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The Economic Complexity Approach to Development Policy: Where Turkey Stands in Comparison to OECD plus China?

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Abstract

In this paper, we classify the OECD countries plus China by means of the economic complexity approach to make a concrete connection between the current and future output structures and potential performance of countries in achieving high levels of per capita income. The aim is to identify the ranking of Turkey among various countries and analyze why Turkey has low GDP per capita according to its current production and export structure. Using export data (STIC Rev.4-3 digit) we calculate a number of economic complexity variables (export sophistication, open forest, diversification and product sophistication) for China and OECD countries, including Turkey. Then, we classify all the countries in terms of method of reflection matrix as in Hidalgo and Hausmann (2009) and identify where Turkey is located. Relying on the tools offered by the product space and economic complexity approach, the findings assert that Turkey is a diversified country, but its current production structure is specialized in less sophisticated products. Therefore, the country has a lower GDP per capita in PPP terms than its potential.

JEL Classification Codes: D24, D62, L15, L52

Keywords: Product space, productive capabilities, cluster analysis

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Introduction

Globalization and technological progress continue to shape national and regional development policies. Naturally the main objective of policy analysis is to develop a set of strategies to keep the economy on track, more sustainable, socially inclusive and prosperous. On a purely conceptual basis, Marshallian externalities and rents are the main reasons why price mechanisms do not provide an economy with an optimal basket of goods. In this case, government interventions may lead to producing goods with positive externalities that support the income and export growth of a country.

For a prosperous future, theoretical studies traditionally are focused on productivity as well as cost of production. However, empirical studies mostly rely on cost advantages and call for low wages and taxes. In a recent series of papers, structural transformations came to the forefront in the discussion about economic development once more. This new approach is rooted in the strategic trade/industrial policy models of the 1980s and 1990s. The economic complexity approach elaborates on empirically analyzing the productivity and product diversification as well as costs. In other words, with the new approach, conceptual measures about productivity and structural transformation becomes more operational. Hausmann et al. (2007, 2009, 2012 etc.) elaborate on this work and offer a more complete conceptual framework called economic complexity analysis. According to this approach, production of each product necessitates a set of capabilities. Hence, production structure represents the capacity of productive capabilities of the region. Regions create variety by developing productive capabilities that are similar to the ones they already possessed. So the development is defined as the learning process to produce more complex goods given the existing related capabilities. Thus, product space of a country/region is path dependent.

Recent studies indicate that the composition rather than the size of export basket matters more for the future per capita income improvement of countries (Hausmann et al. 2007, Minondo 2010). Moreover, the empirical literature supports the idea that the composition of the export basket matters for future economic performance (Felipe et al. 2012, Hausmann and Klinger 2006, Hausmann et. al. 2007, Hidalgo and Hausmann 2009, and Nunes et. al. 2013). Countries that are less diversified and produce less complex products seem to have a low per capita income on average, while countries that are highly diversified and capable of producing more complex goods tend to have high per capita income on average. Based on these observations and conceptual developments, the policy implication is that countries and/or regions should systematically push their current specialization patterns towards more advanced

and complex products. For this purpose, countries should gradually create and move to new varieties by developing new productive capabilities that are similar to the ones they already possess.

In this context, a number of economic complexity variables namely, export sophistication, open forest, diversity and quality of the products (product sophistication), are calculated for OECD countries and China. Based on these measures, countries in the sample are ranked and the ranking of Turkey is assessed. Moreover, specific policy recommendations compatible with the current rank and economic structure of Turkey are derived. Preliminary results point out that Turkey needs parsimonious industrial policies to help jump short distances to nearby, more complex products since Turkey is already a fairly diversified country. However, Turkey has been specialized in less sophisticated products. As a consequence, one of the potential reasons for low GDP per capita is the current specialization structure of the Turkish economy.

Data

The export data (STIC Rev.4-3 digit) are gathered from UN-COMTRADE. GDP per capita in terms of Purchasing Power Parity is from the IMF, World Economic Outlook Database. We use the data for the year of 2015 in calculating economic complexity variables that represent productivity, sophistication and diversity of products for a sample of countries composed of China and OECD countries, including Turkey[4]. Following Hausmann and Klinger (2006), Hausmann et al. (2007), Hidalgo and Hausmann (2009), we rank 214 products and 36 countries.

