# Investigating the Link Between Income Growth and Carbon Footprints of Production: A Case Study on Pakistan

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## Abstract
This paper looks at the production footprints of Pakistan by decomposing aggregated environmental pressure into product-specific environmental pressure for the investigation of the nexus between environmental quality and technological development with increasing economic growth over time. The study is based on secondary data for 38 years, which is taken from the Pakistan Economic Survey. Key to this investigation is the utilization of product-specific standards provided by the Global Footprint Network, which are instrumental in quantifying the ecological footprints associated with Pakistan's production activities. The study has used the ARDL bound testing method to estimate the short-term and long-run relationship between environmental quality technological development and economic growth. The empirical findings disclose a non-linear association between the ecological footprints generated by production activities and the level of technological development in Pakistan. Notably, the results indicate that technological advancements play a crucial role in mitigating environmental pressures over time, particularly as the economy undergoes growth. This underscores the significance of technological innovation as a means to alleviate environmental burdens amidst the backdrop of economic expansion. Better technology helps to offset the environmental pressure over time.
**keywords:** Footprints, Economic growth, Environmental quality, ecological sustainability

## 1.0 Introduction

Ecological footprints measure land area required for production consumption and absorption of waste that is generated. It is also called an ecological accounting, which tell us how much resources we have. And how much we are utilizing and keeping the records of resources regeneration as well Global Footprints Network (2006). The available bio productive space for nation, population or an activity, that's helps in providing natural resources to sustain the life. Its ecological infrastructure which country has developed or has naturally is known is biological capacity. In early (Pelzer, 1941) argued that carrying capacity of a nation cannot be measured by crops land, productivity alone but it must include, all type of productive land available for use. It should also include the available pastureland, forestland, water bodies, climate, access to sea lands with ironic natural sea food and access to trade routes. The land area required for the production, harvesting and processing of products from cropland, pasture lands forest lands and water bodies is included in the production footprints account of a product. A specific portion of these production footprints are exported to other countries in form of trading commodities (Andersson & Lindroth, 2001).

At the very Initial stage the income growth often adversely effects environmental quality (Dasgupta & Mäler, 1995). because in this stage the population growth and income growth lead to increase in aggregate consumption, which is also known as scale effect. The increasing scale of economy requires high amount of resources to sustain but after achieving the certain level of growth, the economy is economically able to afford and install the environmental friendly technologies in the production process, which brands production sectors more environmental friendly and safeguards the overall environmental quality of a nation. This is called the technical effect. Example of break clines can make it clearer, if a country is using old technology in production of breaks in breaks clines, which can accommodate comparative very less breaks but if the country shifts to newly introduced Zigzag technology, which can accommodate reasonably high quantity of breaks. Now this phenomenon can restrict increasing environmental pressure due to cleaner production process and much more efficient comparatively.

The channel of composition effect can also affect the bio-capacity of the nation positively, when inputs-mix in the production process is changed from dirty inputs to clean inputs. Let's say a country produce break clines and use coal as an input after achieving certain level of income growth the country shifts its production process from coal to gas, which cleaner comparatively but This is also expected at higher income level countries (Acar & Aşıcı, 2015). Among these effects composition effect is better to understand the Displacement Hypothesis and Pollution Haven Hypothesis. The economics of international trade associates composition effect with the theory of comparative advantage, where a developing country can be linked

with developed countries, for the purpose, that they can trade for better environmental friendly technologies to reduce the future environmental pressure.

Consequently, single effort to encourage eco-friendly impressions may amplify some additional complications (Suri & Chapman, 1998). (Aşıcı & Acar, 2016)argued that trading cleaner inputs for the production process can save local biocapicity for future. The products, which are highly resource hungry should be imported from other economies on viable economic transactions. This is also called trading biological space. The imports of dirty products reduce the production emissions of a country and so effects the ecological footprints of nation accordingly. This way the negative consequences are exported to other nations and the home environment is ecologically protected on the cost of global environment. The current study has decomposed the analysis of income and environment association by taking selected traded commodities specific footprints standards, to investigate the reallocation of ecological footprints through the income growth and trade expansion over time. The income growth effects efficiency of production and industrialization, which can push the economy towards specialization, consequently reduce the imports footprints and can produce in home country. Also through production specialization producers can produce at low cost and face higher demand through trading at low prices.

