
# PETUNJUK SKRIPSI KAJIAN LITERATUR

JURUSAN ILMU EKONOMI

2020

## PENGANTAR

Sesuai Surat Edaran Wakil Rektor 1 tanggal 23 April 2020 tentang kegiatan akademik di masa Pandemi Covid-19 yang menyatakan skripsi mahasiswa yang terhalang pandemi dapat diganti dengan kajian literatur dengan persetujuan pembimbing dan kepala program studi, berikut panduan singkat kajian studi literature yang dapat dianggap memenuhi beban studi 6 sks di Jurusan Ilmu Ekonomi. Jumlah publikasi yang direview secara detil minimal 15 publikasi.

Pilihan lain yang dapat dilakukan mahasiswa adalah skripsi dengan menggunakan data sekunder untuk menghindari kontak dengan responden. Mahasiswa juga boleh menulis paper degan standar publikasi (5000 - 6000 kata) dengan nama matakuliah ECO401 Tugas Akhir, tapi hanya berbobot 3 sks dan mahasiswa mesti menambah 3 sks lagi dari lebihan matakuliah pilihan untuk mencukupkan persyaratan sks sarjana. ECO401 cocok bagi mahasiswa yang memiliki lebihan beban matakuliah pilihan yang bernilai A.

## PETUNJUK SINGKAT KAJIAN STUDI LITERATUR PENGANTI SKRIPSI

Gambar 1: Step Melakukan Kajian Studi Literatur (Fink, 2014)

# ISI KAJIAN REVIEW LITERATUR

1. Pendahuluan

   1.1. Latar Belakang

   Anda menjelaskan latar belakang dan alasan tertarik mengkaji bidang yang ingin diteliti. Tunjukkan urgensi kajian ini dilakukan dan apa keperluan anda meneliti hal tersebut.

   1.2. Perumusan Masalah

   Anda menjabarkan permasalahan yang mengemuka pada bidang yang diteliti berdasarkan penjabaran latar belakang. Contohnya adanya kemungkinan gap antara teori dengan kenyataan di lapangan, atau apa yang sudah diketahui dan apa yang belum diketahui. Bahagian ini ditutup dengan kalimat-kalimat tanya yang akan menjadi pedoman dalam mereview.

   1.3. Manfaat Penelitian

   Jelaskan manfaat yang diperoleh jika pertanyaan penelitian tersebut terjawab.

2. Metodologi Review

   Mereview literature berarti mengidentifikasi dan menginterpretasikan apa yang sudah diketahui tentang topik tertentu. Untuk mengevaluasi sebuah kajian literature, Anda mesti mempelajari kriteria untuk mengevaluasi kualitas sebuah penelitian.

   2.1. Data Base

   Kajian literature bergantung kepada data yang tersedia dari online bibliographic database, misalnya JSTOR, ScienceDirect, ProQuest, Web of Science, GoogleScholar, Social Science Citation Index, dan sebagainya. Memilih database bergantung dari pertanyaan penelitian yang mesti dijawab. Anda mesti menuliskan alasan memilih sumber bibliografi online yang dipakai untuk mendapatkan jurnal artikel, buku, atau publikasi lain yang akan di review.

## 2.2. Search terms

Pertanyaan penelitian yang jelas sangat menguntungkan Anda karena akan mengandung beberapa kata kunci (keyowords) yang digunakan untuk mencari literature dalam database. Anda mesti menyebutkan kalimat atau kata kunci yang digunakan untuk memilih literature yang akan direview. Pengetahuan tentang Bolean logic AND, OR, dan NOT juga membantu menyeleksi literature.

## 2.3. Practical Screening

Penelusuran awal akan menghasilkan sangat banyak literature terseleksi, namun hanya beberapa yang akan releven dengan pertanyaan penelitian. Anda mesti menjelaskan bagaimana metode anda menyeleksi literatur-literatur tersebut: apa kriteria suatu artikel akan dimasukkan untuk direview atau dikeluarkan dari review. Termasuk ke dalam kriteria practical screening criteria adalah bahasa yang digunakan publikasi, tipe publikasi (jurnal, buku, dsb), rentang waktu publikasi, penulis, responden, disain riset, dan sebagainya.

## 2.4. Methodological Screening

Methodological screening adalah proses seleksi publikasi berdasarkan kualitasnya secara keilmuan. Publikasi berkualitas tinggi menggunakan standar penelitan yang ketat. Untuk melakukan seleksi, Anda menjawab pertanyaan (i) apakah riset desainnya valid secara internal dan eksternal? (ii) apakah sumber data yang digunakan dapat diandalkan dan valid? (iii) apakah metode analisisnya bersesuaian dengan data? (iii) apakah kesimpulannya studinya berarti dan signifikan secara statistic? Termasuk ke dalam kriteria methodological screening adalah teknik sampling, data, dan metode analisis yang digunakan untuk menjawab pertanyaan penelitian. Sebahagian literature menggunakan pendekatan kuantitatif, sebahagian lain kualitatif, dan sebahagian lainnya menggunakan mixed-method, gabungan kualitatif dan

kuantitatif. Pilihan-pilihan pendekatan ini mesti cocok dengan pertanyaan penelitian yang diajukan setiap literature tersebut.

3. Ringkasan Literatur Terpilih

Setelah malakukan penyisiran literature, Anda akan berhadapan dengan pengelolaan (filing) literature tersebut. Penggunaan Bibliographic Software seperti EndNote, Mendeley, ProCite, dan Zotero sangat membantu pengorganisasiannya. Bahkan setiap database menyediakan fasilitas citation manager untuk mendownload literature dan menyajikan bibliografi dalam style yang diinginkan: Jurusan Ilmu Ekonomi mengikuti APA Style. Alasan penting lain menggunakan software adalah memudahkan Anda untuk akurasi dan update library.

3.1. Deskripsi Literatur

Setelah beberapa publikasi terpilih untuk direview, Anda mesti membaca secara seksama dan membuat ringkasannya yang minimal terdiri dari tujuan, metodologi, hasil, dan kritik anda terhadap setiap publikasi tersebut. Pada bagian ini Anda menuliskan ringkasan dari setiap publikasi yang direview satu per satu, minimal 15 publikasi. Membuat *Pitching Research* untuk setiap publikasi akan sangat membantu Anda untuk menuliskan ringkasan publikasi tersebut.

3.2. Tabulasi Pengelompokan

Setelah ringkasannya dicantumkan, setiap publikasi dikelompokkan berdasarkan pertanyaan penelitian atau sub pertanyaan penelitian. Pengelompokan itu ditabulasikan seperti:

| | Measures | References (Data) | Main contribution (Indexes) |
|---|---|---|---|
| Traditional measures of export performance: A focus on export diversification | **Firm's export diversification by product for a given country:** Increase of firms' market shares by product, *i.e.* each mono- or multi-product firm exports progressively more | **Mayer, Melitz, and Ottaviano [2014]** (Country-firm-product level data: French Customs) | Characteristics of destination countries and product mix – Pro-competitive effect (Multi-product firms framework) |
| | | **Lelarge and Nefussi [2010]** (Country-firm-product level data: Community Innovation Survey, National Intellectual Property Institute, European Patent Office, French Customs, French Products Classification, INSEE) | Evolution of product portfolios anc low-wage competition – Pro-active effect (Concentration, Reallocaton, and Inertia) |
| | **Sector's export diversification for a given country:** Reallocation of resources towards the most productive sectors | **Imbs and Wacziarg [2003]** (Country-sector level data: International Labor Office, United Nations Industrial Development Organization, Organisation for Economic Cooperation and Development) | Sectoral concentration and level of per capita income – U-shaped curve (Measures of sectoral concentration such as Gini or Herfindahl indexes) |
| | **Country's export diversification by product:** Reallocation of resources towards the most performant products within or between firms for a given country | **Cadot, Carrère, and Strauss-Kahn [2011]** (Country-product level data: UN Comtrade) | Extensive/intensive margins and hump-shaped curve – Diversification cones (Theil's entropy index) |
| | | **Cheptea, Fontagné, and Zignago [2014]** (Country-product level data: BACI) | Composition effects, pure performance effect and variety of exported products – Reshaping of the world market (Shift-share methodology) |
| New measures of export performance | **Export sophistication:** New way of classifying products based on the level of income in each exporter country, and on the revealed comparative advantage of each exporter country for each given product | **Lall, Weiss, and Zhang [2006]** (Country-product level data: UN Comtrade, World Bank) | Characteristics of exporter countries and promotion of exports – Individual strategies of economic performance (Unique sophistication score) |
| | | **Hausmann, Hwang, and Rodrik [2007]** (Country-product level data: UN Comtrade, World Bank) **Applications:** Kumakura [2007]; Yao [2009]; Jarreau and Poncet [2012] | Implied productivity and revealed comparative advantage – Self-discovery – Quality spectrum (*PRODY* and *EXPY*) |
| | **Product space:** Network of relatedness between each pair of products | **Hidalgo, Klinger, Barabasi, and Hausmann [2007]** (Country-product level data: World Trade Flows) **Applications:** Hausman and Klinger [2007, 2008a&b, 2010a&b]; Hausmann, Klinger, and Lopez-Calix [2010]; Usui and Abdon [2010]; Abdon and Felipe [2011]; Bayudan-Dacuycuy [2012]; Boschma, Minondo, and Navarro [2013]; Kali, Reyes, McGee, and Shirell [2013]; Boschma and Capone [2014]; Lo Turco and Maggioni [2014]; Poncet and Starosta de Waldemar [2015] | Network of relatedness between products and productive structure – Core and periphery – Exports upgrading (Revealed proximity, density index) |
| | **Economic complexity:** Structure of the global network linking the country to its products and its productive capabilities | **Hausmann and Hidalgo [2009, 2011a, 2011b]** (Country-product level data: World Trade Flows) **Applications:** Hidalgo [2009, 2011]; Felipe, Kumar, Abdon, and Bacate [2012]; Poncet and Starosta de Waldemar [2013a, 2013b]; Tacchella, Cristelli, Caldarelli, Gabrielli, and Pietronero [2013] | Bipartite/tripartite network and economic development – Productive capabilities (Method of reflections: Country diversification and product ubiquity) |

atau

**Table-1: Evidences of EKC estimation studies for $CO_2$ emissions**

| *Author(s)* | *Context* | *Power of Income* | *Type of Data* | *Methodology* | *Shape of EKC* | *Turnaround Point(s)* | |
|---|---|---|---|---|---|---|---|
| Shafik and Bandyopadhyay (1992) | 149 countries (1960-1990) | Cubic | Panel | Panel regression | Monotonically Increasing | NA | |
| Shafik (1994) | 149 countries (1960-1990) | Cubic | Panel | Panel regression | Monotonically Increasing | NA | |
| Holtz-Eakin and Selden (1995) | 130 countries (1951-1986) | Quadratic | Panel | Panel regression | Inverted U-shaped | 35,428 | |
| Cole et al. (1997) | 7 countries (1960-1991) | Quadratic | Panel | Panel regression | Inverted U-shaped | Model I | 62,700 |
| | | | | | | Model II | 25,100 |
| Moomaw and Unruh (1997) | 16 countries (1950-1992) | Cubic | Panel | Panel regression | N-shaped | a. 12,813<br>b. 18,133 | |
| Agras and Chapman (1999) | United Nations (1971-1989) | Quadratic | Panel | Panel regression | Inverted U-shaped | Model I | 3.94 |
| | | | | | Inverted U-shaped | Model II | 4.62 |
| | | | | | Monotonically Increasing | Model III | NA |
| | | | | | Inverted U-shaped | Model IV | 2.60 |
| Galeotti and Lanza (1999) | 110 countries (1960-1996) | Quadratic | Panel | Panel regression | Inverted U-shaped | All countries | 16,646 |
| | | | | | | | 15,073 |
| | | | | | | Annex I Countries | 17,855 |
| | | | | | | | 17,961 |
| | | | | | | Non-Annex I Countries | 21,757 |
| | | | | | | | 19,340 |
| Magnani (2001) | 152 countries (1970-1990) | Cubic | Panel | Panel regression | No EKC | NA | |
| Roca et al. (2001) | Spain (1973-1996) | Cubic | Time Series | OLS | No EKC | NA | |
| Hill and Magnani (2002) | 156 countries (1970-1990) | Cubic | Panel | Pooled OLS | N-shaped | a. 3,007.01<br>b. 721,919.40 | |
| Lindmark (2002) | Sweden (1870-1997) | Quadratic | Time Series | Kalman Filter | No EKC | NA | |
| Day and Grafton (2003) | Canada (1958-1995) | Cubic | Time Series | OLS | N-shaped | a. 19,133.10<br>b. 20,760.86 | |

4. Sintesis Literatur Terpilih

   Bagian ini merupakan inti dan produk final dari kajian literatur. Publikasi terpilih yang sudah diringkaskan pada bagian terdahulu disintesiskan secara deskriptif. Sintesis deskiptif ini merupakan interpretasi anda terhadap temuan-temuan dalam publikasi yang direview. Anda mesti mampu menjelaskan 4 hal: (i) kondisi terkini pengetahuan (state of the art) tentang pertanyaan penelitian Anda, (ii) justifikasi kebutuhan penelitian seperti apa yang mesti

dilakukan ke depan, (iii) penjelasan temuan-temuan atas jawaban pertanyaan penelitian Anda, dan (iv) deskripsi kualitas riset yang ada.

5. Kesimpulan

5.1. Ringkasan Penelitian

Cukup jelas.

5.2. Rekomendasi

Identifikasi ide-ide penelitian ke depan yang perlu dilakukan berdasarkan hasil kajian literatur Anda.

Daftar Pustaka

Fink, A. (2014). Conducting Research Literature Reviews: From the Internet to Paper. Sage Publication.

Lampiran: contoh paper hasil kajian literature yang merupakan laporan terhadap bagian hasil Sintesis Literatur Terpilih.

# Attributes, Environment Factors and Women Entrepreneurial Activity: A Literature Review

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**Abstract**

*Purpose*: The purpose of this study is to examine the effect of individual attributes and business environment factors on the entrepreneurial activity of women entrepreneurs. Individual attributes such as education, working experience, attitude towards risk-taking, affect women entrepreneurial activity. Economic constraints such as lack of credit due to lack of asset collaterals and socio-cultural barriers, lack of savings due to low household income, and lack of labour skills due to low educational level also affect women entrepreneurial activity. The effect of these factors on entrepreneurial activity is worth studying because entrepreneurship development is considered a vital link to an overall economic growth of a nation through its positive impact on economic development especially at the grassroots. However, limited studies have reviewed literatures on individual attributes and business environment factors on the entrepreneurial activity of women entrepreneurs. This is the focus of this study.

*Methodology*: The paper is a descriptive study that reviews literature on individual attributes and environment factors on women entrepreneurial activity.

*Conclusion*: The paper concludes that environment factors exert much more influence on women entrepreneurial activity than individual attributes.

*Research limitation*: The paper is limited to a literature review that may need further research by using a framework to investigate the factors on entrepreneurial activity.

*Practical implication*: It shows the need for the government to support entrepreneurs through adequate provision of micro-finance.

*Originality*: The study is a new way to look at crucial factors affecting entrepreneurial activity in a country.

Paper type: This is a research paper.

**Keywords:** Attributes, Environment factors, Women entrepreneurial activity

## 1. Introduction

The identification and exploitation of entrepreneurial opportunity for business start-up or diversification, and subsequent performance depends on the individual attributes of the entrepreneurs and the business environment. Examples of such business environment are competition and lack of micro-finance factors like credit. Individual attributes play a vital role in enterprise activity because entrepreneurship involves risk, and attitude towards risk differ between individuals (Shane, 2003).

Despite the role of individual attributes in exploiting entrepreneurial opportunity for new business or business diversification by women entrepreneurs; however, recent studies have shown that business environment factors such as economic, financial and socio-cultural, plays a greater role in the exploitation of entrepreneurial opportunities by women entrepreneurs (Kuzilwa, 2005; Shastri & Sinha, 2010; Vob & Muller, 2009). For example, Kuzilwa (2005), Shastri & Sinha, (2010) argued that though all conditions for exploiting entrepreneurial opportunity such as education, experience, and energy may exist, but the environmental constraints such as lack of credit, and societal discriminations especially in developing countries, may hinder the entrepreneur. The study is hinged on the fact that there is scarcity of research that reviews literatures on individual attributes and business environment factors on the entrepreneurial activity of women entrepreneurs (e.g Kuzilwa, 2005; Shane, 2003; Shastri & Sinha, 2010).

## 2. Literature Review

The theories most commonly applied in research on entrepreneurship are McClelland's (1961) theory of the need to achieve, and Rotter's (1966) locus of control theory. McClelland's theory suggests that individuals with a strong need to achieve often find their way to entrepreneurship. Rotter's theory suggests that the locus of control of an individual can be seen as either internal or external. The internal control expectation is related to learning and thus motivates and supports active striving, while the external control expectation impedes learning and encourages passivity. An internal control expectation is usually associated with entrepreneurial characteristics (Littunen, 2000). The pull/push model is also a common way of explaining different motives behind why women start a business (Brush, 1999; Buttner & Moore, 1997). Push factors refer to necessities such as unemployment, glass ceiling, redundancy, recession, financial reasons (inadequate family income), dissatisfaction with being employed, or the need to accommodate work and home roles simultaneously. Pull factors are related to independence and the need to succeed better than others as entrepreneurs. According to Rotter's theory, the locus of control of an individual manifests in the need for achievement, financial reasons (desire for profit-wealth), personal development, self-fulfilment, social status and power (Hansemark, 1998; Glancey et al., 1998). However, the situation is rarely a clear-cut selection of pull or push factors, and the factors are often combined (Brush, 1999).

### *2.1 Attributes*

The characteristics or attributes of women entrepreneurs are regarded as the pull factors in entrepreneurial activity (Hisrich, Peters & Shepherd, 2008; Kuzilwa, 2005; North, 1990). These include demography such as age and education, type of employment, type of industry, type of company, financial background and work experience (Harrison & Mason, 2007; Peter, 2001; Okpukpara, 2009). They are regarded as the human capital or internal factors to be contributed by the entrepreneur in exploiting entrepreneurial opportunity for business performance. The ones most critical to women entrepreneurs which are discussed below are education, attitude and experience.

*Education:* Education is one of the characteristics of women entrepreneurs that can affect their business performance, and literature supports that education and managerial experience may contribute to women's business growth but certainly has positive impact on entrepreneurial performance (Gatewood, Brush, Carter, Greene & Hart, 2004). They also stated that human capital is not only the result of formal education and training but also include experience and practical learning derived from previous paid employment or managerial position, and it is a vital condition for technological innovation (Gatewood et al., 2004). According to Wit and Van (1989), individuals with a high level of education are more likely to engage in entrepreneurship. An individual with more work experience, a higher level of education, more knowledge of the market and business practice is more likely to be able to identify an opportunity for starting a new business. On the other hand, it may be expected that people with a low level of education have more difficulties finding a paid job, and therefore see no other possibility than to engage in entrepreneurship. Hence, high educated people are more likely to pursue opportunity-based ventures, while less educated entrepreneurs are more involved in necessity entrepreneurship (Bhola et al., 2006).

In a related study; education, experience, age and social networks were also found to have significant positive influence on entrepreneur's business performance in USA (Shane, 2003), yet women entrepreneurs in developing countries have low educational levels than their counterparts in developed countries (Ibru, 2009). More specific to women studies done by Kavitha et al. (2008), women were found to be more matured in terms of age, level of education and equipped with work experience in comparison to non-entrepreneurs. In USA for example, most women entrepreneurs had tertiary education followed by high school education (Gatewood et al; 2004); though in France for example, a higher percentage of women entrepreneurs had high school education and were in their early 30s (Carter & Shaw, 2006).

*Attitude:* Attitude towards risk-taking is another crucial attribute of entrepreneurs especially women. This is because enterprise involves risk-taking, and risk-averse entrepreneur is less likely to exploit entrepreneurial opportunity (Shane, 2003). Attitude towards risk-taking is entrepreneur's ability and willingness to engage in risky activity (Shane, 2003). Studies have found that attitude and behavioural intention are positively related (Crisp & Turner, 2007) and that attitude towards behaviour leads to intention which eventually leads to actual behaviour (Ajzen, 1991).

*Experience:* Literature asserted that business experience is one of the vital entrepreneurial characteristics (Antoncic, 2006), and evidences support the fact that a minimum of two to three years business experience is sufficient to assess an entrepreneur (Antoncic, 2006; Kuzilwa, 2005; Carter & Shaw, 2006). Other characteristics

of women entrepreneurs include: strong desire for independence, innovation, risk-taking, resourcefulness, business skills, knowledge, and networks (Salman, 2009). Business knowledge includes knowledge of top players in the industry, knowledge of product range and market trends. Business skills include technical and managerial skills which could be acquired through training, seminars and workshops. Experience could be acquired through formal education and business knowledge (Salman, 2009).

The need for achievement and autonomy, risk-taking, control of business and self-efficacy are other vital characteristics of women entrepreneurs (Shane, 2003). Demography, skills and reputation are also essential attributes of women entrepreneurs as single women had less income and less guarantees for loan. Family size also affects women entrepreneurial activity. Despite the fact that women with one or two children were likely to participate in entrepreneurial activity, in Pakistan for example, in order to generate income to support their families (Salman, 2009), it was however discovered that most women with family sizes of more than five people were likely to become entrepreneurs (Allen, Elam, Langowitz & Dean, 2008; Lawal, Omonona, Ajani & Oni, 2009); and large family size is common in developing countries (Lakwo, 2007). Again, most women aged between 25-34 years were found in the early- stage entrepreneurship (Allen et al., 2008). Innovation and decision-making ability are other characteristics (Cunha, 2007). Ambition, self-confidence and high level of energy have also been recognized as vital entrepreneurial characteristics (Idris & Mahmood, 2003). Having the right motive of venturing into business has been found to be one of the attributes of women entrepreneurs. The right motive should be the first determinant before entering into business (Mitchell, 2004; Porter & Nagarajan, 2005; Shane, 2003). Self-evaluation and intuition are also crucial characteristics (Shane, 2003). However, focusing on education, experience and attitude towards risk-taking as vital individual attributes of women entrepreneurs, we therefore make the following proposition:

*P1: Attributes of women entrepreneurs (education, experience, attitude towards risk-taking) affect women entrepreneurial activity.*

*2.2 Environment factors*

Women entrepreneurs face peculiar challenges in an attempt to achieve success (Hatcher, Terjersen & Planck, 2007) and women in less developed countries face much more barriers to formal economic participation than those in developed countries (Allen et al; 2008). Women face unique obstacles in starting and growing their firms such as lack of skill or training, limited access to capital or credit, lack of savings and social networks, and limited choice of industry (Akanji, 2006; Ibru, 2009; Lakwo, 2007; Martin, 1999; Ojo, 2009; Peter, 2001).

Gender-related discriminations, especially in developing countries, occasioned by socio-cultural factors also pose hindrance to women entrepreneurial activity (Otero, 1999). Such discriminations are in the area of distribution of social wealth such as education and health (May, 2007; Mayoux, 1999; Otero, 1999; Porter & Nagarajan, 2005; Roomi & Parrot, 2008).

The type of industry and the industrial differences also affect entrepreneurial performance, and people in knowledge industry have high propensity to access information which leads to business performance in terms of market size and growth (Shane, 2003). Incidence of informal sector investment was higher among firms in the manufacturing, wholesale and retail, and knowledge industry in UK and Canada respectively (Carter & Shaw, 2006; Riding, 2006). Women entrepreneurs are mostly found in agriculture, services such as education and health, retail and manufacturing where they had experience or where experience was not necessary (Akanji, 2006; IFC, 2007; Okpukpara, 2009). Such businesses are most active in the urban centres, except agriculture (Carter & Shaw, 2006). The concentration of women entrepreneurs in these sectors is due to their low level of education because higher educational attainment leads to the possibility of self-employment in economically rewarding industry (Stohmeyer, 2007).