Measuring Complexity

Although the debate about the meaning of competitiveness started in the 1980s and continued with Porter (1990) and Krugman (1994), it has reached a new sphere recently. After a long debate and research in different strands of the literature, one strand, namely the product space or the method of reflection approach, appears to provide fruitful insights about economic policy implications. According to Hidalgo et al. (2007), in the product space approach, each product produced and exported represents an essential set of capabilities. Developed countries produce and export more complex goods that draw on a wider set of capabilities while developing countries produce ubiquitous goods that require less know-how. So, complexity can

[4] China is added to the sample because of two considerations. First, China is the most crowded country in the World and accounts for approximately 20% of the total exports of OECD countries. Second, nowadays China seems to be the manufacturer or the factory of the world.

be measured on two dimensions by looking at the diversification and ubiquity of the goods produced. The studies of the product space approach try to measure complexity by using the weighted average of the income (per capita) level associated with the given product or export basket and name this measure PRODY. The weights used in calculating PRODY is called the revealed comparative advantage (RCA). Another measure is the so called EXPY that represents the productivity associated with a given goods or export basket. The following indices of complexity and ubiquity are utilized to assess what matters for future growth in the Turkish economy.

RCA is an index which is used to calculate the relative advantage and disadvantage of a country in the export of a certain good. The RCA index makes it easier to determine whether the country is a significant producer and/or exporter of a product.

$$RCA_{cp} = \frac{X_{cp}}{\sum_c X_{cp}} / \frac{\sum_p X_{cp}}{\sum_c \sum_p X_{cp}} \tag{1}$$

Where, X_{cp} represents exports of product *p* by country *c*. Let M_{cp} be defined as a matrix entry that is 1 if the country produces product *p* with RCA>1 and 0 otherwise. The number of entries in the matrix gives a measure of how many different types of products a country is able to produce with comparative advantage. Diversity and ubiquity can be measured simply by summing over the rows or columns of that matrix. Diversification defined as the number of products in the country's export basket which has RCA>1.

$$M_{cp} = \begin{cases} 1 & if \quad RCA_{cp} \geq 1; \\ 0 & elsewhere \end{cases} \tag{2}$$

$$Div_c = k_{c,0} = \sum_p M_{cp} \tag{3}$$

Ubiquity is the number of countries that could produce a particular product with RCA>1.

$$Ubiq_p = k_{p,0} = \sum_c M_{cp} \tag{4}$$

Average diversification of a country exporting product *p* is

$$Avg\_div_p = k_{p,1} = (1/Ubiq_p)\sum_c M_{cp} * Div_c \tag{5}$$

Average ubiquity of the products exported by country c is given by

$$Avg\_ubiq_c = k_{c,1} = (1/Div_c)\sum_p M_{cp} * Ubiq_p \quad (6)$$

Hausmann et al. (2007) suggested an indicator which assesses the sophistication level, or the "income content" of a specific product. The PRODY index is defined as the weighted value share of each product in a country's trade basket with that country's per capita GDP. Formally for each product *p*,

$$PRODY_p = \sum_c \frac{X_{cp}/X_c}{\sum_c (X_{cp}/X_c)} Y_c \quad (7)$$

PRODY is simply a measure of income content of a particular product, therefore high PRODY values represent a more sophisticated product in the export basket. Hence, high income countries presumably export more complex products with high PRODY values while low income countries tend to export less sophisticated products with low PRODY values.

The productivity level associated with the export basket of a country is measured by the EXPY index which is calculated as the weighted average of all relevant PRODYs' where the weights are the share of the relevant product in the country's export basket. The EXPY index is used to assess the average sophistication level of the total exports of a country. Formally for each country *c*,

$$EXPY_c = \sum_p \frac{X_{cp}}{X_c} PRODY_p \quad (8)$$

$$M_{cp'} = \begin{cases} 1 & if \quad RCA_{cp'} \geq 1; \\ 0 & elsewhere \end{cases} \quad (9)$$