The population of Pakistan as per 2017 census is 207.68 million which was 132.35 million in 1998. With the growth in population, the nation use of nature is increasing. The 2020 Environmental Performance Index ranked Pakistan on 142$^{nd}$ out of 180 countries with a change of 6.1 in 10 years. The economies experiencing structural changes and paradigm shift from the use of carbon-intensive industrialized countries to having service and information sector as the main contributor towards economic growth, have reduced carbon dioxide ($CO_2$) emission. The transport system, agriculture and services sector of developing economies that are more industrial oriented have been the main drivers of increase in this emission. Moreover, the regulations related to environmental degradation are weak in developing countries which make them more exposed to high-energy carbon-intensive industries. Additionally, increasing population causing higher production and consumption calls for more extraction of natural resources, energy, waste generation and increase in the ecological footprint. Increase in income and enhanced production system tighten the environmental regulations; also, the rapid industrialization increases income level leading towards urbanization. All these factors raise concerns towards environmental quality.

## 2.0 Literature Review

### 2.1. Ecological foot prints of production

Extensive research has attempted to investigate nexus between economic growth or development and ecological footprint. It has been argued that urbanization along with service-based activities have profound effects on the

EF. Urbanization increases energy usage that emits $CO_2$. Such factors increase human consumption of crop, sea products and use of forest and animals. Moreover, the industrial production that adds to consumption based environmental impact. (Hassan, Baloch, Mahmood, & Zhang, 2019) investigated this relationship in case of Pakistan by using 1971 to 2014 data and concluded that the economic growth increases ecological footprint leading towards environmental degradation.

The relationship between growth and environment has been extensively studied by (Wang, Zhang, & Wang, 2018); (Uddin, Alam, & Gow, 2016) in 22 countries including Australia, Belgium, Brazil, Canada, China, Denmark, France, India, Italy, Japan, Mexico, Nepal, Nigeria, Philippines, South Korea, Sri Lanka, Sweden, Switzerland, Thailand, Turkey, UK and USA; (Udemba, 2020) in Nigeria; (Rehman & Rashid, 2017) in SAARC economies; (Özokcu & Özdemir, 2017) in OECD economies and (Rehman & Rashid, 2017) in SAARC countries.

Positive and statistically significant relationship between environmental degradation and economic growth has been found by (Udemba, 2020), (Rehman & Rashid, 2017). (Hassan et al., 2019), (Uddin et al., 2016). While, (Uddin et al., 2016) has made use of Kuznets Curve according to which the environmental degradation follows an inverted U-shape where it first rises and then declines with the increasing economic growth.

Previous studies have found weak impact of urbanization on ecological footprint including studies by (Rashid et al., 2018); (Pata, 2018); (Kasman & Duman, 2015); (Nathaniel & Khan, 2020) and (Ulucak & Khan, 2020). On the other hand, (Ali, Abdul-Rahim, & Ribadu, 2017) have found that urbanization deteriorates environment. They found more severe condition in Singapore compared to Thailand, Vietnam and Indonesia as Singapore remains the most urbanized country among Southeast Asian economies. Almost hundred percent population of Singapore lives in urbanized areas which has propelled deforestation adding to adverse effects on environmental quality (Tan, Feng, & Hwang, 2016). In case of Indonesia, around one-half of its population is living in urban cities. The country has abundant reserves of coal that will serve as the main source of energy in future for the increasing population (Kurniawan & Managi, 2018). Vietnam, although relatively less urbanized but its basic facilities are concentrated in urban centers that propel population towards urban migration (Fan et al., 2019).

Foreign Direct Investment (FDI) is believed to be a major contributor towards pollutions in the host economies. The notion of pollution haven hypotheses considers unfavorable effect of operations of foreign companies on the environment of the host countries; whereas, the pollution halo hypothesis asserts that foreign companies' operations have favorable effects on the environment as well as economy of the host country (Mert & Caglar, 2020). The policies in developing countries are developed in such a way as

to attract the foreign investors that helps in inducing economic growth. It includes exempted reduced taxes, being less hostile to foreign investors regarding environmental protection and regulation. Companies that are not able to carry out energy intensive and emission incline manufacturing in their home countries are attracted to do so in countries that have less stringent regulations. The incoming of such manufacturing companies in host country amount to dirty productive operations that consume high levels of fossil fuels resulting in environmental damage.