The business environment factors pose a lot of challenges to business because they are outside the control of the business owner. Such environmental constraints which are sometimes volatile include the economic, financial, legal, political and socio-cultural factors. These factors play a greater role in entrepreneurial activity because, despite the possession of the requisite personal entrepreneurial characteristics such as education, right attitude to risk, motivation, energy and working experience; the environment may hinder women entrepreneurs from exploiting entrepreneurial opportunities (Kuzilwa, 2005; Shastri & Sinha, 2010; Vob & Muller, 2009).

Business environment factors that seem to be more important to the success of women entrepreneurial activity is financial aid or credit accessibility. Credit or loan is very necessary for new and growing enterprises. Banks, not surprisingly, are inclined toward low-risk ventures. Women were more likely to observe that they were not given due respect by financial institutions; they did not think their account managers were easy to talk to; they reported that they were not made to feel comfortable by financial institutions; and they perceived that bank employees

discriminated against women. Bankers' pessimistic view of women's credit worthiness fostered a reluctance to grant credits. This constituted another obstacle to female entrepreneurship.

On the positive side, however, the popularity of the micro-credit strategy propelled a global movement toward making micro-loans available to people all over the world. Advocacy groups, existing banks, NGOs, and alliances such as the International Coalition on Women and Credit, RESULTS Education Fund (USA), Women's World Bank, Grameen Bank (Bangladesh), Accion International (USA), FINCA (USA), SEWA (India), VOICE (Africa) and many others promoted the idea of micro-credit micro-enterprises in policy circles. In Georgia, women made up 30% of the borrowers at the Micro-finance Bank of Georgia with an average loan size of $7,000. In Ukraine, women obtained 38% of EBRD Small Business Fund loans and women represented 35% of the entrepreneurs purchasing newly privatized land parcels. In Malawi, a micro-finance regulatory framework and strategy were launched in 1998. In Bangladesh, Grameen Bank reported a loan repayment rate of 95-98% from women entrepreneurs (Accion International, 1997; Counts, 1996; Estes, 1999; Shawa, 1999).

The importance of access to credit is identified as a major barrier to entry into self-employment throughout the world. Women setting up micro-enterprises, SMEs, or formal large-scale businesses all encountered varying degrees of difficulty in obtaining capital, collateral, and fair lending terms. In fact, according to a study by Clark and Kays (1995), 41% of entrepreneurs reported that lack of money is the greatest obstacle to starting a business, and 47% cited lack of capital as the greatest barrier to business growth.

Riding (2006) stated that higher percentage of enterprises especially in Canada mostly seek external finance than use personal savings. Much dependence on credit by entrepreneurs, especially women, is due to their inability to raise capital through personal savings (Brana, 2008). The problem is much pronounced in developing countries due to unemployment and gender discrimination in high-paid jobs (Brana, 2008; Carter & Shaw, 2006). However, Gatewood et al. (2004) contended that women use more of personal savings than credit, to start and grow their enterprises.

A relationship also exist between credit and opportunity for entrepreneurial activities of women entrepreneurs. Credit provides the needed opportunity for entrepreneurs to start or improve business in order to make profit and improve their lives (Allen et al., 2008; Brana, 2008; Lans et al., 2008; Majumdar, 2008; Roslan & Mohd, 2009; Salman, 2009; Shane, 2003; Tata & Prasad, 2008). There is a positive relationship between credit and opportunity for entrepreneurial activity. For example, credit was found to have positive effect on opportunity for entrepreneurial activity of women in USA (Allen, 2000), Nigeria (Akanji, 2006) and France (Brana, 2008).

Salman (2009) also argued that loan is not usually good for business start-up but for growing or existing enterprises due to inability of the new business to pay back the loan at the initial business stage. While Karnani (2007) contended that credit does not lead to women's improved welfare rather the government should create jobs for the women. These arguments aside, numerous evidences abound in the literature that credit has positive impact on enterprise performance. For instance, previous studies found that credit had positive impact on enterprise profit in Nigeria, Nicaragua, Canada and Croatia (e.g. Martin, 1999; Ojo, 2009). However, focusing on credit as a vital micro-finance factor, we therefore make the following proposition:

*P2: Credit affects women entrepreneurial activity.*

In order to examine the composite effect of individual attributes and business environment factors on women entrepreneurial activity, we therefore make the following proposition:

*P3: Attributes of women entrepreneurs (education, experience, attitude towards risk-taking) and credit affect women entrepreneurial activity.*

## 3. Conclusion

Individual attributes such as education, experience and attitude toward risk-taking are vital to entrepreneurial activity of women entrepreneurs. Business environment factors, for example credit is also important for entrepreneurial activity. However, literatures have lent strong support to the fact that business environment factors such as credit accessibility exert much more influence on the entrepreneurial activity of women entrepreneurs than individual attributes. This is so because an entrepreneur may have the requisite characteristics for exploiting entrepreneurial opportunity but the environmental constraints may constitute a great hindrance.

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# STUDI LITERATUR TENTANG RISET ZAKAT

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**Abstract.** ***Literature Study on Zakah Research***. Zakah is not only as religious rituality but also could touch humanity aspect by empowering its potency to maximize public wealth. The research related to zakah is still lacking compare to Islamic banking research. This study review on research around zakah. The study use descriptive statistical analysis based on 100 journal publications related to zakah, both national and international journal. The entire sample journal publications have published last 5 years from 2011 to 2015. Results show that the zakah research is still dominated by the discussion of zakah institution (26%), followed by distribution of zakah(22%), zakah management (21%) and poverty (20%). The last theme is about zakah collection (11%). In addition, comparison of quantitative research and mixed methods are still far less than the qualitative approach.

**Keywords:** Zakah Literatures, Zakah Issue, Research on Zakah

**Abstrak.** ***Studi Literatur tentang Riset Zakat***. Zakat tidak hanya sebagai ritual keagamaan tetapi juga bisa menyentuh aspek kemanusiaan dengan memberdayakan potensinya untuk memaksimalkan kekayaan publik. Penelitian yang berkaitan dengan zakat masih kurang jika dibandingkan dengan penelitian perbankan syariah. Penelitian ini mengkaji penelitian-penelitian tentang zakat. Penelitian ini menggunakan analisis statistik deskriptif berdasarkan 100 publikasi jurnal yang berkaitan dengan zakat, baik jurnal nasional maupun internasional. Sampel diambil dari jurnal yang terbit 5 tahun terakhir dari 2011 hingga 2015. Hasil penelitian menunjukkan bahwa penelitian zakat masih didominasi oleh pembahasan lembaga zakat (26%), diikuti oleh distribusi zakat (22%), manajemen zakat (21% ) dan kemiskinan (20%). Tema terakhir adalah tentang koleksi zakat (11%). Selain itu, perbandingan antara penelitian kuantitatif dan metode gabungan masih jauh lebih sedikit dibandingkan dengan pendekatan kualitatif.

**Kata Kunci:** Literatur Zakat, Isu Zakat, Penelitian Zakat

## Pendahuluan

Zakat sebagai salah satu rukun Islam mempunyai ciri khas yang berbeda karena ia tidak hanya berdimensi vertikal seperti rukun Islam lainnya—yaitu hubungan ibadah kepada Allah Swt.—tetapi juga berdimensi horizontal yaitu hubungan ibadah terhadap sesama manusia. Dimensi horizontal ini mempunyai efek yang luas sehingga secara sosial diharapkan dapat membangun masyarakat madani atas dasar silaturahmi dan secara ekonomi, menurut Mustaq Ahmad, adalah sumber utama kas negara dan sekaligus merupakan sokoguru dari kehidupan ekonomi yang dicanangkan Alquran.

Zakat merupakan injeksi dalam perekonomian sehingga memunculkan kekuatan baru dalam penghimpunan investasi yang signifikan sehingga akan mendorong peningkatan produksi dalam siklus perekonomian suatu daerah. Bahkan secara makro zakat akan dapat meningkatkan *agregat demand* karena meningkatnya *purchasing power* (daya beli) masyarakat atas barang-barang dan jasa. Ketika zakat diiplementasikan secara tersistem, dalam artian bahwa zakat adalah peraturan yang mengikat dalam diri setiap Muslim dengan peran pemerintah sebagai regulator sekaligus badan amil zakatnya, maka secara pasti akan menyebabkan munculnya lapangan-lapangan kerja baru yang sangat luas sehingga setiap warga negara mempunyai lahan pekerjaan dan otomatis akan terjadi migrasi pengangguran menjadi karyawan dalam jumlah yang sangat besar.

Zakat juga berperan penting dalam mewujudkan terciptanya keadilan dalam bidang ekonomi dimana seluruh anggota warga negara mempunyai sumber pendapatan dan *income* untuk memenuhi kebutuhan sehari-hari dalam rangka menjalankan roda kehidupan

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di muka bumi ini. Oleh karena itu diperlukan lapangan pekerjaan yang cukup sebagai sumber atau ladang pendapatan yang halal. Dengan zakat maka akan terkumpul dana baru *(fresh capital*) yang bebas dari tekanan-tekanan apapun karena memang bersifat sukarela dan merupakan hak para kaum miskin.

Saat ini institusi zakat tidak hanya sebagai ritualitas keagamaan tetapi bisa menyentuh aspek kemanusiaan dengan memberdayakan potensinya untuk kesejahteraan publik semaksimal mungkin. Namun di sisi lain, riset dan pengembangan terkait zakat dan pengelolaannya masih sangat kurang, padahal hal ini sangat penting dilakukan.

Berdasarkan latar belakang yang dijelaskan di atas maka perumusan masalah dalam penelitian ini adalah: (1) Apa saja area kajian tentang zakat dan berapa persentasenya?; (2) Secara pendekatan metodologi penelitian, bagaimana komposisi riset terkait zakat secara umum? dan (3) Bagaimana persentase jumlah publikasi, tipe riset, pendekatan penelitian, subjek bahasan hingga area studi tentang zakat selama 5 tahun terakhir?

## Fokus Kajian

Kajian dalam penelitian ini memfokuskan pada eksplorasi terhadap 100 penelitian *up to date* terkait zakat yang telah terpublikasi dalam jurnal ilmiah. Ada beberapa isu yang hendak diketahui jawabannya, yaitu berapa persentase riset terkait zakat selama 5 tahun terakhir, bagaimana jenis/tipe penelitian zakat dan komposisinya, bagaimana pendekatan penelitian tentang zakat dikaitkan dengan penggunaan metode penelitian baik kuantitatif, kualitatif maupun *mixed*.

Beberapa riset yang menjadikan Malaysia sebagai objek studi dilakukan oleh Hanapi (2015), Johari (2015) dan Said (2014) dan beberapa riset yang lainnya. Sementara itu riset yang lain menjadikan Indonesia sebagai objek kajian seperti yang dilakukan oleh Huda (2014) dan Rusli (2013). Negara lain juga menjadi area studi dalam penelitian zakat yang penulis telaah.

Selain yang tersebut di atas, fokus kajian juga mencoba menelaah lebih dalam terkait apa saja metode penelitian kuantitatif yang dipakai dan apa yang dominan dipakai. Bagaimana pula subjek pembahasan tentang zakat dan komposisinya. Tidak kalah penting, negara mana saja yang menjadi area studi dan area publikasi tentang riset zakat di seluruh dunia.

Penelitian ini menggunakan analisis statistika deskriptif berdasarkan 100 publikasi jurnal terkait zakat, baik nasional maupun internasional. Seluruh sampel publikasi jurnal yang telah terpublikasi 5 tahun terakhir mulai tahun 2011 hingga 2015. Studi hanya memfokuskan secara spesifik terhadap tulisan jurnal bertema zakat.

Selanjutnya, setelah dilakukan *review* dan analisis, penelitian terkait zakat ini dibagi ke dalam 5 (lima) kategori utama yaitu (1) Manajemen zakat, (2) Distribusi dana zakat, (3) Zakat dan kemiskinan, (4) Institusional zakat, dan (5) Pengumpulan (koleksi) dana zakat. Termasuk ke dalam term institusional adalah kelembagaan, payung hukum dan regulasi tentang zakat. Pengklasifikasian ini dibuat berdasarkan penelaahan isi, abstraksi dan keseluruhan penelitian secara umum, meskipun tidak menutup kemungkinan terjadinya irisan-irisan kategori dan klasifikasi.

## Jumlah Publikasi Setiap Tahun

Pada bagian ini menjelaskan jumlah publikasi jurnal dari tahun 2011 hingga 2015. Terdapat 100 jurnal yang terpublikasi baik jurnal nasional maupun internasional yang berhubungan dengan zakat dari observasi 5 tahun terakhir selama tahun 2011 hingga 2015. Tabel 1 menjelaskan distribusi jurnal per tahun yang menunjukkan jumlah jurnal terpublikasi bervariasi dari tahun 2011 hingga 2015 dengan range 11 hingga 28 jurnal dan publikasi jurnal terbanyak yaitu pada tahun 2014. Sedangkan publikasi jurnal yang lebih sedikit dibandingkan tahun lainnya yaitu pada tahun 2011.

**Tabel 1. Jumlah Publikasi per Tahun**

| Tahun Publikasi | Jumlah Artikel | Persentase |
|---|---|---|
| 2011 | 11 | 11% |
| 2012 | 21 | 21% |
| 2013 | 18 | 18% |
| 2014 | 28 | 28% |
| 2015 | 22 | 22% |
| **Total** | **100** | **1** |

## Jenis Penelitian dari Masing-Masing Publikasi

Tabel 2 menunjukkan jenis (tipe) penelitian yang digunakan untuk setiap publikasi jurnal yang diamati. Menurut Sekaran (2013), secara umum terdapat empat tipe penelitian yaitu analisis, deskriptif, empiris dan penelitian eksploratori. Dalam observasi ini hanya menggunakan tiga jenis tipe penelitian yaitu analisis, deskriptif dan empiris.

Penelitian analisis digunakan untuk mencoba menjawab persoalan mengapa hal tertentu atau bagaimana hal tersebut dapat terjadi. Jenis penelitian ini biasanya berhubungan dengan sebab akibat. Penelitian deskriptif

mencoba untuk menentukan, menggambarkan atau mengidentifikasi hal tertentu. Penelitian deskriptif menggunakan deskripsi, klasifikasi, pengukuran dan perbandingan untuk menggambarkan suatu fenomena. Dan metode penelitian empiris yaitu metode penelitian yang menggunakan observasi studi lapangan (empiris) atau data yang terkumpul dari tanya jawab seperti dalam bentuk kuisioner.

Dari tabel 2 dapat diketahui bahwa jenis metodologi penelitian yang terbanyak digunakan dari jurnal terpublikasi baik jurnal nasional dan internasional terkait zakat selama tahun 2011 hingga 2015 yaitu metodologi penelitian deskriptif sejumlah 49 jurnal, kemudian diikuti oleh metodologi penelitian analisis sejumlah 39 jurnal dan terakhir yaitu jurnal yang menggunakan penelitian empiris sebanyak 12 jurnal.

**Tabel 2. Jenis Penelitian dari Masing- Masing Publikasi**

| Year of Publication | Research Types | | | Total |
|---|---|---|---|---|
| | Analytical | Descriptive | Empirical | |
| 2011 | 4 | 7 | 0 | 11 |
| 2012 | 4 | 14 | 3 | 21 |
| 2013 | 6 | 9 | 3 | 18 |
| 2014 | 14 | 12 | 2 | 28 |
| 2015 | 11 | 7 | 4 | 22 |
| **Total** | **39** | **49** | **12** | **100** |

## Pendekatan Penelitian Masing- Masing Publikasi

Berdasarkan Punch (2013), ada 3 jenis pendekatan penelitian yaitu pendekatan kualitatif, pendekatan kuantitatif dan pendekatan metodologi campuran (*mixed method*). Tabel 3 menunjukkan metodologi penelitian yang digunakan untuk setiap jurnal terpublikasi dalam kurun waktu 5 tahun yaitu 2011 hingga 2015. Dalam observasi ini, pendekatan penelitian yang terbanyak digunakan adalah pendekatan kualitatif sejumlah 61 jurnal, kemudian pendekatan kuantitatif sejumlah 37 jurnal dan terakhir yaitu jurnal yang menggunakan pendekatan kombinasi (*mixed method*) sejumlah 2 jurnal.

**Tabel 3. Pendekatan Penelitian Masing- Masing Publikasi**

| Year of Publication | Research Types | | | Total |
|---|---|---|---|---|
| | Qualitative | Quantitative | Mixed | |
| 2011 | 7 | 4 | 0 | 11 |
| 2012 | 17 | 4 | 0 | 21 |
| 2013 | 12 | 6 | 0 | 18 |
| 2014 | 14 | 13 | 1 | 28 |
| 2015 | 11 | 10 | 1 | 22 |
| **Total** | **61** | **37** | **2** | **100** |

## Jenis Metodologi Kuantitatif

Tabel 4 menunjukkan jenis- jenis metodologi penelitian kuantitatif yang digunakan dalam 100 jurnal publikasi terpilih. Adapun dalam 100 jurnal zakat terdapat 25 jenis metodologi penelitian kuantitatif yang digunakan, yaitu metode *Multiple Regression Analysis* (5), *Structural Equation Modeling* (4), Panel Data (4), VECM (3), AHP (3), DEA (2), Faktor Analisis (2), *Rasch Measurement Model* (2), PLS (2, dan metode lainnya (1).

**Tabel. 4. Jenis Metodologi Penelitian Kuantitatif**

| Quantitative Method | Number |
|---|---|
| Multiple Regression Analysis | 5 |
| Structural Equation Modeling | 4 |
| Panel Data | 4 |
| Vector Error Correction Model | 3 |
| AHP | 3 |
| Data Envelopment Analysis | 2 |
| Factor Analysis | 2 |
| Rasch Measurement Model | 2 |
| Partial Least Square | 2 |
| Partial Least Square path Modeling | 1 |
| Two Stage Data Envelopment Analysis | 1 |
| Linear Regression Model | 1 |
| Wilxocon Analysis | 1 |
| Tobit Regression | 1 |
| Malmquist Productivity Index | 1 |
| ANP | 1 |
| Polynomial Model | 1 |
| Exponential Model | 1 |
| Discrete Malthusian Growth Model | 1 |
| Moderated Regression Analysis | 1 |
| C4.5 Decision Tree algorithm | 1 |
| CAST Method | 1 |
| Quota Sampling | 1 |
| Logistic Regression | 1 |

## Subjek Jurnal Zakat

Tabel 5 menunjukkan subjek pembahasan masing-masing jurnal terkait zakat berdasarkan publikasi jurnal zakat selama tahun 2011 hingga 2015. Adapun dalam observasi ini berdasarkan lima subjek yaitu terkait manajemen zakat, distribusi zakat, pengentasan kemiskinan dan pengumpulan zakat dan institusi zakat. Dari publikasi jurnal 2011-2015 terpilih dalam pengamatan, subjek pembahasan terkait jurnal zakat terbanyak yaitu mengenai institusi zakat sejumlah 26 jurnal dari 100 sampel jurnal, kemudian diikuti oleh subjek pembahasan mengenai distribusi zakat

sejumlah 22 jurnal, manajemen zakat sejumlah 21 jurnal, pengentasan kemiskinan sejumlah 20 jurnal dan terakhir terkait pengumpulan zakat sejumlah 11 jurnal.

**Tabel 5.Subjek Pembahasan Jurnal Zakat**

| Subject of Article | Year of Publication | | | | | Total |
|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | |
| Management | 2 | 4 | 6 | 6 | 3 | 21 |
| Distribution | 2 | 7 | 3 | 4 | 6 | 22 |
| Poverty | 3 | 5 | 4 | 3 | 5 | 20 |
| Collection | 1 | 0 | 3 | 4 | 3 | 11 |
| Institution | 3 | 5 | 2 | 11 | 5 | 26 |
| **Total** | 11 | 21 | 18 | 28 | 22 | 100 |

## Area Studi dan Publikasi Berdasarkan Negara

Tabel 6 menunjukkan daftar terbanyak publikasi berdasarkan letak geografis (negara). Tabel ini dibagi menjadi 2 bagian yaitu lokasi studi 100 jurnal publikasi terpilih dan lokasi publikasi 100 jurnal tersebut. Pada bagian pertama, mengenai lokasi studi jurnal. Dari tabel 6 dapat diketahui bahwa Indonesia menjadi area studi terbanyak terkait penelitian zakat yaitu sejumlah (35 jurnal), diikuti oleh Negara Malaysia (34 jurnal), Nigeria (3 jurnal), Pakistan (3 jurnal) dan negara-negara lainnya (1 jurnal).

Senada dengan area studi, dari segi area publikasi jurnal, Indonesia menjadi negara yang terbanyak publikasi terkait penelitian zakat sejumlah (33 jurnal), USA (13 jurnal), Malaysia (9 jurnal), Timur Tengah (6 jurnal), Australia (3 jurnal), Pakistan (4 jurnal), Bangladesh (4 jurnal), Kanada (4 jurnal), UK (4 jurnal), India (3 jurnal), Australia (3 jurnal), Turki (2 jurnal) dan negara lainnya (1 jurnal).

Adapun area publikasi dari 100 jurnal zakat terpilih bervariasi yaitu terdapat 70 jenis jurnal. Dalam penelitian zakat ini, International Journal of Business and Social Science menjadi jurnal terbanyak dalam mempublikasi-kan jurnal terkait zakat yaitu sejumlah 8 jurnal, kemudian diikuti oleh Middle-East Journal of Scientific Research (5 jurnal), Journal of Islamic Economics, Banking and Finance (4 jurnal), Tazkia Islamic Finance and Business Review (4 jurnal), Jurnal BIMAS Islam (4 jurnal), International Journal of Economics, Management & Accounting (3 jurnal), Jurnal Ekonomi dan Keuangan (3 jurnal), Economic: Jurnal Ekonomi dan Hukum Islam (3 jurnal), Journal of Economic Cooperation and Development (2 jurnal), Australian Journal of Basic and Applied Sciences (2 jurnal), Al- Iqtishad (2 jurnal), International Journal of Management and Commerce Innovations (2 jurnal) dan jurnal lainnya (1 jurnal).

**Tabel 6.Area Studi dan Publikasi Berdasarkan Negara**

| Country | Studied Area | Publication Area |
|---|---|---|
| Indonesia | 35 | 33 |
| Malaysia | 34 | 9 |
| Nigeria | 3 | 0 |
| Pakistan | 3 | 4 |
| Bangladesh | 1 | 4 |
| India | 0 | 3 |
| Turki | 0 | 2 |
| Timur Tengah | 0 | 6 |
| USA | 0 | 13 |
| UK | 0 | 4 |
| Kanada | 0 | 4 |
| Australia | 0 | 3 |
| Lainnya | 6 | 15 |
| TOTAL | 82 | 100 |

## Temuan Penelitian

Analisis 100 publikasi jurnal terkait studi zakat dari tahun 2011 hingga 2015 adalah (1) Terdapat keragaman pembahasan jurnal terkait zakat yang terpublikasi telah didiskusikan. Jumlah publikasi terbanyak yaitu pada tahun 2014 sebanyak 28 jurnal dari 100 sampel jurnal terpublikasi. (2) Umumnya penggunaan metode penelitian deskriptif untuk menjawab fenomena zakat di suatu negara tertentu masih mendominasi metode penelitiannya yaitu sejumlah (49 jurnal) dari 100 sampel jurnal. Sedangkan metode penelitian analisis (39 jurnal) dan metode penelitian empiris (12 jurnal). (3) Secara umum dari 100 publikasi jurnal menggunakan metode pendekatan kualitatif dalam membahas zakat sebanyak (61 jurnal), pendekatan kuantitatif (37 jurnal), pendekatan *mixed method* (2 jurnal). (4) Subjek pembahasan 100 publikasi jurnal zakat tersebut lebih banyak terkait institusi zakat itu sendiri, kemudian disusul terkait distribusi, manajemen, pengentasan kemiskinan dan pengumpulan dana zakat. (5) Negara Indonesia menjadi area studi zakat terbanyak dari 100 sampel publikasi jurnal tersebut dibandingkan negara lainnya. Disamping itu, jurnal- jurnal Indonesia menjadi terbanyak dalam publikasi jurnal tentang zakat.