Hausmann et al. (2014) defines capabilities as the chunks of embedded knowledge that is necessary in producing certain products. The capabilities needed to produce one good may or may not be useful in the production of some other goods. Authors emphasize that capabilities are not observed directly. Hence, they develop a measure that infers similarities between the capabilities required to produce a pair of goods by looking at the probability that they are co-exported. Their measure is based on the conditional probability of a country exporting the product p' given that it already exports product p. Since conditional probabilities are not symmetric, following Hidalgo et al. (2007) we take the minimum of the probabilities.

$$\varphi_{pp'} = \min\left\{P(M_p > 1 \mid M_{p'} > 1), P(M_{p'} > 1 \mid M_p > 1)\right\} \tag{10}$$

$$\varphi_{pp'} = \frac{\sum_c M_{cp} M_{cp'}}{max(k_{p,0}, k_{p',0})} \tag{11}$$

Following Hausmann and Klinger (2006) and using the estimation of the proximity and PRODY in the product space, we can measure the 'option value' of a country's unexploited opportunities. Given the set of products a country is currently producing, we can measure the 'open forest' at its doorstep as the distance-weighted value of all the products it could potentially produce where the value is captured by PRODY. Formally:

$$OF_c = \sum_p \sum_{p'} \frac{\varphi_{pp'}}{\sum_p \varphi_{pp'}} (1 - M_{cp'}) M_{cp} PRODY_{p'} \tag{12}$$

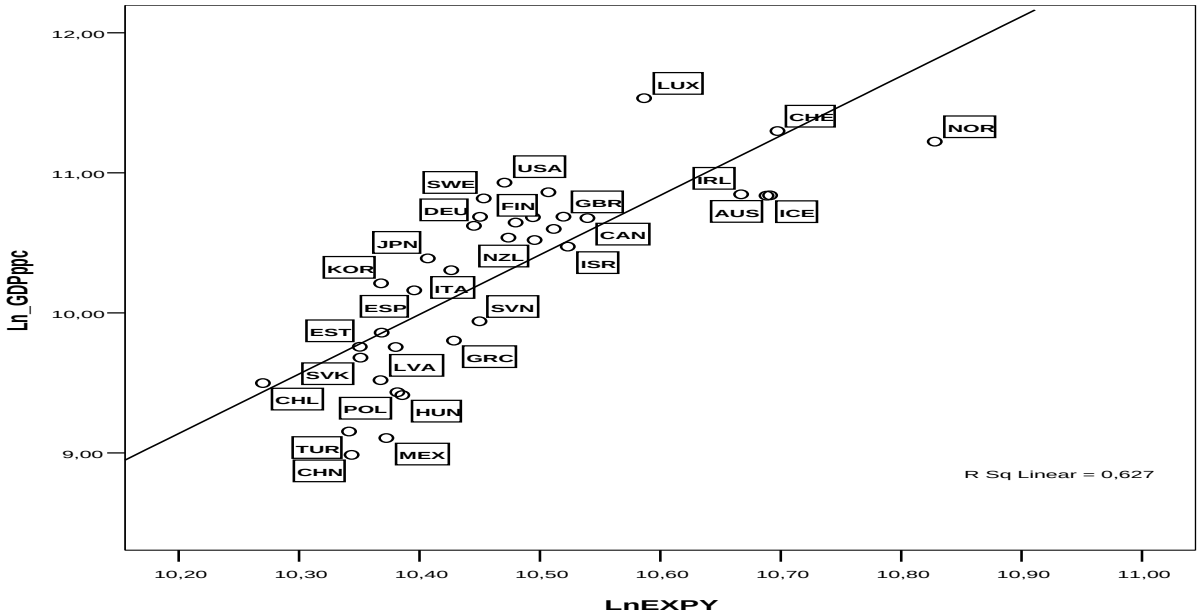
Economic Complexity, Product Complexity and Development

From the ubiquity and complexity measures of the method of reflection we can infer that the Turkish economy is a fairly diversified country in our sample (OECD countries plus China). Additionally, Turkey seems to have a notable potential to create new related varieties of products. Yet, its production structure is not specialized in high PRODY sectors. To illustrate this, we use log values of OF, PRODY, EXPY and GDP per capita in terms of PPP in the graphs and tables below.