During 1990s, the influence of foreign direct investment emerged as the largest source of finance for developing countries and official loans were observed to be an important one in low-income economies. Various studies have proved that FDI is a structural mechanism that can be held partly responsible for the $CO_2$ emission. This emission adversely affects carbon footprint in the total national footprint. (Nathaniel & Khan, 2020) and (Chen & Chang, 2016) and (Solarin & Al-Mulali, 2018) have attempted to find the association of ecological footprint with the foreign direct investment (FDI). (Solarin & Al-Mulali, 2018) have found that increase in FDI leads to a reduction in EF in developed countries. The manufacturing processes depend on some degree use of bio-capacity to be responsible for inputs and removal of wastes at several points in the process of producing a product. Hence these products carry an embodied Footprint. The trade of bio productive space can be seen inform of products trade. The present study calculates production ecological footprints by collecting the estimated standards published by GFN and other researchers at different studies, reports and articles. Per unit ecological footprints standards of Cement, Fertilizers, Wheat, Rice, Plastic, Polyesters, Papers and Fish products are multiplied by quantity produced to calculate the production footprints of any commodity. And at last stage, to make it single series, the horizontal summation of products ecological footprints is done, as Eco Footprint of product one + Eco Foot Print of product 2 +Eco Foot Print of product 3 & so on.

**Table 2.1 Environmental Kuznets curve**

| Year/Authors | Objective of the study | Data and variables of study | EKC Findings |
|---|---|---|---|
| (Munir & Khan, 2014) | To empirically investigate the environmental Kuznets's curve for Pakistan | Pakistan data from 1980 to 2010 on following variables Co2 and Energy consumption Trade openness ,financial development and industrial value added | The results of the study supported inverse U shaped Environmental Kuznets's curve in case of Pakistan along with other trade openness and financial-development variables |
| (Mahmood & Shahab, 2014) | To investigate the relationship between energy consumption | Pakistan data from 1973 to 2012 on the following variables. | The study results showed that ECK is not placed in Pakistan in |

| | | | |
|---|---|---|---|
| | Co2 emission and economy of Pakistan in long run perspective. | Real GDP, Co2 per capita in tons, fixed capital formation ,employed labor force and exports in millions | case of these variables and it may not be possible for developing nations as they are on process. |
| (Shahbaz, 2013) | To find the relationship between economic instability and environmental degradation inside the multivariate frame over the period of 1971–2009 in case of Pakistan | ARDL bound testing approach to co integration for long run and to cover short run dynamics the ECM method was applied. | There existed a long run relationship between both variables and financial instability increases environmental degradation |
| (Shahbaz, Dube, Ozturk, & Jalil, 2015) | To check the empirical evidence of an environmental Kuznets curve (EKC) hypothesis for Portugal from 1971 to 2008 | Autoregressive distributed lag bounds testing approach | The evidence of EKC hypothesis in both the short-run and long-run is confirmed. |
| Tariq Mahmood (2007) | To investigate the long run relationships among the Energy, Environment and the Economy (E-E-E) | Time series data, | We found robust long run relationships between energy, environment and economic growth. It is also found that the capital and labor elasticity's of income show decreasing returns in the presence of energy and emission variables |

**Table 2.2 papers on Income growth and exports**

| Author and year | Objective | Data Methodology | Findings |
|---|---|---|---|
| (Balassa, 1985) & (Gershon, 1982) | To examine the role of exports in growth of economy as well as trade and industry progress. | Panel data Error Correction Modelling (ECM | Promising influences of exports on economic growth in developing economies. |
| (Bahmani-Oskooee, 1993) | To find an association between export growth and economic growth for export-led growth hypothesis | Panel data Error Correction Modelling (ECM) | Strong support for export led growth hypothesis for all of the countries included in the sample of nine developing countries |