Hasil dari analisis di atas dapat diketahui bahwa isu zakat menjadi pembahasan yang intensif oleh pakar-pakar Muslim dari tahun ke tahun. Hal ini dibuktikan dengan dominasi publikasi jurnal 2 tahun terakhir yaitu 2014 dan 2015 yang lebih banyak dibandingkan dengan tahun sebelumnya terkait isu zakat. Selain itu, isu- isu tentang zakat lebih banyak dikaji atau dibahas dengan menggunakan metode deskriptif dan kualitatif.

Subjek pembahasan yang terbanyak didiskusikan mengenai institusi zakat itu sendiri.

## Penutup

Penelitian tentang zakat memiliki peran penting untuk umat Islam dalam menyadari kewajiban menunaikan zakat sebagai salah satu rukun Islam. Selain itu dapat meningkatkan kesadaran dari optimalisasi dana zakat dalam mengentaskan kemiskinan dan menyejahterakan masyarakat. Pembahasan penelitian zakat masih didominasi oleh pembahasan institusi zakat dari tahun 2011 hingga 2015. Sebab mayoritas penulis rata-rata mengangkat isu terkait kelembagaan zakat yang berlandaskan payung hukum yang kuat sehingga dengan hal tersebut diduga dapat meningkatkan kesadaran dan kepercayaan masyarakat untuk membayar zakat yang kemudian akan dikelola serta disalurkan kepada pihak- pihak yang berhak menerimanya (*ashnâf*). Selain itu, perbandingan metode penelitian kuantitatif masih lebih sedikit dibandingkan dengan pendekatan kualitatif. Hal ini menjadi potensi untuk meningkatkan penelitian tentang zakat dengan menggunakan metode kuantitatif.[]

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# Environmental Kuznets Curve for $CO_2$ emission: A Literature Survey

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## Abstract

This paper provides a survey of the empirical literature on Environmental Kuznets Curve (EKC) estimation of carbon dioxide ($CO_2$) emissions over the period of 1991-2017. This survey categorizes the studies on the basis of single country and cross-country contexts. It has been hypothesized that the EKC is an inverted U-shaped association between economic growth and $CO_2$ emissions. For both single country and cross-country contexts, the results of EKC estimation for $CO_2$ emissions are inconclusive in nature. The reasons behind this discrepancy can be attributed to the choice of contexts, time period, explanatory variables, and methodological adaptation. The future studies in this context should not only consider new set of variables (e.g., corruption index, social indicators, political scenario, energy research and development expenditures, foreign capital inflows, happiness, population education structure, public investment towards alternate energy exploration, etc.), but also the dataset should be refined, so that the EKC estimation issues raised by Stern (2004) can be addressed.

**Keywords:** Environmental Kuznets Curve; Carbon Emissions; Economic Growth

## 1. Introduction

When an economy starts moving along the growth trajectory, then at the earliest stage of economic development, environment deteriorates rapidly due to ambient air pollution, deforestation, soil and water contamination, and several other factors. With rise in the level of income, when economy starts to develop, the pace of deterioration slows down, and at a particular level of income, environmental degradation starts to come down and environmental quality improves. This hypothesized association between economic growth and $CO_2$ emissions is termed inverted U-shaped. This phenomenon is also referred as Environmental Kuznets Curve (EKC) hypothesis in environmental economics literature, named after Simon Kuznets (1955), who described an inverted U-shaped association between economic growth and income inequality. Grossman and Krueger (1991) later found its resemblance with Kuznets' inverted U-curve relationship while establishing a relationship between economic growth and environmental degradation.

Following the findings of Grossman and Krueger (1991), a number of researchers started estimating EKC in diverse contexts and using a wide range of methodologies. These studies were conducted on various ambient air pollutants, water and soil contaminations, and ecological footprints. The empirical results obtained from these studies differed largely in terms of model specifications, choice of explanatory variables, shapes of EKC, and turnaround points. Therefore, for any given context and any particular pollutant, there is no consensus among the researchers regarding the shape and nature of EKC. Various earlier studies on the EKC estimation considered income and population as the explanatory variables (Panayotou, 1993), and with graduation of time, several context-specific explanatory variables, e.g. energy consumption, petroleum consumption, trade, corruption index, political collaboration, literacy rate, mortality rate, and

several others have been considered within the EKC framework. Therefore, for any particular country or any group of countries, some of the researchers have found the evidence in support of EKC hypothesis, whereas others did not find any evidence to support the EKC hypothesis.

By and large, the evidences of EKC hypothesis can be divided into two different categories, based on the results obtained in the studies. Following are those two categories:

(a) *Absence of EKC hypothesis*: This condition is visible particularly for the underdeveloped and developing economies. In these countries, economic growth has not reached the level, at which environmental degradation can start coming down. Considering the case of these nations, environmental degradation rises with a rise in income, as achieving economic growth is the primary concern of these countries, more than environmental protection. One of the major reasons behind this scenario is that income elasticity of environmental demand in these contexts is low, and therefore, the level of environmental awareness in also low.

(b) *Presence of EKC hypothesis*: This condition is visible particularly for transitional, emerging, and developed economies. In these cases, the pattern of economic growth is ecologically sustainable, and countries are already in the process of either curbing down fossil fuel based energy consumption, or encouraging clean and renewable energy consumption. Though the chances of pollution export should not be overlooked, these economies are ahead of the others in terms of social development, which is a major catalyst for enhancement of environmental quality. One of the major reasons behind this scenario is that income elasticity of environmental quality demand in these countries is high and rising, and therefore, the level of environmental awareness in also high.

In the study by Dinda (2004) was also concentrated on the conceptual background and theoretical underpinnings of EKC, rather than the empirical evidences. One major contribution of

this study was that it discussed the several facades of policy recommendations, which may come out of an EKC estimation study. The study was concluded with a generalized critique on the conceptual and methodological designs. In the published literature of energy and environmental economics, the latest study in our knowledge was carried out by Kijima et al. (2010), and this study was not very different from the previous two studies, apart from that it specifically focused on the model building exercises of the studies reviewed.

By far, a huge number of studies have been done on EKC estimation of various pollutants, irrespective of the pollutant is global or local in nature. The present study surveys the literature on EKC estimation for $CO_2$ emissions for the period of 1991-2017. The objective of the present study is to envisage the current state of knowledge about the EKC estimation for $CO_2$ emissions, from the perspective of model design, methodological adaptations, and fulfilment of objective. In this paper, all the selected studies are empirical in nature, and we have segregated the studies in terms of the model design (quadratic and cubic specifications), methodological adaptation (time series or panel data techniques), and fulfillment of objective (whether EKC is achieved or not). Apart from pointing out these distinguished features of the studies, we have discussed the impacts of different explanatory variables used in these studies, and how the EKC estimation results vary within a geographical context. This discussion has been done in keeping with the conceptual framework of EKC hypothesis in the background.

The rest of the paper is organized as per the following: Section-2 provides a conceptual background of EKC hypothesis, Section-3 reviews the literature on various model specifications, Section-4 reviews the literature on methodological adaptations, Section-5 reviews the literature on the various outcomes of EKC estimation studies, Section-6 presents the divergence in turnaround

points in geographical contexts, Section-7 reviews the literature on various control variables, and Section-8 presents concludes the study with future directions.

## 2. The conceptual framework of EKC hypothesis

The premise of EKC hypothesis is based on the interaction between economic growth and environmental degradation, and how the pattern of economic growth can have an adverse effect on environmental quality. According to Grossman (1995), this effect can take place by means of three channels, namely scale effect, composition effect, and technique effect. When the economic growth sets pace, it exerts the scale effect on environment. In order to fuel economic growth, demand of natural resources rises, and consequently, the direct and indirect consumption of natural resources is translated into the production process. Once the production process starts, substantial amount of industrial waste is generated and this by-product of industrial and economic growth poses serious threat to environmental quality. In order to boost economic growth, policymakers overlook the damages to environmental quality, and as a whole, environmental degradation starts to rise with a rise in economic growth. This scenario is visible, especially when the economy is dependent majorly on the primary (agricultural sector) and secondary sectors (manufacturing and industrial sectors). Now, with the rise in income, the industrial structure of a nation starts undergoing a transformation, and therefore, the composition of an economy starts changing. This is where economic growth exerts the composition effect on environmental quality, and this is when the effect of economic growth on environmental quality starts to be positive. During this phase, the secondary sector starts maturing and the industries shift towards cleaner technologies. This industrial transformation is reflected in the urbanization pattern, and the demand for cleaner environment starts increasing. This is the time when the industries start to incorporate technologies for increasing energy efficiency. This progress in the path of technological innovation is the way,

by which economic growth exerts the technique effect on environmental quality. During this phase, the tertiary sector (service sector) starts growing, and the economy gradually starts turning out to be knowledge-intensive, rather than capital-intensive. This is the time, when the economy starts investing more in the research and development based activities, and the obsolete and polluting technologies being used in the secondary sector start getting substituted. Therefore, in this phase, environmental quality gradually improves with the rise in economic growth. Now, if this entire phenomenon is graphically represented, then it can be seen that environmental degradation takes a bell-shaped or inverted U-shaped curve, when it is plotted against economic growth (Figure-1). This entire phenomenon is referred to as EKC hypothesis.

Now, income elasticity of environmental quality demand plays a significant role in determining the shape of an EKC, as indicated by several researchers (Beckerman 1992, Stern et al. 1996, Carson et al. 1997, McConnell 1997). The effect of income elasticity on environmental quality can be viewed in terms of the three channels already mentioned. As we have discussed, the scale effect exerts a negative impact on environmental quality during the early stages of economic growth, and it is offset by the positive impacts of composition and technique effects during the later stages of economic growth. This entire phenomenon can be described in terms of income elasticity of environmental quality demand. At the early stages of economic growth, raising the level of income is the primary concern for citizens and policymakers, and this increase in the level of income is achieved even at the cost of environment. When income starts increasing, the living standard of the people improves, and the demand for a better environmental quality starts rising. This demand starts rising which encounters for structural shift. This structural shift takes place in a bilateral manner, i.e. on one hand, the production houses replace their obsolete and polluting technologies with green and cleaner technologies and on other hand, government comes up with

several environmental protection policies and regulations, along with reinstating the existing policy mechanisms. Therefore, the demand for better environment and the response from industrial sector and government encourage the enhancement of environmental quality. This shift becomes possible owing to the rising income elasticity of environmental demand, and it is largely responsible for inverted U-shaped of the EKC.

From another angle, this entire phenomenon can be looked into from the direction of the economists from *Club of Rome*, who came up with their idea of *Limits to Growth*, in the year 1972. According to them, economic growth cannot persist for an indefinite period owing to the inadequate availability of natural resources (Meadows et al. 1972). In 1992, with the publication of *The First Global Revolution*, the Club of Rome stated that, due to human intervention in the natural processes, problems like environmental pollution, scarcity of water, and climatic shifts had been taking place, which had been considered as the main symptoms of environmental degradation (King and Schneider, 1992). In spite of they have been contradicted by several economists based on various contexts and research design related issues (Turner, 2008), emergence of concepts, like intergenerational equity (Solow, 1974) and optimal natural resource extraction path (Stiglitz, 1974a, b) was showing that, the issues being raised by economists of the Club of Rome were noteworthy from sustainable economic growth perspective. An extension of this idea was reflected in the concept of endogenous self-regulatory market mechanism for natural resources (Unruh and Moomaw, 1998). During the early stage of economic growth, more importance is given to the primary (agriculture) and secondary (industrial and manufacturing) sectors, and therefore, natural resources are being faced with high level of exploitation. This overuse of natural resources results in faster depletion of natural resources. Provided the stock of the natural resources is constant at the beginning of economic growth and higher level of economic growth results in higher demand

of natural resources, the price of natural resources starts to rise. This rise in the price level of natural resources discourage the industrial houses to utilize more natural resources, as it increases the cost of production, and therefore, they try to shift towards less resource consuming or resource-efficient technologies (Duflou et al. 2012). This shift takes place at the later stages of economic growth, and it is also responsible for the betterment of environmental quality. Therefore, we can also see that market mechanism is also responsible for determining the shape of the EKC.

**3. Different Specifications of EKC**

Though the number of studies on the EKC estimation for $CO_2$ emissions is extensive, those studies share some common characteristics in terms of the model specification. Most of the studies employed cross-sectional or panel data for the estimation of EKCs, and the model used by those studies can take the following generalized form:

$$C_{it} = \alpha_i + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + D_{it} + \epsilon_{it} \quad (1)$$

Where $C$ is $CO_2$ emissions, $Y$ is economic growth, $D$ is the additional context specific explanatory variables, $i$ is the cross sections, $t$ is the time series, $\alpha$ is the constant term, $\beta_k$ is the coefficients, and $\epsilon$ is the standard error term. The model represented in equation-1 can be used to obtain several forms of growth-$CO_2$ emissions association. Following specifications denote specific functional forms:

(a) $\beta_1 = \beta_2 = \beta_3 = 0$; no growth-$CO_2$ emissions association

(b) $\beta_1 > 0$, $\beta_2 = \beta_3 = 0$; linearly increasing growth-$CO_2$ emissions association

(c) $\beta_1 < 0$, $\beta_2 = \beta_3 = 0$; linearly decreasing growth-$CO_2$ emissions association

(d) $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 = 0$; inverted U-shaped growth-$CO_2$ emissions association

(e) $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 = 0$; U-shaped growth-$CO_2$ emissions association

(f) $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$; N-shaped growth-$CO_2$ emissions association

(g) $\beta_1 < 0,\ \beta_2 > 0, \beta_3 < 0$; inverted N-shaped growth-$CO_2$ emissions association

Out of these model specifications, generally accepted form of EKC is given by the specification (d). In this case, the value of the turnaround point is given by $Y^* = -\beta_1/2\beta_2$. For the case of N-shaped growth-$CO_2$ emissions association, the values of the turnaround points are given by $Y^* = \left(-\beta_2 \pm \sqrt{\beta_2^2 - 3\beta_1\beta_3}\right)/3\beta_3$. Now, if we look closely, then we can see that the model specifications and the corresponding turnaround points vary majorly vary in terms of the power of income. The higher powers of income help in identifying the further impacts of income on $CO_2$ emissions, i.e. finding out the sustainability of EKC in any given context by going beyond the traditional inverted U-shaped form of EKC.

The EKC estimation study on $CO_2$ emissions started with the work of Shafik and Bandyopadhyay (1992). They have analyzed the per capita carbon emissions for 149 countries over the period 1960-1990 using a number of explanatory variables, e.g. investment, income growth, electricity tariff, percentage of trade in GDP, parallel market premium, Dollar's index of openness, debt, political rights, and civil liberties. They used three model specifications, namely linear, quadratic, and cubic, and the EKC hypothesis was not supported. The researchers have attributed to the subsidized electricity in oil exporting countries, which were the major outliers in the dataset used for empirical analysis. Apart from that, it was also found that civil liberties add to the rise in $CO_2$ emissions, whereas the countries with higher political rights demonstrated reduction in $CO_2$ emissions. Similar models and dataset were used in the subsequent study by Shafik (1994) and the results obtained from the study were largely the same. These two studies are the ones to use the EKC estimation models with both lower and higher powers of income, and these studies brought forth the comparative scenarios based on the power of income. Therefore,

we will review the literature based on the impact of power of income, and other explanatory variables.

### 3.1. EKCs with quadratic income

First ever study to consider only quadratic power of income was carried out by Holtz-Eakin and Selden (1995). The study was conducted for a panel of 130 countries over the period of 1951-1986. Using panel regression approach, they found the EKC to be inverted U-shaped, with the turnaround point at $35,428. Apart from income, no other explanatory variables were used in the study. In a subsequent study by Cole et al. (1997), the researchers tried to estimate the EKC of $CO_2$ emissions for 7 regions over the period of 1960-1991. Using panel regression technique, they found the EKC to be inverted U-shaped, with the turnaround points between $25,100 and $62,700. In this study, they have used energy use as an additional explanatory variable.

A summary of the studies on EKC estimation for $CO_2$ emissions is provided in Table-1. It can be seen that the EKC estimation exercise for $CO_2$ emissions has been carried out for a number of contexts over different periods of time. Nearly all of the studies considered different forms of energy consumption as explanatory variables, which is the major factor behind economic growth and environmental degradation. Over the years, the studies have been gradually shifting their focus from fossil fuel energy consumption to renewable energy consumption, along with the macroeconomic and social impacts of environmental degradation (see Table-2). Apart from energy consumption, a diverse set of explanatory variables have been used, as keeping with the respective research contexts. Some of these variables are government effectiveness (Osabuohien et al. 2014), FDI (Tang and Tan 2015, Zhang et al. 2017), financial development (Dogan and Turkekul, 2016), crude oil prices (Balaguer and Cantavella, 2016), urbanization (Farhani and Ozturk 2015, Dogan

and Turkekul 2016), government effectiveness (Ozturk and Al-Mulali, 2015), population growth (Begum et al. 2015), economic liberalization (Tiwari et al. 2013) and many others.

The gradual shift from scale effect to composition and technique effects can be seen in terms of energy consumption and energy use patterns in this scenario. Starting with Cole et al. (1997), researchers started to consider energy consumption within the EKC framework, and the nature of this energy consumption has undergone a change over the years. By using standard OLS model, Lindmark (2002) analyzed the EKC for $CO_2$ emissions in Sweden over the period of 1870-1997. Though this study did not found the evidence of any EKC, but it demonstrated the effect of fossil fuel consumption on $CO_2$ emissions, within an EKC framework. Soon, the researchers started to include renewable energy consumption within the EKC framework, as across the world, energy consumption pattern was undergoing a transformation. The study by Richmond and Kaufmann (2006) considered both fossil fuel and renewable energy consumption within the EKC framework. They have analyzed the EKC for $CO_2$ emissions for 20 developed and 16 developing countries over the period of 1973-1997, and using OLS approach, they have found the EKC to be inverted U-shaped, with the turnaround points between $29,687 and $110,599. In this study, energy consumed from coal, oil, and gas were considered as fossil fuel energy consumption, and energy consumed from hydro and nuclear power were considered as renewable energy consumption. Subsequent to this, a number of studies considered both of the forms of energy into consideration. The first study to consider only renewable energy consumption within an EKC framework was carried out by Iwata et al. (2011). The study was conducted for 28 countries over the period of 1960-2003, and they applied mean group (MG), pooled mean group (PGM), and panel regression techniques to estimate the EKCs. They found the EKC to be inverted U-shaped, with the turnaround points between $77,126.73 and $141,682.59.

### 3.2. EKCs with cubic income

First ever study to consider only cubic power of income was carried out by Moomaw and Unruh (1997). The study was conducted for a panel of 16 countries over the period of 1950-1992. Using panel regression approach, they found the EKC to be N-shaped, with the turnaround points at $12,813 and $18,133. Apart from income, no other explanatory variables were used in the study. In a subsequent study by Suri and Chapman (1998), the researchers tried to estimate the EKC of $CO_2$ emissions for 33 countries over the period of 1970-1991. Using feasible generalized least squares technique (FGLS), they found the EKC to be inverted U-shaped, with the turnaround points between $55,535 and $143,806. In this study, they have used trade openness as an additional explanatory variable.

A summary of the studies on EKC estimation for $CO_2$ emissions using cubic income in the EKC framework is provided in Table-1. It can be seen that the EKC estimation exercise for $CO_2$ emissions has been carried out for a number of contexts over different periods of time, and the results are mostly inconclusive. A number of studies have used energy consumption as an explanatory variable in their empirical models, but the shift from fossil fuel energy consumption to renewable energy consumption has not been much visible in this case (see Table 2). Apart from energy consumption, a diverse set of explanatory variables have been used, as keeping with the respective research contexts. Some of these variables are FDI (Alshehry 2015, Pal and Mitra 2017), public budget in energy research (Álvarez-Herránz et al. 2017), population growth (Akpan and Abang 2015, Shahbaz et al. 2016a), globalization (Shahbaz et al. 2016a), financial development (Moghadam and Dehbashi, 2017) and several others.

The studies in this case also demonstrate the gradual shift from scale effect to composition and technique effects, by means of changes in energy consumption and energy use patterns. The

study by Lee et al. (2009) was conducted on 89 countries over the period of 1960-2000. Using system GMM, they found the EKCs to be inverted U-shaped with turnaround point at $17,620, and N-shaped with turnaround points at $15,400 and $30,780. This was the first ever study to include fossil fuel energy consumption within the EKC framework with cubic income. Following this study, researchers started to include fossil fuel energy consumption within the EKC framework. During the second half of 2010, researchers started to include renewable energy consumption within the EKC framework. López-Menéndez et al. (2014) estimated the EKC for 27 EU countries over the period of 1996-2010, and it was the first ever study to include renewable energy consumption within the EKC framework with cubic income. Using panel cointegration technique, the EKC was found to be N-shaped with the turnaround points outside the sample space.

## 4. Impact of methodological adaptations

In this section, we provide the outcomes of the reviewed EKC estimation studies, which can be segregated into the following categories: (a) studies employing methods pertaining to time series data, and (b) studies employing methods pertaining to panel data. For both of the cases, studies have discovered various shapes of the EKCs, whereas some studies found no evidence of EKC. In the following sections, we will discuss about these two categories.

### 4.1. Impact of time series data methods

We summarize the findings of the reviewed EKC estimation studies for $CO_2$ emissions using time series data in Table-3 and 4. Out of the reviewed studies, quadratic form of EKC is the most prominent one among the entire strata. From methodological perspective, ARDL bounds test has been used the most in the studies, followed by cointegration test.

The first EKC estimation study for $CO_2$ emissions using time series data was carried out by Roca et al. (2001). The study was conducted on Spanish data over the period of 1973-1996, and

OLS was employed to estimate the EKC. However, no EKC was found for Spain. The study by Ang (2007) was the earliest one to find the evidence of EKC using time series data. Employing ARDL bounds test, the study was conducted for France over the period of 1960-2000. The turnaround point of the inverted U-shaped EKC was found to be 11,096.35 (measured in local currency). One of the latest EKC estimation studies carried out in 2017 was done by Ozatac et al. (2017), and this study was conducted for Turkey over the period of 1960-2013. By employing the ARDL bounds test approach, this study also found the evidence of inverted U-shaped EKC for $CO_2$ emissions, with turnaround point at USD 16,648.84.

Now, if we talk about the N-shaped EKC for $CO_2$ emissions, cointegration test comes into picture. This study was carried out by Akbostancı et al. (2009) for Turkey over the period of 1968-2003. They have employed cointegration technique to arrive at the inverted N-shaped form of the EKC, with the turnaround points at USD 1,437.80 and USD 1,603.90. This was also the first study on EKC estimation for $CO_2$ emissions to employ cointegration technique. The study by Chuku (2011) was the first one to provide an evidence of inverted U-shaped EKC. The study was carried out on Nigerian context over the period of 1960-2008, and the turnaround point was achieved at USD 280.84. This is also by far the last study to show the evidence of N-shaped EKC by employing cointegration technique.

During 1991-2017, nearly eight broad categories of time series data methods have been applied, and the results obtained from these studies have been inconclusive. The reviewed studies have demonstrated conflicting results and there is no consensus regarding the existence or shape of the EKC.

### 4.2. Impact of panel data methods

We summarize the findings of the reviewed EKC estimation studies for $CO_2$ emissions using panel data in Table-3 and 4. Out of the reviewed studies, quadratic form of EKC is the most prominent one among the entire strata. From methodological perspective, panel regression test has been used the most in the studies, followed by FMOLS.

The first EKC estimation study for $CO_2$ emissions using panel data was carried out by Holtz-Eakin and Selden (1995). This study was carried out for 130 countries over the period of 1951-1986, and using panel regression approach, this study showed the evidence of inverted U-shaped EKC, with the turnaround point at USD 35,428. Panel regression is the only method found in this review of literature to show the first evidence of all shapes of EKC. Though a number of sophisticated econometric techniques are being discovered for panel data models, panel regression has been proven to be successful for EKC estimation purpose.

