Abstract

Purpose – The purpose of this study is to reveal the magnitude of empty container movements (ECM) arising from cargo seasonality by means of long-term datasets of Turkish terminals. Trade imbalance is one of the well-known major reasons of ECM. Cargo seasonality apart from some other operational drivers and market effect, i.e. commercial decisions of the ship operators, is the major operational driver in Turkish terminals effecting ECM. Furthermore, this study highlights the significance of market effect, leading to take measures for more effective empty container operations in terms of decision makers leading the ship operators.

Design/methodology/approach – Time series analysis of full container datasets was performed through X-13ARIMA-SEATS methodology, implementing seasonal adjustment.

Findings – The results indicate that 17 of 112 time series in hand, based on a terminal/hinterland, container type and “in and out” foreign trade, exhibit cargo seasonality. Roughly, the amount of ECM originating from cargo seasonality in Turkish terminals represents 10 per cent of total ECM except trade imbalance in those terminals where seasonality is present. This reveals that ECM arising from market effect should not be underestimated.

Research limitations/implications – Reefer container traffic could not be sorted from the datasets.

Originality/value – This paper focuses on one of the major reasons of ECM, cargo seasonality. It brings a novel point of view and interpretations which were not suggested previously about ECM, motivating to overcome inefficiency in container operations.

Keywords Time series analysis, Cargo seasonality, Empty container movement, JDemetra+, Maritime container transportation, Market effect

Paper type Research paper

Introduction

In container terminals, the reasons for ECM can be considered in three categories: trade imbalance, operational drivers, and market effect (Basarici and Satir, 2019). In case of having trade and/or container imbalance in a terminal, it is inevitable to face ECM. Here in this study, the amount of additional empty container movements (AECM) refers to the magnitude of ECM other than trade imbalance. The concept of AECM consists of operational drivers, and market effect. The reasons classified under market effect belong to operations resulting from voluntary commercial decisions of ship operators. The reasons for operational drivers occur under the limited control of ship operators or are entirely beyond their control. The operational drivers involve in seasonal demand, abundant container
owners, container condition, uncertainties in demand/handling/shipment, and blind spots in supply chain (Boile et al., 2004; Song and Carter, 2009; Basarici and Satir, 2019). During this study, firstly, one has calculated the magnitude of cargo seasonality (Seasonal AECM), which is the major element of operational drivers in Turkey, on the basis of TEU and then compared it with the magnitude of AECM of each container terminal located in Turkey. Second, the importance of market effect has been inquired.

The production and consumption amounts of some goods differ throughout the year. Harvest of fruits and vegetables, seasonal species of fish, religious days, holidays, festivals and so on causes increases or decreases in due course (Løfstedt et al., 2010). There are fluctuations in the seasonal shipping demand of world trade for reasons related to social activities and seasons. Chinese new-year period is a good example for this. Another example is the vacation period of European automotive manufacturers lasting for about one month in summer season. The transportation traffic slows down during these periods; afterward it starts to get into motion again.

The purpose of seasonal adjustment is to remove seasonal fluctuations from a time series. For this purpose, the methods of seasonal adjustment decompose a time series dataset into its components to capture specific movements. The components of a time series are trend-cycle, seasonality and irregularity. Seasonality in container transportation mode can be detected by analysing change of full container movements in time. Time series analysis (TSA) is a technique examining sequential change in a dataset of any parameter. TSA is used when observations are made repeatedly over 50 or more time periods (Tabachnick and Fidell, 2001). It might aim at detecting patterns to set a model, viewing variation of observations, or detecting existence of seasonality and measuring its magnitude, or forecasting further time periods (Tabachnick and Fidell, 2001). The best solution so far is the model submitted by Box and Jenkins (1970), ARIMA. Dagum adapted X-11 method he had developed between 1975-1977 to the ARIMA model. X-11 method can be used for seasonal adjustment in addition to some other purposes (Dagum, 1978). The ARIMA part incorporated into the X-11 program plays a key role in the estimation of seasonal factor forecasts (Dagum, 1980). Other methods running alike X-11 are TRAMO (Time series Regression with ARIMA noise, Missing observations and Outliers) and SEATS (Signal Extraction in ARIMA Time Series). TRAMO intends a consistent modelling against presence of missing observations and outliers. On the other hand, SEATS intends to detect seasonal signals and to decompose them (Gomez and Maravall, 1997). Improvements on X-11 method resulted in X-12 and then X-13. They both were integrated with SEATS method.