| | | | |
|---|---|---|---|
| (Khan, Malik, Hasan, & Tahir, 1995) | To find strong indications of bi-directional causation between export growth and economic growth in Pakistan. | Time series Simultaneous equation modelling | Established robust relationship amongst trade performance and economic growth in Pakistan. |
| (Ahmed, Butt, Alam, & Kazmi, 2000) | To investigate the relationship between exports, economic growth and foreign debt for Bangladesh, India, Pakistan, Sri Lanka and four South East Asian countries | Panel data Trivariate causality framework | Rejected the export-led growth hypothesis for all the countries, comprised in the sample, excepting Bangladesh economic growth led by exporting sector. |
| (Aurangzeb, 2006) | The relationship between exports and economic growth in Pakistan on time series from 1973 to 2005 | Time series | Marginal factor outputs are considerably higher in the export sector |
| (Shirazi & Manap, 2005) | The relationship between exports, imports and economic growth for Pakistan for the period from 1960-2003 | Time series Long-run causal orderings | There is robust relationship between income growth and trade of Pakistan |
| (Azam & Khattack, 2009) | To investigate the export led growth hypothesis and that output growth is the reason of export growth. | Time series two-way causality conversation Co-integration analyses | Domestic investment, FDI, and trade openness had positive effects on economic growth in Pakistan during 1971-2005 |
| (Makki & Somwaru, 2004) | To find out that the export growth intensifications lead to factor productivity due to advantages gained from increasing returns to scale, by catering to the larger foreign market. | ---------- --------- | Due to the increase in exports efficiency, the exporters are able to participate in foreign markets, which results in technological developments and progression of local industrialists. |

## 2.2 Calculation of Ecological Carrying Capacity

We precede it using the methodology of (Zhang, 2005), the ecological carrying capacity replicates that resources, which are supporting the numbers of individuals, while not compromising the future carry capacity. In the calculation of ecological carrying capacity, as different countries or regions have different natural resource endowment, not only is the ecological production capacity of the unit area of arable land, pasture, forest land, build-up areas, oceans (or water areas) widely different, but the ecological productivity is significantly different as well. Thus, the similar biological productive areas of different countries and regions can't be compared

directly. We need to adjust the different kinds of areas. The difference between regional output and world average output can be corrected with yield factor. As a result, the calculation formula of per capita ecological carrying capacity is:

$$ec = a_j \times r_j \times y_j \qquad (j=1, 2, 6)$$

Where: ec is per capita ecological carrying capacity ($hm^2$ per person);
aj is per capita biological productive area;
rJ is equivalence factor;
yj is yield factor.
Regional ecological carrying capacity:

$$EC = N \times (ec)$$

Where: EC, is regional ecological carrying capacity of the total population ($hm^2$) dependent on these commodities and N is the number of people.

**2.3 Bio-capacity**

The current study has used a very logical methodology to calculate the bio capacity for each product or we can also use it on total sum of product ecological footprints. The emissions in tons are divided on Global average of all kind[1] of productive spaces yield, (2.34) multiply by the land equivalency factor for EF to covert it in global hectares, which is (1.4), to determine the biological productive space in land in global hectares' unit for Pakistan.

*For example:*

Emissions tones / Global average forest yield 2.34 = Hectares of bio-productive area* Land equivalency factor 1.4 = Bio Capacity in Global Hectares

**2.4 Calculating the ecological deficit or ecological surplus.**

If the Ecological Footprint calculation exceeds the regional ecological carrying capacity, the ecological deficit will appear. Similarly, if the Ecological Footprint is smaller than the regional ecological carrying capacity, the ecological surplus will appear. The regional ecological deficit or surplus reflects the natural resources used by people living in that region

**2.5 Econometric methodology**

***The equation for per capita production ecological footprints is formulated as,***

The ARDL model with two lagged terms can be expressed as follows:

$$Yt = \beta 0 + \beta 1 Yt - 1 + \beta 2 Yt - 2 + \gamma 1 X1t + \gamma 2 X2t + \delta 1 X1, t - 1 + \delta 2 X1, t - 2 + \delta 3 X2, t - 1 + \delta 4 X2, t - 2 + \varepsilon t$$

This model captures the short-run dynamics (through the current and lagged values of both dependent and independent variables) as well as the long-run equilibrium relationship between the variables. The equation is specified to test the long-run relationship determinants of Ecological Footprints per capita, where the squared terms of these variables will indicate that increasing GDP and Per capita at initial stages increases the pollution

through importing dirty products in terms of high embodied energies in it, but after a certain level, the ecological footprints of export products start a declining trend, which is a proposition based on EKC hypothesis effects (Kuznets, 1955). The argument is that after the achievement of a certain level of income growth, the economy improves the production process over time and hence exports cleaner products to other countries and can also consequently reduce the Export's eco footprints per capita of the economy in the long run. In this regard, the composition effect, scale effect, and technical effects are famous to ensure a better understanding of the said notion.