Subsequent to panel regression approach, researchers have employed FMOLS the most to estimate the EKC using panel data. The first study to employ the FMOLS was carried out by Apergis and Payne (2009). The study was carried out for 6 Central American countries over the period of 1971-2004. Using FMOLS approach, this study found the evidence of inverted U-shaped EKC. During the last phase of 2017, a study by Zhang et al. (2017) was carried out for 10 Newly Industrialized countries over the period of 1971-2013. Using FMOLS, the study found the evidence of inverted U-shaped EKC, with turnaround point at USD 125.97. Apart from this, this study has also employed OLS and DOLS method, and showed the evidence of inverted U-shaped EKC, both with turnaround points at USD 127.97.

For the entire study period, nearly 23 broad categories of panel data methods have been applied, and the results obtained from these studies have been inconclusive. Similar to the studies

pertaining to time series data models, in this case also the reviewed studies have demonstrated conflicting results and there is no consensus regarding the existence or shape of the EKC.

## 5. Model outcomes

In this section, we provide the outcomes of the reviewed EKC estimation studies, which can be segregated into the following categories: linear (monotonically increasing or decreasing), inverted U-shaped, U-shaped, inverted N-shaped, N-shaped, and no EKC. These studies are further segregated into the nature of data employed in these studies, i.e. time series and panel data. In the consecutive subsections, we will discuss about these two categories.

### 5.1. Model outcomes for time series data

We summarize the findings of the reviewed EKC estimation studies for $CO_2$ emissions using time series data in Table-5. Out of the reviewed studies, inverted U-shaped form of EKC is the most prominent one among the entire strata.

Roca et al. (2001) carried out the earliest EKC estimation study for $CO_2$ emissions using time series data, and the study was conducted on Spanish data over the period of 1973-1996. The researchers used the cubic specification for EKC estimation, and no EKC was found for Spain. The researchers attributed this phenomenon to the low volume of data for carrying out such an analysis. In this context, a latest study by Pal and Mitra (2017) needs special mention. The study was conducted on Indian and Chinese data over the period of 1971-2012, and the researchers employed ARDL bounds test for estimating the EKC for $CO_2$ emissions in these countries. Though the study concluded by a mere mention of an N-shaped EKC, the model specifications did not comply with the conditions outlined in section 3. Therefore, we had to conclude that the study did not actually find the evidence of any EKC.

One of the earliest studies to achieve the generally accepted inverted U-shaped form of EKC was carried out by Ang (2007). Using quadratic model specification, the study was conducted for France over the period of 1960-2000. The researchers employed ARDL bounds test of cointegration, and found the EKC to be inverted U-shaped with the turnaround point at 11,096.35 (measured in local currency). As per our knowledge, this was also the first study in the literature to consider the ARDL bounds test to estimate EKC for $CO_2$ emissions for any given context. On the other hand, the study by Omisakin (2009) on Nigerian data over the period of 1970-2005 was the first EKC estimation study for $CO_2$ emissions to arrive at a U-shaped form of EKC. The researcher employed OLS technique for the estimation purpose, and the turnaround point was estimated at 1,600 (measured in local currency).

The study by Abdallah et al. (2013) is one of the earliest studies to discover the inverted N-shaped EKC for $CO_2$ emissions using time series data. The study was conducted on Tunisian road transport sector over the period of 1980-2010. Using vector error correction method (VECM), the researchers found the EKC to be inverted N-shaped, with the turnaround points at 74.88 and 578.82 (measured in local currency). In this study, per capita transport value added was chosen as the indicator of economic growth. Ten years earlier, the study by Friedl and Getzner (2003) was one of the earliest studies to find the evidence of N-shaped EKC for $CO_2$ emissions using time series data. The study was conducted on Austrian data over the period of 1960-1999, and cointegration technique was used to estimate the EKC. In this study, the researchers found two sets of turnaround points: (a) ignoring the structural breaks, the points were 893.83 and 33,200.96 (measured in Euro), and (b) considering structural breaks, the points were 976.50 and 32,965.66.

**5.2. Model outcomes for panel data**

We summarize the findings of the reviewed EKC estimation studies for $CO_2$ emissions using panel data in Table-5. Out of the reviewed studies, inverted U-shaped form of EKC is the most prominent one among the entire strata.

Magnani (2001) carried out the earliest EKC estimation study for $CO_2$ emissions using panel data, and the study was conducted for 152 countries over the period of 1970-1990. Panel regression was employed to estimate the EKC for $CO_2$ emissions, and the no evidence of EKC was found in the study. In an earlier study, Shafik and Bandyopadhyay (1992) investigated the EKC for $CO_2$ emissions for 149 countries over the period of 1960-1990. Following the same methodological approach, the researchers found the EKC to be Monotonically Increasing.

The earliest study to find the evidence of generally accepted inverted U-shaped form of EKC was carried out by Holtz-Eakin and Selden (1995). The study was conducted for 130 countries over the period of 1951-1986. Following quadratic specification and panel regression approach, the researchers found the EKC to be inverted U-shaped, with the turnaround point at USD 35,428. On the other hand, the study conducted by Halkos and Tzeremes (2009) was one of the earliest one to find the evidence of U-shaped EKC for $CO_2$ emission using panel data. The study was conducted for 17 OECD countries over the period of 1980-2002, and the researchers employed panel regression method to estimate the EKC. Using fixed effect, the turnaround point was achieved at USD 11,151.96, and using random effect, the same was achieved at USD 15,949.37.

The study by Moomaw and Unruh (1997) was the earliest study to find the evidence of N-shaped EKC for $CO_2$ emissions using panel data. The study was conducted for 16 countries over the period of 1950-1992. Following a cubic specification and employing panel regression approach, the researchers found the evidence of N-shaped EKC, with turnaround points at USD

12,813 and USD 18,133. Later, a study by Dijkgraaf and Vollebergh (2005) on 24 OECD countries over the period of 1960-1997 was one of the earliest studies to find the evidence of inverted N-shaped EKC. The study employed panel regression approach, and study revolved around three models: (a) country-fixed effects model, (b) time and country-fixed effects model, and (c) country heterogeneity model. For the first two instances, the EKC was found to be inverted N-shaped, and for the third instance, EKC could not be achieved. For the first model, the turnaround points were USD 252.44 and USD 26,295.51, and for the second model, the turnaround points were USD 358.62 and USD 20,589.59.

**6. Geographical context and divergence in turnaround points**

In the literature of EKC hypothesis, it has been seen that the turnaround point of the EKC for any geographical location varies from one study to another. This divergence arises owing to the changes in study period, methodological adaptation, power of income, and choice of control variables. In this section, we will consider few geographical locations and the turnaround points achieved by the studies conducted in those locations. India, Turkey, and China have been chosen as the sample geographical locations.

For India, the earliest study to achieve an inverted U-shaped EKC was conducted by Pao and Tsai (2010). The study was conducted for BRIC countries over the period of 1971-2005, and using cointegration, the turnaround point was found to be at USD 427.80. By far, Nasreen et al. (2017) has conducted the latest study on EKC estimation for $CO_2$ emissions in India, and to arrive at an inverted U-shaped EKC. This study was carried out for 5 South Asian countries over the period of 1980-2012, and turnaround point was achieved at USD 788.40. The whole spectrum of turnaround points achieved for the studies conducted on $CO_2$ emissions in India is depicted in Figure-2. According to the studies reviewed by us, the lowest turnaround point (≈ USD 209.43)

was achieved by Kanjilal and Ghosh (2013), and the highest turnaround point (≈ USD 26,517.29) was achieved by Tiwari et al. (2013).

Now, we will move towards Turkey. The earliest study to achieve an inverted U-shaped EKC for $CO_2$ emissions in Turkey was conducted by Halicioglu (2009). The study was carried out over the period of 1960-2005, and using ARDL bounds test, the turnaround point was found to be USD 1,661.81. A latest study by Ozatac et al. (2017) was carried out over the period of 1960-2013. Using ARDL bounds test, the turnaround point was found to be USD 16,648.84. The whole spectrum of turnaround points achieved for the studies conducted on $CO_2$ emissions in Turkey is depicted in Figure-3. According to the studies reviewed by us, the lowest turnaround point (≈ USD 1,661.81) was achieved by Halicioglu (2009), and the highest turnaround point (≈ USD 16,945.73) was achieved by Shahbaz et al. (2016b).

Lastly, we will move towards China. The earliest study to achieve an inverted U-shaped EKC for $CO_2$ emissions in China was conducted by Jalil and Mahmud (2009). The study was carried out over the period of 1975-2005, and using ARDL bounds test, the turnaround point was found to be RMB 12,992 (≈ USD 2,063.00). A latest study by Wang et al. (2017) was carried out over the period of 2000-2013 for 30 Chinese provinces. Taking panel regression approach, the turnaround points were found to be between USD 656.37 and USD 176,361.65, across mining, manufacturing, and electricity and heat production sectors. The whole spectrum of turnaround points achieved for the studies conducted on $CO_2$ emissions in China is depicted in Figure-4. According to the studies reviewed by us, the lowest turnaround point (≈ USD 204.51) was achieved by Liu et al. (2015), and the highest turnaround point (≈ USD 176,361.65) was achieved by Wang et al. (2017).

By far, we have looked into the contexts of three countries, where inverted U-shaped EKCs were achieved, and how the turnaround points vary for a single country. Similarly, the divergence can be seen in case of cross-country evidences. For this case, we will take the example of OECD countries. These studies have considered different samples of OECD member countries, different study periods, and various methodological adaptations. Consequently, the studies demonstrate different shapes of EKC, i.e. inverted U-shaped, U-shaped, inverted N-shaped, N-shaped, and linear. The study by Martínez-Zarzoso and Bengochea-Morancho (2004) was conducted on 22 OECD countries over the period of 1975-1998. They found the evidence of both inverted U-shaped and N-shaped EKCs. For the N-shaped EKCs, the first turnaround point ranges from USD 1,302.28 to USD 3,022.86, and the second turnaround point ranges from USD 8,466.38 to USD 59,264.58. For the inverted U-shaped EKC, the turnaround point was found at USD 403.05. Recently, the study by Álvarez-Herránz et al. (2017) provided the evidence of N-shaped EKC for 28 OECD countries over the period of 1990-2014. The turnaround points of the EKC found by the researchers were USD 20,885.38 and USD 67,309.06. On the other hand, the evidence of inverted N-shaped - EKCs were found by Dijkgraaf and Vollebergh (2005) and Vollebergh et al. (2005). For these studies, the first turnaround points range from USD 252.44 to USD 902.72, and the second turnaround points range from USD 15,835.30 to USD 26,295.51. A similar kind of divergence can be seen for the inverted U-shaped EKCs, as well. The maximum value of turnaround point for an inverted U-shaped EKC has been found to be USD 268,337.29 by Bilgili et al. (2016), whereas Martínez-Zarzoso and Bengochea-Morancho (2004) has found the turnaround point to be USD 403.05. Lastly, for U-shaped EKCs, the lowest turnaround point was found to be USD 11,151.96 in a study by Halkos and Tzeremes (2009), whereas the maximum value was found to be USD 206,249.55, as reported by Dogan et al. (2015).

Therefore, we have seen that the divergence in terms of shape and turnaround point of EKC not only varies across the geographical context, but also within the geographical context. However, within a geographical context, temporal boundary, methodological selection, and choice of control variables play significant roles. This finding is in the similar lines with the finding of Stern (2017).

## 7. Impact of other explanatory variables

The mathematical form of EKC given in equation-1 elucidates that the error term might include the influence caused by other explanatory variables. Now, if the scale, composition, and technique effects are considered, then apart from income, three other major explanatory variables come to pass, i.e. trade openness, fossil fuel consumption, and renewable energy consumption. There has been a wide array of control variables used in the EKC estimation studies. However, we have chosen these three variables, as researchers have been employing these three variables mostly in their empirical models.[1] Over the years, researchers are considering these variables within the EKC framework. We will now discuss these three explanatory variables one-by-one.

### 7.1. Impact of trade openness

The study by Agras and Chapman (1999) was the first one to consider the aspect of trade openness in an EKC framework. Following a quadratic specification, the study was conducted for the United Nations over the period of 1971-1989. Using panel regression technique, the EKC was found to be inverted U-shaped, with turnaround points between $51.65 and $101.03. In this study, the researchers found import to have negative impact on $CO_2$ emissions, whereas export has positive impact on $CO_2$ emissions. Atici (2009) analyzed the EKC for 4 countries over the period of 1980-2002. Following a quadratic specification and applying panel cointegration technique, the researcher found the EKC to be inverted U-shaped, with turnaround point between $2,077 and

[1] Out of 171 reviewed studies, 105 studies (Trade Openness - 61, Fossil Fuel Energy Consumption - 88, Renewable Energy Consumption - 19) have referred to these three variables.

$3,156. In this study, the researcher used trade openness index, and it found to have negative impact of $CO_2$ emissions. However, in the study of Halicioglu (2009), the impact was found to be positive. This study was conducted for Turkey over the period of 1960-2005, and using ARDL bounds approach, the EKC was found to be inverted U-shaped with turnaround point at $1,661.81.

The study by Jalil and Mahmud (2009) was the first stud to consider total trade volume as the indicator of trade openness. This study was conducted on China over the period of 1975-2005. Following quadratic specification and ARDL bounds approach, the EKC was found to be inverted U-shaped with turnaround point at $40.82. In this study, the impact of trade volume on $CO_2$ emissions was found to be negative. A subsequent study by Tamazian et al. (2009) introduced foreign direct investment (FDI) as a proxy for trade openness. In this study, they estimated the EKC for BRIC countries over the period of 1992-2004, and following panel cointegration, the EKC was found to be inverted U-shaped with turnaround point between $90.02 and $36,315.50. In this study, FDI stock has both positive and negative impact on $CO_2$ emissions.

A summary of the studies on EKC estimation for $CO_2$ emissions considering trade openness is provided in Table-2. It can be seen that the studies have used various indicators of trade openness and the results obtained from using those indicators are inconclusive in nature, irrespective of the nature of the empirical model or context.

**7.2. Impact of fossil fuel energy consumption**

Cole et al. (1997) conducted the first EKC estimation study on $CO_2$ emissions. Following a quadratic specification, this study was conducted for 7 countries over the period of 1960-1991. Using panel regression approach, the EKC was found to be inverted U-shaped, with turnaround points between $25,100 and $62,700. In this study, the impact of total energy use on $CO_2$ emissions has been found to be positive. Subsequent to this, the work by Lindmark (2002) is the EKC

estimation study carried out on a single country. In this study, the researcher found the fossil fuel based energy consumption to have a direct positive impact on $CO_2$ emissions. However, both of these studies considered quadratic income in the empirical framework of EKC.

The first EKC estimation study for $CO_2$ emissions considering fossil fuel energy consumption within a cubic framework was carried out by Lee et al. (2009). The study was done for 89 countries over a period of 1960-2000. Using system GMM approach, the EKCs were found to be inverted U-shaped with turnaround point at $17,620, and N-shaped with turnaround points at $15,400 and $30,780. In this study, the researchers found the fossil fuel based energy consumption to have a direct positive impact on $CO_2$ emissions. First single country analysis in this context was carried out by He and Richard (2010). The study was conducted for Canada over the period of 1948-2002. Taking OLS approach, the EKC was found to be inverted U-shaped with the turnaround point at $22,615. In this study also, the researcher found the fossil fuel based energy consumption to have a direct positive impact on $CO_2$ emissions.

A brief summary of these studies are provided in Table-2. It can be seen that for all the cases, the impact of fossil fuel based energy consumption on $CO_2$ emissions has been positive.

### 7.3. Impact of renewable energy consumption

In the EKC estimation studies on $CO_2$ emissions, renewable energy consumption has been started to be considered since the mid-2000, and till now, it has been used in various forms and in aggregate form, as well. The first study to consider renewable energy consumption was carried out by Richmond and Kaufmann (2006). Following a quadratic specification, this study was carried out for 36 countries over the period of 1973-1997, and using OLS approach, the EKC was found to be inverted U-shaped, with turnaround points between $29,687 and $110,599. This study used hydro and nuclear energy consumption within the empirical framework. The study by Iwata et al.

(2011) considered only nuclear energy consumption within the EKC framework, and it had a negative impact on $CO_2$ emissions. This segment of result falls in line with the findings of Baek and Kim (2013).

The study by Sulaiman et al. (2013) considered total renewable energy production for the first time within the EKC framework. Following a quadratic model, this study was done for Malaysia over the period of 1980-2009, and using ARDL bounds test, the EKC was found to be inverted U-shaped, with turnaround point at $8.77K. In this case, the impact of renewable energy production on $CO_2$ emissions was found to be negative. This result was supported by Bölük and Mert (2015), Ben Jebli et al. (2015), Al-Mulali and Ozturk (2016), Dogan and Seker (2016), Jebli et al. (2016), and others, whereas contradicted by Bölük and Mert (2014), Farhani and Shahbaz (2014). Jebli and Youssef (2015) presented mixed results in this context. A brief summary of the studies is listed in Table-2.

### 7.4. Impact of socio-political parameters

Apart from the three variables mentioned, social parameters also play a pivotal role in EKC estimation studies. Several researchers identified the significance of social and political parameters in determining the shape of an EKC (Cantore 2009, Ibrahim and Law 2014, Sinha and Bhattacharya 2016). According to Panayotou (1993), when the economy reaches the newly industrialized phase, the high level of economic growth is ecologically threatened, and thereby, disequilibrium is created. In order to settle this disequilibrium, along with economic pressure, social and political pressures are also created for enforcing environmental regulations and ecological protection. Therefore, inclusion of socio-political parameters within an EKC framework can always bring forth significant policy implications.

Farzin and Bond (2006) analyzed the EKC for 45 countries over the period of 1980-1998. In this study, the researchers have theoretically shown the impact of societal preferences on environmental quality. They have included democracy and its interaction with income inequality, age composition, and education level within the empirical framework of EKC. Except democracy, rest of the three factors found to have positive impact on $CO_2$ emissions. This concept was also adapted by Mills and Waite (2009) in the form of democracy index. Dutt (2009) analyzed the EKC for 124 countries over the period of 1984-2002. The researcher included governance, political institutions, government expenditure on education, years of schooling, unemployment, poverty, and consumer confidence within the empirical framework of EKC. These parameters found to have negative impact on $CO_2$ emissions. Tamazian and Rao (2010) analyzed the EKC for 24 transition economies over the period of 1993-2004. They have included institutional quality as a measure for efficiency in the empirical framework, and it has found to have negative impact on $CO_2$ emissions. Taguchi (2013) analyzed the EKC for 19 Asian countries over the period of 1950-2009. They have included the later development of the economy within the empirical framework of EKC, and it has found to have a negative impact on $CO_2$ emissions. Farhani et al. (2014b) analyzed the EKC for MENA countries over the period of 1990-2010. They have included human development indicator (HDI) in their empirical framework, and found to have positive impact on $CO_2$ emissions. However, this segment of their results was contradicted by Sinha and Sen (2016). Osabuohien et al. (2014) analyzed the EKC for 50 African countries over the period of 1995-2010. They have included institutional quality in their empirical model, and it was measured by average value of rule of law, regulatory quality, and government effectiveness. For the oil-producing countries in the sample, institutional quality found to have positive impact on $CO_2$ emissions,

whereas for the non-oil-producing countries, the institutional quality found to have negative impact.

These indicators have been mostly used in the EKC estimation studies on $CO_2$ emissions. It is evident that the impacts of these parameters are highly dependent on the context, as the nature of these parameters change in accordance with the context. Therefore, while choosing any context, the socio-political parameters need to be chosen carefully, as a parameter used in one context might not be a proper fit for the second context.

## 8. Conclusion and Future Directions

The objective of this study is to survey the literature dealing with the EKC estimation of $CO_2$ emissions, and to understand the existing body of knowledge from the perspective of methodological adaptation, model design, and outcome. The literature on this particular field is growing rapidly with the advent of latest technologies in the field of alternate energy sources, and the studies are focusing on emerging and developed economies. As the natures of growth in both of these cases are radically different from each other, therefore the policymakers should be aware of the dual impact of energy consumption pattern on economic growth and environmental degradation. A broad conclusion from the reviewed studies is that there is no consensus regarding the existence or shape of EKC, i.e. for any geographical context, researchers can come up with different and opposing set of results. These conflicting results may arise due to the time frame of the study, the choice of explanatory variables, and the methodological adaptation.

One observation that we can make from these empirical studies is that, almost all of the studies have by and large focused on analyzing the existence of EKCs, the occurrences of the turnaround points, and the shape of the EKCs. However, out of all the studies reviewed, we have encountered only a handful number of studies, which have also considered the height of the EKCs.

This is an aspect, which is largely missing in the recent empirical literature on the EKC estimation. There are possibilities that the emissions beyond a certain level might not be reversible, and that is the point, from where environmental degradation will only rise monotonically. This is one major aspect, which is largely missed out in empirical analysis carried out during estimation of EKC in any context. If the studies done for a particular country or a group of countries can be seen together, then it becomes visible that the EKCs estimated in that context is not stable, as a change in the time frame can change the shape of EKC, and sometimes even its existence (see Table-1). Saying this, it might be wrong to suggest policy implications based on mere empirical results, which just reveal the turnaround level of economic growth, because the policy recommendations should also take into account the height of the EKCs. Therefore, it will make the policymakers not to wait for the turnaround point to occur, but it will make them to intervene for flattening the EKC.

Environmental sustainability is a part of the broader sustainable development. The recent empirical literature on EKC estimation has been largely inclined towards considering the diverse aspects of economic growth, like international trade, financial development, research and development, globalization, crude oil price, population, etc. The definition of turnaround point in EKC hypothesis is based on the idea of environmental awareness, which is highly correlated with social sustainability. It signifies that without social sustainability, a nation can never achieve environmental sustainability. Therefore, the social indicators should be incorporated within the EKC framework. For example, a country with high literacy rate and low unemployment is expected to have lower level of environmental degradation compared to the country with low literacy rate and high unemployment. Perhaps that is the reason why the developed nations have been able to achieve the turnaround point of EKC, when the developing and emerging economies are yet to reach that. This is a lesson, which the developing and emerging economies should learn

from the developed nations, rather than replicating their models in their own countries. In order to achieve the turnaround point in a sustainable manner, these economies should consider a people-public-private partnership approach, which can ensure an inclusive growth, a recipe for sustainable development.

While carrying out any EKC estimation study, it should be remembered that carrying out the study on similar contexts and using new time frame and methodologies might not prove to be fruitful, as it might not add any substantial contribution to the existing energy economics literature. Therefore, the future studies in this context should not only consider new set of variables, but also the dataset should be refined, so that the EKC estimation issues raised by Stern (2004) can be addressed. Considering new perspectives, new set of variables, and going beyond the time series evidences can produce more productive results, based on which the policymakers can come out with substantial policy recommendations for encountering environmental degradation, thereby flattening the EKCs.

The survey of the literature divulged that the number of studies pertaining using panel data is higher compared to those using time series data. While carrying out any EKC estimation study, it should be remembered that providing a cross-country analysis, or intra-provincial analysis for a country, or cross-sector analysis for any country can bring more insights. The major reason behind this is bringing forth comparable references within the geographical context will allow the policymakers to make an informed decision, as the results will depict a comparative scenario. As a future direction, it can be stated that employing robust panel data methods, like FMOLS and GMM might bring forth more significant insights. On the other hand, if the study is conducted on time series data, then the researchers should consider the ARDL bounds test approach, as it will

allow the researchers to consider different lag lengths for the control variables, thereby bringing more flexibility in the study.

If the methodological adaptation is kept apart, future studies should consider the variables, like corruption index, social indicators, political scenario, investment in research and development for alternate energy exploration, economic complexity, exports diversity, foreign capital inflows (especially foreign remittances), economic, social and political cooperation etc. These variables might prove to be fruitful, while considering the developing or emerging economies, as these aspects largely influence the environmental degradation scenario in those nations. A number of studies are also considering the interaction variables, which are bringing forth more robustness to the studies (Balsalobre et al., 2015; Álvarez-Herránz et al., 2017; Sinha et al., 2017). This is an aspect, which should be remembered while designing the robust EKC models. Apart from that, the researchers should also consider the model specifications to go beyond the cubic income, as this can have some far-reaching consequences.

