Afro Eurasian Studies, Vol. 1, Issue 2, Fall 2012, 51-68

Determining Strategic R&D Sectors In Turkey: An Import-Based Approach

Hatice Karahan*

Abstract

Based on the postulates of the endogenous growth theory and the findings of a number of related empirical studies, nations that endeavor to sustain considerable economic growth in the long-run should invest more in R&D activities which should be designed in an effective way considering the needs as well as the prospects of the country. Therefore, national R&D policies should be firmly constructed based on effective diagnoses, which ideally require well-established procedures. In this regard, this paper attempts to contribute to the literature by developing an index that would help identify the strategic sectors for a developing country based on an import approach. The index, which is composed of two stages, initially pinpoints the sectors with high import indicators that are further evaluated based on their technological intensity and value-addedness. The trade data on Turkey are also analyzed using the index to figure out the strategic sectors that should be incorporated within the R&D plans of the country. Results show that the most strategic manufacturing sectors for R&D in Turkey are aircraft & spacecraft, optical, photo, technical & medical apparatus and electric/electronic equipment, followed by organic chemicals and machinery.

Keywords: *R&D, strategic sectors, imports, index, decision making models, Turkey*

* TÜBİTAK, The Scientific and Technological Research Council of Turkey, Marmara Research Center, The Office of the President, Gebze, Kocaeli, Turkey.
E-mail: hatice.karahan@tubitak.gov.tr

Introduction

In order to catch up with the fast pace of development around the globe, research and development (R&D) strategies have increasingly gained importance for nations over the last few decades. For the developed nations who design such strategies, the main focus has been policies for further technological advancements, as the development of those countries have already been realized in technologically- intensive sectors. So, for most developed nations, strategic sectors have been already defined and exploited. In the case of developing countries, however, a need to determine those sectors is still quite apparent. Although some nations in this category present a list of such sectors within their growth plans, the way those areas are determined seems usually ambiguous. Hence, to shape national R&D strategies in today's increasingly competitive world, scientific approaches need to be envisaged and implemented.

In this respect, it should first be underlined that there may exist very different perspectives to enable such an attempt. One possible way of achieving this end would be taking into account the resources that the country possesses and then matching the sectors and products that may be incorporated with those. On the other hand, a focus on exports, considering the latest trends and expectations in world markets may prove to be another avenue. With such an approach, which is based on an export-oriented growth strategy, critical sectors and products that can be produced and sold to potential markets can be determined.

Another perspective that may prove more straightforward would be employing import data to figure out the most basic needs of a country. Since import figures represent the dependency of a country on certain products, the import-based approach would simply reveal the portfolio of products that can be considered for domestic production. Based on this method, sectors with high- import indicators can then be evaluated in terms of technological intensity and value-addedness, as these are the factors that are classified as vital for sustained economic growth. Therefore, in order to find out the areas critical in the design of a proper and effective national R&D program, strategic sectors for import-dependent developing countries can be determined by employing the trade data at hand and designing of a clear decision making process.

In this respect, this paper attempts to model an introductory methodology to employing the import-based approach in shaping national R&D strategies for developing countries. Furthermore, the method developed is directed towards identifying the strategic sectors in Turkey, which is a country that has long exhibited an outstanding performance of growth as a developing economy within the last decade and hence is of interest with respect to its strategic considerations.

The paper proceeds as follows: Section 2 briefly discusses the importance of R&D for developing countries and establishes the relationship between R &D and with imports. Section 3 introduces the methodology developed. Section 4 presents the case study that utilizes data on Turkey. Section 5 concludes the paper.

The Importance of R&D for Developing Nations

Today, it is believed that the developing countries mostly possess comparative advantages in the production of labor-intensive goods and services (IMF, 2001). However, according to endogenous growth models, a country's ability to generate persistent gains in terms of welfare depends critically on its speed of technological advance or innovation. These models clearly recognize the technological change brought about through R&D activities and its impact on productivity and hence growth (Solow, 1957, Grossman &Helpman, 1991). The theory established in these models has also been empirically tested in a number of studies in the literature. Ulku (2004) has analyzed the effects of innovation on income per capita in a set of OECD and non-OECD countries and confirmed the existence of a positive relationship.In a study by UNECE (2004) analyzing a sample of 49 high and middle-income countries, technology competitiveness has exhibited a significantly positive impact on growth. Similarly, Kekic (2007) has found out high returns with regard to innovation in lower-income countries.