**2.6 Model of the study**

Functional form of ARDL: Model for production Ecological footprints and income growth relationship

$$\sum PEFP_t = \beta_0 + \beta_1 \sum PEFP_{t-1} + \beta_2 \sum PEFP_{t-2} + \gamma_1 \text{POPG}_t + \gamma_3 OTT_t + \gamma_4 ENRGPC_t + \gamma_2 BC_t + \delta_1 \text{POPG}_{t-1} + \delta_2 \text{POPG}_{t-2} + \delta_3 OTT_{t-1} + \delta_4 OTT_{t-2} + \delta_5 ENRGPC_t + \delta_6 ENRGPC_{t-1} + \delta_7 BC_t + \delta_8 BC_{t-1} + \varepsilon t$$

**Where**

- PEFPt is the per capita ecological footprint of production activities at time t
- PCIGRWt is the per capita income growth followed by lag values and square terms to track the nonlinearity of the relationship at time t
- POPGt is population growth at time t
- OTTt is trade openness at time t
- ENRGPCt is energy availability per person at time t
- BCt is per capita biocapacity at time t
- Et is the error term of the equation at time t

**Where**

- $Yt$ is the dependent variable at time $t$.
- $X1t$ and $X2t$ are the independent variables at time $t$.
- $0\beta0$ is the intercept term.
- $\beta1$ and $\beta2$ are coefficients for the lagged values of the dependent variable.
- $\gamma1$ and $\gamma2$ are coefficients for the current values of the independent variables.
- , $\delta1$, $\delta2$, $\delta3$, and $\delta4$ are coefficients for the lagged values of the independent variables.
- $\varepsilon t$ is the error term at time $t$.

*Note:* The same model is used for export footprints as a dependent variable because some of the production footprints are traded across borders.

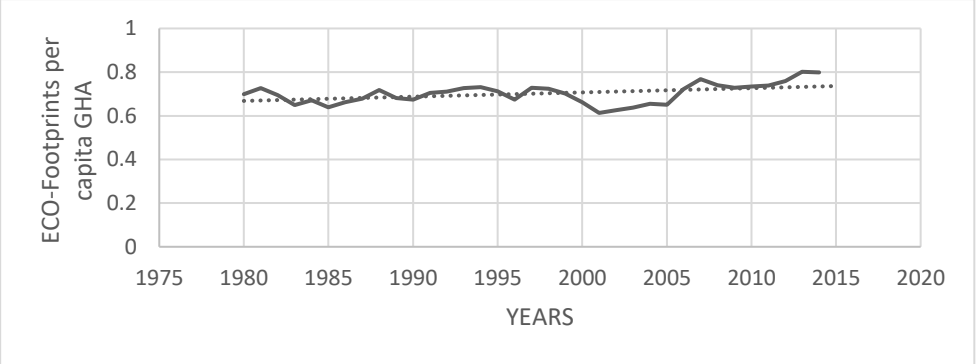
## 3.0 Results and Discussion

**3.1 Pakistan Ecological Footprints of Production and Exports over time 1980-2015**

The figure number 3.1 shows that production footprints of Pakistan from selected commodities have increased over the time. The slop has remained

very low due to high imports of goods from other countries. The imports footprints per capita of Pakistan as almost close to the production footprints per capita. the overall trend remains positive and increasing, however some ups and downs are noticed over the time.

**Figure 3.1 Production Footprints of Pakistan**




### 3.2 Trading negative environmental consequences

Total CO2 emissions of export goods, increased initially up to 8.79 million metric ton in 1988, but reimbursed back to 5.2 million metric tons 1995. Because of production on higher scale, Pakistan exported more. The rising trend of Pakistan exports increased the CO2 emissions from exports and it reached to 16.3 million metric tons in 2004. Growing faster the CO2 emissions from exports of Pakistan, touched the remarkable 22 million metric ton in 2008, "while total emissions of Pakistan were 157 million tons" from agriculture, transport, manufacturing, and energy sector [(ESP 2007-08)].