**Table-1: Evidences of EKC estimation studies for $CO_2$ emissions**

| *Author(s)* | *Context* | *Power of Income* | *Type of Data* | *Methodology* | *Shape of EKC* | *Turnaround Point(s)* | |
|---|---|---|---|---|---|---|---|
| Shafik and Bandyopadhyay (1992) | 149 countries (1960-1990) | Cubic | Panel | Panel regression | Monotonically Increasing | NA | |
| Shafik (1994) | 149 countries (1960-1990) | Cubic | Panel | Panel regression | Monotonically Increasing | NA | |
| Holtz-Eakin and Selden (1995) | 130 countries (1951-1986) | Quadratic | Panel | Panel regression | Inverted U-shaped | 35,428 | |
| Cole et al. (1997) | 7 countries (1960-1991) | Quadratic | Panel | Panel regression | Inverted U-shaped | Model I | 62,700 |
| | | | | | | Model II | 25,100 |
| Moomaw and Unruh (1997) | 16 countries (1950-1992) | Cubic | Panel | Panel regression | N-shaped | a. 12,813<br>b. 18,133 | |
| Agras and Chapman (1999) | United Nations (1971-1989) | Quadratic | Panel | Panel regression | Inverted U-shaped | Model I | 3.94 |
| | | | | | Inverted U-shaped | Model II | 4.62 |
| | | | | | Monotonically Increasing | Model III | NA |
| | | | | | Inverted U-shaped | Model IV | 2.60 |
| Galeotti and Lanza (1999) | 110 countries (1960-1996) | Quadratic | Panel | Panel regression | Inverted U-shaped | All countries | 16,646 |
| | | | | | | | 15,073 |
| | | | | | | Annex I Countries | 17,855 |
| | | | | | | | 17,961 |
| | | | | | | Non-Annex I Countries | 21,757 |
| | | | | | | | 19,340 |
| Magnani (2001) | 152 countries (1970-1990) | Cubic | Panel | Panel regression | No EKC | NA | |
| Roca et al. (2001) | Spain (1973-1996) | Cubic | Time Series | OLS | No EKC | NA | |
| Hill and Magnani (2002) | 156 countries (1970-1990) | Cubic | Panel | Pooled OLS | N-shaped | a. 3,007.01<br>b. 721,919.40 | |
| Lindmark (2002) | Sweden (1870-1997) | Quadratic | Time Series | Kalman Filter | No EKC | NA | |
| Day and Grafton (2003) | Canada (1958-1995) | Cubic | Time Series | OLS | N-shaped | a. 19,133.10<br>b. 20,760.86 | |
| Friedl and Getzner (2003) | Austria (1960-1999) | Linear | Time Series | OLS | Monotonically Increasing | NA | |
| | | Quadratic | | | Monotonically Increasing | NA | |
| | | Cubic | | | N-shaped | a. 893.83<br>b. 33,200.96 | |
| | | | | | N-shaped | a. 976.50<br>b. 32,965.66 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shi (2003) | 93 countries (1975-1996) | Linear | Panel | GLS | Monotonically Increasing | Model I | NA |
| | | | | | Monotonically Increasing | Model II | NA |
| | | | | | Monotonically Increasing | Model III | NA |
| | | Quadratic | | | Inverted U-shaped | Model IV | 4,591,065.28 |
| York et al. (2003) | 111 countries (1960-2000) | Quadratic | Panel | OLS | Inverted U-shaped | Model I | 9.28 |
| | | | | | | Model II | 12.15 |
| | | | | | | Model III | 16.28 |
| Martínez-Zarzoso and Bengochea-Morancho (2004) | 22 OECD countries (1975-1998) | Cubic | Panel | MG | N-shaped | Model I | a. 1,302.28<br>b. 56,916.37 |
| | | | | PMG | No EKC | Model II | NA |
| | | | | Fixed Effect | No EKC | Model III | NA |
| | | | | MG | N-shaped | Model IV | a. 2,602.38<br>b. 19,040.74 |
| | | | | PMG | Inverted U-shaped | Model V | 403.05 |
| | | | | Fixed Effect | No EKC | Model VI | NA |
| | | | | MG | N-shaped | Model VII | a. 1,576.99<br>b. 32,366.41 |
| | | | | PMG | N-shaped | Model VIII | a. 3,022.86<br>b. 47,893.69 |
| | | | | Fixed Effect | No EKC | Model IX | NA |
| | | | | MG | N-shaped | Model X | a. 1,772.15<br>b. 8,466.38 |
| | | | | PMG | N-shaped | Model XI | a. 1,604.56<br>b. 59,264.58 |
| | | | | Fixed Effect | No EKC | Model XII | NA |
| Aldy (2005) | The US (1960-1999) | Quadratic | Panel | OLS | Inverted U-shaped | Model I | 15,581.60 |
| | | | | OLS | Monotonically Increasing | Model II | NA |
| | | | | FGLS | Inverted U-shaped | Model III | 16,279.70 |
| | | | | FGLS | Inverted U-shaped | Model IV | 18,501.02 |
| | | | | OLS | Inverted U-shaped | Model V | 19,979.04 |
| | | | | OLS | Inverted U-shaped | Model VI | 26,903.19 |
| | | | | FGLS | Inverted U-shaped | Model VII | 23,118.47 |
| | | | | FGLS | Inverted U-shaped | Model VIII | 19,674.86 |
| Dijkgraaf and Vollebergh (2005) | 24 OECD countries (1960-1997) | Cubic | Panel | Panel regression | Inverted N-shaped | Model I | a. 252.44<br>b. 26,295.51 |
| | | | | | | Model II | a. 358.62<br>b. 20,589.59 |
| | | | | | No EKC | Model III | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Vollebergh et al. (2005) | 24 OECD countries (1960-2000) | Cubic | Panel | Panel regression (Parametric) | Inverted N-shaped | a. 387.47<br>b. 15,835.30 | |
| | | | | Panel regression (Semi-parametric) | | a. 902.72<br>b. 23,944.04 | |
| Farzin and Bond (2006) | 45 countries (1980-1998) | Cubic | Panel | Panel regression | Monotonically Increasing | NA | |
| Galeotti et al. (2006) | OECD countries (1960-1998) | Cubic | Panel | Panel regression | Inverted U-shaped | Between 8,384.72 and 16,881.79 | |
| Lantz and Feng (2006) | Canada (1970-2000) | Quadratic | Time Series | GLS | Monotonically Increasing | NA | |
| Richmond and Kaufmann (2006) | 36 countries (1973-1997) | Linear | Panel | OLS | Monotonically Increasing | Model I | NA |
| | | Linear | | | Monotonically Increasing | Model II | NA |
| | | Quadratic | | | Monotonically Increasing | Model III | NA |
| | | Linear | | | Monotonically Increasing | Model IV | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | Model V | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Quadratic | | | Monotonically Increasing | Model VI | NA |
| | | Quadratic | | | Inverted U-shaped | | 32,810.92 |
| | | Quadratic | | | Monotonically Increasing | | NA |
| Ang (2007) | France (1960-2000) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 11,096.35 | |
| Faiz-Ur-Rehman et al. (2007) | 4 South Asian countries (1983-2006) | Quadratic | Panel | Pooled regression | Inverted U-shaped | With Trade | 1,500.00 |
| | | | | | | | 1,650.00 |
| | | | | | | With Taxes | 1,610.31 |
| | | | | | | | 598.80 |
| | | | | | | With Import Duties | 994.04 |
| | | | | | | | 649.35 |
| | | | | | | With Export Duties | 1,031.99 |
| | | | | | | | 769.23 |
| Yaguchi et al. (2007) | Japan and China (1975-1999) | Quadratic | Panel | Panel regression | Inverted U-shaped | Japan | 4,340.91 |
| | | | | | | | 4,348.66 |
| | | | | | Monotonically Increasing | China | NA |
| | | | | | | | NA |
| York (2007) | 14 EU countries (1960-2000) | Quadratic | Panel | Prais-Winsten regression | Monotonically Increasing | Model I | NA |
| | | | | | Inverted U-shaped | Model II | 4.44K |
| | | | | | | Model III | 5.43K |
| Akbostancı et al. (2009) | Turkey (1968-2003) | Cubic | Time Series | Cointegration | N-shaped | Model I | a. 1,437.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | b. 1,603.9 |
| | | | | | No EKC | Model II | NA |
| Apergis and Payne (2009) | 6 Central American countries (1971-2004) | Quadratic | Panel | FMOLS | Inverted U-shaped | 1.79K | |
| Atici (2009) | 4 countries (1980-2002) | Quadratic | Panel | Panel cointegration | Inverted U-shaped | Fixed effect | 2,077 |
| | | | | | | Random effect | 3,156 |
| Dutt (2009) | 124 countries (1984-2002) | Quadratic | Panel | Robust OLS | Inverted U-shaped | Model I | 29,158.42 |
| | | | | Panel regression | | Model II | 29,822.46 |
| | | | | | | Model III | 28,730.62 |
| Halicioglu (2009) | Turkey (1960-2005) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 1,661.81 | |
| Halkos and Tzeremes (2009) | 17 OECD countries (1980-2002) | Quadratic | Panel | Panel regression | U-shaped | Fixed effect | 11,151.96 |
| | | | | | | Random effect | 15,949.37 |
| Jalil and Mahmud (2009) | China (1975-2005) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 12,992 | |
| Lee et al. (2009) | 89 countries (1960-2000) | Cubic | Panel | System GMM | Inverted U-shaped | 17,620 | |
| | | | | | N-shaped | a. 15,400<br>b. 30,780 | |
| Omisakin (2009) | Nigeria (1970-2005) | Quadratic | Time Series | OLS | U-shaped | 1,600 | |
| Tamazian et al. (2009) | BRIC countries (1992-2004) | Linear | Panel | Panel cointegration | Monotonically Increasing | BRIC | NA |
| | | | | | | US, Japan and BRIC | NA |
| | | Quadratic | | | Inverted U-shaped | BRIC | 90.02 |
| | | | | | | US, Japan and BRIC | 36,315.50 |
| Acaravci and Ozturk (2010) | 19 European countries (1960-2005) | Quadratic | Time Series | ARDL bounds | No EKC | Austria | NA |
| | | | | | No EKC | Belgium | NA |
| | | | | | Inverted U-shaped | Denmark | 18,285.64 |
| | | | | | No EKC | Finland | NA |
| | | | | | No EKC | France | NA |
| | | | | | No EKC | Germany | NA |
| | | | | | No EKC | Greece | NA |
| | | | | | No EKC | Hungary | NA |
| | | | | | No EKC | Iceland | NA |
| | | | | | No EKC | Ireland | NA |
| | | | | | Inverted U-shaped | Italy | 11,362.86 |
| | | | | | No EKC | Luxembourg | NA |
| | | | | | No EKC | Netherlands | NA |
| | | | | | No EKC | Norway | NA |
| | | | | | No EKC | Portugal | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | No EKC | Spain | NA |
| | | | | | No EKC | Sweden | NA |
| | | | | | No EKC | Switzerland | NA |
| | | | | | No EKC | UK | NA |
| Apergis and Payne (2010) | 11 Commonwealth countries (1992-2004) | Quadratic | Panel | FMOLS | Inverted U-shaped | Without Russia | 1.69 |
| | | | | | | With Russia | 1.71 |
| Bello and Abimbola (2010) | Nigeria (1980-2008) | Quadratic | Time Series | FMOLS | No EKC | NA | |
| Fodha and Zaghdoud (2010) | Tunisia (1961-2004) | Cubic | Time Series | Cointegration | N-Shaped | a. 600.33<br>b. 765.79 | |
| He and Richard (2010) | Canada (1948-2002) | Cubic | Time Series | OLS | No EKC | Model I | NA |
| | | | | | No EKC | Model II | NA |
| | | | | | No EKC | Model III | NA |
| | | | | | No EKC | Model VI | NA |
| | | | | | No EKC | Model V | NA |
| | | | | | No EKC | Model VI | NA |
| Iwata et al. (2010) | France (1960-2003) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Model I | 21,187.96 |
| | | | | | | Model II | 20,620.03 |
| | | | | | | Model III | 21,097.22 |
| Lean and Smyth (2010) | 5 ASEAN countries (1980-2006) | Quadratic | Time Series | DOLS | No EKC | Malaysia | NA |
| | | | | | No EKC | Singapore | NA |
| | | | | | Monotonically Increasing | Indonesia | NA |
| | | | | | Inverted U-shaped | Philippines | 1,480.01 |
| | | | | | No EKC | Thailand | NA |
| | | | Panel | | Inverted U-shaped | 2,197.32 | |
| Lipford and Yandle (2010) | G8 and +5 countries (1950-2004) | Cubic | Time Series | OLS | No EKC | Canada | NA |
| | | Cubic | | | N-shaped | France | a. 15,723.24<br>b. 24,832.32 |
| | | Cubic | | | N-shaped | Germany | a. 16,548.13<br>b. 25,797.54 |
| | | Cubic | | | No EKC | Italy | NA |
| | | Cubic | | | No EKC | Japan | NA |
| | | Linear | | | Monotonically Increasing | Russia | NA |
| | | Cubic | | | N-shaped | UK | a. 13,613.37<br>b. 23,682.67 |
| | | Cubic | | | No EKC | US | NA |
| | | Linear | | | Monotonically Increasing | Brazil | NA |
| | | Cubic | | | No EKC | China | NA |
| | | Linear | | | Monotonically Increasing | India | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Quadratic | | | U-shaped | Mexico | 2,356.78 |
| | | Quadratic | | | U-shaped | South Africa | 3,105.31 |
| Musolesi et al. (2010) | 109 countries (1959-2001) | Quadratic | Panel | Bayesian estimation | Inverted U-shaped | Full sample | 208,981.29 |
| | | | | | Inverted U-shaped | G7 | 17,001.75 |
| | | | | | Inverted U-shaped | EU15 | 14,870.62 |
| | | | | | Inverted U-shaped | OECD | 19,930.37 |
| | | | | | U-shaped | Non-OECD | 37.52 |
| | | | | | U-shaped | 40 Poorest | 54.60 |
| | | | | | Inverted U-shaped | Umbrella | 54,671.12 |
| | | Cubic | | | Inverted N-shaped | Full sample | a. 144.76<br>b. Extremely large |
| | | | | | N-shaped | G7 | a. 19,224.59<br>b. 22,026.47 |
| | | | | | N-shaped | EU15 | a. 17,692.21<br>b. 32,534.63 |
| | | | | | N-shaped | OECD | a. 13,178.92<br>b. Extremely large |
| | | | | | Inverted N-shaped | Non-OECD | a. 186.72<br>b. Extremely large |
| | | | | | No EKC | 40 Poorest | NA |
| | | | | | Inverted N-shaped | Umbrella | a. 167.04<br>b. 170,832.21 |
| Pao and Tsai (2010) | BRIC countries (1971-2005) | Quadratic | Time Series | Panel cointegration | No EKC | Brazil | NA |
| | | | | | U-shaped | Russia | 2,394.65 |
| | | | | | Inverted U-shaped | India | 427.80 |
| | | | | | Inverted U-shaped | China | 605.34 |
| | | | Panel | | Inverted U-shaped | BRIC | 219.83 |
| | | | | | Inverted U-shaped | BIC | 304.35 |
| Seetanah and Vinesh (2010) | Mauritius (1975-2009) | Quadratic | Time Series | OLS | Monotonically Increasing | NA | |
| Tamazian and Rao (2010) | 24 transition economies (1993-2004) | Quadratic | Panel | System GMM | No EKC | Model I | NA |
| | | | | | Monotonically Increasing | Model II | NA |
| | | | | | Monotonically Increasing | Model III | NA |
| | | | | | Monotonically Increasing | Model IV | NA |
| | | | | | Monotonically Increasing | Model V | NA |
| | | | | | Monotonically Increasing | Model VI | NA |
| | | | | | Monotonically Increasing | Model VII | NA |
| | | | | | No EKC | Model VIII | NA |
| Chuku (2011) | Nigeria (1960-2008) | Cubic | Time Series | Cointegration | Inverted U-shaped | Standard Model | 280.84 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | N-shaped | Nested Model | a. 237.23<br>b. 583.33 |
| Guangyue and Deyong (2011) | 27 Chinese provinces (1990-2007) | Quadratic | Panel | Cointegration | Inverted U-shaped | All | 59,874 |
| | | | | | Inverted U-shaped | Eastern | 73,130 |
| | | | | | Inverted U-shaped | Central | 54,176 |
| | | | | | U-shaped | Western | 6,002 |
| Iwata et al. (2011) | 28 countries (1960-2003) | Quadratic | Panel | MG | No EKC | NA | |
| | | | | PMG | Inverted U-shaped | 77,126.73 | |
| | | | | Panel regression | Inverted U-shaped | 141,682.59 | |
| Jalil and Feridun (2011) | China (1953-2006) | Linear | Time Series | ARDL bounds | Monotonically Increasing | Model I | NA |
| | | | | | | Model II | NA |
| | | Quadratic | | | Inverted U-shaped | Model III | 24.59 |
| | | | | | | Model IV | 27.50 |
| Jobert et al. (2011) | 55 countries (1970-2008) | Quadratic | Panel | OLS | Inverted U-shaped | Model I | 10.33 |
| | | | | | | Model II | 13.54 |
| Nasir and Rehman (2011) | Pakistan (1972-2008) | Quadratic | Time Series | Cointegration | Inverted U-shaped | 624.84 | |
| Pao and Tsai (2011a) | Brazil (1980-2007) | Quadratic | Time Series | Cointegration | No EKC | Model I | NA |
| | | | | | Inverted U-shaped | Model II | 1,489.08 |
| | | | | | No EKC | Model III | NA |
| Pao and Tsai (2011b) | BRIC countries (1980-2007) | Quadratic | Panel | Panel Cointegration | Inverted U-shaped | 281.01 | |
| Pao et al. (2011) | Russia (1990-2007) | Quadratic | Time Series | Cointegration | No EKC | Model I | NA |
| | | | | | Monotonically Increasing | Model II | NA |
| | | | | | No EKC | Model III | NA |
| | | | | | Monotonically Decreasing | Model IV | NA |
| | | | | | U-shaped | Model V | 496.42 |
| Wang et al. (2011) | 28 Chinese Provinces (1995-2007) | Quadratic | Panel | Panel Cointegration | U-shaped | 3,287 | |
| Ahmed and Long (2012) | Pakistan (1971-2008) | Cubic | Time Series | ARDL bounds | Monotonically Decreasing | NA | |
| Arouri et al. (2012) | 12 MENA countries (1981-2005) | Quadratic | Time Series | CCE | Inverted U-shaped | Algeria | |
| | | | | | Inverted U-shaped | Egypt | 6,514.00 |
| | | | | | Inverted U-shaped | Jordan | 3,706.00 |
| | | | | | Inverted U-shaped | Lebanon | 2.801.00 |
| | | | | | U-shaped | Morocco | 1413.53 |
| | | | | | Monotonically Increasing | Tunisia | NA |
| | | | | | Inverted U-shaped | Bahrain | 1,984.00 |
| | | | | | Inverted U-shaped | Kuwait | 2,697.00 |
| | | | | | U-shaped | UAE | 2977.36 |
| | | | | | Inverted U-shaped | Oman | 1,840.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Inverted U-shaped | Qatar | 3,593.00 |
| | | | | | Inverted U-shaped | Saudi Arabia | 1,168.00 |
| | | | Panel | | Inverted U-shaped | 37,263.00 | |
| Asghari (2012) | Iran (1980-2008) | Cubic | Time Series | 2SLS | U-shaped | With Openness | 2,655.08 |
| | | | | | | With FDI | 3,049.11 |
| Du et al. (2012) | 29 Chinese Provinces (1995-2009) | Quadratic | Panel | Panel regression | Monotonically Increasing | Model I | NA |
| | | | | Panel regression | Monotonically Increasing | Model II | NA |
| | | | | Panel regression | Inverted U-shaped | Model III | Extremely large |
| | | | | Panel regression | Inverted U-shaped | Model IV | Extremely large |
| | | | | Panel regression | Inverted U-shaped | Model V | Extremely large |
| | | | | System GMM | Monotonically Increasing | Model VI | NA |
| | | | | System GMM | No EKC | Model VII | NA |
| | | | | LSDVC | Inverted U-shaped | Model VIII | Extremely large |
| | | | | LSDVC | No EKC | Model IX | NA |
| Esteve and Tamarit (2012a) | Spain (1857-2007) | Linear | Time Series | Cointegration with structural breaks | No EKC | NA | |
| Esteve and Tamarit (2012b) | Spain (1857-2007) | Quadratic | Time Series | Threshold Cointegration | Inverted U-shaped | 13,246.99 | |
| | | | | | | 14,685.19 | |
| Fosten et al. (2012) | The UK (1830-2003) | Cubic | Time Series | OLS | N-shaped | Without Energy Price | a. 9,565.58<br>b. 18,943.66 |
| | | | | | | With Energy Price | a. 13,678.16<br>b. 23,124.25 |
| Hossain (2012) | Japan (1960-2009) | Cubic | Time Series | ARDL bounds | No EKC | NA | |
| Hussain et al. (2012) | Pakistan (1971-2006) | Cubic | Time Series | OLS | Monotonically Increasing | NA | |
| Jayanthakumaran et al. (2012) | India and China (1971-2007) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | China | 417.06 |
| | | | | | | India | 367.05 |
| Saboori et al. (2012a) | Malaysia (1980-2009) | Quadratic | Time Series | Cointegration | Inverted U-shaped | 4,789.70 | |
| Saboori et al. (2012b) | Indonesia (1971-2007) | Quadratic | Time Series | ARDL bounds | U-shaped | 774.89 | |
| Shahbaz et al. (2012) | Pakistan (1971-2009) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Extremely large | |
| Wang (2012) | 98 countries (1971-2007) | Quadratic | Panel | FMOLS | Monotonically Increasing | NA | |
| Abdallah et al. (2013) | Tunisia (1980-2010) | Cubic | Time Series | VECM | Inverted N-shaped | a. 74.88<br>b. 578.82 | |
| Abdou and Atya (2013) | Egypt (1961-2008) | Quadratic | Time Series | VECM | U-shaped | Model 1 | 120.76 |
| | | Cubic | | | U-shaped | Model 2 | 401.19 |
| | | | | | U-shaped | Model 3 | 384.76 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | N-shaped | Model 4 | a. 653.37<br>b. 1,862.33 |
| Al Sayed and Sek (2013) | 40 countries (1961-2009) | Quadratic | Panel | Panel regression | Inverted U-shaped | Developed countries | 14,890.68 |
| | | | | | | | 67,846.30 |
| | | | | | | Developing countries | 3,719.81 |
| | | | | | | | 8,673.26 |
| Baek and Kim (2013) | Korea (1975-2006) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Case I | Extremely large |
| | | | | | | Case II | |
| Chandran and Tang (2013) | 5 ASEAN countries (1971-2008) | Quadratic | Time Series | Johansen cointegration | Monotonically Increasing | Indonesia | NA |
| | | | | | U-shaped | Malaysia | 232.00 |
| | | | | | No EKC | Singapore | NA |
| | | | | | U-shaped | Thailand | 188.53 |
| | | | | | No EKC | Philippines | NA |
| Kanjilal and Ghosh (2013) | India (1971-2008) | Quadratic | Time Series | Threshold cointegration | U-shaped | Base model | 209.43 |
| | | | | | Inverted U-shaped | Subsample 1 | 212.05 |
| | | | | | No EKC | Subsample 2 | NA |
| Kohler (2013) | South Africa (1960-2009) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 7.39 | |
| Mehrara and ali Rezaei (2013) | BRICS countries (1960-1996) | Quadratic | Panel | Kao Panel cointegration | Inverted U-shaped | 5,269.38 | |
| Ozcan (2013) | 12 MENA countries (1990-2008) | Quadratic | Time Series | FMOLS | U-shaped | Bahrain | 11.84 |
| | | | | | Inverted U-shaped | UAE | 10.50 |
| | | | | | No EKC | Iran | NA |
| | | | | | No EKC | Israel | NA |
| | | | | | Inverted U-shaped | Egypt | 7.91 |
| | | | | | U-shaped | Syria | 6.72 |
| | | | | | No EKC | Saudi Arabia | NA |
| | | | | | U-shaped | Turkey | 8.47 |
| | | | | | U-shaped | Oman | 8.45 |
| | | | | | No EKC | Jordan | NA |
| | | | | | Inverted U-shaped | Lebanon | 10.73 |
| | | | | | U-shaped | Yemen | 11.93 |
| | | | Panel | | U-shaped | 8.24 | |
| Ozturk and Acaravci (2013) | Turkey (1960-2007) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 5,190.83 | |
| Saboori and Sulaiman (2013a) | 5 ASEAN countries (1971-2009) | Quadratic | Time Series | ARDL bounds | U-shaped | Indonesia | 657.82 |
| | | | | | Inverted U-shaped | Malaysia | 116.27 |
| | | | | | U-shaped | Philippines | 1,215.62 |
| | | | | | Inverted U-shaped | Singapore | 5,731.08 |
| | | | | | Inverted U-shaped | Thailand | 1,752.81 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Saboori and Sulaiman (2013b) | Malaysia (1980-2009) | Quadratic | Time Series | ARDL bounds | No EKC | Energy | NA |
| | | | | | Inverted U-shaped | Coal | 5,214.23 |
| | | | | | Inverted U-shaped | Gas | 5,988.87 |
| | | | | | Inverted U-shaped | Electricity | 8,288.94 |
| | | | | | Inverted U-shaped | Oil | 5,851.41 |
| Shahbaz (2013) | Pakistan (1971-2009) | Linear | Time Series | ARDL bounds | No EKC | NA | |
| | | Quadratic | | | Inverted U-shaped | 28,523.84 | |
| Shahbaz et al. (2013a) | Romania (1980-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 197.25 | |
| | | | | | | 201.63 | |
| | | | | | | 105.48 | |
| Shahbaz et al. (2013b) | Turkey (1970-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 4,797.18 | |
| Shahbaz et al. (2013c) | South Africa (1965-2008) | Linear | Time Series | ARDL bounds | Monotonically Increasing | NA | |