In the literature, some studies aiming at various goals make use of TSA. It can be detected, for instance, whether the terminals in the same region compete each other or they collaborate (Yap and Lam, 2006; Da Silva and Rocha, 2012), thus investment plans in a region can be executed firmly. Another one is seasonal fluctuations. They strike not only the terminals but undoubtedly the ship operators, also. Service networks of ship operators suffer from cargo seasonality (Polat and Gunther, 2016). But the most popular execution area of TSA in the literature of container transportation is forecasting (Schulze and Prinz, 2009; Ee et al., 2014; Rashed et al., 2016; Gokkus et al., 2017). Forecasting is highly important for terminal operators who plan investment on constructing new terminals or buying new terminal equipment and for ship operators who charter and/or purchase ships and containers and perform scheduling. However, sorting out seasonal effects from full container throughput has not drawn attention much so far in the literature, because probably its practical outcomes have been found meaningless. However, cargo seasonality in full
container traffic is one of the major reasons of ECM and must be studied in this context as we have uniquely executed in this study.

The studies relevant to TSA and dynamics of ECM have been discussed in Section 2. Section 3 details the method of X-13ARIMA-SEATS benefited herein this study while analysing the datasets. Section 4 discusses a case study in Turkish terminals and the statistical datasets have been analysed in Section 5. Finally, the findings of the study, the implications, the limitation of the research, and the future research directions have been presented in Section 6.

**Literature review**

Most of the studies about empty container repositioning in the literature focus on optimising it to reduce operational cost and environmental depredation. The basic problem of equipment circulation in the literature generally has been taken shape on imports/exports imbalance in terms of cargo and container type. Several solutions have been suggested to minimise the amount of ECM. Song and Carter (2009), Vojdani et al. (2013) and Monios and Wang (2014) focussed on establishing a common container pool with the participation of numerous ship operators. Moon et al. (2010) and Varshavets et al. (2013) scrutinised the popularisation of container leasing among ship operators instead of inventory stock, motivating container sharing. Chang et al. (2008) thought over benefiting 20-foot and 40-foot containers in place of each other. The optimisation studies in the literature extended to locating depot facilities (Dang et al., 2013; Olivo et al., 2013) and container storage areas (Lei and Church, 2011; Mittal et al., 2013) in addition to on board solutions of voyage planning (Christiansen et al., 2013; Braekers et al., 2013; Meng et al., 2015) and empty container allocation (Cheung and Chen, 1998; Song and Dong, 2011; Long et al., 2012). Furthermore, carrier based solutions such as flexible destinations during a voyage (Song and Dong, 2010) and street-turns (Jula et al., 2006; Legros et al., 2016) were discussed. Benefiting and popularising foldable containers (Moon et al., 2012) and deployment of hybrid type of equipment (Malchow, 2016) are quite hot agenda items today. All these studies and more than these aspire to mitigate AECM.

On the other hand, these studies partly touch on the reasons of ECM. A great deal of studies underscored trade/container-type imbalances (Olivo et al., 2005; Song and Dong, 2011). Chang et al. (2008) concluded that container-type imbalance in Los Angeles and Long Beach ports caused extra operational cost. Benefiting 20-foot container in case these ports lack 40-foot container or vice versa, a cost advantage of between 4 and 47 per cent might be obtained.

Some papers underscored seasonal demand explicitly, but some papers gave indication implicitly. Song and Carter (2009) discussed the critical factors affecting ECM. These factors are the regional trade imbalances and dynamic behaviour, demand, handling, and/or shipment uncertainties, container-type differences, blind spots in the transportation chain, and operational and strategic practices of ship operators. The term dynamic behaviour refers to seasonal shipping demand which means cargo seasonality. Song and Dong (2015) refer to dynamic operations as one of the key factors in ECM, too.