In this sense, it can be argued that a developing country with a target of long-term economic growth needs to sustain investment in technology as a vital part of its strategy to remain competitive in a dynamic global economy. Hence, for such a country, certain policy attention is required to increase the scale of research and development activities, not only quantitatively but also qualitatively. That is why; national R&D policies should be firmly constructed on up-to-date and effective diagnoses. One related approach that could well serve the purpose would be looking at recent import trends as they represent an important aspect of national demand as well as indicating the areas in which the country in question somehow lags behind.

In various sources, economic theory suggests a positive relationship between imports and economic growth, although the direction seems ambiguous. On the one hand, it is argued that a raise in the GDP level increases the national demand and hence import levels. On the other hand, imports are claimed to be an engine of growth through the technology transfers that they lead to. The implication of this argument is that a developing economy can acquire technological know-how through imports at a negligible cost. However, empirical findings on this issue are very mixed. This is because while some recent studies like Kasahara and Rodrigue(2008), Jones (2008) and Halpern et al. (2009) have found a significant role of import or imported intermediary inputs, Lawrence and Weinstein (1999), Van Biesebroeck (2003) and Muendler (2004) have shown insignificant or not very sizable impacts emanating from this activity (Sharma, 2011).

In this regard, as presented in a seminal paper by Cohen and Levinthal (1989), some economists argue that firms need to invest in in-home R&D to acquire new technologies, which can alternatively be made available through some other methods including imports. Moreover, the positive relationship between countries' *own R&D activities* and productivity growth has also been confirmed by studies such as those by Frantzen (2000). These findings mainly support the endogenous growth models that draw attention to technological change in order to explain the growth pattern of world economies.

In this framework, the main assumption of this study is the following: In formulating the strategic R&D plans of a developing country, an approach encouraging competition against imports in specific sectors would be more appropriate. This is because thetechnological improvement of a country though a target of a sustainable and competitive growth should not only rely on technology transfers through imports. Therefore, the paper focuses on designing a model that helps determine some critical industries in which research and development funds should be directed to, by adopting an import based approach.

Methodology

To determine the nationally-strategic R&D sectors, a two-step index is developed in this study, using a multi-criteria decision making (MCDM) process. As in most MCDM methods, the following technique is utilized in both steps. (Triantaphyllou et al., 1998)

1. Determining the relevant criteria and alternatives to be evaluated.
2. Attaching numerical measures to the relative importance of the criteria.
3. Processing the numerical values to determine the ranking of each alternative.

At the first stage of the index, a portfolio of promising sectors, which have relatively higher import shares and/or import growth rates are obtained. The portfolio attained is then evaluated and ranked based on two additional criteria: the technological-intensity level and value-addedness level. The scores yielded by this procedure reveal a list of the strategic areas for research and development in the country. Within this framework, the procedure can be summarized as below.

Stage 1: Determining the Promising Sectors

Let S={S_i, for i=1,2,….n} be a set of alternative sectors to be ranked *with respect to* the set of criteria C_1={IS, IG}, where IS stands for import share and IG represents import growth rate. Hence, let

$$IS = [is_i]_{nx1} \text{ for } i=1,\ldots,n \qquad (1)$$

be the vector of the import shares of sectors based on total imports, of which each element takes a value within the range of 0 and 1.

Then, using the import growth rates provided by the dataset, a second vector is formed such that

$$IG = [ig_i]_{nx1} \text{ for } i=1,\ldots,n. \qquad (2)$$

Based on these vectors, the scores to be obtained for the purpose of ranking the sectors in the first step of the index are calculated by taking the weighted averages of the two criteria above. It should be noted that the weighted average approach is the most often used aggregation operator in MCDM models. However, before computing the weighted averages, the vectors have to be normalized. The intuition behind normalization is to use relative values instead of actual ones for an easier way of comparison through the ranking. This approach is also one of the main features adopted by some well-known MCDM models, such as Analytic Hierarchy Process (AHP) which is thoroughly explained by Saaty (2008).

In this sense, for the first vector IS, no normalization process is required due to the fact that import shares would naturally sum up to 1. However, unlike IS, IG has to be normalized and transformed into IG*as below, since the sum of its elements does not equal to 1. Hence,

$$IG^* = [ig_i^*]_{nx1} \text{ for i=1,....,n,} \tag{3}$$

$$\text{where } ig_i^* = \frac{ig_i}{\sum_{i=1}^{n} ig_i} \tag{4}$$

Having obtained the normalized values of the criteria for each sector by the two vectors above, both are multiplied by their weights and then the new vectors obtained are summed up. At this point, it should be underlined that determining the weights for the criteria requires another decision-making model which can provide a topic of further research. In this paper, however, for the sake of simplicity, various weight combinations are used to come up with a ranking. In this regard,

$$w_A = [w_1 \quad w_2 \quad \dots \quad w_c]_{1xc} \quad \text{and} \quad w_B = [1\ 1\ \dots 1]_{1xc} - w_A \tag{5}$$

where w_A and w_B yield the weights assigned to IS and IG*, respectively and c represents the number of combinations. Furthermore, it is assumed that $0 < w_A < 1$ and $0 < w_B < 1$. Then it follows that

$$R = IS\ x\ w_A + IG^* x\ w_B \tag{6}$$

where the matrix represents the final scores obtained through the weighted average calculation. Notice that the rows of the matrix give the scores of each sector based on various weight combinations, which are represented by each column.

As a final procedure to complete the first stage of the index, the columns in the matrix are sorted separately and then by picking the most common sectors in these columns that yield a score above average, a portfolio of the most promising sectors is generated such that

$S^*=\{S_i$, for $i=1,2,\ldots.m\}$, where $m<n$.

Stage 2: Determining the Strategic Sectors

Intuitively, for a developing country that aims to grow in a fast manner, strategic sectors/products would mainly include the ones that offer high technology and/or added value. So, upon determining those sectors, it will be easier for the country to decide on which ones to be possibly engaged in, considering the national capacity. In this regard, at the second stage of the methodology, the portfolio of the sectors chosen at the end of Stage 1, S^*, is subjected to an evaluation of technology intensity as well as value-addedness. Hence, the problem in this step can be defined as follows:

$S^*$is a set of alternatives called the promising sectors to be ranked *with respect to* the set of criteria $C_2=\{TI, VA\}$, where TI and VA stand for technological intensity and value addedness levels, respectively. So, let

$$TI= [ti_i]_{mx1} \text{ for } i=1,\ldots.,m \tag{7}$$

be the vector for the technological intensity level for each sector. The elements in this vector are assigned according to the technological intensity index developed by the OECD. Based on the OECD index which comprises of four categories, the scale used in this paper for the level of technology ranges from 0 to 3 in a linear manner, where 0 corresponds to low-technology sectors at one end and 3 represents high-technology at the other. Details regarding the scale and the sectors are presented in Table 1.

TI, is then required to be normalized such that

$$TI^*= [ti_i^*]_{mx1} \text{ for } i=1,\ldots.,m \tag{8}$$

$$\text{where } ti_i^* = \frac{ti_i}{\sum_{i=1}^{m} ti_i} \tag{9}$$

Table 1. Manufacturing industries classified according to their global technological intensity

Sector	Technology Level	Scale Assigned
Aerospace	High	3
Pharmaceuticals	High	3
Computers, office equipment	High	3
Electronics-communication	High	3
Precision instruments	High	3
Electrical machinery	Medium-high	2
Motor vehicles	Medium-high	2
Chemicals (except pharmaceuticals)	Medium-high	2
Other transport equipment	Medium-high	2
Machinery and equipment	Medium-high	2
Petroleum refining	Medium-low	1
Rubber and plastics	Medium-low	1
Non-metallic mineral products	Medium-low	1
Shipbuilding	Medium-low	1
Basic metals	Medium-low	1
Fabricated metal products	Medium-low	1
Wood and furniture	Low	0
Paper and printing	Low	0
Textiles, clothing, leather	Low	0
Other manufacturing industry	Low	0

Source: OECD Handbook on Economic Globalization Indicators, 2005

Upon the formation of TI*, the next step is to construct the value-addedness vector, VA. The main challenge that emerges here, which can be mentioned as a likely shortcoming of the methodology, is the measurement of the value-addedness factor. Unfortunately, conventional trade statistics do not reveal those sectors of the economy where value-added originates. This task can only be achieved by disentangling the domestic value chain into its sectoral components but in practice we can never have the level of detail needed to conduct a value-added decomposition for all individual products. One approach to solve this issue is the use of Input-Output Tables which were developed by OECD through using aggregated data (OECD, 2012). However, the industries in the tables are mostly large categories which combine several subsectors, causing a problem to appropriately assign the value-addedness data to the specific sectors provided by the trade data. Also, particularly for the purposes of the empirical part of this study, the tables create a time mismatch due to the unavailability of data for recent years. The most recent data supplied in the tables belong to the mid-2000's. Due to these caveats, the Input-Output Tables are not utilized as a source of data in this analysis but can be considered as a good reference for further studies when they are updated with recent statistics and/or aligned with trade data.