| | | Quadratic | | | Inverted U-shaped | 3,463 | |
| Sulaiman et al. (2013) | Malaysia (1980-2009) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 8.77 | |
| Taguchi (2013) | 19 Asian countries (1950-2009) | Quadratic | Panel | System GMM | Inverted U-shaped | 51,102.94 | |
| Tiwari et al. (2013) | India (1966-2009) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 26,517.29 | |
| Arouri et al. (2014) | Thailand (1971-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 138,220.36 | |
| Azlina et al. (2014) | Malaysia (1975-2011) | Quadratic | Time Series | OLS | Monotonically Increasing | NA | |
| Bölük and Mert (2014) | 16 EU countries (1990-2008) | Quadratic | Panel | Panel regression | Inverted U-shaped | 5,549.02 | |
| Boutabba (2014) | India (1971-2008) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 19,370.36 | |
| Cho et al. (2014) | 22 OECD countries (1971-2000) | Quadratic | Time Series | FMOLS | Inverted U-shaped | Australia | 77.13 |
| | | | | | U-shaped | Austria | 81.02 |
| | | | | | U-shaped | Canada | 79.11 |
| | | | | | Inverted U-shaped | Denmark | 74.91 |
| | | | | | U-shaped | Finland | 109.50 |
| | | | | | No EKC | France | NA |
| | | | | | Inverted U-shaped | Germany | 52.66 |
| | | | | | Inverted U-shaped | Greece | 52.57 |
| | | | | | U-shaped | Hungary | 40.72 |
| | | | | | No EKC | Iceland | NA |
| | | | | | Inverted U-shaped | Ireland | 40.14 |
| | | | | | Inverted U-shaped | Italy | 62.54 |
| | | | | | No EKC | Japan | NA |
| | | | | | No EKC | Netherlands | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | No EKC | New Zealand | NA |
| | | | | | No EKC | Norway | NA |
| | | | | | No EKC | Portugal | NA |
| | | | | | U-shaped | Spain | 68.80 |
| | | | | | U-shaped | Sweden | 86.86 |
| | | | | | Inverted U-shaped | Turkey | 28.27 |
| | | | | | No EKC | UK | NA |
| | | | | | U-shaped | US | 85.47 |
| | | | Panel | | Inverted U-shaped | 60.87 | |
| Farhani and Shahbaz (2014) | 10 MENA countries (1980-2009) | Quadratic | Panel | FMOLS | Inverted U-shaped | 296.02 | |
| | | | | | | 34.03 | |
| | | | | DOLS | | 377.55 | |
| | | | | | | 36.81 | |
| Farhani et al. (2014a) | Tunisia (1971-2008) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 4,377.35 | |
| Farhani et al. (2014b) | 10 MENA countries (1990-2010) | Quadratic | Panel | FMOLS | Inverted U-shaped | 31,929.55 | |
| | | | | DOLS | | 33,024.34 | |
| Kivyiro and Arminen (2014) | 6 Sub-Saharan countries (1971-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Congo Republic | 1,080.43 |
| | | | | | Inverted U-shaped | DRC | 462.18 |
| | | | | | Inverted U-shaped | Kenya | 406.67 |
| | | | | | No EKC | South Africa | NA |
| | | | | | No EKC | Zambia | NA |
| | | | | | No EKC | Zimbabwe | NA |
| Lapinskienė et al. (2014) | 27 EU countries (1995-2010) | Cubic | Time Series | OLS | Inverted U-shaped | Between 9,517.02 and 83,973.75 | |
| | | | | | U-shaped | Between 2,239.3 and 6,382.01 | |
| | | | | | Monotonically Increasing Monotonically Increasing | NA | |
| Lau et al. (2014) | Malaysia (1970-2008) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 11,018.40 | |
| López-Menéndez et al. (2014) | EU-27 countries (1996-2010) | Cubic | Panel | Random Effect | N-Shaped | a. 45.43<br>b. 25.05 | |
| | | | | | U-Shaped | 8.11 | |
| | | | | | N-Shaped | a. 64.68<br>b. 31.47 | |
| | | | | Fixed Effect | Monotonically Decreasing | NA | |
| | | | | | U-Shaped | 9.62 | |
| | | | | | Monotonically Increasing | NA | |
| | | | | Fixed & Time Effect | No EKC | NA | |
| | | | | | U-Shaped | 2.77 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Onafowora and Owoye (2014) | 8 countries (1971-2010) | Cubic | Time Series | ARDL bounds | Inverted U-shaped | Brazil | 22.08 |
| | | | | | Inverted U-shaped | China | 17.05 |
| | | | | | Inverted U-shaped | Egypt | 16.59 |
| | | | | | Inverted U-shaped | Japan | 10.26 |
| | | | | | Inverted N-shaped | South Korea | a. 9.12<br>b. Extremely Large |
| | | | | | Inverted U-shaped | Mexico | 21.34 |
| | | | | | Inverted U-shaped | Nigeria | 32.86 |
| | | | | | Inverted U-shaped | South Africa | 22.96 |
| Osabuohien et al. (2014) | 50 African countries (1995-2010) | Quadratic | Panel | PDOLS | Inverted U-shaped | Oil Producing | 2,147.45 |
| | | | | | No EKC | Non-oil Producing | NA |
| Oshin and Ogundipe (2014) | 15 West African countries (1980-2012) | Quadratic | Panel | Pooled OLS | No EKC | NA | |
| | | | | Fixed Effect | Inverted U-shaped | 1,041.68 | |
| | | | | Random Effect | Monotonically Decreasing | NA | |
| Shafiei and Salim (2014) | 29 OECD countries (1980-2011) | Quadratic | Panel | AMG | Monotonically Increasing | NA | |
| Shahbaz et al. (2014a) | Tunisia (1971-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 1,740.56 | |
| Shahbaz et al. (2014b) | The UAE (1975-2011) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 262,158.14 | |
| Yavuz (2014) | Turkey (1960-2007) | Quadratic | Time Series | FMOLS | Inverted U-shaped | 1960-1978 | 2,547.64 |
| | | | | | | 1979-2007 | 3,849.94 |
| | | | | OLS | | 1960-1978 | 2,453.24 |
| | | | | | | 1979-2007 | 4,958.79 |
| Akpan and Abang (2015) | 47 countries (1970-2008) | Quadratic | Panel | GLS | Inverted U-shaped | All | 26,595.74 |
| | | | | | Monotonically Increasing | High Income | NA |
| | | | | | Inverted U-shaped | Low Income | 4,255.32 |
| | | Cubic | | | N-shaped | All | a. 30,650.45<br>b. 20,391.22 |
| | | | | | N-shaped | High Income | a. 29,339.03<br>b. 24,212.89 |
| | | | | | No EKC | Low Income | NA |
| Alshehry (2015) | Saudi Arabia (1970-2010) | Cubic | Time Series | OLS | N-shaped | a. 18,121.94<br>b. 13,528.31 | |
| Apergis and Ozturk (2015) | 14 Asian countries (1990-2011) | Quadratic | Panel | FMOLS | Inverted U-shaped | 10,207.40 | |
| | | | | DOLS | Inverted U-shaped | 10,841.80 | |
| | | | | PMGE | Inverted U-shaped | 10,511.20 | |
| | | | | MG | Inverted U-shaped | 11,695.60 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cubic | | FMOLS | No EKC | NA | |
| | | | | DOLS | No EKC | NA | |
| | | | | PMGE | No EKC | NA | |
| | | | | MG | No EKC | NA | |
| Baek (2015) | 7 Arctic countries (1960-2010) | Linear | Time Series | ARDL bounds | Monotonically Increasing | Canada | NA |
| | | | | | Monotonically Decreasing | Denmark | NA |
| | | | | | No EKC | Finland | NA |
| | | | | | No EKC | Iceland | NA |
| | | | | | No EKC | Norway | NA |
| | | | | | No EKC | Sweden | NA |
| | | | | | Monotonically Decreasing | US | NA |
| | | Quadratic | | | No EKC | Canada | NA |
| | | | | | Monotonically Decreasing | Denmark | NA |
| | | | | | No EKC | Finland | NA |
| | | | | | Inverted U-shaped | Iceland | 2.31 |
| | | | | | U-shaped | Norway | 1.22 |
| | | | | | No EKC | Sweden | NA |
| | | | | | U-shaped | US | 4.24 |
| | | Cubic | | | Monotonically Decreasing | Canada | NA |
| | | | | | Monotonically Decreasing | Denmark | NA |
| | | | | | Monotonically Decreasing | Finland | NA |
| | | | | | No EKC | Iceland | NA |
| | | | | | No EKC | Norway | NA |
| | | | | | N-shaped | Sweden | a. 3.62<br>b. 1.57 |
| | | | | | No EKC | US | NA |
| Balsalobre et al. (2015) | 28 OECD countries (1994-2010) | Cubic | Panel | Panel EGLS | N-shaped | Model 1 | a. 13,804.32<br>b. 54,882.55 |
| | | | | | | Model 2 | a. 15,890.49<br>b. 72,697.08 |
| | | | | | | Model 3 | a. 16,226.77<br>b. 71,007.27 |
| Begum et al. (2015) | Malaysia (1970-1980) | Quadratic | Time Series | ARDL bounds | Monotonically Increasing | NA | |
| | | | | DOLS | U-shaped | 8.78K | |
| Bölük and Mert (2015) | Turkey (1961-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Extremely large | |
| Dogan et al. (2015) | 27 OECD countries (1995-2010) | Quadratic | Panel | DOLS | U-shaped | 206,249.55 | |
| Farhani and Ozturk (2015) | Tunisia (1971-2012) | Quadratic | Time Series | ARDL bounds | Monotonically Increasing | NA | |
| Heidari et al. (2015) | 5 ASEAN countries | Quadratic | Panel | PSTR | Inverted U-shaped | 4,686 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ibrahim and Rizvi (2015) | 8 Asian countries (1971-2009) | Quadratic | Panel | DOLS | No EKC | All countries | NA |
| | | | | | No EKC | | NA |
| | | | | | No EKC | | NA |
| | | | | | Inverted U-shaped | All countries without China | 6,572.34 |
| | | | | | Inverted U-shaped | | 6,617.04 |
| | | | | | Inverted U-shaped | | 6,489.92 |
| | | | | | Inverted U-shaped | ASEAN countries | 1,193.33 |
| | | | | | Inverted U-shaped | | 1,190.49 |
| | | | | | Inverted U-shaped | | 1,663.64 |
| Jebli and Youssef (2015) | Tunisia (1980-2009) | Quadratic | Time Series | ARDL bounds | U-shaped | 2,878.69 | |
| | | | | | | 3,259.37 | |
| Jebli et al. (2015) | 24 Sub-Saharan Africa countries (1980-2010) | Quadratic | Panel | OLS | U-shaped | 244.65 | |
| | | | | | | 157.68 | |
| | | | | FMOLS | | 272.81 | |
| | | | | | | 159.82 | |
| Kasman and Duman (2015) | 15 EU Member countries (1992-2010) | Quadratic | Panel | FMOLS | Inverted U-shaped | 3,630.71 | |
| | | | | | | 3,728.68 | |
| Liu et al. (2015) | 30 Chinese Provinces (1990-2012) | Quadratic | Panel | Pooled OLS | No EKC | Whole China | NA |
| | | | | | No EKC | Eastern China | NA |
| | | | | | U-shaped | Central China | 1,183.93 |
| | | | | | U-shaped | Western China | 204.51 |
| Nasr et al. (2015) | South Africa (1911-2010) | Cubic | Time Series | Co-summability | Inverted N-shaped | a. 1,036.84<br>b. 4,020.42 | |
| Ozturk and Al-Mulali (2015) | Cambodia (1996-2012) | Quadratic | Time Series | 2SLS | U-shaped | Extremely large | |
| | | | | System GMM | | | |
| Seker et al. (2015) | Turkey (1974-2010) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 4,725.39 | |
| Shahbaz et al. (2015) | 13 African countries (1980-2012) | Quadratic | Time Series | Johansen Cointegration | Monotonically Increasing | Benin | NA |
| | | | | | Monotonically Increasing | Botswana | NA |
| | | | | | U-shaped | Cameroon | 1,195.50 |
| | | | | | Inverted U-shaped | Congo Republic | 3,213.85 |
| | | | | | Inverted U-shaped | Ethiopia | 851.74 |
| | | | | | No EKC | Gabon | NA |
| | | | | | No EKC | Ghana | NA |
| | | | | | No EKC | Kenya | NA |
| | | | | | U-shaped | Nigeria | 518.09 |
| | | | | | U-shaped | Senegal | 1,118.07 |
| | | | | | Inverted U-shaped | South Africa | 2.42 |
| | | | | | Inverted U-shaped | Togo | 1,045.87 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | No EKC | Zambia | NA |
| Tang and Tan (2015) | Vietnam (1976-2009) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Extremely large | |
| Tutulmaz (2015) | Turkey (1968-2007) | Linear | Time Series | Cointegration | Monotonically Increasing | NA | |
| | | Quadratic | | | Inverted U-shaped | 6,300 | |
| | | | | | | 6,449 | |
| | | | | | | 6,113 | |
| | | | | | | 6,053 | |
| | | Cubic | | | No EKC | NA | |
| Xu and Lin (2015) | 30 Chinese Provinces (2000-2012) | Linear | Panel | Nonparametric additive regression | Inverted U-shaped | Not specified | |
| Yaduma et al. (2015) | 154 countries (1960-2007) | Cubic | Panel | Quantile regression | Inverted N-shaped | World | a. 182.59<br>b. 17,554.97 |
| | | | | | Inverted N-shaped | OECD | a. 299.57<br>b. 24,398.62 |
| | | | | | Inverted N-shaped | Non-OECD | a. 113.87<br>b. 35,611.87 |
| | | | | | Inverted N-shaped | West | a. 495.32<br>b. 18,344.92 |
| | | | | | No EKC | East Europe | NA |
| | | | | | No EKC | Latin America | NA |
| | | | | | Monotonically Decreasing | East Asia | NA |
| | | | | | No EKC | West Asia | NA |
| | | | | | Monotonically Decreasing | Africa | NA |
| Ahmad et al. (2016) | India (1971-2014) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 1,461.52 | |
| | | | | | | 1,157.78 | |
| | | | | | | 1,010.78 | |
| | | | | | | 786.70 | |
| | | | | | | 863.19 | |
| Al-Mulali and Ozturk (2016) | 27 countries (1990-2012) | Quadratic | Panel | FMOLS | Inverted U-shaped | Extremely Large | |
| Balaguer and Cantavella (2016) | Spain (1874-2011) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 8,103.08 | |
| Bilgili et al. (2016) | 17 OECD countries (1977-2010) | Quadratic | Panel | FMOLS | Inverted U-shaped | 85,574.52 | |
| | | | | DOLS | | 268,337.29 | |
| Chakravarty and Mandal (2016) | BRICS countries (1997-2011) | Quadratic | Panel | GMM | U-shaped | 3,158.15 | |
| | | | | Panel Regression | Inverted U-shaped | 4,822.33 | |
| Destek et al. (2016) | 10 CEECs (1991-2011) | Quadratic | Panel | FMOLS | Inverted U-shaped | 6,609.56 | |
| | | | | DOLS | | 5,091.25 | |
| Dogan and Seker (2016) | | Quadratic | Panel | FMOLS | Inverted U-shaped | 25.40 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 23 countries (1985-2011) | | | | | 32.00 | |
| | | | | | | 31.88 | |
| | | | | DOLS | | 30.88 | |
| | | | | | | 35.33 | |
| | | | | | | 28.80 | |
| Dogan and Turkekul (2016) | The US (1960-2010) | Quadratic | Time Series | ARDL bounds | U-shaped | 126.58 | |
| Dong et al. (2016) | 189 countries (1990-2012) | Cubic | Panel | OLS | Monotonically Increasing | Production based accounting | NA |
| | | Quadratic | | | Inverted U-shaped | | 155,140.19 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | Monotonically Increasing | Consumption based accounting | NA |
| | | Quadratic | | | Inverted U-shaped | | 146,956.52 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | Fixed effect | N-shaped | Production based accounting | a. 36,419.22<br>b. 74,042.12 |
| | | Quadratic | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | Monotonically Increasing | Consumption based accounting | NA |
| | | Quadratic | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | Random effect | N-shaped | Production based accounting | a. 42,059.96<br>b. 72,300.01 |
| | | Quadratic | | | Inverted U-shaped | | 132,701.42 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | No EKC | Consumption based accounting | NA |
| | | Quadratic | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | GMM | No EKC | Production based accounting (All countries) | NA |
| | | Quadratic | | | Inverted U-shaped | | 112,612.61 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | Monotonically Increasing | Consumption based accounting (All countries) | NA |
| | | Quadratic | | | Inverted U-shaped | | 179,321.49 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | GMM | N-shaped | Production based accounting (High income) | a. 38,288.89<br>b. 80,076.89 |
| | | Quadratic | | | No EKC | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | Monotonically Decreasing | Consumption based accounting (High income) | NA |
| | | Quadratic | | | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cubic | | GMM | Inverted N-shaped | Production based accounting (Middle income) | a. 7,506.39<br>b. 20,199.24 |
| | | Quadratic | | | Monotonically Decreasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | | No EKC | Consumption based accounting (Middle income) | NA |
| | | Quadratic | | | U-shaped | | 6,957.55 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Cubic | | GMM | No EKC | Production based accounting (Low income) | NA |
| | | Quadratic | | | Inverted U-shaped | | 2,257.63 |
| | | Linear | | | No EKC | | NA |
| | | Cubic | | | No EKC | Consumption based accounting (Low income) | NA |
| | | Quadratic | | | Monotonically Increasing | | NA |
| | | Linear | | | No EKC | | NA |
| | | Quadratic | | CMG | Monotonically Increasing | Production based accounting | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Quadratic | | AMG | Inverted U-shaped | | 13,645.83 |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Quadratic | | CMG | Monotonically Increasing | Consumption based accounting | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| | | Quadratic | | AMG | Monotonically Increasing | | NA |
| | | Linear | | | Monotonically Increasing | | NA |
| Ertugrul et al. (2016) | 10 Developing countries (1971-2011) | Quadratic | Time Series | ARDL bounds | No EKC | Malaysia | NA |
| | | | | | No EKC | Thailand | NA |
| | | | | | Inverted U-shaped | Turkey | 6,863.63 |
| | | | | | Inverted U-shaped | India | 313.98 |
| | | | | | No EKC | Brazil | NA |
| | | | | | No EKC | South Africa | NA |
| | | | | | No EKC | Mexico | NA |
| | | | | | Inverted U-shaped | China | 2,527.41 |
| | | | | | Monotonically Increasing | Indonesia | NA |
| | | | | | Inverted U-shaped | Korea | 1,665.11 |
| Jebli et al. (2016) | 25 OECD countries (1980-2010) | Quadratic | Panel | FMOLS | Inverted U-shaped | 72,264.18 | |
| | | | | DOLS | | 59,010.76 | |
| Li et al. (2016) | 28 Chinese Provinces (1996-2012) | Quadratic | Panel | PMG | Inverted U-shaped | 12,008.06 | |
| | | | | | | 4,094.98 | |
| | | | | MG | No EKC | NA | |
| | | | | DFE | Inverted U-shaped | 18,661.36 | |
| | | | | | | 7,563.09 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | GMM | Inverted U-shaped | Between 3,267.68 and 3,990.48 | |
| Lorente and Álvarez-Herranz (2016) | 17 OECD countries (1990-2012) | Cubic | Panel | Fixed effect | N-shaped | With energy regulation | a. 21,917.18<br>b. 69,282.09 |
| | | | | 2SLS | | Without dampening effect | a. 24,497.41<br>b. 55,370.58 |
| | | | | | | With dampening effect | a. 21,917.18<br>b. 69,282.09 |
| | | | | PLS | | With AR(1) correction | a. 22,193.98<br>b. 64,426.71 |
| Sephton and Mann (2016) | The UK (1830-2003) | Quadratic | Time Series | OLS | Inverted U-shaped | 9,052.67 | |
| Shahbaz et al. (2016a) | Australia (1970-2012) | Cubic | Time Series | ARDL bounds | Monotonically Decreasing | NA | |
| Shahbaz et al. (2016b) | N11 countries (1972-2013) | Quadratic | Panel | OLS | Inverted U-shaped | Pakistan | 5,267.95 |
| | | | | | | | 3,218.78 |
| | | | | | | Turkey | 16,945.73 |
| | | | | | | | 5,275.43 |
| Sinha and Sen (2016) | BRIC countries (1980-2013) | Quadratic | Panel | System GMM | Inverted U-shaped | Extremely Large | |
| Sugiawan and Managi (2016) | Indonesia (1971-2010) | Linear | Time Series | ARDL bounds | Monotonically Increasing | NA | |
| | | Quadratic | | | Inverted U-shaped | 7,729.24 | |
| Xu and Lin (2016) | 30 Chinese Provinces (2000-2013) | Linear | Panel | Nonparametric additive regression | Inverted U-shaped | Not specified | |
| Zambrano-Monserrate et al. (2016) | Brazil (1971-2011) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 2,240.06 | |
| Ahmad et al. (2017) | Croatia (1992-2011) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 48.68K | |
| Álvarez-Herránz et al. (2017) | 28 OECD countries (1990-2014) | Cubic | Panel | Panel Regression | N-shaped | a. 20,885.38<br>b. 67,309.06 | |
| Apergis et al. (2017) | 48 US States (1960-2010) | Quadratic | Panel | MG | Inverted U-shaped | 2.26 | |
| | | | | MG-FMOLS | | 2.26 | |
| | | | | MG-DOLS | | 2.26 | |
| | | | | CCE-MG | | 2.51 | |
| | | | | CupBC | | 2.23 | |
| | | | | CupFM | | 2.21 | |
| Gill et al. (2017) | Malaysia (1970-2011) | Quadratic | Time Series | ARDL bounds | Monotonically Increasing | NA | |
| Jaforullah and King (2017) | 7 countries (1960-2010) | Linear | Time Series | ARDL bounds | No EKC | NA | |
| | | Quadratic | | | No EKC | Norway | NA |
| | | | | | | Sweden | NA |
| | | | | | | US | NA |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Inverted U-shaped | Canada | 25,168.12 |
| | | | | | | Denmark | 28,638.29 |
| | | | | | | Finland | 29,336.43 |
| | | | | | | Iceland | 27,164.80 |
| | | Cubic | | | No EKC | Denmark | NA |
| | | | | | | Iceland | NA |
| | | | | | | Canada | NA |
| | | | | | | Finland | NA |
| | | | | | | Norway | NA |
| | | | | | | US | NA |
| | | | | | N-shaped | Sweden<br>a. 21,334.09<br>b. 36,527.51 | |
| Moghadam and Dehbashi (2017) | Iran (1970-2011) | Cubic | Time Series | ARDL bounds | Inverted N-shaped | a. 2.36 Million<br>b. 3.98 Million | |
| Nasreen et al. (2017) | 5 South Asian countries (1980-2012) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | Pakistan | 350.72 |
| | | | | | | India | 788.40 |
| | | | | | | Bangladesh | 512.86 |
| | | | | | | Nepal | 589.93 |
| | | | | | | Sri Lanka | 340.36 |
| Neve and Hamaide (2017) | 28 countries (1990-2010) | Cubic | Panel | OLS | No EKC | NA | |
| | | | | WLS | | | |
| Pal and Mitra (2017) | India and China (1971-2012) | Cubic | Time Series | ARDL bounds | No EKC | NA | |
| Rehman and Rashid (2017) | SAARC countries (1960-2015) | Quadratic | Panel | FMOLS | No EKC | NA | |
| | | | | DOLS | | | |
| Sapkota and Bastola (2017) | 14 Latin American countries (1980-2010) | Quadratic | Panel | Panel Regression | Inverted U-shaped | 2,692.05 | |
| | | | | | | 3,157.99 | |
| | | | | | U-shaped | 1,288.83 | |
| Ouyang and Lin (2017) | China (1978-2011) | Quadratic | Time Series | Johansen Cointegration | Inverted U-shaped | Extremely Large | |
| Ozatac et al. (2017) | Turkey (1960-2013) | Quadratic | Time Series | ARDL bounds | Inverted U-shaped | 16,648.84 | |
| Sinha et al. (2017) | N11 countries (1990-2014) | Cubic | Panel | System GMM | N-shaped | All countries | a. 2.78<br>b. 2,207.39 |
| | | | | | | Developed | a. 1.09<br>b. 2,290.36 |
| | | | | | | Industrialized | a. 1.43<br>b. 4,600.57 |
| | | | | | | Emerging | a. 1.71 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | b. 6,355.17 |
| Wang et al. (2017) | 30 Chinese provinces (2000-2013) | Quadratic | Panel | Panel Regression | Inverted U-shaped | Between 656.37 and 176,361.65 |
| Zhang et al. (2017) | 10 Newly Industrialized countries (1971-2013) | Quadratic | Panel | OLS | Inverted U-shaped | 127.97 |
| | | | | FMOLS | | 125.97 |
| | | | | DOLS | | 127.97 |
| Zoundi (2017) | 25 African countries (1980-2012) | Quadratic | Panel | DOLS | No EKC | NA |
| | | | | System GMM | U-shaped | 378.99 |
| | | | | Dynamic Fixed Effect | No EKC | NA |
| | | | | MG | No EKC | NA |
| | | | | PMG | No EKC | NA |