Diaz et al. (2011) underlined the undeniable impact of trade imbalance but revealed the fact that the high number of ECM cannot be explained solely by this impact but must be explained by some practices as Song and Carter (2009) attributed this to the operational and strategic practices of ship operators. This emphasis highlights another impact arising from voluntary commercial decisions of ship operators, called the market effect.

Basarici and Satir (2019) reviewed the literature and suggested a taxonomy indicating the reasons for ECM into three categories. The category trade imbalance consists of
structural trade imbalance and region-based container-type imbalance. Operational drivers include seasonal shipping demand, abundant container owners, container condition, uncertainties in demand/handling/shipment, and blind spots in supply chain. The last category market effect points out the impact of commercial decisions of ship operators. The authors attribute ECM partly to the hub port strategy of ship operators, competition between them on a string basis and ship operator-based container imbalance.

Herein this study the impact of cargo seasonality has been investigated empirically by means of a wide range of datasets to discover its significance level in Turkish container terminals. This study is a complement of the efforts disclosing the dynamics of ECM detailed here in above. It focuses on a specific field i.e. seasonality in container transportation, revealing one of the prominent factors leading to ECM i.e. market effect. It tests the existence of cargo seasonality and its magnitude in one of the significant trade regions in the world then analyses and discusses further dynamics. Therefore, herein this section some papers relevant to maritime container transportation and benefiting TSA methods are examined. Most of below mentioned studies about TSA focus on forecasting of terminal throughput and support the significance of ARIMA model as compared with others. Only one paper benefiting DJemetra+ program hosting X-13ARIMA-SEATS could have been reviewed in this section due to very limited publishing benefiting this method.

Schulze and Prinz (2009) examine container transshipment at the German ports benefiting the Seasonal ARIMA (SARIMA) model and the Holt-Winters exponential smoothing approach. The model makes use of quarterly dataset and is designed especially to take account of the seasonal behaviour. The authors aim to forecast the values of next two years by a dataset between 1989 and 2006. According to forecasting error measures such as Mean Square Error and Theil’s U, the SARIMA-approach yields slightly better values of modelling the container throughput than the exponential smoothing approach. The forecast results indicate strong growth for German container handling in total.

Xie et al. (2013) scrutinised and compared hybrid methods based on least squares support vector regression (LSSVR), intending container throughput forecast. The three hybrid approaches include SARIMA, seasonal decomposition (SD) and classical decomposition (CD). The proposed hybrid approaches, i.e. SARIMA–LSSVR, SD–LSSVR and CD–LSSVR, are based on the principle of divide and conquer to overcome the difficulty in container throughput forecasting. Experimental forecasts of container throughput at Shanghai port and Shenzhen port were made by using the experiment design and methodologies mentioned above. As per the results, SARIMA’s forecasting performance is excellent among single forecasting methods, and better than LSSVR.

Ee et al. (2014) paper is about planning of container terminal equipment which has been uncertain due to seasonal and fluctuating throughput demand along with other factors. They scrutinised the issue by using two methods of TSA, SARIMA and Holt-Winters. Though both the forecasting models share close similarity in results, one can note the superiority of the SARIMA model for its flexibility of transforming and eliminating spikes in autocorrelation and partial autocorrelation functions.

Rashed et al. (2016) paper aims at short-term forecast of container throughput for the port of Antwerp. Two different approaches were applied: The ARIMA model combining seasonality with the intervention function to account for the effect of shocks and, the ARIMAX model with leading economic indicator. They compare the results to determine which model gives a better forecast. A monthly dataset of past 20 years up to 2015 respecting container throughput at the port was used during the research. The authors conclude that the benefit of the ARIMA-intervention model is not related to its forecasting
power, but rather in identifying and quantifying the impact of shocks on the behaviour of the time series.