Figure 1 shows the relationship between the log of EXPY index and log of the per capita GDP for the countries in the sample. EXPY is a proxy for the productivity associated with the export basket of the country. In other words, the EXPY value of a country is the weighted average PRODY of its export basket and represents the income content as well. Figure 1 illustrates an explicit strong positive correlation between EXPY and per capita GDP. However, there exist differences among countries in the sample. The distance between the representative line and location of the country is usually interpreted as the future growth potential of the country in the relevant literature. That is, some countries have an income per capita above or below their potential. Figure 1 gives us some clues or evidence about high income countries tending to export more sophisticated products that have high "income content." Specifically, regressing log of per capita GDP on log of EXPY gives us the following regression equation where the t-ratios are in parenthesis.

$$Y=4.25*expy-34.25 \quad ; R^2=0.63 \qquad (13)$$
$$(7.55) \qquad (-5.81)$$

Figure 1: Scatter Plot between GDP and EXPY (Y=4.25*expy-34.25)



Source: Constructed by authors based on GDP per Capita and authors' own calculation of EXPY.

Hidalgo and Hausmann (2009) classify the countries in four groups in terms of complexity and ubiquity of the products they produce. They call this the method of reflections matrix that represents the building blocks of economic complexity.

Figure 2: Method of Reflections Matrix

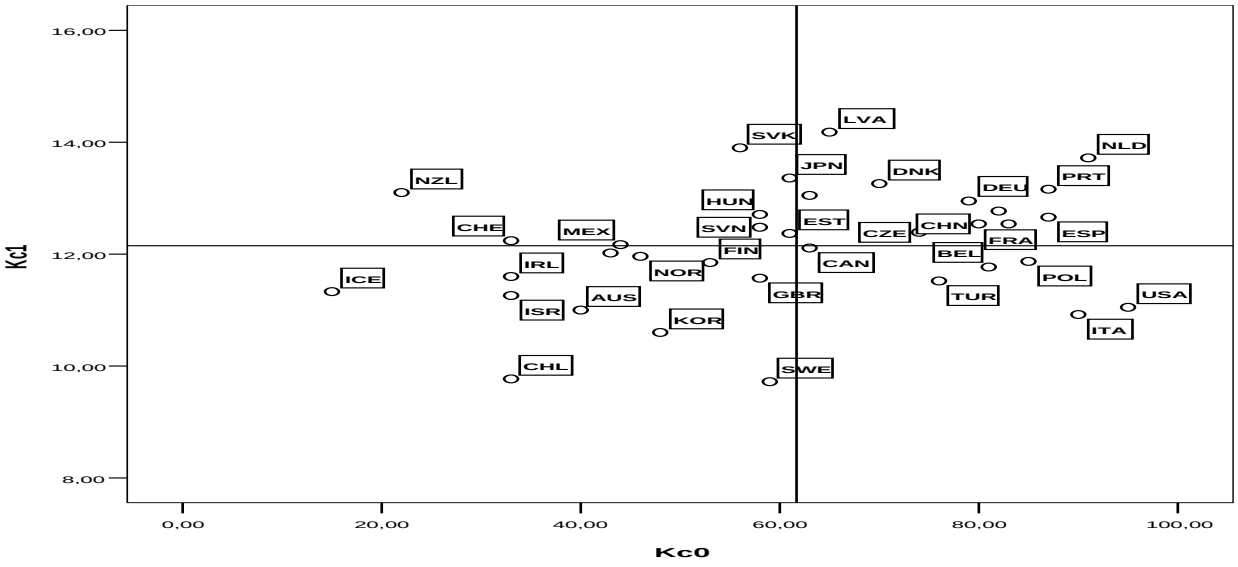
Non- Diversified Countries Producing Standard Products (II)	Diversified Countries Producing Standard Products (I)
Non- Diversified Countries Producing Exclusive Products (III)	Diversified Countries Producing Exclusive Products (IV)

$K_{c,1}$

$K_{c,0}$

Figure 2 gives us an idea about characteristics based on the diversification and average ubiquity of countries. The method of the reflections matrix provides information about whether a certain country produces exclusive products or not. Standard products are typically expected to be produced by non-diversified and poor countries. The ideal location on this plane is the lower-right quadrant: diversified countries producing exclusive products (IV). The upper-right quadrant shows diversified countries producing standard products (I). The lower-left quadrant: Non-diversified countries producing exclusive products (III). Finally, the undesired outcome on this plane is the upper-left quadrant in which Non-diversified countries produce standard products (II). The results from the method of reflection matrix for our sample of countries are given in Figure 3.

Figure 3: Method of Reflections Matrix



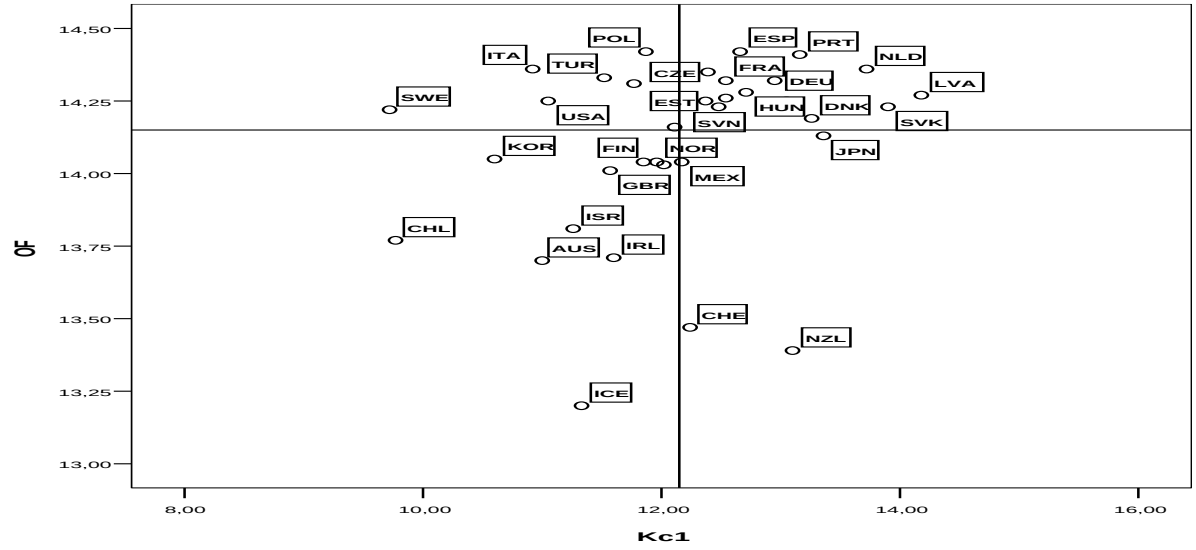
Source: Constructed by authors based on authors' own calculation of average ubiquity (kc,1) and diversification (kc,0).

Figure 3 presents where and in what category each country in our sample is located. Which countries produce exclusive products and which ones produce standard goods can be settled from the information about diversification (K_{c0}) and average ubiquity (K_{c1}) of Figure 3. We assume that a country produces high value products, only if the country possesses all the required productive skill/ knowledge sets and capabilities to produce it. Only under that assumption does the location of a country in Figure 3 provide true information about the capabilities of the country. Turkey is located at the lower-right quadrant: in the group of diversified countries producing exclusive products (IV). Some other countries namely USA, Italy, Poland and Belgium are located in this group too. Iceland, Ireland, Israel, Australia, Chile,

Korea, and Norway are located at the lower-left quadrant of the figure: Non- diversified countries producing exclusive products (III). Netherland, Portugal, Denmark, Germany, China, France are located at the upper-right quadrant of diversified countries producing standard products (I). Turkey seems to be in a group of diversified countries producing and exporting less ubiquitous products.

Figure 4 below gives the scatter plot of open forest against average ubiquity. Turkey, Italy, USA, Poland as well as Sweden appear to be located in a denser part of the forest. As observed in Figure 4, Turkey has a high level of open forest, meaning its option set for future structural transformation is very attractive and Turkey needs parsimonious industrial policies to help jump short distances towards more sophisticated, nearby products. On the other hand, based on Figure 1, Turkey has very low EXPY and GDP per capita in terms of purchasing power parity. Average PRODY values in Table 1 below reflects averages of industries only with RCA>1 in a country. Turkey has the lowest average PRODY value in the sample. On the other hand, Turkey's ubiquity is below average while its diversity is above average. This means that Turkey to a certain extent is specialized in low productivity sectors and products. That seems to be the potential reason of low EXPY and GDP per capita in terms of purchasing power parity[5].

Figure 4: LnOF versus Average Ubiquity



Source: Constructed by authors based on authors' own calculation of "open forest" (OF) and average ubiquity (kc,1).

[5]Ireland, on the other hand, is another special case with low diversity index and high average PRODY. It has specialized in chemicals such as Medicinal and pharmaceutical products, other medicaments of group 542 (541), Medicaments (including veterinary medicaments) (542), and essential oils, perfume and flavor materials (551).

Table 1: Country Ranking According to Average Prody with RCA>1

Country Codes	Country	Average Ubiquity (kc,1)	LnEXPY	Div (kc,0)	Average PRODY	Ln_GDPppc	OF
NOR	Norway	11.96	10.82	46.00	10.61	10.52	14.04
SWE	Sweden	9.72	10.76	59.00	10.58	10.82	14.22
HUN	Hungary	12.71	10.68	58.00	10.55	9.41	14.28
AUS	Australia	11.00	10.70	40.00	10.52	10.84	13.70
GBR	United Kingdom	11.57	10.57	58.00	10.52	10.69	14.01
ICE	Iceland	11.33	10.64	15.00	10.50	10.84	13.20
LVA	Latvia	14.18	10.58	65.00	10.49	9.52	14.27
USA	USA	11.05	10.49	95.00	10.48	10.93	14.25
EST	Estonia	12.37	10.49	61.00	10.46	9.76	14.25
FIN	Finland	11.85	10.46	53.00	10.46	10.64	14.04
ITA	Italy	10.92	10.42	90.00	10.46	10.30	14.36
CAN	Canada	12.11	10.56	63.00	10.45	10.68	14.16
MEX	Mexico	12.17	10.48	44.00	10.44	9.11	14.04
FRA	France	12.54	10.45	83.00	10.44	10.54	14.32
IRL	Ireland	11.60	10.51	33.00	10.44	10.85	13.71
BEL	Belgium	11.77	10.50	81.00	10.43	10.60	14.31
NLD	Netherland	13.72	10.50	91.00	10.43	10.68	14.36
CZE	Czech rep	12.39	10.52	74.00	10.42	9.76	14.35
ESP	Spain	12.66	10.45	87.00	10.42	10.16	14.42
SVK	Slovakia	13.90	10.43	56.00	10.40	9.68	14.23
AUT	Austria	12.77	10.44	82.00	10.40	10.69	14.38
JPN	Japan	13.36	10.38	61.00	10.40	10.39	14.13
KOR	Korea	10.60	10.36	48.00	10.39	10.21	14.05
DEU	Germany	12.95	10.43	79.00	10.39	10.62	14.32
CHE	Switzerland	12.24	10.28	33.00	10.37	11.30	13.47
CHN	China	12.54	10.37	80.00	10.37	8.99	14.26
NZL	New Zealand	13.10	10.37	22.00	10.37	11.22	13.39
SVN	Slovenia	12.48	10.39	58.00	10.36	9.94	14.23
ISR	Israel	11.26	10.42	33.00	10.36	10.47	13.81
PRT	Portugal	13.16	10.34	87.00	10.35	9.86	14.41
DNK	Denmark	13.26	10.37	70.00	10.34	10.86	14.19
GRC	Greece	13.05	10.38	63.00	10.34	9.80	14.25
LUX	Luxemburg	12.02	10.38	43.00	10.30	11.53	14.03
CHL	Chile	9.77	10.33	33.00	10.30	9.50	13.77
POL	Poland	11.87	10.35	85.00	10.30	9.43	14.42
TUR	Turkey	11.52	10.29	76.00	10.29	9.15	14.33
Average of the sample		12.15	10.47	61.25	10.39	10.29	14.11

Source: Constructed by the authors based on GDP per capita and authors' own calculation of average ubiquity (kc,1), export sophistication (EXPY), diversification (kc,0), average PRODY and open forest (OF).