Hence, as a general proxy for value-addedness, unit prices are employed in the formation of the VA vector. For this purpose, weighted averages of the unit prices of the products for every sector are calculated to get a rough idea about the level of the value-addedness of each sector. However, once the unit prices are obtained, it would most probably be noticed that the data obtained include mainly low and medium price levels but also a few high ones which can be considered outliers. This causes a non-normality situation and that is why a data transformation is needed due to the presence of those outliers.

In this regard, in order to respond to the skewness towards large values and hence improve the normality of the values of the criterion, the "natural log" transformation seems suitable to be employed as a mathematical modification tool. Hence, the "ln" of the unit values attained from the sectors is calculated in the first place. The new values would constitute a more normal and symmetric pattern that limit gigantic differences in the calculations of evaluations.

Having generated the vector of the transformed values, the next step is to normalize it by dividing each element by the sum of the values in the vector. So, to summarize mathematically.

Let VA=$[va_i]_{mx1}$ for i=1,….,m represent the original vector of the unit values of the sectors. Then, the logarithmic transformation is performed as follows:

$$VA^* = [va_i^*]_{mx1} \text{ for } i=1,\ldots,m \tag{10}$$

$$\text{where } va_i^* = \ln va_i \tag{11}$$

As a last step to get the final vector of the value-addedness criterion, the values in VA* need to be normalized to obtain

$$VA^{**} = [va_i^{**}]_{mx1} \text{ for } i=1,\ldots,m \tag{12}$$

$$\text{where } va_i^{**} = \frac{va_i^*}{\sum_{i=1}^{m} va_i^*} \tag{13}$$

Once VA**, the vector of "value-addedness" is built, the final scores for the evaluation of the sectors are easily obtained, along with the vector of "technological intensity". In this sense, one simple algebraic formula is enough to rank the most strategic sectors of the country. In other words, let be the matrix of final scores to be attained through the weighted average calculation for the two criteria in question. Similar to the previous stage, by taking advantage of (5), is calculated through assigning a combination of different weights on TI* and VA** such that

$$R^{*} = TI^{*} x\, w_{A} + VA^{**} x\, w_{B} \tag{14}$$

As a result of this procedure, R* yields the final scores of the sectors, based on which a ranking can be conducted to isolate the strategic sectors. In this framework, parallel to the last step in the first stage, the sectors with scores above the average value subject to various weight combinations are chosen to be the most strategic ones as below:

$$S^{**}=\{S_i, \text{ for } i=1,2,\ldots,l\}, \text{ where } l<m \tag{15}$$

It should be reminded that the fact that the selection criterion used in this study is chosen as having a value above the mean does not restrict any further applications from employing another threshold value.

Data and Results

The data for Turkey used in this study were derived from the TradeMap which embodies a database of trade statistics at an international level. The raw data utilized in the first stage of the methodology contain the import volumes of chapters for the year of 2011 as well as the import growth rate of each per annum in the period of 2010 and 2011. The import shares calculated as percentages based on the volume of total imports can be found in Tables 2-a and Table 2-b, along with the growth rates.

As the tables reveal, mineral fuels and oils encompass a conspicuously big portion of total imports, with a share of almost one quarter. Imports in the sector of machinery rank second, with a considerably large slice of 11,26%, followed by iron and steel, motor vehicles, electrical/electronic equipment and plastics, each of which have a share higher than 5%.

Table 2-a. Import Shares and Import Growth Rates of Sectors in Turkey

Chapter	Import Share (2011, %)	Import Growth Rate (p.a., 2010&2011,%)
Mineral fuels, oils, distillation products, etc	22.47	41
Machinery, nuclear reactors, boilers, etc	11.26	27
Iron and steel	8.48	27
Vehicles other than railway, tramway	7.13	28
Electrical, electronic equipment	6.99	15
Plastics and articles thereof	5.22	29
Pearls, precious stones, metals, coins, etc	2.92	131
Organic chemicals	2.29	25
Pharmaceutical products	1.95	7
Copper and articles thereof	1.71	25
Optical, photo, technical, medical, etc apparatus	1.71	20
Aircraft, spacecraft, and parts thereof	1.63	25
Cotton	1.50	7
Rubber and articles thereof	1.40	45
Aluminium and articles thereof	1.35	31
Paper and paperboard, articles of pulp, paper and board	1.29	10
Articles of iron or steel	1.05	28
Manmade staple fibres	1.02	18
Miscellaneous chemical products	0.92	23
Manmade filaments	0.83	19
Cereals	0.80	83
Tanning, dyeing extracts, tannins, derivs,pigments etc	0.78	22
Articles of apparel, accessories, not knit or crochet	0.78	21
Inorganic chemicals, precious metal compound, isotopes	0.71	21
Oil seed, oleagic fruits, grain, seed, fruit, etc, nes	0.70	9
Animal,vegetable fats and oils, cleavage products, etc	0.67	62
Ships, boats and other floating structures	0.63	45
Wood and articles of wood, wood charcoal	0.59	30
Furniture, lighting, signs, prefabricated buildings	0.58	29
Fertilizers	0.57	35
Ores, slag and ash	0.53	27
Articles of apparel, accessories, knit or crochet	0.45	8
Essential oils, perfumes, cosmetics, toileteries	0.44	9
Live animals	0.43	208
Footwear, gaiters and the like, parts thereof	0.36	32
Residues, wastes of food industry, animal fodder	0.36	16
Soaps, lubricants, waxes, candles, modelling pastes	0.34	30
Miscellaneous articles of base metal	0.33	18
Tools, implements, cutlery, etc of base metal	0.33	35
Railway, tramway locomotives, rolling stock, equipment	0.31	42
Raw hides and skins (other than furskins) and leather	0.30	53
Glass and glassware	0.29	14
Toys, games, sports requisites	0.27	39
Pulp of wood, fibrous cellulosic material, waste etc	0.25	11
Knitted or crocheted fabric	0.23	50
Stone, plaster, cement, asbestos, mica, etc articles	0.22	27

Table 2-b. Import Shares and Import Growth Rates of Sectors in Turkey

Chapter	Import Share (2011, %)	Import Growth Rate (p.a., 2010&2011,%)
Meat and edible meat offal	0.21	105
Zinc and articles thereof	0.20	14
Albuminoids, modified starches, glues, enzymes	0.20	15
Cocoa and cocoa preparations	0.20	20
Articles of leather, animal gut, harness, travel goods	0.20	17
Miscellaneous edible preparations	0.20	27
Commodities not elsewhere specified	0.20	29
Wool, animal hair, horsehair yarn and fabric thereof	0.19	24
Ceramic products	0.19	16
Miscellaneous manufactured articles	0.18	15
Salt, sulphur, earth, stone, plaster, lime and cement	0.18	41
Wadding, felt, nonwovens, yarns, twine, cordage, etc	0.17	0
Tobacco and manufactured tobacco substitutes	0.17	9
Edible fruit, nuts, peel of citrus fruit, melons	0.16	25
Edible vegetables and certain roots and tubers	0.15	17
Impregnated, coated or laminated textile fabric	0.15	27
Clocks and watches and parts thereof	0.13	24
Vegetable textile fibres nes, paper yarn, woven fabric	0.11	1
Photographic or cinematographic goods	0.10	7
Lead and articles thereof	0.09	26
Nickel and articles thereof	0.09	28
Beverages, spirits and vinegar	0.09	53
Other made textile articles, sets, worn clothing etc	0.09	41
Special woven or tufted fabric, lace, tapestry etc	0.08	14
Cereal, flour, starch, milk preparations and products	0.08	17
Carpets and other textile floor coverings	0.08	7
Fish, crustaceans, molluscs, aquatic invertebrates nes	0.07	30
Printed books, newspapers, pictures etc	0.07	24
Arms and ammunition, parts and accessories thereof	0.05	-19
Coffee, tea, mate and spices	0.05	14
Other base metals, cermets, articles thereof	0.04	25
Furskins and artificial fur, manufactures thereof	0.04	29
Dairy products, eggs, honey, edible animal product nes	0.04	-18
Vegetable, fruit, nut, etc food preparations	0.04	44
Tin and articles thereof	0.03	40
Live trees, plants, bulbs, roots, cut flowers etc	0.03	36
Milling products, malt, starches, inulin, wheat gluten	0.03	28
Sugars and sugar confectionery	0.03	21
Products of animal origin, nes	0.02	48
Explosives, pyrotechnics, matches, pyrophorics, etc	0.02	47
Headgear and parts thereof	0.02	25
Umbrellas, walking-sticks, seat-sticks, whips, etc	0.02	17
Silk	0.02	12
Works of art, collectors pieces and antiques	0.02	84
Musical instruments, parts and accessories	0.02	12
Bird skin, feathers, artificial flowers, human hair	0.02	20
Lac, gums, resins, vegetable saps and extracts nes	0.02	14
Manufactures of plaiting material, basketwork, etc.	0.01	15
Vegetable plaiting materials, vegetable products nes	0.003	22
Cork and articles of cork	0.003	17
Meat, fish and seafood food preparations nes	0.001	-32

Data Source: Trade Map, Author's Calculations

As for growth, one can clearly observe that the rates are mostly at quite high levels for a good number of chapters, where it is 30% for the overall imports. Among the sectors named above in terms of high import shares, mineral fuels and oils are worthy of attention here too, with a rate of growth of 41%. The rate of annual increase is also quite high for the other top importing sectors, hovering close to 30% .

Taking advantage of these data, the computations in the first stage of the methodology yield the scores for the chapters among which a list of promising sectors should be selected. By ranking the chapters based on the scores under various weight scenarios, 15 sectors above the average in all cases are to be evaluated in the second stage. Table 3 exhibits these sectors with their scores under 3 different weight assignments, along with their standard deviation (SD) intervals around the mean.

Table 3. Sectors with Highest Import Scores: The Promising Sectors in Turkey

Chapter	**R* (Score)**	**SD Interval**	**R** (Score)**	**SD Interval**	**R*** (Score)**	**SD Interval**
Mineral fuels, oils, distillation products, etc	0.162	+7	0.120	+7	0.078	+5
Machinery, nuclear reactors, boilers, etc	0.082	+4	0.061	+4	0.041	+3
Iron and steel	0.062	+3	0.047	+3	0.032	+2
Vehicles other than railway, tramway	0.053	+3	0.041	+3	0.029	+2
Electrical, electronic equipment	0.051	+3	0.038	+2	0.025	+2
Plastics and articles thereof	0.040	+2	0.031	+2	0.023	+2
Pearls, precious stones, metals, coins, etc	0.035	+2	0.039	+2	0.042	+3
Organic chemicals	0.019	+1	0.016	+1	0.013	+1
Cereals	0.015	+1	0.019	+1	0.024	+2
Copper and articles thereof	0.015	+1	0.013	+1	0.012	+1
Rubber and articles thereof	0.015	+1	0.015	+1	0.016	+1
Aircraft, spacecraft, and parts thereof	0.014	+1	0.013	+1	0.011	+1
Optical, photo, technical, medical, etc apparatus	0.014	+1	0.012	+1	0.010	+1
Aluminium and articles thereof	0.013	+1	0.012	+1	0.012	+1
Articles of iron or steel	0.010	+1	0.010	+1	0.010	+1

* denotes the case when W_A=0,7
** denotes the case when W_A=0,5
*** denotes the case when W_A=0,3

According to the table, mineral fuels & oils and machinery turn out to be the top two sectors with significantly large scores and SD intervals in all scenarios. Iron & steel as well as motor vehicles also take place among the noteworthy chapters with their considerably high scores in the rankings, closely followed by electrical/electronic equipment, pearls and precious stones and plastics. The remaining sectors fall within the +1 SD interval around the mean, with scores of mostly between 0,01 and 0,02. It should be pointed out that the other weight combinations evaluated in the calculations, but not listed in the table, bring about similar outcomes, as well.

The whole list of sectors identified at the end of this analysis and labeled as S* is then subjected to a further examination in the second phase of the methodology. At this stage, in order to assess the value-addedness of each sector, unit prices based on product clusters provided by the dataset are utilized. In this regard, the weighted averages of the prices of the clusters are computed to find the average unit prices of the sectors. The unit prices calculated are then used for the evaluation of the level of value-addedness.

Computation results show that the importing chapter with the highest unit price in Turkey is found to be pearls and precious stones with a value of approximately USD44.000 per kg. The next highest-valued chapters turn out to be aircraft &spacecraft and optical, photo, technical, medical apparatus, with 3-digit prices. The rest of the list includes sectors with much lower unit prices, mostly with single-digit values, where the mineral fuels and oils sector bottoms out with a figure below 1 USD. Statistics on the unit prices of the promising sectors can be seen in Table 4.

An issue to be underlined at this point is that the extreme nature of the pearls and precious stones sectors may still be a problem after the logarithmic transformation, as it has an exceptionally high unit price. So, although the data on unit prices are utilized as the best proxy available for value-addedness, this part of the methodology can be tackled in future studies to find a better measure.

Furthermore, the vector of technological intensity level to be used in the second stage is formed based on the index developed by OECD, as explained in the previous chapter of this study. According to this index, among the chapters filtered through the first stage:aircraft &spacecraft, optical, photo, technical & medical apparatus and electrical/electronic equipment appear to constitute the top technological sectors, followed by machinery, motor vehicles, and organic chemicals which are considered sectors with medium-high technological intensity as Table 4 indicates. The remaining sectors in the portfolio take place within the category of medium-low technological concentration, with an exception of cereals which is considered a low technology area.

Table 4. Unit Prices and Technological Intensity Levels of the Promising Sectors in Turkey

Sector	Average Unit Price (per kg, $)	Technological Intensity Level (0-3)
Pearls, precious stones, metals, coins, etc	43,988	1
Aircraft, spacecraft, and parts thereof	816	3
Optical, photo, technical, medical, etc apparatus	138.3	3
Electrical, electronic equipment	69	3
Organic chemicals	30	2
Machinery, nuclear reactors, boilers, etc	26.3	2
Vehicles other than railway, tramway	11.3	2
Copper and articles thereof	9.3	1
Rubber and articles thereof	4.69	1
Articles of iron and steel	4.25	1
Aluminium and articles thereof	3.76	1
Plastics and articles thereof	2.84	1
Mineral fuels, oils, distillation products, etc	0.91	1
Iron and steel	0.46	1
Cereals	0.35	0

Data Source: Trade Map, OECD, Author's Calculations

The results of the index calculations are presented in Table 5. Findings clearly indicate that regardless of the weight assignments to the criteria, including the ones not presented in the table, three sectors appear to be differentiated from the others as listed below:

Aircraft & spacecraft
Optical, photo, technical & medical apparatus
Electric/electronic equipment

Hence, these three sectors can be classified as the most strategic areas for R&D in Turkey, followed by *organic chemicals* and *machinery*, both of which exhibit quite good performance through the ranking. In addition to that, *vehicles* hold a place in the list right after these strategic sectors, with a score just around the mean.

Table 5. Final Scores and Ranking of Sectors

	W_A=0,7		W_A=0,5		W_A=0,3
Aircraft, spacecraft, and parts thereof	0.14	Pearls, precious stones, metals, coins, etc	0.15	Pearls, precious stones, metals, coins, etc	0.19
Optical, photo, technical, medical, etc apparatus	0.13	Aircraft, spacecraft, and parts thereof	0.15	Aircraft, spacecraft, and parts thereof	0.15
Electrical, electronic equipment	0.12	Optical, photo, technical, medical, etc apparatus	0.12	Optical, photo, technical, medical, etc apparatus	0.12
Pearls, precious stones, metals, coins, etc	0.11	Electrical, electronic equipment	0.12	Electrical, electronic equipment	0.11
Organic chemicals	0.09	Organic chemicals	0.08	Organic chemicals	0.08
Machinery, nuclear reactors, boilers, etc	0.08	Machinery, nuclear reactors, boilers, etc	0.08	Machinery, nuclear reactors, boilers, etc	0.08
Vehicles other than railway, tramway	0.08	Vehicles other than railway, tramway	0.07	Vehicles other than railway, tramway	0.07
Copper and articles thereof	0.05	Copper and articles thereof	0.05	Copper and articles thereof	0.05
Rubber and articles thereof	0.04	Rubber and articles thereof	0.04	Rubber and articles thereof	0.04
Articles of iron and steel	0.04	Articles of iron and steel	0.04	Articles of iron and steel	0.04
Aluminium and articles thereof	0.04	Aluminium and articles thereof	0.04	Aluminium and articles thereof	0.04
Plastics and articles thereof	0.04	Plastics and articles thereof	0.03	Plastics and articles thereof	0.03
Mineral fuels, oils, distillation products, etc	0.03	Mineral fuels, oils, distillation products, etc	0.02	Mineral fuels, oils, distillation products, etc	0.01
Iron and steel	0.02	Iron and steel	0.01	Iron and steel	0.00
Cereals	-0.01	Cereals	-0.01	Cereals	-0.02

Pearls and precious stones turns out to be one of the top sectors too but it looks like that it jumps up to this level mainly due to its extremely high unit price. So, considering the limitations in the trade data for a perfect measure for value-addedness, this specific outcome should be re-evaluated upon future improvements to this measurement.

The remaining chapters at the bottom of the table score well below the mean, making it hard to describe them as strategically important as the ones listed above, at least in terms of technological intensity and value-addedness, which are the criteria shaping the borders of this study.

Conclusions

In today's competitive world, it is widely believed that any nation that endeavors to sustain considerable economic growth has to invest more in R&D activities which should be appropriately designed in alignment with the needs as well as the prospects of the country. Concerning this fundamental issue, a few different perspectives can be utilized, among which exports, national resources and imports can be mentioned. This paper attempted to benefit from the imports approach to suggest a methodology that generated an index for focus and then analyzed the case for Turkey through it.

The analysis has revealed that the most strategic manufacturing sectors for R&D in Turkey are aircraft & spacecraft, optical, photo, technical& medical apparatus and electric/electronic equipment. In addition, organic chemicals and machinery compose the next significant category of strategic sectors. Pearls & precious stones can be mentioned as a potentially important category, too, although the sector owes its high score to its high unit price. Focusing the research and development activities on these areas would serve two purposes: producing high technology and high value-added products for sustainable growth while reducing imports and trade deficits. That is why, from an import-based perspective, which significantly represents the fundamental needs of the country, it is apparent that these R&D areas should be taken into consideration by the planners in Turkey for the design of strategic road maps.

To summarize, the index formed in this study based on as a decision-making model has tried to answer a vital national question via a straightforward methodology, and more importantly using figures. Among the sectors indicated, the more advantageous ones, especially in terms of resources, can naturally be considered as those to be given priority to. Plus, it should be mentioned that the method designed can also be employed to specifically determine the critical "products" (within those sectors) that R & D activities need to concentrate on, and which can be examined as a topic of further research. Moreover, it would be a good idea to utilize a group decision-making model in future studies, in order to be able to assign ideal weights to the criteria in the analysis and arrive at more explicit results. Such an approach would also help frame the practical applications of the model for groups of decision makers in the countries concerned.

References

Cohen, W.M., and D.A. Levinthal. (1989). "Innovation and learning: The two faces of R&D." *Economic Journal*, vol. 99, no. 397, pp.569-596.

Frantzen D. (2000). "Innovation, international technological diffusion and changing influence of R&D on productivity."*Cambridge Journal of Economics*, vol. 24, no. 2, pp.193-210.

Grossman, G. M., and E. Helpman. (1991). *Innovation and growth in the global economy*. Cambridge, MA: MIT Press.

Halpern, L., M. Koren, and A. Szeidl. (2009). "Imported inputs and productivity." Center for Firms in the Global Economy (*CeFiG) Working Papers* no. 8.

IMF (2001)."Global trade and liberalization."*IMF Issues Briefs*.

Jones, C.I. (2008). "Intermediate goods and weak links: A theory of economic development." NBER Working Papers no. 13834.

Kasahara, H., and J. Rodrigue. (2008). "Does the use of imported intermediates increase productivity? Plant-level evidence." *Journal of Development Economics,* vol. 87, no. 1, pp.106-118.

Kekic, L. (2007). "Innovation: transforming the way business creates." Economist Intelligence Unit Background Document.

Lawrence, R. Z., and D.E. Weinstein. (1999). "Trade and growth: Import-led or export-led? Evidence from Japan and Korea." NBER Working Papers no. 7264

Meade, L.M., and A. Presley (2002). "R&D project selection using the analytic network process". *IEEE Transactions on Engineering Management*, vol. 49, no. 1, pp.59-66.

Muendler, M.A. (2004). "Trade, technology and productivity: A study Of Brazilian manufacturers, 1986-1998", CESifo Working Paper Series no. 1148.

Nair-Reichert, U. (2001). "R&D investment and import competition in unionized industries." *Applied Economic Letters*, vol. 8, no. 10, pp.669-74.

OECD (2005).*Handbook on Economic Globalization Indicators*. *OECD.*

OECD (2012). "Trade in value-added: Concepts, methodologies and challenges." Joint OECD-WTO Note. OECD.

Saaty, T.L. (2008). "Decision making with the analytic hierarchy process", *International Journal of Services Sciences*, vol. 1, no. 1, pp.83–98.

Sharma C. (2011). "Imported intermediary inputs, R&D and firm's productivity: Evidence from Indian manufacturing". *Proceedings of the German Development Economics Conference*, 74.

Solow, R.M. (1957). "Technical progress and the aggregate production function". *Review of Economics and Statistics*, vol. 39, no. 3, pp.312–320.

Trade Map (2012). *International Trade Center*. Available at: www.trademap.org.

Triantaphyllou E., B. Shu, S. Nieto Sanchez, and T. Ray. (1998). "Multi-criteria decision making: An operations research approach." *Encyclopedia of Electrical and Electronics Engineering*, vol. 15, pp.175-186.

Ulku, H. (2004)."R&D, innovation and economic growth: An empirical analysis". IMF Working Papers no. 04/185.

UNECE (2004). "The competitiveness of nations: Economic growth in the ECE region". *Economic Survey of Europe* 2004 no.2.

Van Biesebroeck, J. (2003). "Revisiting some productivity debates." NBER Working Papers no. 10065.