Literature review indicates that detection of seasonality in time series has been shaped on ARIMA modelling which considers serial effect. Today several institutions such as Eurostat and Statistics Canada use software programs based on ARIMA. In this context JDemetra+ procedure and program were chosen to detect seasonality in this study. No other study benefiting from JDemetra+ for TSA in container transportation was determined in the literature. One of the very rare studies using JDemetra+ was released by Edvinsson and Hegelund (2016). They studied GDP dataset of Sweden in the recent century. Their paper presents a time series back to 1913 on manufacturing and private consumption. As they both are indicators, the authors use standard methods for disaggregation from annual GDP data. Most of all, JDemetra+ procedure and software is applied on the dataset to estimate a deseasonalised time series. Thus, they find that the new series provides new information on the business cycle, confirming its irregular nature and detecting recessions that are not clearly indicated by a set of actual data. In terms of seasonality, they apply both methods embedded in the procedure i.e. X-13ARIMA-SEATS and TRAMO/SEATS. The results indicate that the difference between two methods is, in practice, quite small.

In container transportation, cargo seasonality is substantially referred as one of the reasons leading to ECM but no empirical study about this reason has been coincided in the literature. This study can assist to fill this research gap in this field. Furthermore, this study strengthens the phenomenon of market effect in the way of normal science.

Methodology

There are several techniques to implement seasonal adjustment. They can be divided into two groups: moving average based methods and model based methods. Moving average based methods use filters and do not rely on any explicit underlying model (Eurostat, 2015; Edvinsson and Hegelund, 2016).

The moving average based method in JDemetra+ is X-13ARIMA-SEATS, while the model based method is TRAMO/SEATS. The first step in both methods removes deterministic effects applying a regression model. The difference between two models is in the second step. X-13ARIMA-SEATS is based on Henderson moving average of the seasonal components. Its advantage is its sensitivity to sudden changes in the seasonal component (Edvinsson and Hegelund, 2016).

Therefore, herein this study X-13ARIMA-SEATS was chosen to analyse the datasets of initial AECM. Recent releases of X-13ARIMA-SEATS and JDemetra+ program hosting it have led to a paradigm shift since both seasonal adjustment programs unify the non-parametric X-11 method and the parametric ARIMA model-based approach under one umbrella (Webel, 2016). In 2012, Eurostat released an upgraded version of the software called Demetra+, and in 2014, JDemetra+ consisting of X-13ARIMA-SEATS methodology in collaboration with National Bank of Belgium. Seasonal adjustment instructions of the European Statistical System advice that adjustment must be done only if there is seasonality in a time series. Therefore, during this study, adjustment process is implemented when seasonality has been detected in time series by combined seasonality test (CST).

Combined seasonality test

This test combines the Kruskal–Wallis test along with a test for presence of seasonality assuming stability, and evaluative seasonality test for detecting the presence of identifiable seasonality. The main purpose of the test is to check if the seasonality of the series is identifiable. CST includes four sub alternate tests (Figure 1) which are stable seasonality
Stable seasonality test (also called the Friedman test)
This test is a non-parametric method for testing that samples are drawn from the same population or from populations with equal medians. In the regression equation, the significance of the month effect is tested. Under the null hypothesis of no seasonality, all monthly periods can be treated equally. If the null hypothesis of no stable seasonality is rejected at the 1 per cent significance level, then the series is considered to be seasonal.

Moving seasonality test (also called evaluative seasonality test)
This seasonality test is based on a two-way analysis of variance model. The model uses the values from complete years only. The null hypothesis says that there is no change in seasonality over the years.

Test for presence of identifiable seasonality
This test combines the values of the $F$-statistic of the parametric test for stable seasonality and the values of the moving seasonality test. The test checks if the stable seasonality is not dominated by moving seasonality. In such a case, the seasonality is regarded as identifiable.
**Kruskal–Wallis test**
The Kruskal–Wallis test is a non-parametric test used for testing whether samples originate from the same distribution. The null hypothesis states that all months have the same mean. The rejection of the null hypothesis of the Kruskal–Wallis test implies that at least one sample stochastically dominates at least one other sample. Under the null hypothesis, the test statistic follows a chi-square distribution. When this hypothesis is rejected, it is assumed that the values of a time series differ significantly between periods.