Conclusion

According to the method of reflections matrix, most exclusive products are produced by Iceland, Ireland, Israel, Norway, Australia, Chile, Korea, United Kingdom, Sweden, Belgium, Turkey, Poland, USA and Italy. The finding of the matrix indicates that Turkey's production structure located in the group of diversified countries that produe less ubiquitous products (quadrant IV). Figure 4, on the other hand, shows that open forest values of Switzerland, New Zealand, Ireland and Iceland are well below the average while their ubiquity values are above the average or circa average. Hence, the export baskets of these countries provide few opportunities for future structural transformation possibilities. Turkey, Poland, Italy, Sweden, Belgium as well as the USA, in contrast, are located in the denser part of the forest with ubiquity values below average, signaling wider prospects for structural transformation.

Measuring and analyzing complexity and ubiquity of production and export structure provide us with useful clues in determining specific development policy recommendations for Turkey. We find a strong positive correlation between EXPY and GDP per capita of the countries in the sample. Turkey has relatively low EXPY and GDP per capita compare to other countries, signaling a low-income content and/or unsophisticated productive skill/knowledge set (current EXPY and per capita GDP values are very low). Turkey's product space, nevertheless, is well diversified and it's 'Open Forest' (OF) value is so high that the country certainly appears to have the capacity to jump to the nearby high PRODY sectors. Lower average ubiquity is a sign for production of exclusive products; high level of 'Open Forest' is an indicator of the capacity to jump to new products. Hence, both measures provide significant signs of capability for accelerating the speed of structural transformation.

Currently Turkey's production is not specialized at high PRODY sectors. Indeed, the country tends to produce low PRODY products and its average PRODY ranks last in the sample. However, Turkey appears to be producing at least some products within very close proximity of high PRODY sectors and its low ubiquity indicates the capability to produce some exclusive products. Consequently, the country must target some high PRODY sectors within the proximity of current capabilities, as well as the sectors that would lead to fast accumulation of relevant capabilities to produce exclusive, high EXPY, high PRODY products. So the country needs a range of policy measures both to create new and to enhance the existing capabilities of firms in the economy.

References

Comtrade, U. N. (2016). UN trade statistics. *URL: http://comtrade. un. org.* Accessed 10 January 2016.

Felipe, J., Kumar, U., Abdon, A., &Bacate, M. (2012). Product complexity and economic development. *Structural Change and Economic Dynamics*, *23*(1), 36-68.

Hausmann, R., & Klinger, B. (2006). Structural transformation and patterns of comparative advantage in the product space (Working paper No. 128). Harvard University Center for International Development.

Hausmann, R., Hwang, J., &Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, *12*(1), 1-25.

Hausmann, R., Zahidi, S., Tyson, L., Hausmann, R., Schwab, K., & Tyson, L. D. A. (2009). The global gender gap report 2009. World Economic Forum.

Hausmann, R. (2010). The future Scenario for the Economy and Manufacturing. *Istanbul Chamber of Industry (ISO).*

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yıldırım, M. A. (2012). *The atlas of economic complexity: Mapping paths to prosperity*. Mit Press.

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

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

Hidalgo, C. A., &Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences*, *106*(26), 10570-10575.

IMF, (2016). World Economic Outlook Database. IMF (Internationally Monetary Fund), *URL:http://www.imf.org/external/pubs/ft/weo/2016/01/weodata/index.aspx.* Accessed 10 January 2016.

Krugman, P. (1994). Competitiveness: a dangerous obsession. *Foreign Affairs*, 28-44.

Marshall, A. (1920). *Industry and trade: a study of industrial technique and business organization; and of their influences on the conditions of various classes and nations*. Macmillan.

Minondo, A. (2010). Exports' quality-adjusted productivity and economic growth. *The Journal of International Trade & Economic Development*, *19*(2), 257-287.

Nunes, L. C., da Costa Neves, R. J., & de Freitas, M. L. (2013, September). Specialization patterns and structural transformation: the cases of China and India. In *Manuscript. A preliminary version is available in the proceedings of the 9th Iberian International business conference, NIPE Universidade do Minho*.

Porter, M. E. (1990). The competitive advantage of nations. *Harvard Business Review*, *68*(2), 73-93.