The reason for upward trends of emissions from exports of Pakistan, might be the increasing trends of vehicles in trading sectors of the economy, which is, grown so fast. According to Pakistan Economic Survey 2006-07 the users of the road transport are also increased in 1990 there were 2.7 million vehicles, which has increased to 5.5 million in 2005, increasing it over 100%, and the growth continued to 9.8 million tons in next 3-4 years. Again, this trend came down to 1.61 million metric tons' due decrease in exports volume of the economy. Right After 2008 crises, strait to the time of floods in 2010 Co2 trend remain down as we needed such goods to allocate in our economy. Overall the exports emissions are increasing before 2008 and decreasing after 2009 tell date for selected specific goods. According to Research & Development Cell, PRGMEA (2012) The exports of cotton made products were diminished by 13.81% in total produce volume and were also augmented by 1.68% in monetary value. The decrease in production volume was due to the shortage of energy and increasing cost of inputs. In last of 1980s our exports were growing and high polluting but after 1990, the slop remains almost zero over 5 years. Overall Increasing trend has been seen after mid 90s in CO2 emissions from exported goods in Pakistan.

**Table 3.1 Production Ecological Footprints and Income growth**

| Dependent Variable: PCPFP: Sample (adjusted): Included observations: 33 after adjustments Maximum dependent lags: 3 Automatic selections, | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
| PCPFP (-1) | 0.195794 | 0.099634 | 1.965137 | 0.0621 |
| PCIGRW | 0.947839 | 0.200392 | 1.735795 | 0.0566 |
| PCIGRW (-1) | 0.241600 | 0.171593 | 1.407984 | 0.1731 |
| PCIGRW (-2) | 0.139507 | 0.152637 | 0.913975 | 0.3706 |
| PCIGRW (-3) | 0.460018 | 0.140763 | 3.268027 | 0.0035 |
| PCIGRWSQ | -6.231244 | 1.742796 | -3.575429 | 0.0017 |
| POPG | 0.000128 | 0.000279 | 0.460507 | 0.6497 |
| OTT | 1.775405 | 0.856884 | 2.071931 | 0.0502 |
| ENPC | -1.71E-05 | 0.000160 | -0.106930 | 0.9158 |
| BC | 0.330534 | 0.042087 | 7.853670 | 0.0000 |
| C | 0.068577 | 0.075794 | 0.904783 | 0.3754 |
| R-squared | 0.928804 | Mean dependent var | | 0.701357 |
| Adjusted R-squared | 0.896442 | S.D. dependent var | | 0.047323 |
| S.E. of regression | 0.015229 | Akaike info criterion | | 5.270054 |
| Sum squared resid | 0.005102 | Schwarz criterion | | 4.771218 |
| Log likelihood | 97.95589 | Hannan-Quinn criter. | | 5.102211 |
| F-statistic | 28.70043 | Durbin-Watson stat | | 1.565038 |
| Prob(F-statistic) | 0.000000 | | | |

This model was selected on the base of Akaike information criteria. The grape above tells us, which model and in how many model the current work of piece is brought in lights.

### 3.3.1 Bound testing for Production Footprints and income growth

The results of joint testing are statistically significant, which indicates to move further for long run and short relationship investigation through ARDL. The F value is greater than upper bond, which means there is expected, a significant relationship between production per capita and income growth of Pakistan over time. But before making any decision, let's move for Co integration form of the relationship among the available set of variables.

**Table 3.2 ARDL Bounds Test for Production Footprints**

| Date: 01/09/17 Time: 01:04, Sample: 1983 2015 | | |
|---|---|---|
| Null Hypothesis: No long-run relationships exist | | |
| Test Statistic | Value | K |
| F-statistic | 48.76801 | 1 |
| Critical Value Bounds | | |
| Significance | I0 Bound | I1 Bound |

| | | |
|---|---|---|
| 10% | 4.04 | 4.78 |
| 5% | 4.94 | 5.73 |
| 2.5% | 5.77 | 6.68 |
| 1% | 6.84 | 7.84 |

Table shows that, bio capacity and income growth are associated with per capita ecological footprints in short run as well as in long run. Most important is long run relation between variables of interest in our study. These long run coefficients are highly significant and validate EKC type relation between income growth and ecological footprints in production sector of Pakistan. Increasing bio capacity increase the production of goods demanded within the boundaries of Pakistan and the associated environmental pressure. The model specifies a good fit model and acceptance of proposed relationship of the current study.

**Table 3.3 Production Footprints and Income growth in ARDL Co integrating and Long Run Form,**

| **Selected Model: ARDL (1, 3)** | | | | |
|---|---|---|---|---|
| Dependent Variable: PCPFP, Date: 01/09/17 Time: 01:07Sample: 1980 2015 | | | | |
| Short run Cointegrating Form | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(PCIGRW) | 0.347839 | 0.200392 | 1.735795 | 0.0966 |
| D (PCIGRW (-1)) | -0.139507 | 0.152637 | -0.913975 | 0.3706 |
| D (PCIGRW (-2)) | -0.460018 | 0.140763 | -3.268027 | 0.0035 |
| D(PCIGRWSQ) | -6.231244 | 1.742796 | -3.575429 | 0.0017 |
| D(POPG) | 0.000128 | 0.000279 | 0.460507 | 0.6497 |
| D(OTT) | 1.775405 | 0.856884 | 2.071931 | 0.0502 |
| D(ENPC) | -0.000017 | 0.000160 | -0.106930 | 0.9158 |
| D(BC) | 0.330534 | 0.042087 | 7.853670 | 0.0000 |
| CointEq (-1) | -0.804206 | 0.099634 | -8.071611 | 0.0000 |
| Cointeq = PCPFP - (1.4784*PCIGRW -7.7483*PCIGRWSQ + 0.0002 *POPG + 2.2076*OTT -0.0000*ENPC + 0.4110*BC + 0.0853) | | | | |
| Long Run Coefficients | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| PCIGRW | 1.478432 | 0.415189 | 3.560863 | 0.0017 |
| PCIGRWSQ | -7.748320 | 2.612430 | -2.965944 | 0.0071 |
| POPG | 0.000160 | 0.000340 | 0.468864 | 0.6438 |
| OTT | 2.207649 | 1.122022 | 1.967563 | 0.0619 |
| ENPC | -0.000021 | 0.000198 | -0.107531 | 0.9153 |
| BC | 0.411006 | 0.043804 | 9.382869 | 0.0000 |
| C | 0.085273 | 0.087272 | 0.977095 | 0.3391 |

### 3.4 Exports Footprints and income growth

After studying Pakistan trade across borders in context of environmental pressure imposed and relaxed on available bio productive space, the current research found that Pakistan is exporting minor negative environmental consequences to its trading partners over time. Current Income growth and squared term are not cointegrated with Exporting pollution of Pakistan to other economies. Trade openness is negatively associated with negative environmental pressure. This is because of our high imports as compare to exports and it is opposite to the concept of negative terms of trade effects. The results indicate that negative environmental consequences of exports were much higher previously but current income growth is not signifying the increasing environmental pressure due to exports of Pakistan. Up behind the certain limits of emissions, some of our foreign consignments were received back, this might also be the reason that our exports are much cleaner as compared to past.

**Table 3.4 ARDL Results for Exports Footprints**

| Method: ARDL<br>Dependent Variable: EFP_EXP_PC Sample (adjusted): Included observations: 32 after adjustments Model selection method: Akaike info criterion (AIC) | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
| EFP_EXP_PC (-1) | 5.599032 | 8.175986 | 0.684814 | 0.5022 |
| EFP_EXP_PC (-2) | 0.884202 | 0.323219 | 2.735616 | 0.0136 |
| PCIGRW | 0.023128 | 0.062619 | 0.369347 | 0.7162 |
| PCIGRW (-1) | 0.126204 | 0.066331 | 1.902644 | 0.0732 |
| PCIGRW (-2) | -0.007471 | 0.046536 | -0.160547 | 0.8742 |
| PCIGRW (-3) | 0.099101 | 0.045824 | 2.162641 | 0.0443 |
| PCIGRW (-4) | 0.050153 | 0.044524 | 1.126427 | 0.2748 |
| PCIGWSQ | -0.802534 | 0.510357 | -1.572495 | 0.1332 |
| PCIGWSQ (-1) | -1.49.771 | 0.602146 | -2.475761 | 0.0235 |
| POPG | -0.000232 | 0.000158 | -1.464879 | 0.1602 |
| SERVICES SHARE | -0.000757 | 0.000674 | -1.123161 | 0.2761 |
| ENPC | 0.001170 | 6.35E-05 | 2.677792 | 0.0154 |
| OTT | -4.938309 | 8.087365 | -0.610620 | 0.5491 |
| BC | 0.016850 | 0.008235 | 2.046271 | 0.0556 |
| R-squared | 0.776047 | Mean dependent var | | 0.020937 |
| Adjusted R-squared | 0.714304 | S.D. dependent var | | 0.006406 |
| S.E. of regression | 0.003979 | Akaike info criterion | | -7.916160 |
| Sum squared resid | 0.000285 | Schwarz criterion | | -7.274900 |
| Log likelihood | 140.6586 | Hannan-Quinn criter. | | -7.703600 |
| Durbin-Watson stat | 1.881560 | | | |

The results show that bound testing value of F statistics is less than the critical bound values, which indicates that we can accept null hypothesis of no long run relationship exits. Also, the ARDL results confirms no long run association between Income Growth and Exports Ecological Footprints.

**Table 3.5 Exports Footprints and income growth ARDL Bounds test**.

| Test, Included observations: 35 | | |
|---|---|---|
| Null Hypothesis: No long-run relationships exist | | |
| Test Statistic | Value | K |
| F-statistic | 2.984858 | 1 |
| Critical Value Bounds | | |
| Significance | I0 Bound | I1 Bound |
| 10% | 4.04 | 4.78 |
| 5% | 4.94 | 5.73 |
| 2.5% | 5.77 | 6.68 |
| 1% | 6.84 | 7.84 |

### 3.6 Major Findings and Answers to the Research Questions

Our study found that Per capita ecological footprint of production and Income growth is significantly co integrated in long run and also provides the evidences regarding the EKC hypothesis. EKC holds for production footprints and income growth also imports footprints are significant to this kind of relation with economic indicators of current study. However, the export ecological footprints are portraying slightly a different story. Answering to the given set of research questions, we can say exports footprints are not significantly reallocated by income growth in Pakistan. Exports footprints are more effectively affected due to biocapacity trade openness and energy per capita.

The production footprints are reallocated due to income growth over the time. These evidences follow long run association over time. The imports products footprints are smaller than footprints of products produced in Pakistan, which is good for us in terms of saving the biological productive space in Pakistan. It means if we produce same products in Pakistan, it will cost us higher resource use and extractions from our reserves. If these products are imported from others on reasonable economic transactions, it is possible that these products might help Pakistan to increase the welfare of increasing population.

### 4.0 Conclusion

It is not only the income growth but also other economic indicators that might lead to deviating the patterns in environmental quality of Pakistan. Yet again our study has provided some evidences of EKC existence in Pakistan for disaggregated analysis through ARDL bound tests and co integrating technique. This study found that exports footprints of Pakistan is quite smaller than the imported footprints, which indicates that Pakistan is not a

production-based pollution driven country but a consumption-based pollution driven economy. Pakistan is importing high of its consumption share in total ecological footprints from other countries in form of products. But for Pakistan evidences are supported by ground realities for observable and changing responses from one economic activity (agriculture sector) to another economic activity (industrial sector) from one kind of pollution to other kind of pollution.

### 4.1 Policy Recommendations

Consumption Footprints are reallocated by GDP growth in long run, which might be significantly reduced by deployment of environmentally friendly technologies and inputs composition changed in the production process of under research products. So, it is required for policy makers and implementers to be aware of, the inputs used in production of commodities and standards of emissions allowed for a firm. Products with high resource requirements should be imported from countries, with specialization in production of such products, it will help us to save biological productive space of our own economy for future generation. And it will increase our social welfare as of saving the environment and resources. It is very important to reduce the emission of garment making and tinning industries in Pakistan, which are putting higher environmental stress on hosting economy as well as the receiving economies for the products we export.

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