**X-13Arima-seats**
The method of X-13ARIMA-SEATS especially focuses on detecting seasonal signals and decomposition (Gomez and Maravall, 1997) and furthermore it is quite sensitive to sudden seasonal changes (Edvinsson and Hegelund, 2016). X-13ARIMA-SEATS can adjust seasonality by means of two different ways (Grudkowska, 2016). First one is SEATS which is based on ARIMA. The other one is upgraded version of X-11 method. Whereas X-11 method processes on monthly or quarterly based, SEATS can be practised on a dataset including number of 2, 3, 4, 6 and 12 observation units in a year. SEATS is a method being used to estimate unobserved stochastic elements. Time series incur deterministic effects as much as they usually are under the effects of outliers and missing observations. Therefore, original series are modelled by ARIMA and linearized to get rid of such effects (Grudkowska, 2016). One of the fundamental assumptions made by SEATS is that the stochastic time series $x_t$ follows the ARIMA model.

$$\Phi(B)\delta(B)x_t = \theta(B)a_t$$

where:
- $B = \text{backshift operator}$;
- $\delta(B) = \text{a non-stationary autoregressive polynomial in } B (\text{unit roots});$
- $\theta(B) = \text{an invertible moving average (MA) polynomial in } B;$
- $\Phi(B) = \text{a stationary autoregressive (AR) polynomial in } B \text{ and stationary seasonal polynomial in } B;$ and
- $a_t = \text{a white-noise variable with the variance (Grudkowska, 2016).}$

$$x_t = \sum_{i=1}^{k} x_{it}$$

where:
- $i = \text{trend, seasonal, transitory or irregular components; and}$
- $k = \text{number of components.}$

The procedure consists in estimation of time series components by means of the Wiener-Kolmogorov filters as the minimum mean square estimators using unobserved component ARIMA model.

**Seasonal adjustment procedure for a dataset**
A raw dataset might handicap a healthy analysis due to presence of outliers, missing observation units and incomprehensible rise and fall in time series. Outliers in a raw dataset must be sorted out since they may affect results due to parametric test procedures. The JDemetra+ program can detect outliers and any weird change in time series. These are described as follows (Grudkowska, 2015).
• **Additive outlier (AO)** – abnormal value in isolated point of the series;
• **Transitory change (TC)** – a series of outliers with temporarily decreasing effects on the level of the time series;
• **Level shift (LS)** – a series of innovation outliers with a constant long-term effect on the level of the time series, where for innovation outlier is meant anomalous values in the innovation series.

A hinterland may include a few terminals. In this study, a genuine procedure suggested and detailed here below was used to discover presence of seasonality based on a terminal or a hinterland.

- A raw dataset is tested by CST. If seasonality is present, the process is ceased.
- If seasonality is not present, or probably not present as described in the program, a dataset is adjusted in terms of AO, TC and LS without spoiling its essence.
- An adjusted dataset is tested by CST to reveal if seasonality is present or not.

After deducting seasonality on a terminal/hinterland basis, further items determine if seasonality is to be held on a terminal or a hinterland basis.

- If there is no seasonality on the basis of a terminal in a hinterland, seasonality in a dataset might be accepted on a hinterland basis if it exists.
- If one or more number of terminals display seasonality, it is accepted that seasonality is on the basis of terminal regardless there is seasonality on the basis of a hinterland.

**Case study for container terminals in Turkey**
The analysis of cargo seasonality was performed by means of full container throughput. The statistical datasets were requested from the Communications Centre of Turkish Prime Ministry (BIMER) and acquired from relevant government office, the directorate of planning and information management. The methodology was applied on the eleven-year datasets of 20-foot and 40-foot containers based on imports and exports respectively between 2006 and 2016. The special type of equipment movements such as reefer containers could not be distinguished. The original datasets include monthly full and empty equipment movements on the basis of terminal. They include only the foreign trade in Turkey (i.e. the datasets of imports/exports and inbound/outbound ECM with respect to international trade) but excludes the data relevant to transit and cabotage liftings. Due to limited amount of lines, only the results between 2014 and 2016 could have been delivered herein this study.