Note:

2SLS: Two-Stage Least Square;

AMG: Augmented Mean Group;

ARDL: Autoregressive Distributed Lag;

CCE: Common Correlated Effects;

CupBC: Bias-Corrected Continuously Updated Estimator

CupFM: Fully-Modified Continuously Updated Estimator

DEA: Data Envelope Analysis;

DFE: Dynamic Fixed-Effects Estimator;

DOLS: Dynamic Ordinary Least Square;

EGLS: Empirical Generalized Least Squares;

FGLS: Feasible Generalized Least Squares;

FMOLS: Fully Modified Ordinary Least Square;

GLS: Generalized Last Square;

GMM: Generalized Method of Moments;

LSDVC: Least Square Dummy Variable Estimator;

MG: Mean Group;

OLS: Ordinary Least Square;

PDOLS: Panel Dynamic Ordinary Least Square;

PLS: Panel Least Square;

PMG: Pooled Mean Group;

PSTR: Panel Smooth Transition Regression;

VECM: Vector Error Correction Model;

WLS: Weighted Least Square

**Table 2: EKC estimation studies on $CO_2$ emissions: Classification by explanatory variables**

| *Explanatory Variables* | *Studies with quadratic specification* |
|---|---|
| Trade Openness | Agras and Chapman (1999), Atici (2009), Halicioglu (2009), Jalil and Mahmud (2009), Tamazian et al. (2009), Bello and Abimbola (2010), Iwata et al. (2010), Tamazian and Rao (2010), Jalil and Feridun (2011), Nasir and Rehman (2011), Pao and Tsai (2011b), Du et al. (2012), Jayanthakumaran et al. (2012), Saboori et al. (2012b), Shahbaz et al. (2012), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Kohler (2013), Ozturk and Acaravci (2013), Shahbaz (2013), Shahbaz et al. (2013b, c), Sulaiman et al. (2013), Tiwari et al. (2013), Arouri et al. (2014), Boutabba (2014), Farhani et al. (2014a, b), Kivyiro and Arminen (2014), Lau et al. (2014), Osabuohien et al. (2014), Oshin and Ogundipe (2014), Shahbaz et al. (2014a, b), Akpan and Abang (2015), Ben Jebli et al. (2015), Dogan et al. (2015), Farhani and Ozturk (2015), Jebli and Youssef (2015), Kasman and Duman (2015), Ozturk and Al-Mulali (2015), Seker et al. (2015), Tang and Tan (2015), Al-Mulali and Ozturk (2016), Dogan and Seker (2016), Dogan and Turkekul (2016), Ertugrul et al. (2016), Jebli et al. (2016), Li et al. (2016), Sinha and Sen (2016), Ozatac et al. (2017), Sapkota and Bastola (2017), Zhang et al. (2017) |
| Fossil Fuel Energy Consumption | Cole et al. (1997), Lindmark (2002), Richmond and Kaufmann (2006), Ang (2007), Apergis and Payne (2009), Atici (2009), Halicioglu (2009), Jalil and Mahmud (2009), Tamazian et al. (2009), Acaravci and Ozturk (2010), Apergis and Payne (2010), Bello and Abimbola (2010), Iwata et al. (2010), Lean and Smyth (2010), Pao and Tsai (2010), Tamazian and Rao (2010), Nasir and Rehman (2011), Pao and Tsai (2011a, b), Pao et al. (2011), Wang et al. (2011), Arouri et al. (2012), Du et al. (2012), Jayanthakumaran et al. (2012), Saboori et al. (2012b), Shahbaz et al. (2012), Baek and Kim (2013), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Kohler (2013), Ozcan (2013), Ozturk and Acaravci (2013), Saboori and Sulaiman (2013a, b), Shahbaz (2013), Shahbaz et al. (2013a, b), Tiwari et al. (2013), Arouri et al. (2014), Bölük and Mert (2014), Boutabba (2014), Cho et al. (2014), Farhani and Shahbaz (2014), Farhani et al. (2014a, b), Kivyiro and Arminen (2014), Shahbaz et al. (2014a, b), Yavuz (2014), Akpan and Abang (2015), Dogan et al. (2015), Farhani and Ozturk (2015), Heidari et al. (2015), Jebli and Youssef (2015), Kasman and Duman (2015), Ozturk and Al-Mulali (2015), Seker et al. (2015), Shahbaz et al. (2015), Tang and Tan (2015), Ahmad et al. (2016), Al-Mulali and Ozturk (2016), Chakravarty and Mandal (2016), Dogan and Seker (2016), Dogan and Turkekul (2016), Ertugrul et al. (2016), Jebli et al. (2016), Li et al. (2016), Shahbaz et al. (2016b), Sinha and Sen (2016), Zambrano-Monserrate et al. (2016), Nasreen et al. (2017), Rehman and Rashid (2017), Sapkota and Bastola (2017), Ozatac et al. (2017), Ouyang and Lin (2017) , Wang et al. (2017), Zhang et al. (2017), Zoundi (2017) |
| Renewable Energy Consumption | Richmond and Kaufmann (2006), Iwata et al. (2011), Baek and Kim (2013), Sulaiman et al. (2013), Bölük and Mert (2014, 2015), Farhani and Shahbaz (2014), Ben Jebli et al. (2015), Jebli and Youssef (2015), Al-Mulali and Ozturk (2016), Dogan and Seker (2016), Jebli et al. (2016), Sugiawan and Managi (2016), Zambrano-Monserrate et al. (2016), Gill et al. (2017), Zoundi (2017) |
| *Explanatory Variables* | *Studies with cubic specification* |
| Trade Openness | Hill and Magnani (2002), Friedl and Getzner (2003), Lee et al. (2009), He and Richard (2010), Asghari (2012), Onafowora and Owoye (2014), Akpan and Abang (2015), Shahbaz et al. (2016a), Moghadam and Dehbashi (2017) |
| Fossil Fuel Energy Consumption | Lee et al. (2009), He and Richard (2010), Fosten et al. (2012), Hussain et al. (2012), Abdallah et al. (2013), Onafowora and Owoye (2014), Akpan and Abang (2015), Shahbaz et al. (2016a), Álvarez-Herránz et al. (2017), Moghadam and Dehbashi (2017), Sinha et al. (2017) |
| Renewable Energy Consumption | López-Menéndez et al. (2014), Lorente and Álvarez-Herranz (2016), Sinha et al. (2017) |

**Table 3: EKC estimation studies on $CO_2$ emissions: Classification by data, model specification, and outcome**

| *Model Specification* | *Time Series* | |
|---|---|---|
| Linear | *Monotonically Increasing* | *No EKC* |
| | Friedl and Getzner (2003), Lipford and Yandle (2010), Jalil and Feridun (2011), Shahbaz et al. (2013c), Baek (2015), Tutulmaz (2015), Sugiawan and Managi (2016) | Esteve and Tamarit (2012a), Shahbaz (2013), Baek (2015), Jaforullah and King (2017) |
| Quadratic | *Monotonically Increasing* | *Monotonically Decreasing* |
| | Friedl and Getzner (2003), Lantz and Feng (2006), Lean and Smyth (2010), Seetanah and Vinesh (2010), Pao et al. (2011), Arouri et al. (2012), Chandran and Tang (2013), Azlina et al. (2014), Begum et al. (2015), Farhani and Ozturk (2015), Shahbaz et al. (2015), Ertugrul et al. (2016), Gill et al. (2017) | Pao et al. (2011), Baek (2015) |
| | *Inverted U-shaped* | |
| | Ang (2007), Halicioglu (2009), Jalil and Mahmud (2009), Acaravci and Ozturk (2010), Iwata et al. (2010), Lean and Smyth (2010), Pao and Tsai (2010), Jalil and Feridun (2011), Nasir and Rehman (2011), Pao and Tsai (2011a), Arouri et al. (2012), Esteve and Tamarit (2012b), Jayanthakumaran et al. (2012), Saboori et al. (2012a), Shahbaz et al. (2012), Baek and Kim (2013), Kanjilal and Ghosh (2013), Kohler (2013), Ozcan (2013), Ozturk and Acaravci (2013), Saboori and Sulaiman (2013a), Saboori and Sulaiman (2013b), Shahbaz (2013), Shahbaz et al. (2013a, b, c), Sulaiman et al. (2013), Tiwari et al. (2013), Arouri et al. (2014), Boutabba (2014), Cho et al. (2014), Farhani et al. (2014a), Kivyiro and Arminen (2014), Lau et al. (2014), Shahbaz et al. (2014a, b), Yavuz (2014), Baek (2015), Bölük and Mert (2015), Seker et al. (2015), Shahbaz et al. (2015), Tang and Tan (2015), Tutulmaz (2015), Ahmad et al. (2016), Balaguer and Cantavella (2016), Ertugrul et al. (2016), Sephton and Mann (2016), Sugiawan and Managi (2016), Zambrano-Monserrate et al. (2016), Ahmad et al. (2017), Jaforullah and King (2017), Nasreen et al. (2017), Ouyang and Lin (2017), Ozatac et al. (2017) | |
| | *U-shaped* | *No EKC* |
| | Omisakin (2009), Lipford and Yandle (2010), Pao and Tsai (2010), Pao et al. (2011), Arouri et al. (2012), Saboori et al. (2012b), Abdou and Atya (2013), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Ozcan (2013), Saboori and Sulaiman (2013a), Cho et al. (2014), Baek (2015), Begum et al. (2015), Jebli and Youssef (2015), Ozturk and Al-Mulali (2015), Ozturk and Al-Mulali (2015), Shahbaz et al. (2015), Dogan and Turkekul (2016) | Lindmark (2002), Acaravci and Ozturk (2010), Bello and Abimbola (2010), Lean and Smyth (2010), Pao and Tsai (2010), Pao and Tsai (2011a), Pao et al. (2011), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Ozcan (2013), Saboori and Sulaiman (2013b), Cho et al. (2014), Kivyiro and Arminen (2014), Baek (2015), Shahbaz et al. (2015), Ertugrul et al. (2016), Jaforullah and King (2017) |
| Cubic | *Monotonically Increasing* | *Monotonically Decreasing* |
| | Hussain et al. (2012), Lapinskienė et al. (2014) | Ahmed and Long (2012), Baek (2015), Shahbaz et al. (2016a) |
| | *Inverted U-shaped* | *U-shaped* |
| | Chuku (2011), Lapinskienė et al. (2014), Onafowora and Owoye (2014) | Asghari (2012), Abdou and Atya (2013), Lapinskienė et al. (2014) |
| | *Inverted N-shaped* | *N-shaped* |
| | Abdallah et al. (2013), Onafowora and Owoye (2014), Nasr et al. (2015), Moghadam and Dehbashi (2017) | Day and Grafton (2003), Friedl and Getzner (2003), Akbostancı et al. (2009), Fodha and Zaghdoud (2010), Lipford and Yandle (2010), Chuku |

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| | | (2011), Fosten et al. (2012), Abdou and Atya (2013), Alshehry (2015), Baek (2015), Jaforullah and King (2017) |
| | *No EKC* | |
| | Roca et al. (2001), Akbostancı et al. (2009), He and Richard (2010), Lipford and Yandle (2010), Hossain (2012), Baek (2015), Tutulmaz (2015), Jaforullah and King (2017), Pal and Mitra (2017) | |
| *Model Specification* | *Panel* | |
| Linear | *Inverted U-shaped* | *No EKC* |
| | Xu and Lin (2015, 2016) | Dong et al. (2016) |
| | *Monotonically Increasing* | |
| | Shi (2003), Richmond and Kaufmann (2006), Tamazian et al. (2009), Dong et al. (2016) | |
| Quadratic | *Monotonically Increasing* | *Monotonically Decreasing* |
| | Agras and Chapman (1999), Aldy (2005), Richmond and Kaufmann (2006), Yaguchi et al. (2007), York (2007), Tamazian and Rao (2010), Du et al. (2012), Wang (2012), Shafiei and Salim (2014), Akpan and Abang (2015), Dong et al. (2016) | Oshin and Ogundipe (2014), Dong et al. (2016) |
| | *Inverted U-shaped* | |
| | Holtz-Eakin and Selden (1995), Cole et al. (1997), Agras and Chapman (1999), Shi (2003), York et al. (2003), Aldy (2005), Richmond and Kaufmann (2006), Faiz-Ur-Rehman et al. (2007), Yaguchi et al. (2007), York (2007), Apergis and Payne (2009, 2010), Atici (2009), Dutt (2009), Tamazian et al. (2009), Lean and Smyth (2010), Musolesi et al. (2010), Pao and Tsai (2010), Guangyue and Deyong (2011), Iwata et al. (2011), Jobert et al. (2011), Pao and Tsai (2011b), Arouri et al. (2012), Du et al. (2012), Du et al. (2012), Al Sayed and Sek (2013), Mehrara and ali Rezaei (2013), Taguchi (2013), Bölük and Mert (2014), Cho et al. (2014), Farhani and Shahbaz (2014), Farhani et al. (2014b), Osabuohien et al. (2014), Oshin and Ogundipe (2014), Akpan and Abang (2015), Apergis and Ozturk (2015), Heidari et al. (2015), Ibrahim and Rizvi (2015), Kasman and Duman (2015), Al-Mulali and Ozturk (2016), Bilgili et al. (2016), Bilgili et al. (2016), Chakravarty and Mandal (2016), Destek et al. (2016), Dogan and Seker (2016) | |
| | *U-shaped* | *No EKC* |
| | Halkos and Tzeremes (2009), Musolesi et al. (2010), Guangyue and Deyong (2011), Wang et al. (2011), Ozcan (2013), Dogan et al. (2015), Jebli et al. (2015), Liu et al. (2015), Chakravarty and Mandal (2016), Dong et al. (2016), Sapkota and Bastola (2017), Zoundi (2017) | Tamazian and Rao (2010), Iwata et al. (2011), Du et al. (2012), Osabuohien et al. (2014), Oshin and Ogundipe (2014), Ibrahim and Rizvi (2015), Liu et al. (2015), Dong et al. (2016), Li et al. (2016), Rehman and Rashid (2017), Zoundi (2017) |
| Cubic | *Monotonically Increasing* | *Monotonically Decreasing* |
| | Shafik and Bandyopadhyay (1992), Shafik (1994), Farzin and Bond (2006), López-Menéndez et al. (2014), Dong et al. (2016) | López-Menéndez et al. (2014), Yaduma et al. (2015), Dong et al. (2016) |
| | *Inverted U-shaped* | *U-Shaped* |
| | Martínez-Zarzoso and Bengochea-Morancho (2004), Galeotti et al. (2006), Lee et al. (2009) | López-Menéndez et al. (2014) |
| | *N-shaped* | *Inverted N-shaped* |
| | Moomaw and Unruh (1997), Hill and Magnani (2002), Martínez-Zarzoso and Bengochea-Morancho (2004), Lee et al. (2009), Musolesi | Dijkgraaf and Vollebergh (2005), Vollebergh et al. (2005), Musolesi et al. (2010), Yaduma et al. (2015), Dong et al. (2016) |

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| | et al. (2010), López-Menéndez et al. (2014), Akpan and Abang (2015), Balsalobre et al. (2015), Dong et al. (2016), Lorente and Álvarez-Herranz (2016), Álvarez-Herránz et al. (2017), Sinha et al. (2017) | |
| | *No EKC* | |
| | Magnani (2001), Martínez-Zarzoso and Bengochea-Morancho (2004), Dijkgraaf and Vollebergh (2005), Musolesi et al. (2010), López-Menéndez et al. (2014), Akpan and Abang (2015), Apergis and Ozturk (2015), Yaduma et al. (2015), Dong et al. (2016), Neve and Hamaide (2017) | |

**Table 4: EKC estimation studies on $CO_2$ emissions: Classification by data, methodological adaptation, and outcome**

| *Time Series* | | |
|---|---|---|
| *Method* | *Shape of EKC* | *Studies* |
| 2SLS | U-shaped | Asghari (2012), Ozturk and Al-Mulali (2015) |
| ARDL bounds | Monotonically Increasing | Jalil and Feridun (2011), Shahbaz et al. (2013c), Baek (2015), Begum et al. (2015), Farhani and Ozturk (2015), Ertugrul et al. (2016), Sugiawan and Managi (2016), Gill et al. (2017) |
| | Monotonically Decreasing | Ahmed and Long (2012), Baek (2015), Shahbaz et al. (2016a) |
| | Inverted U-shaped | Ang (2007), Halicioglu (2009), Jalil and Mahmud (2009), Acaravci and Ozturk (2010), Iwata et al. (2010), Jalil and Feridun (2011), Jayanthakumaran et al. (2012), Shahbaz et al. (2012), Baek and Kim (2013), Kohler (2013), Ozturk and Acaravci (2013), Saboori and Sulaiman (2013a, b), Shahbaz (2013), Shahbaz et al. (2013a, b, c), Sulaiman et al. (2013), Tiwari et al. (2013), Arouri et al. (2014), Boutabba (2014), Farhani et al. (2014a), Kivyiro and Arminen (2014), Lau et al. (2014), Onafowora and Owoye (2014), Shahbaz et al. (2014a, b), Baek (2015), Bölük and Mert (2015), Seker et al. (2015), Tang and Tan (2015), Ahmad et al. (2016), Balaguer and Cantavella (2016), Ertugrul et al. (2016), Sugiawan and Managi (2016), Zambrano-Monserrate et al. (2016), Ahmad et al. (2017), Jaforullah and King (2017), Nasreen et al. (2017), Ozatac et al. (2017) |
| | U-shaped | Saboori et al. (2012b), Saboori and Sulaiman (2013a), Baek (2015), Jebli and Youssef (2015), Dogan and Turkekul (2016) |
| | N-shaped | Baek (2015), Jaforullah and King (2017) |
| | Inverted N-shaped | Onafowora and Owoye (2014), Moghadam and Dehbashi (2017) |
| | No EKC | Acaravci and Ozturk (2010), Hossain (2012), Saboori and Sulaiman (2013b), Shahbaz (2013), Kivyiro and Arminen (2014), Baek (2015), Ertugrul et al. (2016), Jaforullah and King (2017), Pal and Mitra (2017) |
| CCE | Monotonically Increasing | Arouri et al. (2012) |
| | Inverted U-shaped | Arouri et al. (2012) |
| | U-shaped | Arouri et al. (2012) |
| Cointegration | Monotonically Increasing | Pao et al. (2011), Chandran and Tang (2013), Shahbaz et al. (2015), Tutulmaz (2015) |
| | Monotonically Decreasing | Pao et al. (2011) |
| | Inverted U-shaped | Chuku (2011), Nasir and Rehman (2011), Pao and Tsai (2011a), Esteve and Tamarit (2012b), Saboori et al. (2012a), Kanjilal and Ghosh (2013), Shahbaz et al. (2015), Tutulmaz (2015), Ouyang and Lin (2017) |
| | U-shaped | Pao et al. (2011), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Shahbaz et al. (2015) |
| | N-shaped | Akbostancı et al. (2009), Fodha and Zaghdoud (2010), Chuku (2011) |

| | | |
|---|---|---|
| | No EKC | Akbostancı et al. (2009), Pao and Tsai (2010), Pao and Tsai (2011a), Pao et al. (2011), Esteve and Tamarit (2012a), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Shahbaz et al. (2015), Tutulmaz (2015) |
| DOLS | No EKC | Lean and Smyth (2010) |
| FMOLS | No EKC | Bello and Abimbola (2010), Ozcan (2013), Cho et al. (2014) |
| Kalman Filter | No EKC | Lindmark (2002) |
| OLS | No EKC | Roca et al. (2001), He and Richard (2010), Lipford and Yandle (2010) |
| *Panel* | | |
| *Method* | *Shape of EKC* | *Studies* |
| 2SLS | N-shaped | Lorente and Álvarez-Herranz (2016) |
| AMG | Monotonically Increasing | Shafiei and Salim (2014), Dong et al. (2016) |
| | Inverted U-shaped | Dong et al. (2016) |
| Bayesian estimation | Inverted U-shaped | Musolesi et al. (2010) |
| | U-shaped | Musolesi et al. (2010) |
| | Inverted N-shaped | Musolesi et al. (2010) |
| | N-shaped | Musolesi et al. (2010) |
| | No EKC | Musolesi et al. (2010) |
| CCE | Inverted U-shaped | Arouri et al. (2012), Apergis et al. (2017) |
| CMG | Monotonically Increasing | Dong et al. (2016) |
| Cointegration | Monotonically Increasing | Tamazian et al. (2009) |
| | Inverted U-shaped | Atici (2009), Tamazian et al. (2009), Pao and Tsai (2010), Guangyue and Deyong (2011), Pao and Tsai (2011b), Mehrara and ali Rezaei (2013) |
| | U-shaped | Guangyue and Deyong (2011), Wang et al. (2011) |
| CupBC | Inverted U-shaped | Apergis et al. (2017) |
| CupFM | Inverted U-shaped | Apergis et al. (2017) |
| DFE | Inverted U-shaped | Li et al. (2016) |
| DOLS | Inverted U-shaped | Lean and Smyth (2010), Farhani and Shahbaz (2014), Farhani et al. (2014b), Osabuohien et al. (2014), Apergis and Ozturk (2015), Ibrahim and Rizvi (2015), Bilgili et al. (2016), Destek et al. (2016), Dogan and Seker (2016), Jebli et al. (2016), Zhang et al. (2017) |
| | U-shaped | Dogan et al. (2015) |
| | No EKC | Osabuohien et al. (2014), Apergis and Ozturk (2015), Ibrahim and Rizvi (2015), Rehman and Rashid (2017), Zoundi (2017) |
| Panel regression | Monotonically Increasing | Shafik and Bandyopadhyay (1992), Shafik (1994), Agras and Chapman (1999), Farzin and Bond (2006), Yaguchi et al. (2007), López-Menéndez et al. (2014), Dong et al. (2016) |
| | Monotonically Decreasing | López-Menéndez et al. (2014), Oshin and Ogundipe (2014) |
| | Inverted U-shaped | Holtz-Eakin and Selden (1995), Cole et al. (1997), Agras and Chapman (1999), Galeotti et al. (2006), Yaguchi et al. (2007), Dutt (2009), Iwata et al. (2011), Du et al. (2012), Al Sayed and Sek (2013), Bölük and Mert (2014), Oshin and Ogundipe (2014), Chakravarty and Mandal (2016), Dong et al. (2016), Sapkota and Bastola (2017), Wang et al. (2017) |
| | U-shaped | Halkos and Tzeremes (2009), López-Menéndez et al. (2014), Sapkota and Bastola (2017) |

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|---|---|---|
| | N-shaped | Moomaw and Unruh (1997), López-Menéndez et al. (2014), Dong et al. (2016), Lorente and Álvarez-Herranz (2016), Álvarez-Herránz et al. (2017) |
| | Inverted N-shaped | Dijkgraaf and Vollebergh (2005), Vollebergh et al. (2005) |
| | No EKC | Magnani (2001), Martínez-Zarzoso and Bengochea-Morancho (2004), Dijkgraaf and Vollebergh (2005), López-Menéndez et al. (2014), Dong et al. (2016), Zoundi (2017) |
| FGLS | Inverted U-shaped | Aldy (2005) |
| FMOLS | Monotonically Increasing | Wang (2012) |
| | Inverted U-shaped | Apergis and Payne (2009), Apergis and Payne (2010), Cho et al. (2014), Farhani and Shahbaz (2014), Farhani et al. (2014b), Apergis and Ozturk (2015), Kasman and Duman (2015), Al-Mulali and Ozturk (2016), Bilgili et al. (2016), Destek et al. (2016), Dogan and Seker (2016), Jebli et al. (2016), Zhang et al. (2017) |
| | U-shaped | Ozcan (2013), Jebli et al. (2015) |
| | No EKC | Apergis and Ozturk (2015), Rehman and Rashid (2017) |
| GLS | Monotonically Increasing | Shi (2003), Akpan and Abang (2015) |
| | Inverted U-shaped | Shi (2003), Akpan and Abang (2015) |
| | N-shaped | Akpan and Abang (2015) |
| | No EKC | Akpan and Abang (2015) |
| GMM | Monotonically Increasing | Tamazian and Rao (2010), Du et al. (2012), Dong et al. (2016) |
| | Monotonically Decreasing | Dong et al. (2016) |
| | Inverted U-shaped | Lee et al. (2009), Taguchi (2013), Dong et al. (2016), Li et al. (2016), Sinha and Sen (2016) |
| | U-shaped | Chakravarty and Mandal (2016), Dong et al. (2016), Zoundi (2017) |
| | Inverted N-shaped | Dong et al. (2016) |
| | N-shaped | Lee et al. (2009), Dong et al. (2016), Sinha et al. (2017) |
| | No EKC | Tamazian and Rao (2010), Du et al. (2012), Dong et al. (2016) |
| LSDVC | Inverted U-shaped | Du et al. (2012) |
| | No EKC | Du et al. (2012) |
| MG | Inverted U-shaped | Apergis and Ozturk (2015), Apergis et al. (2017) |
| | N-shaped | Martínez-Zarzoso and Bengochea-Morancho (2004) |
| | No EKC | Martínez-Zarzoso and Bengochea-Morancho (2004), Iwata et al. (2011), Apergis and Ozturk (2015), Li et al. (2016), Zoundi (2017) |
| Nonparametric additive regression | Inverted U-shaped | Xu and Lin (2015), Xu and Lin (2016) |
| OLS | Monotonically Increasing | Aldy (2005), Richmond and Kaufmann (2006), Dong et al. (2016) |
| | Inverted U-shaped | York et al. (2003), Aldy (2005), Richmond and Kaufmann (2006), Dutt (2009), Jobert et al. (2011), Dong et al. (2016), Shahbaz et al. (2016b), Zhang et al. (2017) |
| | U-shaped | Jebli et al. (2015), Liu et al. (2015) |
| | N-shaped | Hill and Magnani (2002) |
| | No EKC | Oshin and Ogundipe (2014), Liu et al. (2015), Neve and Hamaide (2017) |
| PLS | N-shaped | Lorente and Álvarez-Herranz (2016) |
| PSTR | Inverted U-shaped | Heidari et al. (2015) |

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|---|---|---|
| Quantile regression | Monotonically Decreasing | Yaduma et al. (2015) |
| | Inverted N-shaped | Yaduma et al. (2015) |
| | No EKC | Yaduma et al. (2015) |
| WLS | No EKC | Neve and Hamaide (2017) |

**Table 5: EKC estimation studies on $CO_2$ emissions: Classification by data and model outcomes**

| *EKC Model Outcomes* | *Time Series* |
|---|---|
| Monotonically Increasing | Friedl and Getzner (2003), Lantz and Feng (2006), Lean and Smyth (2010), Lipford and Yandle (2010), Seetanah and Vinesh (2010), Jalil and Feridun (2011), Pao et al. (2011), Arouri et al. (2012), Hussain et al. (2012), Chandran and Tang (2013), Shahbaz et al. (2013c), Azlina et al. (2014), Lapinskienė et al. (2014), Baek (2015), Begum et al. (2015), Farhani and Ozturk (2015), Shahbaz et al. (2015), Tutulmaz (2015), Ertugrul et al. (2016), Sugiawan and Managi (2016), Gill et al. (2017) |
| Monotonically Decreasing | Pao et al. (2011), Ahmed and Long (2012), Baek (2015), Shahbaz et al. (2016a) |
| Inverted U-shaped | Ang (2007), Halicioglu (2009), Jalil and Mahmud (2009), Acaravci and Ozturk (2010), Iwata et al. (2010), Lean and Smyth (2010), Pao and Tsai (2010), Chuku (2011), Jalil and Feridun (2011), Nasir and Rehman (2011), Pao and Tsai (2011a), Arouri et al. (2012), Arouri et al. (2012), Esteve and Tamarit (2012b), Jayanthakumaran et al. (2012), Saboori et al. (2012a), Shahbaz et al. (2012), Baek and Kim (2013), Kanjilal and Ghosh (2013), Kohler (2013), Ozcan (2013), Ozturk and Acaravci (2013), Saboori and Sulaiman (2013 a, b), Shahbaz (2013), Shahbaz et al. (2013 a, b, c), Sulaiman et al. (2013), Tiwari et al. (2013), Arouri et al. (2014), Boutabba (2014), Cho et al. (2014), Farhani et al. (2014a), Kivyiro and Arminen (2014), Lapinskienė et al. (2014), Lau et al. (2014), Onafowora and Owoye (2014), Shahbaz et al. (2014 a, b), Yavuz (2014), Baek (2015), Bölük and Mert (2015), Seker et al. (2015), Shahbaz et al. (2015), Tang and Tan (2015), Tutulmaz (2015), Ahmad et al. (2016), Balaguer and Cantavella (2016), Ertugrul et al. (2016), Sephton and Mann (2016), Sugiawan and Managi (2016), Zambrano-Monserrate et al. (2016), Ahmad et al. (2017), Jaforullah and King (2017), Nasreen et al. (2017), Ouyang and Lin (2017), Ozatac et al. (2017) |
| U-shaped | Omisakin (2009), Lipford and Yandle (2010), Pao and Tsai (2010), Pao et al. (2011), Arouri et al. (2012), Asghari (2012), Saboori et al. (2012b), Abdou and Atya (2013), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Ozcan (2013), Saboori and Sulaiman (2013a), Cho et al. (2014), Lapinskienė et al. (2014), Baek (2015), Begum et al. (2015), Jebli and Youssef (2015), Ozturk and Al-Mulali (2015), Shahbaz et al. (2015), Dogan and Turkekul (2016) |
| Inverted N-shaped | Abdallah et al. (2013), Onafowora and Owoye (2014), Nasr et al. (2015), Moghadam and Dehbashi (2017) |
| N-shaped | Day and Grafton (2003), Friedl and Getzner (2003), Akbostancı et al. (2009), Fodha and Zaghdoud (2010), Lipford and Yandle (2010), Chuku (2011), Fosten et al. (2012), Abdou and Atya (2013), Alshehry (2015), Baek (2015), Jaforullah and King (2017) |
| No EKC | Roca et al. (2001), Lindmark (2002), Akbostancı et al. (2009), Acaravci and Ozturk (2010), Bello and Abimbola (2010), He and Richard (2010), Lean and Smyth (2010), Lipford and Yandle (2010), Pao and Tsai (2010), Pao and Tsai (2011a), Pao et al. (2011), Esteve and Tamarit (2012a), Hossain (2012), Chandran and Tang (2013), Kanjilal and Ghosh (2013), Ozcan (2013), Saboori and Sulaiman (2013b), Shahbaz (2013), Cho et al. (2014), Kivyiro and Arminen (2014), Baek (2015), Shahbaz et al. (2015), Tutulmaz (2015), Ertugrul et al. (2016), Jaforullah and King (2017), Pal and Mitra (2017) |
| *EKC Model Outcomes* | *Panel* |

| | |
|---|---|
| Monotonically Increasing | Shafik and Bandyopadhyay (1992), Shafik (1994), Agras and Chapman (1999), Shi (2003), Aldy (2005), Farzin and Bond (2006), Richmond and Kaufmann (2006), Yaguchi et al. (2007), York (2007), Tamazian et al. (2009), Tamazian and Rao (2010), Du et al. (2012), Wang (2012), Shafiei and Salim (2014), Akpan and Abang (2015), Dong et al. (2016) |
| Monotonically Decreasing | López-Menéndez et al. (2014), Oshin and Ogundipe (2014), Yaduma et al. (2015), Dong et al. (2016) |
| Inverted U-shaped | Holtz-Eakin and Selden (1995), Cole et al. (1997), Agras and Chapman (1999), Galeotti and Lanza (1999), York et al. (2003), Aldy (2005), Galeotti et al. (2006), Richmond and Kaufmann (2006), Faiz-Ur-Rehman et al. (2007), Yaguchi et al. (2007), York (2007), Apergis and Payne (2009), Atici (2009), Dutt (2009), Lee et al. (2009), Tamazian et al. (2009), Apergis and Payne (2010), Lean and Smyth (2010), Musolesi et al. (2010), Pao and Tsai (2010), Guangyue and Deyong (2011), Iwata et al. (2011), Jobert et al. (2011), Pao and Tsai (2011b), Du et al. (2012), Al Sayed and Sek (2013), Mehrara and ali Rezaei (2013), Taguchi (2013), Bölük and Mert (2014), Cho et al. (2014), Farhani and Shahbaz (2014), Farhani et al. (2014b), Osabuohien et al. (2014), Oshin and Ogundipe (2014), Akpan and Abang (2015), Apergis and Ozturk (2015), Heidari et al. (2015), Ibrahim and Rizvi (2015), Kasman and Duman (2015), Xu and Lin (2015), Al-Mulali and Ozturk (2016), Bilgili et al. (2016), Chakravarty and Mandal (2016), Destek et al. (2016), Dogan and Seker (2016), Dong et al. (2016), Jebli et al. (2016), Li et al. (2016), Li et al. (2016), Shahbaz et al. (2016b), Sinha and Sen (2016), Xu and Lin (2016), Apergis et al. (2017), Sapkota and Bastola (2017), Wang et al. (2017), Zhang et al. (2017) |
| U-shaped | Halkos and Tzeremes (2009), Musolesi et al. (2010), Guangyue and Deyong (2011), Wang et al. (2011), Ozcan (2013), López-Menéndez et al. (2014), Dogan et al. (2015), Jebli et al. (2015), Liu et al. (2015), Chakravarty and Mandal (2016), Dong et al. (2016), Sapkota and Bastola (2017), Zoundi (2017) |
| Inverted N-shaped | Dijkgraaf and Vollebergh (2005), Vollebergh et al. (2005), Musolesi et al. (2010), Yaduma et al. (2015), Dong et al. (2016) |
| N-shaped | Moomaw and Unruh (1997), Hill and Magnani (2002), Martínez-Zarzoso and Bengochea-Morancho (2004), Lee et al. (2009), Musolesi et al. (2010), López-Menéndez et al. (2014), Akpan and Abang (2015), Dong et al. (2016), Álvarez-Herránz et al. (2017), Sinha et al. (2017) |
| No EKC | Magnani (2001), Martínez-Zarzoso and Bengochea-Morancho (2004), Dijkgraaf and Vollebergh (2005), Musolesi et al. (2010), Tamazian and Rao (2010), Iwata et al. (2011), Du et al. (2012), López-Menéndez et al. (2014), Osabuohien et al. (2014), Oshin and Ogundipe (2014), Akpan and Abang (2015), Apergis and Ozturk (2015), Ibrahim and Rizvi (2015), Liu et al. (2015), Yaduma et al. (2015), Dong et al. (2016), Li et al. (2016), Neve and Hamaide (2017), Rehman and Rashid (2017), Zoundi (2017) |

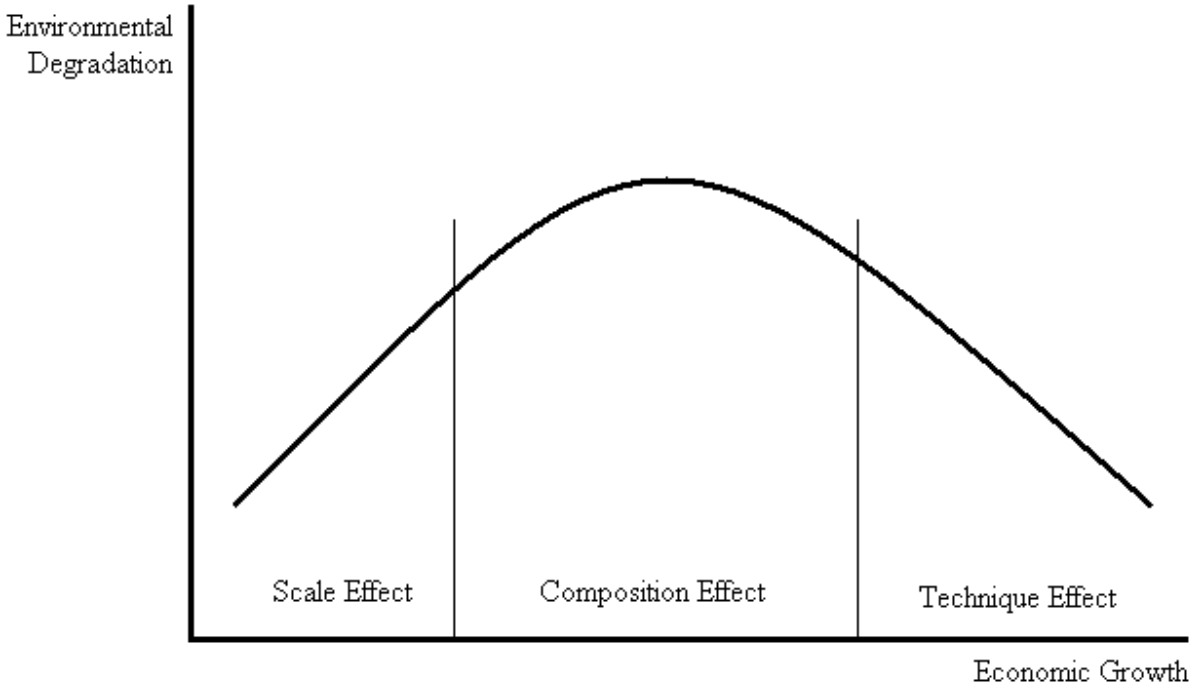


**Figure-1: Environmental Kuznets Curve and channels of economic growth effect**

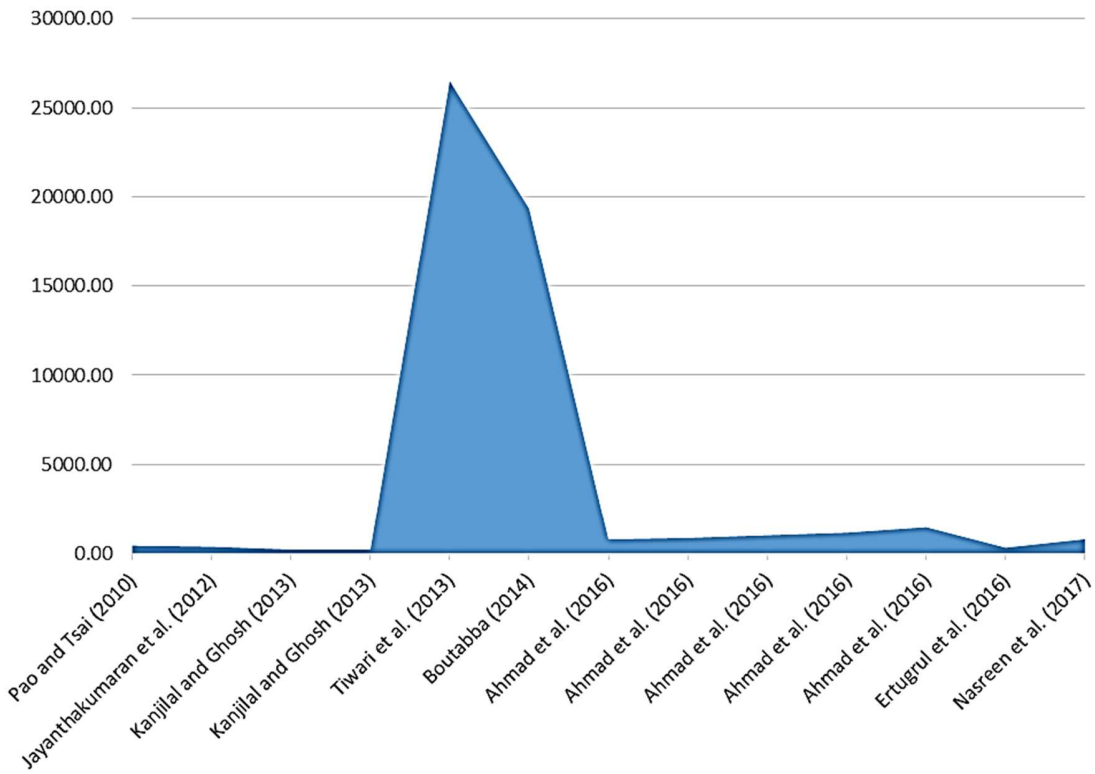


**Figure 2: Divergence in turnaround points (in USD) for India**

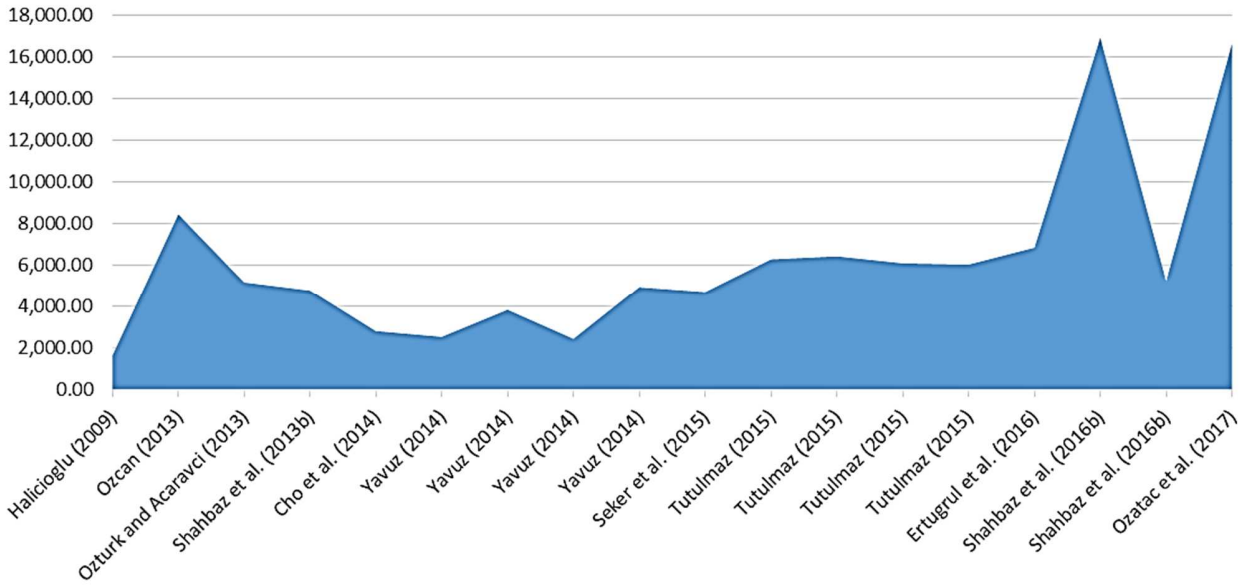


**Figure 3: Divergence in turnaround points (in USD) for Turkey**

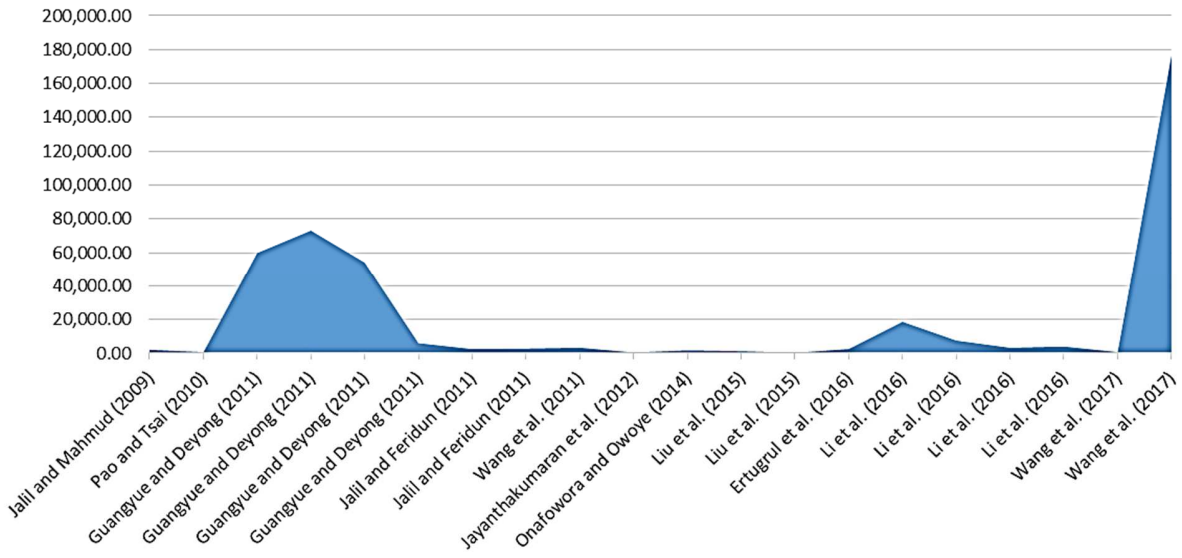


**Figure 4: Divergence in turnaround points (in USD) for China**

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