e-ISSN: 2459-1718

# Journal of Transportation and Logistics

http://www.iujtl.com/

Volume 5 Issue 2

2020

İSTANBUL UNIVERSITY PRESS

Available online at www.iujtl.com

Journal of Transportation and Logistics
5 (2) 2020

International Peer - Reviewed Journal

e-ISSN: 2459-1718

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http://iujtl.com/ • http://jtl.istanbul.edu.tr/

**Publisher**
Istanbul University Press
Istanbul University Central Campus,
34452 Beyazıt, Fatih / Istanbul, Turkey
Phone: +90 (212) 440 00 00

The JTL is published twice (in April and October of) a year, as an official international peer-reviewed journal of the School of Transportation and Logistics at Istanbul University.

The publication languages of the journal are Turkish and English.

**Publication Type:** Periodical

Available online at www.iujtl.com

Journal of Transportation and Logistics
5 (2) 2020

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JTL

Journal of Transportation and Logistics
5 (2) 2020

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## CONTENTS

### RESEARCH ARTICLES

Available online at www.iujtl.com

Journal of Transportation and Logistics
5 (2) 2020

**DOI:** 10.26650/JTL.2020.0020

RESEARCH ARTICLE

# Examination of the Operating Costs and Environmental Impact of Alternative Fuels Used in Ships

## Gemilerde Kullanılan Alternatif Yakıtların İşletme Maliyetleri ve Çevresel Etkilerinin İncelenmesi

Tarik Kocal[1]

**ABSTRACT**

Nowadays, transportation has reached dimensions that have never been seen before, the amount of cargoes has diversified with quantity increases with the development of industry. Low cost, the number of goods transported, and security are the most important factors in the transportation sector. Due to these reasons, the majority of cargo transport in the world is carried out by seaway. In addition, the high increases in the costs of diesel fuel in ship transportation lead shipowners to use different fuels. Alternative fuels have started to be used on new ships and certain old ships. In this study in a one-year period, the costs and carbon dioxide emission values of alternative fuels that can be used in ships were calculated in different operating conditions. The ship used in this study has a diesel engine with a power of 5975 kW at full load. The costs of using LNG, LPG and methanol fuels as an alternative to diesel fuel (HFO, MDO) in the selected engine are calculated according to different load conditions and different annual working hours. When the results of the calculations are examined, it is seen which fuel could be more economical and environment friendly.

**Keywords:** Alternative Fuel, Annual Carbon Dioxide Release, Cost, Emission, Transportation

**ÖZ**

Sanayinin gelişmesiyle ticareti yapılan yüklerin çeşitlenerek miktarının arttığı günümüzde, taşımacılık geçmişte hiç olmadığı kadar büyük boyutlara ulaşmıştır. Düşük maliyet, taşınan mal miktarı ve güvenlik taşımacılık sektöründe en önemli unsurlardır. Bu nedenlerden dolayı dünyadaki yük taşımacılığının büyük bir kısmı deniz yoluyla yapılmaktadır. Deniz taşımacılığı diğer taşımacılık türlerine göre daha çevrecidir. Ancak uluslararası ticaret hacminin ve dolayısıyla gemi sayılarının artışı, gemi kaynaklı emisyon miktarlarını arttırmıştır. Bu açıdan bakıldığında gemi emisyonları konusu irdelenmesi gereken önemli bir konu haline gelmiştir. Ayrıca gemi taşımacılığında dizel yakıtın maliyetlerinde meydana gelen yüksek artışlar armatörleri farklı yakıtları kullanmaya yönelmelerine neden olmuştur. Yeni yapılan gemilerde ve bazı eski gemilerde revizyon yapılarak alternatif yakıtlar kullanılmaya başlanmıştır. Bu çalışmada gemilerde kullanılabilecek alternatif yakıtların yıllık bazda farklı çalışma koşullarına göre maliyet hesaplamaları yapılmıştır. Ayrıca karbondioksit salınım değerleri elde edilmiştir. Referans olarak alınan gemi %100' lük yük durumunda 5975 kw' lık bir güç çıkışına sahip bir dizel makineye sahiptir. Ele alınan bu geminin dizel yakıta alternatif olarak LNG, LPG, Metanol yakıtlarını kullanarak ne gibi maliyetlere sahip olacağı farklı yük durumları ve farklı yıllık çalışma saati koşullarına göre hesaplanmıştır. Bu hesaplamalarla birlikte hangi yakıtın daha hesaplı ve daha çevreci olabileceği incelenmiştir.

**Anahtar Kelimeler:** Alternatif Yakıt, Yıllık Karbondioksit Salınımı, Maliyet, Emisyon, Taşımacılık

**Submitted:** 17.09.2020 • **Accepted:** 20.10.2020

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**Citation:** Kocal, T. (2020). Examination of the operating costs and environmental impact of alternative fuels used in ships. *Journal of Transportation and Logistics, 5*(2), 83-91. https://doi.org/10.26650/JTL.2020.0020

## 1. Introduction

In this study, the effect the type of fuel used on ship management cost was calculated. These costs were examined and compared according to different fuel types and different load conditions annually. Depending on the fuel consumption, the ship's annual carbon emission was observed for different fuels.

In previous studies, Iannccone and his colleagues explored the sustainability of innovative ship fuel systems based on LNG fuel use. As a result of their research, they concluded that LNG fuel system technologies are more sustainable in terms of their impact on the environment, economic feasibility and safety than conventional marine fuel technologies (Iannaccone, Landucci, Tugnoli, Salzano & Cozzani, 2020).

Ammar discussed the environmental and economic effects of fuels by addressing the methanol-diesel dual-fuel ship engine in his study. This research established that methanol reduced NOx, SOx, CO, CO2, and PM emissions and made economic gains (Ammar, 2019).

In their paper, Schinas and Butler proposed a methodology for evaluating the commercial incentives needed to promote LNG as a marine fuel. They discussed the challenges preventing LNG from being adopted as a marine fuel (Schinas & Butler, 2016).

Helgason and his colleagues compared Conventional Methanol, renewable methanol, and heavy fuel oil fuels in terms of their costs in their study (Helgason, Cook & Davíðsdóttir, 2020). During this research, these stages were used:

- The existing main engine of the ship with a 5850 kW max power is the MAKITA MITSUI MAN B&W 6S42MC.
- LNG, LPG, Butane, LPG Propane, and Methanol are alternative fuels to diesel fuel.
- Lower thermal values of the specified fuels are held in accord with ISO 8217 fuel standards.
- Using the verified specific fuel consumption specified in the main engine operator's manual, the amount of diesel fuel to be burned to obtain the desired power is calculated.
- This operation was repeated for 50%, 75%, 85% and 100% load conditions of ship and diesel fuel consumption was found according to 2000, 4000, and 6000 working hours in one year.
- To have the same brake power the mass that must be burned for the alternative fuel types was calculated.
- World market prices of specified fuels were researched, and these fuel's price averages of Asia, Europe, and America were taken to examine the cost according to the main engine, load and work hours situations.
- The referenced ship's carbon emission was calculated annually.
- At the end of the examination, alternative fuel costs wereanalyzed and carbon emissions were examined and compared.

## 2. Calculations Values

**Table 1.** Lower heat values of alternative fuels ("Alternative Fuel Properties", 2019)

| Type of fuel | Reference | Lower Calorific Value (kj/kg) |
|---|---|---|
| Diesel | ISO 8217 Grades | 42700 |
| Liquefied Petroleum | Propane | 46300 |
| Gas (LPG) | Butane | 45700 |
| Liquefied Natural Gas (LNG) | | 48000 |
| Methanol | | 19900 |

The lower heat value is heat energy is when water is in the steam phase in a combustion reaction. In Table 1, the lower heat values of diesel, LPG, LNG, and Methanol are given.

**Table 2.** Market values of using fuels ("Diesel, LNG, Methanol and LPG Fuel Prices", 2019)

| Regions | Methanol ($/Ton) | LNG ($/Ton) | LPG Propane ($/Ton) | LPG Butane ($/Ton) | Diesel ($/Ton) |
|---|---|---|---|---|---|
| America | 432 | 142,5 | 110 | 100 | 730 |
| Europe | 360 | 512,5 | 470 | 450 | 690 |
| Asia | 370 | 580,5 | 535 | 515 | 770 |

Market prices of fuels were taken on April 26, 2019. Table 2 shows average fuel prices from 5 different ports in the USA, Europe, and Asia.

**Table 3.** Power and Specific Fuel Consumption Based on Load Condition of Reference Ship [9]

| LOAD | P(kw) | SFOC(g/kwh) |
|---|---|---|
| 50% | 2925 | 177,3 |
| 75% | 4391 | 172,4 |
| 85% | 5000 | 172,8 |
| 100% | 5861 | 173,8 |

Specific Fuel Consumption values based on the main engine load condition to be calculated are shown in Table 3. Also, carbon dioxide amounts as a result of combustion of all fuels are given in Table 4.

**Table 4.** $CO_2$ emission values of fuels ("CO2 Emission Values of Fuels", 2019).

| | METHANOL | LNG | LPG PROPANE | LPG BUTANE | DİESEL |
|---|---|---|---|---|---|
| $CO_2$($kgCO_2$/kgFUEL) | 1,37 | 2,75 | 2,99 | 3,03 | 3,2 |

## 3. Calculations & Evaluations

The calculation of the fuel consumption of the main engine that we evaluate was taken from the main engine operator's manual which is specific fuel consumption(SFOC) values. The equation (1) is below,

$$SFOC = \frac{\dot{m}}{P} \tag{1}$$

With the mass flow rate, total fuel consumption was calculated in 2000, 4000 and 6000 working hours running situations in a year. Fuel consumption for diesel and LNG fuels are given in Table 5.

**Table 5.** Diesel and LNG Fuel Consumptions

| | DİESEL | LNG (%95 LNG) | LNG (%5 DO) |
|---|---|---|---|
| LOAD | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) |
| 50% | 1037,21 | 876,55 | 51,86 |
| 75% | 1514,02 | 1279,50 | 75,70 |
| 85% | 1728,00 | 1460,34 | 86,40 |
| 100% | 2037,28 | 1721,72 | 101,86 |
| LOAD | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) |
| 50% | 2074,41 | 1753,09 | 103,72 |
| 75% | 3028,03 | 2559,00 | 151,40 |
| 85% | 3456,00 | 2920,68 | 172,80 |
| 100% | 4074,57 | 3443,43 | 203,73 |
| LOAD | 6000 hour (ton/year) | 6000 hour (ton/year) | 6000 hour (ton/year) |
| 50% | 3111,62 | 2629,64 | 155,58 |
| 75% | 4542,05 | 3838,51 | 227,10 |
| 85% | 5184,00 | 4381,02 | 259,20 |
| 100% | 6111,85 | 5165,15 | 305,59 |

LNG fuel consumption is based on diesel fuel consumption by diesel fuel burned multiplied lower heat energy of diesel fuel then divided by lower heat energy of LNG. The reason for getting 95% LNG fuel 5% diesel fuel in the calculations is that the petroleum fuels produced by liquefying from the gaseous state are not appropriate for the first operation of the main engine and the maneuvering circumstances. In other words, diesel fuel use

**Table 6.** Propane and LPG Butane Fuel Consumptions

| | LPG PROPANE | LPG PROPANE (%5 DO) | LPG BUTANE | LPG BUTANE (%5 DO) |
|---|---|---|---|---|
| LOAD | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) |
| 50% | 908,73 | 51,86 | 920,66 | 51,86 |
| 75% | 1326,48 | 75,70 | 1343,90 | 75,70 |
| 85% | 1513,96 | 86,40 | 1533,84 | 86,40 |
| 100% | 1784,93 | 101,86 | 1808,37 | 101,86 |
| LOAD | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) |
| 50% | 1817,46 | 103,72 | 1841,32 | 103,72 |
| 75% | 2652,96 | 151,40 | 2687,79 | 151,40 |
| 85% | 3027,92 | 172,80 | 3067,67 | 172,80 |
| 100% | 3569,87 | 203,73 | 3616,74 | 203,73 |
| LOAD | 6000 hour (ton/year) | 6000 hour (ton/year) | 6000 hour (ton/year) | 6000 hour (ton/year) |
| 50% | 2726,19 | 155,58 | 2761,98 | 155,58 |
| 75% | 3979,44 | 227,10 | 4031,69 | 227,10 |
| 85% | 4541,88 | 259,20 | 4601,51 | 259,20 |
| 100% | 5354,80 | 305,59 | 5425,10 | 305,59 |

while starting the main engine and in maneuvering circumstances. LPG Propane, LPG Butane, and Methanol fuels are given in Table 6 and Table 7 according to the main engine's loading situations and operation hours.

**Table 7.** Methanol Fuel Consumption

| | METHANOL | METHANOL (%5 DO) |
|---|---|---|
| LOAD | 2000 hour (ton/year) | 2000 hour (ton/year) |
| 50% | 2114,28 | 51,86 |
| 75% | 3086,24 | 75,70 |
| 85% | 3522,43 | 86,40 |
| 100% | 4152,88 | 101,86 |
| LOAD | 4000 hour (ton/year) | 4000 hour (ton/year) |
| 50% | 4228,56 | 103,72 |
| 75% | 6172,47 | 151,40 |
| 85% | 7044,86 | 172,80 |
| 100% | 8305,77 | 203,73 |
| LOAD | 6000 hour (ton/year) | 6000 hour (ton/year) |
| 50% | 6342,85 | 155,58 |
| 75% | 9258,71 | 227,10 |
| 85% | 10567,28 | 259,20 |
| 100% | 12458,65 | 305,59 |

When the tables are analyzed, LPG and LNG fuels, which can be used as an alternative to diesel fuel have less fuel consumption compared to diesel fuel. LNG fuel consumption is starting to be more common in the usage area of ships due to being environment-friendly, 12% less than diesel fuel consumption. LNG fuel usage has a terrific advantage in terms of cost and environmental factors, but due to the IMO's standards, the tanks that are used for the storage of LNG fuel are most costly than diesel fuel tanks.

Usage of LPG Propane and Butane too also provides cost efficiency when compared to diesel fuel. Methanol is identified as having the highest fuel consumption compared to other alternative fuel resources. The reason for this is the combustion of 1 gr methanol exposes less energy compared to other fuels. To provide the required power we must burn more methanol than other fuels.

When the emission values of the discussed main engine were analyzed, it was seen that the emission values of all fuels were lower than diesel fuel. $CO_2$ emissions of the referenced ship are given in Table 8. When we examined $CO_2$ emissions of the possible alternatives to diesel fuel, Methanol seems like the most environmentally friendly fuel. But, when we analyze the reference ship's carbon emissions values on an annual basis, it shows that Methanol comes after LNG and LPG derivatives. The reason for this is that Methanol fuel has twice the consumption compared to LNG and LPG derivatives in order to provide the desired energy. That's why carbon emission increases.

**Table 8.** $CO_2$ Emission Values of reference ship

| | DİESEL | LNG | LPG PROPANE | LPG BUTANE | METHANOL |
|---|---|---|---|---|---|
| LOAD | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) | 2000 hour (ton/year) |
| 50% | 3319,05 | 2576,45 | 2883,05 | 2955,55 | 3062,51 |
| 75% | 4844,85 | 3760,87 | 4208,42 | 4314,25 | 4470,38 |
| 85% | 5529,60 | 4292,41 | 4803,21 | 4924 | 5102,20 |
| 100% | 6519,307 | 5060,68 | 5662,91 | 5805,31 | 6015,41 |
| LOAD | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) | 4000 hour (ton/year) |
| 50% | 6638,11 | 5152,91 | 5766,11 | 5911,11 | 6125,03 |
| 75% | 9689,70 | 7521,74 | 8416,84 | 8628,50 | 8940,77 |
| 85% | 11059,20 | 8584,83 | 9606,43 | 9848 | 10204,41 |
| 100% | 13038,61 | 10121,37 | 11325,83 | 11610,63 | 12030,83 |
| LOAD | 6000 hour (ton/year) | 6000 hour (ton/year) | 6000 hour (ton/year) | 6000 saat (ton/yıl) | 6000 hour (ton/year) |
| 50% | 9957,16 | 7729,36 | 8649,17 | 8866,66 | 9187,55 |
| 75% | 14534,56 | 11282,61 | 12625,26 | 12942,75 | 13411,15 |
| 85% | 16588,80 | 12877,24 | 5371,31 | 14772,01 | 15306,61 |
| 100% | 19557,92 | 15182,06 | 16988,74 | 17415,95 | 18046,25 |

When Table 8 examined, LNG is seen as the most environmentally friendly fuel after methanol. Although LNG fuel has a ratio close to the LPG Propane and Butane fuels, it has a significant difference when considered as the annual $CO_2$ emission of a ship. It was calculated that the reference ship produces an average of 5000 tons less carbon compared to LPG derivatives in LNG fuel at 6000 working hours per year at 85% load. According to calculations made, LPG Propane is the second most environmentally friendly fuel and LPG Butane is the third.

**Table 9.** Fuel Cost of American Region

| | DİESEL | LNG | LPG PROPANE | LPG BUTANE | METHANOL |
|---|---|---|---|---|---|
| LOAD | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) |
| 50% | 757159,65 | 162765,82 | 137818,33 | 129924,11 | 951228 |
| 75% | 1105232,26 | 237590,63 | 201174,57 | 189651,31 | 1388515,45 |
| 85% | 1261440 | 271170,45 | 229607,53 | 216455,63 | 1584760,95 |
| 100% | 1487217,02 | 319705,50 | 270703,50 | 255197,63 | 1868407,12 |
| LOAD | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) |
| 50% | 1514319,30 | 325531,65 | 275636,66 | 259848,22 | 1902456 |
| 75% | 2210464,52 | 475181,26 | 402349,14 | 379302,62 | 2777030,91 |
| 85% | 2522880 | 542340,9 | 459215,06 | 432911,26 | 3169521,91 |
| 100% | 2974434,05 | 639411,00 | 541407,01 | 510395,26 | 3736814,24 |
| LOAD | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) |
| 50% | 2271478,95 | 488297,47 | 413455 | 389772,33 | 2853684 |
| 75% | 3315696,79 | 712771,90 | 603523,72 | 568953,93 | 4165546,37 |
| 85% | 3784320 | 813511,35 | 688822,60 | 649366,89 | 4754282,87 |
| 100% | 4461651,08 | 959116,51 | 812110,52 | 765592,89 | 5605221,36 |

Diesel and other alternative fuels in respect of regions are given on an annual basis in Table 9, Table 10, and Table 11 depending on the main engine loading.

**Table 10.** Fuel Cost of Europe Region

| | DİESEL | LNG | LPG PROPANE | LPG BUTANE | METHANOL |
|---|---|---|---|---|---|
| LOAD | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) |
| 50% | 715671,45 | 485013,53 | 462886,89 | 450081,15 | 796925,25 |
| 75% | 1044671,59 | 707978,30 | 675679,86 | 656987,21 | 1163278,45 |
| 85% | 1192320 | 808040,25 | 771176,91 | 749842,34 | 1327690,13 |
| 100% | 1405725,68 | 952666,174 | 909204,90 | 884051,80 | 1565324,84 |
| LOAD | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) |
| 50% | 1431342,90 | 970027,0689 | 925773,78 | 900162,30 | 1593850,51 |
| 75% | 2089343,18 | 1415956,61 | 1351359,79 | 1313974,43 | 2326556,90 |
| 85% | 2384640 | 1616080,50 | 1542353,83 | 1499684,69 | 2655380,26 |
| 100% | 2811451,36 | 1905332,34 | 1818409,81 | 1768103,60 | 3130649,68 |
| LOAD | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/ year) |
| 50% | 2147014,35 | 1455040,60 | 1388660,68 | 1350243,45 | 2390775,76 |
| 75% | 3134014,77 | 2123934,91 | 2027039,59 | 1970961,64 | 3489835,35 |
| 85% | 3576960 | 2424120,75 | 2313530,74 | 2249527,03 | 3983070,39 |
| 100% | 4217177,05 | 2857998,52 | 2727614,72 | 2652155,40 | 4695974,53 |

**Table 11.** Fuel Cost of Asian Region

| | DİESEL | LNG | LPG PROPANE | LPG BUTANE | METHANOL |
|---|---|---|---|---|---|
| LOAD | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) | 2000 hour ($/year) |
| 50% | 798647,85 | 548767,50 | 526103,19 | 514072,95 | 822216,90 |
| 75% | 1165792,93 | 801040,50 | 767957,22 | 750396,58 | 1200196,87 |
| 85% | 1330560 | 914255,37 | 876496,27 | 856453,70 | 1369826,41 |
| 100% | 1568708,37 | 1077892,05 | 1033374,70 | 1009744,84 | 1615002,82 |
| LOAD | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) | 4000 hour ($/year) |
| 50% | 1597295,70 | 1097535 | 1052206,38 | 1028145,91 | 1644433,80 |
| 75% | 2331585,87 | 1602081 | 1535914,45 | 1500793,17 | 2400393,75 |
| 85% | 2661120 | 1828510,74 | 1752992,55 | 1712907,41 | 2739652,82 |
| 100% | 3137416,74 | 2155784,11 | 2066749,40 | 2019489,68 | 3230005,65 |
| LOAD | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) | 6000 hour ($/year) |
| 50% | 2395943,55 | 1646302,50 | 1578309,58 | 1542218,86 | 2466650,70 |
| 75% | 3497378,80 | 2403121,51 | 2303871,68 | 2251189,75 | 3600590,62 |
| 85% | 3991680 | 2742766,11 | 2629488,82 | 2569361,12 | 4109479,23 |
| 100% | 4706125,11 | 3233676,16 | 3100124,11 | 3029234,53 | 4845008,47 |

When LPG consumption costs are examined, LPG fuel is seen as a better alternative compared to Diesel fuel.

## 4. Conclusion

In this study, cost computations and carbon dioxide emission values of alternative fuels that can be used in ships are calculated according to different operational situations on an annual basis. The ship taken as a reference has a diesel engine with a 5850 kW brake power at 100% load condition. The kind of costs involved in the case of using LNG, LPG, and Methanol fuels as an alternative to diesel fuel were calculated according to different load conditions, different annual working hour circumstances, and different regions. It was seen which fuel is more economical and more environmentally friendly with the help of these calculations. The benefits that can be gained as a result of the use of alternative fuels that can be replaced with diesel fuel were observed. In addition to these situations, carbon emissions of alternative fuels were calculated and their effects on the environment were observed.

The following results were obtained in this study:

1) When we examined LNG fuel, we notice that carbon emission is the most important point. LNG fuel has less $CO_2$ emission values compared to the other fuels named as alternative fuels. When considering research done, LNG fuel also has a lower release of sulfur and nitrogen than the other fuels. Looking at the value of the LNG in the world market, it is seen that it is the 3rd cheapest in America, the 4th cheapest in Asia and in Europe. When the reference ship operates with LNG fuel at the 85% load in the America region for 2000 working hours per year, it is concluded that it has less fuel consumption of approximately $990,000 compared to Diesel fuel. In terms of the annual consumption of LNG fuel in the Europe and Asia regions, it is concluded that the reference ship operating at 85% for 2000 hours per year has a lower cost of about $384,000 when compared to diesel fuel in Europe and $416,000 in the Asian region.

2) Looking at the LPG Butane fuel's price in the world market, it is seen that it is the cheapest fuel in all regions. When the carbon emission values of LPG butane fuel examined, it is seen that it is higher than the other alternative fuels. But it doesn't mean LPG butane is not environmentally friendly. It was calculated that LPG butane fuel emits 1814 less $CO_2$ compared to diesel fuel in terms of 85% load at 6000 working hours per year. Turning to the fuel costs calculation, LPG Butane in conditions of 85% load with 2000 hours per year saved $1million compared to Diesel in the America region and $442,000 in the European region and $474,000 in the Asian region.

3) When we look at the value of the LPG Propane in the world market, it is seen that it is the 2nd cheapest fuel in the continent of America and the 3rd cheapest fuel in Asia and in Europe. When we compare the $CO_2$ emissions of alternative fuels, LPG Propane is the third lowest, after Methanol and LNG. LPG Propane is the second most environmentally friendly fuel according to calculations of $CO_2$ emission of the reference ship. If the reference ship works 2000 working hours with a 85% load, it will cause $1,031 millionsaving in the USA, $421,000 savings in Europe, and $454,000 savings in Asia.

**Peer-review:** Externally peer-reviewed.
**Conflict of Interest:** The author has no conflict of interest to declare.
**Grant Support:** The author declared that this study has received no financial support.

**Hakem Değerlendirmesi:** Dış bağımsız.
**Çıkar Çatışması:** Yazar çıkar çatışması bildirmemiştir.
**Finansal Destek:** Yazar bu çalışma için finansal destek almadığını beyan etmiştir.

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Available online at www.iujtl.com

JTL

Journal of Transportation and Logistics
5 (2) 2020

İSTANBUL UNIVERSITY PRESS

**DOI:** 10.26650/JTL.2020.0018

RESEARCH ARTICLE

# Measuring Digital Divide in E-Commerce by Log-Linear Models and Non-Parametric Tests: An Application of Turkey

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**ABSTRACT**

The purpose of the study is to examine the relationships between individuals who engage in e-commerce and their demographic factors and to investigate whether their status of e-commerce engagement differentiates according to demographic factors. In case of differences, demographic factors caused by the Digital Divide were examined. If Digital Division is not detected, the reasons for this are emphasized. For this purpose, the overall profile of the customer group engaged in e-commerce in Turkey was summarized, and the demographic variables that e-commerce is associated with were determined using Non-Parametric techniques. Then, utilizing the Log-Linear Models, one of the methods of the Advanced Contingency Table Analysis, the effects including two-way and three-way interactions were investigated. Consequently, among those who engage in e-commerce in Turkey, it was determined that education caused the digital divide, however, gender remained ineffective.

**Keywords:** Digital Divide, E-Commerce, Contingency Table, Non-Parametric Tests, Log-Linear Models

**Submitted:** 01.07.2020 • **Accepted:** 06.10.2020

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**Citation:** Kuzu Yildirim, S. & Aricigil Cilan, C. Measuring digital divide in e-commerce by log-linear models and non-parametric tests: an application of Turkey. *Journal of Transportation and Logistics, 5*(2), 93-104. https://doi.org/10.26650/JTL.2020.0018

## 1. Introduction

In the digitalizing world, the importance of e-commerce activities is increasing every passing year. As a concept, electronic commerce: according to the World Trade Organization (WTO), is the production, advertising, sale and distribution of goods and services via telecommunications networks. According to the Organisation for Economic Co-operation and Development (OECD), it refers generally to the carrying out of commercial activities by individuals and organizations based upon the transmission of digitized data, including text, sound, and visual images. According to the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), is defined as sharing of unstructured or structured business information by any electronic means (such as electronic mail or messaging, electronic bulletin boards, World Wide Web technology, smart cards, electronic funds transfers, and electronic data interchange) among suppliers, customers, governmental bodies and other partners in order to conduct transactions in business, administrative and consumer activities. Canpolat (2001) defines e-commerce as a process among consumers, businesses, and public institutions, based upon the processing, transmission, and storage of digital information in the form of text, sound, and visual images in an electronic environment (internet or intranet), for the activities of getting informed and doing research, making a commitment, delivering goods and services to the customer, making payment, performing after-sales maintenance and support services.

As in the world, in Turkey, electronic commerce is growing and becoming more and more popular. Among the reasons for this growth are widespread and affordable internet access, increasing young population, the rise in digital literacy, and the proliferation of smartphone use day by day. When examined from the viewpoint of consumer perceptions, the most important value proposition of e-commerce for Turkish consumers is its *price advantage*. In advanced e-commerce markets, the perception of *convenience* stands out more prominently (Turkish Industry & Business Association, TÜSİAD-T/2017).

The Internet is a channel that enables people to acquire new hobbies and create innovations, facilitates continuing education, encourages personal growth and allows new relationships to be established (Cohendet, 2003). Despite the fact that the primary step in being able to engage in e-commerce is internet access, there are still regions in the world that cannot get access to the internet. Therefore, this situation makes e-commerce activity impossible. This has led to the concept of *"Digital Divide"*, which is known as the gap between individuals, households, business, and geographic areas with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the internet. This concept, first introduced in the late 1990s, has become an attractive subject for researchers.

## 2. The Digital Divide and Its Causes

The OECD (2001) defined the term "Digital Divide" as the gap between individuals, households, businesses, and geographic areas with regard to both their opportunities to access Information and Communication Technologies (ICT) and to their use of the internet. Dragulanescu (2002) defined it as the gap between those who can afford to purchase

the computer hardware and software necessary to participate in the global information network, and those that cannot. Hargittai (2003) defined it as the gap between those who have access to digital technologies and those who do not. Dijk (2006) defined it as the gap between those who have access to computers and the internet and those who do not. It is thought that no further deepening of the digital divide and preventing digital poverty will affect the world welfare positively. For reduction of the digital divide and digital poverty, the work carried out at a global level needs to be continued with determination and greater participation (Kalaycı, 2013).

While the number of studies analyzing the digital divide has increased rapidly in recent years, Hoffman and Novak's (1998) study, as an example of pioneering works, assessed whether there was a difference between Whites and African Americans in the United States with respect to computer access and internet use, by examining the income and education levels of the races, and they observed that there was a serious digital divide between these two groups. Ono and Zavodny (2007) examined the microdata of the United States, Sweden, Japan, South Korea and Singapore to determine whether gender, age, education, and income factors created digital inequality[1]. They found that in the United States and Sweden, gender did not have an impact on digital inequality. However, in the other three Asian countries, this inequality was quite profound. Brandtzæg et al. (2011) grouped internet user types as "Non-Users", "Sporadic Users", "Instrumental Users", "Entertainment Users" and "Advanced Users", and he argued that 60% of users in five European countries consisted of "Non-Users" and "Sporadic Users" and the digital divide in European countries was quite deep. Friemel (2014), when measuring the digital divide between age groups, argued that in parallel with the literature, there was a divide between young people and seniors. In addition, the rate of Internet usage among seniors was also quite different. According to this research, he found that only a quarter of the seniors over 65 got internet access, and as the age increased, this ratio decreased, in other words, the gap widened.

## 3. Measurement of the digital divide and the domestic digital divide

There are two dimensions of the digital divide analysis. These are divided into; measuring the gap between countries (the international digital divide) and measuring the gap between groups within the country (the domestic digital divide) (Cuervo & Menendez, 2006). The international digital divide is largely the consequence of the social and economic imbalance that exists between developed and developing countries. Countries with lower income and lower educational attainment tend to show lower rates of ICT (Information and Communication Technologies) access and use when compared to countries with higher income and better education (Chinn & Fairlie, 2007). The Domestic Digital Divide, shows whether there is a division among factors such as gender, age, educational attainment, and income level within the same society (Cuervo & Menendez, 2006). Keniston (2003) discussed the digital divide in three dimensions as the result of his analytical reviews. The first of these exists within every nation, industrialized or developing, between individuals who are rich, educated, and powerful, and those who are not, the second one is linguistic

1 They considered the digital divide concept as the inequality in information access.

and cultural (stated as a relatively less noted situation), and the third one is the divide between the rich and poor nations. Kennedy (2003) argued that there was a digital divide between women and men within the same nation and found that women spent less time on the internet due to their domestic responsibilities. Kılıç (2011) stated that in Turkey, in addition to the disparities between low-income and high-income families, significant divides were also observed between regions and educational levels and consequently this caused serious gaps between regions within the country as well. Tsetsi & Rains (2017) measured the digital divide over smartphone dependence and argued that in the United States, smartphone dependence was correlated with race, gender, age, education. and income level and that there was a gap between the group categories.

## 4. Research

In the present study, the overall profile of those engaged in e-commerce in Turkey was identified first. Then, this profile was examined in terms of what factors of engagement in e-commerce caused the digital divide and which factors were ineffective in the digital divide. The variables used in the research, are given in Table 1.

**Table 1.** Research variables

| Variable | Scale | Category Number |
|---|---|---|
| Engagement in e-commerce | Nominal | Yes – No |
| Gender | Nominal | Male – Female |
| Age | Ordinal | [16-25], [26-35], [36-45], [46-55], [56-65], [66-74] |
| Education | Ordinal | Literate but did not finish any school, Primary School, Secondary School, High School, Two-year vocational college, Four-year license, Postgraduate, Doctoral graduates |

Most of the research variables are categorical. Therefore, the "age" variable, which takes place in the original questionnaire numerically, was examined by dividing into categories, within the scope of the study.

### 4.1. Purpose and Scope of Research

TURKSTAT regularly conducts "Information and Communication Technology (ICT) Usage Survey on Households and Individuals" every year since 2003. In this study, the data of the Information and Communication Technology (ICT) Usage Survey on Households and Individuals from 2016, which was most recently published by TURKSTAT, was used and an analysis was carried out. The purpose of the research was to determine whether there was a digital divide originating from e-commerce. To this end, 14,236 people, in the age range of 16-74, who answered the question of whether or not to engage in e-commerce, were included in the survey.

### 4.2. Research Methods

In field surveys conducted in the Social Sciences, categorical data analysis occupies a large volume. These are frequently used in the analysis of nominal variables, ordinal variables, and discrete variables with a limited number of categories. In research performed utilizing

categorical data, creating contingency tables has great importance. These tables might be two-way, small-sized, or can also be arranged in larger dimensions and ways. In such cases, frequently used categorical data analysis methods such as Pearson's Chi-Square Test remain insufficient. In three or more dimensional tables, advanced contingency methods are used to determine relationship structures better. Examples of these methods are Log-Linear Models, Correspondence Analysis, and Latent Class Analysis.

### *Non-Parametric Tests*

Non-parametric tests have an important and extensive place, especially in the analysis of nominal and ordinal scale variables, which are not based on any assumptions about the population distributions and are frequently used in social sciences. One of the most well-known non-parametric statistical techniques is the Pearson Chi-Square ($\chi^2$) test showing Chi-square ($\chi^2$) distribution developed by Karl Pearson in 1900. In this test, which examines the independence between two nominal categorical variables, independence is tested in the null hypothesis. Another test that is used to investigate the independence of the categorical variables included in the contingency tables and which is again Chi-Squared ($\chi^2$) is the Likelihood Ratio Chi-Square (*G2*) test. It is claimed that the *G2* statistic is a more favorable test statistic than the $X^2$ statistic, in larger dimension contingency tables (Çilan, 2009).

$$G^2 = 2\sum n_{ijk} \log\left(\frac{n_{ijk}}{\hat{\mu}_{ijk}}\right), \qquad X^2 = \sum \frac{\left(n_{ijk} - \hat{\mu}_{ijk}\right)^2}{\hat{\mu}_{ijk}} \tag{1}$$

Examples of independence tests used in Nominal-Ordinal tables include Mann-Whitney/Wilcoxon and Kolmogorov Smirnov tests, and examples of independence tests used in Ordinal-Ordinal tables include the Jonckheere-Terpstra, Linear Trend Alternative to Independence, and Cochran-Armitage trend tests. These tests are used only for the examination of the two-way relationship. For this reason, in addition to the above tests, it is necessary to examine the multi-way contingency tables as well. In particular, if there is a control variable that is thought to influence the relationship between the two variables, it must be included in the model. Thus, it can be possible to investigate whether the categories of the control variable affect the relationship between the two categorical variables. The Cochran-Mantel-Haenszel test is one of the important tests showing these associations. Log-Linear Models, in which relationships with three-way and more are detected and in which interactions between variables are included in the model, are also used in this research.

### *Log-Linear Models*

Log-Linear Models are mainly used to specify the associations and interactions between categorical data showing Poisson distribution (Agresti, 1996, p.145). In the literature, these models are generally divided into four groups. These are,

Independence Models;

$$\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C \quad (2)$$

It is estimated when the variables A, B, and C are independent of each other, in other words, when there are no binary and triple interactions.

Conditional Independence Models;

$$\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} \quad (3)$$

It is used when one of the variables is dependent on the other two variables and when these two variables are inter-independent. Equation 3, as an example, is based on the assumption that variables B and C are inter-independent but related to variable A.

Homogeneous Association Models;

$$\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} \quad (4)$$

These are the models which contains both the respective effects of the three variables and all their binary interactions with each other.

Saturated Models;

$$\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} + \lambda_{ijk}^{ABC} \quad (5)$$

It is estimated in the case when all one-way, two-way and three-way associations that can be formed using variables are meaningful.

### 4.3. Analysis Results

According to the data obtained from TURKSTAT's Information and Communication Technology (ICT) Usage Survey on Households and Individuals 2016, there were 14,236 people from the age group 16-74 who responded to the question of whether or not engaging in e-commerce. Accordingly, in Turkey, the proportion of those who at least once over the past year engaged in e-commerce is 28.5%. 54.2% of those engaging in e-commerce are male and 45.8% female. In addition, those between the ages [16-25] comprise 27.2% of the e-commerce users, those between the ages [26-35] comprise 28.7%, those between the ages [36-45] comprise 24.2%, those between the ages [46-55] comprise 13.2%, those between the ages [56-65] comprise 5.6%, and those between the ages [66-74] comprise 1.2%. According to the education levels, 22.8% are primary school + literate uneducated individuals, 52.5% are secondary school + high school graduates, 22.3% are 2-year + 4-year faculty graduates and 2.5% are postgraduate and doctoral graduates.

Whether or not the gender affects engagement in e-commerce was first investigated by Pearson Chi-Square and Likelihood Ratio tests, and no relation was found, according to the results in Table 2. Accordingly, gender does not affect engagement in e-commerce.

**Table 2.** Results of Pearson Chi-Square & Likelihood Ratio Tests

| | Pearson Chi-Square | | Likelihood Ratio | |
|---|---|---|---|---|
| | *Value* | *Asym. Sig* | *Value* | *Asym. Sig* |
| e-commerce & gender | 0.001 | 0.971 | 0.001 | 0.971 |

The Cochran-Mantel-Haenszel Test was applied to examine whether there was a relationship between e-commerce and gender, also at different education levels in addition to the dual interaction. When the "Education level" was considered as the control variable here, the results are given in Table 3. Accordingly, it was determined, with $p = 0.465$ and $p = 0.478$ probabilities, that engagement-nonengagement in e-commerce was not related to gender; that is, similar results were obtained with Chi-square tests.

**Table 3.** Results of Cochran-Mantel-Haenszel Test

| | Chi-Squared | Asymp. Sig. |
|---|---|---|
| Cochran's | 0.533 | 0.465 |
| Mantel-Haenszel | 0.504 | 0.478 |

Whether or not the engagement in e-commerce is related to the ordinal variables "age" and "education" were examined via Mann-Whitney U & Wilcoxon W Tests. According to the results in Table 4, the status of engaging in e-commerce is related to the variables "education" and "age".

**Table 4.** Results of Mann-Whitney U & Wilcoxon W Tests

| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. |
|---|---|---|---|---|
| e-commerce & age | 18197209.500 | 26416694.500 | -11.382 | 0.000 |
| e-commerce & education | 11514846.000 | 63356499.000 | -45.184 | 0.000 |

According to the results of the Jonckheere-Terpstra test, which analyzes the relation between Ordinal-Ordinal variables, there is a relation between the "age" and "education" variables (probability $p = 0.000$). Finally, the relationship between gender and education were also examined and found to be related by a probability of $p = 0.000$.

The odds ratios between the education and age variables, which were found to be relevant, were calculated. The odds ratio between the education level variable, which was rearranged as "pre-high school" and "post-high school", and the e-commerce engagement-nonengagement variable is 5.54. In other words, those with high school and above education levels are approximately 5.54 times more likely to engage in e-commerce. The odds ratio between the age variable, which was rearranged as "under the age of 45" and "over the age of 45", and the e-commerce engagement-nonengagement variable is 2.32. In other words, the probability of engaging in e-commerce for those under the age of 45 is *approximately* 2.32 times more.

The relationships found between e-commerce, gender, and education variables are summarized in Figure 1. According to this, it was observed that gender does not create any discrimination in the case of engaging in e-commerce, however, those who engage in e-commerce and those who do not, differ according to their education levels. In addition, the level of education as well was found to be dependent on gender.

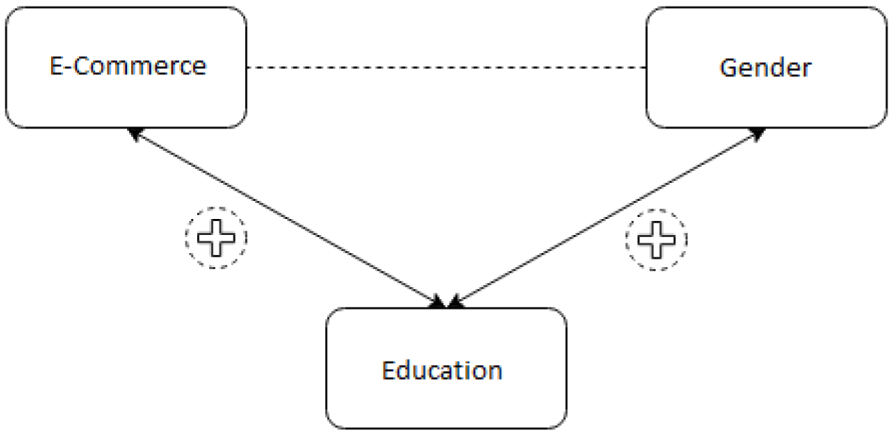


**Figure 1.** E-Commerce, Gender, Education relationship

All the Log-linear models that can be set up in the light of the above information and in the direction of the models proposed by Agresti are given in Table 5.

**Table 5.** Three-way Log-Linear Models between E-Commerce, Gender, Education

| Model | Goodness-of-Fit | | | | |
|---|---|---|---|---|---|
| | Likelihood Ratio | Sig. | Pearson Chi-Square | Sig. | S.D. |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C$ | 2194.31 | 0.000 | 2191.58 | 0.000 | 10 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB}$ | 2194.31 | 0.000 | 2191.48 | 0.000 | 9 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ik}^{AC}$ | 13.939 | 0.052 | 13.835 | 0.054 | 7 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{jk}^{BC}$ | 2182.85 | 0.000 | 2170.30 | 0.000 | 7 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ik}^{AC} + \lambda_{jk}^{BC}$ | **2.475** | **0.649** | **2.478** | **0.649** | **4** |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{jk}^{BC}$ | 2182.85 | 0.000 | 2170.26 | 0.000 | 6 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC}$ | 13.938 | 0.030 | 13.835 | 0.032 | 6 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC}$ | **1.942** | **0.585** | **1.945** | **0.584** | **3** |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} + \lambda_{ijk}^{ABC}$ | 0.000 | 0.000 | 0.000 | 0.000 | 0 |

Table (Agresti, 2002, p.320) A=E-Commerce B=Gender C=Education

When Table 5 is examined, it shows that only two models are significant. Among these models, the model with high goodness-of-fit is the model that at the same time comprises the associations (dual interactions) which are also found in non-parametric test results. In this case, the selected log-linear model is the conditional independence model which is indicated as follows:

$$\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} \quad (6)$$

According to the model shown by Equation 6, the dual interactions of E-Commerce & Education and Gender & Education are also included in the model. The parameter estimates pertaining to this model are given in Table 6.

**Table 6.** Parameter Estimates

| Parameters | Estimated Value | Standard Error | Z Value | Sig. |
|---|---|---|---|---|
| Invariant | 3.634 | 0.121 | 29.997 | 0.000 |
| [E-Commerce = 1.00] | 0.942 | 0.118 | 7.952 | 0.000 |
| [E- Commerce = 2.00] | 0 | . | . | . |
| [Gender = 1.00] | 0.479 | 0.110 | 4.376 | 0.000 |
| [Gender = 2.00] | 0 | . | . | . |
| [Education = 1.00] | 3.616 | 0.124 | 29.184 | 0.000 |
| [Education = 2.00] | 4.222 | 0.123 | 34.461 | 0.000 |
| [Education = 3.00] | 2.850 | 0.125 | 22.714 | 0.000 |
| [Education = 4.00] | 0 | . | . | . |
| [E-Comm = 1.00] * [Educat = 1.00] | -3.377 | 0.135 | -25.029 | 0.000 |
| [E- Comm = 1.00] * [Educat = 2.00] | -2.096 | 0.122 | -17.247 | 0.000 |
| [E- Comm = 1.00] * [Educat = 3.00] | -0.738 | 0.124 | -5.963 | 0.000 |
| [E- Comm = 1.00] * [Educat = 4.00] | 0 | . | . | . |
| [E- Comm = 2.00] * [Educat = 1.00] | 0 | . | . | . |
| [E- Comm = 2.00] * [Educat = 2.00] | 0 | . | . | . |
| [E- Comm = 2.00] * [Educat = 3.00] | 0 | . | . | . |
| [E- Comm = 2.00] * [Educat = 4.00] | 0 | . | . | . |
| [Gender = 1.00] * [Educat = 1.00] | -0.370 | 0.115 | -3.221 | 0.001 |
| [Gender = 1.00] * [Educat = 2.00] | -0.297 | 0.112 | -2.655 | 0.008 |
| [Gender = 1.00] * [Educat = 3.00] | -0.317 | 0.115 | -2.751 | 0.006 |
| [Gender = 1.00] * [Educat = 4.00] | 0 | . | . | . |
| [Gender = 2.00] * [Educat = 1.00] | 0 | . | . | . |
| [Gender = 2.00] * [Educat = 2.00] | 0 | . | . | . |
| [Gender = 2.00] * [Educat = 3.00] | 0 | . | . | . |
| [Gender = 2.00] * [Educat = 4.00] | 0 | . | . | . |

When the Z values of one-way relation terms are examined, it shows that the most important factor determining the frequencies in the contingency table is “education”. It also shows that dependence exists between the variables of e-commerce & education and education & gender. It is understood that engagement in e-commerce is dependent on education and this dependency is mostly in groups with education categories 1, 2, 3. It is not possible to mention any relationship between education and the status of not engaging in e-commerce. Furthermore, it is seen that education is dependent on gender and this dependence is mostly on men and in groups with education categories 1, 2, 3. However, looking at the Z values, this dependence is not as high as between e-commerce and education.

In addition, the Poisson distribution of this selected model is shown in Figure 2, and the observed and expected frequencies and percentages are given in Table 7.

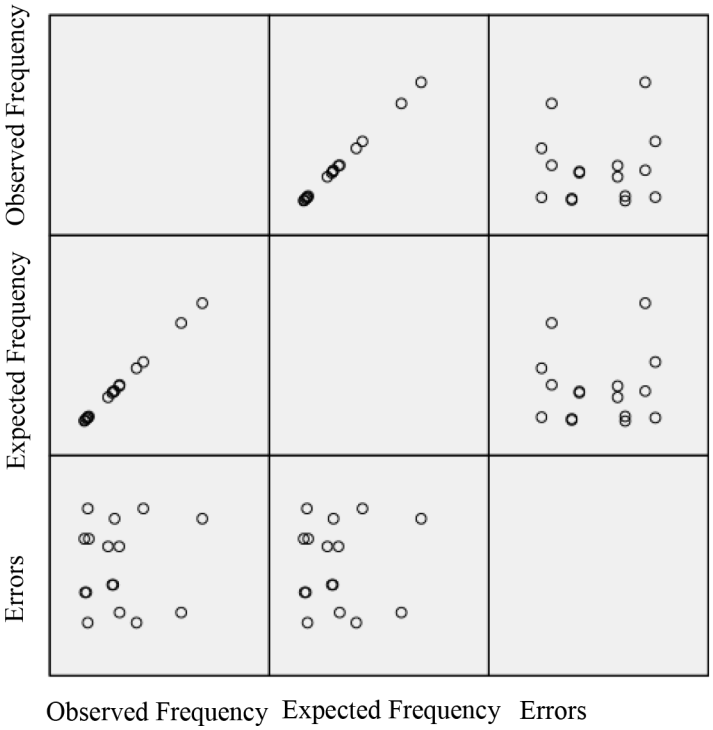


**Figure 2.** Poisson Model

**Table 7. Observed and Expected Frequencies**

| Gender | Education | E-Commerce | Observed | | Expected (E) | |
|---|---|---|---|---|---|---|
| | | | Frequency | % | Frequency | % |
| Male | Primary School | Yes | 129 | 0.9% | 137.589 | 1.0% |
| | | No | 1579 | 11.1% | 1570.411 | 11.0% |
| | Secondary School | Yes | 960 | 6.7% | 976.778 | 6.9% |
| | | No | 3114 | 21.9% | 3097.222 | 21.8% |
| | High School | Yes | 950 | 6.7% | 944.790 | 6.6% |
| | | No | 765 | 5.4% | 770.210 | 5.4% |
| | Two-Year College | Yes | 159 | 1.1% | 156.861 | 1.1% |
| | | No | 59 | 0.4% | 61.139 | 0.4% |
| Female | Primary School | Yes | 132 | 0.9% | 123.411 | 0.9% |
| | | No | 1400 | 9.8% | 1408.589 | 9.9% |
| | Secondary School | Yes | 831 | 5.8% | 814.222 | 5.7% |
| | | No | 2565 | 18.0% | 2581.778 | 18.1% |
| | High School | Yes | 798 | 5.6% | 803.210 | 5.6% |
| | | No | 660 | 4.6% | 654.790 | 4.6% |
| | Two-Year College | Yes | 95 | 0.7% | 97.139 | 0.7% |
| | | No | 40 | 0.3% | 37.861 | 0.3% |

Log-Linear Models were re-established by taking "Age" variable instead of "Education" variable, but no meaningful model could be found according to the results in Table 8.

**Table 8.** Three-way Log-Linear Models between E-Commerce, Gender, Age

| Model | Goodness-of-Fit | | | | |
|---|---|---|---|---|---|
| | Likelihood Ratio | Sig. | Pearson Chi-Square | Sig. | S.D. |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C$ | 546.072 | 0.000 | 518.561 | 0.000 | 16 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB}$ | 546.071 | 0.000 | 518.678 | 0.000 | 15 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ik}^{AC}$ | 178.084 | 0.000 | 174.497 | 0.000 | 11 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{jk}^{BC}$ | 386.159 | 0.000 | 365.625 | 0.000 | 11 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ik}^{AC} + \lambda_{jk}^{BC}$ | 18.171 | 0.006 | 17.851 | 0.007 | 6 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{jk}^{BC}$ | 386.158 | 0.000 | 365.629 | 0.000 | 10 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC}$ | 178.082 | 0.000 | 174.498 | 0.000 | 10 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC}$ | 15.227 | 0.009 | 15.022 | 0.010 | 5 |
| $\ln \mu_{ijk} = \lambda + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} + \lambda_{ijk}^{ABC}$ | 0.000 | 0.000 | 0.000 | 0.000 | 6 |

## 5. Conclusion

In the digitalizing world, the internet and conveniences that it provides are drawing greater interest, day by day. Nevertheless, there are still regions in the world that do not have internet penetration, which results in a digital divide among individuals. In general, the digital divide is measured in two ways. The first is the difference between countries/regions in accessing the internet and computer technologies, and the second is the difference between individuals' access to the internet and computer technologies within the same country/region. In this study, according to the individuals' demographic structures in Turkey, the effect on the status of e-commerce engagement was investigated. In addition, it examined whether there was a digital divide between individuals who engaged in e-commerce and those who did not. Consequently, unlike other developing countries, in Turkey, it was determined that the status of engaging or not engaging in e-commerce did not vary by sex, that is, gender did not cause a digital divide. However, the status of engaging in e-commerce presented a significant difference according to education levels. Parallel to the literature, also in Turkey, as educational levels increase the number of people who use e-commerce applications rise. According to the analysis carried out via MicroData Set, 2016 of TURKSTAT's Information Technologies Usage Survey on Households, the probability of engaging in e-commerce for those with high school and above education levels is *approximately* 5.54 times higher. It is argued that the digital divide exists between individuals in Turkey, according to their educational levels. It was suggested to increase digital literacy first in order to see a a decrease in the

digital divide. The rise in digital literacy will cause a proliferation of internet usage and an increase in transactions over the Internet. Besides, individuals should benefit more from the price advantage and convenience provided by e-commerce.

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Available online at www.iujtl.com

Journal of Transportation and Logistics
5 (2) 2020

**DOI:** 10.26650/JTL.2020.0014

RESEARCH ARTICLE

# Settlement of Railway Track on Reinforced Ballast Overlain by Clayey

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**ABSTRACT**

Air transportation development is strictly related to airport competitiveness, since the airport management seeks to improve the capacity to produce services, increase passenger and aircraft movement, improve revenues from aeronautical and non-aeronautical activities, and optimise the other items related to the competitiveness of this type of organisation. In this sense, this study seeks to identify variables associated with the competitiveness of airports, based on their infrastructures, operations, and locations, which can influence the decision-making of airport managers continuously and efficiently. An analysis of the seven busiest Brazilian airports, in terms of aircraft and passenger movement, has been made, and multivariate data analysis has been used through a multiple regression, verifying the relationship between the variables of airports competitiveness, such as the total area of the airport site, number of aircraft parking positions, number of airlines, quantity of aircraft movement-landings and takeoffs, total number of passengers and the GDP of the city where the airport under study is located. The results present an index of competitiveness for each airport analysed after the data mathematical treatment, showing the coefficients at the general equations form aircraft and passenger movement.

**Keywords:** Air Transport, Competitiveness Index, Mathematical Modelling

**Submitted:** лн◊лс◊нлнл • **Accepted:** лс◊мл◊нлнл

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**Citation:** Fattah, Y.M., Al-Qaissi, M.R.M. & Aswad, M.F. (2020). Settlement of railway track on reinforced ballast overlain by clayey. *Journal of Transportation and Logistics, 5*(2), 105-128. https://doi.org/10.26650/JTL.2020.0014

## Introduction

Railroad ballast consists of open graded crushed stone used as a bed for railroad track to provide stability. It plays a significant role in providing vertical and lateral support for the track base and distributing the load to the weaker subgrade below. Ballast also helps with drainage, which is an important factor for any type of transportation structure, including railroads.

Track maintenance operations are very time consuming and costly. In addition, trains have become much heavier and faster than in the past, while track conditions have not been substantially improved. The primary potential advantage of geogrids is to extend the maintenance cycle through reinforcement of the ballast. It is also possible to reinforce the sub-ballast which increases the bearing capacity of soft subgrade.

Oxford University carried out model footing experiments to investigate the benefit of reinforcing a granular layer over soft clay. The test consistently demonstrated a 40% improvement in bearing capacity. It was concluded that the interlocking mechanism of the polymer grid resisted tensile strains preventing lateral movement of particles in the loaded area (Milligan and Love, 1984). Data from the test indicated that the mean angle of load spread increased from 38 degrees in the unreinforced case to more than 50 degrees with a polymer grid. It was concluded that a reinforced granular layer can reduce construction thickness by approximately 50% to achieve a similar stress on the subgrade.

Research carried out at the University of Waterloo, Canada, showed a 300% increase in the number of load applications in reinforced pavement. In their tests, asphalt pavement sections were laid over a granular base layer. A test load of 40 kN applied via a 300 mm diameter circular plate was used representing a standard 80kN design axle (Haas et al., 1988). It was observed that a 200 mm reinforced section sees a threefold increase in load applications to reach a given settlement. Interestingly, the 100 mm reinforced section performed as well as the 200 mm control. The test was performed with CBRs ranging from 0.5 to 8%. This validates the results over a range of subgrade conditions.

In the mid-1980s, the United Kingdom's Transport and Road Research Laboratory (TRRL - now known as TRL) investigated the effect of polymer grid reinforcement on rut depth. Comparable findings to those of the University of Waterloo were obtained. Geogrid reinforcement for a given sub-base thickness carried 3.5 times more traffic.

Chan (1990) did a series of full-scale experiments to investigate the influence of Geosynthetics on the permanent deformation characteristics of granular bases in pavement. In his experiments, different types and stiffnesses of Geosynthetics were considered as well as varying placement levels in the granular base. It was concluded that the permanent deformation resistance of most geosynthetic-reinforced granular bases was improved. The improvement level depends largely on the quality and thickness of the granular base as well as the location of the geosynthetic within the base.

For weak granular bases, e.g. low elastic stiffness, such as those constructed of sand and gravel, a significant improvement in permanent deformation resistance was achieved with

the introduction of a polymer grid. The effect is most obvious with the grid installed either in the middle or at the bottom of the layer. A stiffer grid also produced better results with the large vertical deformations and high stresses which Chan applied to this granular base.

Chan concluded that there is minimal benefit if the geosynthetic is placed too far down in the layer. In his opinion, placing geosynthetics at the middle of a base layer, not exceeding 200mm depth, gives an optimum improvement. Chan also noted that geogrid performs better than geotextile in terms of reducing permanent deformation, even where it has a lower stiffness. He attributed this to the interlocking effect of the geogrid.

Raymond (2001) studied the behavior of reinforced ballast subjected to repeated loading. The performance of a thin layer of granular material, reinforced and unreinforced was studied, when acting as a foundation material under repeated loading. Compressibility of the subgrade was varied through the use of rubber layers. Raymond concluded that grid reinforcement reduces plastic settlement by 13-30%. It was noted that a bigger improvement was observed when the foundation was weak. It was later deduced that the inclusion of a geogrid on railway track bed can extend the existing 3-month maintenance cycle to a cycle of over 3 years.

Chen (2007) carried out four series of tests, small-scale laboratory tests on silty clay soil, small scale laboratory tests on sandy soil, small-scale laboratory tests on Kentucky crushed limestone, and large-scale field tests on silty clay embankment soil. The influences of different variables and parameters contributing to the improved performance of reinforced soil foundation (RSF) were examined. The investigated parameters included top layer spacing ($u$), number of reinforcement layers ($N$), vertical spacing between reinforcement layers ($h$), tensile modulus and type of reinforcement, embedment of the footing ($Df$), shape of footing, and type of soil. An axisymmetric finite element analysis with three series of reinforcement layout strategies was performed to study the scale effect on the results of model footing tests. It was found that the inclusion of reinforcement generally resulted in increasing the ultimate bearing capacity of soils and reducing the footing settlement. The optimum depth for the first reinforcement layer was estimated to be at about 0.33B (B is the footing width) below the footing for all soil types tested in the study. The bearing capacity of reinforced soil increases in tandem with reinforcement layers (at the same vertical spacing). However, the significance of an additional reinforcement layer decreases with the increase in the number of layers. The reinforcing effect becomes negligible below the influence depth. The influence depth of reinforced sand was obtained at approximately 1.25 B in this study, regardless of the type of reinforcement and footing embedment depth, while the influence depth of geogrid and geotextile reinforced silty clay was obtained at about 1.5B and 1.25B, respectively. The bearing capacity ratio (BCR) decreases with increasing vertical spacing of reinforcement layers. Geogrid beyond the effective length (4.0~6.0B) results in insignificant mobilized tensile strength, and thus provides negligible reinforcement benefit. The inclusion of reinforcement will redistribute the applied load to a wider area, thus minimizing stress concentration and achieving a more uniform stress distribution, and thus improving the bearing capacity of soil.

Abu-Farsakh et al. (2008) made a series of laboratory model tests on silty clay embankment soil. The aim of the study was to investigate the potential benefits of using the reinforced soil foundations to improve the bearing capacity and reduce the settlement of shallow foundations on soils. The influences of different variables and parameters contributing to the improved performance of reinforced soil foundation were examined in these tests. The test results showed that the inclusion of reinforcement can significantly improve the soil's bearing capacity and reduce the immediate footing settlement. The geogrids with higher tensile modulus performed better than geogrids with lower tensile modulus. The strain developed along the reinforcement is directly related to the settlement, and therefore higher tension would be developed for geogrid with higher modulus under the same footing settlement. The test results also showed that the inclusion of reinforcement will redistribute the applied load to a wider area, thus minimizing stress concentration and achieving a more uniform stress distribution.

Heidari and El Naggar, (2010) investigated the effect of the soil reinforcement on the performance characteristics for different configurations of shock absorbing foundations. The results showed that soil reinforcement can be used to increase the stiffness of the supporting medium. This increase can be designed to achieve a superior dynamic performance for shock-producing equipment when the mounting system alone cannot achieve a satisfactory design. It was shown that for small hammers, that the reinforced soil foundation can reduce the foundation response amplitude by up to 80%. For large hammers and presses, the reinforced soil foundation can be designed to reduce the foundation response by up to 60% in the case of no soil reinforcement.

Fattah et al., (2010) analyzed a strip footing resting on a reinforced granular trench by the finite element method. The angle of friction of the trench soil, the modulus of elasticity of the reinforcement material, the depth, width and shape of the granular trench, the locations, and number of the reinforcement layers were studied. The results showed that using a granular trench beneath foundations will increase the bearing capacity and reduce the settlement. Moreover, using polymers as a reinforcement material has a significant effect on both bearing capacity and settlement.

Hayano et al., (2013) studied the effects of ballast thickness and tie-tamper repair on the settlement characteristics of ballasted tracks by conducting a series of cyclic loading tests on model grounds. Results suggest that the 250 mm ballast thickness, currently adopted as the standard design, is ineffective for minimizing settlement that occurs when the nonlinearity of roadbed compressibility is relatively moderate. Moreover, characteristics of the initial settlement process are altered significantly after tie-tamper implementation, although the degree of gradual subsidence undergoes minimal change regardless of ballast thickness and roadbed type.

Geeta et al., (2013) studied soil- foundation interaction by modeling a square footing to investigate the effect of different types of geogrid on settlement, contact pressure and elastic strain. Performance levels of geogrids made from three different types of polymer have been tested. These polymers are: polypropylene (PP), polyester (PET) and non-polymer (NP).. An analysis was carried out by using the computer software

program ANSYS with a two dimensional linear 8-noded isoperimetric element. The results indicated that at ratio (u/B=2), the contact pressure and elastic strain values become insignificant for two-layered reinforced soil conditions (where u is the depth of the first reinforcing layer from the base of the footing and B is the footing width). Geogrid efficiency increases with the increased thickness of the geogrid reinforcement up to a certain limit. When the increase in thickness goes beyond the ratio h/B=1, the reduction in settlement is marginal (where h is the spacing between reinforcing layers). Using the geogrid made from polypropylene (PP), the reduction in settlement value, contact pressure value as well as elastic strain value were found to be consistently higher as compared to other two cases (PET and NP).

Extensive laboratory tests were conducted by Fattah et al. (2019) to investigate the effect of load amplitude, geogrid position, number of geogrid layers, thickness of ballast layer and clay stiffness on the behavior of the reinforced ballast layer and induced strains in a geogrid. A half-scale railway was constructed for carrying out the tests. It was concluded that the amount of settlement increased as the simulated train load amplitude increased, and there was a sharp increase in settlement up to cycle 500. The increased amount in settlement depended on the presenceof the geogrid and other parameters studied. The transmitted average vertical stress for ballast thicknesses of 30 cm and 40 cm increased as the load amplitude increased, regardless of the ballast reinforcement for both soft and stiff clay. The position of the geogrid had no significant effect on the transmitted stresses. The value of the soil pressure and pore water pressure on ballast thicknesses of 20 cm was higher than for 30 cm and 40 cm thicknesses. This meant that the ballast attenuated the induced waves. The soil pressure and pore water pressure for reinforced and unreinforced ballast was higher in stiff clay than in soft clay.

The objective of the present study is to understand the mechanics of geogrid reinforced ballast degradation resting on clayey soil. The research is directed at investigating the benefits of using geogrid reinforcement in minimizing the rate of deterioration of ballasted rail track geometry resting on clayey soil due to dynamic load, and to explore the effect of load amplitude and the position of geogrid layer in ballast layer on the parameters mentioned up on.

The novelty of this study is experimental exploration of the advantages of utilizing geogrid as reinforcement to minimize the amount of degradation of ballast under railway track bases resting on clayey soil.

## Laboratory Work and Model Preparation

The laboratory test work consists of laboratory model tests to investigate the reduction in the compressibility and stress distribution induced in soft clay under a ballast railway reinforced by geogrid reinforcement subjected to dynamic load. An experimental model based on an approximate half scale for general rail track engineering practices, currently used in Iraqu railways, was adapted for this study. The investigated parameters are load amplitude, geogrid position, number of geogrid layers and thickness of ballast layer.

## 2.1 Soil and materials used

**B**rown clayey soil was brought from a site in Baghdad. Standard tests were performed to determine the physical properties of the soil. Details are given in Table 1. Grain size distribution of the soil used is shown in Figure 1. According to the Unified Soil Classification System (U.S.C.S.), the soil is classified as CL. A consolidation test was performed for soft and stiff clay states. Table 2 lists the consolidation test results for both soil states.

The ballast was obtained from a private crushed stone factory. It was produced as a result of crushing big stones; the ballast is of white color with angular shapes. Particle size distribution is shown in Figure 2 and the effective size, uniformity coefficient and coefficient of gradation are listed in Table 3. The ballast is of uniform size with poorly graded gradation (GP) according to the .U.S.C.S.

The geogrid used in all tests was manufactured by Tensar type SS2( Figure 3a.) Its engineering properties are shown in Table 4, as provided by the manufacturing company. The sheet of geogrid was used from test to test but was replaced whenever it became visibly overstressed or damaged, as shown in Figure 3b.

**Table 1.** Physical properties of used clay.

| Test | Value | Specification |
|---|---|---|
| Liquid Limit (LL), % | 46 | ASTM D 4318-00 |
| Plastic Limit (PL), % | 21 | ASTM D 4318-00 |
| Plasticity Index, % | 25 | ASTM D 4318-00 |
| Specific gravity (Gs) | 2.65 | ASTM D854-00 |
| Gravel %, > 4.75, mm | 0 | ASTM D 422-00 |
| Sand %, 0.075-4.75, mm | 4 | ASTM D 422-00 |
| Silt %, 0.005-0.075, mm | 37 | ASTM D 422-00 |
| Clay %, < 0.005 mm | 59 | ASTM D 422-00 |

**Table 2.** Consolidation test results for soft and stiff clay.

| Parameter | Soft State | Stiff State |
|---|---|---|
| Undrained shear strength, $C_u$ | 20-25 kN/m$^2$ | ≈ 50 kN/m$^2$ |
| Initial void ratio, $e_o$ | 0.61 | 0.38 |
| Dry unit weight, $\gamma_{dry}$ | 16.6 | 19.3 |
| Saturated unit weight, $\gamma_{sat}$ | 21.6 | 23.4 |
| Compression index, $C_c$ | 0.18 | 0.1 |
| Swelling index, $C_r$ | 0.1 | 0.05 |

**Table 3.** Ballast particle size characteristics.

| Parameter | Value |
|---|---|
| $D_{60}$, mm | 21.59 |
| $D_{30}$, mm | 20.61 |
| $D_{10}$, mm | 18.35 |
| Coefficient of uniformity, $C_u$ | 1.18 |
| Coefficient of gradation, $C_c$ | 1.07 |
| $\gamma_{dry\ min}$, kN/m$^3$ | 10.21 |
| $\gamma_{dry\ max}$, kN/m$^3$ | 11.25 |
| $\gamma_{used}$, kN/m$^3$ | 10.92 |
| Relative Density | 70% |

**Table 4.** Tensar SS2 geogrid specification.

| Property | Units | |
|---|---|---|
| Polymer (1) | | PP |
| Minimum carbon black (2) | % | 2 |
| Roll width | m | 4.0 |
| Roll length | m | 50 |
| Unit weight | kg/m$^2$ | 0.29 |
| Roll weight | Kg | 60 |
| **Dimensions** | | |
| $A_L$ | mm | 28 |
| $A_T$ | mm | 40 |
| $W_{LR}$ | mm | 3.0 |
| $W_{TR}$ | mm | 3.0 |
| $t_J$ | mm | 3.8 |
| $t_{LR}$ | mm | 1.2 |
| $t_{TR}$ | mm | 0.9 |
| Rib shape | Rectangular | |
| **Quality Control Strength (longitudinal)** | | |
| $T_{ult}$ (3) | kN/m | 17.5 |
| Load at 2% strain (3) | kN/m | 7.0 |
| Load at 5% strain (3) | kN/m | 14.0 |
| Approx. strain at $T_{ult}$ | % | 12.0 |
| **Quality Control Strength (transverse)** | | |
| $T_{ult}$ (3) | kN/m | 31.5 |
| Load at 2% strain (3) | kN/m | 12.0 |
| Load at 2% strain (3) | kN/m | 23.0 |
| Approx. strain at $T_{ult}$ | % | 10.0 |
| **Junction strength as % of QC strength (4)** | | |
| Minimum junction strength | % | 90 |

(1) PP denotes polypropylene.

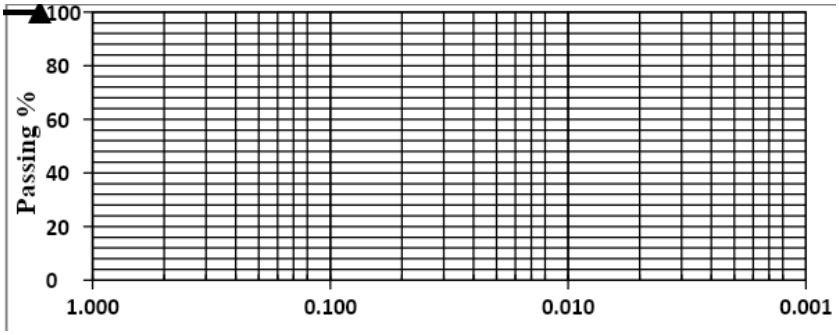



**Figure 1.** Grain size distribution for the clay.

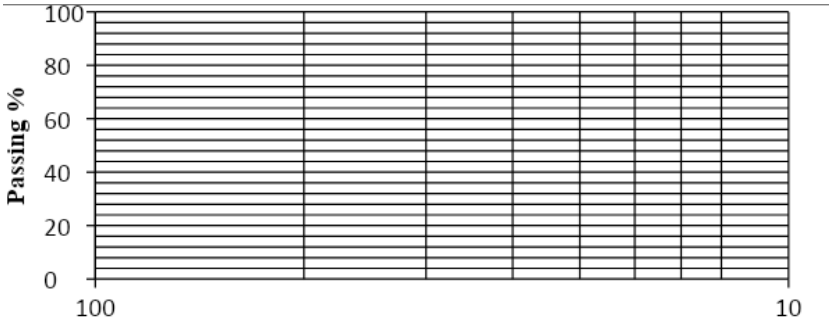
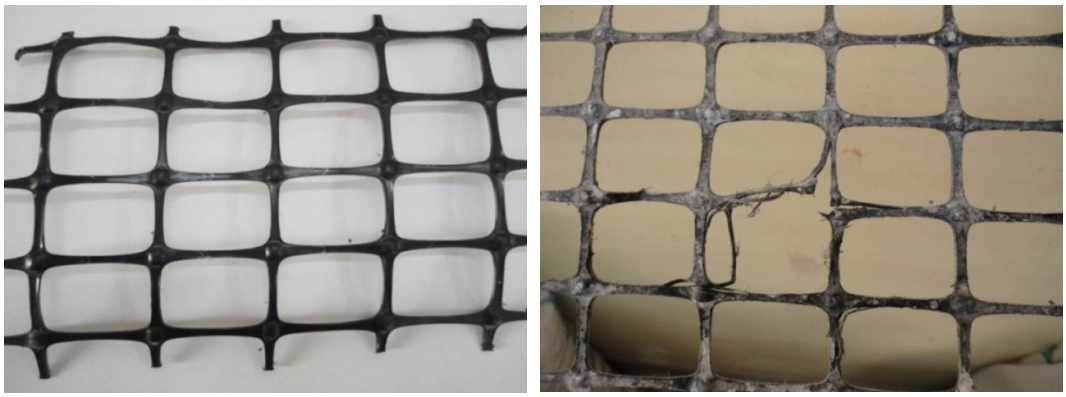



**Figure 2.** Grain size distribution for the ballast.



a. Before test. b. Damage in geogrid reinforcement used

**Figure 3.** Geogrid reinforcement used.

## 2.2 Model tests

### 2.2.1 Load setup design and manufacturing

To study the response of the railway loads on soft clay, it was necessary to simulate the conditions as close as possible to those occurring in the field. To achieve this aim, a special testing apparatus and other accessories were designed and manufactured. The apparatus had the capability of applying different dynamic loads under different frequencies.

The general view of the apparatus is shown in Figures 4 and 5.

The apparatus consists of the following:

Loading steel frame. 2. Hydraulic loading system. 3. Load spreader beam. 4. Data acquisition. 5. Shaft encoder. 6. Steel container.

### 2.2.2 Loading steel frame

To support and ensure the verticality of the hydraulic jack used in applying the central concentrated load, a steel frame was designed and constructed. The steel frame consisted mainly of four columns and four beams. Each column and beam was made of steel with a square cross section area of 100 mm×100 mm, and is 4 mm thick. The dimensions of the steel frame (length× width× height) were 1700 mm× 700 mm×1700 mm. To strengthen the steel frame, two vertical steel channels were welded.

A 20 mm thick steel plate with dimensions of 700 mm×500 mm was welded on the center of the frame in order to carry the hydraulic jack and the settlement measurement device (Encoder). The steel frame was fixed to the floor using four base plates of dimension 200 mm×200 mm×20 mm. Each base plate was fixed to the floor using four bolts.

### 2.2.3 Hydraulic loading system

As shown in Figure 6, the system consisted of a hydraulic steel tank with a capacity of 70 liters. The tank consisted of two holes; the upper one was used to fill the oil and the lower one is for discharge. The tank consisted of a gear type hydraulic pump with a fixed geometrical volume giving a discharge about 12 liter/min with a maximum pressure of 150 bars. The axis of the pump was connected by a coupling with a three phase electrical rotary motor of 3hp capacity and 1450 rpm rotation speed. The pump and the motor were fixed in housing on the upper surface of the tank.

During the rotation of the pump, it sent the hydraulic through a flexible hose to a distributional block where there were two directional valves fixed to it, the first one which worked in one direction was used as a key to lock the hydraulic in the system or send it back to the tank. This hydraulic valve was connected with another directional valve which controlled the moving of the hydraulic cylinder jack up and down (Figure 6). The movement of the hydraulic cylinder jack was controlled electrically by a programmable logic control (PLC), through which the movement (up and down) could be controlled by choosing the hearts that we need to control data acquisition. The data acquisition also displays the load magnitude that was applied on the rail. An 80 cm ×5 cm ×5 cm solid steel beam was used to apply the load on the track panel as shown in Figure 7.

The tests were carried out in a steel container with plan dimensions of 1.5 m length ×1 m width×1 m height. Each part of the container is made of a 5 mm thick steel plate. The container is made of five welded parts, one for the base and others for the four sides of the container. The long sides were braced externally by angles at their edges.

### 2.2.4 Data acquisition

Data acquisition was used to measure and sense the occurring displacement during the tests, which enabled the tests to obtain a large amount of data in a very short time. Moreover, it was used to choose the specified frequency used in the test.

The data acquisition was done using Programmable Logic Controller (PLC), which can be defined as a digital computer used for electro-mechanical automation processes, and it is a high-tech processing unit. This type of system analyzes the data digitally.

The program of Programmable Logic Controller (PLC) is executed repeatedly whenever the controlled system is running and then the data is saved in its memory..

A shaft encoder is an electro-mechanical device used to convert the motion of the shaft to digital code. The output of incremental encoders supply information of the motion of the shaft which is processed into information such as, displacement, revolution per minute (rpm), speed, and position.

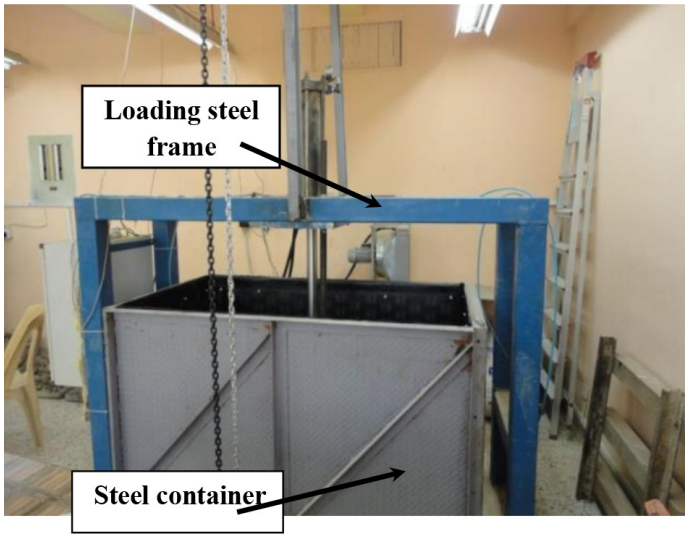



**Figure 4.** Steel frame of the loading system.

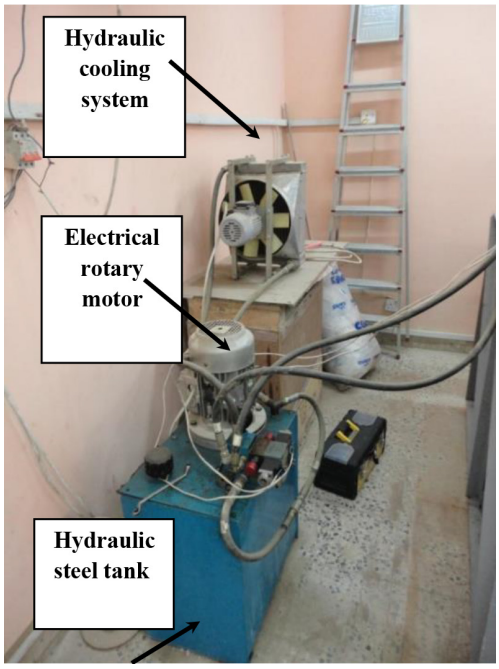



**Figure 5.** Hydraulic loading system.


**Figure 6.** Hydraulic cylinder jack.


**Figure 7.** Load spreader beam.

### 2.2.5 Instrumentation

A total of four Linear Variable Differential Transformers (LVDTs) were used to instrument the ends of the track panel. The LVDTs were used to measure the surface displacement of the railroad track to check it with the shaft encoder measurement.

## 2.3 Model preparation

### 2.3.1 Preparation of bed of soil

Prior to the preparation of the bed of soil, trial tests were performed to control the efficiency of the method of preparation. These control tests were carried out to check two main important points for the preparation of homogenous soft beds of soil. The first was to determine the variation of undrained shear strength with time at different water amounts

(25%, 28%, 32%, 35% and 40%). These tests specify the time required for the remolded soil to regain its strength after a rest period following the mixing process. To accomplish this, five samples were prepared individually and placed in three layers in molds. Each layer was tamped gently with a special hammer to extract any entrapped air. The samples were then covered with polythene sheet and left for a period of six days. The undrained shear strength was measured daily by using a portable vane shear device. It was found that the time required for the remolded soil to regain its strength was about three days.

The second test was to determine the variation of shear strength after the three days of mixing versus different liquidity indices. The results of the variation of the undrained shear strength with different liquidity indices are shown in Figure 8.

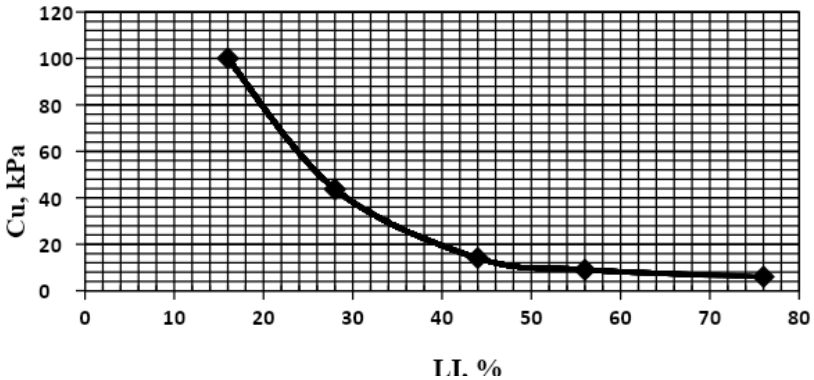



**Figure 8.** Variation of the undrained shear strength with liquidity index at 3 day curing.

### 2.3.2 Preparation of the ballast layer

The construction of the ballast layer started three days after the preparation of the soil bed. The ballast was placed carefully on the surface of the bed of soil in layers; each layer was not more than 100 mm thick. A predetermined volume of ballast was prepared which was sufficient to create a uniform layer. Each layer was compressed gently by a tamping rod to attain a placement dry unit weight of about 10.92 kN/m$^3$. This placement unit weight corresponded to a relative density of about 70%.

A half-scale railway was constructed for carrying out the tests. Two rails of 900 mm in length with three wooden slippers (900 mm x 90 mm x 90 mm) were used to construct the track panel (Figure 9). Three ballast thicknesses of 200, 300 and 400 mm were used in the tests, each side of the ballast was sloped down on about a 2:1 slope. The ballast was overlying 500 mm thick clay in both soft and stiff states. The tests were carried out with and without geogrid reinforcement. The angle of the slope of the ballast was controlled by maintaining alignment with markings on the wall of the box.

### 2.3.3 Test procedure

The test was carried out in a well tied steel box of 1.5 m length×1 m width ×1 m height. The box was padded with two layers, the first one consisting of compressed styropor sheets 5mm thick and the other one of 4mm thick rubber to prevent wave reflection during the test.

The box was filled with relatively soft clay which was placed in 100 mm layers to ensure the consistency and was compressed by plywood to a depth of 500 mm. After the placement of each layer, it was pressed gently with a wooden tamper in order to remove entrapped air.

The clay material used in the tests had a wet unit weight of 21.6 kN/m$^3$, moisture content of about 30% and a drained shear strength of about 25 kN/m$^{2.}$ It was placed in the box in its soft state with a wet density of 23.4 kN/m$^3$, moisture content of about 21% and a drained shear strength about 50 kN/m$^{2.}$ When it was placed in its stiff state, the liquid limit of the clay was found to be 46% while the plastic limit was 21%.

During preparation of the ballast layer, the geogrid was laid in a predetermined position, as specified in the reinforced ballast tests shown in Figure 10.

The track panel was then placed into its position, using manual chain hoists. A good seating on the surface of the ballast was achieved by tamping it carefully. Special care was given to the levelling of the track panel and sleeper at the position where the rail must be placed (Figure 11). Additional ballast was then added between and at ends of the sleepers to achieve restraint.

After preparing the model for test, it was carried and centered in the load setup and then the load-spreader beam was lowered carefully until it touched the rails. After that, the load and frequency was adjusted by the LCD touch-screen as required and then the test began.

The built-in displacement transducer records a measurement of central track panel displacement once the load comes into contact with the track panel. The jack load was applied through the load-spreader beam, which was connected to the jack in to the track panel and then to the rails and sleepers.

The hydraulic jack and the builtin displacement transducer were connected to control data acquisition. This control data acquisition stores control functions and acquires data. The data acquisition is then connected to a computer, which receives and stores the data.

The traffic loading simulation on the sleepers was executed by applying rectified sine wave loading. This type of loading was suggested by Awoleye (1993). It simulates a running train over three sleepers in which 50% of the wheel load transmits to the middle sleeper and 25% of the wheel load on both outer sleepers.

The frequency of loading in the test was up to 2 Hz. This frequency is considered very low when compared to the usual frequency in the track of approximately 8–10 Hz. This frequency, however, was associated with the pressure and flow capacity of the hydraulic loading system.

The effect of applying geogrid reinforcement was examined by the comparison of settlement magnitude, as well as the pressure and pore water pressure developed in the clay layer, which was performed in various tests with and without geogrid in the ballast layer. A flowchart of the testing program is shown in Figure 12.

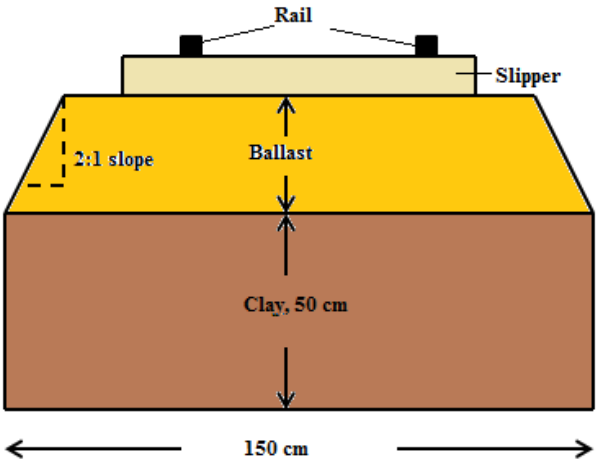



**Figure 9.** The laboratory test section.

**Figure 10.** Placing the geogrid.

**Figure 11.** Placing and leveling the track panel.

T= Test, A= Amplitude, f= frequency, No. = Number of Geogrid Layers

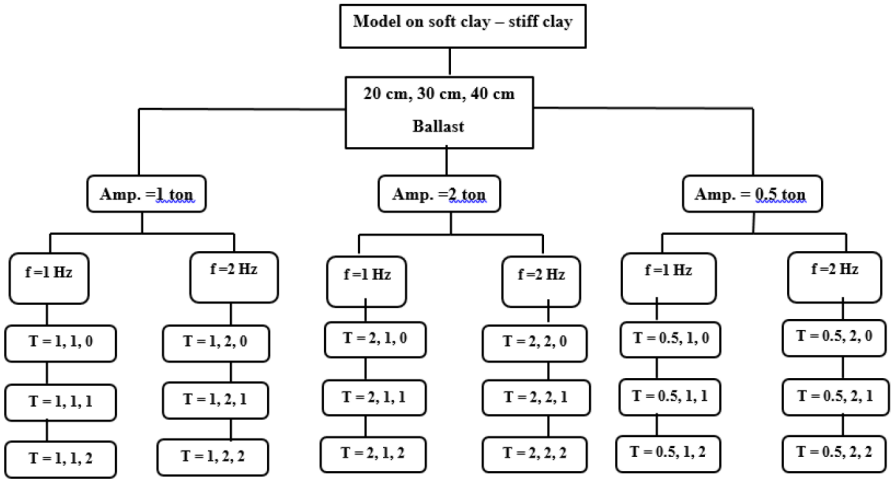



**Figure 12.** Flowchart of the testing program.

## 3. Experimental Results and Interpretation

This section presents the results of the laboratory tests that were conducted on the half-scale ballasted railway model; the ballast was resting on soft or stiff clay and the ballast was stabilized with geogrid. The model was subjected to a dynamic load by a dynamic load setup to represent the passage of the train on the rail road. Settlement in ballast and clay was investigated in reinforced and unreinforced ballast. The studied parameters were the load amplitude, geogrid position, number of geogrid layers and thickness of the ballast layer.

Figures 13 to 30 show the typical relationship of settlement versus number of cycles for different load amplitudes. In these figures for all sections, to focus only on the effect of the foregoing parameter, the other investigated parameters will be fixed.

The symbols used in the figures are defined as follows:

T: ballast layer thickness for soft clay tests, cm,

ST: ballast layer thickness for stiff clay tests, cm,

DT: ballast layer thickness with sand drains tests, cm,

A: load amplitude, ton,

f: load frequency, Hz,

NL: number of geogrid layers and layer position (h/T), and

h: position of geogrid layer in ballast layer from the upper surface of the clay layer.

Obviously as seen in these figures, the amount of settlement increased when the load amplitude increased, there was a sharp increase in settlement up to 500 cycles. After

that, there was a gradual increase, finally levelling out at between 2,500 to 4,500 cycles depending on the load frequency. These findings are consistent with those of Paute et al. (1996) who concluded that "there will be a decrease in the rate of permanent deformation in granular material under repeated loading and that it is possible to derive a limit value for the accumulation of permanent strain."

From the figures, it can be observed that there was little increase in the induced settlement when the load amplitude increased from 0.5 to 1 ton, but it was higher when the load amplitude increased to 2 tons, the increasing amount in settlement depending on the geogrid existence and the other studied parameters.

Figures 31 to 36 present the relationship between the load amplitude and settlement ratio S/T (settlement ratio is the cumulative settlement (S) divided by ballast thickness (T)) for soft and stiff clay layers. These figures show that for most cases and in all stages of the tests at low load amplitude (0.5 ton), that there was almost equal settlement for reinforced and unreinforced ballast layers. This is because at low load amplitude, the ballast acts as unreinforced material as a result of little strain occurring in the geogrid.

As seen from the figures, the effect of load amplitude on the settlement of the composite in the beginning of the tests was almost negligible with both reinforced and unreinforced ballast layer, so the settlement ratio difference was small between them. It increased with increasing numbers of cycles. This was likely due to ineffective interlocking between the ballast particles and the geogrid at the beginning of the test.

All the figures show that the initial settlement ratio for the 2 ton amplitude varied between 1-2 %, while for 0.5 and 1 ton amplitudes, it varied between 0.5-1 %. This observation includes reinforced and unreinforced ballast. This likely happened because of the high rearrangement of the ballast particles in the beginning of the test under the 2 ton load amplitude.

From Figures 34 to 36, it can be seen that there was little difference in the effect of load amplitude on the settlement ratio between reinforced and unreinforced ballast with stiff clay at the beginning of the test, especially at low load amplitude. While at 500 cycles and more of the test, especially at high load amplitude, the settlement ratio was lower for the unreinforced ballast than the reinforced. This is likely to happen because in stiff clay subgrade, there is little to no strain happening in the geotextile, which introduces a reduction in the interlocking between the ballast particles and geogrid, and a slip surface may occur at the geogrid surface at high load amplitude, which increases settlement. This is consistent with Rymond, (2001) who noted a large improvement in the grid-reinforced composite system when the foundation soil was weak.

Fattah et al. (2020), from finite element analysis, found that at low speed (30 km/hr), about 100 % of the total settlement appeared in the clay layer. After this speed, the percentage in settlement levelled out at about 80 % at the clay layer and 20 % at the ballast layer. For both reinforced and unreinforced models, the settlement percentage was about 95 % for the clay layer and about 5 % for the ballast layer at 30 km/hr, as the settlement percentage levelled out at about 80 % for the clay layer and 20 % for the ballast layer for speeds 60 km/hr and more.

The geogrid employs the effect of interlocking between granular particles. The granular particles penetrate the apertures of geogrid and are locked between the strands of geogrid. This mechanism of immobilization of the reinforced particles gives strong shear resistance, which reduces the lateral movement and increases the bearing capacity of the base layer.

As seen in these figures, the effect of load frequency on the settlement ratio was almost constant after 500 cycles. This is due to the total settlement almost reaching its peak value after 500 cycles, which means that the ballast particles became very close to each other, so the load frequency was less effective for the high-contact particle forces.

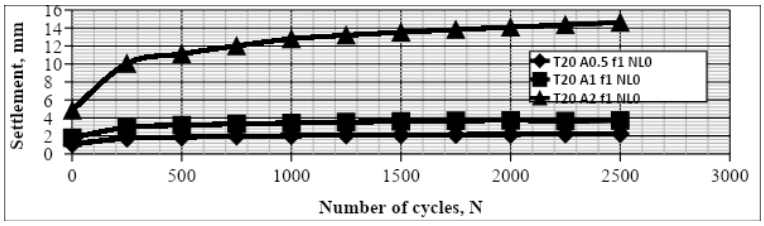



**Figure 13.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 1 Hz and without reinforcement.

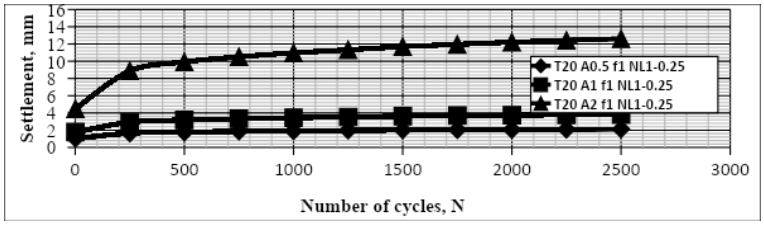



**Figure 14.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 1 Hz and with one layer reinforcement h/T=0.25.

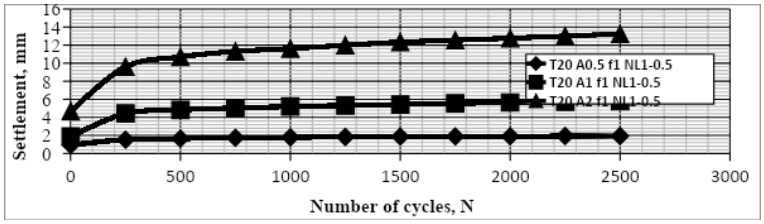



**Figure 15.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 1 Hz and with one layer reinforcement h/T=0.5.

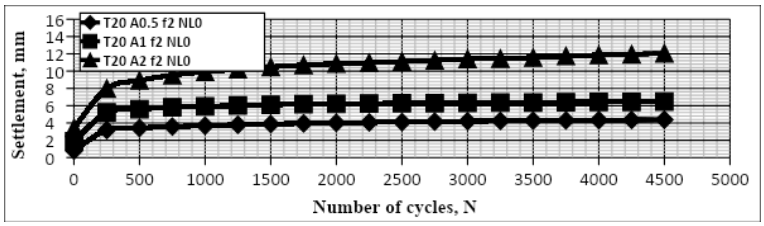



**Figure 16.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 2 Hz and without reinforcement.

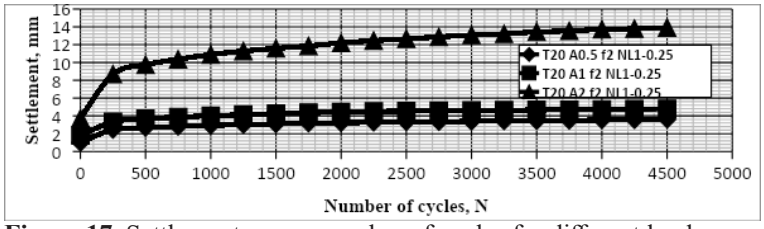



**Figure 17.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 2 Hz and with one layer reinforcement h/T=0.25.

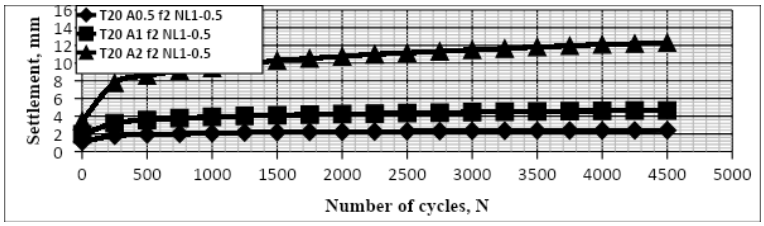



**Figure 18.** Settlement versus number of cycles for different load amplitudes with ballast thickness 20 cm, frequency 2 Hz and with one layer reinforcement h/T=0.5.

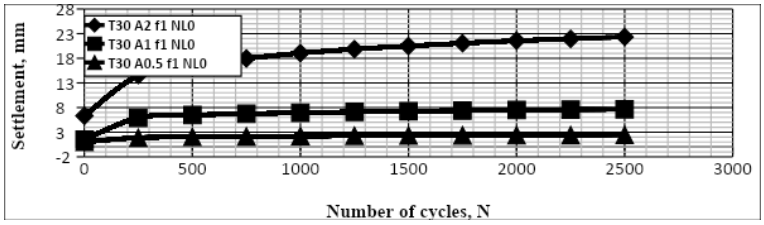



**Figure 19.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1 Hz and without reinforcement.

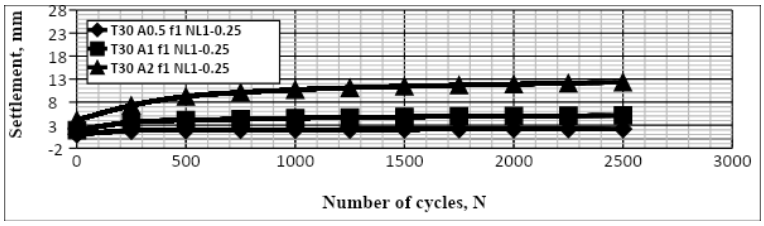



**Figure 20.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1 Hz and with one layer reinforcement h/T=0.25.

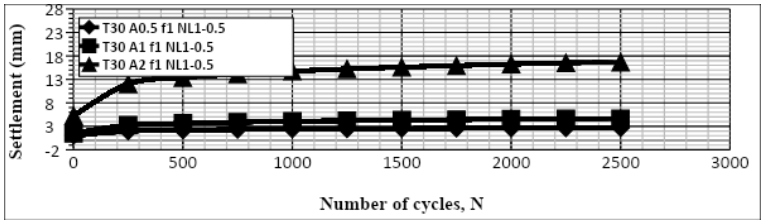



**Figure 21.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1 Hz and with one layer reinforcement h/T=0.5.

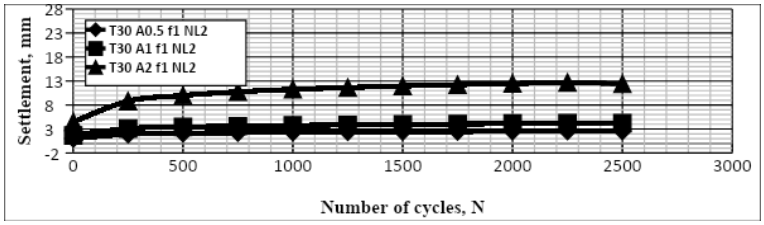



**Figure 22.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1 Hz and with two layer reinforcement h/T=0.25.

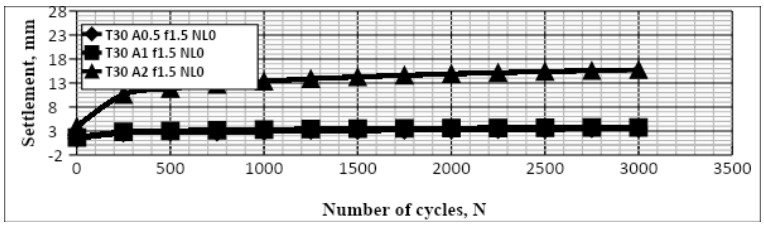



**Figure 23.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1.5 Hz and without reinforcement.

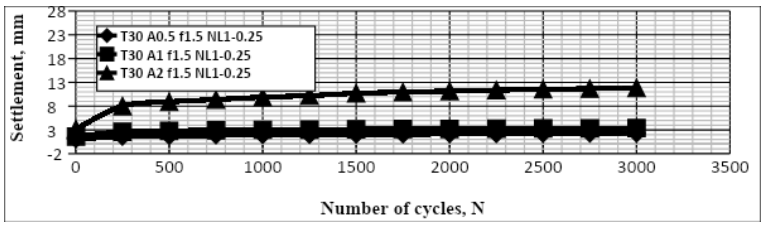



**Figure 24.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1.5 Hz and with one layer reinforcement h/T=0.25.

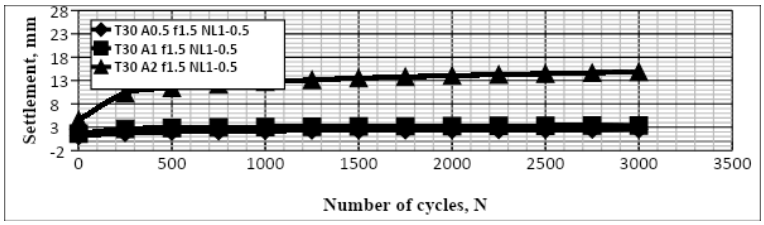



**Figure 25.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1.5 Hz and with one layer reinforcement h/T=0.5.

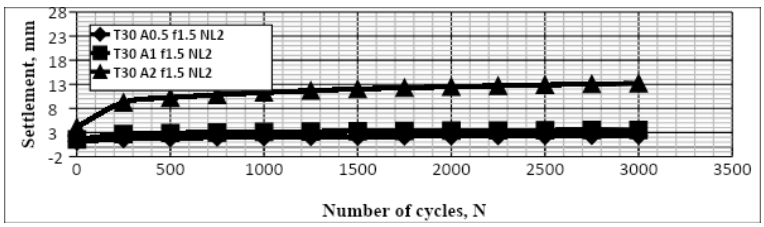



**Figure 26.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 1.5 Hz and with Two layer reinforcement h/T=0.25.

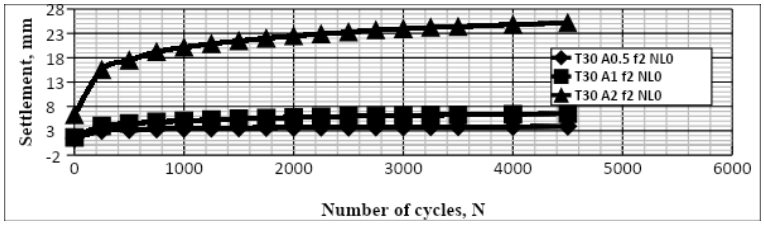



**Figure 27.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 2 Hz and without reinforcement.

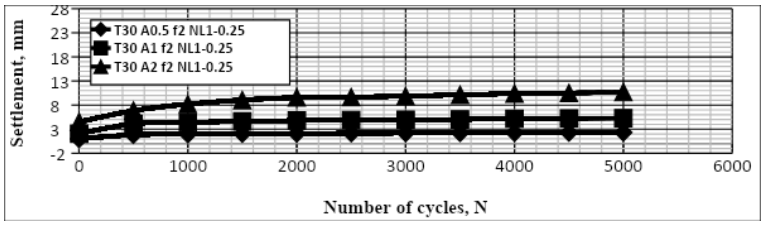



**Figure 28.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 2 Hz and with one layer reinforcement h/T=0.25.

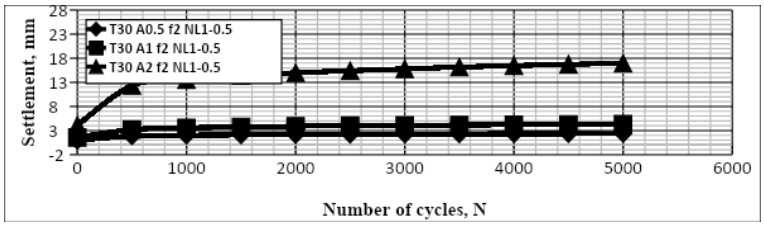



**Figure 29.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 2 Hz and with one layer reinforcement h/T=0.5.

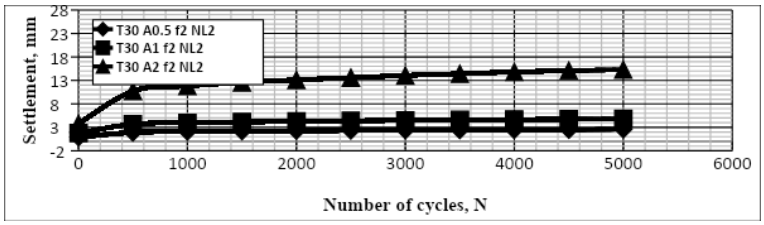



**Figure 30.** Settlement versus number of cycles for different load amplitudes with ballast thickness 30 cm, frequency 2 Hz and with two layer reinforcement h/T=0.25.

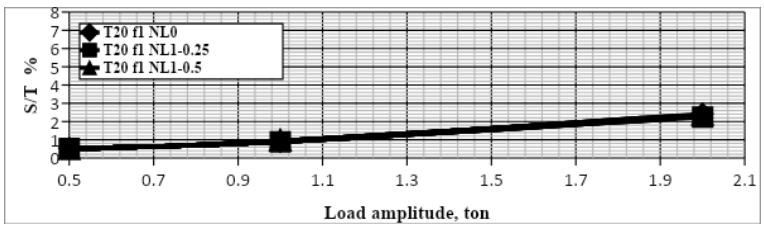



**Figure 31.** Effect of load amplitude on settlement ratio at the beginning of the test, with ballast thickness 20 cm, frequency 1 Hz.

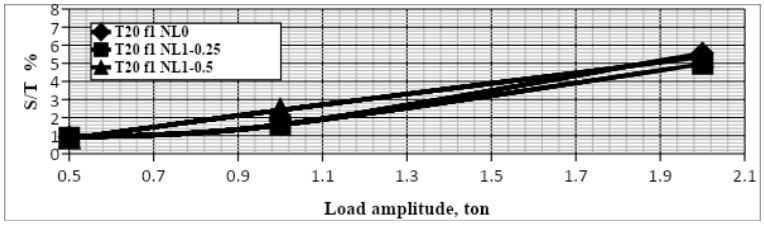



**Figure 32.** Effect of load amplitude on settlement ratio with ballast thickness 20 cm, frequency 1 Hz after 500 cycles.

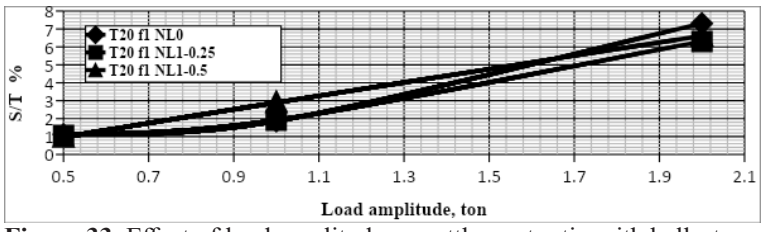



**Figure 33.** Effect of load amplitude on settlement ratio with ballast thickness 20 cm, frequency 1 Hz after 2,500 cycles

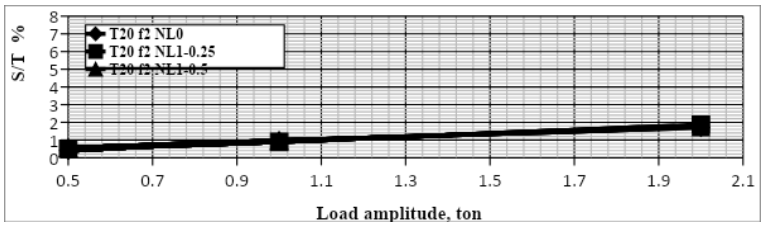



**Figure 34.** Effect of load amplitude on settlement ratio at the beginning of the test, with ballast thickness 20 cm, frequency 2 Hz.

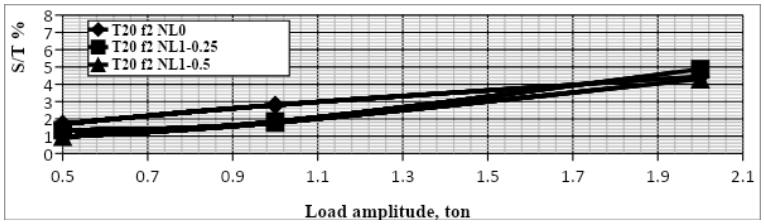



**Figure 35.** Effect of load amplitude on settlement ratio with ballast thickness 20 cm, frequency 2 Hz after 500 cycles.

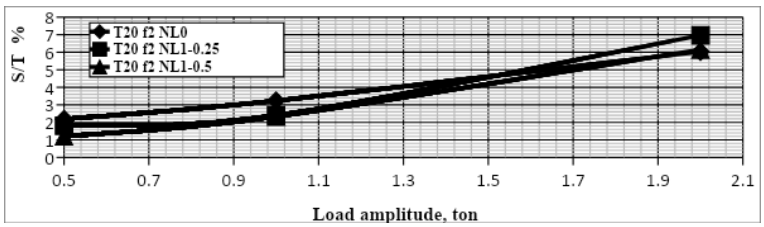



**Figure 36.** Effect of load amplitude on settlement ratio with ballast thickness 20 cm, frequency 2 Hz after 4,500 cycles.