**Results and discussion**
The datasets were scrutinised for 18 terminals and 10 hinterlands located in Turkey. In total 28 terminals/hinterlands have been reviewed for 20-foot and 40-foot containers and respectively for imports and imports. This reveals 112 datasets to analyse. In 33 datasets of total 112, seasonality effect was detected (Table I). A genuine procedure (see Methodology, Seasonal adjustment procedure for a dataset) to determine whether seasonality exists on a terminal or a hinterland basis has revealed that 17 terminals/hinterlands consist of cargo seasonality and a genuine interpretation helped to sort the seasonality effect out from AECM. One must take in consideration that a ship operator may call at different terminals concurrently. Therefore, seasonality might be detected on a hinterland basis though no seasonality is detected on a terminal basis located in this hinterland. In Ambarli Istanbul
hinterland, level shifts in datasets observed in January 2011 and in February 2016 are good examples for this. In 2011, Kumport Istanbul terminal had a growing trend whereas Marport Istanbul terminal in the same hinterland was facing downtrend. In 2016, on the contrary, Marport had a growing trend and Kumport was facing downtrend.

Since cargo seasonality is scrutinised merely the datasets consisting of full containers have been adjusted. Seasonality in a time series must be investigated in series for both imports and exports respectively. However, seasonality might be detected for both simultaneously. This brings up a further interpretation. Such a case was observed during the analysis of the datasets belonging to Izmir Alsancak terminal for both 20-foot and 40-foot full containers. This event leads to absorption of reciprocal ECM. Simultaneous analysis of datasets for imports and exports displays an amount of absorption, and the non-absorbed amount equals to AECM originating from seasonality. If the difference between actual and adjusted (SA) data in a month has the same direction for both inbound and outbound traffics (Figure 2), AECM originated from seasonality is absorbed. Any probable AECM is prevented accordingly. For instance, AECM for an amount of 100 TEU in inbound traffic absorbs AECM for an amount of 100 TEU in outbound traffic. Hence no AECM occurs. Otherwise, inbound and outbound datasets must be assessed independent of each other.

| Terminal                        | Imports          | Exports          | Imports          | Exports          |
|---------------------------------|------------------|------------------|------------------|------------------|
| Kumport                         | Prob. Not Present| Prob. Not Present| Not Present      | Not Present      |
| Mardas                          | Not Present      | Not Present      | Not Present      | Not Present      |
| Marport                         | Prob. Not Present| Not Present      | Prob. Not Present| Not Present      |
| Ambarlı hinterland              | Prob. Not Present| PRESENT          | PRESENT          | Not Present      |
| Haydarpaşas                     | PRESENT          | Not Present      | PRESENT          | Not Present      |
| İstanbul hinterland             | Present          | Present          | Present          | Not Present      |
| Evyap port                      | Not Present      | Not Present      | Prob. Not Present| Not Present      |
| Yilport                         | Prob. Not Present| Not Present      | Prob. Not Present| Not Present      |
| Limas                           | Not Present      | Not Present      | Not Present      | Not Present      |
| Kocaeli hinterland              | Not Present      | Not Present      | Not Present      | PRESENT          |
| Borusan                         | Prob. Not Present| PRESENT          | Not Present      | Not Present      |
| Gempor                          | Not Present      | Not Present      | Prob. Not Present| Not Present      |
| Rodaport                        | Not Present      | PRESENT          | Not Present      | Prob. Not Present|
| Germlik hinterland              | Prob. Not Present| Present          | Present          | Present          |
| Marmara hinterland              | Present          | Present          | Present          | Present          |
| TCDD Izmir Alsancak             | PRESENT          | PRESENT          | PRESENT          | PRESENT          |
| Ege Gubre                       | Prob. Not Present| Not Present      | Prob. Not Present| Not Present      |
| Nemport                         | Not Present      | Prob. Not Present| Not Present      | Not Present      |
| İzmir – Aliaga hinter.          | Present          | Prob. Not Present| Present          | Present          |
| Assan                           | Not Present      | Not Present      | