table 3 provides the matching of explanatory factors and the independent variables, whereas Figures 16 and 17 represent the statistical characteristics of these variables. Then we identified data sources for each independent variable (as outlined in Table 2) and gathered the latest available data. We iterated a step-by-step process for data gathering, cleaning, and matching.

We preferred the country-level data between 1990 and 2020 by five years intervals. Hence gathered seven data columns for each country per variable and consolidated data for 126 nations. Due to the characteristics of the variables, there are missing cells, especially for 2020 (which may not be published yet). For those cells, we appointed the historically latest available data.

Names of countries might change or vary (i.e., different letter(s) used for the same country in other data sources). We referred Economic Complexity Index dataset for country names and adapted the rest accordingly.

We created a dummy variable named ID, representing the country code and year matrix (i.e., TR1990). Therefore, we achieved seven rows per country and treated them as independent data strings. Overall, we reached a dataset of 807 rows and 40 columns. While the rows should be 882 (126 countries and 7-time intervals), we observed missing data for some countries for some years.

Table 1. Literature Review on HDCA

Explanatory Factors	# of Papers	Explanatory Factors	# of Papers
Basic Human Needs (BHN)	12	Gender (GEN)	6
Inequality (INQ)	9	Science, Technology, Innovation (STI)	4
Democracy (DEM)	8	Trade, Economy, Financial Flow (TEF)	4
Education (EDU)	7	Work and Employment (WEM)	2

Source. Author's summary based on articles published in Journal of Human Development and Capabilities between 2010-2019

All machine learning (ML) algorithms were performed in R software language under the R Studio development environment. The data sources and their descriptions, the dataset's summary statistics and the correlation matrix are summarized in the following tables.

Table 2. List of Variables for ML Analyses**Data Sources**

* UN: United Nations ** WB: World Bank *** FH: Freedom House
 Ω OECD: Organisation for Economic Cooperation and Development
 ∫ VD: V-Dem Institute; Department of Political Science, University of Gothenburg
 @ AEC: Atlas of Economic Complexity, Growth Lab, Harvard University

Code	Variable
ID	Country abbreviation with year information (i.e., TR.1990) *
ECI	Economic Complexity Index (dependant variable) @
HDI	Human Development Index *
CHE	Current health expenditure (% of GDP) *
CRM	Assault rate per 100,000 population *
DCP	Domestic credit provided by financial sector (% of GDP) *
DW	Population using improved drinking-water sources (%) *
EDB	Ease of doing business score (0 = lowest performance to 100 = best performance) **
EI	Exports and imports (% of GDP) *
EPR	Employment to population ratio (% ages 15 and older) *
ERS	Electricity production from renewable sources, excluding hydroelectric (% of total) **
EYS	Expected years of schooling *
FAI	Freedom of association index ∫
FDI	Foreign direct investment, net inflows (% of GDP) *
FFE	Fossil fuel energy consumption (% of total energy consumption) *
FNA	Share of employment in non-agriculture female (% of total employment in non-agriculture) *
FOE	Freedom of expression ∫
GEE	Government expenditure on education (% of GDP) *
GFC	Gross fixed capital formation (% of GDP) *
IE	Inequality in education (%) *
II	Inequality in income (%) *
ILE	Inequality in life expectancy (%) *
LEB	Life expectancy at birth *
LF	Skilled labour force (% of labour force) *
MA	Median age (years) *
MYS	Mean year of schooling *
PAT	Grants of patents (number) *

Table (Cont.)	
Code	Variable
PR	Political Rights ***
PSE	Population with at least some secondary education (% ages 25 and older) *
PTR	Pupil-teacher ratio, primary school (number of pupils per teacher) *
PU	Population, urban (%) *
RDE	Research and development expenditure (% of GDP) *
RDP	Researchers in R and D (per million people) **
RIR	Real Interest Rate **
SF	Population using improved sanitation facilities (%) *
STJ	Scientific and technical journal articles **
UNE	Unemployment, total (% of labour force) *
WP	Share of seats in parliament (% held by women) *
YOU	Youth not in school or employment (% ages 15-24) *
TPF	Triadic patent families – Total Ω
CBS	Cost of business start-up procedures (% of GNI per capita) **
GNIPPP	GNI per capita (PPP \$) *

Table 3. Factors and Variables Grouping

Factors	Variable		Factors	Variable		Factors	Variable
BHN	CHE		TEF	DCP		TEF	EI
BHN	CRM		TEF	EDB		TEF	ERS
BHN	DW		EDU	GEE		TEF	FDI
BHN	EYS		EDU	PSE		TEF	FFE
BHN	LEB		EDU	LF		TEF	GFC
BHN	MA		EDU	PTR		TEF	PU
BHN	MYS		STI	PAT		TEF	RIR
BHN	SF		STI	RDE		TEF	GNIPPP
BHN	YOU		STI	RDP		WEM	EPR
DEM	FAI		STI	STJ		WEM	UNE
DEM	FOE		STI	TPF		WEM	CBS
DEM	PR		INQ	ILE			
GEN	FNA		INQ	II			
GEN	WP		INQ	IE			

HDI	Min. : 0.2090 1st Qu.: 0.5950 Median : 0.7014 Mean : 0.7014 3rd Qu.: 0.8250 Max. : 0.9530	EYS	Min. : 2.50 1st Qu.: 10.70 Median : 12.90 Mean : 12.76 3rd Qu.: 15.20 Max. : 23.30	MYS	Min. : 0.800 1st Qu.: 5.800 Median : 8.300 Mean : 8.215 3rd Qu.: 10.800 Max. : 14.100	LEB	Min. : 41.70 1st Qu.: 67.30 Median : 73.30 Mean : 71.15 3rd Qu.: 77.00 Max. : 83.90	GNTPPP	Min. : 360 1st Qu.: 4978 Median : 11639 Mean : 19026 3rd Qu.: 28409 Max. : 117896	MA	Min. : 15.50 1st Qu.: 21.30 Median : 28.70 Mean : 29.25 3rd Qu.: 37.30 Max. : 46.30	PU	Min. : 0.126 1st Qu.: 0.467 Median : 0.619 Mean : 0.611 3rd Qu.: 0.777 Max. : 1.000	CHE	Min. : 0.01700 1st Qu.: 0.04400 Median : 0.06100 Mean : 0.06297 3rd Qu.: 0.07900 Max. : 0.16800
GEE	Min. : 0.00900 1st Qu.: 0.03400 Median : 0.04200 Mean : 0.04271 3rd Qu.: 0.05100 Max. : 0.12500	PSE	Min. : 0.0190 1st Qu.: 0.3680 Median : 0.5420 Mean : 0.5694 3rd Qu.: 0.8000 Max. : 1.0000	PTR	Min. : 8.00 1st Qu.: 16.00 Median : 21.00 Mean : 24.22 3rd Qu.: 30.00 Max. : 82.00	WP	Min. : 0.0010 1st Qu.: 0.0900 Median : 0.1500 Mean : 0.1726 3rd Qu.: 0.2380 Max. : 0.5180	FNA	Min. : 0.0680 1st Qu.: 0.3740 Median : 0.4310 Mean : 0.3977 3rd Qu.: 0.4690 Max. : 0.5930	IE	Min. : 0.0080 1st Qu.: 0.0510 Median : 0.1380 Mean : 0.1687 3rd Qu.: 0.2620 Max. : 0.4740	II	Min. : 0.0630 1st Qu.: 0.1630 Median : 0.2060 Mean : 0.2276 3rd Qu.: 0.2740 Max. : 0.5810	FDI	Min. : -0.16000 1st Qu.: 0.00900 Median : 0.02200 Mean : 0.03658 3rd Qu.: 0.04400 Max. : 0.81000
ILE	Min. : 0.0260 1st Qu.: 0.0500 Median : 0.1090 Mean : 0.1497 3rd Qu.: 0.1960 Max. : 0.5370	LF	Min. : 0.0520 1st Qu.: 0.3850 Median : 0.6200 Mean : 0.5891 3rd Qu.: 0.7930 Max. : 0.9990	RDE	Min. : 0.001000 1st Qu.: 0.003000 Median : 0.006000 Mean : 0.008936 3rd Qu.: 0.011000 Max. : 0.043000	DW	Min. : 0.1670 1st Qu.: 0.6740 Median : 0.9110 Mean : 0.8743 3rd Qu.: 0.9970 Max. : 1.0000	SF	Min. : 0.0310 1st Qu.: 0.6740 Median : 0.9110 Mean : 0.7766 3rd Qu.: 0.9910 Max. : 1.0000	EI	Min. : 0.0020 1st Qu.: 0.5130 Median : 0.7030 Mean : 0.7997 3rd Qu.: 0.9820 Max. : 1.42260	PR	Min. : 0.0020 1st Qu.: 0.5130 Median : 0.7030 Mean : 0.7997 3rd Qu.: 0.9820 Max. : 1.42260	RIR	Min. : -0.16000 1st Qu.: 0.00900 Median : 0.02200 Mean : 0.03658 3rd Qu.: 0.04400 Max. : 0.81000
EPR	Min. : 0.3060 1st Qu.: 0.5040 Median : 0.5800 Mean : 0.5758 3rd Qu.: 0.6340 Max. : 0.8740	UNE	Min. : 0.00200 1st Qu.: 0.04300 Median : 0.07100 Mean : 0.08539 3rd Qu.: 0.11000 Max. : 0.37300	FFE	Min. : 0.0330 1st Qu.: 0.5000 Median : 0.7600 Mean : 0.6779 3rd Qu.: 0.8840 Max. : 1.0000	DCP	Min. : -0.148 1st Qu.: 0.364 Median : 0.607 Mean : 0.761 3rd Qu.: 1.055 Max. : 3.418	GFC	Min. : 0.0200 1st Qu.: 0.1870 Median : 0.2190 Mean : 0.2224 3rd Qu.: 0.2520 Max. : 0.4500	CRM	Min. : 0.20 1st Qu.: 20.70 Median : 43.75 Mean : 125.32 3rd Qu.: 134.20 Max. : 1010.60	RDP	Min. : 7.415 1st Qu.: 88.724 Median : 576.392 Mean : 1455.765 3rd Qu.: 2283.620 Max. : 8250.474	PAT	Min. : 1 1st Qu.: 131 Median : 350 Mean : 7248 3rd Qu.: 1860 Max. : 359316
ERS	Min. : 0.0000095 1st Qu.: 0.0039471 Median : 0.0115984 Mean : 0.0467944 3rd Qu.: 0.0465608 Max. : 0.6544374	EDB	Min. : 30.24 1st Qu.: 156.74 Median : 67.40 Mean : 65.92 3rd Qu.: 76.43 Max. : 187.17	FAI	Min. : 0.0340 1st Qu.: 0.6010 Median : 0.8240 Mean : 0.6894 3rd Qu.: 0.8930 Max. : 0.9540	FOE	Min. : 0.0160 1st Qu.: 0.5690 Median : 0.8070 Mean : 0.7098 3rd Qu.: 0.9420 Max. : 0.9860	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927
STJ	Min. : 4.3 1st Qu.: 216.6 Median : 1741.1 Mean : 16709.3 3rd Qu.: 10752.7 Max. : 429139.0	YOU	Min. : 0.60 1st Qu.: 11.70 Median : 14.60 Mean : 16.85 3rd Qu.: 21.20 Max. : 37.70	TPF	Min. : 1.0 1st Qu.: 1.0 Median : 1.0 Mean : 504.4 3rd Qu.: 50.0 Max. : 20108.0	CBS	Min. : 0.10 1st Qu.: 25.50 Median : 38.75 Mean : 367.18 3rd Qu.: 70.00 Max. : 41365.90	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927	ECI	Min. : -2.35951 1st Qu.: -0.62044 Median : 0.09533 Mean : 0.15791 3rd Qu.: 0.85504 Max. : 2.55927

Figure 16. Statistical Summary of the Dataset

Source: See Table 2

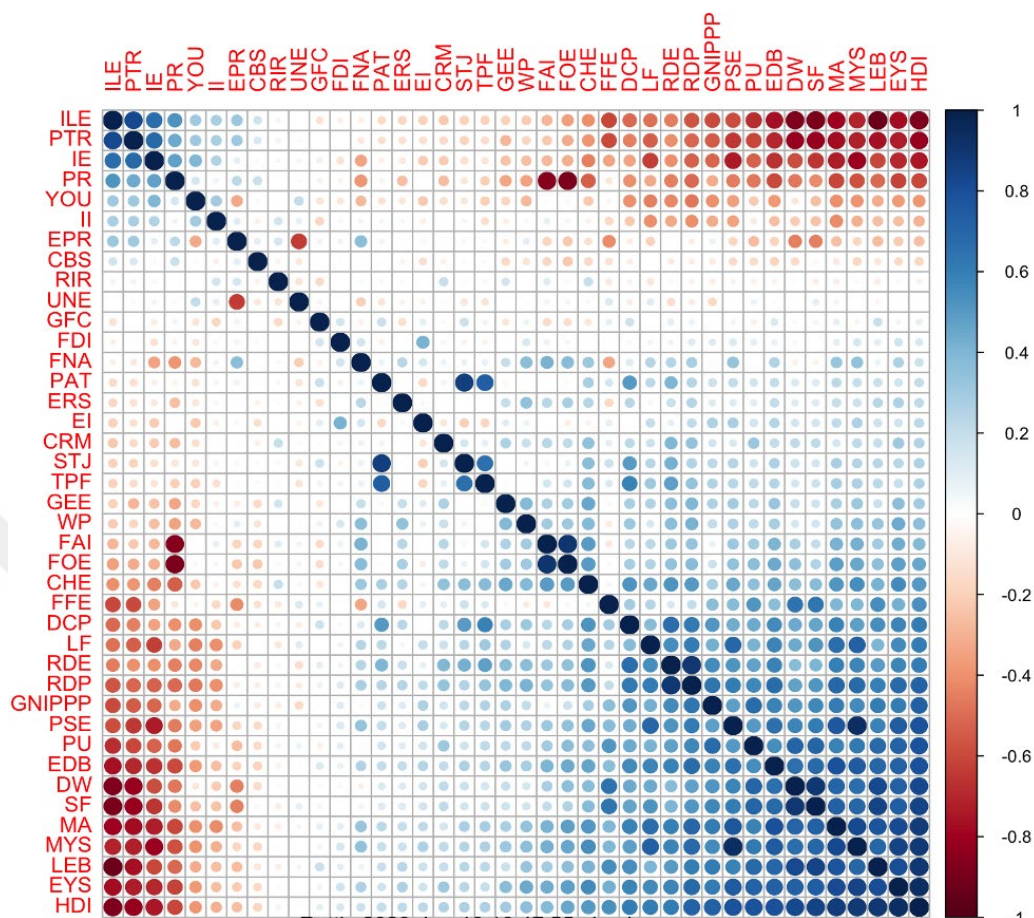


Figure 17. Correlation Matrix

Source: See Table 2

Note. Positive correlations are displayed in blue and negative correlations in red colour. Colour intensity and the size of the circle are proportional to the correlation coefficients³.

Our methodology consists of the following steps:

- **Step 1.** Linear Regression between HDI (Human Development Index) and ECI. HDI is utilized as a proxy for basic capabilities. Therefore, we shall test the relationship between basic and complex capabilities.

³ <http://www.sthda.com/english/wiki/correlation-matrix-a-quick-start-guide-to-analyze-format-and-visualize-a-correlation-matrix-using-r-software>

- **Step 2.** Linear Regression with the components of HDI. As a basic capability proxy, HDI has three main components long and healthy life, knowledge, and a decent standard of living.
- **Step 3.** Linear Regression with 39 independent variables excluding HDI.
- **Step 4.** Random Forest Technique is a non-linear classification technique for analysing the importance of variables. It is a supervised classification algorithm often used for feature selection in data science workflows. We aim to identify highly influential features among 39 independent variables.
- **Step 5.** Dimensionality Reduction with Confirmatory Factor Analysis. Confirmatory factor analysis (CFA) is a statistical technique used to verify a set of observed variables' factor structure⁴. CFA allows the researcher to test the hypothesis that a relationship between observed variables and their underlying latent constructs exists. We shall combine the results of step 4 – identifying key variables and steps the latent variables accordingly. Ultimately, we shall reduce the number of variables and construct meaningful indexes for the next step.
- **Step 6.** Partitioning of the Data Space with Hierarchical Clustering Technique. Clustering aims to partition n observations into h number of clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster⁵. By utilising latent variables of the previous step, we may cluster the countries into different groups in this step.

⁴ 200-31: Exploratory or Confirmatory Factor Analysis?
<https://support.sas.com/resources/papers/proceedings/proceedings/sugi31/200-31.pdf>

⁵ Big Data Analytics - K-Means Clustering - Tutorialspoint.
https://www.tutorialspoint.com/big_data_analytics/k_means_clustering.htm

- **Step 7.** Discriminative Classification with Decision Tree Technique. A decision tree is a decision support tool that uses a tree-like graph or model of decisions and possible consequences. It is one way to display an algorithm containing conditional control statements⁶. We will apply this technique to each cluster to identify threshold patterns.

Technically, all machine learning (ML) algorithms were performed in R software language under the R Studio development environment. The data sources and their descriptions, summary statistics of the dataset and the correlation matrix are summarized in the following tables.

3.5. Research Results

Step 1. In step 1, we have performed simple linear regression with one independent variable – HDI (Human Development Index), against ECI (Economic Complexity Index) as the dependent variable. Figure 18 contains summary statistics of the variables, a summary of the linear regression model, and a predicted vs obtained plot. This initial step tests the linearity between basic and complex capabilities indexes. The regression results below provide the insight that HDI is highly significant and correlated with ECI. Such a result interprets that, basic capabilities are a means of complex capabilities. For additional insights, we will test the linear regression among the sub-components of HDI and ECI.

⁶ Decision Tree - https://www.tutorialspoint.com/r/r_decision_tree.htm

Summary of the Linear Regression Model

Call:
lm(formula = ECI ~ ., data = crs\$dataset[crs\$train, c(crs\$input,
crs\$target)])

Residuals:

	Min	1Q	Median	3Q	Max
	-1.68833	-0.41109	0.01181	0.44285	1.68890

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-3.3810	0.1237	-27.33	<2e-16 ***
HDI	5.0612	0.1729	29.28	<2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6137 on 533 degrees of freedom
Multiple R-squared: 0.6166, Adjusted R-squared: 0.6159
F-statistic: 857.2 on 1 and 533 DF, p-value: < 2.2e-16

Predicted Versus Observed Plot

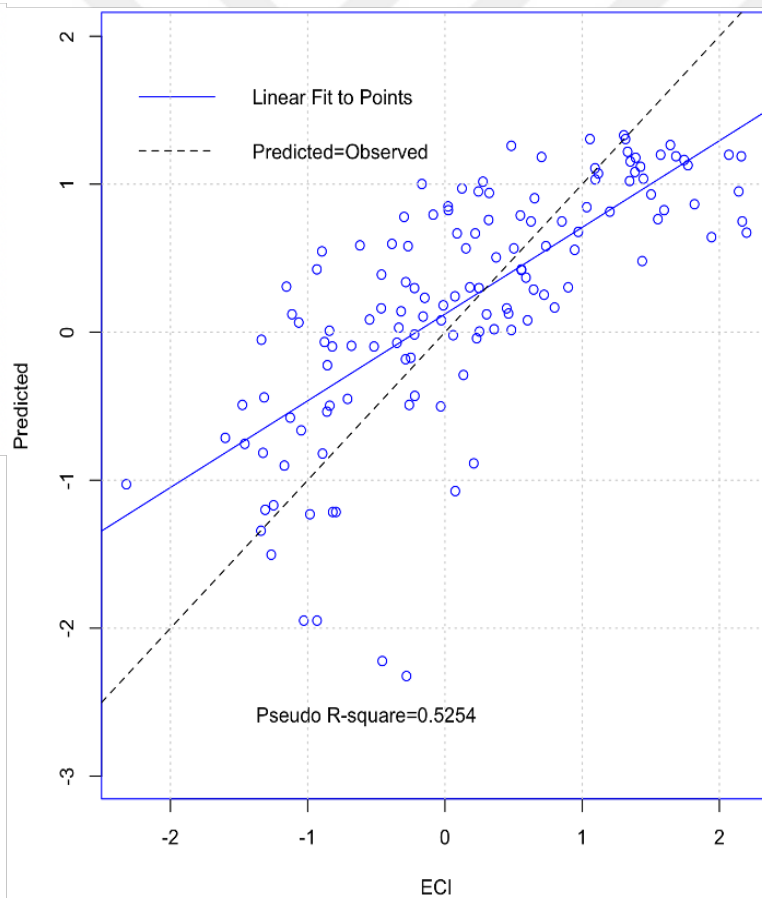


Figure 18: Step 1 Model Outcome

Step 2. Further analysis, the three components of HDI, as basic capability proxies, are tested against ECI. The components and the variable definitions are as follows: long and healthy life (life expectancy at birth - LEB), knowledge (mean year of schooling – MYS) and a decent standard of living (GNI per capita in Purchasing Power Parity in US dollar - GNIPPP). We again split the data as training and validation, like Step 1, in line with the ML technique. The regression resulted in that all independent variables are highly significant with ECI (see Figure 19). Together with Step 1 results, we can interpret that HDI, and its components have explanatory power on ECI.

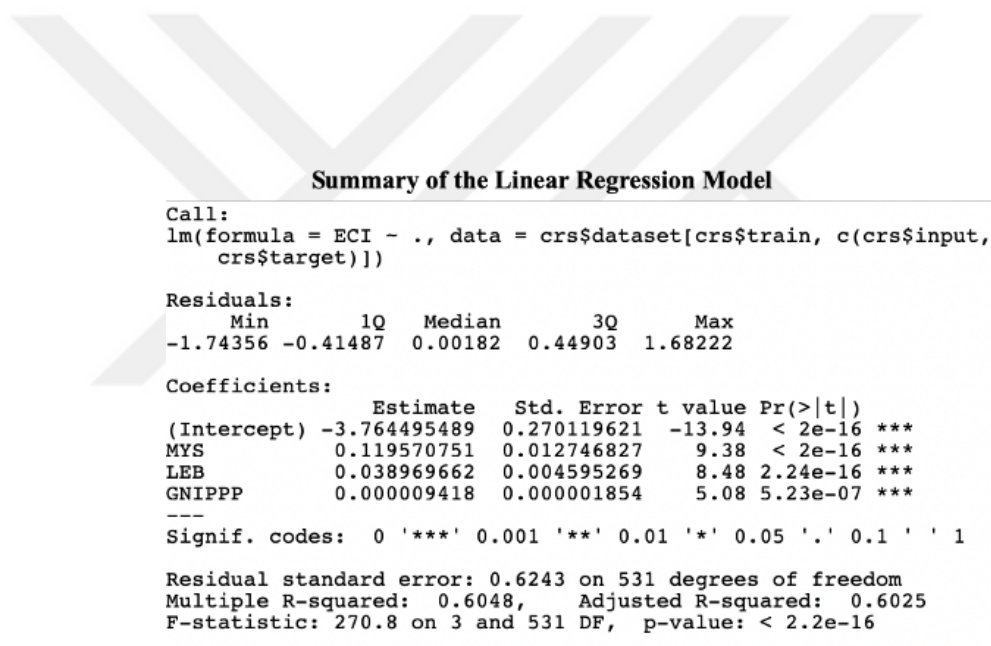


Figure 19. Step 2 Model Outcome (1)

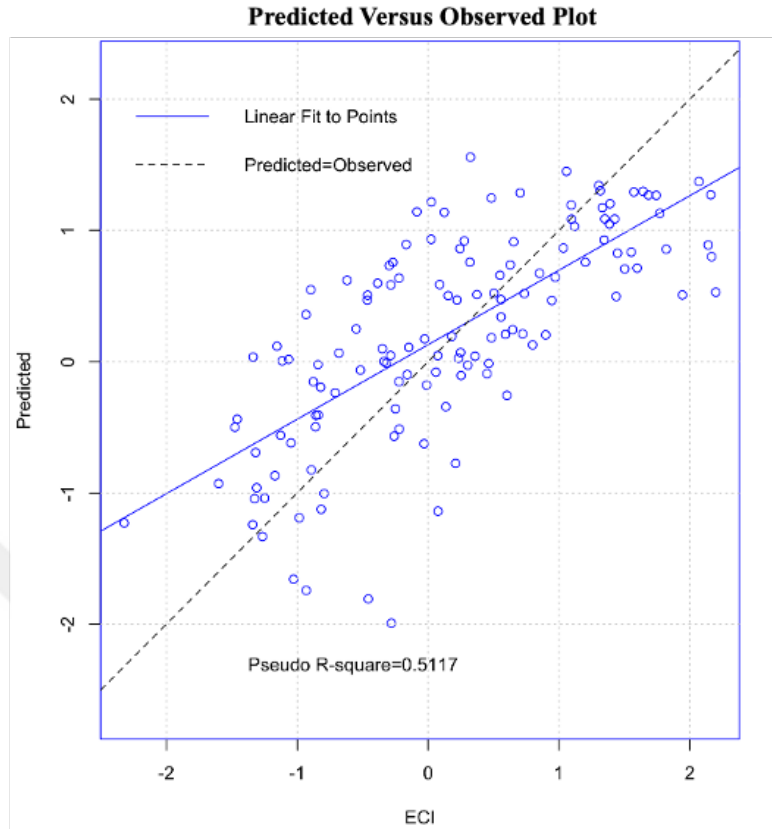


Figure 20. Step 2 Model Outcome (2)

Step 3. In this step, we reiterate another linear regression with 39 independent variables one at a time (listed in Table 2) to test various development factors and their explanatory power on complex capabilities. Accordingly, the following variables are significant: EYS (Expected years of schooling), LEB (Life expectancy at birth), MA (Median age), PTR (Pupil-teacher ratio, primary school), IE (Inequality in education), ILE (Inequality in life expectancy), RDE (Research and development expenditure), DW (Population using improved drinking-water sources), EI (Exports and imports), FFE (Fossil fuel energy consumption), PR (Political Rights), EDB (Ease of doing business score), CRM (Assault rate), PAT (Grants of patents), STJ (Scientific and technical journal articles) and TPF (Triadic patent families). Therefore, we can interpret that BHN (Basic Human Needs), STI (Science, Technology, Innovation), EDU (Education), and TEF (Trade, Economy, Financial Flow) dimensions have strong explanatory power on complex capabilities (see Figure 20 and 21).

```

Coefficients:
              Estimate      Std. Error t value Pr(>|t|)
(Intercept) -0.4547432843    0.7132956571   -0.638  0.524078
EYS          -0.0576354671    0.0154904167   -3.721  0.000221 ***
MYS          -0.0270927836    0.0270299178   -1.002  0.316676
LEB          -0.0155530666    0.0070097686   -2.219  0.026955 *
GNIPPP       0.0000004309    0.0000021256    0.203  0.839431
MA           0.0361934152    0.0060964471    5.937  5.47e-09 ***
PU          -0.1148020649    0.1803853338   -0.636  0.524792
CHE          -0.6603681886    1.2461711668   -0.530  0.596407
GEE          -2.0995235167    1.4231886539   -1.475  0.140788
PSE          -0.0585386012    0.2198070705   -0.266  0.790105
PTR           0.0119200114    0.0033975684    3.508  0.000492 ***
WP           0.0893388605    0.2245538267    0.398  0.690912
FNA          -0.1617171072    0.3097715505   -0.522  0.601867
IE           -0.8471352268    0.2966332058   -2.856  0.004473 **
II            0.3325956857    0.2809570343    1.184  0.237062
ILE          -2.5874746417    0.5601329410   -4.619  4.91e-06 ***
LF            0.1295787392    0.1425555623    0.909  0.363808
RDE          43.6005664158    5.9530848134    7.324  9.83e-13 ***
DW            0.9348666984    0.3357295320    2.785  0.005565 **
SF           -0.0385454614    0.2129314229   -0.181  0.856424
EI            0.1346133498    0.0547251851    2.460  0.014242 *
FDI           0.2641038678    0.3289943843    0.803  0.422498
EPR          -0.0578966237    0.3832859662   -0.151  0.879995
UNE          -0.0452543924    0.4734793666   -0.096  0.923894
FFE           0.2469893830    0.1177536621    2.098  0.036455 *
DCP           0.1065885481    0.0590981840    1.804  0.071904 .
GFC           0.1263600877    0.3629103682    0.348  0.727849
PR           -0.0728097964    0.0244851612   -2.974  0.003087 **
RIR           0.0021679642    0.0011442473    1.895  0.058719 .
ERS          -0.1037419111    0.2480934591   -0.418  0.676014
EDB           0.0092703767    0.0029345597    3.159  0.001680 **
FAI           0.0595476875    0.1839729332    0.324  0.746320
FOE           0.0804141962    0.2035532310    0.395  0.692974
CRM           0.0002853740    0.0001298218    2.198  0.028397 *
RDP          -0.0000266985    0.0000288014   -0.927  0.354385
PAT          -0.0000035721    0.0000011023   -3.241  0.001272 **
STJ           0.0000021234    0.0000007402    2.869  0.004297 **
YOU          -0.0033431990    0.0034736860   -0.962  0.336301
TPF           0.0000367952    0.0000131963    2.788  0.005503 **
CBS          -0.0000007193    0.0000077457   -0.093  0.926051
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3981 on 495 degrees of freedom
Multiple R-squared:  0.8502,    Adjusted R-squared:  0.8384
F-statistic: 72.01 on 39 and 495 DF,  p-value: < 2.2e-16

```

Figure 21. Step 3 Model Outcome (1)

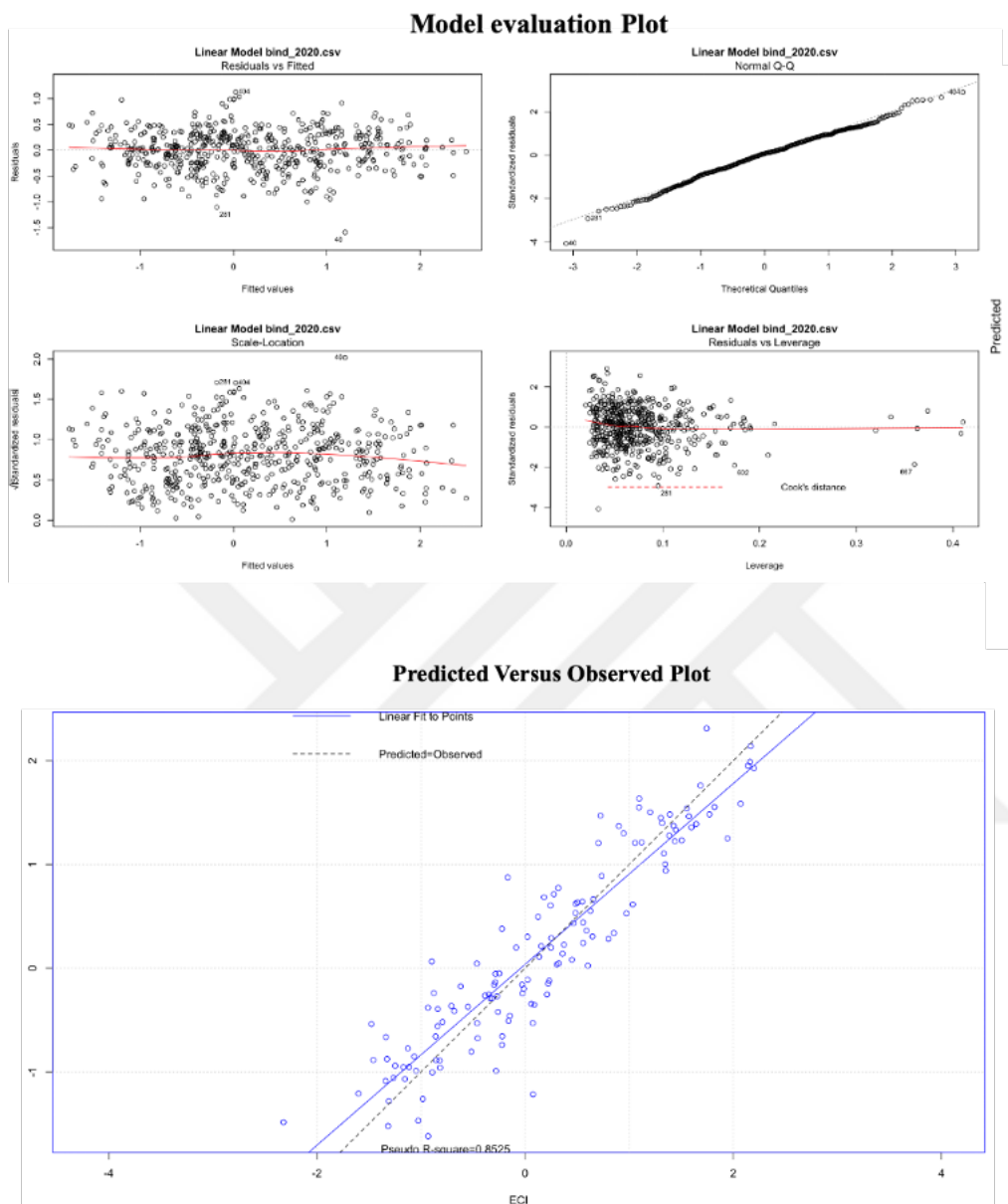


Figure 22. Step 3 Model Outcome (2)

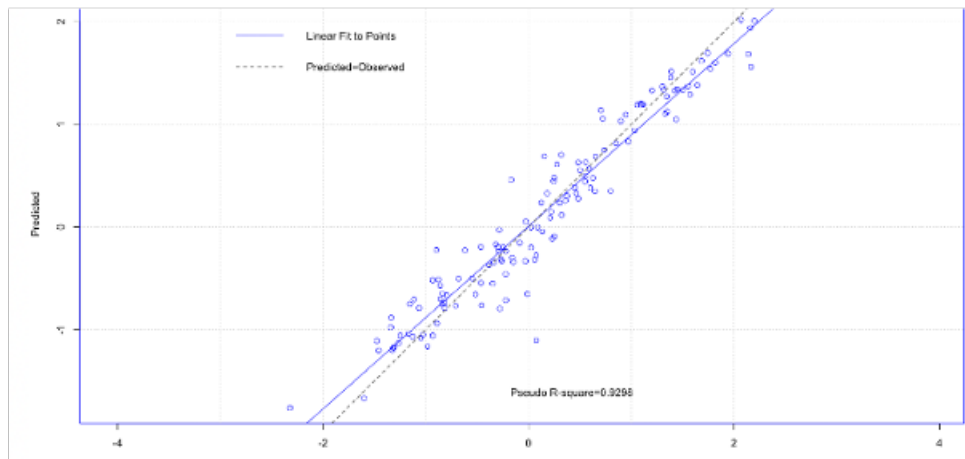
Step 4. We have identified the linear relationship of variables with the dependent variable in the previous step. However, the analysis does not provide any insight into potential non-linear relations and cannot diversify the level of importance (relative significance of each variable) among variables. Therefore, in this new step, we performed the Random Forest (RF) Technique as a non-linear classification to analyse variables' importance (see Figures 22 and 23).

Variable Importance

Mean of squared residuals: 0.06694416		
% Var explained: 93.16		
Variable Importance		
=====		
	%IncMSE	IncNodePurity
TPF	20.12	30.29
ILE	17.08	37.76
II	16.92	3.50
YOU	16.17	4.67
SF	15.95	12.14
EDB	15.79	33.70
PAT	15.68	5.86
STJ	15.47	12.91
CRM	14.36	1.97
RDE	14.01	25.50
DW	13.91	16.66
EPR	13.73	1.75
FFE	13.34	3.81
LF	13.20	13.34
MA	12.76	19.73
RDP	12.71	35.20
FNA	12.51	2.50
IE	12.47	2.98
CBS	12.21	1.08
CHE	12.08	2.08
PTR	11.75	2.36
ERS	11.47	1.02
EI	11.24	1.88
EYS	11.06	6.15
GEE	10.90	1.19
PU	10.86	2.62
WP	10.57	1.23
GNIPPP	10.55	17.20
PSE	10.53	3.91
FOE	9.73	3.29
FAI	9.59	1.67
PR	8.85	2.28
UNE	8.81	1.19
DCP	8.37	2.15
FDI	7.82	1.02
LEB	7.80	5.48
MYS	6.87	3.31
GFC	5.86	1.08
RIR	4.68	0.81

Figure 23. Variable Importance – Step 4

Predicted Versus Observed Plot



Error Rates

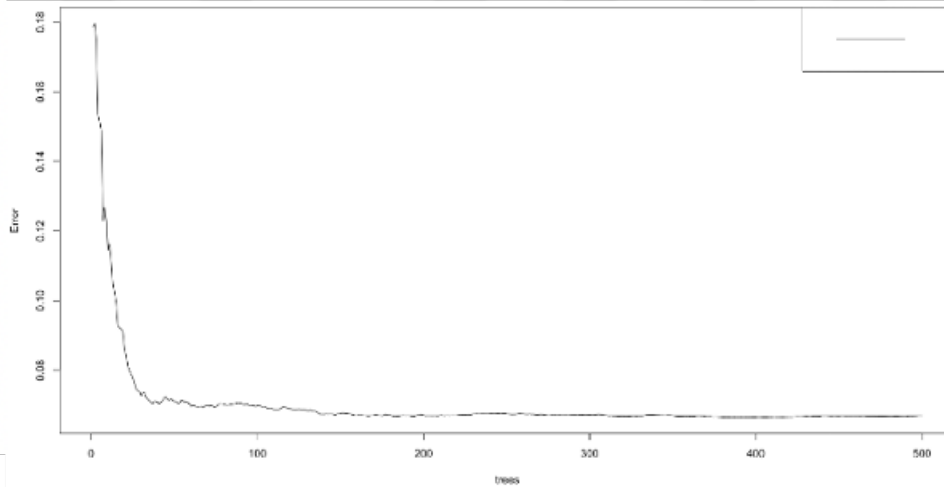


Figure 24. Step 4 Model Outcome

In Figures 22 and 23, X.IncMSE refers to an increase in mse (mean of squared residuals) of predictions due to variable j being permuted. IncNodePurity measures the decrease in tree node purity that results from all splits of a given variable over all trees. Inspecting both together allows us to compare all variables' importance ranking across both measures. After the 25th tree, by explaining 93% of the variance, the random forest model reached its efficiency capacity. As a result of RF, we can conclude that BHN (Basic Human Needs), EDU (Education), STI (Science, Technology, Innovation), and INQ (Inequality) dimensions have the highest impact on economic complexity – which is a proxy for complex capabilities.

Step 5. RF Technique allowed us to capture essential dimensions for explaining our dependent variable. Each dimension has multiple sub-variables; therefore, to construct clusters, we first apply Confirmatory Factor Analysis (CFA) as a technique for dimensionality reduction. As a result, we benefit from Step 4 results and decrease the number of variables to 4 by constructing latent variables – indexes. The latent model is summarized in Table 5. Our CFA model is illustrated as the path diagram in Figure 24. Summary statistics are provided in Figure 25.

Table 4. Latent Construction

Variables	Latent
CHE, CRM, DW, EYS, LEB, MA, MYS, SF, YOU	BHN
LF, PSE, PTR	EDU
PAT, RDE, RDP, STJ, TPF	STI
ILE, II, IE	INQ

The model output of CFA – four latent variables and values for each row in this case, then used as an input for our clustering process in the following step.

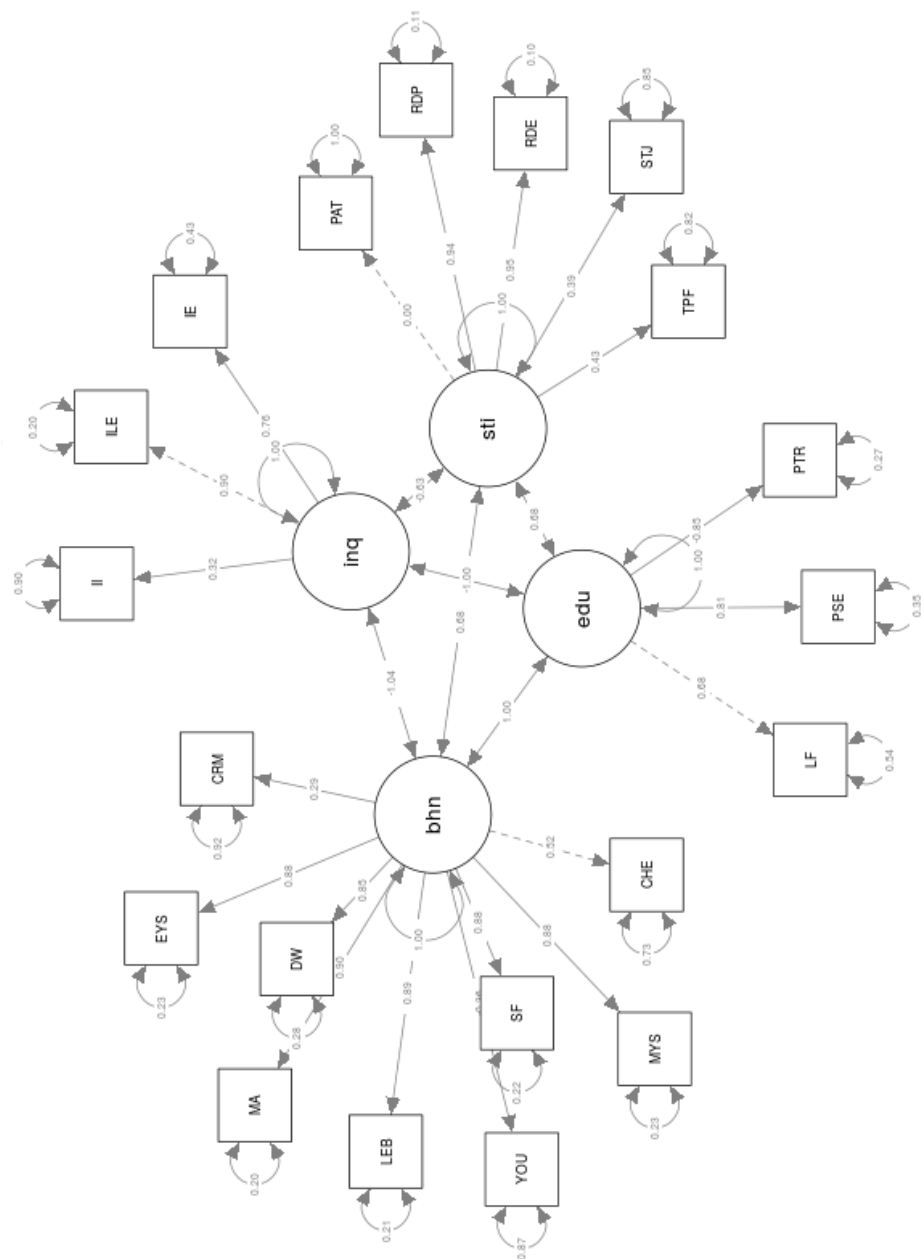


Figure 25. CFA Path Diagram

bhn	edu	sti	inq
Min. :-0.039676	Min. :-0.51361	Min. :-8.347	Min. :-0.15494
1st Qu.:-0.007232	1st Qu.:-0.09303	1st Qu.:-5.565	1st Qu.:-0.08636
Median : 0.001380	Median : 0.01868	Median :-3.236	Median :-0.01792
Mean : 0.000000	Mean : 0.00000	Mean : 0.000	Mean : 0.00000
3rd Qu.: 0.009895	3rd Qu.: 0.12572	3rd Qu.: 3.771	3rd Qu.: 0.06223
Max. : 0.020150	Max. : 0.25470	Max. :25.925	Max. : 0.36516

Figure 26. Summary Statistics for Latent Variables

Step 6. Based on the output of step 5, Hierarchical Clustering Technique was applied to identify cluster patterns for our data (see Figure 26). We observed three identical clusters for the four latent variables based on the clustering analysis graph. Our data point analysis also clearly demonstrates that we can separate the clusters from each other. The data point sizes of each 3 clusters are 179, 404 and 86.

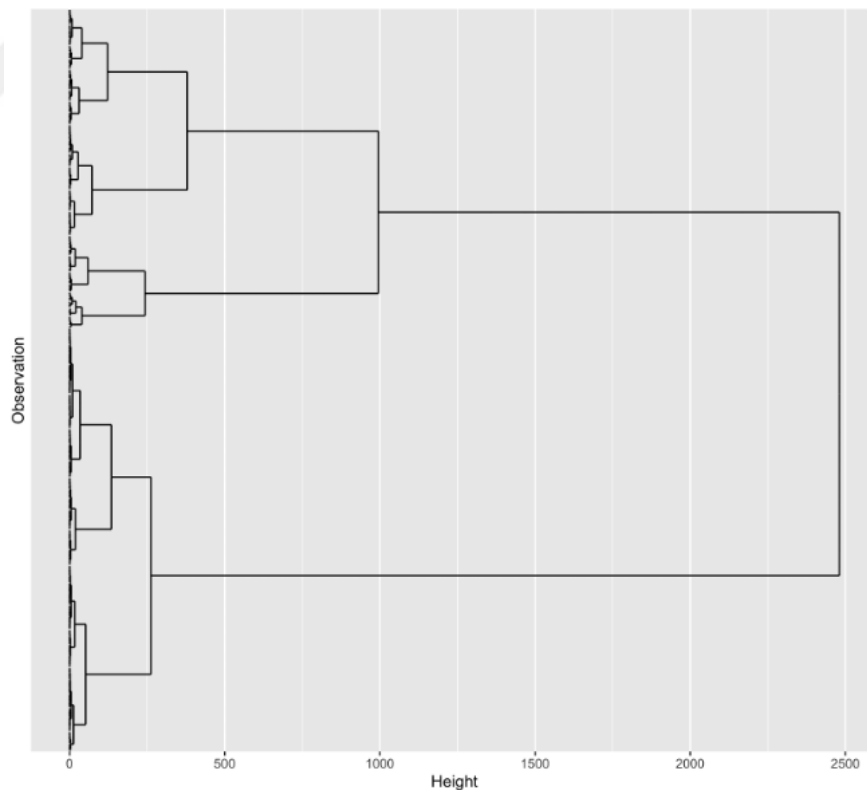


Figure 27. Hierarchical Clustering Analysis

Figure 27 reveals that our 3 clusters are well separated, and the model can explain 100% of the variability. The correlation graph (on right) points out that the latent variable for science, technology, and innovation (STI) is vital to observe cluster separation. Hence, we expect STI to be the threshold for our analysis in Step 7 for the 3 clusters individually. The following cluster means data (figure 28) also define that STI can better separate the cluster distributions.

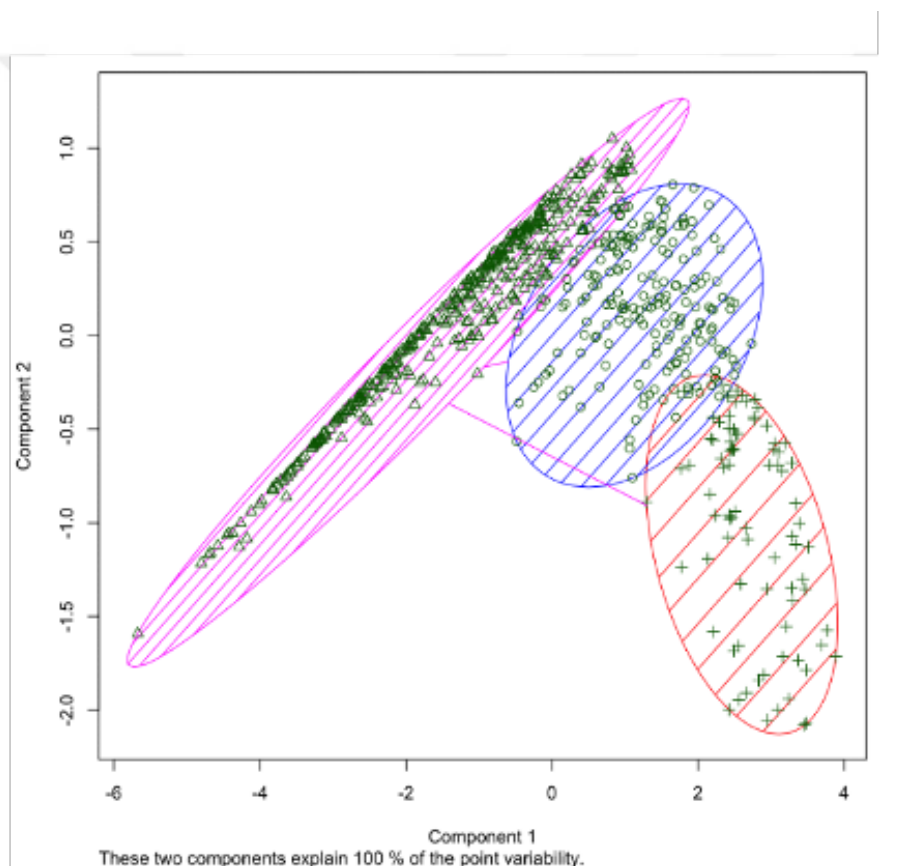


Figure 28. Step 6 Model Output (1)

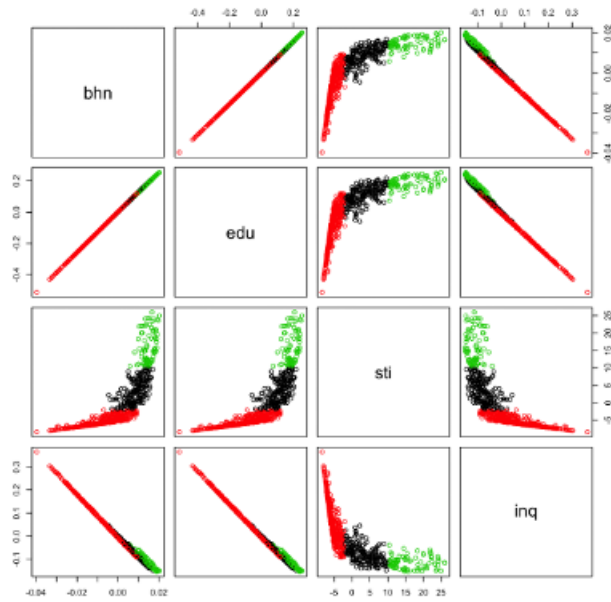


Figure 29. Step 6 Model Output (2)

	bhn	edu	sti	inq
[1,]	0.008572306	0.11052185	3.233961	-0.07672285
[2,]	-0.007782464	-0.09965039	-5.245745	0.06578797
[3,]	0.014748807	0.18698783	16.194536	-0.11421138

Figure 30. Cluster Means

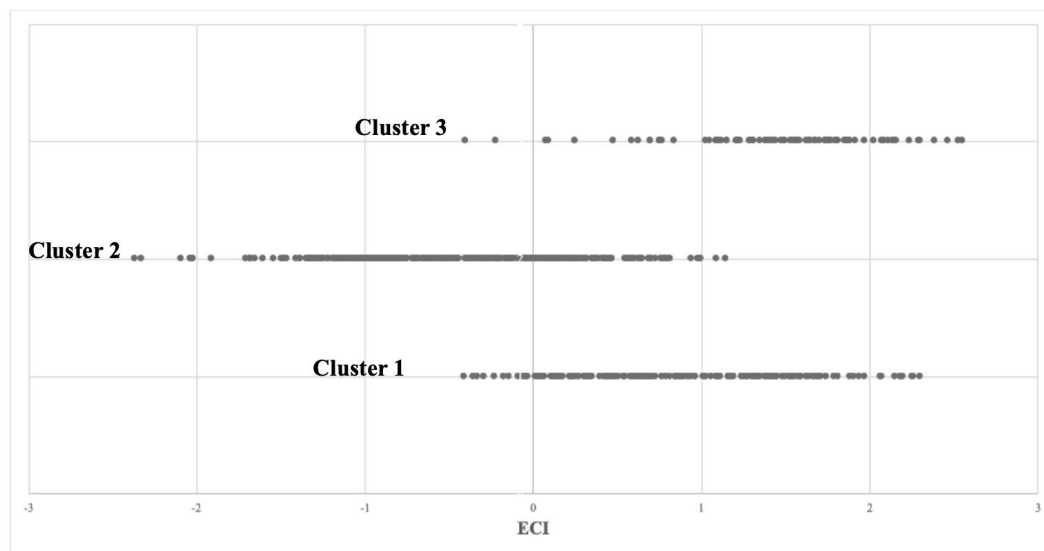


Figure 31. Cluster Distributions by ECI Scores

Table 5 describes selected countries' cluster movements on our data set over 5-year intervals. Data reveals that several countries represent a path-dependent development that moves together with its cluster, and there is no structural change. Only a few countries can extend their complexity level and move into a higher-performing cluster. In a nutshell, we can claim that clusters can be ranked as $3 > 1 > 2$ in the order of economic complexity performance (see Figure 29).

Some emerging economies, such as Argentina, China, Turkey and Malaysia, did increase their economic complexity during the last decade. Similarly, countries like Canada, France, South Korea, and the United Kingdom have joined top performers over different periods. USA, Israel, Japan, Finland and Sweden have sustained their economic complexity performances over the years.

Table 5. Cluster Movements of Selected Countries

Country	Codes	1990	1995	2000	2005	2010	2015	2020*
Argentina	AR	2	2	2	2	1	1	1
Brazil	BR	2	2	2	2	2	2	2
Bulgaria	BG	1	1	1	1	1	1	1
Canada	CA	1	1	1	3	3	3	3
China	CN	2	2	2	2	1	1	1
Egypt	EG	2	2	2	2	2	2	2
Finland	FI	3	3	3	3	3	3	3
France	FR	1	1	1	1	3	3	3
Germany	DE	1	1	1	1	3	3	3
Greece	GR	2	2	1	1	1	1	1
Hungary	HU	2	2	1	1	1	1	1
India	IN	2	2	2	2	2	2	2
Indonesia	ID	2	2	2	2	2	2	2
Iran (Islamic Rep. of)	IR	2	2	2	2	2	2	2
Israel	IL	3	3	3	3	3	3	3
Italy	IT	1	1	1	1	1	1	1
Japan	JP	3	3	3	3	3	3	3
Korea (Republic of)	KR	1	1	1	1	3	3	3
Malaysia	MY	2	2	2	2	1	1	1
Mexico	MX	2	2	2	2	2	2	2
Netherlands	NL	1	1	1	1	1	3	3
Pakistan	PK	2	2	2	2	2	2	2
Poland	PL	1	1	1	1	1	1	1
Portugal	PT	1	1	1	1	3	1	3
Romania	RO	1	1	2	2	2	2	2
Russian Federation	RU	1	1	1	1	1	1	1
South Africa	ZA	2	2	2	2	2	2	2
Spain	ES	1	1	1	1	1	1	1
Sweden	SE	3	3	3	3	3	3	3
Switzerland	CH	1	1	1	1	1	3	3
Turkey	TR	2	2	2	2	2	1	1
United Kingdom	UK	1	1	1	3	3	3	3
United States	US	3	3	3	3	3	3	3

(*) Latest available data is used as a proxy for 2020 data. The earliest is belonging to 2017.

Step 7. At this step, we applied discriminative classification with the Decision Tree Technique for each of the three clusters to display threshold patterns. As an initial step, we test our entire data without clustering to understand the threshold patterns. Figure 30 provides the decision tree. STI (Science, Technology, Innovation) is the sole threshold for a single cluster. Therefore, analysing the patterns of additional thresholds for each cluster will help gain policy-level insight.

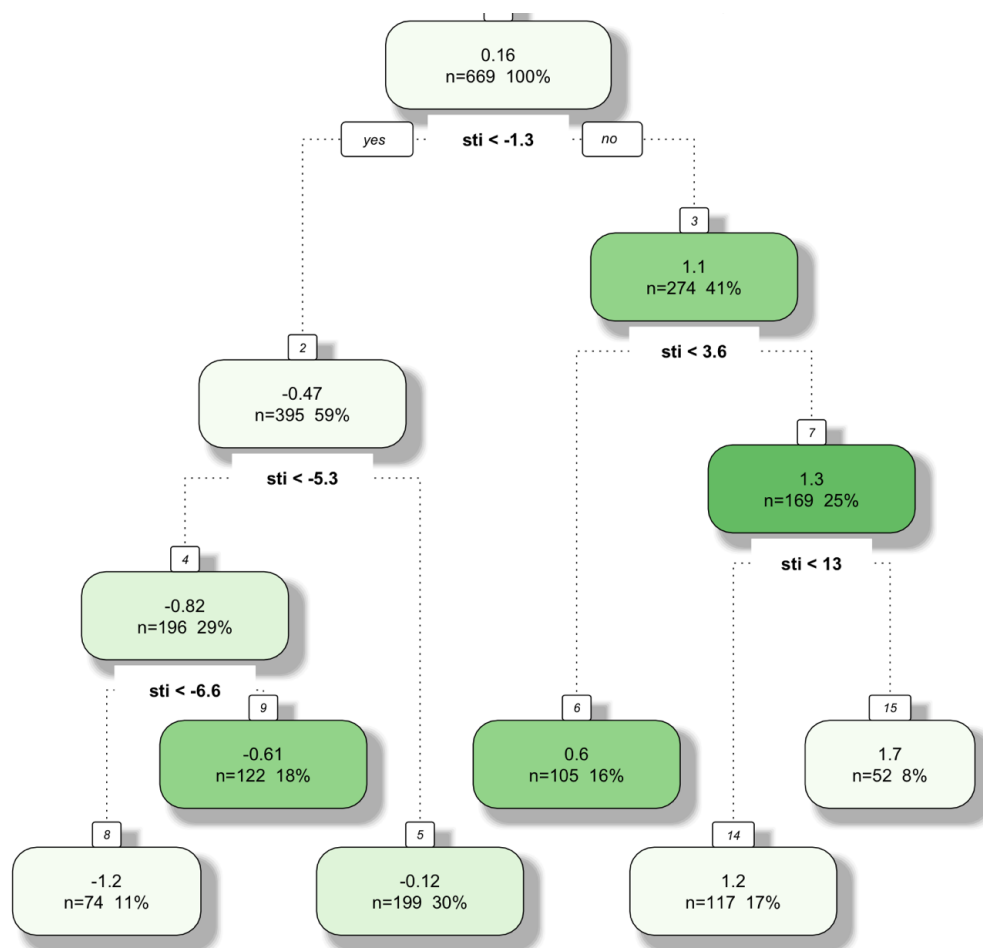


Figure 32: Decision Tree Analysis (without clustering)

Cluster 1 mainly consists of emerging economies that aim to catch up with cluster 3 countries. For this group, the science, technology, and innovation (STI) index is the core factor that supports our threshold hypothesis. As shown in Figure 31, for lower STI levels, BHN (basic human needs) emerges as an additional threshold – meaning that without satisfying basic human needs, those countries that fit into the lower edge of STI levels cannot enjoy higher economic complexity. On the other hand, INQ (inequality) emerged as an additional threshold for higher STI levels. Therefore, those countries should concentrate on deliberate policies to overcome inequalities within their societies to further enhance their economic complexities and cultivate their STI investments.

For Cluster 2, again, STI is the primary threshold. As shown in Figure 32, almost half of the sample fits into the lower STI edge within Cluster 2. For those countries, we cannot find a piece of clear evidence on the availability of any other threshold rather than STI. Therefore, STI related policies are essential for these economies to enhance economic complexity. For the economies with the highest STI scores (only 4% of the cluster), which are the candidates for migrating to Cluster 1, we can claim that their current capability stocks are sufficient to allow them to enjoy their STI capabilities without any limitations. For the rest of the economies within this cluster, both INQ and BHN emerge as thresholds in diversified levels. If inequality is high, lower economic complexity is inevitable, even if the STI level is relatively high. If inequalities are low, then progress on the basic human needs is necessary to exploit the potential of STI capabilities.

Cluster 3 are high performers, and the STI level is again the primary threshold. As shown in Figure 33, BHN (basic human needs) is an additional threshold for lower STI performers within the cluster. However, for higher STI levels, inequality level is a crucial determinant for potential benefits of STI investments.

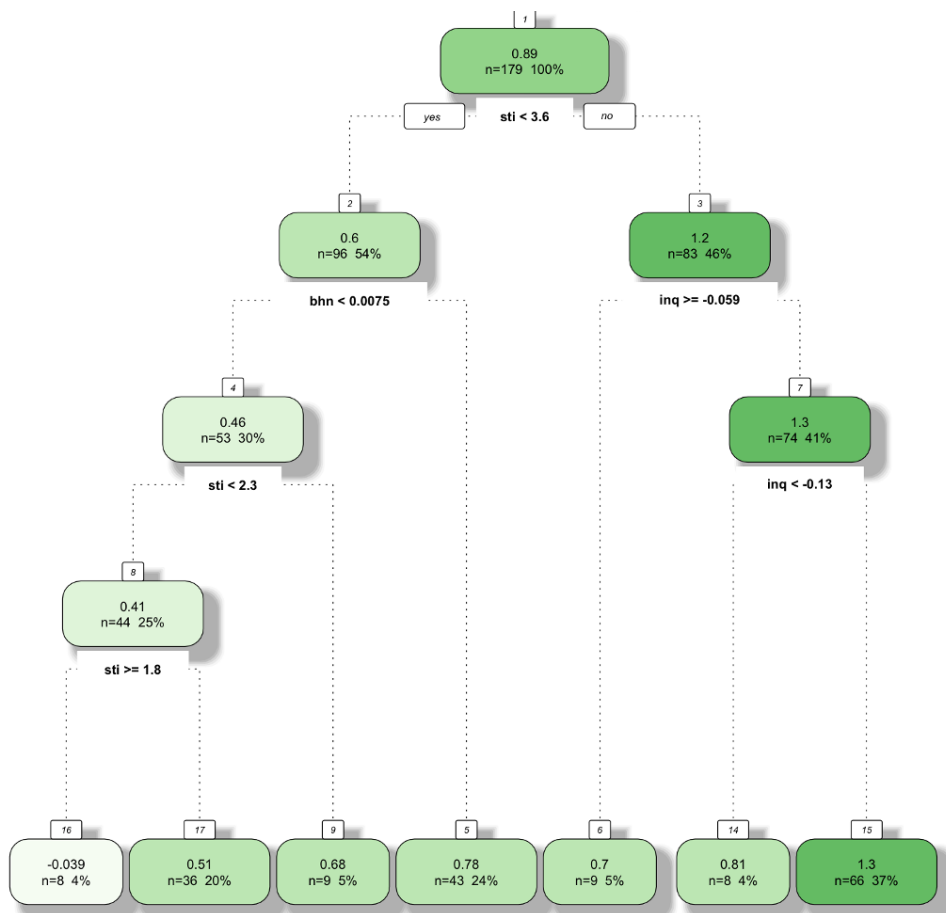


Figure 33. Cluster 1 Decision Tree
Source: R Output

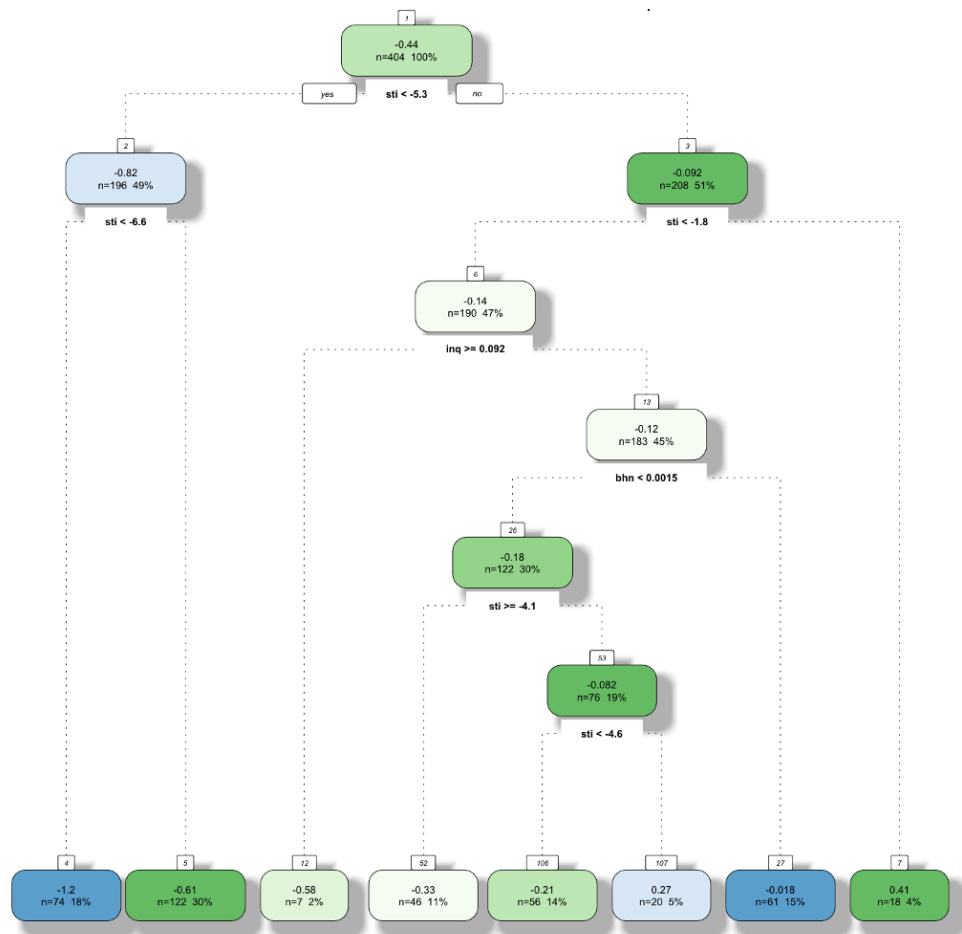


Figure 34. Cluster 2 Decision Tree
Source: R Output

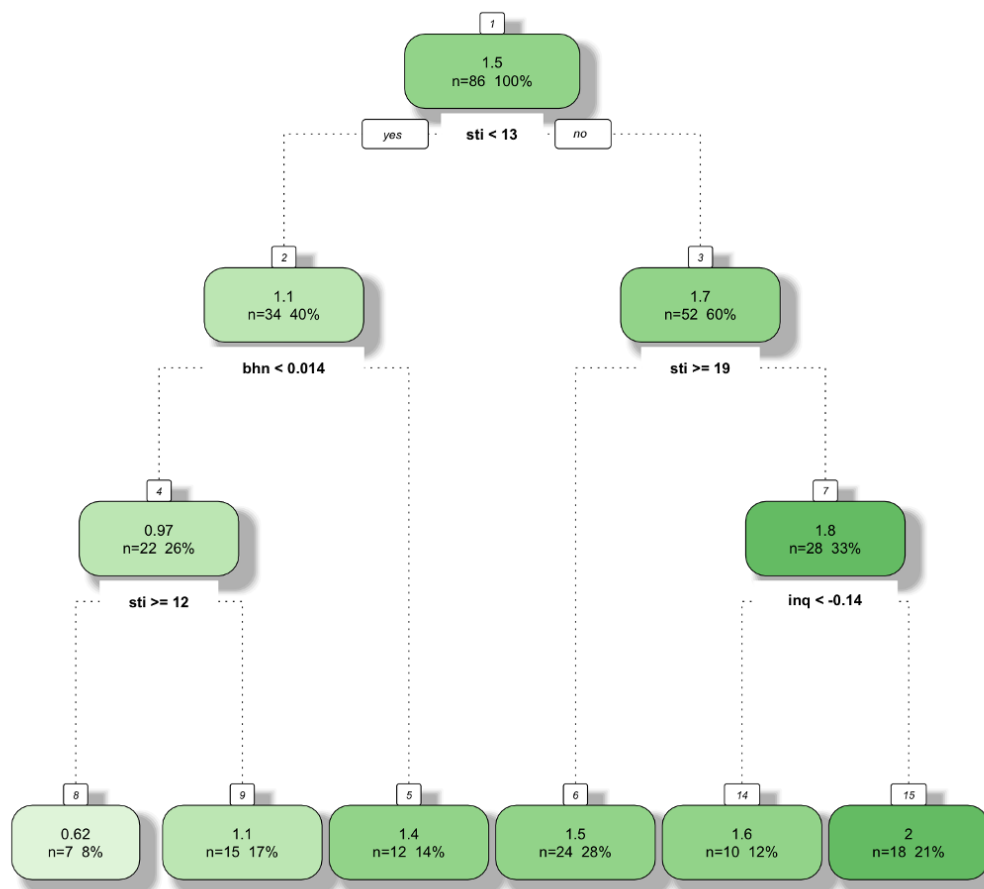


Figure 35. Cluster 3 Decision Tree
Source: R Output

3.6. Conclusion

Development is all about empowering individuals and social groups to live a life they have valued. But it is an ongoing process – a moving target. The needs and demands of individuals and the social groups they constitute are evolving, qualitatively and quantitatively. As a process, development necessitates removing a new level of unfreedoms that leave people with limited choices. Governments' roles in this process are to define the direction of change and socially construct competitive assets that accurately fit the new direction. Overall, we name these roles as the sophistication of the capability space. However, each capability has its components. Understanding the inner mechanism of such components is vital to designing and evaluating the targeted capability. The real value that the human development and capability approach brings to this thesis is that it provides a structural understanding of how capabilities are working, their inner mechanics and their components.

Our empirical analysis reveals that the level of a country's science, technology and innovation capability is vital to determine its potentiality for complex capabilities. Therefore, STI is the critical threshold for development, independent of cluster belonging. However, STI alone cannot explain countries' performance since other thresholds over development and economic complexity exist. Our results demonstrated that the education index (EDU) is not a direct determinant. The primary reason is that the education index values of Cluster 1 and 3 are so close to each other. Therefore, EDU cannot explain the variation. For the top performers (high STI levels in Cluster 3), inequality (INQ) is the only additional threshold. For the lowest performers (low STI in Cluster 2), STI is the only threshold, but when they enhance their STI levels (relatively higher STI in Cluster 2), they have faced with INQ and BHN as additional thresholds. For the emerging economies (Cluster 1), lower STI performers need to surpass certain BHN thresholds, while higher STI performers should tackle INQ as a threshold. The following graph illustrates the thresholds for each cluster and sub-clusters.

Sub-Cluster #	Cluster #	STI Level	% of Population	→ Additional Threshold
SC1:	Cluster 2 >	Lower STI:	49%	→ N/A
SC2:	Cluster 2 >	Higher STI:	45%	→ INQ & BHN
SC3:	Cluster 1 >	Lower STI:	54%	→ BHN
SC4:	Cluster 1 >	Higher STI:	46%	→ INQ
SC5:	Cluster 3 >	Lower STI:	40%	→ BHN
SC6:	Cluster 3>	Higher STI:	33%	→ INQ

Figure 36. Thresholds Distribution within Clusters

Note: Population totals do not add up to 100% since there are other smaller sub-clusters.

Figure 34 shows that STI is the actual threshold for economic complexity. SC1 is the lowest STI performer, and the results reveal no other additional significant thresholds. Transition to SC3 to SC4 and SC5 to SC6 are identical: in lower STIs, BHN emerges as an additional threshold, while for higher STIs, INQ is another determinant.

One should note that both BHN and INQ threshold levels are not identical for different clusters. As we have defined early, development is a moving target. Therefore, actual threshold levels are changing over the development process (moving within the same cluster or between clusters). INQ thresholds of SC4 and SC6, for instance, are not identical.

We hypothesised that "There are complexity thresholds over the stages of development", and the research question was "What are the threshold patterns for different country clusters?". Our research results confirmed the existence of thresholds – mainly STI and INQ and BHN for sub-clusters. We have defined these thresholds for each cluster and their magnitude (demonstrated in Figure 30-31-32).

Consequently, as shown in Figure 35, STI should boost our ECI performance, where basic human needs are fully satisfied, and inequalities do not exist. Otherwise, an economy cannot fully utilize its STI investments, thus achieving the expected economic complexity level (ECI-theoretical). Instead, the thresholds in other factors (BHN and INQ) shall diminish the return on STI investments (ECI- α and ECI- β).

Over the development process, many other factors limit the full utilisation of STI investments and call for crossing some different thresholds for complexity enhancement.

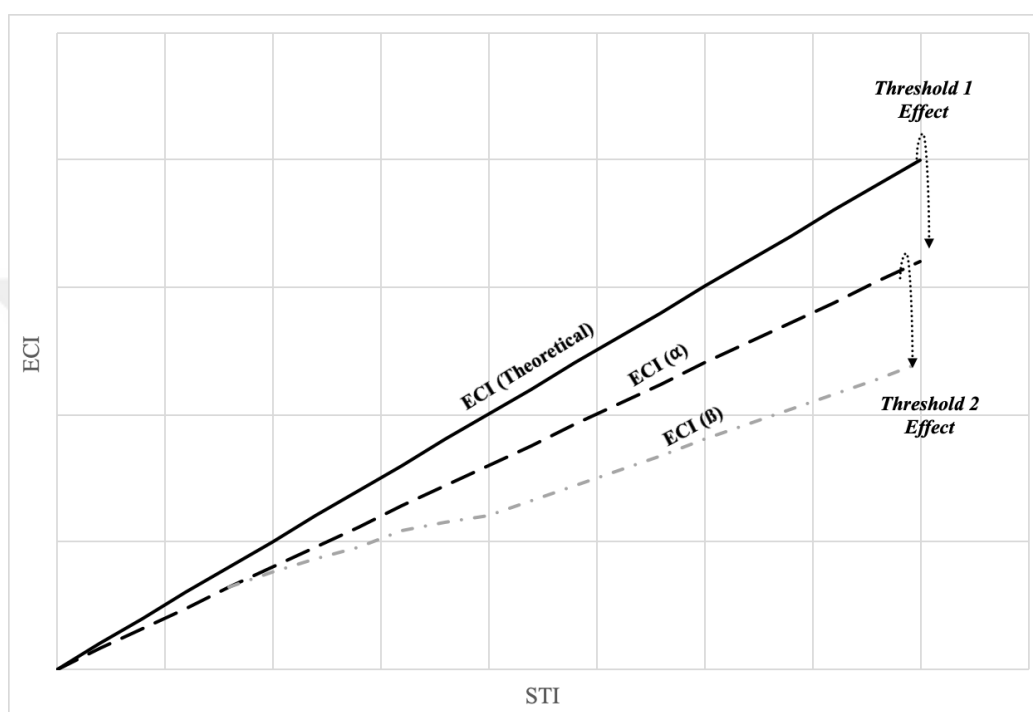


Figure 37. Effect of Thresholds

Source: Author's illustration

Our multiple state analysis reveals that economies should extend their STI capabilities while solving non-STI thresholds that they would face according to their cluster belongings for achieving economic complexity. To further advance our understanding of the complexity, we will deep dive into the innovation capability.

Chapter Four will explore the innovation capability and its components from a capability approach perspective and define policy development tools to build practical applications.

CHAPTER 4

INNOVATION AND COMPLEXITY

4.1. Introduction

In previous chapters, we have defined development as building and sophisticating capabilities to bring economic complexity through qualitative changes. Qualitative change, which refers to a broad range of changes in the economic system's composition, comprises today's and tomorrow's production structures. Production routines and incremental improvements are the building blocks of today's production structure. Nevertheless, tomorrow's production structure is attributed to innovation and rapid adaptation, which paves the way for new opportunities (Lent and Lockwood, 2010). With this in mind, we have defined innovation capability, a complex one, by employing the economics of innovation as an explanatory theory of the capability approach.

Qualitative change necessitates sequential processes of variation, selection, and retention. Variation is attached to innovation capability, while selection and retention are more linked to production capability. Lock-in to the current production structure, i.e., unable to sophisticate the innovation capability, might increase inequalities (unfreedoms) for the society. New production structure necessitates capability enhancement on a broader group of organizations since production systems have significant backward and forward linkages.

Government roles – the direction of change and development of competitive assets – can only be achieved by well-structured policy actions targeting each capability space component.

Amartya Sen defined the Capability Approach “as a policy evaluation and designing toolkit” (Sen, 1999). However, scholars working on HDCA do not reach a consensus on a standard framework for policy design. So, we decided to employ the Approach with its original purpose. This thesis aims to construct a policy framework and then use it more specifically for innovation policy.

Each capability, such as innovation, has a specific role in addressing various degrees of inequalities. For instance, innovation capability has a fundamental role in tackling knowledge-based inequalities. Knowledge acquisition today is a prerequisite to extending the economy's composition – i.e., initiating and sustaining qualitative change and economic complexity. Consequently, special attention is given to knowledge-based inequalities.

In this chapter, we define innovation as a complex capability in Section Two. Section Three will outline our theoretical perspective on the policy domain. Section Four is on our Four-P policy design and evaluation model. In the following section, we will perform Machine Learning Techniques of Random Forest and Decision Trees, built upon the empirical study results of Chapter 3. We will also perform a descriptive case study analysis – innovation policy evolution of Turkey over the years, which will also be utilized as a sensitivity analysis. The final section concludes.

Our ML-based empirical assessment revealed that for developed economies (Cluster 3), P1 (resource providing) is the most critical innovation policy role to enhance innovation capability and boost economic complexity. For emerging economies (Cluster 1), P2 (capacity building), P3 (developing appropriate institutions) and P4 (have an impact on the choice mechanism of the change agents) has equal weights. In contrast, for developing economies (Cluster 2), P3 has a significant impact, followed by P1.

Such results are fundamental to operationalising the Four-P Model and identifying how to define the innovation policy mix within the overall innovation capability space – depending on cluster belonging.

Our case study on Turkey revealed that Turkey followed the right approach and invested in the appropriated policies as a Cluster 2 member. This process resulted in STI capability improvements, and the country moved up to Cluster 1. However, Turkey has been locked into the Cluster 1 low performers sub-group since then due to limited diversification of its policy efforts and the continuation of the policy mix that she utilised during Cluster 2 membership.

4.2. Innovation as a Complex Capability

'Innovation economics' deals with the dynamic processes of qualitative transformations, which are assumed to be driven by the introduction of novelties in its various forms, including technological, institutional, organisational, social and political (Hanusch and Pyka, 2007), with the interaction of the capabilities of heterogeneous actors. Accordingly, the theory identifies economic development as the co-evolution of technologies, firms and industry structures and supporting and governing institutions (Nelson, 2016).

A growing economic doctrine reformulates conventional economics theory. Knowledge, technology, entrepreneurship, and innovation are positioned at the centre of the model rather than seen as independent forces that are largely unaffected by policy (Antonelli, 2006).

In a similar vein, Alice Amsden (Amsden, 2007) pinpoints critical conditions that affect an economy's ability to avoid poverty traps: availability of an industrial organisation (i.e., presence of domestically owned diversified industrial groups), disciplined support of a developmental state and the supportive global political-economic conditions.

This understanding fits our previous analysis of complex capabilities under the Capability Approach. Since it is an approach, it needs an engagement with an explanatory theory to explore its potential application in each domain. In this study, we employed innovation economics as the explanatory theory.

One crucial causal process of co-evolution is variation (while the others are selection and retention that follows variation). Over time, economic systems become more efficient in producing a given set of goods and services, thus creating a growing output per unit of population (Saviotti and Pyka, 2004b). Evidently, as shown in Figure 35a, “the mere efficiency growth would lead to unemployment” (Hartmann, 2012) even with the increased supply of superior capabilities. Therefore, the capitalist system necessitates variety growth by continually innovating, diversifying (Pier Paolo Saviotti, 1996) and sustaining demand for enhanced capabilities through formal job opportunities. Consistently, the supply of such complex capabilities is vital to maintaining the economy to innovate and diversify. Thus, the co-evolution of supply and demand for more sophisticated capabilities is the healthy economic development process with a virtuous cycle that we have outlined in the discussion in Section 3.3.

As shown in Figure 36b, while variety growth leads to new sectors, new employment opportunities – efficiency growth in existing sectors may sustain in parallel. So, variety and efficiency growths are complementary and not independent aspects of economic development (Saviotti and Pyka, 2004a). Referring to Section 3.3., mere efficiency-based growth leads to growth without development.

Efficiency and variety growths together constitute the qualitative change process. Productivity growth in pre-existing sectors creates the resources required for search activities that catalyse new products and services. Likewise, the new sectors' capabilities are generally built upon the capabilities in the pre-existing sectors. However, a radical departure from the pre-existing sector may require gaining new-to-the-system capabilities that might have limited linkage to the current stock of capabilities.

In recent literature, economic complexity analysis is a field that concentrates on how economies can design their direction towards efficiency and variety growths to compete internationally.

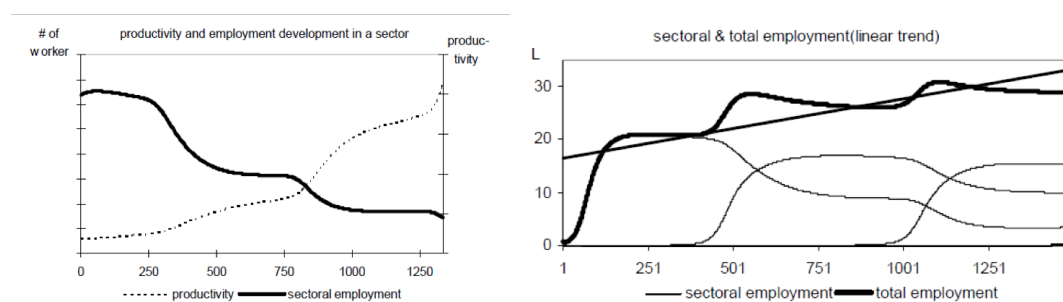


Figure 38. Effects of Growth Types on Employment

Note. Left Graph (a) is on the Effect of Efficiency Growth.

Right Graph (b) is on the Total Effect of Variety and Efficiency Growths.

Source: Saviotti and Pyka, 2004b

While labour and capital move towards more dynamic activities within qualitative change, the capabilities an economy needs to supply are also evolving. Knowledge intensity of workouts increase, and better skills are on demand. As a result, labour cost increases and entry barriers are scaled up.

The characteristics of higher-quality activities recall the fundamental role of technological capabilities in a qualitative change. According to Martin Bell (Bell, 2009), there are two main sub-sets of such technological capabilities: production and innovation.

While production capability is defined as "the capability to carry on producing goods and services with given product technologies and to use and operate given forms of process technologies in existing organisational configurations".

Innovation capability, on the other hand, "is the capability to create new configurations of product and process technologies and implement changes and improvements to technologies already in use" (Bell, 2009).

As stated before, the causal processes of qualitative change are variation, selection, and retention. New varieties are needed to sustain development, which can only be mobilised by utilising innovation capability. Further, for selection and retention, matching productive capability is desirable.

Variation-selection-retention sequence results in new technologies and corresponding new sectors (diversification of the production structure). After a certain period, this loop needs to be repeated since lack of the virtuous cycle may block further development of the economy due to over-retention (or technological lock-in). Such lock-in might drive many agents to face various inequalities in the long run.

Therefore, the innovation capability enables economies to produce high value-added and more complex products, recombine and sophisticate productive capabilities and further diversify and grow. Hence, these capabilities' co-evolution is necessary for a healthy economic development process.

As United Nations Conference on Trade and Development (UNCTAD) stated, together, these capabilities facilitate diversification away from sectors characterised by diminishing returns towards sectors characterised by increasing returns (UNCTAD, 2010).

Moving up on the ladder to any capability requires convincing efforts with apparent costs. Economic diversification requires strong co-evolution of innovation and production capabilities and that the enhancement of any of these capabilities requires the enhancement of the other. From the Capability Approach point of view, they are both the means and the ends of each other.

Since most of the backward countries display an absolute disadvantage in everything, development entails closing the gap in both production knowledge (productive capability) and learning how to produce novel goods (innovation capability) (Cimoli et al., 2009a). As expected, there is a natural threshold that few countries can enhance their technological capabilities (production and innovation capabilities together) towards higher levels. We have analysed this issue in the previous chapter in detail.

Historical evidence also supports this understanding. As Pisano and Shih (2009) interpreted, decades of outsourcing manufacturing diminished the productive capability and has left the U.S. industry without the means to invent (Pisano and Shih, 2009).

In fact, for the U.S. case, outsourcing was not limited to low-value tasks only (i.e., simple assembly stuffing) but has continued with sophisticated engineering, design, and other complex activities.

Outsourcing inflicts not only on a single firm's capabilities but also on other companies with backward and forward linkages, hence destructing the whole industry's collective capabilities. "Many high-tech products can no longer be manufactured in the U.S. since critical knowledge, skills, and suppliers of advanced materials, tools, production equipment and components have vanished through outsourcing" (Pisano and Shih, 2009).

On the other side, Hobday articulated how countries like South Korea and Taiwan enhanced their innovation capabilities (Hobday, 2003). In the early days, they initiated manufacturing by establishing productive capabilities. Then they enhanced their process innovation capabilities through daily interactions with manufacturing processes. Companies could conduct advanced research on the next generation of process technologies with enhanced process engineering capabilities and more sophisticated production capabilities. Such an ability to develop new processes paved the way for product innovation capabilities in the long run (Hobday, 2003).

As we underlined before, complex capabilities are collective. Innovation capability as a collective one necessitates the network structures due to tacit elements of the primary input, namely knowledge. Such tacit aspects are embodied in agents' minds, firms' routines and relationships between people and organisations (Dosi, 1999; Polanyi and Sen, 2009). In this regard, innovation capability can be defined as a collective capability embedded in interactions (Lundvall et al., 2009). The individual capabilities are transformed into an upgraded collective capability (Arocena and Sutz, 2001).

During such transformation from individual into collective, one of the essential resources is the social capital. Social capital constitutes *"the glue that holds societies together"* (Serageldin, 1995, p.196) - *"in the forms of embedded rules, norms, obligations, reciprocity and trust in social relations, structures and institutional arrangements"* (Frediani, 2010, p.174). Together with knowledge capital, they constitute the innovation capability's primary resources.

Recalling that capabilities are freedoms, whereas functionings are real achievements, there is a necessity to define the central functioning for the innovation capability. Furthermore, since available resources are transformed into value(s) by grounding capacities within a given functioning, the appropriate capacity for innovation capability also requires attention. Hence, the life process of the functioning for the innovation capability is learning. Formalised and purposeful learning methods include education, training, research, and development (Conceição et al., 2001). Diversity and heterogeneity across actors will always entail some inequality in learning performance.

Like capabilities, functionings also have different sophistication levels based on the available resources and appropriate capacities. According to OECD, learning contains three degrees of sophistication (or as OECD called loops) (Remoe and Guinet, 2002):

(1) Single-loop learning, which involves accessing to, accumulating, and applying knowledge; (2) Double-loop learning, which also involves reacting to changes in the environment; and (3) Triple-loop learning, which –in addition to the first two – involves using internally generated knowledge to transform the environment.

Real achievement (functioning) results from combining all these learning processes at all aggregation levels – i.e., individual, organisational, and national.

While such a definition explicitly highlights knowledge as the learning process's central resource, it implicitly refers to social capital by attaching importance to interactions. According to social capital theory, it may be the adequate combination of strong and weak ties and the position and role of the actor within the network that provides different opportunities to access and control the resource flow. Hence, actors might require a network of strong ties on which they can trust and rely and access to weak ties that provide them with new information and opportunities (Burt 1992; Coleman 1988).

In the learning process, agents transform knowledge (embodied and disembodied forms) into the desired value by grounding absorptive capacity. More sophisticated absorptive capacity is expected for the upper degrees of learning in which past achievements influence future learning potential (Cimoli et al., 2009a). Throughout this thesis, the absorptive capacity is understood as “...ability to recognize the value of new information, assimilate it, and apply it...” (Cohen and Levinthal, 1990, p.128) to generate value by the agent. Figure 37 illustrates the innovation capability space based on the discussions up to now.

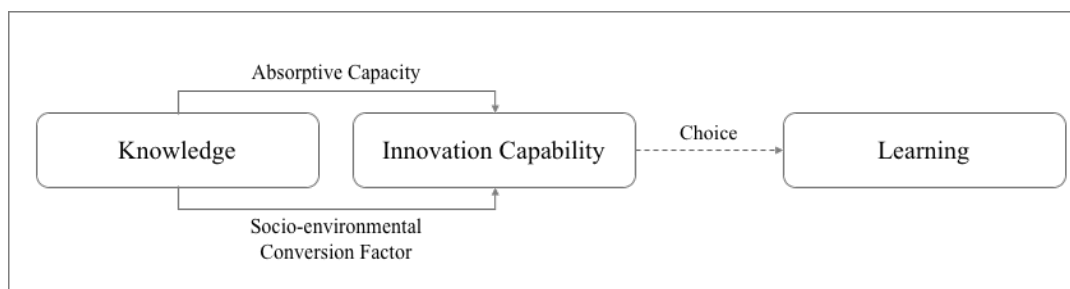


Figure 39. Innovation Capability Space

Source: Author's illustration

For the transition from the capability to functioning (real achievement), agents make a 'choice' to do so (that means attaching value to such realisation) and should have the opportunity (socio-environmental conversion factors such as institutions) since what people can achieve is undoubtedly influenced by the available opportunities.

At this point, we introduce a second theoretical extension to the original capability approach (in addition to the first one, which is the collective nature of innovation capabilities) to examine such a choice-opportunity couple.

This second extension is on (Robeyns, 2005) emphasising the necessity of introducing explanation theories. Since the capability approach only provides a framework for policy intervention but is not a formal theory, its application requires explanation theories. For this study's purpose, an attempt was made to employ the previously discussed innovation economics as the extension mentioned above.

This selection reflects the claim that the capability approach's two primary components, namely the 'choice mechanism' and the 'opportunity expansion', are generally neglected in the mainstream development discourse.

In the neoclassical school (to aggregate from micro to macro) the homogenous representative agent's idea was applied (Hanusch and Pyka, 2007). It refers to a situation in which the actors face given and fully understood choices, and make optimal choices (Nelson, 2016) because the economic context is unchanging. Innovation economists, however, claim that such representation is assumed to have one general rule of behaviour (optimisation) and hence eliminates the 'real choice' (Johnson et al., 2004; Nelson, 2016) because it is hard to capture dynamic changes.

There are significant heterogeneities among people, their choices and capabilities due to several factors such as individual differences, environmental diversities, socioeconomic variations, and differences in relational perspectives (Sen, 1999). Similarly, heterogeneity is essential for innovation economics, attributed as "the main source of novelty" (Nelson and Winter, 2002).

Heterogenous agents bring change (realising their capabilities that result in functioning) to their own lives by activating choice mechanisms. The freedom is to choose performing the functioning (to do or to be) with the attached value. Therefore, functioning is the real achievement where the resources and capacities are mobilised. However, the lack of opportunities may also prevent many people in the developing world from advancing. Opportunities have effects on capacities, resources, and relationships. They may either upgrade capacities or provide channels to reach related resources. Furthermore, they may eliminate constraints for functionings because the problem often is not the absence of local capacities or resources. Instead, they might be hidden or remain socially invisible – due to the lack of opportunities (Arocena and Sutz, 2001).

Economic development is associated with structural transformation and increased complexity of production. The core mechanism of complexity is evolution. For an economy, the evolution postulates the constant development of new industries, technologies, organisations, and capabilities.

In complexity, economics products are presented as the vehicles for knowledge. A country with a high complex economic system can cope with various types of economic challenges – i.e., high degree inequalities.

The contemporary discussions on the capability approach are more mainly concentrated over basic human capabilities. Therefore, the real value that the complexity theory brings to this study is the fact that it allows us to extend the capability approach towards more complex unfreedoms – arising due to economic inequalities.

This thesis aims to construct an operational policy framework. In this regard, under the theoretical discussions of this section and the previous chapter, we try to build a policy framework in the following section.

4.3. Policy Framework Construction

Available resources may potentially initiate change through capacities (personal conversion factors) and supportive institutions (socio-environmental conversion factors). This potentiality is labelled as capabilities, and the realisation of this potentiality is named functionings. Accordingly, functioning is the realised actions for potential capabilities. The connector between capability and functioning is the choice mechanism of the actors.

The choice is also subject to institutions since the availability or lack of appropriate institutions may catalyse or hinder the actors' choice decision. Another fundamental component of the overall human agency is valuation.

People can take actions if they value the results of these actions, which is given at the level of choice mechanism. Hence, institutions may also affect the valuation of society. As a result, the role of government – through institutions – is highly comprehensive within the scope of the capability approach.

The capability approach and its literature heavily concentrated on central (basic) human capabilities by design. One popular list of central capabilities belongs to Nussbaum (2011), who defined them as (1) life, (2) bodily health, (3) bodily integrity, (4) senses, imagination, and thought, (5) emotions, (6) practical reason, (7) affiliation, (8) other species, (9) play, and (10) control over one's environment – both political and material.

Such basic capabilities are measured through the human development index (HDI) and the inequality-adjusted human development index (IHDI). Former is associated with capabilities – the potential level of basic human capabilities.

The latter accounts for inequality within society so more directly measure the actual achievements. Inequalities are masking to reach the capabilities' full potential due to various degrees of barriers. In short, one can claim that HDI and IHDI are measurements of basic human capabilities and functionings, respectively.

Figure 38 below summarises our understanding of human agency, which will help us construct our policy framework.

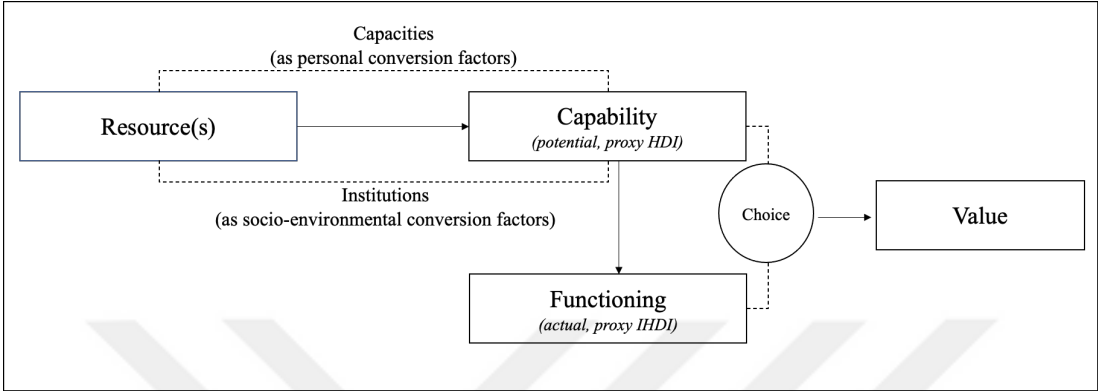


Figure 40: Components of Human Agency (extended)
 Source: Author’s illustration

The capability approach defines a dynamic process in which we can observe continuous evolution in the composition of resources, the conversion factors, the capability set, and agents' valuation.

According to the capability approach, governments' core roles are defining the direction of change and expanding capabilities to initiate or sustain the change process towards the desired direction. Therefore, policy instruments shall need to be aligned with these roles.

We have previously discussed the direction of change and defined two main alternative directions. One is the quantitative change which is mainly associated with growth. In this direction, the ultimate aim is to increase productivity within the current composition of productive sectors. Capability enhancement is primarily incremental, and institutions' current set will be supportive with minor adjustments, which sustain the growth and enable advances towards sectors that necessitate a similar set of capabilities.

Qualitative change, on the other hand, requires significant changes in capabilities and institutions. Radically new capabilities and appropriate new-to-the-context institutions shall be needed to initiate sectors that will be the future growth engine.

The capability approach is a tool that needs an explanatory theory to work correctly. For the discussion on qualitative change, we have selected ‘economics of innovation’ as the explanatory theory that deals with the dynamic processes of qualitative transformations driven by the introduction of novelties in their various forms. With the help of explanatory theory, we structured the innovation capability space components – knowledge as the primary resource and absorptive capacity as the leading conversion factor.

The capability approach literature has always heavily emphasised basic individual capabilities. Our observations revealed that superior capabilities (such as innovation capability) could not be analysed at the level of individuals since these are collective.

Figure 39 illustrates the policy matrix. To avoid misguidance, we need to emphasise that the quadrants are not alternatives to each other. Instead, it provides an insight into the policy mix and highlights the need for defining dedicated policy instruments for each quadrant.

Division A is the fundamental responsibility of the governments. Governments can lower the fundamental inequalities and enhance society's potentiality for future development by addressing basic capabilities. Division B is necessary to sustain the growth and efficiency in the current composition of the sectors, what we call today's engines. However, for future development and competitiveness of the economy, qualitative change is essential, increasing the economy's complexity, labelled as tomorrow's engine (Division C). The set of institutions, the targeted capabilities, necessary resources, and conversion factors are somewhat different for each division, including the change agents to realise the choice mechanism.

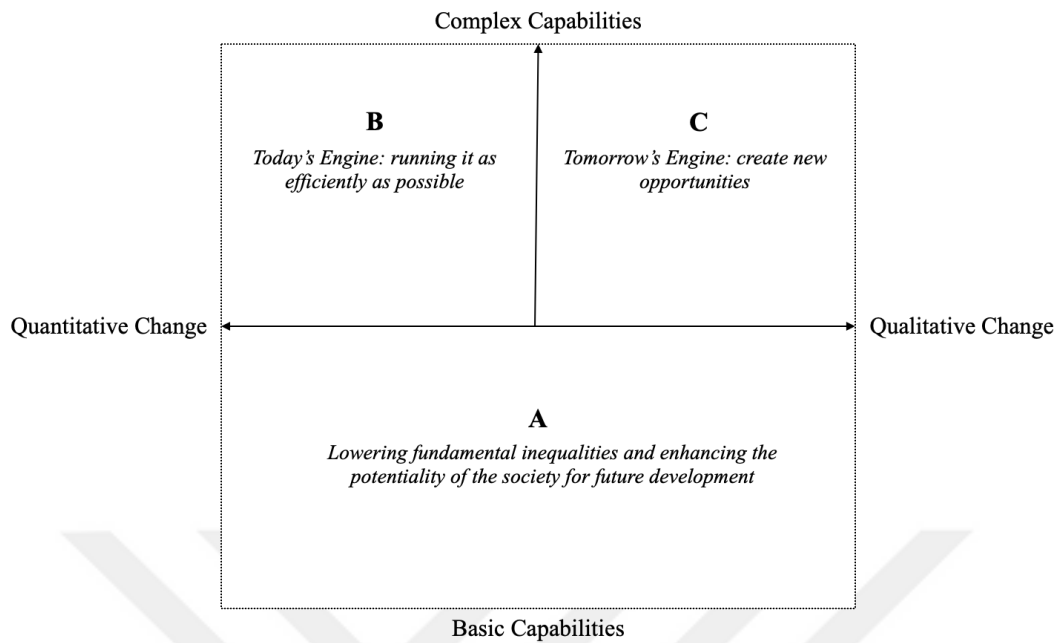


Figure 41: Policy Matrix

Source: Author's illustration

We can further construct the policy mix that a government should prioritize based on the initial level of basic capabilities (HDI), current inequalities (IHDI vs HDI) and composition of economic complexity (ECI). Table 7 lists the policy mix for the capability approach.

Table 6: Policy Mix under Capability Approach

Source: Author's illustration

Increasing the level of basic capabilities (HDI)
Overcoming the inequalities within the society (IHDI vs. HDI)
Diversifying towards short distance product space (today's engine)
Diversifying towards long-distance product space (tomorrow's engine(s))

The two-step diversification within the policy mix list is illustrated in Figure 40. Such diversification models underline the different groups of change actors. At the same time, incumbent firms that accumulate today's capabilities are the drivers of the first opportunity space. The entrepreneurs, that are expected to acquire new capabilities, are the change agents for the second opportunity space. So, within the economy, two change actors will function. How they share the limited resources and how to manage the potential resistance of one actor to another's change process are essential policy concerns during this two-step diversification process.

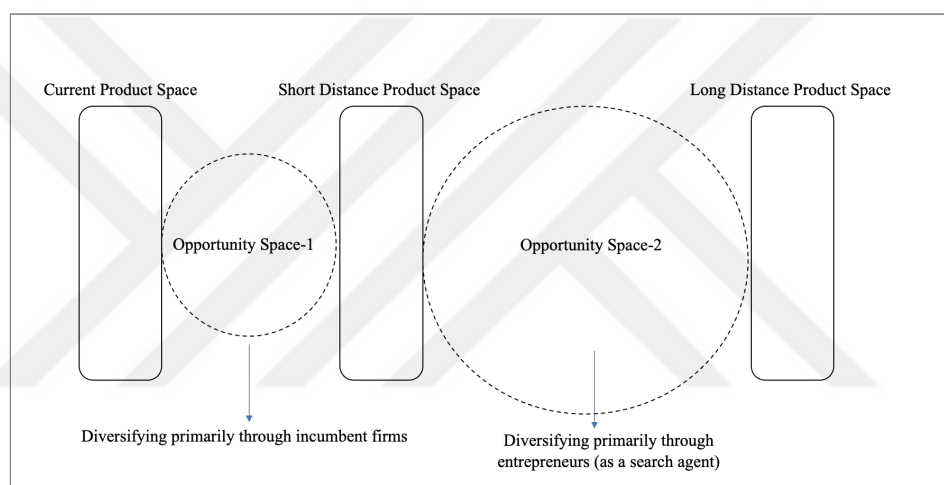


Figure 42: Two-step Diversification Strategy

Source: Author's illustration

Institutional change is a critical policy intervention mechanism for the capability approach. The role of policy, in this regard, is to align targeted capability space and relevant institutional changes. As shown in Table 8, new to the society capabilities necessitates new institutions to realise functionings and overcome the targeted inequalities. Therefore, the role of policy is to design appropriate institutions to overcome mismatch with targeted capabilities. With old capabilities, old institutions shall result in a capability trap while new capabilities with relevant institutions shall catalyse the virtuous cycle. Both types of institutions and capabilities should co-evolve within an economy to provide growth and development.

Table 7: Role of Policy

Source: Author's illustration

Capability vs. Institutions	Old	New
Old	Capability Trap	Mismatch
New	Mismatch	Virtuous Cycle

Overall, institutional change is governments' fundamental intervention to expand the opportunity space – i.e., preventing inequalities by addressing bottlenecks within the capability space and catalysing individual or collective agents' freedom.

The opportunity mechanism of the capability approach is associated with the theory of institutions. The term institution is used here in a sense suggested by (North, 1990, p.98) and understood as *"any form of constraint the human beings devise to shape human interaction... Institutions can be either formal (for instance, laws and regulations) or informal (conventions and codes of behaviour, to name a few)"*.

With the rise of new institutional economics in the 1980s, institutions started to gain popularity to explain international differences in the economic development (Chang, 2011). Poor-quality institutions are viewed as the root causes of economic underdevelopment (Acemoglu, 2003).

Rodrik has made a distinction between initiating and sustaining economic growth. He claimed that to initiate growth, one needs to identify the binding constraints of an economy. Since those are contextually rooted, "there are no standard recipes for kick-starting growth" (Rodrik, 2007). However, to maintain growth, gradual institutional improvements are necessary. Institutional improvement is an important policy mechanism to bring change to the system. However, the direction of such institutional improvements is highly path-dependent and replicating successful institutions of 'others' does not always result in favourable results. Matching new institutions with new or targeted capabilities is necessary for the change process.

Institutions formally similar or even identical can show completely different performances in different contexts. History points out that imported institutions may work much less satisfactory (Arocena and Sutz, 2001). Despite these facts, under the dominant development discourse, there is still pressure on the developing countries to adopt traditional institutions determined at the global level. For instance, the World Trade Organization (WTO) has forced developing countries to adopt American-style IPR laws through trade-related intellectual property rights (TRIPS) agreements (Chang, 2014).

This approach is problematic due to its narrow focus on the market supporting institutions and underestimation of the path dependency in the process of institutional evolution (Chang, 2010; Johnson and Bonilla, 2010). However, institutions should be designed to be sensitive to local constraints and opportunities (Rodrik and Rosenzweig, 2009).

Human Development Report's 2010 edition stated that *"development process and the possibilities facing poor countries today are so different from those that once faced the now-developed countries... development is not so much about copying the experiences of developed countries, as about finding new paths to progress in today's world"* (UNDP, 2010, p.48).

Much before, (Gerschenkron, 1979) emphasised the importance of initial conditions. Development processes are never the same as earlier processes since entry barriers and opportunities for development would have been changing. He argued that for each development case, the idea of the same set of preconditions is an example of historical determinism. His model focused on institutions' role in which institution building is a central part of economic development policy and hence positively correlated with the policy attempt of Rodrik (kick-start to growth vs maintaining growth).

Since each developing country possesses its particular advantages and disadvantages, it is necessary to build up new institutional arrangements (institutional diversification) to compensate latecomer disadvantages (Hobday, 2003) and to substitute for the missing prerequisites (Escosura, 2005).

Such an institutional perspective is also highly relevant to Sen's capability approach. According to (Sen, 1999), there is a robust institutional dimension within the capability approach since capabilities depend on institutions to build, sustain and improve capabilities. Accordingly, institutional change is required, and opportunity mechanism is the component where the institutions are dealt with (Huq, 2004; Johnson et al., 2004). The matching and mismatching between capabilities and institutions (Cimoli et al., 2009a) have a decisive effect on realising the valued functionings.

Gerschenkronian perspective is highly relevant to Sen's approach to expanding opportunity mechanisms at the policy-making level. Since the development process brings new challenges, it is crucial to sustain appropriate capabilities.

Institutional diversification, hence, is a vital policy mechanism (1) to address the main components of the capabilities: resources and capacities; and (2) to catalyst the transformation of the given capabilities to real achievements (functionings). At any policy stage (either the design of the policy or its evaluation), 'opportunity enhancement' should consider these sub-components.

4.4. Four-P Model

While building the capability approach, Sen's original objective was to assess welfare with a new understanding that extends mainstream concentration on utilities, primary rights or goods (Sen, 1985). Hence, the capability approach is not a theory that can explain poverty, inequality, or well-being; instead, it provides a framework to conceptualize and evaluate this phenomenon.

Sen argues that our evaluations and policies should focus on what people can do and be, on the quality of their lives, and on removing obstacles in their lives to have more freedom to live the kind of life that they have reason to value (Robeyns, 2005).

In short, Sen focuses on functionings (real achievements) –i.e., doings and beings – and capabilities, which constitute, together with resources (commodities), the three building blocks of the capability approach. They provide a valuable framework to assess and design public policies.

Transforming resources into functioning is influenced by some factors. Sen labelled them as "conversion factors" (Sen, 1999). As (Robeyns, 2005) defined, there are two main conversion factors; personal and socio-environmental. Both types of conversion factors influence how a person can convert a commodity's characteristics into real achievement. Knowing the goods, a person owns or can use is not sufficient to know which functionings s/he can achieve.

The capability approach truly considers diversity, both personal and socio-environmental, unlike the mainstream development discourse. Hence public interventions should be designed to provide resources by simultaneously ensuring conversion factors.

Furthermore, they should address the functionings that trigger development and social valuation (the choice mechanism). Social context (institutions, norms, other people's behaviour, and historical experiences) impacts the agent's choice pattern. Institutional diversification is necessary to cope with contextual and path-dependent development challenges. Therefore, such diversification –policy actions – should be designed and evaluated by considering the factors in Table 9. The positions of each P are illustrated in Figure 41.

Table 8. Policy Levels in Four P Model

P1	the necessary resources are provided
P2	capacities (personal conversion factor) are well sophisticated to benefit from newly provided resources
P3	socio-environmental factors pave the way to capability enhancement
P4	the social valuation (choice) of the politically targeted functioning by the change agent is positive

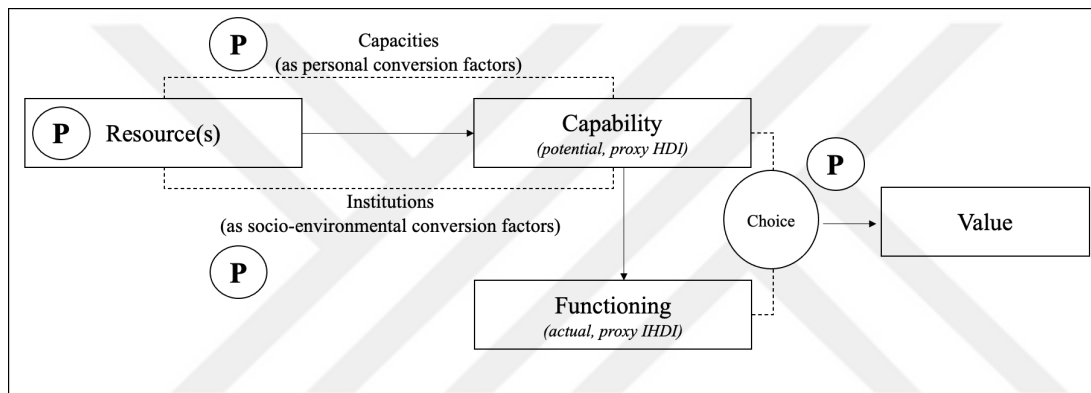


Figure 43: Role of Policy in the Capability Approach

Source: Author's illustration

Note: 'P' refers to the policy

Figure 42 summarizes the proposed mechanism behind the 4P Model Framework. Resources are vital inputs for activating capabilities – functionings. Problems in accessing resources, such as lack of awareness on resource availability and struggling access to resources for some actors due to power asymmetry within the society, shall result in perfect inequality (equality at the bottom) and necessitate activating P1 policies – accessing or developing new resources. Personal conversion factors are fundamental in bridging the gap between resources and capabilities. The availability of resources without the appropriate capacity shall result in a competitive disadvantage. There is a necessity to activate P2 policies – sophisticating capacities relevant to new resources.

The second conversion factor (among resource and capability) is socio-environmental factors – i.e., institutions. Resources might be available, and necessary capacities may also be already developed. However, without appropriate institutions, all efforts may mismatch either with resources or capacities or with both. If this is the case, policies that fit into the P3 must be initiated – developing appropriate institutions for the targeted capability. The last situation might happen when the problem is related to agents' choice decisions who hold the capability, even when the resources are available and conversion factors are well matching. This case shall result in an under-utilized competitive advantage. The policymaker should address P4 to enable attitude change (changing the agents' social valuation to operationalize the targeted capability).

can access to Resource	have the necessary Capacity	there are appropriate Institutions	agents have Choice		4-P
no				<i>perfect inequality</i>	P1
yes	no			<i>competitive disadvantage</i>	P2
yes	yes	no		<i>institutional mismatch</i>	P3
yes	yes	yes	no	<i>under-utilized competitive advantage</i>	P4
yes	yes	yes	yes	<i>long-term competitive advantage</i>	✓

Figure 44: 4P Model Framework

Source: Author's illustration

As outlined above, the roles of government for qualitative change are twofold: (i) to define the direction of change and to channel the agents towards this direction, and (ii) to construct competitive assets that well fit with the new direction. Such roles are fundamental for building and sophisticating capabilities towards complexity and overcoming knowledge-based inequalities. Naturally, Ps can be linked with these two roles, and Figure 43 illustrates our understanding.

We consider that knowledge generation and capacity building are vital processes for constructing competitive assets. Policy instruments such as research funding, clustering and human resources constitute the primary interventions for competitive assets. Different institutions can affect either direction or competitive assets. For instance, while IPR measures align with forming competitive assets, standard settings are more linked with the direction setting. Finally, instruments for influencing the choice decisions of agents, such as technology plans and entrepreneurship supports, are merely changing the direction.

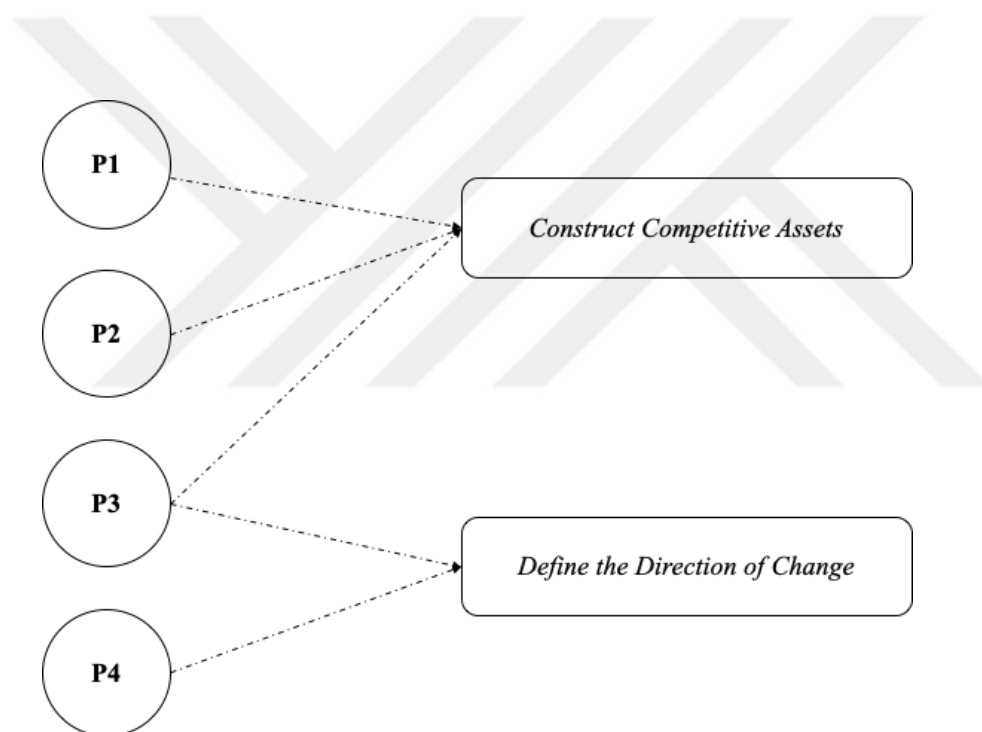


Figure 45: Four-Ps and the Roles of Government

Source: Author's illustration

4.5. Innovation Policy under Four-P Model

Diversification into related products allows a country to exploit its knowledge. In contrast, diversification into unrelated products would necessitate a nation to acquire new knowledge. A country that continues to develop only by diversifying into related activities runs a severe risk of running out of opportunities. It will become increasingly harder to find related activities to exploit, since they have already been explored in the past (Faber and Frenken, 2009). Therefore, a related diversification strategy should go hand in hand with an unrelated-diversification strategy (Frenken, 2016). Related and unrelated diversifications are labelled as opportunity spaces 1 and 2 under Figure 40 as a two-step diversification strategy. In the neoclassical framework underlying the market-failure arguments, the notion of knowledge is primarily one of codified knowledge. Indeed, if knowledge is codified, it can easily spill over to competing firms.

Writing this knowledge down into a legal document such as a patent would then be, in principle, an effective instrument to protect new knowledge. The system failure concept of the innovation system framework has a more subtle notion of knowledge. First, it is recognised that knowledge is distributed among many actors that may contribute critically to innovation processes. Second, it is also recognised that a lot of knowledge relevant to innovation is tacit and resides in people in the form of experience-based knowledge and organisations in the form of organisational capabilities. Hence, to combine tacit knowledge in people and organisations with other people and organisations, collaboration within and across organisations is critical and stable institutions such as laws, norms, and public policies to support such collaborations (Nelson and Winter, 2002). *"Knowledge on collecting, accessing, accumulating, combining, analysing, adding meaning and creating value over it"* is the challenge of modern societies (Cohen and Levinthal, 1990, p.128).

As history reveals, unequal access to value-generating resources (knowledge, talent, energy, land, etc.) has always been an essential source of inequalities (Tilly, 2007). The powerholders might control these resources and prevent others from exploiting them fully. Accordingly, this thesis defined economic development as a process during which a society overcome the barriers to access value-generating resources and utilise them to generate value. However, development is a continuous process. While overcoming the initial level of inequality, a society shall face a new level of inequality and barriers to access value-generating resources of this new level.

In different forms of embodiment, knowledge has always been subject to inequalities. Today, the key technologies have become so complicated that science intensity increases evenly. Hence, unequal access to scientific knowledge and unequal control over its production or distribution matter in the twenty-first-century world (Tilly, 2007). In this regard, innovation capability can be labelled as the fundamental complex capability to utilise knowledge as a value-generation resource.

Accordingly, innovation capability is classified as a collective and complex capability that individuals alone could not achieve without social interaction. While innovation capability is the freedom to overcome knowledge-based inequalities and provide the opportunity to catalyse agency by bringing qualitative change, learning is the real achievement with different sophistication levels with an appropriate level of capability. As defined before, in the capability space, resources and capacities are combined in a dynamic way to realise the functioning. In the innovation capability space, while knowledge and social capital are the primary resources, absorption is the main capacity.

One open question is 'how to define innovation policy for human development and capability approach'? Since the policy mechanism is related to the opportunity component of any given capability space, this question necessitates understanding the opportunity expansion mechanism in conjunction with the capability approach – which will be addressed in the following part.

Among others, the opportunity mechanism is an essential contribution of the capability approach associated with the theory of institutions. There is a robust institutional dimension within the capability approach; since capabilities depend on institutions to build, sustain and improve capabilities, institutional change processes are required. The matching and mismatching between capabilities and institutions (Cimoli et al., 2009b) have a decisive effect on realising the valued functionings.

The human development perspective pays attention to the context-sensitivity of institutions and path dependency of its change process. We claimed that this approach aligns with Gerschenkronian institutional diversification strategy for development. Such diversification – policy actions – should be designed and evaluated as defined in Table 9.

Table 9. Dimensions of Institutional Diversification

1	Whether the value-generating resources are provided.
2	That capacity (the personal conversion factor) is well sophisticated to benefit from newly provided resources.
3	socio-environmental factors pave the way to capability enhancement
4	the social valuation (choice) of the politically targeted functioning by the change agent is positive

Recalling that the ultimate aim of this thesis is to define innovation policy for the capability approach, we claimed that innovation systems are an appropriate policy tool to design and evaluate innovation policy. In the countries where the innovation-driven economy has emerged, the innovation system is an ex-post concept. It is an ex-ante concept in the rest of the world (Arocena and Sutz, 2012).

Accordingly, an emerging consensus among scholars is the need for inclusive innovation systems: relating and re-inventing research and innovation practices so that it helps to reduce inequalities rather than reproducing them (Cozzens, 2008).

The value of well-functioning innovation systems is that they may increase learning through interactions and sharing. Hence, local knowledge flows are crucial in an innovation system as they strengthen the local knowledge base and the local actors' absorptive capacity.

However, the emphasis has also more recently been placed on the role of global knowledge flows in bringing new ideas to local innovation systems – providing new opportunities for knowledge generated abroad to be exploited locally – and thereby avoiding typical systems failures such as learning failures (Foray, 2010). Therefore, in a time of globalisation, local innovation systems should not be insulated from global knowledge sources.

Developing countries' local interactions cannot be limited to the national knowledge ecology (Foray, 2010) since it is generally incomplete. For that reason, such systems are labelled as "Disarticulated Knowledge Systems: ...with bits and pieces of the knowledge system operating as isolated islands with little or no connection to the rest of the economy" (Soete, 2009a).

In today's open and networked systems paradigm, transforming unarticulated knowledge systems into effective innovation systems also necessitates benefiting from global knowledge flows (interaction with scientific and technological activities in other countries) through deliberate policies through appropriate institutions (Lundvall and Borrás, 1998).

The extent to which countries can profit from such global knowledge flows depends on the absorptive capacities and the available linkages (Szirmai, 2008, p.19): *“The evolutionary theory postulates a race between (1) technological change and domestic spillovers in the lead countries resulting in divergence and (2) international diffusion of knowledge to follower countries resulting in catch up. The balance of these two forces depends on the size of the technology gap –when the gap is more extensive than some threshold level, the disadvantages of backwardness outweigh the potential advantages and depend on differences in absorptive capacities between developing countries”*.

While rapid technological change leads to increased global inequalities, the Gerschenkronian advantages of backwardness may allow a developing country to profit from spillovers if backed by willingness (choice), readiness by deliberate policies (opportunities) and finally, appropriate skills (absorptive capacity). Hence, carefully constructing international research collaborations to address local constraints offers equitable development possibilities (Kraemer-Mbula and Wamae, 2010).

Resource-based inequalities are diversifying based on the level of development. While accessing food or water might be the reason for inequalities for some, for others, private property owners might be the source of inequalities. Today, access to new knowledge – the value-generating resource of our time – is limited due to the limitations of international regulations and the nature of knowledge itself.

As the knowledge divide expands, the inequality between the rich and the poor is also rising. Previously, we have pointed out that innovation capability is the fundamental freedom to overcome knowledge-based inequalities. However, as a complex capability by nature, the necessary set of policies on innovation – innovation policy as a whole – is also highly problematic. Figure 44 illustrates the innovation policy framework based on the Four-P Model as a starting point.

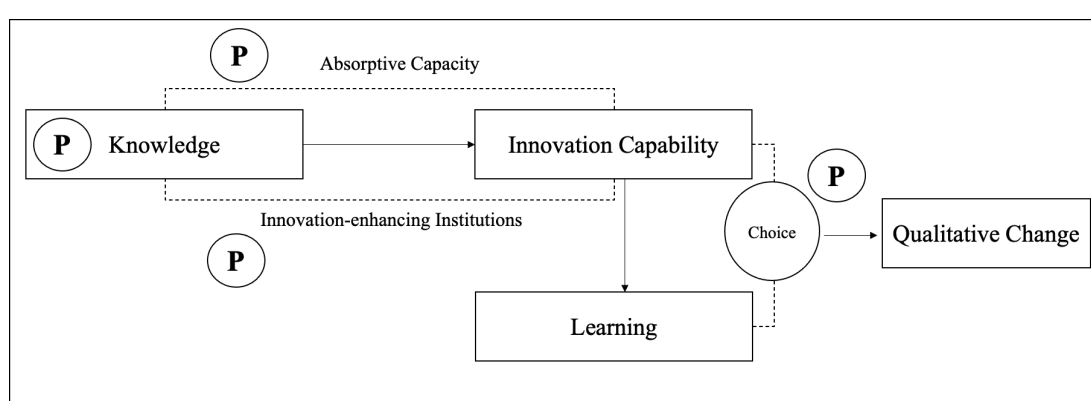


Figure 46: Innovation Policy Framework

Source: Author's illustration

Note: 'P' refers for the policy

In developing countries, policymakers' challenge is to kick-start the productive industries and increase their complexity. In that regard, (Freire, 2017) lists two approaches: the neoliberal and the structuralist approaches. The neoliberal approach advocates integration in the global economy and resource allocation by free markets. In contrast, the structuralist approach advocates government interventions with selective policies that support particular activities, firms or technologies. The latter's primary instrument is innovation policy, which is usually associated with targeted government interventions that foster specific sectors to accelerate structural transformation (Chang, 2011; Freire, 2017; Shapiro, 2007).

Innovation policy is an essential component of economic policy almost for all countries. By stimulating innovative activities, governments hope to enhance prosperity. Predominantly there are two main innovation policy approaches, namely market-failure and system-failure. For the market-failure approach, innovation is a knowledge production activity that transforms knowledge into new products and production processes. Accordingly, failure happens when firms generally under-invest in R and D (Arrow, 1972). However, in the systems approach, failures may refer to low-performing components or underdeveloped linkages (Woolthuis et al., 2005).

(UNCTAD, 2010) recalled a more proactive approach for developing countries to build relevant capabilities that would require the state to play a more developmental role, such as:

- macroeconomic policies oriented to promote growth, investment, and employment,
- a developmental innovation policy aligned with industrial policy,
- a strategic trade policy that supports economic complexity, and
- an active approach to entrepreneurship to catalyse agency.

According to the capability approach, any policy design or evaluation attempt shall define the policy's objective, the desired functioning, and underlying capabilities, and ensure agency. With this regard, innovation policy is expected to ensure agents bring qualitative change to their lives by catalysing innovative capability and achieving more sophisticated learning.

Furthermore, institutional diversification should sustain 'change agents' exposure to new knowledge with enhanced social capital. Simultaneously ensure the expansion of conversion factors with the latest resources and their transformation processes. However, the interactions of the components are a critical challenge. (OECD, 2010) claimed that a systemic approach to innovation is an important policy tool to understand the components above, their interactions and co-evolvments.

The idea that innovation occurs within a system reflects the recognition that structural, institutional, and social factors shape knowledge conversion into value. Accordingly, (Lundvall et al., 2009, p.9) defined innovation systems as: "... an open, evolving and complex system that encompasses relationships within and between organisations, institutions and socioeconomic structures that determine the rate and direction of technological change". Therefore, innovation capability should be built and upgraded to influence both the rate and direction of technological change.

In general, technology transfer is the leading prescription for developing countries to rapidly increase technological change rate since they have been treated as "simply non-innovating economies" (World Bank, 2008a). They can – and should – meet almost all their technological needs by choosing (and then adopting) from external sources. The implicit assumption is that "technology imports inherently and automatically carry with them associated flows of knowledge, skills and experience that effortlessly spillovers into the local context" (Bell, 2009). (Soete, 2009b) called this routine the old mode of technological progress: "Since the 1950s, there has been a strong focus on industrial, large-scale, science-based and professionalised R and D in support of economic growth. Inside R and D facilities, knowledge creation, engineering and design took place, outside of these labs, production, and consumption.

Quite naturally, this mode emphasises the importance of technology transfer and imitation" (Soete, 2009a, p.33). Hence, it seems widely accepted that development processes need substantially more than importing knowledge and technology; developing countries must have their own scientific and technological capabilities (Bell, 2009).

However, in the new model, innovation is anything but imitation (Fu and Soete, 2010). Every innovation is unique for its application –even be re-usage or a new combination of old or new pieces of knowledge – because social, cultural and institutional dimensions (Oosterlaken, 2008) play a role in the process. In a similar vein, evolutionary economics theory highlighted that efficient imitation requires the same type of capabilities to innovate (Nelson and Winter, 2002).

Hence, this highlights the importance of local capabilities to enhance the rate of technological change. Although the rate is quite naturally crucial in development, the direction phenomenon is generally neglected. While the developed world has been performing innovative activities, which generated a stock of technology, there are still several technical challenges resulting from the lack of innovative solutions in the developing world.

That means the available technology stock does not automatically guarantee the appropriation for the developing world's needs. (Stewart, 1972) considered this as western-originated complexity. He elaborated that "*... in order to respond to the demands of high income and largely urban consumers, suppliers have developed products with advanced technological features that exceeded the functional needs of the majority*" (Stewart, 1972, p.99).

Thus, developing countries should not be simply the users of the ready-made technologies but should also be the adopters, improvers and creators of the technologies needed in their developments (Bell, 2009). Throughout the catching-up process, technological learning involves many imitations and reverse engineering (Cimoli et al., 2009a). However, historically, such imitative activities have occurred under lax conditions regarding the international enforcement of IPR regimes.

Things have changed dramatically with the strict enforcement of the TRIPS Agreement, which has also acted as an inequality enhancement mechanism for underdeveloped countries in their catching-up process. It is vital to ensure some flexibility (policy space) for those countries to develop their economies further.

Therefore, it is vital to build and continuously sophisticate the innovation capability for substantial engagement in the technological change process. This could only be materialised by tapping into already existing local sources of tacit knowledge and context-sensitive adaptation throughout the process of innovation (Arond et al., 2010). Since the intrinsic value lies in the enhanced agency, such appropriation of indigenous knowledge and context-sensitive adaptation will allow people to use new science and technology developments to engage in social, economic, and political life.

Otherwise, the agents' freedom is delimited to be and to do and to introduce qualitative change to their own lives (Hartmann, 2012). Accordingly, there is an emerging consensus among scholars on the need for inclusive innovation systems, relating and re-inventing research and innovation practices to help reduce inequalities rather than reproducing them (Cozzens, 2008).

4.6. Research Methodology and Data

Our particular focus is on innovation, which is a complex capability. As our Four-P Model postulates, there are four main policy domains for each capability and understanding the inner mechanisms are essential to design and evaluate innovation policies. We shall apply some machine learning techniques at country-level data to compare innovation capability components of various countries. We will follow a two-step procedure for this section, defined below.

Step 1. As we discussed in detail in Section 4.2, the components of innovation capability space are as follows: knowledge, absorptive capacity, institutions, and choice for innovation. In this step, we aim to compare innovation capability components' impact on economic complexity at the country level—we group countries into three clusters that we identified in Chapter 3. The data is from Global Innovation Index indicators published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO). We perform the Random Forest technique to understand which components of the Four-P model are more important in explaining the variation of ECI scores for each cluster. The data descriptions are provided in Table 11. Our dependent variable is, once more, Economic Complexity Index.

Table 10. Data Source for Innovation Capability

Four-P Model Component	Indexes and Sub-indicators
Resource	<i>Knowledge Creation</i> *Patent applications by origins *PCT international applications by origin *Utility model application by origin *Scientific and technical publications *Citable Documents H-index
Capacity	<i>Knowledge Absorption</i> *Intellectual Property Payments *High-tech imports *ICT imports *FDI, net inflows *Research Talent
Institutions	<i>Institutions</i> *Political Environment *Regulatory Environment *Business Environment
Choice	<i>Knowledge Impact</i> *New Business Density *Gross Expenditure on R and D *Venture Capital Deals *Innovation Linkages

Source: <https://www.globalinnovationindex.org/analysis-indicator>

Step 2. In Sections 4.4 and 4.5, we have framed a policy design and evaluation tool within the scope of Capability Approach – labelled as Four-P Model, and then adapted it to innovation policy. Then we have applied machine learning algorithms to identify the relative impact of independent variables (components of the Four-P Model) on the dependent variable (Economic Complexity Index) and segment it according to our identified country clusters in Chapter 3. After that, we performed a case study for Turkey as a sensitivity analysis of the research outcome of Step 1. The case study is a descriptive innovation policy analysis applied to Turkey and its innovation policy change pattern. The descriptive analysis methodology is illustrated in Figure 45.



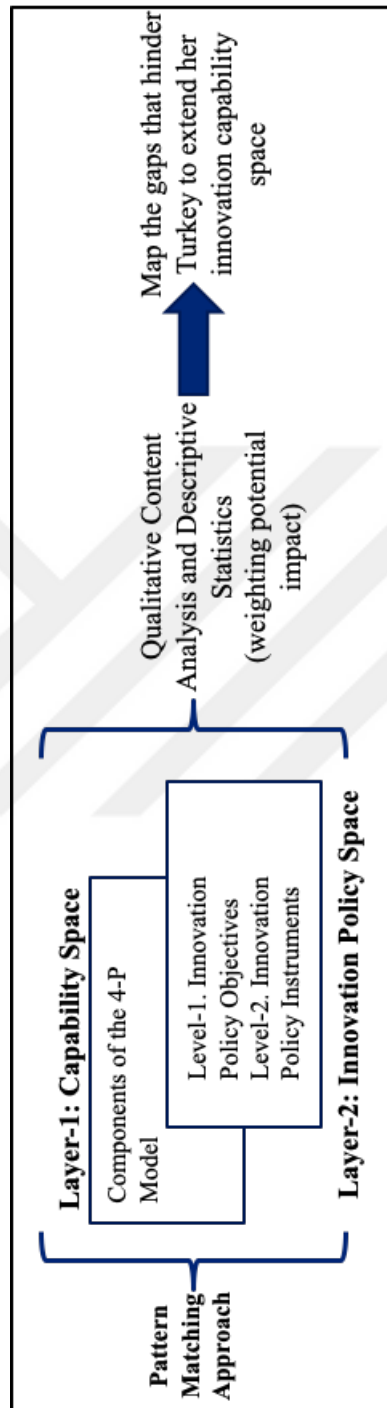


Figure 47. Descriptive Innovation Policy Analysis
Source: Author's illustration

In brief, we aim to develop a pattern matching algorithm among the innovation policy space (Layer-2 in Figure 45) and the capability space (Layer-1 in Figure 45). We can link each policy instrument of innovation policy space with one component of the Four-P model. In this way, we can define innovation policy instruments concerning the capability approach policy terminology. One instrument might have multiple objectives; however, for the sake of this study, the main objective is linked to a single P within the Four-P Model. Domain experts (described in Table 13) match two main layers within our methodology: the Capability Space and Innovation Policy Space, listed in Table 12. The Capability Space Layer is taken from our previous discussions.

Table 11. Innovation Capability Space Layers

Capability Space	Components of the 4-P Model
Resource	P1: Accessing and developing new knowledge
Capacity	P2: Sophisticating absorptive capacity
Institutions	P3: Developing appropriate institutions for innovation capability
Choice	P4: Enabling social valuation of agents, i.e., attitude change

Source: Author's illustration

Simultaneously, the Innovation Policy Space is defined as a hybrid version of the OECD's and European Commission's (EC) policy surveys to identify a set of policy objectives and instruments (see Table 13). There are 6 main policy objectives (level 1), and each has various types of instruments. In total, we consolidate such instruments under 24 headings (level 2). In this study, all policy instruments are given equal weight at this stage since limited research exists in the intersection of the capability approach and innovation policy, which should be considered as a limitation of the research. Therefore, we assume that all policies deserve equal weighting appears to be the most appropriate approach at this early stage.

Table 12. Innovation Policy Layers

Innovation Policy Objectives (Level 1)	Innovation Policy Instruments (Level 2)
1. Policies for good governance	1.1. National STI plan or strategy
	1.2. Sector and technology specific plans
	1.3. Horizontal policy coordination
	1.4. Evaluation and impact assessment
2. Policies to support investment in research and technologies	2.1. Competitive research funding
	2.2. Exploratory and high-risk research
	2.3. R and D infrastructure
	2.4. Centres of excellence
	2.5. IPR measures
3. Policies to enhance innovation in firms and to support innovative entrepreneurship	3.1. Financial support to business R&D
	3.2. Knowledge-intensive FDI
	3.3. Incubators and accelerators
	3.4. Support to venture capital
	3.5. Tax incentives
	3.6. Entrepreneurship culture
4. Policies to strengthen linkages within innovation systems	4.1. Collaborative research programmes
	4.2. Clustering and networking
	4.3. Intersectoral mobility
	4.4. Commercialisation of public research results
	4.5. Science and technology parks
5. Policies for enhancing skills for innovation	5.1. Support to human resources for R&D
	5.2. Innovation related skills education
6. Policies on demand for innovation	6.1. Public procurement
	6.2. Standards

Source: Adopted from (OECD, 2019)

We need a proper pattern matching algorithm among layer-1 (capability space) and layer-2 (innovation policy space) for the descriptive innovation policy analysis. To do so, we have approached domain experts through an online survey named expert opinion survey. We had identified 41 experts, and all of them have responded fully. All experts all pre-informed on the process and the aim of the exercise. Among 41 experts, 18 are female (~44%). 12% are in academia, 44% are in the public sector and the rest are in the private sector. The experts are selected based on their familiarity with the innovation policy instruments, either as a current/former innovation policy related instruments' executer or the current/former beneficiary of such instruments. The average familiarity score⁷ is 78 over 100. This score is subjective, defined by the experts personally, but gives us confidence since none awarded low points. Table 14 represents the distribution of experts' expertise, demonstrating the broad coverage of the main domains of innovation policy.

Table 13. Expertise Category of Experts

Expertise Category	# of Experts
Entrepreneurship	8
Clustering	7
Innovation Policy	6
Technology Transfer	6
Technology Management	5
R&D	4
Venture Capital	5
Total	41

Source: Author's illustration

Experts are enquired to match each of the 24 innovation policy instruments (Level-2 of the Innovation Policy Space) with only one component of the Four-P model (Capability Space). The survey template is provided in Annex (section 7.4.).

⁷ During the digital survey, experts were asked to define their familiarity with the innovation policy tools – through a scale of 0 to 100.

For most of the matches, we have few indecisions, and in case of ties, we have given the final decisions. Pattern matching results for level-2 and level-1 of innovation policy space are provided in Tables 15 and 16. In aggregation, P1 (Resource) and P3 (Institutions) matches with seven instruments, while P2 (Capacity) and P4 (Choice) matches with five instruments. For the government role, previously, we have identified two leading roles as defining the direction of change and constructing competitive assets. In addition to the above analysis, we further match the Innovation Policy Instruments at level-2 with the two government roles to evaluate the government's main concentrations over time in Table 17.

Table 14. Pattern Matching (Level-2)

Level-2 Classification / Four-P Model	P1	P2	P3	P4
1.1. National STI plan or strategy				
1.2. Sector and technology specific plans				
1.3. Horizontal policy coordination				
1.4. Evaluation and impact assessment				
2.1. Competitive research funding				
2.2. Exploratory and high-risk research				
2.3. R&D infrastructure				
2.4. Centres of excellence				
2.5. IPR measures				
3.1. Financial support to business R&D				
3.2. Knowledge-intensive FDI				
3.3. Incubators and accelerators				
3.4. Support to venture capital				
3.5. Tax incentives				
3.6. Entrepreneurship culture				
4.1. Collaborative research programmes				
4.2. Clustering and networking				
4.3. Intersectoral mobility				
4.4. Commercialisation of public research results				
4.5. Science and technology parks				
5.1. Support to human resources for R and D				
5.2. Innovation related skills education				
6.1. Public procurement				
6.2. Standards				

Source: Experts Matching

Table 15. Pattern Matching (Level-1)

Level-1 Classification / Four-P Model	P1	P2	P3	P4
1. Policies for good governance	-	-	3	1
2. Policies to support investment in research and technologies	4	-	1	-
3. Policies to enhance innovation in firms and to support innovative entrepreneurship	2	-	1	3
4. Policies to strengthen linkages within innovation systems	1	3	1	-
5. Policies for enhancing skills for innovation	-	2	-	-
6. Policies on demand for innovation	-	-	1	1
Total	7	5	7	5

Source: Aggregation of Table 15

Table 16. Policy Instruments vs. Roles of Government

Level-2 Classification	Roles of Government
1.1.	Direction
1.2.	Direction
1.3.	Direction
1.4.	Direction
2.1.	Competitive Assets
2.2.	Competitive Assets
2.3.	Competitive Assets
2.4.	Competitive Assets
2.5.	Competitive Assets
3.1.	Competitive Assets
3.2.	Competitive Assets
3.3.	Direction
3.4.	Direction
3.5.	Competitive Assets
3.6.	Direction
4.1.	Competitive Assets
4.2.	Competitive Assets
4.3.	Competitive Assets
4.4.	Competitive Assets

Table (Cont.)	
Level-2 Classification	Roles of Government
4.5.	Competitive Assets
5.1.	Competitive Assets
5.2.	Competitive Assets
6.1.	Direction
6.2.	Direction

Source: Experts Matching

The data source for Step 2 [identifying the relative impact of independent variables (components of the Four-P Model) on the dependent variable (Economic Complexity Index)] is gathered from the Supreme Council for Science and Technology (SCST)⁸ reports published on the website of the Scientific and Technological Research Council of Turkey (TUBITAK). SCST was the highest-ranking STI policy-making body in Turkey chaired by the Prime Minister with the national STI policy's decision-making power. Per meeting, over 40 institutions had participated and provided their inputs (statistics, policy-level developments since the previous meeting and future targets). The comprehensive reports (generally over 250 pages) of each meeting delivered valuable historical insight on policy-level developments and allowed content analysis. For each meeting, we have identified policy instruments from the reports. Specific attention is given to future actions since a decision may not turn into policy action and stay as a declaration of will. So, cross-checking among the meeting reports is necessary for us during the content analysis. For instance, a decision was given during meeting x. However, such a decision has never transformed into action, and such inertia could only be captured from the next meetings. After identifying innovation policy instruments (which were actually implemented), each instrument was matched with the Four-P model component according to a matching algorithm that experts collectively constructed. The following section provides our analyses' quantitative and qualitative results of Step 1 and Step 2.

⁸ SCST was operational between 1989 till 2016, after which a new body was formed.

4.7. Research Results

Step 1. At this step, we perform the random forest (RF) technique, which is a popular tool of Machine Learning (ML) for identifying the importance of independent variables (for innovation capability, they are knowledge, absorptive capacity, institutions, and choice) on the dependent variable (in this empirical assessment it is Economic Complexity Index). The dataset source for independent variables was provided in Table 10, while the independent variable data is identical to Chapter 3. We prefer to use the three clusters identified in the previous chapter. R programming language is chosen for running ML algorithms. The initial results of RFs for each cluster are given in Table 18.

With the help of Table 18, we can identify the important independent variables for each cluster. There are two leading output indicators of the RF technique. Mean Decrease Accuracy (%IncMSE) shows how much our model accuracy decreases if we leave out that variable; and Mean Decrease Gini (IncNodePurity), which is a measure of variable importance based on the Gini impurity index used for calculating the splits in trees⁹. The higher the values of both indicators, the higher the importance of the variable to our model. As a rule of thumb, machine learning practitioners prefer to select independent variables with a double-digit number for any output indicators (either %IncMSE or IncNodePurity). To remind, we have identified Cluster 3 as developed, Cluster 1 as developing and Cluster 2 as catching-up economies in Chapter 3.

⁹ <https://www.rdocumentation.org/packages/randomForest/versions/4.6-14/topics/randomForest>

Table 17. Four-P Model and Random Forest Results

Four-P Model Components	Cluster 3		Cluster 1		Cluster 2	
	%Inc MSE	Inc Node Purity	%Inc MSE	Inc Node Purity	%Inc MSE	Inc Node Purity
Knowledge	20.76	3.87	9.93	2.12	16.89	8.36
Capacity	9.99	2.64	14.76	2.33	6.85	5.53
Institutions	7.33	1.49	16.11	2.12	43.59	15.51
Choice	-4.59	2.10	18.76	3.77	5.33	4.88

Source: R Output

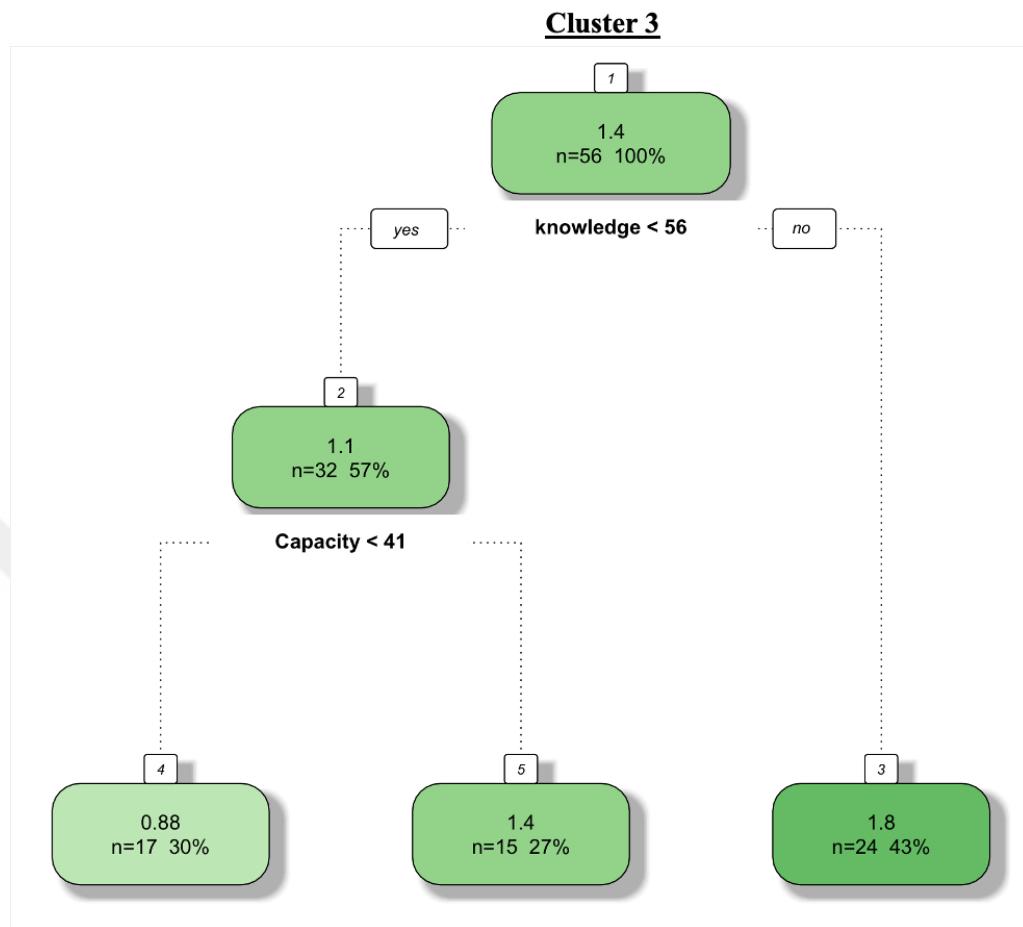


Figure 48. Decision Tree Analysis of 3 Cluster (1)

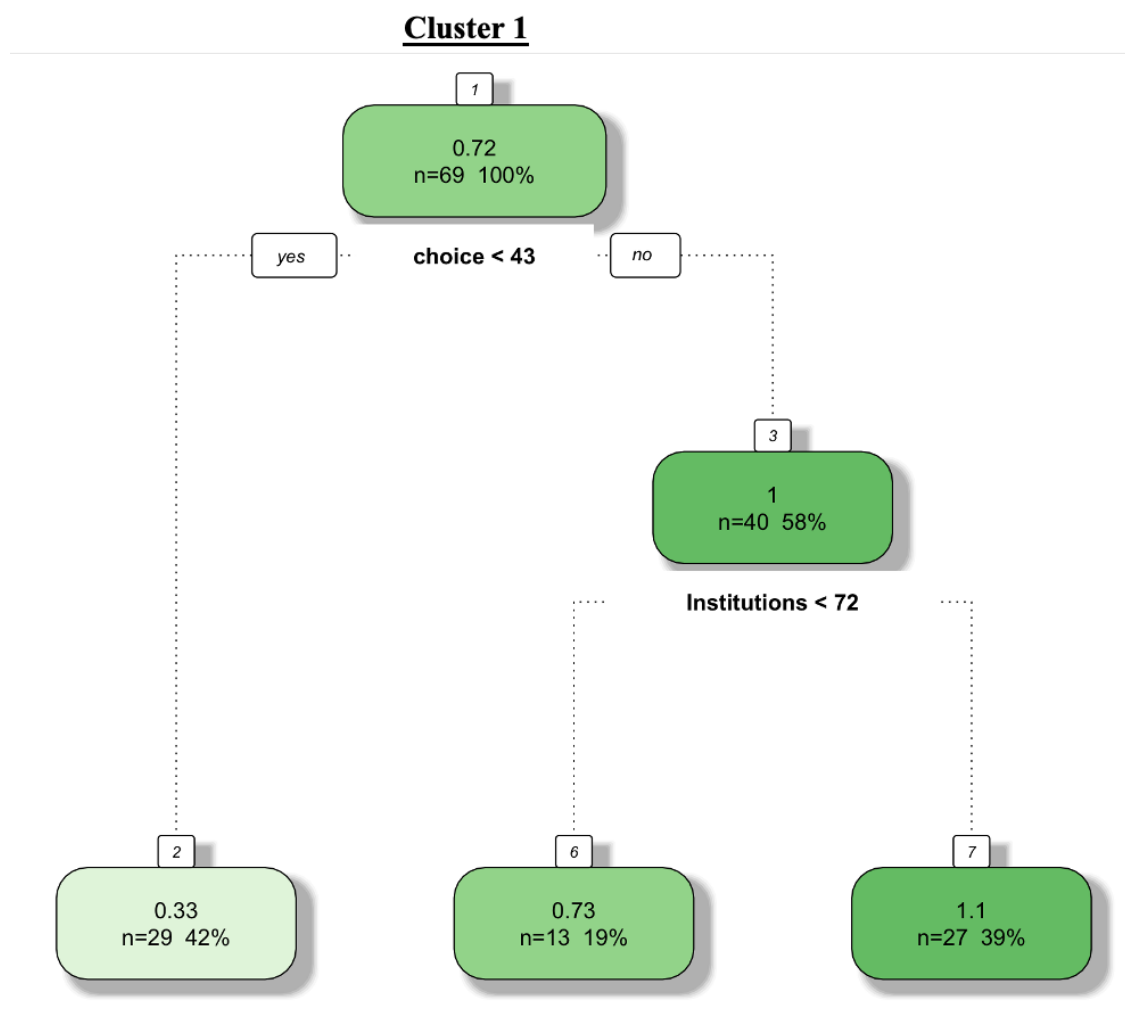


Figure 49. Decision Tree Analysis of 3 Cluster (2)

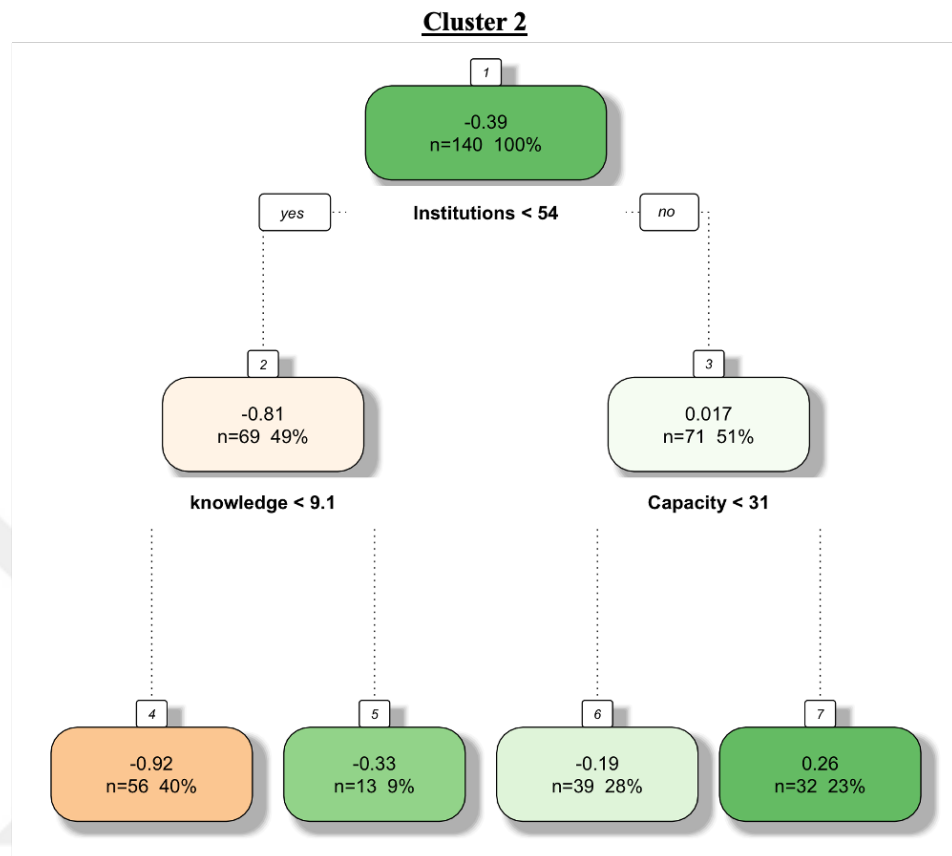


Figure 46 provides the insight that for the most developed economies (Cluster 3), the critical variable of importance is Knowledge. Countries in this group have set their institutional infrastructure, strengthened their capacities. A consensus within the society that innovation is vital for prosperity (UNCTAD, 2010); hence the Choice is not a policy concern. Therefore, policy intervention should concentrate on accessing state-of-the-art Knowledge to sustain welfare and catalyse its transformation to innovations.

Catching up economies (Cluster 1) are generally able to adapt good institutions of developed economies, enhancing their absorptive capacity to benefit from global circulation of Knowledge and influence their change agents' choice decisions towards innovation. Table 17 and Figure 46 jointly revealed that all these three components of our Four-P Model are essential variables.

Finally, the developing economies (Cluster 2) generally have systemic failures that need good governance and institutions' improvements are indispensable concerns. Accordingly, we have witnessed that institutions have a dominant score in our analysis of variable importance.

Step 2. At this step, we apply the iterative methodology built upon the Four-P Model and described in the previous chapter. We have identified 250 individual policy instruments for over 27 years for Turkey between 1989-2016. A key observation is that the number of instruments had significantly increased when a new President was appointed to TUBITAK. As shown in Figure 47 (arrows represent the years of appointments), the numbers of instruments have been significantly increased during the SCST meeting following such changes.

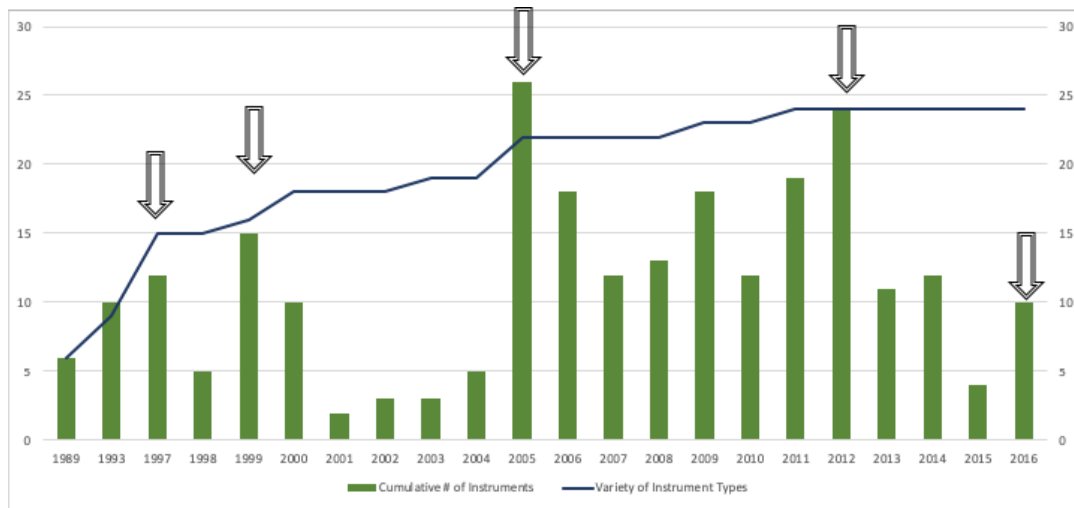


Figure 51. Innovation Policy Instruments per year

Source: Author's illustration

Note: The arrows represent the appointment years of new Presidents of TUBITAK

The top instruments heavily used in Turkey's national innovation system are outlined in Figure 48. Strategic initiatives (both at the national and sectoral level), infrastructure building, and human resource development are the main concentrations of the Turkish Innovation System. We have observed that the dominant position of the national STI plan and strategies category (1.1.) has been replaced by sector and technology-specific plans (1.2.) since 2005.

Further on, after 2006, significant emphasis is given to centres of excellence (2.4.) and R and D Infrastructures (2.3.) which might be seen as an outcome of the sectoral and technological perspective that we have underlined.

Support for human resources for R and D (5.1.) was a key concentration topic, especially between 2004 till 2010, but then no new specific instruments have been implemented in this area. In line with the increased number of instruments over time, horizontal coordination (1.3.) has emerged as a need, and various bodies established. Research funding instruments for academia and business (2.1. and 3.1.) have gradually flourished over time.

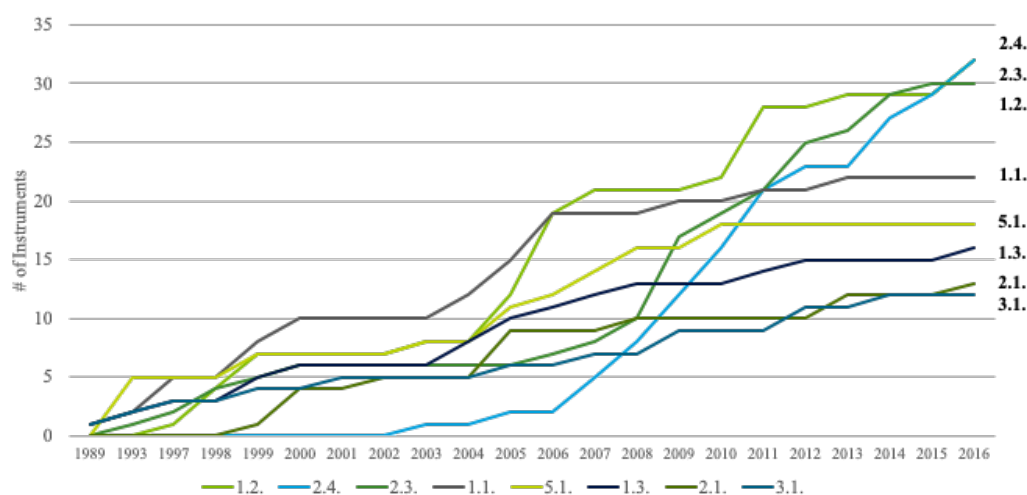


Figure 52. Top Innovation Policy Instruments

Note. At Level-2 and Cumulative

Source: Author's illustration

We also observe various changes over time for the remaining innovation policy instruments, as illustrated in Figure 49. Four instrument categories have not been on the political agenda before 2005: Entrepreneurial activities (3.6.) on innovation, skills development for innovation (5.2.), commercialisation of public research (4.4.) and incubators and accelerators (3.3.). The decision-makers have not shown interest in two instruments: intersectoral mobility (4.3.) and standards (6.2.). Regarding the category of clustering and networking (4.2.), we have observed that clustering policies dominated over the late 1990s and early 2000s, while late 2000s, such interest has shifted into networking. In line with the increase in the number of instruments for financial support to business R and D (3.1.), the number of instruments on tax incentives (3.5.) has also been diverse.

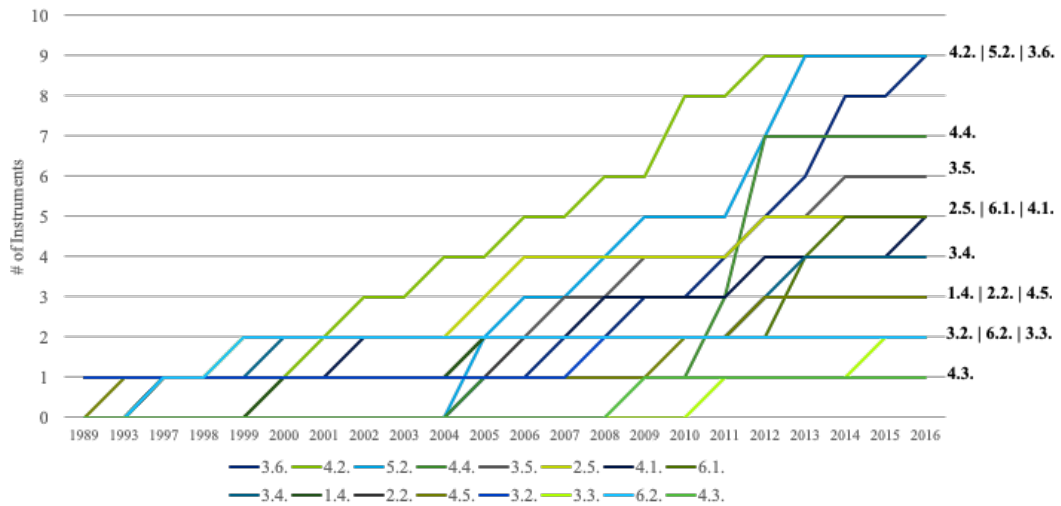


Figure 53. Other Innovation Policy Instruments

Note. At Level-2 and Cumulative

Source: Author's illustration

A similar analysis on level-1 of innovation policy instruments classification is illustrated in Figure 50. At Level-1, two categories of innovation policy objectives have dominated the national innovation policy activities, namely '2. Policies to Support Investment in Research and Technologies' and '1. Policies for good Governance'. It is not really a surprise since directing investments toward innovation and defining such direction is critical for emerging economies. However, limited attention on the demand side of innovation and linkages within the system prevents such investments' value generation potential.

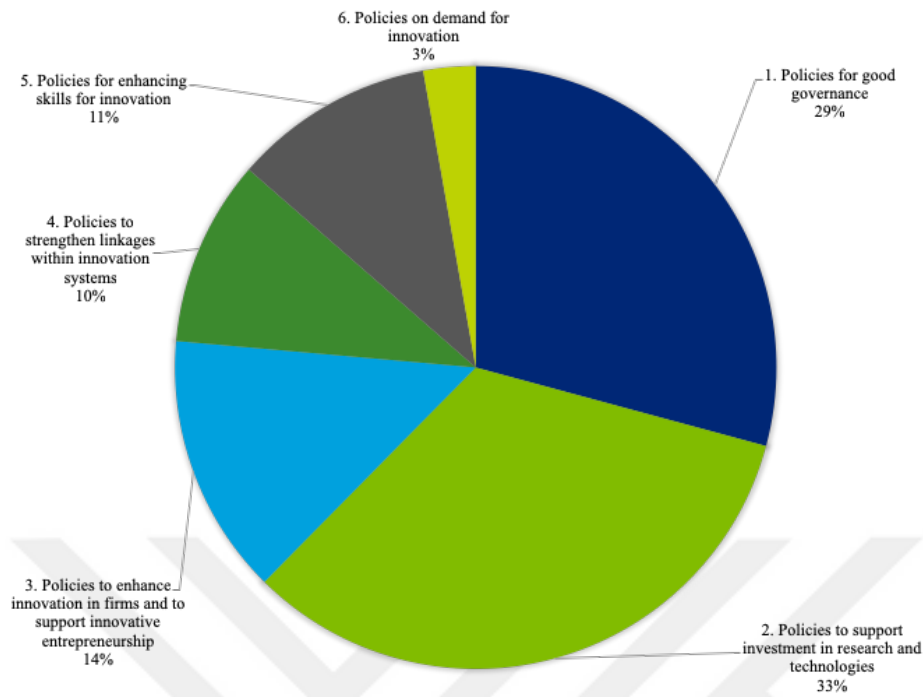


Figure 54. Innovation Policy Instruments at Level-1

Source: Author's illustration

Based on the pattern matching algorithm, the cumulative distribution of 4P over time is shown in Figure 51. Historically, until 2006, P3 (developing appropriate institutions for innovation capability) has dominated Turkey's national innovation system's political agenda. Both physical infrastructure and institutional infrastructure were seen as critical components of the system. After 2005, however, strict attention has been given to P1 (accessing and developing new knowledge) to respond to the increasing role of knowledge as a resource to overcome knowledge-based inequalities. From 2005 to 2012, P1 and P2 (sophisticating absorptive capacity) run together to enhance exploitation and knowledge exploration. P2 has also been a critical choice to benefit from global knowledge spillovers. P4 (Social valuation of society to operationalize innovation capability, i.e., attitude change) has been a significant policy choice after 2004.

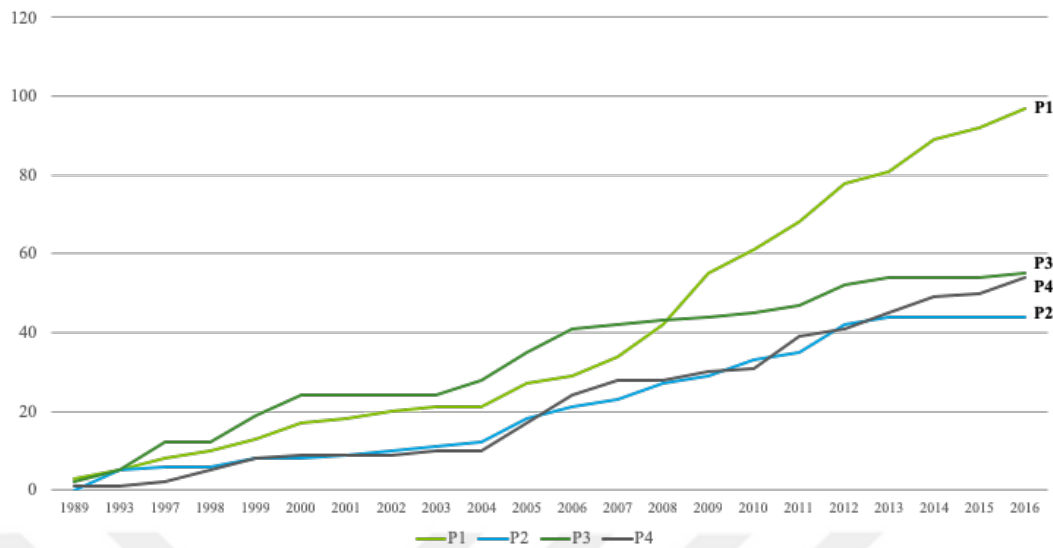


Figure 55. Cumulative Distribution of 4Ps
Source: Author's illustration

At this stage, we prefer to dig into further details for each P and its distribution at level-2 innovation policy instruments. Regarding P1 (accessing and developing new knowledge) in Figures 52 and 53, the main routes the decision-makers have chosen are 2.4. (Centres of excellence) and 2.3. (R and D infrastructure), both are CAPEX (Capital Expenditures) heavy instruments. Additionally, research project-based instruments have been flourishing by numbers under the categories of 2.1. (Competitive research funding), 3.1. (Financial support to business R and D), 4.1. (Collaborative research programmes) and 2.2. (Exploratory and high-risk research). We can observe that the importance of knowledge generation through collaborations were underestimated while the tendency has been towards single actor instruments. Further on, even 3.2. (Knowledge-intensive FDI) has been a fundamental innovation policy instrument category for many emerging economies; Turkish decision-makers have not paid specific attention to this over the last 30 years. The dominant position of CAPEX intensive P1 instruments observed decade-level distribution.

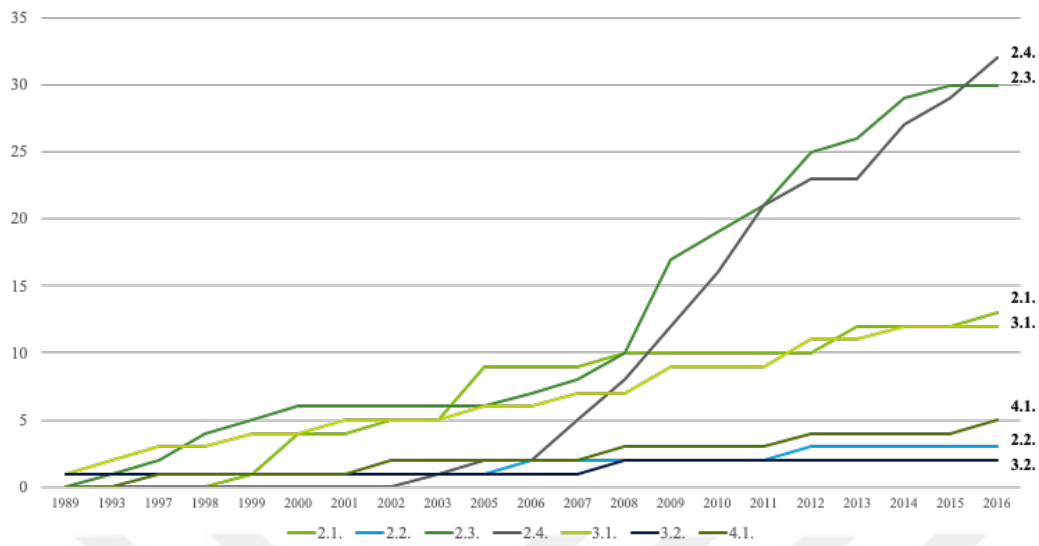


Figure 56. Cumulative Distribution of P1 Category
Source: Author's illustration

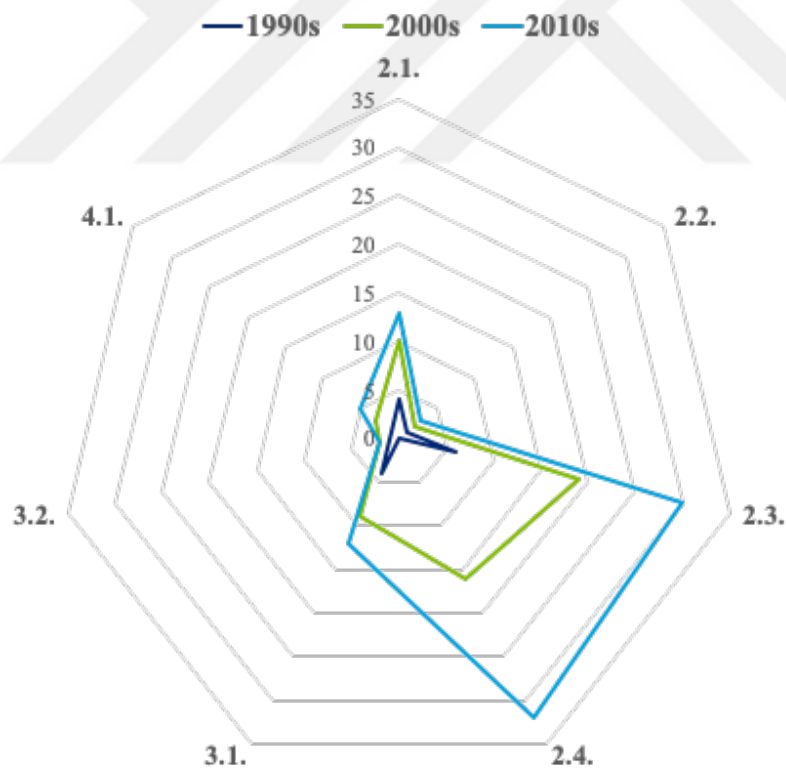


Figure 57. Change in P1 Category
Source: Author's illustration

Regarding P2 (Sophisticating absorptive capacity) in Figures 54 and 55, one eye-catching fact is the dominant position of innovation instrument 5.1. (Support to human resources for R and D). This is not a surprise since human capital is the main route to benefit from knowledge spillovers. However, we were surprised to observe that while the number of activities under 5.1. has flourished in the 2000s, no new program has been implemented since 2010. Instrument group of 4.2. (Clustering and networking) have always been on the agenda, and several programs have been implemented over time. Innovation related skills education (5.2.) was not a key concentration area before 2004. Since then, however, various programs have been initiated. The commercialisation of public research results (4.4.) entered the policy agenda in the 2000s, with a significant boost after 2010. This might be a natural outcome of expectations regarding enhanced activities regarding P1. Hence, policymakers might expect to cultivate the investments under P1 through 4.4. type of instruments. Surprisingly Intersectoral mobility¹⁰ (4.3.) has never been a critical concentration of Turkey's innovation policy system.

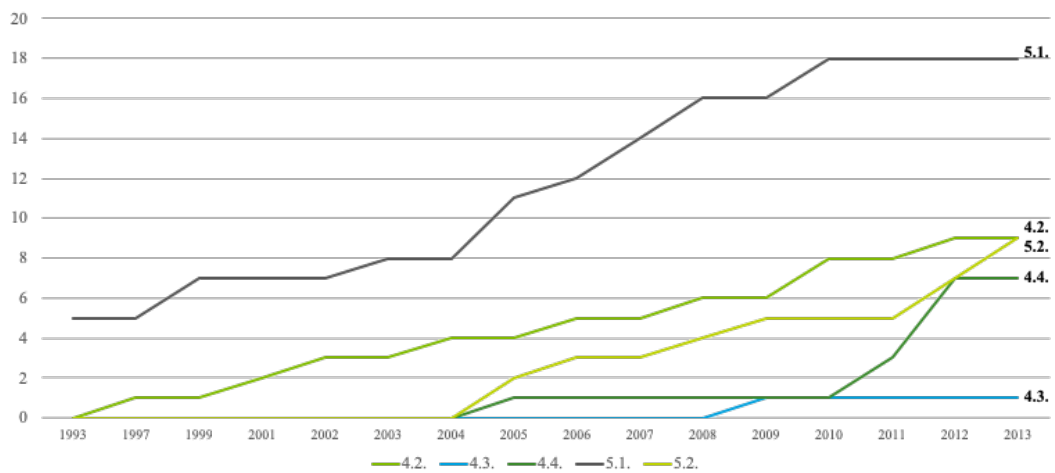


Figure 58: Cumulative Distribution of P2 Category

Source: Author's illustration

¹⁰ Refers to all possible bridges that can be built between university, industry and other sectors of employment.

Source: https://cdn1.euraxess.org/sites/default/files/policy_library/report-intersectoral-mobility.pdf

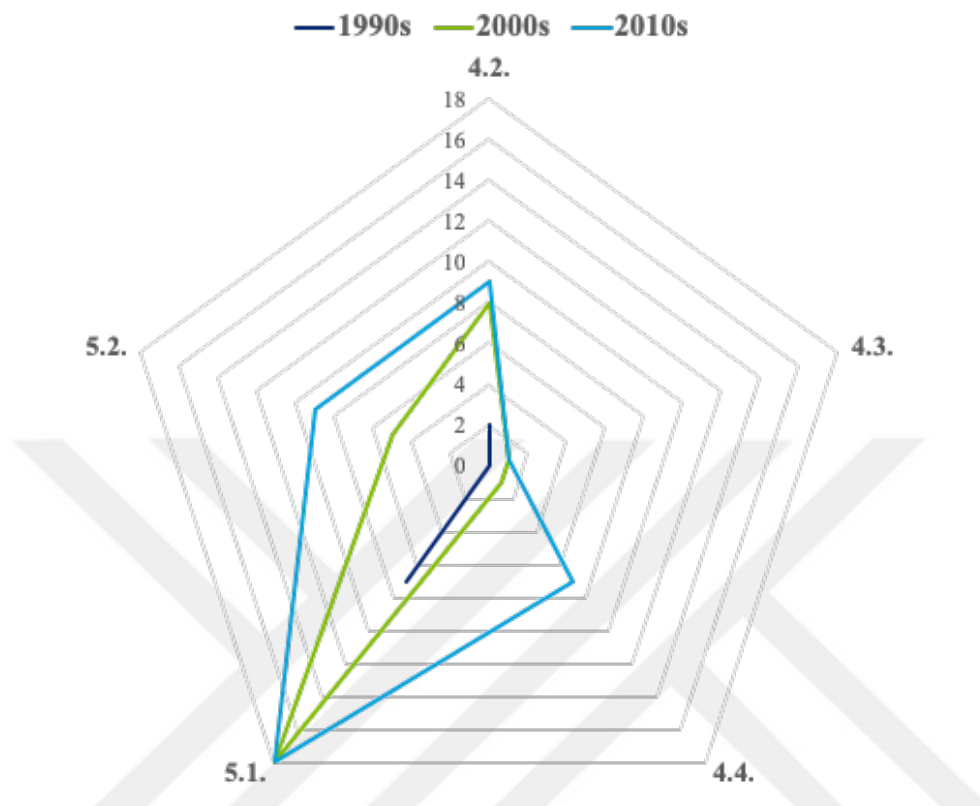


Figure 59: Change in P2 Category

Source: Author's illustration

Concerning P3 (Developing appropriate institutions for innovation capability), in Figures 56 and 57, activities tend to converge into two main categories, namely 1.1. (National STI plan or strategy) and 1.3. (Horizontal policy coordination) – both have been on the political agenda since the very early days. IPR measures (2.5.) interestingly seem to be updated in each decade, mainly due to bottom-up demands and policy learning. Instrument group 4.5. (Science and technology parks) always have been on the agenda since the very early days with few adjustments. Further on, few attempts could be detected within the national innovation system on 3.4. (Support to venture capital) and 6.2. (Standards).

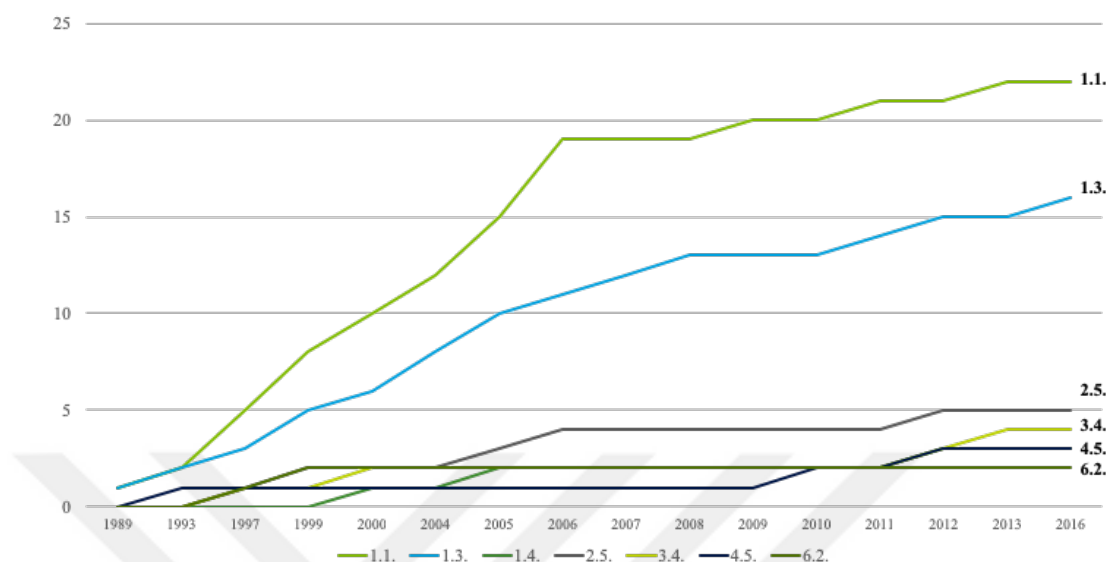


Figure 60: Cumulative Distribution of P3 Category

Source: Author's illustration

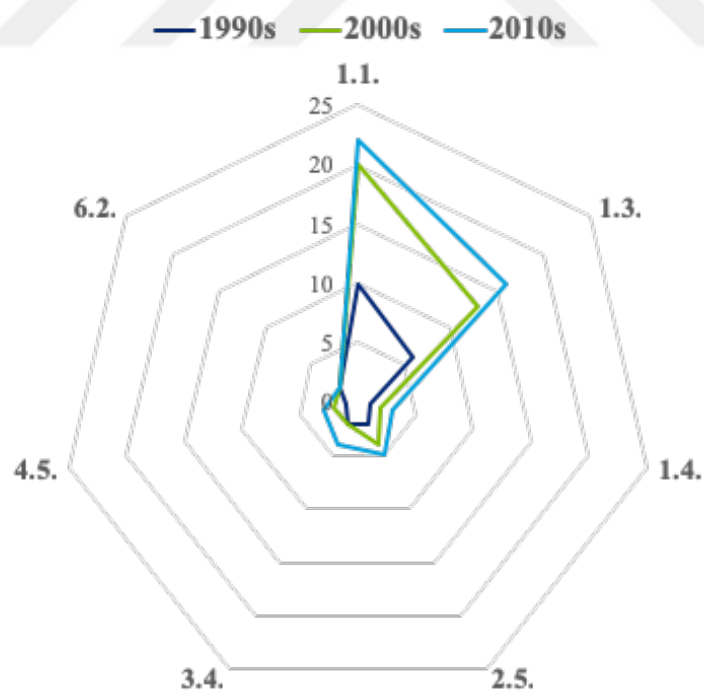


Figure 61: Change in P3 Category

Source: Author's illustration

Finally, for P4 (Social valuation of society to operationalize innovation capability, i.e., attitude change), in Figures 58 and 59, the decision-makers preferred to utilize 1.2. (Sector and technology-specific plans) to influence the direction of agents within the system. The expectation is that actors will capture the government's directional choices and value such change since resource allocation would be attached to selected directions. The dominant role of 1.2. is followed by 3.6. (Entrepreneurship culture). By 3.6., which has flourished after 2010, the decision-makers expect to channel mostly young engineers toward entrepreneurship. Such a shift is in line with global trends of innovation policy applications. 3.5. (Tax incentives) had been initiated but with minor changes over time. 6.1. (Public procurement) received the attention of policymakers first in 2005 and then in 2012 to observe new initiatives. 3.3. (Incubators and accelerators) became popular after 2014 as a response to similar initiatives' global popularity.

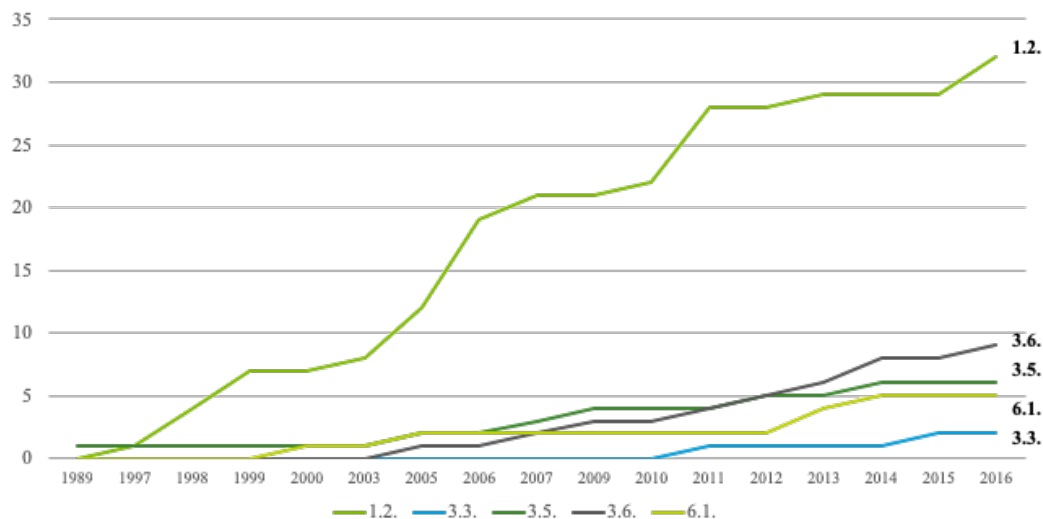
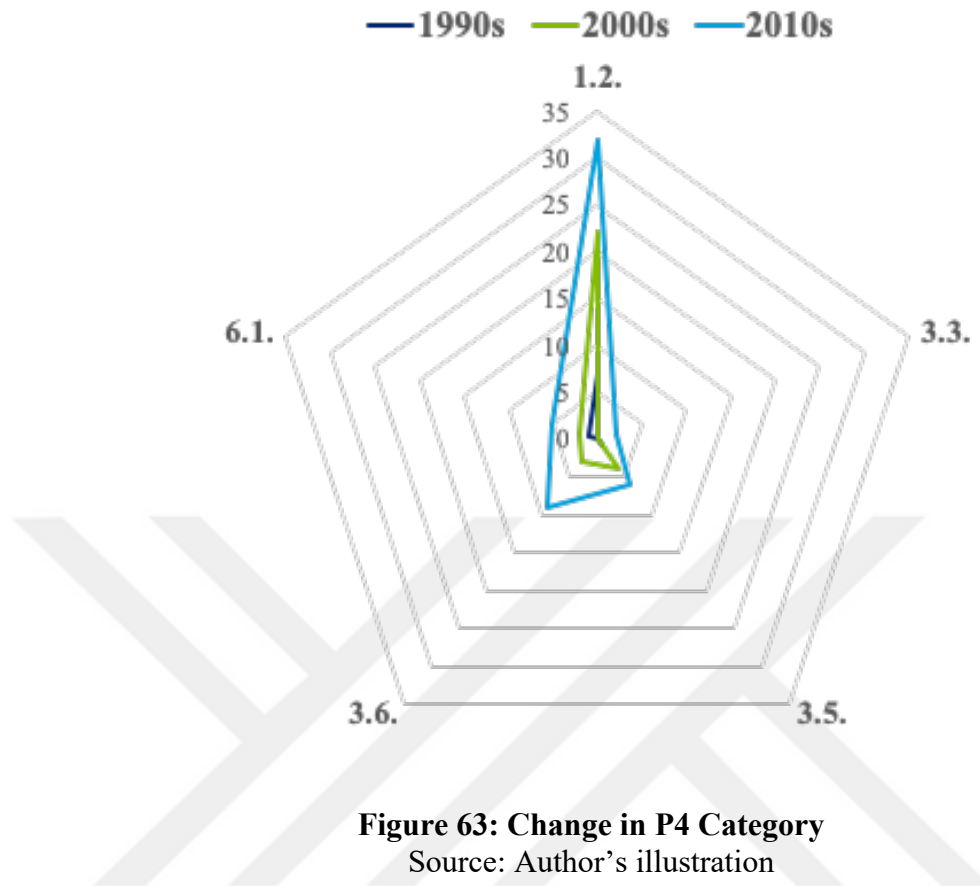


Figure 62: Cumulative Distribution of P4 Category

Source: Author's illustration



A Hybrid Assessment of Key Findings on the Turkish Case.

Chapter 3 found that Turkey was part of the 2nd Cluster between the 1990s to 2010 and then moved up to the 1st Cluster. As a reminder, STI (science, technology, innovation) capability is the primary development threshold for all economies when the economic complexity index is used as a proxy of economic development. Depending on the cluster membership, however, there are other thresholds – such as basic human needs or various types of inequalities – limiting the potential contribution of STI capability increases. We observed that since the 1990s, STI investments have gradually increased in Turkey while its position within Cluster 2 was relatively low for the STI capability level. Therefore, neither basic human needs nor inequalities hindered Turkey to enjoy its STI investments. There was a relative improvement in basic human needs and inequalities; therefore, Turkey continued to benefit from its STI investments.

The outcome of Step 1 analysis in this Chapter highlighted that, concerning Four-P Model, innovation policy interventions should concentrate heavily on P3 (developing appropriate institutions for innovation capability) and P1 (Accessing and developing new knowledge). Our descriptive analysis revealed that Turkey followed the right approach and invested in P3 and P1 to sophisticate its innovation capability. Such improvements mainly have been sustained through National STI Plans and Strategies (Policy Instrument ID: 1.1) and Horizontal Policy Coordination (ID: 1.3) at the level of P3; and through Competitive research funding (ID: 2.1), Financial support to business R and D (ID: 3.1) and R and D infrastructure (ID: 2.3.) at the level of P1.

Our in-depth reading of SCST reports showed that STI capability improvement was a policy goal within the scope of Turkey's political integration into Europe. European Union Accession Process, which also contains integration at Science and Research¹¹ domain, is a fundamental institutional change process over this initial period. The European integration process on STI initiated with the alignment of research policy objectives by setting ambitious targets¹² for (a) GERD (gross expenditure of R&D over the domestic product (GERD/GDP)) and (b) level of full-time equivalent researchers. Accordingly, public resources devoted to funding research, technology development and innovation have also sharply increased in magnitude and variety. Institutionally, European regulations on state aid rules for R&D activities were integrated into national legislation.

¹¹ 'Science, Technology and Innovation' related legislations legally covered under Chapter 25 (Science and Research) of the European Union Membership Acquis (see https://ec.europa.eu/neighbourhood-enlargement/policy/conditions-membership/chapters-of-the-acquis_en for more details, last accessed on 30.04.2021). In Turkey's accession process to the European Union, as of December 2016, 'Science and Research' has still been the only accession chapter that was opened and provisionally closed (Source: www.ab.gov.tr last accessed on 10.01.2021).

¹² Over the years, the Supreme Council of Science and Technology has updated the targeted figures.

Such financial incentives, channelled mainly by the Scientific and Technological Research Council of Turkey (TUBITAK), have been an important mechanism to affect agents' choice (academic and industrial) to utilize their untapped innovation research potentials. To understand the integration process in chronological order, we compiled SCST reports (outlined in Annex, Section 7.6).

STI efforts till 2010 resulted in shifting cluster membership towards Cluster 1 (more specifically SC3 as defined in Figure 33) by implementing P3 and P1 type of instruments. Turkey has been locked into Cluster 1 low performers sub-group since then, and there is a need to understand the root cause of this locked-in.

Our empirical analysis in Chapter 3 showed that lower performers of Cluster 1 have two primary thresholds STI and BHN (basic human needs). Therefore, without a leap forward at BHN investments, STI capability improvements shall not contribute to overall economic development. According to the analysis of Step 1 of this Chapter, we captured a need for fundamental change in the innovation policy's composition under Four-P Model. While P3 and P1 are key concentrations for Cluster 2, after the transition to Cluster 1, the desired components of the Four-P Model are P4 (Choice: social valuation of agents to operationalize innovation capability, i.e., attitude change), P3 and P2 (Capacity: sophisticating absorptive capacity). As we have claimed in this thesis, development is a moving target, and each stage necessitates diversified policy approaches to cope with the challenges of the new stage. Our descriptive assessment at Step 2 of this Chapter provided that Turkey paid attention to P4 appropriately by leveraging the instrument of Sector and Technology Specific Plans (ID: 1.2).

Regarding P3 and P2, however, Turkey lacked further sophistication. Regarding P3, there has been an institutional lock-in to Cluster 2 period's institutions with limited instrument improvements or diversifications. Also, for P2, the country continued to benefit only from Support to human resources for R&D (ID: 5.1) and the commercialisation of public research results (4.4).

Turkey, however, significantly allocated its resources to P1, although the necessity was on other components of the Four-P Model. Table 18 summarizes the key findings of the case study analysis. Stars in ‘Necessity’ Columns are based on each clusters’ Random Forest Algorithm results (variable importance) where an economy in the given cluster should concentrate on. The stars are defined according to the variable importance levels in Table 19.

‘Performance of TR’ columns, however, represent the density of instruments exercised by Turkey over the same period. The stars are defined according to the number of instruments applied in the period by the Turkish government. We could argue that while we can observe a great match during Period 1, there is a major deviation during Period 2.

Table 18. Case Study Results[§]

	Period 1 (1990-2010)		Period 2 (2010 onwards)	
Cluster	2		1	
	Necessity	Performance of TR	Necessity	Performance of TR
P1	**	***	<u>*</u>	<u>***</u>
P2	*	*	<u>**</u>	<u>*</u>
P3	***	***	<u>**</u>	<u>*</u>
P4	*	*	**	**

(§) The mismatches are underlined.

4.8. Conclusion

Chapter 3 aimed to theorize complex capabilities within the human development and capability approach's scope and differentiate them from basic human capabilities. We approached our research question of development threshold patterns for different country clusters through an in-depth empirical assessment. Our analysis in Chapter 3 revealed that innovation capability is the main differentiator between low and high economic development performers, together with other development-related independent variables, such as various kinds of inequalities or satisfying basic human needs.

This chapter aimed to extend our discussion on complex capabilities, specifically innovation capability and its role in qualitative change. Innovation economics theory deals with the dynamic processes of qualitative transformations with sequential variation, selection, and retention processes. The Capability Approach necessitates explanatory theories to apply it in different domains. Therefore, for innovation capability, we preferred Innovation Economics as the explanatory theory throughout this Chapter, which allowed us to identify the components of the innovation capability opportunity space within the capability approach's scope. In this regard, knowledge is the primary resource for the innovation capability space. At the same time, absorptive capacity is the fundamental conversion factor, and learning is the functioning (realization of the potential) of the innovation capability.

The Capability Approach has been developed intending to provide practical policy tools that are easy to implement. While the approach offers flexibility, the lack of frameworks limits its applicability in various domains. This thesis proposed a policy framework, namely the Four-P Model, where each P stands for complementary roles within the overall capability space. P1 aims to maximize a systems' exposure to resources where lack of such resources generates inequalities. For innovation capability, P1 aims to generate or acquire new-to-the-system knowledge. P2 includes policies for enhancing the actors' resource-related capacities so that such capacities function as conversion factors.

In our analysis, absorption capacity plays this role under P2 category policies. Socio-environmental conversion factors (i.e., institutions) stand for the P3 category, and innovation policy literature has a broad perspective on system-related institutions that allow capability enhancement and resource-capability match. Finally, P4 defines the social valuation (a choice mechanism) of the politically targeted functioning.

Early in the previous chapter, we have defined the roles of government for qualitative change as (a) to define the direction of change and to motivate change towards this direction, and (b) to socially construct competitive assets that will fit with the new direction. Within our Four-P Model, P1, P2, and P3 are related to constructing competitive assets, while P3 and P4 are related to the defining direction of change.

Then we applied this framework to innovation policy to better articulate our understanding of the policy within the capability approach's scope. Therefore, the components of innovation policy are as follows: (P1) accessing and developing new knowledge; (P2) sophisticating absorptive capacity; (P3) developing appropriate institutions for innovation capability; and (P4) social valuation of agents to operationalize innovation capability, i.e., attitude change.

We then apply a two-step analysis, quantitative and qualitative. In quantitative one, we gathered data from multiple sources to construct a data set of independent variables that fit the Four-P Model components of innovation capability. At this step, the Random Forest Technique was applied to identify which components of the Four-P model are more important to explain the variation of economic complexity (dependent variable) for each cluster identified in Chapter 3. The analysis in this initial step revealed that for Cluster 3, top performers, P1 is the most critical innovation policy segment to enhance innovation capability and boost economic complexity. For Cluster 1, P2-P3-P4 has equal weights, while for Cluster 2, P3 has a significant impact, followed by P1. Such results are fundamental to operationalizing Four-P Model and to identifying how to define the innovation policy mix within the overall innovation capability space – depending on cluster belonging.

Within the qualitative part, Step 2, we performed a case study as a sensitivity analysis of the research outcome of Step 1. The case study was a descriptive innovation policy analysis applied to Turkey and its innovation policy change pattern. In brief, we developed a pattern-matching algorithm among innovation policy space and capability space, which allowed us to match each innovation policy instrument with one component of the Four-P model. For the matching algorithm, we have approached domain experts through an online survey and utilized the outcome to evaluate Turkey's innovation policy change over decades.

Turkey was part of the 2nd cluster between the 1990s and 2010 and moved up to the 1st cluster. Starting from the 1990s, we observed advances in STI investment for the Turkish economy when its relative position within Cluster 2 was relatively low for STI capability.

The outcome of Step 1 analysis in this chapter highlighted that, concerning Four-P Model, innovation policy interventions should concentrate heavily on P3 (developing appropriate institutions for innovation capability) and P1 (Accessing and developing new knowledge). In Turkey's case, our descriptive analysis revealed that Turkey followed the right approach and invested in P3 and P1 to sophisticate its innovation capability during Period 1 (as defined in Table 18), which – as we outlined – was a reflection of Turkey's political integration to Europe, including integration at Science and Research domain.

The increased STI capability improvement efforts weighted on P3 and P1 policies moved up to Cluster 1 from the cluster's bottom edge. However, Turkey has been locked into the Cluster 1 low performers sub-group since then.

We previously defined a need for continuous change in the composition of the innovation policy over economic development since it is a moving target with evolving challenges. While P3 and P1 are key concentrations for Cluster 2, after the transition to Cluster 1, the Four-P Model's desired components should be P4, P3 and P2. Our descriptive assessment at Step 2 of this Chapter provided that Turkey paid attention to P4 appropriately.

Regarding P3 and P2, however, Turkey has suffered further sophistication. Regarding P3, there has been an institutional lock-in to Cluster 2 period's institutions with limited diversification. Also, for P2, the country continued to benefit only a limited type of policy instruments.

Overall, our qualitative assessment methodology and the case study results validated the results of the quantitative assessment. Together with the results of chapter 3, we believe that there are enough pieces of evidence to define a set of policy recommendations in chapter 5.



CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATIONS

5.1. Summary of Our Findings

Undoubtedly, there is a consensus that prosperity relies on economic transformations driven by the various forms of innovations and delivered by entrepreneurs and innovative incumbent corporations – generally referred to as the contributions of Austrian economist Joseph Schumpeter. Economic transformations evolve hand in hand with social changes – some societies succeed while others lack behind. Therefore, if the policymakers fail to act in responsibly and timely, co-evolution of economic and social transformations is also the root cause of inequalities in various forms.

Human Development and the Capability Approach is interdisciplinary thinking that focuses on people, their opportunities, and their choices to understand inequalities and design idiosyncratic policies that match society's specific inequalities. Thus, the approach hesitates to generalize prescriptions but provides toolkits to enable policymakers to design policies. While saying that, scholars focused on the foundational aspects of human development (live a long, healthy, and creative life, be knowledgeable, and have access to resources needed for a decent standard of living), what we call basic human needs. From our point of view, the capability approach has the potentiality to provide solutions for more complex inequalities.

Once there is a certain level of progress on the basics of human development, they open up opportunities for advancement in other aspects of life – towards more complex capabilities. Development is a continuous process of enlarging individuals' choices by expanding their capability space towards complexity and allowing them to freely utilise those capabilities to bring valued change to their own lives.

The development community's efforts should be concentrated on the components of any targeted capability and the relevant conversion factors while working on extending the theoretical understanding towards complex capabilities as a response to inequalities that exceed the basic human needs.

Economic complexity is a crucial topic that enables us to further expand our thinking on the human development and capability approach. Economic complexity is driven by diversification of economic outputs where such outputs (products and services) are the vehicles of accumulated knowledge and production and innovation capabilities of the society. Because individuals are limited in what they know, societies can only expand their knowledge base by facilitating individuals' interaction in increasingly complex networks. A country with higher economic complexity can better cope with the crisis, generate high-quality jobs and prevent not all but many forms of inequalities.

Increasing economic complexity necessitates long-term commitment and integrated policies. Governments' roles are to define the direction of change and socially construct competitive assets that accurately fit the new direction. Overall, we name these roles as the sophistication of the capability space, while the ultimate aim is to remove unfreedoms and inequalities that leave people with the limited choice to exercise their agency.

In chapter 3, we hypothesised that there are complexity thresholds over the stages of development, and one of our research aims was to identify these threshold patterns for different country clusters. Methodologically, we used various machine learning algorithms that feed each other to test our hypothesis. At the same time, the dependent variable for the analyses is ECI (Economic Complexity Index), which is a proxy for complex capabilities for economic development.

Starting from 1990, we gathered each country's data for 5-years intervals and labelled them as separate objects – i.e., Turkey 1990 is a different object than Turkey 1995 in our dataset. All data objects are clustered under 3 clusters upon results of clustering algorithms that we have run.

Our empirical analysis reveals that a country's STI capability level is vital to determine its potentiality for complex capabilities. Therefore, STI is a critical threshold for development, independent of cluster belonging. However, STI alone cannot explain countries' performance since there are other thresholds over the process of development and economic complexity. For the top performers (high STI levels in Cluster 3), inequality (INQ) is the only threshold. For the lowest performers (low STI in Cluster 2), STI is the only threshold, but when they enhance their STI levels (relatively higher STI in Cluster 2), they have faced with INQ and BHN as additional thresholds. For the emerging economies (Cluster 1), lower STI performers need to surpass certain BHN thresholds, while higher STI performers should tackle INQ as a threshold.

We conclude that STI should boost ECI performance when basic human needs are provided, and inequalities are low. However, over the development process, many other factors limit the full utilisation of STI investments and call for crossing some different thresholds for complexity enhancement. Our empirical study reveals that economies should extend their STI capabilities while solving non-STI thresholds that they would face according to their cluster belongings for achieving economic complexity. The summary of an economy's development journey is illustrated in Figure 60 – where the six sub-clusters (2 for each cluster) are visualised together with the thresholds for each sub-cluster.

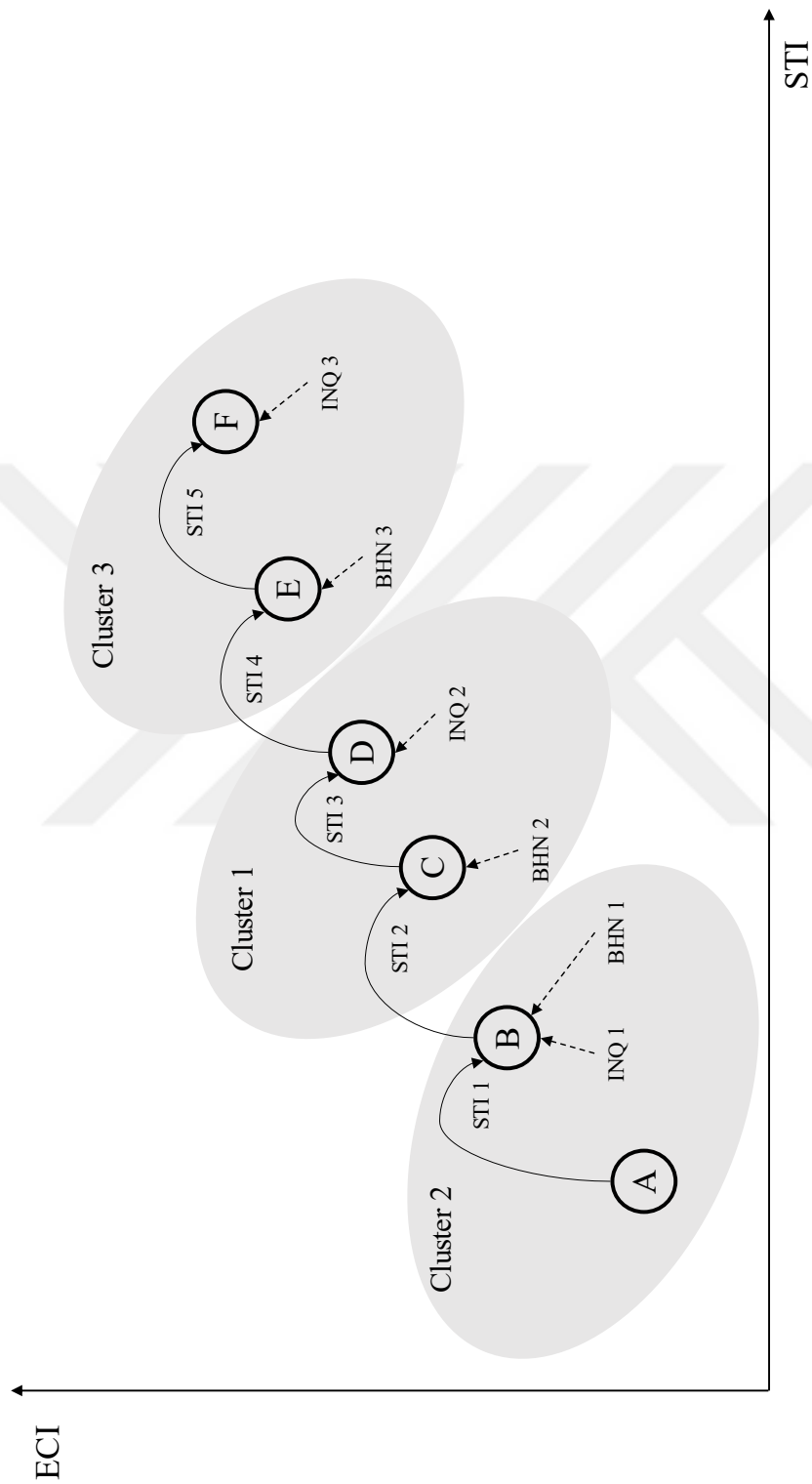


Figure 64. Economic Development Journey Map

Source: Author's illustration

To further extend our understanding of complexity, we deep dived into innovation capability. As a starting point, we explored the innovation capability and its components from a capability approach perspective and tried to define a policy development tool to build practical applications. (Sen, 1999) defined the Capability Approach as a policy evaluation and designing toolkit. So, we decided to employ the Approach with its original purpose. However, the Capability Approach literature is highly immature to provide an appropriate framework for policy development. Therefore, we constructed a policy framework (Four-P Model) and then used it more specifically for innovation policy.

Innovation economics deals with the dynamic processes of qualitative transformations with sequential variation, selection, and retention processes. The capability Approach necessitates explanatory theories to apply it in different domains. Therefore, for innovation capability, we preferred Innovation Economics as the explanatory theory in this thesis, which allowed us to identify the components of the innovation capability opportunity space within the capability approach's scope. In this regard, knowledge is the primary resource for the innovation capability space. At the same time, absorptive capacity is the fundamental conversion factor, and learning is the functioning (realization of the potential) of the innovation capability.

Our Four-P Model address the main components of the capability framework and their relationships. The key questions are as follows:

- Does the system access the necessary resources?
- Are conversion factors (personal and socio-environmental) sophisticated enough to benefit from new resources?
- Is the social valuation (a choice mechanism) of the politically targeted functioning positive?

In Four-P Model, each P stands for complementary roles within the overall capability space. P1 aims to maximize a systems' exposure to resources where lack of such resources generates inequalities.

For innovation capability, P1 aims to generate or acquire new-to-the-system knowledge. P2 refers to policies for enhancing the actors' resource-related capacities so that such capacities function as conversion factors. In our analysis, absorption capacity plays this role under P2 category policies. Socio-environmental conversion factors (i.e., institutions) stand for the P3 category, and innovation policy literature has a broad perspective on system-related institutions that allow capability enhancement and resource-capability match. Finally, P4 defines the social valuation (a choice mechanism) of the politically targeted functioning.

Therefore, the components of innovation policy are as follows: (P1) accessing and developing new knowledge; (P2) sophisticating absorptive capacity; (P3) developing appropriate institutions for innovation capability; and (P4) social valuation of agents to operationalize innovation capability, i.e., attitude change.

For an empirical assessment, we benefitted from our cluster analysis of the third chapter. To remind, we ranked the clusters as $3 > 1 > 2$ regarding their economic complexity. Our study revealed that innovation capability is the main differentiator between low and high economic development performers, together with other development-related independent variables, such as various kinds of inequalities or satisfying basic human needs.

Once again, we used multiple machine algorithms in chapter 4 and obtained the following results. For the most developed economies (Cluster 3), the critical variable of importance is Knowledge. Countries in this group have set their institutional infrastructure and strengthened their capacities. A consensus within the society that innovation is vital for prosperity (UNCTAD, 2010); hence the Choice is not a policy concern. Therefore, the fundamental component for concentration is to access state-of-the-art Knowledge to sustain welfare and catalyse its transformation to innovations.

Catching up economies (Cluster 1) are generally able to adapt good institutions of developed economies, enhancing their absorptive capacity to benefit from global circulation of Knowledge and influence their change agents' choice decisions towards innovation. We witness in the table that all these three components of our Four-P Model are essential variables.

Finally, the developing economies (Cluster 2) generally have systemic failures that need good governance and institutions' improvements are indispensable concerns. Accordingly, we have witnessed that institutions have a dominant score in our analysis of variable importance.

We performed a case study of the research outcome of the previous step's variable importance, as a sensitivity analysis. The case study was a descriptive innovation policy analysis applied to Turkey and its innovation policy change pattern. In brief, we developed a pattern-matching algorithm among innovation policy space and capability space, which allowed us to match each policy instrument of innovation policy space with one component of the Four-P model. For the matching algorithm, we have approached domain experts through an online survey and utilized the outcome to evaluate Turkey's innovation policy change over decades.

Turkey was part of the 2nd cluster between the 1990s and 2010 and moved up to the 1st cluster. Starting from the 1990s, we observed advances in STI investment for the Turkish economy when its relative position within Cluster 2 was relatively low for STI capability. The outcome of Step 1 analysis in this Chapter highlighted that, concerning Four-P Model, innovation policy interventions should concentrate heavily on P3 (developing appropriate institutions for innovation capability) and P1 (Accessing and developing new knowledge). In Turkey's case, our descriptive analysis revealed that Turkey followed the right approach and invested in P3 and P1 to sophisticate its innovation capability during this period, which – as we outlined – was a reflection of Turkey's political integration to Europe, including integration at Science and Research domain.

The increased STI capability improvement efforts weighted on P3 and P1 policies moved up to Cluster 1 from the cluster's bottom edge. However, Turkey has locked into Cluster 1 low performers sub-group since then.

Before, we defined a need for continuous change in the composition of the innovation policy over economic development since it is a moving target with evolving challenges. While P3 and P1 are key concentrations for Cluster 2, after the transition to Cluster 1, the Four-P Model's desired components should be P4, P3 and P2.

Our descriptive assessment at Step 2 of this Chapter provided that Turkey paid attention to P4 appropriately. Regarding P3 and P2, however, Turkey has suffered further sophistication. Regarding P3, there has been an institutional locked-in to Cluster 2 period's institutions with limited diversification. Also, for P2, the country continued to benefit only a limited type of policy instruments.

Overall, our qualitative assessment methodology and the case study results validated the results of the quantitative assessment. Together with the results of chapter 3, we thought that there are enough pieces of evidence to define a set of policy recommendations.

5.2. Policy Recommendations

Innovation Policy and Transformative Change. Policymakers, nowadays, are facing a critical challenge in designing innovation policies. For a quite long era, generic policies with one-fit-for-all instruments have dominated the policy circles. The departmentalisation of innovation agencies has resulted in isolated science, technology, and innovation programs, mainly focused on academics or industry players. We could also observe a similar phenomenon among innovation policy and industrial policy objectives and instruments.

Nevertheless, things are changing. Scholars attach new responsibilities to innovation policymakers with a solid emphasis on transformative changes and mission-orientated approaches. We outline a general framework in Figure 61.

As a paradigm shift in the innovation policy thinking, missions concentrate on challenges (either at the global or local level) that bundle diversified technologies instead of a single technology and their implementation in multiple sectors. Therefore, a mission shall contain a policy mix that includes various forms of innovation policy instruments – accompanied by implementing agencies and targeted change agents, who are expected to collaborate extensively.

As our empirical study and theoretical extensions in this thesis reveal, innovation policy in isolation cannot realise transformative change. Other socio-economic policy instruments should be mobilised, such as education, monetary, social, trade, development, etc., to maximise the merits of the innovation policy instruments.

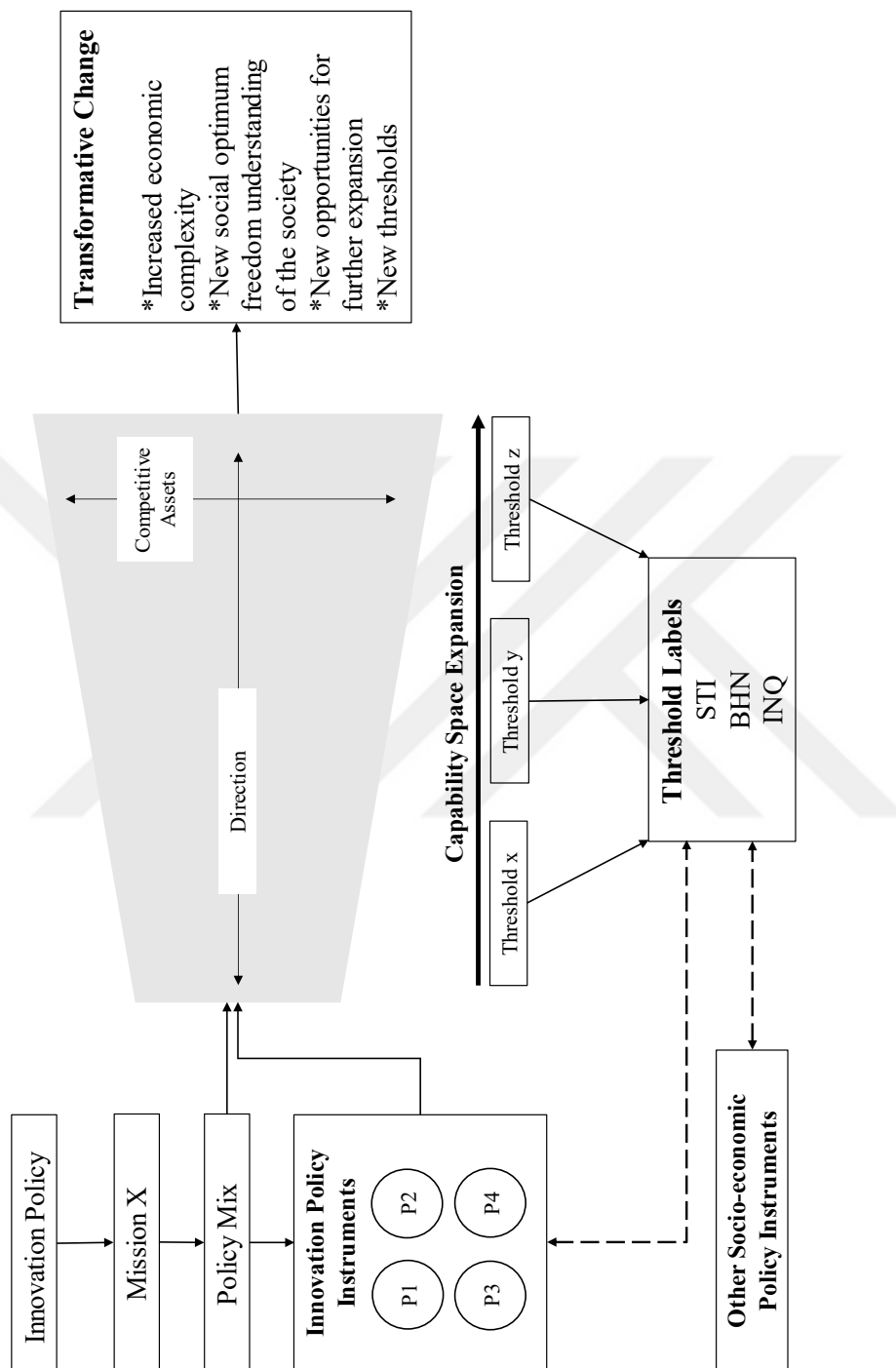


Figure 65. Policy Framework
 Source: Author's illustration

Human Development and Capability Approach have the potential to operationalise the innovation policy design process. By examining the limits of the available capabilities, policymakers can design capability space expansion in two main dimensions: the policy mix's direction and the competitive assets that the system should acquire. Capability space expansion is a process of opportunity expansion since the enhancement of capabilities also overcome various degrees of inequalities within society.

Our empirical study in chapter 3 showed that STI capability is the main factor for economic transformation. Further, in chapter 4, we first theorised the Four-P model. We identified which Ps are more influential at each stage of economic development (i.e., belonging to one of the three clusters of economies) to expand the capability space.

Although STI capability is the main factor, economies may not fully utilise their STI investments upon facing various non-STI thresholds over the process of capability enhancements. Our analysis revealed that either BHN (basic human needs) or INQ (inequalities) might appear as thresholds in different stages. Our research results also provide which thresholds may occur for every 3 clusters' members over the process of transformative change.

Transformative changes might generally result in multiple outcomes. One expects substantial progress on economic complexity – through which the economy can utilise more complex products that add value to its competitiveness. By extending the capability space, the policymakers gain an advantage for further expansion, where the new capabilities serve as a means for more complex ones. Development is a moving target. As a result, when an economy overcome particular development bottlenecks, new ones emerge due to the achieved level. The economy has new challenges and new thresholds to deal with.

An outcome of transformative change is that there will be a shift in understanding social optimum on certain freedoms. In each stage of development, there are diversifying understanding of human dignity.

At the early stages of development, human dignity might be associated with basic human needs; this might shift upwards in the following stages towards other resources or capabilities that prevent further expansion of opportunities.

In a nutshell, the innovation policy design process should kick-start with analysing the current economic complexity level and understanding the existing stock of production capabilities. The policymakers can map the potential expansion route for complexity and new product knowledge in the next step. By doing so, the magnitude of search efforts for variety and innovative capabilities might be identified. Then, policymakers could integrate the policy objectives into the mission(s) – bundles of policy mixes that define the problems to catalyse various change agents' search efforts. Those missions also determine the direction of transformative change and the necessary competitive assets that boost the opportunity space. We suggest that the policy mix should be defined upon our proposed Four-P Model. In parallel, identifying the current and future cluster memberships, based on our analytical research finding, maximise the utilisation of innovation policy instruments by putting other socio-economic policy instruments in operation to hurdle the development thresholds and unlock growth potential.

Product Space Expansion. Innovation policy has a strategic role in the opportunity expansion process by sophisticating capabilities, where some are means of the others. In the design process of innovation policies, understanding such means and ends is crucial. Although we could find similarities among economies where country cluster membership has defined the natural thresholds over complexity increase, there is a path-dependent characteristic when we dig into the product space layer. Even in the same cluster, economies significantly deviate for their value generation capabilities in various product spaces. Therefore, we can claim abstract policy guides, but each economy's complexity journey is unique and defined by its current capability space. We could benefit from 'Three Horizons' thinking of futures work for strategizing product space expansions (Sharpe, 2013).

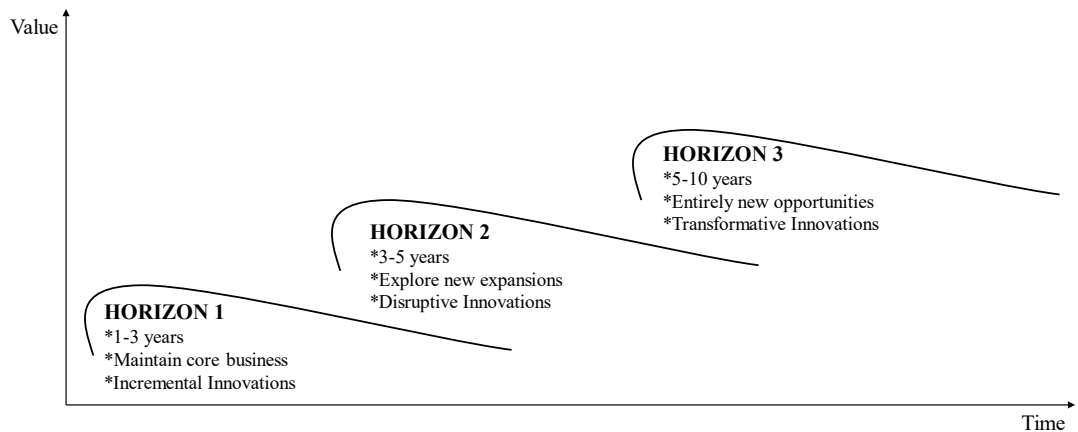


Figure 66. The 3 Horizons Model

Source: www.boardofinnovation.com/blog/what-is-the-3-horizons-model
(last accessed on 28.03.2021)

As a foresight tool (see Figure 62), Three Horizons Model provide a practical way of structuring our future. Horizon 1 is the established pattern, where incremental innovations sustain the status quo. Horizon 3 is the expected outcome of the transformative policies in the future, while Horizon 2 is the bridge between Horizon 1 and 3, where disruptive innovation occurs with entrepreneurial activities. We aim to adjust the tool to adapt it to our research, as shown in Figure 63. Therefore, Horizon 1 is the stock of an economy's current product space, which builds up the current economic complexity level. Horizon 3 is the expected outcome of the targeted transformative change, for which the implemented innovation policies set the direction and the rate.

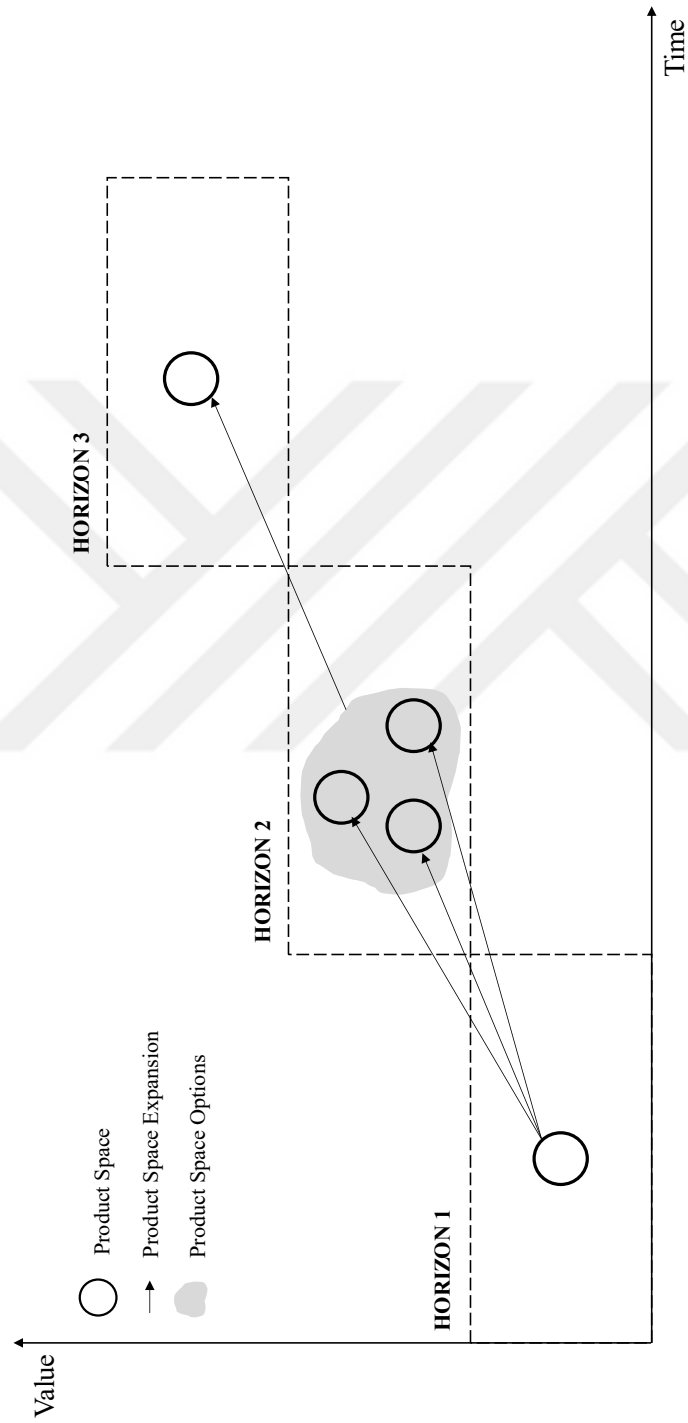


Figure 67. Single Economy Product Space Options Map
Source: Author's illustration

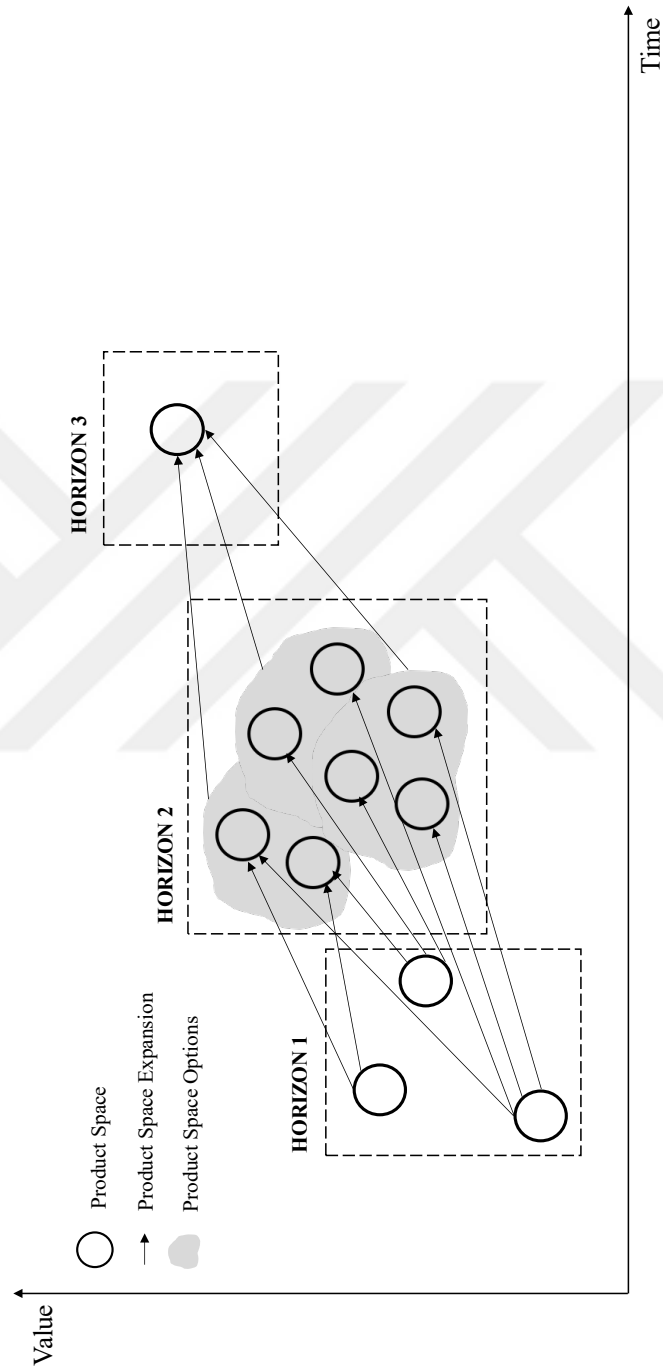


Figure 68. Competition at Horizon 2 Level
Source: Author's illustration

Economic complexity is an interactive process. There are apparent trade-related interdependencies among different economies. An increase in an economy's complexity position shall result in a change of some other economies. Assume that one economy starts to produce a better or similar quality product and lower its cost for the customers, resulting in diminishing exporting capacity of producers in another economy. Or one economy may hinder others from accessing resources that are necessary for capability sophistication.

As shown in Figure 64, various economies might target similar product spaces for their Horizon 3 objectives, while their starting points (Horizon 1) are different. Horizon 2 has tactical importance in these situations. The shortest path (Horizon 2) for Horizon 1 to 3 may not be the most efficient. The economy might face the trap of over-competition under this path (Horizon 2). Overall, despite the strategic choices for Horizon 3, tactical operations for Horizon 2 are also vital for successful transformations.

Four-P Model. Development is all about empowering individuals and social groups to live a life they have valued. But it is an ongoing process – a moving target. The needs and demands of individuals and the social groups they constitute are evolving, qualitatively and quantitatively. As a process, development necessitates removing a new level of unfreedoms that leave people with limited choices. Governments' roles in this process are to define the direction of change and socially construct competitive assets that accurately fit the new direction. Overall, we name these roles as the sophistication of the capability space. However, each capability has its components. Understanding the inner mechanism of such components is vital to designing and evaluating the targeted capability. The real value that the human development and capability approach brings to this thesis is that it provides a structural understanding of how capabilities are working, their inner mechanics and their components. Therefore, it enriches our experience of policy design.

Our theoretical contribution at this point is to deliver a systemic policy design framework – the so-called Four P Model, through which a government agency can design and implement effective policy instruments that lead to capability sophistication.

Each P addresses either a specific component or a linkage among components. P1 relates with the resources and questions whether the resources required to realize functionings are provided or not. P2 is on the agent-based conversion factor, where the capacity agent defines the abilities. P3 addresses the socio-environmental conversion factors (institutions) where the potential mismatches prevent the well-functioning of the capability space. P2 and P3 jointly catalyse the transformation of resources into capabilities and then into doings and beings (functionings). Finally, P4 is related to the social valuation (choice) of the politically targeted functioning, which should be positive to realize capability to functioning conversion.

On Turkey's Case. Our analysis revealed that Turkey has shifted from Cluster 2 to Cluster 1 after 2010 but has been stuck into it since then. A major boost in STI capability was the fundamental reason for the initial progress. Neither basic human needs nor inequalities hindered Turkey from enjoying its STI investments since the country also gradually increased BHN and INQ capabilities. Upon our Four-P model assessments, we obtained insight that Turkey has applied the appropriate innovation policy tools during this successful era so that she could realize a high STI return on investment.

There are two main reasons for underperforming after joining Cluster 1. Turkey has been a member of the low-performers group of this cluster. For this specific sub-group, BHN emerged as a threshold for improving economic complexity with STI investments. The BHN improvement momentum of Turkey has diminished, which limits the efficiency of further STI improvements. Despite that, however, the composition of STI instruments has its challenge.

During the period of cluster shift, the European integration process was the fundamental institutional change catalyser, where Turkey can “... *follow the path... skip some steps along the way, and narrow the gap*” (Gerschenkron, 1979, p.9).

Our Four-P Model analysis revealed that Turkey had applied an appropriate policy mix that fit into the needs of a Cluster 2 member. However, along with the political shift – interruption of the European integration process due to various reasons, Turkey has no longer adopted the new institutional changes of Europe. Instead, Turkey lacked further sophistication and was locked into Cluster 2 period's policy instruments.

This has been confirmed by both our machine learning algorithm results and case study analysis at Four-P Model. As we outlined before, development is a continuous process, where the matching of capabilities and institutions is fundamental for realizing targeting functionings.

We suggest that Turkey should follow the policy framework that we have proposed in this chapter. The process might start with defining a new set of product spaces (Horizon 3) and the ones that bridge (Horizon 2) the current stock of product spaces (Horizon 1) with the targeted ones. This initial process is unique for each economy. However, the innovation policy mixes are mainly related to the cluster membership and the next cluster where the economy aims to move in.

Between 2000 to 2019¹³, Turkey improved six positions in the ECI ranking from 56th to 40th – an accelerated complexity increases between 2000 (56th) to 2010 (42nd), followed by a moderate pace over the last decade. Figure 65 represents Turkey's export basket and the complexity level of its product space. Turkey's most significant goods exports are in the moderate complexity segment. Turkey added 22 new products over the last 15 years (2004 to 2019) and ranked 10th in diversity ranking. However, those new products only represent 1% of her 2019 export portfolio.

¹³All numbers and rankings in this section are gathered by analysing the data of the Economic Complexity Index published on <https://atlas.cid.harvard.edu>. 2019 is the latest year for available data as of October 2021.

Therefore, we can claim that Turkey has diversified into a sufficient number of new products but is too small in volume. The challenge of the volume is due to high competition in the moderate complexity segment among Cluster 1 countries.

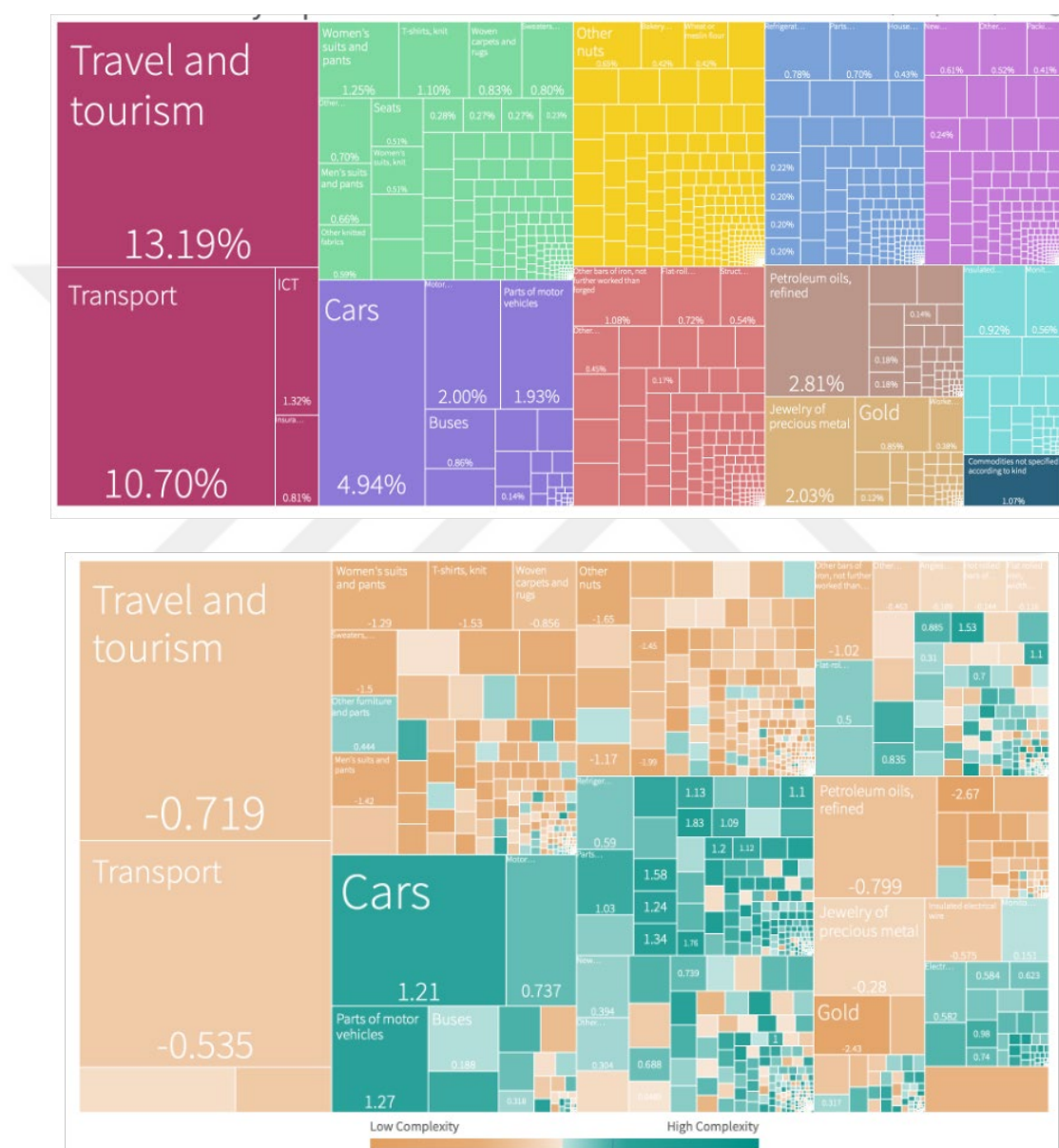


Figure 69. Turkey's Economic Complexity

Source: <https://atlas.cid.harvard.edu>

Note: The first graph represents the shares of Turkey export basket in 2019 (latest available data for Economic Complexity Index). The second graph illustrates the level of complexity for Turkey's product space.

Previously, we discussed that countries tend to diversify to new products that require similar capabilities (see Figure 63). Existing product space composition could provide insight on how a country can diversify to further complex products. More significant, the present product space defines the opportunity space. Turkey ranked 3rd regarding its potential of moving into more complex products. However, as illustrated in Figure 64 before, opportunity spaces might intersect – several countries compete for identical product spaces.

Potential paths to diversify (increasing economic complexity) is a policy choice. Short jumps to nearby opportunities might limit the utilisation of an economy's potential. A balanced portfolio approach necessitates both a coordinated plan for long jumps (Horizon 3 in Figure 64) and targeting low hanging fruits (Horizon 2 in Figure 64).

In a similar vein, Turkey should decide on its strategic bets (high complexity products) that bring long term diversification opportunities (relative higher complexity brings new linkages to more complex product spaces). However, defining the direction of change should consider the competitive assets on hand – since building up competitive assets is a resource-intensive process (see Figure 61).

Our case study on Turkey reminds us that P2 (capacity enhancement) and P3 (institutional diversification) have been Turkey's emerging policy challenges since its membership to Cluster 1. For P2, we have witnessed (see Figure 55) limited diversification of policy instruments that limit the merits of capacity enhancement. For P3, there has been an institutional lock-in to Cluster 2 period's institutions. Therefore, Turkey needs diversification of policy instruments and resource allocation for policy choices that should be well-aligned with its cluster membership. During the Cluster 2 era, Turkey enjoyed the European integration process as an opportunity to benchmark and adapt policy instruments. We do not observe the same enthusiasm nowadays. Europe has been renewing its innovation policy direction and sophisticating its policy instruments as of 2020. Benefiting from such dynamism could allow Turkey to escape from the current lock-in situation.

In Section 5.2., we outlined that (see Figure 61), transformative changes (including reallocation of economic activities towards complexity) should align various forms of socio-economic policies and define mission-oriented innovation policies as a means for this alignment. Defining the missions and setting the boundaries of these missions could allow Turkey to decide on its direction of change. Such a decision might also enable Turkey to identify potential paths to diversify its economy together with underlying competitive assets.

Today developed economies (Cluster 3) tend to concentrate their diversification efforts by defining various global challenges as their missions. This might allow emerging economies (Cluster 1) to define their own strategy and strategize such change as an opportunity for complexity enhancement.

5.3. Final Thoughts

Development is all about empowering individuals and social groups to live a life they have valued. But it is an ongoing process – a moving target. The needs and demands of individuals and the social groups they constitute are evolving, qualitatively and quantitatively. As a process, development necessitates removing a new level of unfreedoms that leave people with limited choices.

Governments' roles in this process are to define the direction of change and socially construct competitive assets that accurately fit the new direction. Overall, we name these roles as the sophistication of the capability space. However, each capability has its components. Understanding the inner mechanism of such components is vital to designing and evaluating the targeted capability. The real value that the human development and capability approach brings to this thesis is that it provides a structural understanding of how capabilities are working, their inner mechanics and their components.

Economic development is associated with structural transformation and increased complexity of production. The core mechanism of complexity is evolution. For an economy, the evolution postulates the constant development of new industries, technologies, organisations, and capabilities. In complexity, economics products are presented as the vehicles for knowledge.

A country with a high complex economic system can cope with various types of economic challenges – i.e., high degree inequalities. The contemporary discussions on the capability approach are more mainly concentrated over basic human capabilities. Therefore, the real value that the complexity theory brings to this study is the fact that it allows us to extend the capability approach towards more complex unfreedoms – arising due to economic inequalities.

Innovation is one of the fundamental economic complexity processes. Increasing economic complexity necessitates a long-term commitment to innovation efforts guided by an integrated policy attempt. Contemporary challenges that generate inequalities and driven from economic, environmental, and societal roots gave birth to a new understanding in innovation policy understanding. In this new frame, the innovation policy does not solely target technological leap forward but also changes in capabilities, institutions, industry structures, regulations, and social choices. Therefore, this new understanding necessitates an alignment with economic complexity theory and the capability approach. Throughout this thesis, we aimed to establish such link and proposed policy design mechanisms for implementing various forms of innovation policy instruments.

Complexity is a combined effect of productive and innovative capabilities. Product spaces, therefore, inherently reflect these accumulated competitive assets and available knowledge stock. They are also vehicles of economic development by increasing their complexity, therefore, the capabilities of the society.

Transformative innovation policies have a central role in this change process. Although these policies fundamentally concentrate on STI investments, our previous analysis revealed that STI-based transformations achieve success if an economy can overcome certain development thresholds – either in the form of BHN vs. INQ or both.

Which thresholds emerge at which stage of development are well examined at the cluster level in this study. We also outlined the specific innovation policy mix within our Four-P Model assessment again at the cluster level. Those prescriptions should be considered as guidelines for policy design processes.

There is an apparent heterogeneity among economies, but such divergence is mainly related to the product spaces. Therefore, an economy can benefit from the results of this study by defining its unique development journey concerning product space complexity enhancement and then acknowledging the threshold patterns and designing the innovation policy mix that well matches its development journey.

In the empirical assessments of this thesis, all policy instruments are given equal weight. To the best of our knowledge, limited research exists at the intersection of the capability approach and innovation policy. Therefore, we do not have any benchmark to evaluate alternative weighting options. This should be considered as a limitation of our empirical research. In future studies, a cluster-based weighting model for policy instruments might be tested.

Our Four-P Model provides valuable insights for innovation capability assessment. In future studies, other complex capabilities and related policies could be reviewed through Four-P Model. To remind, an explanatory theory is necessary for applying the Capability Approach for a given capability set. We have used innovation economics while studying innovation policy. One should consider and decide the appropriate explanatory theory while examining other complex capabilities.

Collective capabilities recall for the collective agency. Contemporary research on innovation defines the social and collaborative nature of entrepreneurship. Shedding light on entrepreneurship processes as active practices of social construction and understanding collective entrepreneurship as a change agent might be ideal research topics under the capability approach in future studies.

Finally, the policymakers should consider the rise of a new generation of inequalities triggered by digitalisation, data privacy, cutting edge technologies, climate change, etc. Coping with such complex inequalities necessitates setting the right directions and building up competitive assets around the necessary complex capabilities. Therefore, understanding the nature of complex capabilities and future research on them through the merits of the capability approach will be an ongoing process.

Long story short, development is a moving target, and societies continue to face emerging inequalities that need sophisticated capabilities to cope with.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER



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15 NİSAN 2021

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr.M.Teoman PAMUKÇU

Danışmanlığını yürüttüğünüz Okan KARA'nın "İnovasyon Politika Araçları ile yetkinlik temelli yaklaşım eşleştirme çalışması" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **135-ODTU-2021** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Dr.Öğretim Üyesi Ali Emre TURGUT
İAEK Başkan Vekili

B. CURRICULUM VITAE

Personal Information

Surname, Name : Kara, Okan
Nationality : Turkish (TC)
Date, Place of Birth :
Email :

Education (Degree, Institution, Year of Graduation)

PhD – Middle East Technical University,
Science and Technology Policy Studies, 2022
MBA – University of Illinois Urbana Champaign,
GIES Business School, 2020
MS – Middle East Technical University,
Science and Technology Policy Studies, 2007
BS – Marmara University, Engineering Faculty,
Industrial Engineering, 2001

Work Experience (Year, Place, Enrolment)

2015-Present	ACT VC	Managing Partner
2013- 2015	PERA EEMEA	Managing Director
2004-2013	TUBITAK	Deputy Head, Head of Department
2002-2004	TELSİM	Business Analyst, Team Leader

Foreign Languages: English, Full Professional Proficiency

Programming Language: R Programme

C. TURKISH SUMMARY/TÜRKÇE ÖZET

Tezin Özet Bulguları

Bu tez, Beşeri Kalkınma ve Yetenek Yaklaşımı kapsamında 'inovasyon kabiliyetini' kuramlaştırmayı amaçlamaktadır. Günümüzde kalkınma düşüncesi, insanlara ve çeşitli derecelerde ve türlerdeki eşitsizliklerin üstesinden gelme özgürlüklerine giderek daha fazla odaklanmaktadır. Özgür olmak için, insanların yeteneklerini genişletmeleri ve takiben bu yetenekleri kendi yaşamlarına değer atadıkları bir değişim getirmek için kullanmaları gerekmektedir. Bununla birlikte, söz konusu literatür, karmaşık ekonomik zorlukları ele alma gücünü sınırlayan temel bireysel yeteneklere yoğunlaşmıştır. Bu tez, Yetenek Yaklaşımı konusundaki tartışmaları karmaşıklığa doğru genişletmeyi amaçlamaktadır. Kalkınmanın 'sürekli bir yetenek oluşturma ve karmaşıkleştirme süreci' olduğunu ve ekonomilerin çeşitli karmaşıklık eşikleri ile karşı karşıya kalırken belirli aşamalardan geçmeleri gerektiğini varsayıyoruz. Bu nedenle, araştırma sorumuz 'farklı ülke kümelenmeleri için eşik değerler nelerdir?' Bu tez kapsamında kullanılan metodoloji keşifsel araştırmadır. Çalışmanın amacı, bir ekonominin inovasyon politikaları aracılığıyla bu tür eşiklerle nasıl başa çıkabileceğini ortaya çıkartmaktır. Tez aynı zamanda, yetenek alanı ile inovasyon politikası araçları arasındaki ilişkiyi yapılandırmak için analitik bir yaklaşım olarak Dört-P Modeli olarak adlandırılan bir politika tasarımı ve değerlendirme çerçevesi önermektedir. Metodolojik olarak, ülke düzeyindeki verilerde çeşitli makine öğrenimi algoritmalarını kullanan iki aşamalı bir yaklaşım geliştirdik. İlk olarak, eşik modellerini araştırıyoruz. Ardından, politika düzeyinde öneriler oluşturmak için Dört-P modeli üzerine kurgulanmış inovasyon yetkinliğine odaklanıyoruz. Bu son aşamada, Türkiye'nin inovasyon politikası gelişimini değerlendirerek bir vaka çalışması da gerçekleştirdik. Vaka çalışmasının metodolojisi, kantitatif analiz sonuçlarımıza dayanan tanımlayıcı politika analizleridir ve analitik sonuçlarımızın duyarlılık analizi olarak değerlendirilmelidir.

Bu tez, Beşeri Kalkınma ve Yetenek Yaklaşımı'nı üç ana teorik sınırlamayı ele alacak şekilde genişletir:

1. Yetenek Yaklaşımı bir teori değil, etkin özgürlüklerin değerlendirilmesine yönelik bir yaklaşımdır. Bu nedenle, söz konusu yetenek için açıklayıcı bir teori gerektirir. Bu tezde, inovasyon kabiliyetine ilişkin analizimiz için açıklayıcı teori olarak İnovasyon Ekonomisi'ni kullanıyoruz.
2. Mevcut literatür, bireysel yetenekleri incelerken kolektif yeteneklere daha az ilgi göstermiştir. Bu tez, mevcut literatürü temel yeteneklerden karmaşık yeteneklere doğru genişletmektedir.
3. Nihai amacı bir politika değerlendirme ve tasarım araç seti olmasına rağmen, Beşeri Kalkınma ve Yetenek Yaklaşımını uygulamak için net bir metodoloji yoktur. Bu tez, Dört-P Modeli adında bir politika tasarımı ve değerlendirme çerçevesi sunmaktadır.

Bu tür teorik uzantılar, merkezi hipotezimizi test etmemize izin verir. Kalkınma nihayeti olmayan bir hedeftir. Bu nedenle, her bir yetenek için sosyal asgari eşikler, kalkınma aşamaları boyunca yukarı veya kalkınamama durumunda aşağı doğru kayacaktır. Yetenekler, diğer yeteneklerin aracı olduğu için, karmaşıklık artışı üzerinde çeşitli yetenek eşikleri olmalıdır. Genel olarak, "farklı ülke kümeleri için eşik örüntüleri nelerdir?" hipotezimizin ana araştırma sorusudur. Deneysel olarak, eşik kalıplarını belirlemeye yönelik araştırma sorumluluğunu ele almak için ülke düzeyindeki verilere çeşitli makine öğrenimi tekniklerini uygulayacağız.

Özellikle odak noktamız, karmaşık bir yetenek olan inovasyondur. Dört-P Modelimizin varsaydığı gibi, her bir yeteneği oluşturan bileşenler (kaynaklar ve kapasiteler gibi) vardır. Bu tür bileşenlerin iç mekanizmasını anlamak, inovasyon politikalarını tasarlamak ve değerlendirmek için hayati önem taşımaktadır. Yine, çeşitli ülke kümelerinin yenilik yeteneği bileşenlerini karşılaştırmak için ülke düzeyindeki verilerde makine öğrenimi tekniklerini uygulayacağız. Buna göre politika önerileri çıkaracağız. Hiçbir modelin mükemmel olmadığını kabul ediyoruz.

Ancak modelimiz, karmaşık yeteneklerin arkasındaki mekanizmayı ve bunların gelişimdeki temel rolünü keşfetmemiz için bize bir yol göstermektedir.

Tezin temel bulguları sırası ile şunlardır:

- Beşeri Kalkınma ve Yetenek Yaklaşımı, genel olarak temel beşeri ihtiyaçları ve ilgili yetenekler için uygulanmıştır. Bu çalışmada, temel beşeri ihtiyaçları aşan karmaşık yeteneklere (ve altında yatan) eşitsizliklere yönelik Beşeri Kalkınma ve Yetenek Yaklaşımı'nın potansiyelini gösterdik.
- Kalkınma, bireylerin yetenek alanlarını daha karmaşık yeteneklere doğru genişleterek ve kendi yaşamlarına değerli değişiklikler getirmek için bu yetenekleri özgürce kullanmalarına izin vererek, bireylerin seçeneklerini genişleten sürekli bir süreçtir.
- Devletlerin rolleri, değişimin yönünü belirlemek ve yeni yöne tam olarak uyan rekabetçi varlıkları sosyal olarak inşa etmektir. Genel olarak, bu rolleri yetenek alanının karmaşıklığı olarak adlandırıyoruz, nihai amaç ise insanlara yeteneklerini kullanma konusunda sınırlı seçenek bırakan eşitsizlikleri ortadan kaldırmaktır.
- Bu çalışmada, hipotezimiz, kalkınma aşamaları üzerinde karmaşıklık eşikleri olduğu ve araştırma amacımız, farklı ülke kümeleri için bu eşik modellerini belirlemektir. Yöntem olarak hipotezimizi test etmek için birbirini besleyen çeşitli makine öğrenmesi algoritmaları kullandık. Çalışmamız, bir ülkenin bilim, teknoloji ve yenilik kapasitesinin seviyesinin, o ülkenin karmaşık yetenekler potansiyelini belirlemek için hayati önem taşıdığını ortaya koymaktadır. Bu nedenle, Bilim, Teknoloji ve Yenilik küme aidiyetinden bağımsız olarak kalkınma için kritik bir eşiktir.

- Ancak, kalkınma ve ekonomik karmaşıklık üzerinde başka eşikler bulunduğundan, Bilim, Teknoloji ve Yenilik tek başına ülkelerin ekonomik performanslarını (bağımlı değişkenin ekonomik karmaşıklık endeksi olduğu yerde) açıklayamaz. En yüksek performans gösteren ekonomiler için eşitsizlik mutlak bir eşiktir. Bilim, Teknoloji ve Yenilik, en düşük performans gösterenler için ise tek eşiktir, ancak Bilim, Teknoloji ve Yenilik seviyelerini yükselttiklerinde, ek eşikler olarak eşitsizlikler ve temel beşeri ihtiyaçlar ile karşı karşıya kalmışlardır. Kalkınmakta olan ekonomiler için, düşük Bilim, Teknoloji ve Yenilik performans gösterenlerin belirli temel beşeri ihtiyaçlar eşiklerini aşması gerekirken, daha yüksek Bilim, Teknoloji ve Yenilik performansı gösterenlerin eşitsizlikleri bir eşik olarak ele alması gerekir.
- Bilim, Teknoloji ve Yenilik kapasitesine yapılan yatırımların geliştirme süreci boyunca ekonomik performansı artırması gerekirken, diğer birçok faktörün Bilim, Teknoloji ve Yenilik yatırımlarının tam kullanımını sınırladığı ve karmaşıklığın artırılması için bazı farklı eşiklerin aşılması gerektiği sonucuna varıyoruz.
- Ülkeler arası analizimiz, ekonomilerin ekonomik karmaşıklığa ulaşmak için kümelenme aidiyetlerine göre karşılaşacakları Bilim, Teknoloji ve Yenilik dışı eşikleri aşarken, Bilim, Teknoloji ve Yenilik yeteneklerini genişletmeleri gerektiğini ortaya koymaktadır.
- Yetenek Yaklaşımı literatürü, politika geliştirme için uygun bir çerçeve sağlamak için oldukça olgunlaşmamıştır. Bu nedenle bir politika çerçevesi oluşturduk (Dört-P Modeli olarak adlandırıyoruz).

- Dört-P Modelinde, her P, genel yetenek alanı içinde tamamlayıcı rolleri temsil eder. P1, kaynak eksikliğinin eşitsizlikler oluşturduğu durumlarda, bir sistemin kaynaklara erişimini en üst düzeye çıkarmayı amaçlar. İnovasyon yeteneği için P1, sistem için yeni bilgi üretmeyi veya edinmeyi amaçlar. P2, aktörlerin kaynaklarla ilgili kapasitelerini geliştirmeye yönelik politikaları içerir – kaynakları işlevlere dönüştürmek için aktöre özel bir dönüştürme faktörünü temsil eder. Analizimizde, P2 kategori politikaları altında bilgiyi özümseme kapasitesi bu rolü oynamaktadır. Çevresel dönüşüm faktörleri (yani kurumlar) P3 kategorisini temsil eder ve yenilik politikası literatürü, yetenek geliştirme ve kaynak-yetenek eşleşmesine izin veren sistemle ilgili kurumlar hakkında geniş bir perspektife sahiptir. Son olarak, P4, politik olarak hedeflenen işleyişin aktörler tarafından tercih edilmesini (bir seçim mekanizmasını) tanımlar.
- Bu nedenle, yenilik politikasının bileşenleri şunlardır: (P1) yeni bilgiye erişim ve yeni bilgi üretimi; (P2) gelişmiş bilgiyi özümseme kapasitesi; (P3) yenilik yeteneği için uygun kurumların geliştirilmesi; ve (P4) yenilik kabiliyetini uygulayabilmek için aktörlerin tercihleri, yani tutum değişikliği.
- Dört-P Modelini ampirik olarak değerlendirmek için bir kez daha çoklu makine öğrenme algoritmaları kullandık. İnovasyonun refah için hayati rolü genel kabul gören bir olgudur. En gelişmiş ekonomiler için kritik önemdeki değişken bilgidir. Bu gruptaki ülkeler kurumsal altyapılarını oluşturmuş ve kapasitelerini güçlendirmiştir. Bu nedenle temel mesele, refahı sürdürmek ve bunun yeniliklere dönüşümünü hızlandırmak için bilgiye erişimi sürdürülebilir kılmaktır.
- Gelişmekte olan ülkeler, genellikle gelişmiş ekonomilerin kurumlarını kendilerine adapte etmek, küresel bilgi dolaşımından faydalanmak için özümseme kapasitelerini arttırmak ve değişimi sağlayacak aktörlerin İnovasyon faaliyetlerini odaklanmayı tercih etmelerini sağlamak konumundadır.

- Kalkınma da geride kalan ekonomiler genellikle iyi yönetişime ve kurumların sürekli iyileştirilmesine ihtiyaç duyan sistemik başarısızlıklara sahiptir. Buna göre, değişken önem analizimizde kurumsalların baskın bir öneme sahip olduğunu gözlemledik.
- Duyarlılık analizi olarak, önceki adımın değişken önem analizinin araştırma bulgularına dayalı bir vaka çalışması gerçekleştirdik. Vaka çalışması, Türkiye'nin inovasyon politikası değişim sürecine uygulanan betimsel bir politika analizidir.
- Tanımlayıcı analizimiz, Türkiye'nin 1990'lar ve 2000'ler boyunca yenilikçilik kapasitesini geliştirmek için doğru yaklaşımı izlediğini ve P3 ve P1'e yatırım yaptığını ortaya koydu; bu da – ana hatlarıyla belirttiğimiz gibi – Türkiye'nin Bilim ve Araştırma entegrasyonu da dahil olmak üzere Avrupa'ya siyasi entegrasyonunun bir yansımasıydı.
- P3 ve P1 politikalarına ağırlık verilen artan Bilim, Teknoloji ve Yenilik yetenek geliştirme çabaları, ülkenin bir üst kümeye geçişi ile sonuçlandı. Ancak Türkiye'nin, politik araçlarını çeşitlendirmede sıkıntılar yaşadığını ve daha önce yer aldığı eski kümenin kurumlarına sıkıştığını gözlemledik.
- Genel olarak, analizimiz Dört-P modelinin ve küme analizimizin uygulanabilir bir politika tasarımı ve değerlendirme aracı sağlayabileceğini ortaya koydu.

Karmaşık Bir Yetkinlik Olarak İnovasyon Yetkinliği

Kalkınma, bireylerin ve sosyal grupların değer verdikleri bir hayatı yaşamalarını sağlamakla ilgilidir. Ancak bu devam eden bir süreçtir – hareketli bir hedeftir. Bireylerin ve oluşturdukları sosyal grupların ihtiyaç ve talepleri nitelik ve nicelik olarak gelişmektedir. Bir süreç olarak kalkınma, insanları sınırlı seçeneklerle baş başa bırakan yeni bir eşitsizlik düzeyini ortadan kaldırmayı gerektirir. Devletlerin bu süreçteki rolleri, değişimin yönünü belirlemek ve yeni yöne tam olarak uyan rekabetçi varlıkları sosyal olarak inşa etmektir. Genel olarak, bu rolleri yetenek alanının karmaşıklığı olarak adlandırıyoruz. Ancak, her yeteneğin bileşenleri vardır. Bu tür bileşenlerin iç mekanizmasını anlamak, hedeflenen yeteneği tasarlamak ve değerlendirmek için hayati önem taşır. Beşeri kalkınma ve yetenek yaklaşımının bu çalışmadaki temel katkısı, yeteneklerin nasıl çalıştığına, iç mekaniğine ve bileşenlerine ilişkin yapısal bir anlayış sağlamasıdır.

Ampirik analizimiz, bir ülkenin bilim, teknoloji ve yenilik kapasitesinin seviyesinin, o ülkenin karmaşık yetenekler potansiyelini belirlemek için hayati önem taşıdığını ortaya koymaktadır. Bu nedenle Bilim, Teknoloji ve Yenilik, küme aidiyetinden bağımsız olarak gelişme için kritik eşiktir. Ancak, kalkınma ve ekonomik karmaşıklık üzerinde başka eşikler bulunduğundan, Bilim, Teknoloji ve Yenilik tek başına ülkelerin performansını açıklayamaz.

Sonuçlarımız, eğitim indeksinin doğrudan bir belirleyici olmadığını göstermiştir. Birincil sebep, Küme 1 ve 3'ün eğitim endeksi değerlerinin birbirine çok yakın olmasıdır. Bu nedenle, eğitim düzeyi varyasyonu açıklayamamaktadır. En iyi performans gösterenler için (Küme 3'teki yüksek Bilim, Teknoloji ve Yenilik seviyeleri), tek ek eşik eşitsizliktir. En düşük performans gösterenler için (Küme 2'de düşük Bilim, Teknoloji ve Yenilik), Bilim, Teknoloji ve Yenilik tek eşiktir, ancak Bilim, Teknoloji ve Yenilik seviyelerini yükselttiklerinde (Küme 2'de nispeten daha yüksek Bilim, Teknoloji ve Yenilik), ek eşikler olarak eşitsizlikler ve temel beşeri ihtiyaçlar ile karşı karşıya kalmışlardır.

Gelişmekte olan ekonomiler için (Küme 1), düşük Bilim, Teknoloji ve Yenilik performans gösterenlerin belirli temel beşeri ihtiyaçlar eşiklerini aşması gerekirken, daha yüksek Bilim, Teknoloji ve Yenilik performans gösterenlerin için eşitsizlikleri bir eşik olarak ele alması gerekir.

Hem temel beşeri ihtiyaçlar hem de eşitsizlikler eşik seviyelerinin farklı kümeler için aynı olmadığına dikkat edilmelidir. Daha önce tanımladığımız gibi, kalkınma hareketli bir hedeftir. Bu nedenle, gerçek eşik seviyeleri geliştirme süreci boyunca değişmektedir (kümeler arasında aynı küme içinde hareket etmektedir).

Bu tez kapsamında temel hipotezimiz "Kalkınma aşamaları üzerinde karmaşıklık eşikleri vardır" şeklindedir ve araştırma sorumuz ise "Farklı ülke kümeleri için eşik seviyeleri nelerdir?" idi. Araştırma sonuçlarımız, farklı ülke kümeleri için eşiklerin varlığını doğruladı. Çalışmamızda her küme için eşikleri ve rakamsal değerlerini tespit ettik.

İnovasyon Politikası ve Yetenek Yaklaşımı

Bu bölüm, karmaşık yetenekler, özellikle yenilik yeteneği ve niteliksel değişimdeki rolü hakkındaki tartışmamızı genişletmeyi amaçladı. Yetenek Yaklaşımı, onu farklı alanlarda uygulamak için açıklayıcı teoriler gerektirir. Bu nedenle, yenilik yeteneği için, bu bölüm boyunca açıklayıcı teori olarak Yenilik Ekonomisi'ni tercih ettik ve bu, yetenek yaklaşımı kapsamında yenilik yeteneği fırsat alanının bileşenlerini belirlememize fırsat verdi. Bu bağlamda bilgi, inovasyon yeteneği alanı için birincil kaynaktır. Aynı zamanda, özümseme kapasitesi temel dönüşüm faktörüdür ve öğrenme, inovasyon kabiliyetinin uygulanma biçimidir.

Yetenek Yaklaşımı, uygulanması kolay pratik politika araçları sağlamak amacıyla geliştirilmiştir. Yaklaşım bu açıdan bir esneklik sunarken, hazır çerçevelerin olmaması, çeşitli alanlarda uygulanabilirliğini sınırlar.

Bu tez, her P'nin genel yetenek alanı içinde tamamlayıcı rolleri temsil ettiği Dört-P Modeli adlı bir politika çerçevesi önerdi. P1, kaynakların eksikliğinin eşitsizlikler yarattığı durumlarda, bir sistemin kaynaklara erişimini en üst düzeye çıkarmayı amaçlar. İnovasyon yeteneği için P1, sistem için yeni bilgi üretmeyi veya edinmeyi amaçlar. P2, aktörlerin kaynaklarla ilgili kapasitelerini geliştirmeye yönelik politikaları içerir, böylece bu kapasiteler dönüşüm faktörleri olarak işlev görür. Analizimizde, P2 kategori politikaları altında özümseme kapasitesi bu rolü oynamaktadır. Sosyo-çevresel dönüşüm faktörleri (yani kurumlar) P3 kategorisini temsil eder ve yenilik politikası literatürü, yetenek geliştirme ve kaynak-yetenek eşleşmesine izin veren sistemle ilgili kurumlar hakkında geniş bir perspektife sahiptir. Son olarak, P4, politik olarak hedeflenen yetkinliğin değişim aktörlerince tercih edilmesini (bir seçim mekanizması) tanımlar.

Önceki bölümün başlarında, devletin niteliksel değişim için rollerini (a) değişimin yönünü belirlemek ve değişimi bu yöne doğru motive etmek ve (b) yeni yöne uyacak şekilde sosyal olarak rekabetçi varlıklar inşa etmek olarak tanımlamıştık. Dört-P Modelimizde, P1, P2 ve P3, rekabetçi varlıkların oluşturulmasıyla, P3 ve P4 ise değişimin tanımlayıcı yönü ile ilgilidir.

Ardından, politika anlayışımızı yetenek yaklaşımı kapsamında daha iyi ifade etmek için bu çerçeveyi inovasyon politikasına uyguladık. İnovasyon politikasının bileşenleri şunlardır: (P1) yeni bilgiye erişim ve geliştirme; (P2) gelişmiş bilgiyi özümseme kapasitesi; (P3) inovasyon yeteneği için uygun kurumların geliştirilmesi; ve (P4) inovasyon kabiliyetinin değişim aktörlerince tercih edilmesi, yani tutum değişikliği.

Daha sonra nicel ve nitel olmak üzere iki aşamalı bir analiz uyguladık. Nicel olanda, yenilikçilik yeteneğinin Dört-P Model bileşenlerine uyan bağımsız değişkenlerden oluşan bir veri seti oluşturmak için birden çok kaynaktan veri topladık.

Bu adımda, daha önce tanımlanan her küme için ekonomik karmaşıklığın (bağımlı değişken) varyasyonunu açıklamak için Dört-P modelinin hangi bileşenlerinin daha önemli olduğunu belirlemek için makine öğrenme teknikleri uygulandı. Küme 3 (en iyi performans gösterenler) için P1 inovasyon kapasitesini geliştirmek ve ekonomik karmaşıklığı artırmak için en kritik politika uygulama araç setidir. Küme 1 için P2-P3-P4 eşit ağırlıklara sahipken, Küme 2 için P3 önemli bir etkiye sahiptir ve bunu P1 takip eder. Bu tür sonuçlar, Dört-P Modelinin operasyonel hale getirilmesi ve kümelenme aidiyetine bağlı olarak, genel inovasyon yeteneği alanı içinde inovasyon politikası karışımının nasıl tanımlanacağını belirlemek için oldukça pratik bir araç sunmaktadır.

Nitel araştırmamızda ise, bir önceki nicel araştırma sonucunun duyarlılık analizi olarak bir vaka çalışması gerçekleştirdik. Vaka çalışması, Türkiye'ye ve onun inovasyon politikası değişim modeline uygulanan betimsel bir politika analiziydi. Özetle, inovasyon politikası alanı ve yetenek alanı arasında, her bir inovasyon politikası aracını Dört-P modelinin bir bileşeniyle eşleştirmemize izin veren bir eşleştirme algoritması geliştirdik. Eşleştirme algoritması için etki alanı uzmanlarına başvurduk. Nihayetinde Türkiye'nin on yıllar boyunca inovasyon politikası değişimini değerlendirme fırsatı bulduk.

Analizimize göre Türkiye 1990'lar ve 2010 yılları arasında 2. kümenin bir parçasıydı ve 1. kümeye yükseldi. 1990'lardan başlayarak, Küme 2'deki göreceli konumu Bilim, Teknoloji ve Yenilik kapasitesi açısından nispeten düşüken, takip eden yıllarda Bilim, Teknoloji ve Yenilik yatırımlarında ilerlemeler gözlemledik.

Bu bölümdeki Adım 1 analizinin sonucu, Dört-P Modeli ile ilgili olarak, inovasyon politikası müdahalelerinin ağırlıklı olarak P3 (inovasyon kabiliyeti için uygun kurumların geliştirilmesi) ve P1'e (Yeni bilgiye erişme ve geliştirme) odaklanması gerektiğini vurguladı. Türkiye örneğinde, betimleyici analizimiz, Türkiye'nin doğru yaklaşımı izlediğini ve 1. Dönemde inovasyon yetkinliğini karmaşık hale getirmek için P3 ve P1'e yatırım yaptığını ortaya koydu; bu – ana hatlarıyla belirttiğimiz gibi – Türkiye'nin Avrupa ile olan siyasi entegrasyonunun Bilim, Teknoloji ve İnovasyon alanını da kapsamasının bir yansımasıydı.

P3 ve P1 politikalarına ağırlık verilmesi sonunu artan Bilim, Teknoloji ve Yenilik yetkinliği, Türkiye’yi bir üst kümeye taşımıştır. Ancak, Türkiye o zamandan beri Küme 1 düşük performanslı alt grubunda hareketsiz konumdadır.

Daha önce belirttiğimiz üzere kalkınma hareketli bir hedeftir. Keza İnovasyon politika araçlarının da bu sürece uyum sağlaması ve zaman içinde bulunulan kümeye göre güncellenmesi gereklidir. P3 ve P1, Küme 2 için temel konsantrasyonlar iken, Küme 1'e geçişten sonra, Dört-P Modelinin önerdiği bileşenler P4, P3 ve P2 şeklindedir. Bu Bölümün 2. Adımındaki betimleyici değerlendirmemiz, Türkiye'nin P4'e uygun şekilde dikkat ettiğini göstermektedir. Ancak P3 ve P2 ile ilgili olarak aynı şeyleri söyleyemiyoruz. P3 ile ilgili olarak, Küme 2 döneminin kurumlarına bağlı kalınmış ve çeşitlendirmeye gidilememiştir. Ayrıca, P2 için sınırlı türden politika araçlarından yararlanmaya devam edilmiştir.

Genel olarak, nitel değerlendirme metodolojimiz ve vaka çalışması sonuçları nicel değerlendirmenin sonuçlarını doğrulamaktadır.

Politika Önerileri

İnovasyon Politikası ve Dönüştürücü Değişim. Politika yapıcılar, günümüzde inovasyon politikaları tasarlamada kritik bir zorlukla karşı karşıyadır. Oldukça uzun bir dönem boyunca, her koşula uygun araçlara sahip jenerik politikalar politika çevrelerine egemen olmuştur. İnovasyon ajanslarının bölümlere ayrılması, çoğunlukla akademisyenlere veya endüstri oyuncularına odaklanan izole bilim, teknoloji ve inovasyon programlarıyla sonuçlandı. Benzer bir olguyu yenilik politikası ile sanayi politikası amaç ve araçları arasında da gözlemleyebiliriz.

Ancak ihtiyaçlar değişmektedir. Akademik çevrelerde, dönüştürücü değişiklikler ve misyon odaklı yaklaşımlar öne çıkmakta ve politika yapıcılarına yeni sorumluluklar yüklemektedir.

İnovasyon politikası düşüncesinde bir paradigma kayması olarak misyonlar, tek bir teknoloji yerine çeşitli teknolojileri bir araya getiren zorluklara (küresel veya yerel düzeyde) ve bunların birden çok sektörde uygulanmasına odaklanır. Bu nedenle, bir misyon, kapsamlı bir şekilde işbirliği yapması beklenen uygulayıcı kurumlar ve hedeflenen değişim aktörlerinin eşlik ettiği çeşitli inovasyon politikası araçlarını içeren bir politika karışımını nitelemektedir.

Bu tezdeki ampirik çalışmamız ve teorik uzantıların ortaya koyduğu gibi, inovasyon politikası tek başına dönüştürücü değişimi gerçekleştiremez. İnovasyon politikası araçlarının yararlarını en üst düzeye çıkarmak için mali, sosyal, ticaret, kalkınma vb. diğer sosyo-ekonomik politika araçları birlikte hareket etmelidir.

Beşeri Kalkınma ve Yetenek Yaklaşımı, inovasyon politikası tasarım sürecini işlevsel hale getirme potansiyeline sahiptir. Politika yapıcılar, mevcut yeteneklerin sınırlarını inceleyerek, yetenek alanı genişlemesini iki ana boyutta tasarlayabilirler: politika karışımının yönü ve sistemin kazanması gereken rekabetçi varlıklar. Yetenek alanı genişlemesi, aynı zamanda toplumdaki çeşitli derecelerdeki eşitsizliklerin üstesinden geldiği için bir fırsat penceresidir.

Bilim, Teknoloji ve Yenilik kabiliyeti ana faktör olmasına rağmen, ekonomiler yetenek geliştirme sürecinde çeşitli Bilim, Teknoloji ve Yenilik dışı eşiklerle karşı karşıya kaldıklarında Bilim, Teknoloji ve Yenilik yatırımlarını tam olarak kullanamayabilirler. Analizimiz, temel beşeri ihtiyaçları veya farklı düzeyde eşitsizliklerin eşik olarak ortaya çıkabileceğini gösterdi. Araştırma sonuçlarımız ayrıca dönüştürücü değişim sürecinde her 3 kümenin üyesi için hangi eşiklerin oluşabileceğini de ortaya koydu. Sonuç olarak, bir ekonomi belirli gelişme darboğazlarını aştığında, ulaşılan seviye nedeniyle yenileri ortaya çıkar. Ekonominin üstesinden gelmesi gereken yeni zorluklar ve yeni eşikler vardır.

Dönüştürücü değişimin bir sonucu olarak özgürlükler konusunda sosyal optimum noktasına ilişkin bir değişim söz konusudur. Gelişimin her aşamasında, insan onuruna uygun olanın ne olduğu konusunda farklılaşan anlayışlar vardır. Gelişimin ilk aşamalarında insan onuru, temel beşeri ihtiyaçlar ile ilişkilendirilebilir; bu, sonraki aşamalarda fırsatların daha da genişlemesini önleyen diğer kaynaklara veya yeteneklere doğru kayabilir.

Özetle, inovasyon politikası tasarım süreci, mevcut ekonomik karmaşıklık düzeyini analiz etmek ve mevcut üretim yetenekleri stokunu anlamakla başlamalıdır. Politika yapıcılar, bir sonraki adımda karmaşıklık ve yeni ürün bilgisi için potansiyel genişleme yolunu belirleyebilir. Ardından, politika yapıcılar politika hedeflerini misyonlara - çeşitli değişim ajanlarının arama çabalarını hızlandırmak için sorunları tanımlayan politika karışımları demetlerine - entegre edebilirler. Bu görevler aynı zamanda dönüştürücü değişimin yönünü ve fırsat alanını artıran gerekli rekabetçi varlıkları da belirler. Politika karışımının Dört-P Modelimize göre tanımlanmasını öneriyoruz. Buna paralel olarak, analitik araştırma bulgumuza dayalı olarak mevcut ve gelecekteki küme üyeliklerini belirlemek, kalkınma eşiklerini aşmak ve büyüme potansiyelini ortaya çıkarmak için diğer sosyo-ekonomik politika araçlarını devreye sokarak yenilik politikası araçlarının kullanımını en üst düzeye çıkartılmasını bir yol haritası olarak sunuyoruz.

Üretim Kompozisyonunu Genişletmek. İnovasyon politikası, bazılarının diğerlerinin aracı olduğu yetenekleri karmaşıklıştırarak fırsat genişletme sürecinde stratejik bir role sahiptir. İnovasyon politikalarının tasarım sürecinde, bu ilişkileri anlamak kritik önemdedir. Ülke kümelenmeleri arasında karmaşıklık artışı için eşikler değerler benzerlikler gösterse de ürün uzayı katmanına girdiğimizde farklılaşmalar söz konusudur. Aynı kümede bile ekonomiler, çeşitli ürün alanlarında değer üretme yetenekleri açısından önemli ölçüde sapma göstermektedir.

Bu nedenle, her ekonominin karmaşıklık yolculuğu benzersizdir ve mevcut kapasite alanı tarafından tanımlanır. Ürün uzayı genişletme stratejileri için gelecek araştırmalarında kullanılan 'Üç Ufuk' yaklaşımından yararlanabiliriz (Sharpe, 2013).

Bir öngörü aracı olarak Üç Ufuk Modeli geleceğimizi yapılandırmak için pratik bir yol sağlar. Ufuk 1, artan yeniliklerin statükoyu sürdürdüğü yerleşik kalıptır. Ufuk 3, dönüştürücü politikaların gelecekte beklenen sonucu olurken, Ufuk 2, yıkıcı inovasyonun girişimci faaliyetlerle gerçekleştiği Ufuk 1 ve 3 arasındaki köprüdür. Aracı, araştırmamıza uyarlamak için adapte etmeyi amaçlıyoruz.

Bu nedenle, Ufuk 1, bir ekonominin mevcut ekonomik karmaşıklık seviyesini oluşturan mevcut ürün alanının stoğudur. Ufuk 3, uygulanan inovasyon politikalarının yönünü ve oranını belirlediği, hedeflenen dönüştürücü değişimin beklenen sonucudur.

Ekonomik karmaşıklık etkileşimli bir süreçtir. Farklı ekonomiler arasında ticaretle ilgili karşılıklı bağımlılıklar söz konusudur. Bir ekonominin karmaşıklık pozisyonundaki artış, diğer bazı ekonomiler üzerinde etki eder. Bir ekonominin daha iyi veya benzer kalitede bir ürün üretmeye başladığını ve müşteriler için maliyetini düşürdüğünü ve bunun başka bir ekonomideki üreticilerin ihracat kapasitesinin azalmasına neden olduğunu varsayalım. Veya bir ekonomi, diğerlerinin yetenek karmaşıklığı için gerekli olan kaynaklara erişmesini engelleyebilir.

Çeşitli ekonomiler, Ufuk 3 hedefleri için benzer ürün alanlarını hedefleyebilirken, başlangıç noktaları (Ufuk 1) farklıdır. Ufuk 2 bu durumlarda taktiksel öneme sahiptir. Ufuk 1 ile 3 için en kısa yol (Ufuk 2) en verimli olmayabilir. Ekonomi bu yolda aşırı rekabet tuzağıyla karşı karşıya kalabilir (Ufuk 2). Genel olarak, Ufuk 3 için stratejik seçeneklere rağmen, Ufuk 2 için taktik operasyonlar da başarılı dönüşümler için hayati önem taşıyor.

Dört-P Modeli. Kalkınma, bireylerin ve sosyal grupların değer verdikleri bir hayatı yaşamalarını sağlamakla ilgilidir. Ancak bu devam eden bir süreçtir – hareketli bir hedeftir. Bireylerin ve oluşturdıkları sosyal grupların ihtiyaç ve talepleri nitelik ve nicelik olarak gelişmektedir. Bir süreç olarak kalkınma, insanları sınırlı seçeneklerle baş başa bırakan yeni bir özgürlüksüzlük düzeyini ortadan kaldırmayı gerektirir. Devletlerin bu süreçteki rolleri, değişimin yönünü belirlemek ve yeni yöne tam olarak uyan rekabetçi varlıkları sosyal olarak inşa etmektir. Genel olarak, bu rolleri yetenek alanının karmaşıklığı olarak adlandırıyoruz. Ancak, her yeteneğin bileşenleri vardır. Bu tür bileşenlerin iç mekanizmasını anlamak, hedeflenen yeteneği tasarlamak ve değerlendirmek için hayati önem taşır. İnsani gelişme ve yetenek yaklaşımının bu teze getirdiği gerçek değer, yeteneklerin nasıl çalıştığına, iç mekaniğine ve bileşenlerine ilişkin yapısal bir anlayış sağlamasıdır.

Bu noktada teorik katkımız, bir devlet kurumunun, kapasite karmaşıklığına yol açan etkili politika araçlarını tasarlayıp uygulayabileceği, Dört P Modeli olarak adlandırılan sistemik bir politika tasarım çerçevesidir.

Her P, ya belirli bir bileşeni ya da bileşenler arasındaki bir bağlantıyı ele alır. P1 kaynaklarla ilgilidir ve işlevleri gerçekleştirmek için gerekli kaynakların sağlanıp sağlanmadığını sorgular. P2, kapasite aracısının yetenekleri tanımladığı aracı tabanlı dönüştürme faktörü üzerindedir. P3, potansiyel uyumsuzlukların yetenek alanının iyi işleyişini engellediği sosyo-çevresel dönüşüm faktörlerini (kurumları) ele alır. P2 ve P3, kaynakların yeteneklere ve daha sonra da eylemlere ve varlıklara (işlevlere) dönüşümünü birlikte katalize eder. Son olarak, P4, politik olarak hedeflenen yetkinliğin değişim aktörlerince tercih edilmesi ile ilgilidir.

Tarihin de gösterdiği gibi, değer yaratan kaynaklara (bilgi, yetenek, enerji, arazi vb.) eşit olmayan erişim, her zaman eşitsizliklerin temel bir kaynağı olmuştur (Tilly, 2007). İktidar sahipleri bu kaynakları kontrol edebilir ve başkalarının bunları tam olarak kullanmasını engelleyebilir. Buna göre, bu tez ekonomik kalkınmayı, bir toplumun değer yaratan kaynaklara erişimin önündeki engelleri aştığı ve bunları değer üretmek için kullandığı bir süreç olarak tanımladı.

Ancak, bu devam eden sürekli bir süreçtir. Bir toplum, başlangıçtaki eşitsizlik düzeyinin üstesinden gelirken, yeni bir eşitsizlik düzeyiyle ve bu yeni düzeyin değer yaratan kaynaklarına erişmenin önündeki engellerle karşı karşıya kalacaktır. Politika tasarımında söz konusu kaynak ihtiyaç değişimi göz önünde bulundurulmalıdır.

Bir kaynak olarak bilgi her zaman eşitsizliklere konu olmuştur. Yirmi birinci yüzyıl dünyasında ise bilimsel bilgiye eşit olmayan erişim ve onun üretimi veya dağıtımı üzerinde eşit olmayan kontrol meselesi kritik öneme haiz bir eşitsizlik kaynağıdır. Bu bağlamda, yenilik yeteneği, bilgiyi değer yaratan bir kaynak olarak kullanmaya yönelik temel karmaşık yetenek olarak değerlendirilebilir.

Bu nedenle, teknolojik değişim sürecine önemli ölçüde katılım için inovasyon kapasitesini oluşturmak ve sürekli olarak karmaşık hale getirmek hayati önem taşımaktadır.

Bu ancak, inovasyon süreci boyunca halihazırda var olan yerel örtük bilgi kaynaklarından ve bağlama duyarlı adaptasyondan yararlanılarak gerçekleştirilebilir. Bu süreçte Dört-P modeli sistematik bir politika araç örgüsü tasarlamak için faydalı bir uygulama yöntemi olarak değerlendirilebilir.

Türkiye Vakası Üzerine. Analizimiz, Türkiye'nin 2010'dan sonra Küme 2'den Küme 1'e geçtiğini ancak o zamandan beri bu kümedeki konumunda takılıp kaldığını ortaya koydu. Dört-P model değerlendirmelerimiz sonucunda, Türkiye'nin bu başarılı dönemde yüksek bir Bilim, Teknoloji ve Yenilik yatırım getirisi elde edebilmesi için uygun inovasyon politikası araçlarını uyguladığını gördük.

Küme 1'e katıldıktan sonra düşük performans göstermesinin iki ana nedeni vardır. Türkiye bu kümenin düşük performans gösterenler grubunun bir üyesi olmuştur. Bu özel alt grup için, temel beşeri ihtiyaçlar Bilim, Teknoloji ve Yenilik yatırımlarıyla ekonomik karmaşıklığı iyileştirmek için aşılması gereken bir eşik olarak ortaya çıkıyor.

Türkiye'nin temel beşeri ihtiyaçları iyileştirme ivmesi zamanla azalmış, bu da daha fazla Bilim, Teknoloji ve Yenilik yatırımının verimliliğini sınırlandırmıştır. Buna ek olarak Bilim, Teknoloji ve Yenilik araçlarının kompozisyonu da önem arz etmektedir.

Kümelenme dönemi boyunca, Avrupa entegrasyon süreci, Türkiye'nin belirleyici temel kurumsal değişim katalizörü olmuştur. Dört-P Model analizimiz, Türkiye'nin Küme 2 üyesinin ihtiyaçlarına uyan uygun bir politika karışımı uyguladığını ortaya koydu. Ancak, Avrupa entegrasyon sürecinin çeşitli nedenlerle kesintiye uğraması ve siyasi kayma ile birlikte Türkiye, Avrupa'nın yeni kurumsal değişikliklerini benimsemekte imtina etmiş ve Küme 2 döneminin politika araçlarına bağımlı kalmıştır. Bu, hem makine öğrenimi algoritması sonuçlarımız hem de Dört-P Modelindeki vaka çalışması analizi ile doğrulanmıştır. Daha önce ana hatlarıyla belirttiğimiz gibi, kalkınmanın sürdürülebilirliği için yeteneklerin ve kurumların eşleştirilmesi bir gerekliliktir.

Türkiye'nin bu fasılda önerdiğimiz politika çerçevesini izlemesini öneriyoruz. Süreç, yeni bir ürün alanı seti (Ufuk 3) ve mevcut ürün alanı stoğunu (Ufuk 1) hedeflenenlerle birleştirenleri (Ufuk 2) tanımlamakla başlayabilir. Bu başlangıç süreci her ekonomi için farklılık gösterir. Bununla birlikte, inovasyon politikası karışımları esas olarak küme üyeliği ve ekonominin hareket etmeyi hedeflediği bir sonraki küme ile ilgilidir.

2000 ile 2019 arasında Türkiye, ECI sıralamasında 56. sıradan 40. sıraya yükseldi. Bu dönemde hızlanan bir karmaşıklık artışı, son on yılda mütevazı bir tempo takip etti. Şekil 65, Türkiye'nin ihracat sepetini ve ürün alanının karmaşıklık düzeyini göstermektedir. Türkiye'nin en önemli mal ihracatı orta karmaşıklık segmentinde yer almaktadır. Türkiye, son 15 yılda (2004-2019) ürün uzayına 22 yeni ürün ekledi ve çeşitlilik artış sıralamasında 10. sırada yer aldı. Ancak bu yeni ürünler, 2019 ihracat portföyünün yalnızca %1'ini temsil ediyor. Dolayısıyla Türkiye'nin yeterli sayıda yeni ürün çeşitlendirdiğini ancak hacim olarak yeni ürünlerin etkisinin zayıf kaldığını söyleyebiliriz. Söz konusu zorluk, Küme 1 ülkeleri arasındaki orta düzeyde karmaşıklık segmentindeki yüksek rekabetten kaynaklanmaktadır. Yani Türkiye çeşitlendirme yolculuğunda kalabalık bir bölgeye girmeyi tercih etmiştir.

Çeşitlendirmeye yönelik potansiyel yollar (artan ekonomik karmaşıklık) bir politika seçimidir. Yakındaki fırsatlara kısa atlamalar, bir ekonominin potansiyelinin kullanımını sınırlayabilir. Dengeli bir portföy yaklaşımı, hem uzun atlamalar için koordineli bir plan (Şekil 64'te Ufuk 3) hem de yakın ürün uzayını hedeflemeyi (Şekil 64'te Ufuk 2) gerektirir. Benzer bir şekilde, Türkiye, uzun vadeli çeşitlendirme fırsatları sunan hedeflere (yüksek karmaşıklıkta ürünler) karar vermelidir (nispeten daha yüksek karmaşıklık, daha uzak ürün uzaylarına yeni bağlantılar sunar). Bununla birlikte, değişimin yönünün belirlenmesi, eldeki rekabetçi varlıkları dikkate almalıdır - çünkü rekabetçi varlıkların oluşturulması kaynak yoğun bir süreçtir (bkz. Şekil 61). Türkiye ile ilgili vaka çalışmamız bize, P2 (kapasite artırma) ve P3'ün (kurumsal çeşitlendirme) Türkiye'nin Küme 1'e üyeliğinden bu yana ortaya çıkan yeni politika zorlukları olduğunu hatırlatıyor.

Türkiye'nin küme üyeliği ile uyumlu olması gereken politika seçenekleri için politika araçlarının çeşitlendirilmesine ve kaynak tahsisine ihtiyacı vardır. Küme 2 döneminde Türkiye, politika araçlarını karşılaştırma ve uyarlama için bir fırsat olarak Avrupa entegrasyon sürecinden yararlandı. Bugünlerde aynı coşkuyu görmüyoruz. Avrupa, 2020 itibarıyla inovasyon politikası yönünü yenilemekte ve politika araçlarını çeşitlendirmektedir. Bu tür bir dinamizmden yararlanmak, Türkiye'nin mevcut kilitleme durumundan kurtulmasını sağlayabilir.

Bölüm 5.2.'de (bkz. Şekil 61), dönüştürücü değişikliklerin (ekonomik faaliyetlerin karmaşıklığa doğru yeniden tahsisi dahil) çeşitli sosyo-ekonomik politika biçimlerini uyumlu hale getirmesi ve bu uyum için bir araç olarak misyon odaklı yenilik politikalarını tanımlaması gerektiğini belirttik. Misyonların tanımlanması ve bu misyonların sınırlarının belirlenmesi, Türkiye'nin değişim yönüne karar vermesini sağlayabilir. Böyle bir karar, Türkiye'nin ekonomisini temel rekabetçi varlıklarla birlikte çeşitlendirmenin potansiyel yollarını belirlemesine de olanak sağlayabilir. Günümüzde gelişmiş ekonomiler (Küme 3), çeşitli küresel zorlukları misyonları olarak tanımlayarak çeşitlendirme çabalarını yoğunlaştırma eğilimindedir. Bu, gelişmekte olan ekonomilerin (Küme 1) kendi stratejilerini tanımlamasına ve bu yolla karmaşıklık artırma fırsatı olarak değerlendirmesine izin verebilir.

Sonuç

Kalkınma, bireylerin ve sosyal grupların değer verdikleri bir hayatı yaşamalarını sağlamakla ilgilidir. Ancak bu devam eden bir süreçtir – hareketli bir hedeftir. Bireylerin ve oluşturdukları sosyal grupların ihtiyaç ve talepleri nitelik ve nicelik olarak gelişmektedir. Bir süreç olarak kalkınma, insanları sınırlı seçeneklerle baş başa bırakan yeni bir eşitsizlik düzeyini ortadan kaldırmayı gerektirir. Devletlerin bu süreçteki rolleri, değişimin yönünü belirlemek ve yeni yöne tam olarak uyan rekabetçi varlıkları sosyal olarak inşa etmektir. Genel olarak, bu rolleri yetenek alanının karmaşıklığı olarak adlandırıyoruz. Ancak, her yeteneğin bileşenleri vardır. Bu tür bileşenlerin iç mekanizmasını anlamak, hedeflenen yeteneği tasarlamak ve değerlendirmek için hayati önem taşır. Beşeri gelişme ve yetenek yaklaşımının bu teze getirdiği gerçek değer, yeteneklerin nasıl çalıştığına, iç mekaniğine ve bileşenlerine ilişkin yapısal bir anlayış sağlamasıdır.

Ekonomik gelişme, yapısal dönüşüm ve artan üretim karmaşıklığı ile ilişkilidir. Karmaşıklığın temel mekanizması evrimdir. Bir ekonomi için evrim, yeni endüstrilerin, teknolojilerin, organizasyonların ve yeteneklerin sürekli gelişimini varsayar. Karmaşıklık içinde, ekonomi ürünleri bilgi araçları olarak sunulur.

Yüksek düzeyde karmaşık bir ekonomik sisteme sahip bir ülke, çeşitli ekonomik zorluklarla, yani yüksek derecede eşitsizliklerle başa çıkabilir. Yetenek yaklaşımına ilişkin çağdaş tartışmalar, daha çok temel insan yetenekleri üzerinde yoğunlaşmaktadır. Bu nedenle, karmaşıklık teorisinin bu çalışmaya kattığı gerçek değer, yetenek yaklaşımını ekonomik eşitsizliklerden kaynaklanan daha karmaşık adaletsizliklere doğru genişletmemize izin vermesidir.

İnovasyon, temel ekonomik karmaşıklık süreçlerinden biridir. Artan ekonomik karmaşıklık, entegre bir politika girişimi tarafından yönlendirilen yenilik çabalarına uzun vadeli bir bağlılık gerektirir.

Eşitsizlikler yaratan ve ekonomik, çevresel ve toplumsal köklerden kaynaklanan çağdaş zorluklar, inovasyon politikası anlayışında yeni bir anlayışı doğurdu. Bu yeni çerçevede, inovasyon politikası yalnızca teknolojik sıçramayı değil, aynı zamanda yeteneklerdeki, kurumlardaki, endüstri yapılarındaki, düzenlemelerdeki ve sosyal tercihlerdeki değişiklikleri de hedeflemektedir. Bu nedenle, bu yeni anlayış, ekonomik karmaşıklık teorisi ve yetenek yaklaşımı ile bir uyum gerektirmektedir. Bu tez boyunca, çeşitli yenilik politikası araçlarının uygulanması için bu tür bağlantı ve önerilen politika tasarım mekanizmalarını kurmayı amaçladık.

Karmaşıklık, üretken ve yenilikçi yeteneklerin birleşik etkisidir. Bu nedenle ürün alanları, bu birikmiş rekabetçi varlıkları ve mevcut bilgi stokunu doğal olarak yansıtır. Aynı zamanda karmaşıklıklarını, dolayısıyla toplumun yeteneklerini artırarak ekonomik kalkınmanın araçlarıdır. Dönüştürücü inovasyon politikaları bu değişim sürecinde merkezi bir role sahiptir. Bu politikalar temelde Bilim, Teknoloji ve Yenilik yatırımlarına odaklansa da, önceki analizimiz, bir ekonomi belirli gelişme eşiklerini aşabilirse (temel beşeri ihtiyaçlar ile eşitsizlikler veya her ikisi şeklinde) Bilim, Teknoloji ve Yenilik tabanlı dönüşümlerin başarıya ulaştığını ortaya koydu.

Bu çalışmada, hipotezimiz, kalkınma aşamaları üzerinde karmaşıklık eşikleri olduğu ve araştırma amacımız, farklı ülke kümeleri için bu eşik modellerini belirlemektir. Gelişimin hangi aşamasında hangi eşiklerin ortaya çıktığı bu çalışmada küme düzeyinde detaylı bir şekilde incelenmiştir. Ayrıca, küme düzeyinde yine Dört-P Model değerlendirmemizde belirli inovasyon politikası karışımını ana hatlarıyla belirledik. Bu yönergeler, politika tasarım süreçleri için kılavuz olarak düşünülmelidir.

Ekonomiler arasında belirgin bir heterojenlik vardır, ancak bu farklılık esas olarak ürün alanlarıyla ilgilidir. Bu nedenle, bir ekonomi, ürün alanı karmaşıklığının arttırılmasıyla ilgili benzersiz geliştirme yolculuğunu tanımlayarak ve ardından eşik modellerini kabul ederek ve geliştirme yolculuğuna iyi uyan yenilik politikası karışımını tasarlayarak bu çalışmanın sonuçlarından yararlanabilir.

Bu tezin ampirik deęerlendirmelerinde tm politika aralarına eřit aęırlık verilmiřtir. Bildięimiz kadarıyla, yetenek yaklařımı ve yenilik politikasının kesiřtięi noktada sınırlı arařtırma mevcuttur. Bu nedenle, alternatif aęırlıklandırma seeneklerini deęerlendirmek iin herhangi bir kriterimiz yoktu. Bu, ampirik arařtırmamızın bir sınırlaması olarak dřnlmelidir. Gelecekteki alıřmalarda, politika araları iin kme tabanlı bir aęırlıklandırma modeli test edilebilir.

Drt-P Modelimiz, inovasyon yeteneęi deęerlendirmesi iin deęerli bilgiler saęlar. Gelecekteki alıřmalarda, dięer karmařık yetenekler ve ilgili politikalar Drt-P Modeli aracılıęıyla gzden geirilebilir. Hatırlatmak gerekirse, belirli bir yetenek seti iin Yetenek Yaklařımını uygulamak iin aıklayıcı bir teori gereklidir. İnovasyon politikasını incelerken inovasyon ekonomisini kullandık. Dięer karmařık yetenekleri incelerken uygun aıklayıcı teoriyi dřnmeli ve karar vermelidir. Yenilik zerine aędař arařtırmalar, giriřimcilięin sosyal ve iřbirliki doęasını tanımlar. Sosyal inřanın aktif uygulamaları olarak giriřimcilik srelerine ıřık tutmak ve kolektif giriřimcilięi bir deęiřim aktr olarak anlamak, gelecekteki alıřmalarda yetenek yaklařımını altında ideal arařtırma konuları olabilir.

Son olarak, politika yapıcılar dijitalleřme, veri gizlilięi, son teknolojiler, iklim deęiřiklięi vb. tarafından tetiklenen yeni nesil eřitsizliklerin ykseliřini gz nnde bulundurmalıdır. Bu tr karmařık eřitsizliklerle bařa ıkmak, yn belirlemeyi ve gerekli karmařık yetenekler etrafında rekabeti varlıklar oluřturmayı gerektirir. Bu nedenle, karmařık yeteneklerin doęasını anlamak ve bunlar zerinde yetenek yaklařımının esasları aracılıęıyla gelecekteki arařtırmaları devam eden bir sre olacaktır. Uzun lafın kısıası, kalkınma hareketli bir hedeftir ve toplumlar, ykselen eřitsizliklerle bařa ıkmak iin karmařık yeteneklere ihtiya duymaya devam etmektedir.

D. ANALYSED PUBLICATIONS FOR VARIABLE SELECTION

Table 19. Analysed Publications for Variable Selection

Explanatory Factor: Basic Human Needs (BHN)
(Saith, 2011)
(Allen, 2011)
(Mukhopadhyay, 2011)
(Herrero et al., 2012)
(Hu and Mendoza, 2013)
(Salehi-Isfahani, 2013)
(Levine et al., 2014)
(Langford and Winkler, 2014)
(Fukuda-Parr and Orr, 2014)
(Devkota and Upadhyay, 2015)
(von Fintel, 2017)
(Okkolin et al., 2018)
Explanatory Factor: Inequality (INQ)
(Greenstein et al., 2014)
(Díaz-Martínez and Gibbons, 2014)
(Wendelspiess Chávez Juárez, 2015)
(Liberati, 2015)
(Ray and Sinha, 2015)
(Wisor, 2016)
(Chiappero-Martinetti, 2016)
(Martínez, 2016)
(Burchardt and Hick, 2018)
Explanatory Factor: Democracy (DEM)
(Nussbaum, 2010)
(Cecchini and Notti, 2011)
(Fukuda-Parr, 2011)
(Jayadev, 2011)
(Clark and Fennell, 2014)
(Peruzzi, 2014)
(Byskov, 2017)
(M. Walker, 2018)

Explanatory Factor: Education (EDU)
(Biggeri and Santi, 2012)
(Wood and Deprez, 2012)
(Vaughan and Walker, 2012)
(Manion and Menashy, 2013)
(Mutanga, 2014)
(Unterhalter, 2014)
(Okkolin et al., 2018)
Explanatory Factor: Gender (GEN)
(Addabbo et al., 2010)
(Sanchíz, 2010)
(Béranger and Verdier-Chouchane, 2011)
(G. Sen and Mukherjee, 2014)
(J. Walker et al., 2014)
(Greco et al., 2018)
Explanatory Factor: Science, Technology, Innovation (STI)
(Oosterlaken, 2011)
(Boni and Gasper, 2012)
(Ranis and Zhao, 2013)
(O'Donovan and Smith, 2020)
Explanatory Factor: Trade, Economy, Financial Flow (TEF)
(Sharma, 2010)
(Singh, 2012)
(Stiglitz, 2012)
(Burger et al., 2017)
Explanatory Factor: Work and Employment (WEM)
(Jolly, 2010)
(Van Der Hoeven, 2014)

Source: Journal of Human Development and Capabilities

E. EXPERT OPINION SURVEY

Below is the content of the survey that we have applied to selected experts, followed by the matching template (Table 20).

Expert Opinion - Pattern Matching Exercise

In this survey, we aim to benefit from the opinion of innovation policy practitioners to match Policy Instruments (in each row) with Innovation Capability Components (in the columns). The Policy Instruments are selected from OECD's and EC's recent innovation surveys. Policy Instruments are designed to sophisticate the Innovation Capability. Our goal is to understand how practitioners perceive the link between the Policy Instruments and the outcome in terms of Innovation Capability. The components of Innovation Capability are identified based the 'Capability Approach'.

Those components are as follows:

- Resource (for innovation policy, the main resource is knowledge)
- Capacity (in this study, the capacity is the absorptive capacity which facilitates the process of recognition, assimilation and application of new knowledge)
- Institutions (socio-environmental conversion factors that catalyses exploration of new knowledge and exploitation of new-to-the-system knowledge)
- Choice (capability is a 'potential' and agents should voluntarily choose to activate this potential)

Even though one instrument might address multiple components, please select only one column for each row.

Hint-1: Research funding aims to generate new knowledge (resource)

Hint-2: Supporting entrepreneurship aims behavioural change (choice)

Further on, please match each instrument with one role of governments in innovation policy objective setting, which are defining the direction of change and constructing competitive assets.

Thank you so much for your attention and participation.

Okan Kara

Table 20: Pattern Matching Exercise for Experts-1

Innovation Policy Instruments	Four P Model Axis				Government Role Matching	
	Resource	Capacity	Institutions	Choice	Direction of Change	Competitive Assets
01. National science, technology, and innovation plan/strategy						
02. Sector and technology specific plans						
03. Horizontal policy coordination						
04. Evaluation and impact assessment						
05. Competitive research funding						
06. Exploratory and high-risk research						
07. R and D infrastructure						
08. Centres of excellence						
09. IPR measures						
10. Financial support to business R and D						
11. Knowledge-intensive FDI						
12. Incubators and accelerators						
13. Support to venture capital						
14. Tax incentives						
15. Entrepreneurship culture						
16. Collaborative research programmes						
17. Clustering and networking						
18. Intersectoral mobility						
19. Commercialisation of public research results						
20. Science and technology parks						
21. Support to human resources for R and D						
22. Innovation related skills education						
23. Public procurement						
24. Standards						

F. LIST OF INNOVATION POLICY INSTRUMENTS

Table 21: Innovation Policy Instruments (Turkey)

ID	Year	Meeting #	Name of Instrument
1	1989	1	National STI Strategy (1983-2003)
2	1989	1	Revised TUBITAK Legislation
3	1989	1	Defence Sector R and D Support
4	1989	1	Supporting Knowledge- Intensive FDI
5	1989	1	Research Funding for Universities
6	1989	1	Tax incentive for Business R and D
7	1993	2	National ST Strategy (1993-2003)
8	1993	2	Brain gains from Former Soviet Union Researchers
9	1993	2	Scholarships for PhD in abroad by TUBITAK
10	1993	2	Scholarships for PhD in abroad by Ministry of Education
11	1993	2	Scholarships for PhD in abroad by Council of Higher Education
12	1993	2	Technology Development Centres in Universities
13	1993	2	R and D Infrastructure Funding by National Planning Agency
14	1993	2	Business R and D Support Programme by TTGV
15	1993	2	Establishment of Turkish Academy of Science
16	1993	2	Support for International Publications
17	1997	3	Leap forward in ST Project
18	1997	3	Establishment of Patent Institute
19	1997	3	Direct R and D Business Support by TUBITAK
20	1997	3	National Information Infrastructure
21	1997	3	WTO Regulations
22	1997	3	Regulation of Techno parks
23	1997	3	National STI Policy and TUBITAK's mission
24	1997	3	National R and D Budget Allocation
25	1997	3	Legislation on VC Funds
26	1997	3	Industry-University Joint Research Centres
27	1997	3	National Committee on Aviation and Defence
28	1997	3	Financial Support for international R and D programmes

ID	Year	Meeting #	Name of Instrument
29	1998	4	Development of e-infrastructure
30	1998	4	National Academic IT Network
31	1998	4	Agriculture Research Strategy
32	1998	4	Energy Technologies Research Strategy
33	1998	4	Defence Sector Technology Strategy
34	1999	5	Capacity building of National Patent Institution
35	1999	5	Capacity building of National Accreditation Centre
36	1999	5	New Business R and D Support Programme by TTGV
37	1999	5	National Innovation Project
38	1999	5	Protocol on leveraging off-set for STI Capacity Building
39	1999	5	Budget Allocation for R and D
40	1999	5	Restructuring Support to SMEs in STI
41	1999	5	Policy on Public Procurement
42	1999	5	Regulation on R and D Support
43	1999	5	Clean-tech Strategy
44	1999	5	TUBITAK-TOKTEN Brain Gain programme
45	1999	5	DOPROG Brain Gain Programme
46	1999	5	Bio-tech Strategy
47	1999	5	R and D Strategy on natural disaster
48	1999	5	Atomic Accelerator Centre
49	2000	6	National STI Strategy (2003-2023)
50	2000	6	Foresight Study - Vision 2023
51	2000	6	Resource Analysis in STI
52	2000	6	Bio-technology R and D Support Program
53	2000	6	Enhancement of National Academic IT Network
54	2000	6	Energy R and D Support Program
55	2000	6	Coordination of Earthquake Research Activities
56	2000	6	Budget Allocation for R and D over Public Procurement
57	2000	6	Social Science Support Program
58	2000	6	Venture Capital Support Program by TTGV
59	2001	7	Budget Allocation for Business R and D
60	2001	7	Regulation on Technology Development Zones
61	2002	8	Participation into 6th FP of EU
62	2002	8	National Multiplier Network

ID	Year	Meeting #	Name of Instrument
63	2002	8	Ministry of Treasury - Academic Research Support Program
64	2003	9	Human Resource Analysis on STI
65	2003	9	National boron research institute
66	2003	9	Research on Thorium as an energy resource
67	2004	10	EU National Coordination Office
68	2004	10	Networking Support for EU Projects
69	2004	10	National STI Policy Implementation Plan (2005-2010)
70	2004	10	Future SCST Meetings' Planning
71	2004	10	Setting-up of TARAL
72	2005	11	Launching TARABIS System
73	2005	11	National Young Researcher Career Programme
74	2005	11	Establishment of Social Science Research Group in TUBITAK
75	2005	11	Setting up National STI KPIs
76	2005	11	Defining National STI Priorities
77	2005	11	National Public Research Program
78	2005	11	Endorsement of OECD Reference Books in TARAL
79	2005	11	Establishment of Defence Research Group in TUBITAK
80	2005	11	Establishment of Space Research Group in TUBITAK
81	2005	11	Techno-entrepreneurship program
82	2005	11	IP Protection Support
83	2005	11	Science and Society Program
84	2005	11	Tax Incentive for R and D
85	2005	11	Improvement on STI Statistics
86	2005	12	Budget Increase for Academic Research under TARAL
87	2005	12	Budget Increase for Innovation Grants under TARAL
88	2005	12	Budget Increase for Human Resource Development under TARAL
89	2005	12	National Agriculture Research Program
90	2005	12	National Health Research Program
91	2005	12	National Energy Research Program
92	2005	12	National STI Targets for 2010
93	2005	12	New Legislation of TUBITAK
94	2005	12	Infrastructure Resource Analysis
95	2005	12	Excellent Centre Support via EU FP6

ID	Year	Meeting #	Name of Instrument
96	2005	12	Formula G Organization
97	2005	12	SANTEZ Program
98	2006	13	National Environmental Research Program
99	2006	13	National Justice and Law Research Program
100	2006	13	Science in Primary and Secondary Education Program
101	2006	13	Restructured Scholarships for Bachelors, Masters, PhDs and post-docs
102	2006	13	R and D Funding Policy of TUBITAK for 2006
103	2006	14	Cooperation with International Agencies on Space Research
104	2006	14	STI Policy in 9th Development Plan
105	2006	14	New Patent Granting Support Program
106	2006	14	EU Accession Process in STI Policy
107	2006	14	National Security Research Program
108	2006	14	National Social Politics Research Program
109	2006	14	National Innovation Strategy and Activity Plan (2007-2010)
110	2006	14	National Transportation Research Program
111	2006	14	National Culture and Tourism Research Program
112	2006	14	National Education Research Program
113	2006	14	Budget Increase for R and D Centres Support Program
114	2006	14	Sector-specific Platform Establishment Support Program
115	2006	14	International STI Strategy
116	2007	15	New regulation on industrial R and D support program
117	2007	15	STI Strategy on Climate Change
118	2007	15	National Nuclear Research Program
119	2007	15	Igniter Research Centre
120	2007	15	Marine Sciences Research Centre
121	2007	15	Hybrid Vehicles Research Centre
122	2007	15	Secure Space Infrastructure
123	2007	16	Brain Gain Initiative
124	2007	16	Initial R and D Project Support for SMEs
125	2007	16	Techno-entrepreneurship program
126	2007	16	Human Resources in STI Program
127	2007	16	Tax incentive for R and D activities
128	2008	17	Science Centres Funding Program

ID	Year	Meeting #	Name of Instrument
129	2008	17	Improvement of Investment Environment
130	2008	17	Global Researcher Program
131	2008	17	Participation to International R and D Projects Support Program
132	2008	17	R and D Budget Allocation for 2009-2011
133	2008	18	International Researchers Coordination Council
134	2008	18	Alliance of civilizations scholarships
135	2008	18	City-level Innovation Platforms Initiative
136	2008	18	Cell Isolation Research Centre
137	2008	18	Drilling Research Centre
138	2008	18	Lidar Research Centre
139	2008	18	OLED Research Infrastructure
140	2008	18	Electrical Vehicles Lab
141	2009	19	Strategy on gifted individuals
142	2009	19	Policy Responses to The Economic Crises
143	2009	19	FARABI Brain Exchange Program
144	2009	19	Industrial R and D Centre Support Program
145	2009	20	STI Strategy 2011-2016
146	2009	20	Agricultural Crops Research Centre
147	2009	20	Explosives Research Centre
148	2009	20	Experimental Health Research Centre
149	2009	20	CMOS Infrastructure
150	2009	20	Microwave Infrastructure
151	2009	20	Quantum Cryptology Research Centre
152	2009	20	Antenna Testing Lab
153	2009	20	Bio-security Lab
154	2009	20	Innovation in Food Research Centre
155	2009	20	Spectroscopy Lab
156	2009	20	Environmental Testing Centre
157	2009	20	Development Agencies - Entrepreneurship Support Program
158	2009	20	Development Agencies - Innovation Support Program
159	2010	21	STI Human Resources Strategy
160	2010	21	National Strategy on Water, Energy and Food Security Research
161	2010	21	Brain Gain Program for Young Researchers

ID	Year	Meeting #	Name of Instrument
162	2010	21	Program on Development of International Competitiveness
163	2010	22	Research Infrastructure National Strategy
164	2010	22	Technology Development Centres in Universities
165	2010	22	Biotech Research Centre
166	2010	22	Software Testing Centre
167	2010	22	Security Systems Infrastructure
168	2010	22	Thrust Motors Research Centre
169	2010	22	Energy Storage Research Centre
170	2010	22	KOSGEB Collaboration for Competition Program
171	2011	23	Strategy Document on Automotive Sector
172	2011	23	Strategy Document on Machinery Sector
173	2011	23	Strategy Document on ICT Sector
174	2011	23	STI Strategy on Water
175	2011	23	STI Strategy on Energy
176	2011	23	STI Strategy on Food
177	2011	23	National Innovation System Targets towards 2023
178	2011	23	Coordination Committee on STI Support Programs
179	2011	23	Strategy on R and D Intensive Start-ups
180	2011	23	Support Program on Technology Transfer Offices
181	2011	23	Support Program on Incubators
182	2011	23	Support Program on Enhancement of Entrepreneurial Culture
183	2011	23	National Botanic Park for Research
184	2011	23	Early Diagnosis Research Centre
185	2011	23	Natural Language Processing Centre
186	2011	23	Bio-information Research Centre
187	2011	23	Natural Gases Research Centre
188	2011	23	Wind Tunnel Infrastructure
189	2011	23	Ballistic Research Centre
190	2012	24	Development of E-Sources for Science Education
191	2012	24	Participation into Horizon 2020
192	2012	24	TUBITAK 1003 - Targeted Academic R and D Program
193	2012	24	TUBITAK 1511 - Targeted Industrial R and D Program
194	2012	24	Photovoltaic Test Centre

ID	Year	Meeting #	Name of Instrument
195	2012	24	Boron in Agriculture Research Program
196	2012	24	National Energy Research Platform
197	2012	24	Technology-based Product Patent Support
198	2012	24	Technology-based Product Marketing Support
199	2012	24	Technology-based Product Investment Support
200	2012	24	Science Museum Support Program
201	2012	24	Entrepreneurship Training Program
202	2012	24	Accelerating the Commercialisation of Technology VC FoF
203	2012	24	Entrepreneurial and Innovative University Index
204	2012	24	TUBITAK 1512 - Entrepreneurial Support Program
205	2012	24	Update on Technology Development Zones Regulation
206	2012	24	TUBITAK 1505 - Technology Transfer Program for SMEs
207	2012	24	Photovoltaic Research Centre
208	2012	24	Turbine Design Infrastructure
209	2012	24	Test Centre for Counter Measure Explosives
210	2012	24	Material Characterization Centre
211	2012	24	Technology Bank for Least Developed Countries
212	2012	24	Clustering Support Program
213	2012	24	Tax Incentives for Angel Investing
214	2013	25	DSI Water R and D Support Program
215	2013	25	Targeted Calls Program on Public Pre-Procurement
216	2013	25	Targeted Calls Program on Defence Research
217	2013	25	Public Bodies Cooperation on Science Education
218	2013	25	Science and Society Support Program
219	2013	25	1514 TUBITAK VC Support Program
220	2013	25	E-Infrastructure Centre
221	2013	25	National Strategy on Health Research
222	2013	26	SME Support Program for Listing in Stock Exchange
223	2013	26	Research Infrastructure Roadmap
224	2013	26	EN-AR Energy Research Support Program
225	2014	27	TUBITAK 1601 - Capacity Building in Innovation and Entrepreneurship
226	2014	27	Entrepreneurial Award Program

ID	Year	Meeting #	Name of Instrument
227	2014	27	Technology-based Product Investment Promotion Program
228	2014	27	High Power Laser Centre
229	2014	27	Big Data Research Centre
230	2014	27	Battery Technologies Excellence Centre
231	2014	27	Materials in High Temperatures Centre
232	2014	27	Biomechanism Excellence Centre
233	2014	27	Marine Research Centre
234	2014	27	Remote Pilot Lab
235	2014	27	Regulation on National Technology Promotion in Public Procurement
236	2014	27	Tax Exemption on Commercialisation of IPR
237	2015	28	Business Incubations on Abroad
238	2015	28	TUBITAK 1515 Leading Labs Program
239	2015	28	Updated Regulation on the Management of Research Infrastructures
240	2015	28	National Mobility Research Centre
241	2016	29	Transportation Research Support Program
242	2016	29	National Strategy on Nanotechnology
243	2016	29	National Strategy on Biotechnology
244	2016	29	Program on Exploiting Research Capability of Universities
245	2016	29	Solar Panel Research Centre
246	2016	29	Automotive Excellence Centre
247	2016	29	Motor Excellence Centre
248	2016	29	Coopetition Program
249	2016	29	Roadmap on Smart Manufacturing
250	2016	29	Private Market by Istanbul Stock Exchange

G. EUROPEANIZATION OF TURKISH RESEARCH AREA

Table 22: Europeanization of Turkish Research Area

Source: Compiled by the author from SCST Reports

5th Framework Programme Participation
The participation of Turkey in EU Framework Programmes entered the agenda following the acquisition of the candidate country status in the Helsinki Summit. It was discussed for the first time in Brussels on 25 March 1999, in the meeting held between the representatives of Turkish government officials and the EU Commission. The participation of the candidate countries in the Research and Technological Development Programmes of the Union was conceived as an important step towards full membership. The participation of Turkey to the 5th Framework Programme (FP5) through a partnership agreement necessitating a participation fee which was not deemed appropriate within the prevailing conditions of the time, and the participation on a project basis so as to prepare for the next programme was preferred. Accordingly, the Turkish researchers, which were accepted to participate in a project within the context of the FP5, were granted by TUBITAK (the Scientific and Technological Research Council of Turkey).
6th Framework Programme Participation
In the 6th Science and Technology Supreme Council Meeting (held on 13 December 2000), the decision to complete the necessary procedures for Turkey to participate in the 6th Framework Programme was taken. The commitment of Turkey to participate in the 6th Framework Programme was stated in the national Programme announced on 19 March 2001, and the participation to the prevailing 5th Framework Programme on a project basis was encouraged. In line with this decision, the task of directing the related organisations to Framework Programs has been delegated to TUBITAK.

European Union Council of Ministers, with the decision it has taken on 5 June 2001, has given the EU Commission the authorization to initiate negotiations related to signing of a framework agreement that would enable Turkey to participate in all community programmes on equal terms with other candidate countries which have signed such agreements. Signing such a framework agreement is the prerequisite of participation in the EU Framework Programme.

During the 7th Supreme Council Meeting, 24 December 2001, as the participation in the Sixth Framework Programme required the payment of a considerable participation fee, the importance of the production of numerous and international level projects by the Turkish scientists, the acquisition of positive evaluation from the EU screening, and bringing back as much as possible percentage of this sum was emphasized. It was also stressed that the success in this field requires the internalisation of the evaluation criteria and the reflection of these criteria to the project proposals, and furthermore excellent application of project proposal preparation skills both as to form and as to content. The need for establishing a mechanism of “Contact Points” which has been applied successfully for this purpose in other candidate countries, also in our country with the cooperation of EU, has been discussed.

An evaluation report related to the costs and benefits of participation in the European Union Sixth Framework Program has been submitted on April 2002 for the 8th Supreme Council Meeting. The main points in the report are as follows:

- Participation in the European Union Sixth Framework Program is an opportunity that enables Turkey to mature in the field of science and technology together with Europe. There is a cost involved, as with every development, and if this cost is not paid now, the developments in technology and its reflection on people’s welfare would render us a bystander position in these concerns.
- Although the amount to be paid might seem high compared to national resources allocated to R&D, it would not seem that much high compared to the contribution of Turkey to R&D expenditures of foreign players through imported products

- There is great benefit for Turkey, which is preparing to enter the European Union, in initiating the integration process with Europe in the field of science and technology as soon as possible. If Turkey does not participate in the programme at this stage, the increasing of the distance with other candidate countries that benefit from resources obtained through this program would be unavoidable. As a result, the relative position of Turkey in this field would undoubtedly be much weaker than today.
- If Turkey is to sustain her claim of reaching the contemporary level of science and technology, Turkish science and technology circles must compete and succeed in the international field. The Turkish research institutions and industrial establishments might not have the sufficient experience for competition at this level, but they have the sufficient ability and capacity.
- Targeting to develop in cooperation with the EU and together with them in the field of science and technology is in line with the “reaching the contemporary civilisation level” concept. To participate in the European Union Sixth Framework Program, to pay the price and face the hardships is the unavoidable initial steps of this development. The issue must be considered beyond a EU accession perspective, and be approached as a healthy and strong entry opportunity to the global competition, which should not be missed. The amount set forth is not so big compared to such an objective.

Accordingly, the Council decided that, negotiations aiming at the participation in the EU Sixth Framework Program from the start, to be conducted with the European Commission are to be initiated while keeping in mind the economic difficulties Turkey faces.

During the 9th Supreme Council Meeting, 06 February 2003, it was decided to the establishment of “Sixth Framework Program Coordination Council”, for determining the strategies that would enable Turkey to obtain the maximum benefit from the Program for developing solutions to legal, administrative and financial implementation difficulties.

The developments concerning the participation of FP6 had been reported during 10 th and 11 th Supreme Council Meetings.
7th Framework Programme Participation
It has been decided on the 12 th Supreme Council Meeting that TUBITAK, in cooperation with related government agencies, is the responsible organisation for carrying out the negotiations with the European Commission on the determination of the probable participation fees and other relevant matters related to Turkey's participation in EU 7 th Framework Programme.
Developments concerning capacity building for utilizing FP system had been reported on the 13 th Supreme Council Meeting on March 2006.
During the 14 th Supreme Council Meeting, 12 September 2006, it was stated that negotiations on FP7 participation with the EU Commission is being carried out both at the technical level and at higher levels. It has also been stated that science and research chapter has been the first chapter where actual negotiations have been initiated and has been temporarily closed.
During the 15 th Supreme Council Meeting, 07 March 2007, it was stated that TUBITAK is conducting its studies pertaining to FP7 under 5 main strategic objectives. These were presented as: strengthening the administrative infrastructure, providing information and training, strengthening cooperation, efforts targeting other countries, and carrying out the negotiations at the technical level.
During the 16 th Supreme Council Meeting, 20 November 2007, it was stated that the Memorandum of Understanding formalizing the participation of Turkey to the EU 7 th Framework Programme was signed on 1 June 2007. The decision on the subject was published in the Official Journal dated 29 June 2007.
Developments related to the participation in the Framework Programmes were presented during the 17 th , 18 th , 19 th , 20 th , 21 st , 22 nd and 23 rd Supreme Council Meetings.

H2020 Program Participation

During the 24th Supreme Council Meeting, 07 August 2012, it has been stated that Chapter Nr.25 “Science and Research”, is the only chapter that has been opened and temporarily closed to negotiations, and that the main component of the harmonisation studies carried out in this field is the participation in the framework programmes. It has been stressed that Turkey has participated to the FP6 that covered the 2002-2006 period and the 7th Framework Programme, with an associated country status. It has been decided that, TUBITAK, in cooperation with relevant Ministries, is the responsible organisation for conducting the technical negotiations with the European Union, related to participation of Turkey to the Horizon 2020 Programme, the determination of the probable participation fee and other related matters.

Developments related to the participation in the Framework Programmes were summarized during the 25th Supreme Council Meeting. Turkey’s Position Paper on Horizon 2020 was submitted to the European Commission. A decision was given on ex-post evaluation for Turkey’s FP7 participation which would contribute to the decision-making process of H2020 participation. Ex-Ante Impact Assessment of “Horizon 2020: The EU Framework Programme for Research and Innovation” for Turkey was also initiated.

During the 26th Supreme Council Meeting, the information was shared with respect to H2020 negotiations including the draft version of H2020 negotiations position paper.

Horizon 2020 Programme was kick-started on January 2014. The negotiations with the European Commission, concerning Turkey’s association to Horizon 2020 Programme, was held. The association agreement was signed on 04 June 2014. TUBITAK has appointed to coordination body for Horizon 2020 Programme in Turkey. This progress was reported during the 27th Supreme Council Meeting.

Progress with respect to Horizon 2020 participation of Turkey was reported during the 28th and 29th Supreme Council Meetings.

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