## Conclusions

The present work can be considered with the following limitations. The present work cannot be considered as a complete study of the response of reinforced ballast to dynamic loading which are restricted to the number of variables studied especially for the measurements of displacements and stresses inside soil media. Other parameters that influence the behavior of such a track system have not been taken into consideration in this work because of the limited time available and cost. Hence, the limitations within the testing program are:

The ballast railway reinforced by geogrid reinforcement is subjected to a dynamic load of half sine wave shape with a range of frequency between 1 and 2 Hz and load amplitude between 0.5 and 2 tons.

The experimental model is based on an approximate half-scale model for a general rail track engineering practice,

The soil used is soft to stiff clay, and

One type of geogrid reinforcement is used.

The following conclusions could be obtained:

The amount of settlement increased when the load amplitude increased, there was a sharp increase in settlement up to the 500 cycles and after that, there was a gradual increase, leveling out between 2,500 to 4,500 cycles, depending on the load frequency.

There was a little increase in the induced settlement when the load amplitude increased from 0.5 to 1 ton but it was higher when the load amplitude increased to 2 tons. The increasing amount in settlement depends on the presence of the geogrid and the other studied parameters.

For most cases and in all stages of the tests at low load amplitude (0.5 ton), there was almost equal settlement for reinforced and unreinforced ballast layers. The effect of load amplitude on the settlement of the composite was almost negligible in the beginning of the tests with reinforced and unreinforced ballast layers, so the settlement ratio (S/T) (the cumulative settlement (S) divided by ballast thickness (T)) difference was small between them while it increased with an increase in the number of cycles.

The effect of load amplitude on the settlement of the composite in the beginning of the tests was almost negligible with reinforced and unreinforced ballast layers, so the settlement ratio difference was small between them, while it increased with an increase in the number of cycles.

The initial settlement ratio for 2 tons amplitude varied between 1-2 % while for 0.5 and 1 ton amplitude, it varied between 0.5-1 percent.This observation includes reinforced and unreinforced ballast.

There was little difference between the performance of placing the geogrid at the middle of the ballast layer or placing two geogrid layers than placing one geogrid layer in the bottom of the ballast layer. Almost the best geogrid position h/t is 0.25, i.e. when the ballast layer is lying on soft clay but it is not the case in stiff clay.

It is recommended to make laboratory tests on ballast material. More tests should be conducted on other types of fresh and recycled ballast to confirm the observations made for ballast used in this study. More test results can be generated with installation of different ballast materials. For example, each section can be filled with different sizes of ballast to observe the resulting breakage.

**Peer-review:** Externally peer-reviewed.
**Conflict of Interest:** The authors has no conflict of interest to declare.
**Grant Support:** The authors declared that this study has received no financial support.

**Hakem Değerlendirmesi:** Dış bağımsız.
**Çıkar Çatışması:** Yazarlar çıkar çatışması bildirmemiştir.
**Finansal Destek:** Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

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Available online at www.iujtl.com

JTL
Journal of Transportation and Logistics
5 (2) 2020

İSTANBUL UNIVERSITY PRESS

**DOI:** 10.26650/JTL.2020.0013

RESEARCH ARTICLE

# Deniz Ulaşımında Engelli Yolcuların Erişilebilirlik ve Emniyetine İlişkin Uluslararası Normlar ile Türkiye'nin Ulusal Denizcilik Mevzuatının Karşılaştırması

## A Comparison of International Norms and Turkey's National Maritime Legislation on Accessibility and Safety of Disabled Passengers in Maritime Transportation

Fatih Yılmaz[1]

**ÖZ**

Engellilere kolay ve erişilebilir ulaşım imkânları sunulması, Birleşmiş Milletler (BM) Engellilerin Haklarına İlişkin Sözleşme (2006)'nin taraf ülkelere yüklediği bir sorumluluktur. Deniz ulaşımında erişilebilirlik konusu ise, Uluslararası Denizcilik Örgütü (IMO) ve Avrupa Birliği (AB) normları ile düzenlenmiştir. Söz konusu uluslararası normlar, başta 5378 sayılı Engelliler Hakkında Kanun olmak üzere farklı zamanlarda ve kapsamlarda kabul edilen çeşitli düzenlemeler ile ulusal mevzuata aktarılmıştır. Bu çalışmada; deniz ulaşımında engelli yolcuların erişilebilirlik ve emniyetine ilişkin IMO ve AB normları ile Türkiye'nin ulusal mevzuatının karşılaştırması ve varsa ulusal mevzuattaki boşlukların belirlenmesi amaçlanmıştır. Bu amaçla; öncelikle engellilik ve erişilebilirlik kavramları, dünyada ve Türkiye'de engellilerin durumu, engellilerin ihtiyaçları ve çevresel etkenler, Türkiye'de denizyolu ile yolcu taşımacılığının durumu, BM'nin "evrensel tasarım" ilkesi gibi literatüre ilişkin konular sistematik olarak incelenmiştir. Akabinde, yolcu gemilerinde/terminallerde engellilerin erişilebilirliği ve emniyetine ilişkin IMO ve AB normlarına göre Türkiye'nin ulusal mevzuatına yönelik bir boşluk analizi yapılmıştır. Sonuçta ise, incelenen IMO ve AB normlarının büyük ölçüde Türkiye'nin ulusal mevzuatına aktarılmış durumda olduğu belirlenmiştir. Ayrıca, yolcu terminalleri ve gemilerindeki ilgili ve sorumlu personelin erişilebilirlikle ilgili eğitimlerine ağırlık verilmesi konusu başta olmak üzere belirlenen bazı boşluklar ve etkin uygulama hakkında öneriler de sunulmuştur.

**Anahtar Kelimeler:** Deniz ulaşımı, Yolcu taşımacılığı, Engelli yolcular, Ulaşımda erişilebilirlik, Ulaşımda emniyet

**ABSTRACT**

Providing easy and accessible transportation to persons with disabilities is a responsibility imposed by the Convention on the Rights of Persons with Disabilities (2006) of the United Nations (UN) to the States Parties. The issue of accessibility in maritime transportation is regulated by the norms of the Maritime Organisation (IMO) and the European Union (EU). These international norms have been transposed onto national legislation with various regulations adopted at different times and scopes, especially Law No. 5378 on Diasabled Persons. The aim of this study is to carry out an analysis to compare the norms of the IMO and EU and the national legislation of Turkey on accessibility and safety of disabled passengers in maritime transportation, and to identify gaps in national legislation, if any. In accordance with this aim, the relevant international norms and topics have been examined. Then, Turkey's national legislation on accessibility and safety of disabled passengers in terminals and ships has been analyzed compared with the norms of the IMO and EU. It has been concluded that Turkey's national legislation has widely covered the relevant IMO and EU requirements. Additionally, some recommendations concerning effective implementation and the gaps identified, which include particularly training of the relevant personnel of ships/terminals, have been also presented.

**Keywords:** Maritime transportation, Passenger transportation, Disabled passengers, Accesibility in transport, Safety in transport

**Başvuru/Submitted:** 17.07.2020 • **Kabul/Accepted:** 06.10.2020

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**Atıf/Citation:** Yilmaz, F. (2020). Deniz ulaşımında engelli yolcuların erişilebilirlik ve emniyetine ilişkin uluslararası normlar ile Türkiye'nin ulusal denizcilik mevzuatının karşılaştırması. *Journal of Transportation and Logistics, 5*(2), 129-142 https://doi.org/10.26650/JTL.2020.0013

**EXTENDED ABSTRACT**

Disability is part of the human condition. Almost everyone will be temporarily or permanently impaired at some point in their life, and those who survive to old age will experience increasing difficulties in functioning. Over a billion people (or about 15% of the world's population) were estimated to be living with a disability (WHO, 2011, p.1-2). According to the statistics of the Directorate General for Disabled and Elderly Persons (EYGM, 2017), there were 106,988 disabled persons in Turkey as of 2017. Maritime transportation is one of the different public transportation systems widely used by persons with disabilities in Turkey.

The United Nations (UN) Convention on the Rights of Persons with Disabilities (CRPD) was adopted in 2006 and came into force in 2008. Turkey is also a party to this convention. The purpose of the CRPD is "to promote, protect and ensure the full and equal enjoyment of all human rights and fundamental freedoms by all persons with disabilities, and to promote respect for their inherent dignity". In the scope of the CRPD, persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.

Providing easy and accessible transportation to persons with disabilities is a responsibility imposed by the CRPD on the States Parties. Accessibility in maritime transportation was basically regulated by MSC/Circ.735 on the "Recommendation on the Design and Operation of Passenger Ships to Respond to Elderly and Disabled Persons' Needs" of the International Maritime Organization (IMO), which is a specialized maritime agency of the UN, on 24 June 1996. Directive 2009/45/EC of the European Parliament and of the Council of 6 May 2009 on "Safety Rules and Standards for Passenger Ships" was adopted by European Union (EU).

Those international norms mentioned above have been widely transposed onto Turkey's national legislation with various regulations adopted at different times and scopes, especially Law No. 5378 on Diasabled Persons. However, there are not sufficient studies which compare international norms and Turkey's national legislation on the accessibility and safety of disabled passengers in maritime transportation. Therefore, the aim of this study is to carry out an analysis to compare the norms of the IMO and EU and the national legislation of Turkey on accessibility and safety of disabled passengers in maritime transportation, and to identify gaps in national legislation, if any. In accordance with this aim, the relevant international norms and topics have been examined. Then, Turkey's national legislation on the accessibility and safety of disabled passengers in terminals and ships has been analyzed compared with the norms of the IMO and EU.

As a result of the gap analysis carried out in this study, it has been observed that Turkey's national legislation has widely covered the relevant IMO and EU requirements. Additionally, some recommendations about effective implementation and the gaps identified, which include particularly training of the relevant personnel of ships/terminals, have been also presented.

In particular, taking necessary safety precautions and providing the guidance and information to the passengers who are elderly, physical disabled, sensory disabled and wheelchair users, pregnant women and young childeren are of great importancewhen moving between the terminals and passengers ships. Therefore, it is very important that the terminal and ship personnel, who are on duty and responsible for coordination and communication, are well trained.

Another important issue is the effective implementation of national legislation. The function of the Accessibility Monitoring and Supervision Commissions established in the provinces is of great importance for the effective implementation of national legislation regarding accessibility of passenger ships, ferries and terminals.

## 1. Giriş: Engellilik ve Erişilebilirlik

Engellilik (disability), Birleşmiş Milletler (BM) terminolojisinde "persons with disabilities", Avrupa Birliği (AB) mevzuatında "persons with reduced mobility", Uluslararası Denizcilik Örgütü (IMO) terminolojisinde "disabled persons" gibi farklı kullanım şekilleri olmakla birlikte, Türkçe'ye "hareket yeteneği kısıtlı kişiler" şeklinde tercüme edilen bir kavramdır. Yaşlı kimseler, fiziksel engelliler, duyusal engelliler ve tekerlekli sandalye kullananlar, hamile kadınlar ve küçük çocuklu kimseler dahil, genel taşıma araçlarını kullanırken özel olarak zorlanan kimseler bu kapsama girmektedir.

Engellilik insan olma halinin bir parçasıdır. Neredeyse herkes yaşamının belli bir noktasında geçici veya kalıcı olarak zayıf düşer ve yaşlılıklarında (fiziksel ve ruhsal) işlevlerini yerine getirme konusunda artan güçlüklerle karşılaşırlar. Nüfusun yaşlanıyor olması ve diyabet, kalp-damar hastalıkları ve akıl hastalığı gibi engellilikle bağlantılı kronik sağlık problemlerinin dünya çapında artıyor olması nedeniyle engellilerin sayısı da artmaktadır. Günümüzde dünyada 1 milyardan fazla insanın veya başka bir ifadeyle dünya nüfusunun yaklaşık %15'inin bir tür engellilik ile yaşadığı tahmin edilmektedir (WHO, 2011, s.1-2).

Engelli hakları, BM tarafından 2006 yılında kabul edilen "Engellilerin Haklarına İlişkin Sözleşme (Convention on the Rights of Persons with Disabilities)" ile düzenlenmiştir. Sözleşme, 3 Mayıs 2008 tarihinde yürürlüğe girmiştir. Türkiye, Sözleşmeyi 30 Mart 2007 tarihinde imzalamıştır. Sözleşmenin onaylanması 3 Aralık 2008 tarih ve 5825 sayılı Kanunla uygun bulunmuştur. Sözleşmenin onayına ilişkin 27 Mayıs 2009 tarih ve 2009/15137 sayılı Bakanlar Kurulu Kararı ve Sözleşmenin resmi Türkçe çevirisi, 14 Temmuz 2009 tarih ve 27288 sayılı Resmî Gazetede yayımlanmıştır. Onay belgeleri, 28 Eylül 2009 tarihinde BM Genel Sekreterliğine bildirilmiş ve Türkiye için 28 Ekim 2009 tarihinde yürürlüğe girmiştir. Türkiye'nin Sözleşmeye ilişkin bir çekincesi veya beyanı olmamıştır (İBÜ, 2019).

Sözleşmenin amacı; "tüm engelli insanların temel özgürlüklerden ve bütün insan haklarından tam ve eşit bir şekilde faydalanmasını teşvik etmek, sağlamak, korumak ve insan olmaktan ileri gelen haysiyetlerine yönelik saygıyı arttırmaktır" şeklinde tanımlanmakta olup 9 uncu maddesi engellilerin "erişilebilirlik" hakları ile ilgili hükümleri düzenlemektedir. Buna göre; engellilerin bağımsız olarak yaşamalarını ve yaşamın tüm alanlarına tam anlamıyla katılmalarını sağlamak için Taraf Devletlere sorumluluklar yüklenmiş olup hem kentsel hem de kırsal alanlarda başkalarıyla eşit bir şekilde, fiziksel çevreye, ulaşıma, bilgi ve iletişim teknolojileri ve sistemler de dahil olmak üzere bilgi ve haberleşmeye, açık veya kamusal alanlardaki diğer tesislere ve hizmetlere engellilerin erişimini sağlamak için uygun tedbirlerin alınması görevi yüklemiştir. Erişilebilirliğin önündeki engellerin ve bariyerlerin belirlenmesi ve ortadan kaldırılmasını da içeren söz konusu tedbirler; okullar, konutlar, tıbbi tesisler ve işyerleri dahil olmak üzere binalar, yollar, ulaşım ve diğer iç ve dış mekân tesisleri ile elektronik hizmetler ve acil durum hizmetleri dahil olmak üzere bilgi, iletişim ve diğer hizmetleri de kapsamaktadır. Ayrıca, yine Taraf Devletler, açık veya kamusal tesis ve hizmetlerin erişilebilirliği için asgari standartların ve rehberlerin uygulanmasını geliştirmek, yayınlamak ve takip etmekle,

özel kuruluşların engellilerin erişiminin tüm yönlerinin göz önünde bulundurmasını sağlamakla, paydaşlara engellilerin karşılaştığı erişilebilirlik sorunları hakkında eğitim vermekle, açık veya kamusal alanlardaki binalar ve diğer tesislerde kolay okunabilir ve anlaşılabilir "Braille" harfleri ile yazılı tabelalar sağlamakla, kamuya açık binalarda ve diğer tesislerde erişilebilirliği kolaylaştırmak için rehberler, okuyucular ve profesyonel işaret dili tercümanları dahil olmak üzere canlı yardım ve aracılar sağlamakla, bilgiye erişimlerini sağlamak için engelli insanlara diğer uygun yardım ve destek türlerini teşvik etmekle, internet dahil engelli kişilerin yeni bilgi ve iletişim teknolojilerine ve sistemlerine erişimini teşvik etmekle, bilgi ve iletişim teknolojilerinin ve sistemlerin tasarım, geliştirme, üretim ve dağıtımını erken bir aşamada teşvik etmek suretiyle erişilebilirlik maliyetini minimize etmekle de yükümlü kılınmışlardır (BM, 2006, Madde 9).

Buradan da anlaşıldığı gibi, engellilere kolay ve erişilebilir ulaşım imkanları sunulması, BM'nin Engellilerin Haklarına İlişkin Sözleşme ile taraf devletlere yüklediği sorumlulukların gereğidir. Anayasamızın milletlerarası anlaşmalarla ilgili 90 ıncı maddesinde yer alan "Usulüne göre yürürlüğe konulmuş Milletlerarası antlaşmalar kanun hükmündedir. Bunlar hakkında Anayasaya aykırılık iddiası ile Anayasa Mahkemesine başvurulamaz. Usulüne göre yürürlüğe konulmuş temel hak ve özgürlüklere ilişkin milletlerarası antlaşmalarla kanunların aynı konuda farklı hükümler içermesi nedeniyle çıkabilecek uyuşmazlıklarda milletlerarası antlaşma hükümleri esas alınır." hükmü (T.C. Anayasası, 1982, Madde 90) göz önünde bulundurulduğunda, bu sorumluluğun önemi daha iyi anlaşılmaktadır. Bununla birlikte, 2005 yılında kabul edilen 5378 sayılı Engelliler Hakkında Kanun (EHK)'un "erişilebilirlik" hakkındaki 7 inci maddesi "Yapılı çevrede engellilerin erişilebilirliğinin sağlanması için planlama, tasarım, inşaat, imalat, ruhsatlandırma ve denetleme süreçlerinde erişilebilirlik standartlarına uygunluk sağlanır. Özel ve kamu toplu taşıma sistemleri ile sürücü koltuğu hariç dokuz veya daha fazla koltuğu bulunan özel ve kamu toplu taşıma araçlarının engellilerin erişilebilirliğine uygun olması zorunludur. Bilgilendirme hizmetleri ile bilgi ve iletişim teknolojisinin engelliler için erişilebilir olması sağlanır" hükümlerini (EHK, 2005, Madde 7) içermektedir. Söz konusu maddede belirtilen toplu taşıma sistemleri ve toplu taşıma araçlarından bir tanesi de "denizyolu taşımacılığı sistemi" ve bu sistemin en temel unsurları olan *"yolcu gemileri"* ile *"yolcu terminalleri"*dir.

## 2. Çalışmanın Yöntemi

Deniz ulaşımında engelli yolcuların erişilebilirlik ve emniyetine ilişkin IMO ve AB normları ile Türkiye'nin ulusal mevzuatının karşılaştırılmasını amaçlayan bu çalışma, amacı bakımından keşfedici (exploratory) ve veri toplama yöntemi bakımından nitel bir araştırmadır. Keşfedici araştırma; bir konuyu gün ışığına çıkarmayı ön gören araştırma türüdür. Araştırılan konu hakkında yeterli bilgi toplandıktan sonra genel durum hakkında bir portre çizilir. Bu tür araştırma, konu hakkında mümkün olan verileri bir araya getirerek bir fenomeni keşfetmeyi öngörür (Usta, 2012, s.102-103). Keşfedici araştırma, belirli bir alanda üzerinde genellikle az çalışılmış konularda yapılan çalışmalar için uygun bir yöntem olarak görülmektedir (Acar ve Sey, 2006, s.56). Nitel araştırmalar; gözlem, görüşme ve doküman analizi gibi nitel veri toplama yöntemlerinin kullanıldığı, algıların ve olayların

doğal ortamda gerçekçi ve bütüncül biçimde ortaya konmasına yönelik nitel bir sürecin izlendiği araştırmalardır (Yıldırım ve Şimşek, 2016, s.41). Bu çalışmada, öncelikle, engellilik ve erişilebilirlik kavramları, dünyada ve Türkiye'de engellilerin durumu, engellilerin ihtiyaçları ve çevresel etkenler, Türkiye'de denizyolu ile yolcu taşımacılığının durumu, BM'nin *"evrensel tasarım"* ilkesi gibi literatüre ilişkin konular incelenmiştir. Akabinde ise, *"boşluk analizi"* yaklaşımı ile yolcu gemilerinde ve terminallerde engellilerin erişilebilirliği ve emniyetine ilişkin IMO ve AB normları ile Türkiye'nin ulusal mevzuatı mukayese edilmiştir. Boşluk analizi (gap analysis), mevcut bir sistemin bir dizi şartı yerine getirme kabiliyetini ve derecesini mukayese etmek ve belirlemek için kullanılabilen bir yöntemdir. Bu yöntem ilk olarak Merton tarafından 1938 yılında kültürel hedefler ve kurumsal normlar arasındaki farklılıkların belirlenmesi için kullanılmış ve 2000'li yıllara kadar psikotik davranış, biyoçeşitlilik, insan kaynakları planlaması, askeri savunma, finansal rekabet analizi gibi farklı alanlarda kullanılmıştır. Yöntemin başlangıç aşamasını, dayanak şartlarının ve temel ölçütlerin belirlenmesi oluşturmaktadır (Langford ve ark., 2018, s.11-12). Bu çalışma açısından denizyolu ulaşımında kullanılan yolcu gemilerinde ve terminallerde engellilerin erişilebilirliği ve emniyetine yönelik tasarıma ilişkin IMO ve AB normlarının belirlenmesi başlangıç aşamasını oluşturmaktadır. İkinci aşamada ise Türkiye'nin ilgili ulusal mevzuat hükümlerini tespit edilmiş ve sonrasında IMO ve AB normları ile mukayese edilmiştir. Son aşamada ise ulusal mevzuatın uluslararası normları karşılama düzeyi ve boşluklar belirlenmiştir.

## 3. Dünyada ve Türkiye'de Engellilerin Durumu

BM Ekonomik ve Sosyal İşler Bölümü (Department of Economic and Social Affairs DESA)'nın web sitesinde yayınlanan bilgilere göre (BM-DESA, 2019); günümüzde, dünya genelinde nüfusun %15'inin veya bir başka deyişle 1 milyar insanın bir veya daha fazla engelleyici koşulla yaşadığı tahmin edilmektedir. 60 ve üzeri yaşlardaki kişilerin %46'sından fazlasının engeli olup 250 milyondan fazla yaşlı orta ve şiddetli sakatlık yaşamaktadır. BM'nin 2015 nüfus beklentileri verilerine göre; son yıllarda pek çok ülkede ve bölgede yaşlı nüfus önemli ölçüde artmış ve gelecekte de bu artışın devam edeceği, 2015-2030 yılları arasında dünyada 60 yaş ve üstü bireylerin sayısının 901 milyondan 1,4 milyara yükselerek %56 oranında artacağı ve 2050 yılına geldiğinde ise dünyadaki yaşlı nüfusun yaklaşık 2,1 milyara ulaşacağı öngörülmektedir. Yaşam boyunca hastalık, yaralanma ve kronik hastalıklarla birlikte sağlık risklerinin birikiminin sonucu olarak, yaşlılar arasında sakatlık oranı da yüksek olmaktadır (BM-DESA, 2019).

Ülkemize gelince, Engelli ve Yaşlı Hizmetleri Genel Müdürlüğü (EYGM)'nün web sitesinde yayımlanan "engelli ve yaşlı bireylere ilişkin istatistikler" (EYGM, 2017) incelendiğinde; 2017 yılı itibariyle Türkiye'de çalışan engelli birey sayısının, 10.268'i kamuda ve 96.720'si özelde olmak üzere 106.988 kişi olduğu, yine 2017 yılı itibariyle engelli maaşı alan engelli bireyler arasında bakıma muhtaç engellilerin (%70 ve üzeri) sayısının 284.625 kişi, engelli sayısının (%40-%69) 335.769 kişi, engelli yakını aylığı (18 yaş altı) alanların sayısının 94.268 kişi ve silikozis (meslek hastalığı) olanların sayısının 177 kişi olduğu, ayrıca özel eğitim kurumlarında örgün eğitim alan öğrencilerin sayısının 2017-2018 öğretim yılı itibariyle 353.610 kişi, özel eğitim ve rehabilitasyon merkezlerinde

öğrenim gören öğrenci sayısının ise 2016-2017 itibariyle 403.104 kişi olduğu, 2017 yılı itibariyle yaşlı (65+) maaşı alan kişilerin 618.162 kişi olduğu, evde bakım yardımından yararlanan engelli sayısının 2018 (Eylül) itibariyle 511.915 kişi olduğu, özel bakım merkezlerinde bakım hizmeti alan engellilerin sayısının 2018 (Eylül) itibariyle 16.205 kişi olduğu, huzur evlerinde bakılan yaşlı sayısının 2018 (Eylül) itibariyle 13.798 kişi olduğu, gelir vergisi indiriminden faydalanan engelli bireylerin sayısının 2017 (Ocak-Aralık) itibariyle 53.392 kişi olduğu belirtilmektedir (EYGM, 2017). Bütün bu sayılar ve oranlar, dünyada ve ülkemizde engelli ve yaşlı bireylerin toplam nüfus içerisinde ciddi bir yeri olduğunu ve artarak devam edeceğini açıkça ortaya koymaktadır.

Tüm dünyada, engelliler, yaşamın tüm alanlarına tam ve eşit katılımlarını önleyen tutumlarla, çevresel ve kurumsal engeller dahil bir dizi engelle karşı karşıya kalmaktadırlar. Çoğunlukla engelli yaşlı insanlar, toplumdaki ileri yaş engelleri ile karşı karşıya kalan ve en fazla olumsuz etkilenenler arasındadırlar. Bu durum, ülkelerin, yaşlılık ve engellilik arasındaki kesitleri de dikkate alarak tüm kullanıcıların ihtiyaçlarını ve kapasitelerini karşılayan bir toplum oluşturma hedefine doğru ilerlemede, çevresel kapsayıcılığı ve erişilebilirliği sağlamak için planlama, tasarım ve inşaat yatırımlarına daha uzun vadeli bakmaları gerektiğini ortaya koymaktadır (BM-DESA, 2019).

Engellilik ile dezavantaj arasında bir ilişki söz konusu olmakla birlikte, engelli bireylerin hepsi eşit derecede dezavantajlı değildir. Örneğin; fiziksel sakatlığı olan çocukların durumu zihinsel ya da duyusal sakatlığı olan çocuklarınkinden daha iyidir. İşgücü piyasasından en fazla dışlananlar akıl sağlığı sorunları ya da zihinsel sakatlığı olanlardır. Başka bir ifadeyle, daha şiddetli sakatlıkları olan insanlar daha büyük dezavantaj yaşarlar. Engellilerin yaşamında dezavantaj oluşturan sadece bireysel kısıtlılıkları değil aynı zamanda çevresel etmenlerdir. Örneğin; bir ülkede engelli haklarına ilişkin var olan politikalar ve standartların yerine getirilmemesi, engellilerin eğitimi, istihdamı, sağlık ve sosyal katılımına ilişkin önyargılar, çalışma yaşamında engellilerin daha az verimli olduğuna dair işverenlerin yanlış kanaatleri, engelli insanlara yönelik özellikle sağlık, rehabilitasyon, destek ve yardım hizmetlerindeki eksiklikler, kamusal kullanıma açık alanlar ve binalar dahil birçok mekanın, ulaşım sistemlerinin ve bilgi edinmenin herkes için erişilebilir olmaması, kendi yaşamlarını doğrudan etkileyen hususlarda karar alma süreçlerine katılımdan dışlanmaları vb. gibi pek çok çevresel etmen de engellilerin yaşamına ve sosyo-kültürel hayata katılımlarına olumsuz etki etmektedir (WHO, 2011, s.2-4).

## 4. Türkiye'de Denizyolu ile Yolcu Taşımacılığının Durumu

Ülkemizde denizyolu ile yolcu ve araç taşımacılığına ilişkin kayıtların tutulması ve yolcu taşımacılığına görelik düzenli hat izinlerinin verilmesi Deniz Ticareti Genel Müdürlüğü (DTGM) tarafından yürütülmektedir. Tablo 1'de; 2004-2018 yılları arasında ülkemizde kabotaj dahilinde taşınan yolcu ve araç sayısının yıllara göre değişimi yer almaktadır (DTGM, 2019). Söz konusu istatistiklerden, kabotajda denizyolu ile taşınan araç ve yolcu sayısının yıldan yıla arttığı görülmektedir.

**Tablo 1.** Kabotajda taşınan yolcu ve araç sayısı (DGM, 2020).

| Yıl | Araç sayısı | Yolcu sayısı |
|---|---|---|
| 2008 | 8.866.797 | 151.645.639 |
| 2009 | 9.315.772 | 159.194.370 |
| 2010 | 9.400.735 | 154.198.088 |
| 2011 | 10.402.917 | 156.968.095 |
| 2012 | 10.710.645 | 159.076.921 |
| 2013 | 11.318.561 | 164.433.679 |
| 2014 | 12.166.505 | 161.048.004 |
| 2015 | 13.042.399 | 163.723.544 |
| 2016 | 12.719.301 | 147.435.529 |
| 2017 | 12.638.289 | 137.195.691 |
| 2018 | 13.159.820 | 139.556.332 |
| 2019 | 13.420.802 | 150.312.216 |

Kabotaj hattında taşınan yolcular ve araçlar arasında engelli ve yaşlılar ile kullandıkları araçların sayısında ilişkin detaylı bilgiye bu çalışma kapsamında ulaşılmamış olsa da özellikle şehirler arası ulaşımda yaşlı ve engellilerin denizyolu ulaşım sistemini ve yolcu gemilerini/feribotları/vapurları kullandıkları bilinmektedir.

Tabii ki, yaşlı ve engelliler, yolcu gemilerini/feribotları/vapurları sadece şehirler arası ulaşımda değil, özellikle İstanbul, İzmir, Çanakkale, Bursa gibi illerimizde şehir içi ulaşım ve hatta gezinti amacıyla da sıklıkla kullanmaktadırlar.

## 5. Yolcu Gemileri ve Terminallerde Engelliler İçin Gerekler

### 5.1. BM'nin "Evrensel Tasarım" İlkesi

Dünya Sağlık Örgütü (WHO) tarafından yayınlanan Dünya Engelliler Raporunda (2011); farklı alanlarda erişilebilirliği sağlamak ve olumsuz tavırları azaltmak için alınması gereken tedbirler; kamu-özel sektör işbirliğinin sağlanması, uygulamaların koordine edilmesinden sorumlu olan yönetici bir kurumun belirlenmesi, erişilebilirlik eğitimlerinin ve kullanıcıların katılımının arttırılması, planlamacılar, mimarlar ve tasarımcılar tarafından evrensel tasarım ilkelerinin uygulanması ve halkın eğitilmesi şeklinde ifade edilmektedir (WHO, 2011, s.8).

Literatürde farklı tanımlamalara ve değerlendirmelere rastlanmakla birlikte, Birleşmiş Milletler (BM) Engellilerin Haklarına İlişkin Sözleşmenin "tanımlar" başlıklı 2 inci maddesi esas alındığında *"evrensel tasarım"* kavramının; *"ürünlerin, çevrenin, programların ve hizmetlerin özel bir ek tasarıma veya düzenlemeye gerek duyulmaksızın, mümkün olduğunca herkes tarafından kullanılabilecek şekilde tasarlanması"* şeklinde ifade edildiği görülmektedir (BM, 2006, Madde 2). Bu tanım, hayatın doğal akışı içerisinde engellilerin diğer bireylerle aynı şartlar altında yaşamlarını sürdürebilmelerine olanak sağlayan tasarımların evrensel nitelikte olduğuna işaret etmektedir.

Duman (2017)'a göre; evrensel tasarımın amacı, yaş, bedensel özellik, kişisel gelişim ve beceri açısından farklı bireylerin ihtiyaçlarını aynı uygulamada karşılayacak ortak tasarımlar yapmaktır (Duman, 2017, s.5). Mace (1998)'ye göre; evrensel tasarımın hedef

kitlesi tüm kullanıcılardır ve insanlar antropolojik ve fizyolojik özellikleri ile görsel, işitsel ve zihinsel yetenekleri bakımından farklı oldukları için klasik tasarım yaklaşımındaki "ortalama (normal) insan" kavramından farklı bir anlama ve hedef kitlesine sahiptir (Mace, 1998 & Duman, 2017, s.5).

### 5.2. IMO'nun Yolcu Gemilerinin Tasarım ve İşletmesinde Engelli ve Yaşlıların İhtiyaçlarının Gözetilmesine Dair Tavsiye Kararı

IMO Deniz Emniyeti Komitesi (MSC) Tasarım ve Ekipman (DE) Alt Komitesi tarafından hazırlanan, 14 Haziran 1996 tarihli ve MSC/Circ.735 rumuzlu sirküler ile yayınlanan *"Yolcu Gemilerinin Yaşlı ve Engelli Kişilerin İhtiyaçlarının Karışlanmasına Yönelik Tasarımı ve İşletimi Hakkında Tavsiye (Recommendation on the Design and Operation of Passenger Ships to Respond to Elderly and Disabled Persons' Needs)"* (IMO, 1996) kararı bulunmaktadır. Söz konusu tavsiye kararın giriş kısmında, kısa süreli uluslararası sefer yapan yüksek yoğunluklu yolcu gemileri ile feribotlardaki acil durumlarda görevli personelin eğitimi ile ilgili A.770(18) rumuzlu karara da atıf yapılmakta olup yeni inşa edilecek gemilerin tasarımında, acil durumlarda diğer yolcularla birlikte engellilerin, gençlerin ve yaşlıların gemiden tahliyesinin de özel olarak göz önünde bulundurulması gerektiği belirtilmektedir. Söz konusu tavsiye kararının (MSC/Circ.735) ekinde özetle aşağıdaki konu başlıklarını ihtiva eden bir de rehber bulunmaktadır (IMO, 1996):

- Gemiye Binmeden Önce Genel Bilgilendirme
- Terminale Erişim
- Gemiye Erişim
- Araçlarının Yönlendirilmesi/Takibi
- Araçların Gemiye Park Edilmesi
- Asansörler
- Yolcu Mahalleri
- Koridorlar, Kapılar ve Tırabzanlar
- Güverte ve Zeminler
- Kamaralar
- Lavabolar
- Kamaraların Yerleşimi
- Mürettebatın Eğitimi
- Alerjisi Olan Kişiler İçin Önlemler
- Bilgilendirme
- Servis

### 5.3. AB'nin Yolcu Gemilerinde Engellilerin Erişilebilirliği ve Emniyetine Yönelik Normları

Yolcu gemileri için emniyet standartlarını ve kurallarını düzenleyen başlıca AB mevzuatı 17 Mart 1998 tarihli ve 98/18/EC sayılı Konsey Direktifi idi. Söz konusu Direktifte zaman içerisinde muhtelif değişikler yapılmış olup nihayetinde yerini 6 Mayıs 2009 tarihli ve 2009/45/EC Sayılı Konsey Direktifine bırakmıştır. 1998 tarihli Konsey Direktifinin "6b" numaralı maddesinde yer alan *"safety requirements for persons with reduced mobility (hareket yeteneği az olan kişilere ilişkin şartlar)"* maddesinin ise 2009 tarihli Konsey Direktifinde aynen korunduğu ve 8 numaralı maddeye taşınması dışında kapsam ve içerik olarak herhangi bir değişiklik olmadığı görülmektedir. 2009 Direktifinde de yine 1998 Direktifinde olduğu gibi 14 Haziran 1996 tarihli ve MSC/Circ.735 rumuzlu sirküler ile yayınlanan tavsiye kararına atıf yapılmak suretiyle 1 Ekim 2004 tarihinden sonra inşa edilen ve toplu taşımacılıkta kullanılan A, B, C ve D sınıfı tüm yolcu gemilerinde hareket yeteneği az olan kişilere ilişkin şartların uygulanmasına yönelik tedbirlerin alınması gerektiği ile bu tarihten önce inşa edilen ve toplu taşımacılıkta kullanılan A, B, C ve D sınıfı yolcu gemileri ile yüksek hızlı yolcu teknelerinin tadilatına yönelik olarak ise ekonomik bakımdan makul olma ve yapılabilirlik ölçüsünde uygulanabileceği belirtilmektedir (2009/45/EC, 2009, Madde 2, 8).

### 5.4. Türk Denizcilik Mevzuatının Yolcu Gemileri ve Terminallerde Engelliler İçin Gerekleri

Yolcu gemilerinin ve terminallerin engelliler için gerekleri içeren ve çalışma kapsamında incelenen ulusal mevzuat Tablo 2'de yer almaktadır.

**Tablo 2.** Çalışma Kapsamında İncelenen Ulusal Mevzuat

| Mevzuat Adı | Yayımlandığı Resmi Gazete | |
|---|---|---|
| | Tarih | Sayı |
| Engelliler Hakkında Kanun | 07.07.2005 | 25868 |
| Kıyı Tesislerine İşletme İzni Verilmesine İlişkin Usul ve Esaslar Hakkında Yönetmelik (KTİY) | 18.02.2007 | 26438 |
| Yolcu Gemilerinin Emniyetine ve Gemilerdeki Yolcuların Kayıt Altına Alınmasına İlişkin Yönetmelik (YGE&YKAY) | 12.12.2007 | 26728 |
| Gemilerin Teknik Yönetmeliği (GTY) | 17.11.2009 | 27409 |
| Deniz Yolu ile Yapılacak Düzenli Seferlere Dair Yönetmelik (DSY) | 25.11.2010 | 27766 |
| Erişilebilirlik İzleme ve Denetleme Yönetmeliği (EİDY) | 20.07.2013 | 28713 |
| Şehirler Arası Yolcu Taşıma Hizmeti İle Servis ve Turizm Taşımacılığı Hizmetinin Erişilebilir Hâle Getirilmesine Dair Yönetmelik | 13.01.2017 | 29947 |

## 6. Tartışma

Bu çalışma kapsamında yapılan inceleme sonucunda; yolcu gemileri ve terminallerde engellilerin erişilebilirliği ve emniyetine yönelik tasarım gereklerine ilişkin temel kaynağın, IMO tarafından 14 Haziran 1996 tarihli ve MSC/Circ.735 rumuzlu sirküler ile

yayınlanan *"Yolcu Gemilerinin Yaşlı ve Engelli Kişilerin İhtiyaçlarının Karışlanmasına Yönelik Tasarımı ve İşletimi Hakkında Tavsiye (Recommendation on the Design and Operation of Passenger Ships to Respond to Elderly and Disabled Persons' Needs)"* tavsiye kararı olduğu görülmüştür. Bunun yanısıra, AB'nin yolcu gemileri için emniyet standartlarını düzenleyen 17 Mart 1998 tarihli ve 98/18/EC sayılı Konsey Direktifinin yerini alan 6 Mayıs 2009 tarihli ve 2009/45/EC Sayılı Konsey Direktifi de bulunmaktadır.

Bu çalışma kapsamında hazırlanan Tablo 3'ten de görüldüğü üzere; söz konusu IMO ve AB gereklerinin ufak tefek boşluklar olmakla birlikte farklı zamanlarda yayımlanmış Yönetmelikler ile çok büyük ölçüde ulusal mevzuatımıza aktarılmış durumda olduğu anlaşılmaktadır. Ancak, ulusal mevzuatın "Gemiye Binmeden Önce Genel Bilgilendirme", "Mürettebatın Eğitimi", "Alerjisi Olan Kişiler İçin Önlemler" ve "Servis" gibi spesifik alanlarda boşluklar ve geliştirilmeye müsait yönlerinin bulunduğu da görülmektedir.

**Tablo 3.** Engellilerin Erişilebilirliği ve Emniyeti Açısından IMO ve AB Normları ile Türkiye'nin Ulusal Denizcilik Mevzuatının Karşılaştırması

| | **Uluslararası Mevzuat** | | **Ulusal Mevzuat** | | | |
|---|---|---|---|---|---|---|
| **Normlar** | IMO 1996 (MSC/ Circ.735) | 98/18/EC 1998 & 2009/45/EC 2009* | YGE&YKAY 2007* | GTY 2009 | KTİY 2007 (2011) | EİDY 2013 (2016) |
| Gemiye Binmeden Önce Genel Bilgilendirme | ● | | | | | |
| Terminale Erişim | ● | | | | ●** | ●*** |
| Gemiye Erişim | ● | ● | ● | ● | ●** | ● |
| Araçların Gemiye Park edilmesi | ● | ● | ● | ● | | ● |
| Asansörler | ● | ● | ● | ● | | ● |
| Yolcu Mahalleri | ● | ● | ● | ● | | ● |
| Koridorlar, Kapılar ve Tırabzanlar | ● | ● | ● | ● | | ● |
| Güverte ve Zeminler | ● | ● | ● | ● | | ● |
| Kamaralar | ● | ● | ● | ● | | ● |
| Lavabolar | ● | ● | ● | ● | | ● |
| Kamaraların Yerleşimi | ● | | | ● | | ● |
| Mürettebatın Eğitimi | ● | | | | | |
| Alerjisi Olan Kişiler İçin Önlemler | ● | | | | | |
| Bilgilendirme | ● | ● | ● | ● | | ● |
| Servis | ● | | | | | ●** |

** EK III rehberde MSC/Circ.735'e atıf yapıldığından içeriğin yeterli olduğu kabul edilmiştir.*
*** EK-5 kriterlerin terminal-gemi ve gemi-terminal erişilebilirlik şartlarını içerdiği kabul edilmiştir.*
**** Binalara erişim formunun yolcu terminallerin fiziki yapısı ile hizmetleri de kapsadığı kabul edilmiştir.*
**Kaynak:** Tablo, yazar tarafından oluşturulmuştur.

Ulusal mevzuattaki geliştirilmeye müsait konular arasında görece daha önemli ve öncelikli olan konu *"eğitim"* konusudur. Son yıllarda ulusal basına da yansıyan yolcuların gemiye binerken veya inerken denize düşme vakalarının önlenmesi bakımından da önemli bir konudur. Özellikle yaşlı kimseler, fiziksel engelliler, duyusal engelliler ve tekerlekli sandalye kullananlar ile hamile kadınlar ve küçük çocuklu kimseler başta olmak üzere yolcuların veya araçların terminale girişinden gemiye binişine veya gemiden inişinden terminalden ayrılışına kadar olan süreçte gerekli emniyet tedbirlerinin alınması ve terminal ile gemi arasındaki yönlendirme, bilgilendirme, takip ve haberleşmenin koordinasyonu büyük önem arz etmektedir. Bunun için görevli ve sorumlu olan terminal ve gemi personelinin de çok iyi eğitilmiş olması kritik önemdedir.

Ayrıca, terminallerde olduğu gibi yolcu gemileri/feribotlarda da sağlanan her türlü hizmetin engelli yolcular düşünülerek planlanması ve uygulanması önem arz etmektedir. Çeşitli durumlara ve cisimlere karşı alerjisi olan kişilerin yolcu gemilerinde/feribotlardaki seyahatleri süresince mümkün olduğunca söz konusu durumlardan/cisimlerden uzak kalmalarını sağlamaya yönelik birtakım önlemler alınması da üzerinde durulması gereken bir konudur.

Her ne kadar muhteviyatı itibariyle ulusal mevzuatımız IMO ve AB normları ile büyük ölçüde uyumlu olsa da ulusal mevzuatımızdaki ilgili Yönetmeliklerin farklı zamanlarda yayımlanmış olmalarından dolayı kapsamlarında ve yürürlük tarihlerinde de farklılıklar söz konusudur. Oldukça zor olsa da Yönetmeliklerin erişilebilirliğe ilişkin hükümleri bakımından kapsam ve yürürlük tarihlerinin uyumlaştırılmasına yönelik bir çalışma yapılmasının faydalı olacağı değerlendirilmektedir.

Ayrıca, Yönetmeliklerde, yolcu terminalleri/gemilerinde engellilerin erişilebilirliğine ilişkin hükümlerin olabildiğince görsellerle desteklenerek somutlaştırılmasının uygulayıcılar ve denetleyiciler açısından yararlı olacağı değerlendirilmektedir. Bu arada, mevzuatın etkin uygulanması çok önemlidir. Yolcu gemileri/feribotlar ve yolcu terminallerine yönelik olarak illerdeki Erişilebilirlik İzleme ve Denetleme Komisyonlarına mevzuatın etkin uygulanması noktasında büyük iş düşmektedir.

## 7. Sonuç

Bu çalışmada; deniz ulaşımında engelli yolcuların erişilebilirlik ve emniyetine ilişkin IMO ve AB normları ile Türkiye'nin ulusal mevzuatı karşılaştırılmış ve söz konusu IMO ve AB normlarına göre Türkiye'nin ulusal mevzuatının bir analizi yapılmıştır. Analiz neticesinde; ilgili IMO ve AB normlarının ufak tefek boşluklar olmakla birlikte çok büyük ölçüde ulusal mevzuatımıza aktarılmış olduğu belirlenmiştir. Bununla birlikte, ulusal mevzuatta, engelli yolculara yönelik "Gemiye Binmeden Önce Genel Bilgilendirme" ve "Mürettebatın Eğitimi" ile "Alerjisi Olan Kişiler İçin Önlemler" ve "Servis" gibi spesifik bazı alanlarda ufak boşluklar olduğu da gözlenmiştir. Engellilerin yolcu gemilerine ve terminallere erişilebilirliği açısından IMO ve AB normları ile Türkiye'nin ulusal mevzuatının karşılaştırması Tablo 3'te sunulmuştur.

Şehir içi veya şehirlerarası yolculuklarda denizyolunu tercih eden engelli bireylerin, kullanacakları yolcu terminallerine ve yolcu gemilerine kolay bir şekilde erişerek

emniyetli ve konforlu bir yolculuk yapabilmeleri, ülkemizin gelişmişlik düzeyine katkı sağlaması bakımından önemli bir göstergedir. Bu alanda yapılan ve yapılacak olan bilimsel çalışmalar, engelli bireylerin denizyolu ulaşımına erişilebilirlik seviyesinin geliştirilmesine ve dolayısıyla sosyal hayata katkı sağlamaktadır. Bu çalışma ile ortaya konulan uluslararası ve ulusal erişilebilirlik normlarının, yolcu gemilerinde/feribotlarda ve terminallerde fiili olarak uygulanabilme etkinliğinin ölçülmesi, taraflarca karşılaşılan zorlukların tespiti ve çözüm önerilerine yönelik konuların, ilgi duyan araştırmacılar tarafından farklı çalışmalarda ele alınması da yararlı olacaktır.

**Peer-review:** Externally peer-reviewed.
**Conflict of Interest:** The author has no conflict of interest to declare.
**Grant Support:** The author declared that this study has received no financial support.

**Hakem Değerlendirmesi:** Dış bağımsız.
**Çıkar Çatışması:** Yazar çıkar çatışması bildirmemiştir.
**Finansal Destek:** Yazar bu çalışma için finansal destek almadığını beyan etmiştir.

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Available online at www.iujtl.com

Journal of Transportation and Logistics
5 (2) 2020

**DOI:** 10.26650/JTL.2020.0015

RESEARCH ARTICLE

# Airport Competitiveness Analysis from Aircraft and Passenger Movement

**Fernanda Henriqueta Sabina de Moura**[1], **Mauro Caetano**[2], **Maico Roris Severino**[3]

**ABSTRACT**

Air transportation development is strictly related to airport competitiveness, since the airport management seeks to improve the capacity to produce services, increase passenger and aircraft movement, improve revenues from aeronautical and non-aeronautical activities, and optimise the other items related to the competitiveness of this type of organisation. In this sense, this study seeks to identify variables associated with the competitiveness of airports, based on their infrastructures, operations, and locations, which can influence the decision-making of airport managers continuously and efficiently. An analysis of the seven busiest Brazilian airports, in terms of aircraft and passenger movement, has been made, and multivariate data analysis has been used through a multiple regression, verifying the relationship between the variables of airports competitiveness, such as the total area of the airport site, number of aircraft parking positions, number of airlines, quantity of aircraft movement-landings and takeoffs, total number of passengers and the GDP of the city where the airport under study is located. The results present an index of competitiveness for each airport analysed after the data mathematical treatment, showing the coefficients at the general equations form aircraft and passenger movement.

**Keywords:** Air Transport, Competitiveness Index, Mathematical Modelling

**Submitted:** 01.06.2020 • **Accepted:** 06.10.2020

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**Citation:** Moura, F.H.S., Caetano, M. & Severino, M.R. (2020). Airport competitiveness analysis from aircraft and passenger movement. *Journal of Transportation and Logistics, 5*(2), 143-157. https://doi.org/10.26650/JTL.2020.0015

## Highlights

- The study presents the main variables associated with the competitiveness of airports;
- Case studies with seven of the busiest airports in Brazil have been analysed to identify a mathematical index related to its competitiveness;
- Variables such as the number of aircraft movements, total airport area, number of aircraft positions arranged at the airport, number of non-aeronautical establishments, number of airlines, passenger movement and the GDP ratio of the city where the airport is located were analysed with statistical instruments to identify the main impact at the airport performance.

## 1. Introduction

Air transportation efficiency is directly combined with the management conditions of infrastructure, including airport facilities. As one of the main components of the air transportation system, airports organisations must be effective and efficient in its core business, reaching competitive conditions to operate. According to Morrel (2016), airport competitiveness is linked to the attraction of airlines, and consequently their passengers, and other types of services, such as food, clothing, entertainment, car rental, etc.

It is noted that the airport is the first impression for a person landing at his or her final destination. For Carillho (2009), it is indisputable that air services are fundamental for society, for the value that the existence of an airport creates for the region where it is inserted, promoting the development of tourism, the employment sector, investments, taxes and regional development among others. With this, airports need to be competitive organisations to perform a critical role in economic development at local, national and international levels (Graham, 2004; Wiltshire, 2018).

The objective of this study is to identify and describe variables associated with the competitiveness of airports, as well as to perform a comparative analysis between the main Brazilian airports, making it possible for tourism destinations management to analyse, improve and innovate their definitions of service quality and competitiveness.

## 2. Theoretical Basis

To designate an airport as competitive, it is necessary to study and analyse these airport structures to know each competitive variable deeply and how the airport applies its strategies to obtain a final result on the existing competitive factors. Carilho (2009) states that one of the methodologies that can be applied to the resolution of competitive analysis in airports is one of the five competitive forces proposed by Porter (2004). In this proposal, the author analyses as a whole the threats of new participants in a given market or also possible threats of substitutes, the existing bargaining power of buyers and suppliers and the rivalry between existing organisations.

The main competitive strategies defined by Porter (2004) are cost, leadership, differentiation and focus, as shown in Figure 1. These variables are considered in this study because each airport can have its differentiated type of competitive strategy, being able to provide products and services to a broader clientele or focus that supply specific customers. Therefore, Porter (1992) states that if an organisation follows any of these strategies, there is a great chance of success in the market.

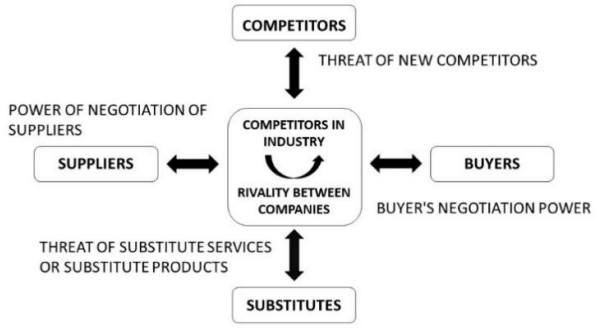


**Figure 1.** Demonstration of the five competitive forces
**Source:** adapted from Porter (1992)

In this strategic model discussed by Porter (2004), factors are analysed from all possible points, that is, everything that encompasses the organisation can serve as a benefit or not to the business strategy and must be analysed. The author explains that the competitive strategic variables of his model are the cost of goods and services, leadership in the market, as well as the differentiation in the market and the focus on a certain goal to be achieved.

Another type of analysis is proposed by Graham (2004) on airport management, and considers the amount of control or influence that an airport has over the two fundamental sources of competitive advantage: prices and products. The author demonstrates that the area where the airport has the greatest competitive advantage lies in its services and non-aeronautical facilities in the airport terminal. As it has the largest concentration of people and retail operators, their types of services are rendered to exploit to the maximum, non-aeronautical and commercial opportunities.

Regarding the aeronautical opportunities associated with the operating procedures at the airport, the amount of freedom that airports have in this area will depend on how much the government has direct control over the airport or the economic nature in which the airport works. This will also be influenced by the market power that the airline has. The ability of an airport to compete will also differ depending on which type of airline is being accommodated and its degree of price sensitivity (Graham, 2004)

For Wiltshire (2018), to discern whether or not an airport is subject to competitive pressures, its behaviour with prices, in this case, airport charges are analysed. There is evidence, for example, that airports that reduce rates may suggest that their prices are constrained by competitive pressure from competing airports, i.e., competing airports, which may or may not have greater power in the airport market can influence the change

in rates at other airports. Airport charges are usually more influential for short-haul operations as they are charged more frequently.

Areas which airports have little or no control over and can reflect in little competitive advantage, can be exemplified as the availability of slots in an airport and its physical location. According to ANAC (2014), slots are the arrival or departure times allocated for the movement of an aircraft on a specific date at a given airport, and for planning, the time at which the aircraft arrives or leaves the terminal.

Regarding the physical structure of an airport, the factors that will determine the attractiveness of the location of the airport structure include the size of the population and its propensity to use air transport services, and the tourist's economic and commercial strength of the area (Favotto, 1998). It can be said that, to a large extent, airports concentrated in regions that do not have a local market focused on receiving tourists or with little demand for flights and passengers can be characterised as an airport with little prominence in a competitive position.

It should also be considered that airports operating short-haul flights have more competitors than those operating longer long-haul flights. Given that, according to ANAC (2016), demand for domestic flights is relatively higher than demand for international flights, taking into account the distance and duration of flights, existing customs conditions and airlines operating within the international airport structure among others.

Wiltshire (2018) states that the identification, treatment, and management of a competitive airport should be done on a case-by-case basis. Each airport has its individuality to be studied and considered by numerous factors that may or may not be competitive in the market.

The competitiveness of airports is not only linked to their location or their qualities of infrastructure. In Tretheway and Kincaid's (2005) report, factors that compose airport competition can be understood as the competition for serving a shared local market, traffic connections, freight traffic, destinations most demanded for a service, service non-aeronautical (retail, food and beverage, etc.), as well as competition with other modal types, such as rail, road and waterway.

McKinnon (2011) shows that the variables that participate in the competitiveness of airports are highlighted in location, i.e., airports closer to shippers have cost and time advantages, and airport infrastructure; such as lane capacity, terminal configuration and transport, choice and the quality of freight forwarders (international freight transport).

To ascertain the degree of competitiveness of an airport, it is necessary to evaluate the correlated infrastructure, the location of the airport by analysing the region in which it is located, from the level of regional development expressed by GDP, the number of connections between terminals, the size of the network of influence from the airport to the related locations and the airport infrastructure; such as courtyards, positions available for aircraft, aircraft movement, the number of existing airlines, billing generated and the projection of future revenues due to concessions. A summary of the main variables

associated with the airport competitiveness identified in the literature is presented in Table 1.

**Table 1.** Summary of the main variables associated with airport competitiveness identified in the literature

| Authors | Variables considered | Area of application | Measurement form |
|---|---|---|---|
| Favotto (1998) | Airport infrastructure: size of airports (m²) | Boarding and disembarking areas, check-in, food court, stores, lobbies and parking. | Population size (the larger the population, the greater the use of air transport services). |
| McKinnon (2004) | Airport location | Airports located close to the shippers, and / or easily accessible, have time and cost advantages. | Time and cost. |
| | Airport infrastructure: size of airports (m²) | Airports with more types of aircraft offering a wider range of service types. | Track capacity, track configuration, transportation of terminals as well as appropriate facilities for freight forwarders. |
| | Airport fees | It is commonly applied in air tickets for airport maintenance. | Prices of airport charges. |
| | Environmental restrictions | Airports located very close to urban centres, and in cities with severe climate change. | Population dissatisfaction with noise, locations suffering from mild climatic events. |
| Graham (2004) | Prices and products | Airport management, non-aeronautical services, trades (shopping facilities). | Revenue from services rendered, revenues from trade-in non-aeronautical products. |
| Tretheway and Kincaid (2005) | Non-aeronautical services | Non-aeronautical services. | Revenues from retail sales, food, clothing, etc. |
| | Traffic connections | Airports located on routes close to each other compete for flight connections. | Number of connections for same-destination flights. |
| | Competition with other modal types | Airports still compete with other modes, even having a greater advantage of time, such as modal rail, road and waterway. | Number of routes made by other modes, distances covered by other modes, user sensitivity to the price of other modes |
| Renzetti (2015) | Competition with the local market | More than one airport infrastructure can be used in the same locality (e.g. GRU and CGH airports), the local market can influence the services provided by airports. | Quantity and variety of services in the local market that can influence the services provided by airports. |
| Wiltshire (2018) | Airport fees | Airport behavior regarding the collection of aeronautical charges. | Collection of aeronautical charges. |
| **Source:** search data | | | |

As shown in Table 1, the main variables identified in the literature are related to airports operating daily. The airport's physical location can be described as variable of competitiveness in relation to other airports close by. It is believed that an airport can become competitive by supplying such variables and trying to outperform its competitors in the airport market.

## 3. Methods

Multivariate statistical analysis data, using multiple regression, has been used to identify the variables that influence and make an airport competitive. A multivariate analysis of data is done when it is necessary to work simultaneously with several variables, in which there is no direct relation between them. That is, this method is used when there is a large grouping of data seeking to summarise and / or simplify the similar behaviour of them. It can be used and applied for several purposes even when there is no theoretical model that structures the relation of the variables operated (Bakke, Leite and Silva, 2008).

There are some types of techniques for obtaining a multivariate analysis of data, such as factorial analysis, regression and multiple correlation, multiple discriminant analysis, multivariate analysis of variance and covariance, and joint analysis among others. In this study, the multiple regression method has been used.

Multiple regression is characterised by a multivariate method of analysis that relates a single dependent variable to a set of independent variables. This indicates a high flexibility and adaptability, granting its use in almost every relation of dependence of variables. To perform a multiple linear regression, three main questions must be considered: (a) adjusting the problem to the research, (b) specifying the statistical relationship between the variables for the analysis and (c) selecting and specifying which are the dependent and independent variables to be analysed (Hair et al., 2009).

The study of the competitive variables was based on input and output factors in which inputs are related to input resources, inputs, or services in an organisation and the outputs are related to the results obtained by the input processing. For Graham (2008), these are the most relevant factors that define the performance of an airport.

The competitive criteria analysed at airports is based on their infrastructures, operations and locations. Thus, variables related to infrastructures (the total area of the airport site, number of aircraft parking positions and non-aeronautical establishments), to operations (the number of airlines, quantity of aircraft movement - landings and takeoff and the total number of passengers - domestic and international) and to airport's location (GDP of the city where the airport under study is located) were considered as independent variables (inputs). For the dependent variable (output), the operating variable corresponding to the annual aircraft movement (landings and takeoffs) was used for the first simulation, and the annual passenger movement for the second simulation to verify the behaviour of the variables for conditions.

All these variables were collected and treated in a comparative manner in the year 2016 between airports to define which of them could be considered as being competitive, according to the data obtained. The sample of this study is composed of the 7 largest Brazilian airports (AET, 2018): The São Paulo - Guarulhos International Airport (GRU), São Paulo - Congonhas Airport (CGH), Brasília International Airport (BSB), Rio de Janeiro - Galeão International Airport (GIG), Campinas - Viracopos Internacional Airport (VCP), Rio de Janeiro - Santos Dumont Airport (SDU), and Belo Horizonte - Confins International Airport (CNF). The main characteristics and variables considered for each airport studied are presented in Table 2.

**Table 2.** Main airports variables considered

| Airports | Operation (Output) | Infrastructure (*Input*) | | | Operation (*Input*) | | Location |
|---|---|---|---|---|---|---|---|
| | Aircraft movement (thousands) | Total area (m²) | Aircraft parking positions (n) | Non-aeronautical establishments (n) | Number of airlines (n) | Movement of passengers (millions) | GDP of the city (millions of R$) |
| **GRU** | 267746 | 11905056 | 123 | 241 | 42 | 36596326 | 570.706.192 |
| **CGH** | 213043 | 1647000 | 55 | 150 | 8 | 20816957 | 570.706.192 |
| **BSB** | 161167 | 28995153 | 70 | 120 | 9 | 18564113 | 175362791 |
| **GIG** | 125566 | 17881696 | 214 | 126 | 25 | 16103011 | 282538827 |
| **VCP** | 115276 | 17659300 | 32 | 218 | 6 | 9325252 | 51347711 |
| **SDU** | 105671 | 833703 | 13 | 156 | 5 | 906988 | 282538827 |
| **CNF** | 99422 | 15010000 | 43 | 33 | 11 | 9638798 | 81426708 |

**Source:** ANAC (2018) , IBGE (2013), Airport concessionaires site (2016).

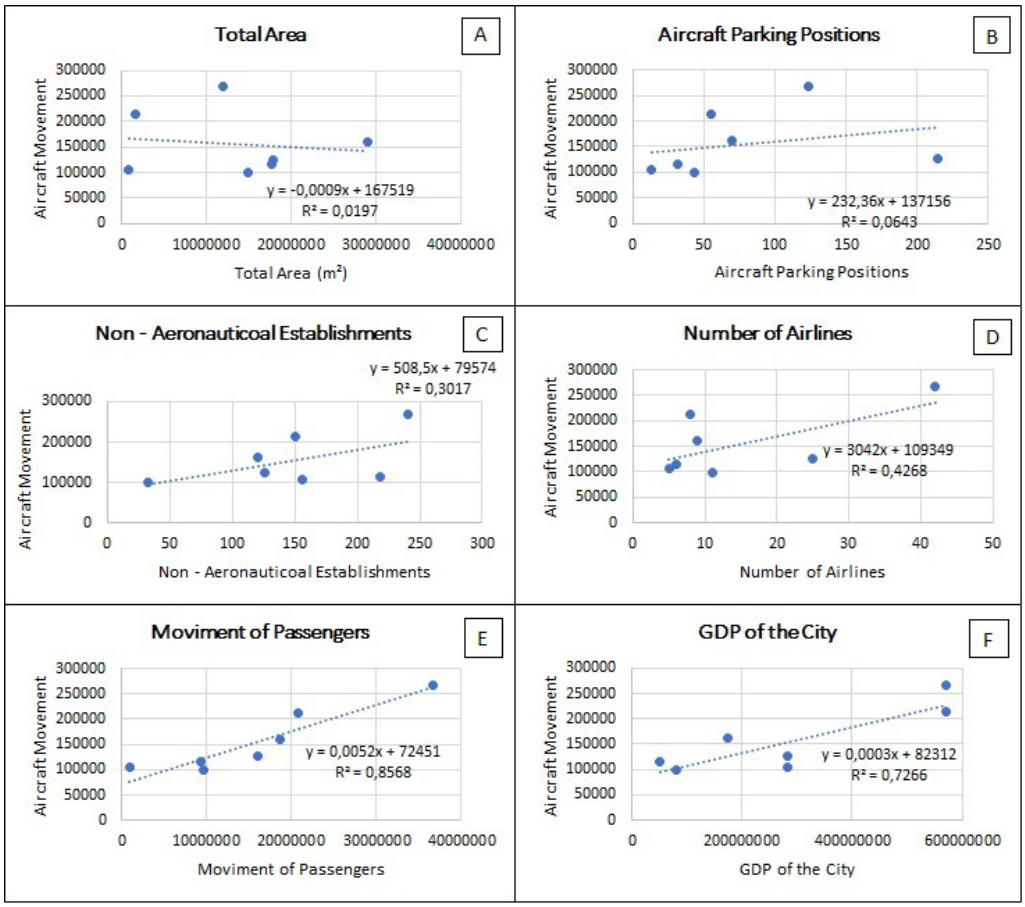


**Figure 2.** Relation of independent variables to the dependent variable

In which: A - scatter plot and line of a linear trend between the total area and the aircraft movement; B - scatter plot and linear trend line between the number of parking lots and the movement of aircraft; C - scatter plot and linear trend line between the number of non-aeronautical establishments and the movement of aircraft; D - scatter plot and linear trend line between the number of airlines and the movement of aircraft; E - dispersion chart and trend line between the movement of passengers and the movement of aircraft; F - graph of dispersion between the GDP of the city and the movement of aircraft.
**Source:** search data

To conduct the study of how the competitive variables chosen are related to the dependent variable, dispersion graphs were plotted with linear trend lines. It can be seen from Figure 2 that few independent variables can be linearly related to the dependent variable.

According to Figure 2, whenever the value of $R^2$ is close to 1 or equal to 1, it means that the variables are linearly related. The independent variables that are related in a linear way to the dependent variable (aircraft movement) are: passenger movement (Figure 2-E) and city GDP (Figure 2-F). For this reason, few dependent variables relate to the independent variable linearly, the analysis made takes into account that the distribution is non-linear and the methodology used becomes specific for this group of selected variables.

The coefficients of each of the competitiveness variables of each airport were identified. Equations 1 and 2 were used as a reference in the multiple regression and, in a comparative way, the independent variables were used with a single dependent variable. Thus, it is assumed that the independent variables are not linearly related to the dependent variable. In Equation 1, $D$ correspond to the dependent variable, $X, Y, Z...$ to the independent variables, and $a, \beta, \gamma...$ the coefficients.

$$D = X^{\alpha} \times Y^{\beta} \times Z^{\gamma} \times \ldots \quad (1)$$

Applying the $ln$ on both sides of the Equation 1, the Equation 2 was obtained for the multiple regression.

$$\begin{aligned} ln\, D &= ln(X^{\alpha} \times Y^{\beta} \times Z^{\gamma} \ldots) \\ ln\, D &= ln\, X^{\alpha} + ln\, Y^{\beta} + ln\, Z^{\gamma} + \ldots \\ ln\, D &= \alpha \times ln\, X + \beta \times ln\, Y + \gamma \times ln\, Z + \cdots \end{aligned} \quad (2)$$

Thus, it becomes possible to apply the multiple regression for the determination of parameters $a, \beta$ and $\gamma$.

## 4. Data analysis

From the identification of the $ln$ values of the competitive airports' variables, the corresponding values are presented in Table 3.

**Table 3.** Value corresponding to the natural logarithms of the competitive airports' variables

| Airports | Aircraft movement | Total area | Aircraft parking positions | Non-aeronautical establishments | Number of airlines | Movement of passengers | GDP of the city |
|---|---|---|---|---|---|---|---|
| **GRU** | 12,498 | 16,292 | 4,812 | 5,485 | 3,738 | 17,415 | 20,162 |
| **CGH** | 12,269 | 14,314 | 4,007 | 5,011 | 2,079 | 16,851 | 20,162 |
| **BSB** | 11,990 | 17,183 | 4,248 | 4,787 | 2,197 | 16,737 | 18,982 |
| **GIG** | 11,741 | 16,699 | 5,366 | 4,836 | 3,219 | 16,595 | 19,459 |
| **CNF** | 11,507 | 16,524 | 3,761 | 3,497 | 2,398 | 16,081 | 18,215 |
| **SDU** | 11,568 | 13,634 | 2,565 | 5,050 | 1,609 | 13,718 | 19,459 |
| **VCP** | 11,655 | 16,687 | 3,466 | 5,384 | 1,792 | 16,048 | 17,754 |

**Source:** search data (2016)

After obtaining the values corresponding to the *ln* of the variables, the analysis was then adopted by multiple regression, and the Table 4 shows the parameters returned by the regression.

**Table 4.** Multiple regression analysis

| **Summary of results** | |
|---|---|
| *Regression Statistics* | |
| R multiple | 0,99999999 |
| R - square | 0,99999998 |
| R - square adjusted | -1,15E-07 |
| Standard error | 0,00435618 |
| Note | 7 |
| **Source:** search data | |

In analysing Table 4 (multiple regression), in which the values of *R* vary from 0 to 1, it is observed that the regression model can explain the values found. It means that, the higher the values of *R*, or the closer to 1, the better it fits the sample. According to the *R-squared* found, it can be noted that 99% of the dependent variables can be explained by the regressors (independent variables raised by their coefficients). Table 5 shows the coefficients returned by the multiple regression performed.

**Table 5.** Coefficients returned by multiple regression

| **Variable** | **Nomenclature** | **Coefficient** |
|---|---|---|
| Total area | $T_{area}$ | 0,0896 |
| Aircraft parking positions | $n_{parking}$ | -0,3604 |
| Non-aeronautical establishments | $n_{estab}$ | 0,1258 |
| Number of Airlines | $n_{airlines}$ | 0,0722 |
| Aircraft movement | $A_{mov}$ | 0,2849 |
| GDP of the city | $GDP$ | 0,3398 |
| **Source: search data** | | |

From the values presented in Table 5, Equation 3 presents the mathematical representation of these results for the dependent variable aircraft movement (*Amov*) .

$$A_{mov} = \frac{{T_{area}}^{0,0896} \times {n_{estab}}^{0,1258} \times {n_{airlines}}^{0,0722} \times {P_{mov}}^{0,2849} \times GDP^{0,3398}}{{n_{parking}}^{0,3604}} \quad (3)$$

It is worth noting that the variables that are inversely proportional to the dependent variable must be interpreted differently from the others, since there is an inconsistency in exposing that a larger "aircraft parking number" returns a smaller contribution to the "aircraft movement". This is due to the multiple regression process, which aims to adjust the values of the database to a general equation.

After the manipulation of the values through the multiple regression, the values referring to the aircraft movement were determined, which are the values referring to the dependent

variables of each airport. These values are described in Table 6, together with the percentage of error that the equation accompanies after the estimation of the values. The error is calculated by the actual value module minus the estimated value, divided by the actual value. The error was calculated to demonstrate that the error percentage of the estimated value for this dependent variable is low.

**Table 6.** Estimated value for the dependent variable (aircraft movement) and their respective errors (%)

| Airports | Estimated value by Equation | Error (%) |
|---|---|---|
| **GRU** | 267516,36 | 0,09 |
| **CGH** | 213132,89 | 0,04 |
| **BSB** | 160607,31 | 0,35 |
| **GIG** | 125753,02 | 0,15 |
| **CNF** | 99516,16 | 0,09 |
| **SDU** | 105663,85 | 0,01 |
| **VCP** | 115470,58 | 0,17 |

**Source:** search data

The next step was to apply each variable to its respective exponent separately, as shown in Table 7.

**Table 7. Variables raised to their respective coefficients, obtained by multiple regression**

| Airports | Total area | Aircraft parking positions | Non-aeronautical establishments | Number of airlines | Movement of passengers | GDP of the city |
|---|---|---|---|---|---|---|
| **GRU** | 4,3070 | 0,1765 | 1,9935 | 1,3097 | 142,7483 | 944,0950 |
| **CGH** | 3,6073 | 0,2359 | 1,8780 | 1,1619 | 121,5550 | 944,0950 |
| **BSB** | 4,6648 | 0,2163 | 1,8261 | 1,1719 | 117,6530 | 632,2675 |
| **GIG** | 4,4670 | 0,1446 | 1,8373 | 1,2615 | 112,9815 | 743,4940 |
| **CNF** | 4,3974 | 0,2578 | 1,5524 | 1,1890 | 97,6147 | 487,1977 |
| **SDU** | 3,3938 | 0,3968 | 1,8873 | 1,1232 | 49,7877 | 743,4940 |
| **VCP** | 4,4620 | 0,2868 | 1,9685 | 1,1381 | 96,6994 | 416,5538 |

**Source:** search data

For the final analysis and the competitive airports ranking, a competitive index was established of the division of the variables in Table 7 by the highest value of these. After that, the sum of these was made for each airport, finally having a competitiveness index for each one.

For the variable that is related inversely proportional to the dependent variable returned by the regression, an adjustment of its contribution to the competitiveness index was made. In this sense, to obtain a coherent value, the value 1 (one) was subtracted. That is to say that a larger number of aeronautical establishments would return a greater contribution to the competitiveness index, for example, if value 1 (one) was subtracted.

Thus the values obtained are consistent, since for example, the larger the number of

non-aeronautical establishments, the greater is the contribution to the competitiveness index (according to Table 8).

**Table 8.** Index of competitiveness of the airports studied

| Airports | Total area | Aircraft parking positions | Non-aeronautical establishments | Number of airlines | Movement of passengers | GDP of the city | Competitivity index |
|---|---|---|---|---|---|---|---|
| **GRU** | 0,9233 | 0,5551 | 1,0000 | 1,0000 | 1,0000 | 1,0000 | 5,4784 |
| **CGH** | 0,7733 | 0,4054 | 0,9421 | 0,8872 | 0,8515 | 1,0000 | 4,8595 |
| **BSB** | 1,0000 | 0,4549 | 0,9160 | 0,8948 | 0,8242 | 0,6697 | 4,7596 |
| **GIG** | 0,9576 | 0,6356 | 0,9217 | 0,9632 | 0,7915 | 0,7875 | 5,0571 |
| **CNF** | 0,9427 | 0,3502 | 0,7787 | 0,9078 | 0,6838 | 0,5160 | 4,1793 |
| **SDU** | 0,7275 | 0,0000 | 0,9468 | 0,8576 | 0,3488 | 0,7875 | 3,6682 |
| **VCP** | 0,9565 | 0,2772 | 0,9875 | 0,8690 | 0,6774 | 0,4412 | 4,2088 |

**Source:** search data

According to Table 8, the results confirm Porter's (1992) competitive analysis tool that states the five competitive forces that should be explored by organisations seeking competitive advantages. This is also supported by Carrilho (2009). Following Porter's five forces and analysing the results, an airport should always analyse its competitors to stand out or seek to improve its strategies for the cost and differentiation of its services, market leadership and to focus its attitudes to makes it more competitive. Analysing this way, good administration can contribute to the increase of all the indexes indicated in the study and consequently, to the increase of the competitiveness index of an airport.

Another argument supported by the study was that of Graham (2008), stating that the airports that have the greatest competitive advantage are those that have a great influence on non-aeronautical services at the airport terminal, where retail business opportunities exist and a greater number of people are present. This rationale can be seen in Table 8, where the highest competitiveness figures for airports are concentrated in the variable of non-aeronautical establishments. It is worth mentioning that this study also supports the Wiltshire (2018) statement, where each airport has individual characteristics and should be analysed on a case-by-case basis, since they may have different competitive variables.

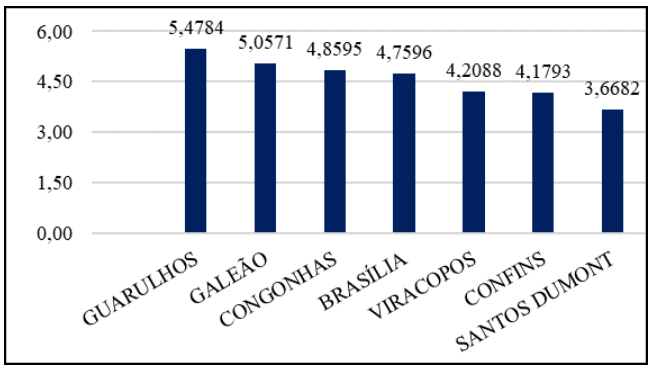


**Figure 3.** Competitiveness indexes - aircraft movement

**Source:** search data

It can be seen in Table 8 that the highest indices belong to GRU airport, and Figure 3 shows the ranking of the competitive airports studied according to the variables analysed for the variable chosen as dependent: aircraft movement.

To simulate the case of a commercial airport to value more by the quantity of passengers than by the quantity of aircraft, a new simulation was performed in which it considered the movement of passengers (*Pmov*) as a dependent variable. The entire process described in the previous sections was performed again to obtain Equation 4 and Figure 4 as results.

$$P_{mov} = \frac{{n_{parking}}^{1,2651} \times {A_{mov}}^{3,5101}}{{T_{area}}^{0,3146} \times {n_{estab}}^{0,4415} \times {n_{airlines}}^{0,2534} \times GDP^{1,1925}} \quad (4)$$

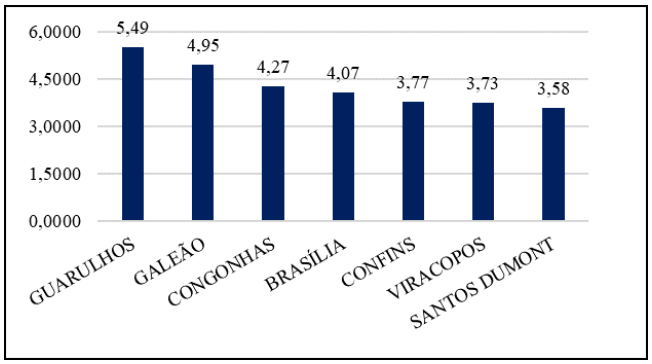


**Figure 4.** Competitiveness Index - movement of passengers

**Source:** search data

In Figure 4, a small change in the ranking of airports is noted. The change in this ranking can be affirmed for the reason that in this index, CNF simulation has a greater movement of passengers, and in the previous simulation, VCP has a greater movement of aircraft (passengers + loads). However, it is noted that by comparing airports, the distances between their indexes vary, once again concluding that airports have different characteristics and should be analysed on a case-by-case basis as Wiltshire (2018) states. Taking as an example BSB airport, it can be concluded that the difference between the competitiveness indexes obtained by the two simulations is because the airport has, in this case, a high cargo movement.

## 5. Final considerations and future studies

Considering the results obtained, this study allowed a competitive comparison by a multivariate analysis of data from Brazilian airports, some of them managed by Infraero and others administered by their respective private concessionaires, offering a partial perspective on the subject.

The difficulty of choosing variables and obtaining their data justifies the option to work with a non-linear distribution and the use of the methodology presented in this study.

It was possible to identify an incoherence when using the non-linear distribution method of the independent variables with the dependent variable. When performing the multiple regression process, for a variable dependent on the aircraft movement, the coefficient related to the number of negative non-aeronautical establishments was obtained. However, this does not necessarily show that this factor is not linked to airport competitiveness. This is because some independent variables chosen are not linearly related to the dependent variable. This can be seen at the plots with a linear trend line, according to Figure 2. It was possible to notice that the independent variables are linearly related to the dependent variable, and have a greater influence on the composition of the competitiveness indexes.

The study of variables considered competitive in airports, serves to make visible how much the airport sector can be considered to have an impact within a country, and shows how it can be related to the economy, organisational culture, the number of services and strategic location among factors. And with this, the study can serve a purpose in the forecasting, researching and implementation and of improvements, while always considering the need for constant innovation and user satisfaction.

According to the ranking of airports and their respective competitiveness indexes, it is noted that GRU presented the highest competitiveness index between the airports practiced for both analyses. On the other hand, SDU presented the worst competitiveness index. This does not necessarily mean or points to this airport as being bad or insufficient compared to others, but may be because this airport is located in the same city as GIG, which, having a larger portfolio of final destinations for flights and, consequently, greater passenger movement, is classified as being international.

It is also verified that the two simulations allowed to visualise the variation of the indexes obtained since the airports were analysed differently. This is because airports have different characteristics, that is, even if they are more or less valued by the movement of aircraft and by the movement of passengers, the indexes will always have variations.

As a suggestion for future studies, it is recommended to analyse a greater number of airports in the country and to compare them with airports in other parts of the world. Environmental issues, regional differences, cultures, policies and demands for aeronautical services should be taken into consideration and it should be decided upon which factors would be relevant to the Brazilian airport sector to further develop and influence the progress of this sector.

The discovery of independent variables that are linearly related to the dependent variable allows a better analysis of how they contribute to the composition of the dependent variable. In this sense, further investigation of the criteria established for each airport (infrastructure, operation, location) would allow a better analysis of the contribution of each of these parameters.

Another analysis that would be beneficial for future studies would be an application of airport benchmarking, where indexes of all the airports are analysed to quantify and to identify the competitive positions of each one. In this way, an airport listed as uncompetitive has the study of what to apply for improvements in its airport management and thus the opportunity to change its indexes mainly by improving management, the

quality of the way its services are provided and the operational capacity of the airport. This benchmarking application is widely performed in the international environment and due to the scarcity of aeronautical studies in Brazil, this study would be also applicable to analysing international airports, not only Brazilian airports.

**Peer-review:** Externally peer-reviewed.
**Conflict of Interest:** The author has no conflict of interest to declare.
**Grant Support:** National Council for Scientific and Technological Development (CNPQ) and The State of Goiás Research Foundation (FAPEG).

**Acknowledgement:** National Council for Scientific and Technological Development (CNPQ), The State of Goiás Research Foundation (FAPEG) and the MTOW: Research Group in Air Transport Innovation.

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**AMAÇ VE KAPSAM**

Ulaştırma ve Lojistik Dergisi (JTL), İstanbul Üniversitesi Ulaştırma ve Lojistik Fakültesi'nin çok disiplinli ve altı aylık resmi bir dergisidir. Derginin amacı, taşımacılık ve lojistik endüstrisinin küresel ekonomi için geri döndürülemez hale gelen sorunları hakkında yeni fikirleri yayınlamaktır. JTL, akademisyenlere ve saha uygulayıcılarına ulaştırma ve lojistik için yeni konuları tartışmak ve analiz etmek için dinamik bir platform sunmaktadır. JTL Dünya çapında iş yöneticileri ve araştırmacılar arasında lojistik ve tedarik zinciri yönetimi ile ilgili bilgi alışverişinin yanı sıra, lojistik ve tedarik zinciri yönetim sorunları ve teknikleri hakkında yeni bir düşünce platformunda bağımsız, özgün ve özenli bir analiz olanağı sunar. Dergimize akademisyenler ve saha uygulayıcıları tarafından yapılan ulaştırma, lojistik ve tedarik zinciri yönetimi ve uygulamalarını geliştiren makaleler, araştırma çalışmaları, örnek olay analizleri ve inceleme makaleleri davet edilmektedir. Ulaştırma, lojistik veya tedarik zinciri yönetiminin herhangi bir alanındaki makaleler dergimize kabul edilmektedir. Dergimiz editörleri gelen çalışmalar ile ilgili eserlerin teorik ve yöntemsel süreçlerin uygulamalar ile ne derecede örtüştüğünü test etmektedirler. Yayınlanmak üzere gönderilen makalelerin tedarik zincirinde ulaştırma ve lojistik süreci perspektifinden uygulamalarının yapılması ve yorumlanması kabul için öncelikli tercih nedeni olmaktadır. Bu nedenle, dergimize işletmecilik, girişimcilik, yönetim, muhasebe, kurumsal yönetim müşteri ilişkileri yönetimi (CRM), pazarlama, insan kaynakları yönetimi, ekonomi, finans, işletme, imalat sanayi, lojistik, tedarik zinciri yönetimi, ulaşım endüstrileri, yeşil lojistik, ters lojistik, insani lojistik, sürdürülebilirlik, şehir lojistiği sektörleri ile ilgili çalışmalar kabul edilmektedir. Tüm makaleler, hakemler tarafından yayınlanmak üzere olarak incelenmektedir.

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Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir.

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Makale yayınlanmak üzere dergiye gönderildikten sonra yazarlardan hiçbirinin ismi, tüm yazarların yazılı izni olmadan yazar listesinden silinemez ve yeni bir isim yazar olarak eklenemez ve yazar sırası değiştirilemez.

Yayına kabul edilmeyen makale, resim ve fotoğraflar yazarlara geri gönderilmez.

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**ETİK**

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- Araştırmanın tasarlanması, tasarımın gözden geçirilmesi ve araştırmanın yürütülmesinde, bütünlük, kalite ve şeffaflık ilkeleri sağlanmalıdır.
- Araştırma ekibi ve katılımcılar, araştırmanın amacı, yöntemleri ve öngörülen olası kullanımları; araştırmaya katılımın gerektirdikleri ve varsa riskleri hakkında tam olarak bilgilendirilmelidir.
- Araştırma katılımcılarının sağladığı bilgilerin gizliliği ve yanıt verenlerin gizliliği sağlanmalıdır. Araştırma katılımcıların özerkliğini ve saygınlığını koruyacak şekilde tasarlanmalıdır.
- Araştırma katılımcıları gönüllü olarak araştırmada yer almalı, herhangi bir zorlama altında olmamalıdırlar.
- Katılımcıların zarar görmesinden kaçınılmalıdır. Araştırma, katılımcıları riske sokmayacak şekilde planlanmalıdır.
- Araştırma bağımsızlığıyla ilgili açık ve net olunmalı; çıkar çatışması varsa belirtilmelidir.
- Deneysel çalışmalarda, araştırmaya katılmaya karar veren katılımcıların yazılı bilgilendirilmiş onayı alınmalıdır. Çocukların ve vesayet altındakilerin veya tasdiklenmiş akıl hastalığı bulunanların yasal vasisinin onayı alınmalıdır.
- Çalışma herhangi bir kurum ya da kuruluşta gerçekleştirilecekse bu kurum ya da kuruluştan çalışma yapılacağına dair onay alınmalıdır.
- İnsan öğesi bulunan çalışmalarda, "yöntem" bölümünde katılımcılardan "bilgilendirilmiş onam" alındığının ve çalışmanın yapıldığı kurumdan etik kurul onayı alındığı belirtilmesi gerekir.

**Yazarların Sorumluluğu**

Makalelerin bilimsel ve etik kurallara uygunluğu yazarların sorumluluğundadır. Yazar makalenin orijinal olduğu, daha önce başka bir yerde yayınlanmadığı ve başka bir yerde, başka bir dilde yayınlanmak üzere değerlendirmede olmadığı konusunda teminat sağlamalıdır. Uygulamadaki telif kanunları ve anlaşmaları gözetilmelidir. Telife bağlı materyaller (örneğin tablolar, şekiller veya büyük alıntılar) gerekli izin ve teşekkürle kullanılmalıdır. Başka yazarların, katkıda bulunanların çalışmaları ya da yararlanılan kaynaklar uygun biçimde kullanılmalı ve referanslarda belirtilmelidir.

Gönderilen makalede tüm yazarların akademik ve bilimsel olarak doğrudan katkısı olmalıdır, bu bağlamda "yazar" yayınlanan bir araştırmanın kavramsallaştırılmasına ve dizaynına, verilerin elde edilmesine, analizine ya da yorumlanmasına belirgin katkı yapan, yazının yazılması ya da bunun içerik açısından

eleştirel biçimde gözden geçirilmesinde görev yapan birisi olarak görülür. Yazar olabilmenin diğer koşulları ise, makaledeki çalışmayı planlamak veya icra etmek ve / veya revize etmektir. Fon sağlanması, veri toplanması ya da araştırma grubunun genel süpervizyonu tek başına yazarlık hakkı kazandırmaz. Yazar olarak gösterilen tüm bireyler sayılan tüm ölçütleri karşılamalıdır ve yukarıdaki ölçütleri karşılayan her birey yazar olarak gösterilebilir. Yazarların isim sıralaması ortak verilen bir karar olmalıdır. Tüm yazarlar yazar sıralamasını Telif Hakkı Formunda imzalı olarak belirtmek zorundadırlar.

Yazarlık için yeterli ölçütleri karşılamayan ancak çalışmaya katkısı olan tüm bireyler "teşekkür / bilgiler" kısmında sıralanmalıdır. Bunlara örnek olarak ise sadece teknik destek sağlayan, yazıma yardımcı olan ya da sadece genel bir destek sağlayan, finansal ve materyal desteği sunan kişiler verilebilir.

Bütün yazarlar, araştırmanın sonuçlarını ya da bilimsel değerlendirmeyi etkileyebilme potansiyeli olan finansal ilişkiler, çıkar çatışması ve çıkar rekabetini beyan etmelidirler. Bir yazar kendi yayınlanmış yazısında belirgin bir hata ya da yanlışlık tespit ederse, bu yanlışlıklara ilişkin düzeltme ya da geri çekme için editör ile hemen temasa geçme ve işbirliği yapma sorumluluğunu taşır.

**Editör, Hakem Sorumlulukları ve Değerlendirme Süreci**

Baş editör, makaleleri, yazarların etnik kökeninden, cinsiyetinden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirir. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlar. Gönderilen makalelere ilişkin tüm bilginin, makale yayınlanana kadar gizli kalacağını garanti eder. Baş editör içerik ve yayının toplam kalitesinden sorumludur. Gereğinde hata sayfası yayınlamalı ya da düzeltme yapmalıdır.

Baş editör; yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkiye sahiptir ve dergide yayınlanacak makalelerle ilgili nihai kararı vermekle yükümlüdür.

Hakemlerin araştırmayla ilgili, yazarlarla ve/veya araştırmanın finansal destekçileriyle çıkar çatışmaları olmamalıdır. Değerlendirmelerinin sonucunda tarafsız bir yargıya varmalıdırlar. Gönderilmiş yazılara ilişkin tüm bilginin gizli tutulmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar.

Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir. Bazı durumlarda editörün kararıyla, ilgili hakemlerin makaleye ait yorumları aynı makaleyi yorumlayan diğer hakemlere gönderilerek hakemlerin bu süreçte aydınlatılması sağlanabilir.

**Hakem Süreci**

Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir. Gönderilen ve ön kontrolü geçen makaleler iThenticate yazılımı kullanılarak intihal için taranır. İntihal kontrolünden sonra, uygun olan makaleler baş editör tarafından orijinallik, metodoloji, işlenen konunun önemi ve dergi kapsamı ile uyumluluğu açısından değerlendirilir. Baş editör, makaleleri, yazarların etnik kökeninden, cinsiyetinden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirir. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlar.

Seçilen makaleler en az iki ulusal/uluslararası hakeme değerlendirmeye gönderilir; yayın kararı, hakemlerin talepleri doğrultusunda yazarların gerçekleştirdiği düzenlemelerin ve hakem sürecinin sonrasında baş editör tarafından verilir.

Hakemlerin değerlendirmeleri objektif olmalıdır. Hakem süreci sırasında hakemlerin aşağıdaki hususları dikkate alarak değerlendirmelerini yapmaları beklenir.

- Makale yeni ve önemli bir bilgi içeriyor mu?
- Öz, makalenin içeriğini net ve düzgün bir şekilde tanımlıyor mu?
- Yöntem bütünlüklü ve anlaşılır şekilde tanımlanmış mı?

- Yapılan yorum ve varılan sonuçlar bulgularla kanıtlanıyor mu?
- Alandaki diğer çalışmalara yeterli referans verilmiş mi?
- Dil kalitesi yeterli mi?

Hakemler, gönderilen makalelere ilişkin tüm bilginin, makale yayınlanana kadar gizli kalmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar. Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir.

**YAZILARIN HAZIRLANMASI**

**Dil**

Dergide Türkçe ve İngilizce makaleler yayınlanır. Gönderilen makalelerde makale dilinde öz, İngilizce öz ve İngilizce geniş özet olmalıdır. Ancak makale İngilizce ise, İngilizce geniş özet istenmez.

**Yazıların Hazırlanması ve Yazım Kuralları**

Aksi belirtilmedikçe gönderilen yazılarla ilgili tüm yazışmalar ilk yazarla yapılacaktır. Makale gönderimi online olarak https://jtl.istanbul.edu.tr/en/_ sayfasından erişilen https://mc04.manuscriptcentral.com/jtl üzerinden yapılmalıdır. Gönderilen yazılar, makale türünü belirten ve makaleyle ilgili detayları içeren (bkz: Son Kontrol Listesi) Kapak Sayfası; yazının elektronik formunu içeren Microsoft Word 2003 ve üzerindeki versiyonları ile yazılmış elektronik dosya ve tüm yazarların imzaladığı Telif Hakkı Anlaşması Formu eklenerek gönderilmelidir.

1. Yazılar Makale Şablonu kullanılarak hazırlanmalıdır. Makale ana metninde, çift taraflı kör hakemlik süreci gereği, yazarın / yazarların kimlik bilgileri yer almamalıdır.
2. Yayınlanmak üzere gönderilen makale ile birlikte yazar bilgilerini içeren Kapak Sayfası gönderilmelidir. Kapak Sayfasında, makalenin başlığı, yazar veya yazarların bağlı bulundukları kurum ve unvanları, kendilerine ulaşılabilecek adresler, cep, iş ve faks numaraları, ORCID ve e-posta adresleri yer almalıdır (bkz. Son Kontrol Listesi).
3. Giriş bölümünden önce 180-200 kelimelik çalışmanın kapsamını, amacını, ulaşılan sonuçları ve kullanılan yöntemi kaydeden makale dilinde öz ve İngilizce öz ile 600-800 kelimelik İngilizce genişletilmiş özet yer almalıdır. Makale İngilizce ise İngilizce geniş özet istenmez. Özlerin altında çalışmanın içeriğini temsil eden, 3'er adet anahtar kelime yer almalıdır.
4. Çalışmaların başlıca şu unsurları içermesi gerekmektedir: Makale dilinde başlık, öz ve anahtar kelimeler; İngilizce başlık, öz ve anahtar kelimeler; geniş özet, ana metin bölümleri, kaynaklar, tablolar ve şekiller.
5. **Makale Türleri:**

   **Araştırma Makaleleri:** Orijinal araştırma makaleleri derginin kapsamına uygun konularda önemli, özgün bilimsel sonuçlar sunan araştırmaları raporlayan yazılardır. Orijinal araştırma makaleleri, Öz, Anahtar Kelimeler, İngilizce Geniş Özet, Giriş, Yöntem, Bulgular, Tartışma, Sonuçlar, Kaynaklar bölümlerinden ve Tablo, Grafik ve Şekillerden oluşur.

   **Öz:** Makale dilinde başlık ve İngilizce başlık öz'lerin üzerinde yer almalıdır. Araştırma yazılarında Türkçe ve İngilizce özler 180-200 kelime arasında olmalı ve çalışmanın amacı, yöntemi, ana bulguları ve sonuçlarını ifade etmelidir. Ayrıca Türkçe, Almanca, Fransızca ya da İtalyanca makaleler için özlerden sonra 600-800 kelimelik İngilizce geniş özet de yer almalıdır.

   **Giriş:** Giriş bölümünde konunun önemi, tarihçe ve bugüne kadar yapılmış çalışmalar, hipotez ve çalışmanın amacından söz edilmelidir. Hem ana hem de ikincil amaçlar açıkça belirtilmelidir. Sadece gerçekten ilişkili kaynaklar gösterilmeli ve çalışmaya ait veri ya da sonuçlardan söz edilmemelidir. Giriş bölümünün sonunda çalışmanın amacı, araştırma soruları veya hipotezler yazılmalıdır.

   **Yöntem:** Yöntem bölümünde, veri kaynakları, çalışmaya katılanlar, ölçekler, görüşme/değerlendirmeler ve temel ölçümler, yapılan işlemler ve istatistiksel yöntemler yer almalıdır. Yöntem bölümü, sadece çalışmanın planı ya da protokolü yazılırken bilinen bilgileri içermelidir; çalışma sırasında elde edilen tüm bilgiler bulgular kısmında verilmelidir.

   **Bulgular:** Ana bulgular istatistiksel verilerle desteklenmiş olarak eksiksiz verilmeli ve bu bulgular

uygun tablo, grafik ve şekillerle görsel olarak da belirtilmelidir. Bulgular yazıda, tablolarda ve şekillerde mantıklı bir sırayla önce en önemli sonuçlar olacak şekilde verilmelidir. Tablo ve şekillerdeki tüm veriyi yazıda vermemeli, sadece önemli noktaları vurgulanmalıdır.

**Tartışma:** Tartışma bölümünde o çalışmadan elde edilen veriler, kurulan hipotez doğrultusunda hipotezi destekleyen ve desteklemeyen bulgular ve sonuçlar irdelenmeli ve bu bulgu ve sonuçlar literatürde bulunan benzeri çalışmalarla kıyaslanmalı, farklılıklar varsa açıklanmalıdır. Çalışmanın yeni ve önemli yanları ve bunlardan çıkan sonuçları vurgulanmalıdır. Giriş ya da sonuçlar kısmında verilen bilgi ve veriler tekrarlanmamalıdır.

**Sonuçlar:** Çalışmadan elde edilen sonuçlar belirtilmelidir. Sonuçlar, çalışmanın amaçları ile bağlantılı olmalıdır, ancak veriler tarafından yeterince desteklenmeyen niteliksiz ifadeler ve sonuçlardan kaçınılmalıdır. Yeni hipotezler gerektiğinde belirtilmeli, ancak açıkça tanımlanmalıdır.

Şekil, Resim, Tablo ve Grafikler:. Metin içinde kullanılan fotoğraf, plân, harita vb. materyallerin ".jpg / .tiff" uzantılı kayıtları gönderilecek dokümanlara eklenmelidir. Bu tür belgelerin baskı tekniğine uygun çözünürlükte (en az 300 piksel) ve sayfa alanını aşmayacak büyüklükte olmasına dikkat edilmelidir. Fotoğraf ve levhaların 10 sayfayı aşmamasına dikkat edilmeli ve metin içinde parantezle atıfta bulunulan resim, harita veya diğer ekler makalenin sonuna eklenmelidir.

**Derleme:** Yazının konusunda birikimi olan ve bu birikimleri uluslararası literatüre yayın ve atıf sayısı olarak yansımış uzmanlar tarafından hazırlanmış yazılar değerlendirmeye alınır. Yazarları dergi tarafından da davet edilebilir. Derleme yazısı, başlık, öz, anahtar kelimeler, İngilizce geniş özet (Türkçe, Almanca, Fransızca ve İtalyanca makaleler için), ana metin bölümleri ve kaynaklardan oluşmalıdır.

6. Referanslar derginin benimsediği American Psychological Association (APA) 6 stiline uygun olarak hazırlanmalıdır.
7. Kurallar dâhilinde dergimize yayınlanmak üzere gönderilen çalışmaların her türlü sorumluluğu yazar/ yazarlarına aittir.

**KAYNAKLAR**

**Referans Stili ve Formatı**

Journal of Transportation and Logistics, metin içi alıntılama ve kaynak gösterme için APA (American Psychological Association) kaynak sitilinin 6. edisyonunu benimser. APA 6.Edisyon hakkında bilgi için:

- American Psychological Association. (2010). Publication manual of the American Psychological

Association (6th ed.). Washington, DC: APA.

- http://www.apastyle.org/

Kaynakların doğruluğundan yazar(lar) sorumludur. Tüm kaynaklar metinde belirtilmelidir. Kaynaklar aşağıdaki örneklerdeki gibi gösterilmelidir.

**Metin İçinde Kaynak Gösterme**

Kaynaklar metinde parantez içinde yazarların soyadı ve yayın tarihi yazılarak belirtilmelidir.

Birden fazla kaynak gösterilecekse kaynaklar arasında (;) işareti kullanılmalıdır. Kaynaklar alfabetik olarak sıralanmalıdır.

**Örnekler:**

***Birden fazla kaynak;***
(Esin ve ark., 2002; Karasar 1995)
***Tek yazarlı kaynak;***
(Akyolcu, 2007)
***İki yazarlı kaynak;***
(Sayıner ve Demirci, 2007, s. 72)
***Üç, dört ve beş yazarlı kaynak;***
Metin içinde ilk kullanımda: (Ailen, Ciambrune ve Welch, 2000, s. 12–13) Metin içinde tekrarlayan kullanımlarda: (Ailen ve ark., 2000)
***Altı ve daha çok yazarlı kaynak;***
(Çavdar ve ark., 2003)

**Kaynaklar Bölümünde Kaynak Gösterme**

Kullanılan tüm kaynaklar metnin sonunda ayrı bir bölüm halinde yazar soyadlarına göre alfabetik olarak numaralandırılmadan verilmelidir.

**Kaynak yazımı ile ilgili örnekler aşağıda verilmiştir.**

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***e) Podcast***

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***f) Bir Televizyon Dizisinden Tek Bir Bölüm***

Shore, D. (Senarist), Jackson, M. (Senarist) ve Bookstaver, S. (Yönetmen). (2012). Runaways [Televizyon dizisi bölümü]. D. Shore (Baş yapımcı), *House M.D.* içinde. New York, NY: Fox Broadcasting.

***g) Müzik Kaydı***

Say, F. (2009). Galata Kulesi. *İstanbul senfonisi* [CD] içinde. İstanbul: Ak Müzik.

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Aşağıdaki listede eksik olmadığından emin olun:

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**Citations in the Reference**

All the citations done in the text should be listed in the References section in alphabetical order of author surname without numbering. Below given examples should be considered in citing the references.

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**a) Turkish Book**
Karasar, N. (1995). *Araştırmalarda rapor hazırlama* (8th ed.) [Preparing research reports]. Ankara, Turkey: 3A Eğitim Danışmanlık Ltd.
***b) Book Translated into Turkish***
Mucchielli, A. (1991). *Zihniyetler* [Mindsets] (A. Kotil, Trans.). İstanbul, Turkey: İletişim Yayınları.
***c) Edited Book***
Ören, T., Üney, T., & Çölkesen, R. (Eds.). (2006). *Türkiye bilişim ansiklopedisi* [Turkish Encyclopedia of Informatics]. İstanbul, Turkey: Papatya Yayıncılık.
***d) Turkish Book with Multiple Authors***
Tonta, Y., Bitirim, Y., & Sever, H. (2002). T*ürkçe arama motorlarında performans değerlendirme* [Performance evaluation in Turkish search engines]. Ankara, Turkey: Total Bilişim.
***e) Book in English***
Kamien R., & Kamien A. (2014). *Music: An appreciation.* New York, NY: McGraw-Hill Education.
***f) Chapter in an Edited Book***
Bassett, C. (2006). Cultural studies and new media. In G. Hall & C. Birchall (Eds.), *New cultural studies: Adventures in theory* (pp. 220–237). Edinburgh, UK: Edinburgh University Press.
***g) Chapter in an Edited Book in Turkish***
Erkmen, T. (2012). Örgüt kültürü: Fonksiyonları, öğeleri, işletme yönetimi ve liderlikteki önemi [Organization culture: Its functions, elements and importance in leadership and business management]. In M. Zencirkıran (Ed.), *Örgüt sosyolojisi* [Organization sociology] (pp. 233–263). Bursa, Turkey: Dora Basım Yayın.
***h) Book with the same organization as author and publisher***
American Psychological Association. (2009). *Publication manual of the American psychological association* (6th ed.). Washington, DC: Author.

**Article**

***a) Turkish Article***
Mutlu, B., & Savaşer, S. (2007). Çocuğu ameliyat sonrası yoğun bakımda olan ebeveynlerde stres nedenleri ve azaltma girişimleri [Source and intervention reduction of stress for parents whose children are in intensive care unit after surgery]. *Istanbul University Florence Nightingale Journal of Nursing, 15*(60), 179–182.

***b) English Article***

de Cillia, R., Reisigl, M., & Wodak, R. (1999). The discursive construction of national identity. *Discourse and Society, 10*(2), 149–173. http://dx.doi.org/10.1177/0957926599010002002

***c) Journal Article with DOI and More Than Seven Authors***

Lal, H., Cunningham, A. L., Godeaux, O., Chlibek, R., Diez-Domingo, J., Hwang, S.-J. ... Heineman, T. C. (2015). Efficacy of an adjuvanted herpes zoster subunit vaccine in older adults. *New England Journal of Medicine, 372,* 2087–2096. http://dx.doi.org/10.1056/NEJMoa1501184

***d) Journal Article from Web, without DOI***

Sidani, S. (2003). Enhancing the evaluation of nursing care effectiveness. *Canadian Journal of Nursing Research, 35*(3), 26–38. Retrieved from http://cjnr.mcgill.ca

***e) Journal Article wih DOI***

Turner, S. J. (2010). Website statistics 2.0: Using Google Analytics to measure library website effectiveness. *Technical Services Quarterly, 27,* 261–278. http://dx.doi.org/10.1080/07317131003765910

***f) Advance Online Publication***

Smith, J. A. (2010). Citing advance online publication: A review. *Journal of Psychology.* Advance online publication. http://dx.doi.org/10.1037/a45d7867

***g) Article in a Magazine***

Henry, W. A., III. (1990, April 9). Making the grade in today's schools. *Time, 135,* 28–31.

**Doctoral Dissertation, Master's Thesis, Presentation, Proceeding**

***a) Dissertation/Thesis from a Commercial Database***

Van Brunt, D. (1997). *Networked consumer health information systems* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 9943436)

***b) Dissertation/Thesis from an Institutional Database***

Yaylalı-Yıldız, B. (2014). *University campuses as places of potential publicness: Exploring the politicals, social and cultural practices in Ege University* (Doctoral dissertation). Retrieved from Retrieved from: http://library.iyte.edu.tr/tr/hizli-erisim/iyte-tez-portali

***c) Dissertation/Thesis from Web***

Tonta, Y. A. (1992). *An analysis of search failures in online library catalogs* (Doctoral dissertation, University of California, Berkeley). Retrieved from http://yunus.hacettepe.edu.tr/~tonta/yayinlar /phd/ickapak.html

***d) Dissertation/Thesis abstracted in Dissertations Abstracts International***

Appelbaum, L. G. (2005). Three studies of human information processing: Texture amplification, motion representation, and figure-ground segregation. *Dissertation Abstracts International: Section B. Sciences and Engineering, 65*(10), 5428.

***e) Symposium Contribution***

Krinsky-McHale, S. J., Zigman, W. B., & Silverman, W. (2012, August). Are neuropsychiatric symptoms markers of prodromal Alzheimer's disease in adults with Down syndrome? In W. B. Zigman (Chair), *Predictors of mild cognitive impairment, dementia, and mortality in adults with Down syndrome.* Symposium conducted at the meeting of the American Psychological Association, Orlando, FL.

***f) Conference Paper Abstract Retrieved Online***

Liu, S. (2005, May). *Defending against business crises with the help of intelligent agent based early warning solutions.* Paper presented at the Seventh International Conference on Enterprise Information Systems, Miami, FL. Abstract retrieved from http://www.iceis.org/iceis2005/abstracts_2005.htm

***g) Conference Paper - In Regularly Published Proceedings and Retrieved Online***

Herculano-Houzel, S., Collins, C. E., Wong, P., Kaas, J. H., & Lent, R. (2008). The basic nonuniformity of the cerebral cortex. *Proceedings of the National Academy of Sciences, 105,* 12593–12598. http://dx.doi.org/10.1073/pnas.0805417105

***h) Proceeding in Book Form***

Parsons, O. A., Pryzwansky, W. B., Weinstein, D. J., & Wiens, A. N. (1995). Taxonomy for psychology. In J. N. Reich, H. Sands, & A. N. Wiens (Eds.), *Education and training beyond the doctoral degree: Proceedings of the American Psychological Association National Conference on Postdoctoral Education and Training in Psychology* (pp. 45–50). Washington, DC: American Psychological Association.

***i) Paper Presentation***

Nguyen, C. A. (2012, August). *Humor and deception in advertising: When laughter may not be the best medicine.* Paper presented at the meeting of the American Psychological Association, Orlando, FL.

**Other Sources**

***a) Newspaper Article***

Browne, R. (2010, March 21). This brainless patient is no dummy. *Sydney Morning Herald, 45.*

***b) Newspaper Article with no Author***

New drug appears to sharply cut risk of death from heart failure. (1993, July 15). *The Washington Post,* p. A12.

***c) Web Page/Blog Post***

Bordwell, D. (2013, June 18). David Koepp: Making the world movie-sized [Web log post]. Retrieved from http://www.davidbordwell.net/blog/page/27/

***d) Online Encyclopedia/Dictionary***

Ignition. (1989). In *Oxford English online dictionary* (2nd ed.). Retrieved from http://dictionary.oed.com

Marcoux, A. (2008). Business ethics. In E. N. Zalta (Ed.). *The Stanford encyclopedia of philosophy.* Retrieved fromhttp://plato.stanford.edu/entries/ethics-business/

***e) Podcast***

Dunning, B. (Producer). (2011, January 12). *in Fact: Conspiracy theories* [Video podcast]. Retrieved from http://itunes.apple.com/

***f) Single Episode in a Television Series***

Egan, D. (Writer), & Alexander, J. (Director). (2005). Failure to communicate. [Television series episode]. In D. Shore (Executive producer), *House;* New York, NY: Fox Broadcasting.

***g) Music***

Fuchs, G. (2004). Light the menorah. On *Eight nights of Hanukkah* [CD]. Brick, NJ: Kid Kosher.

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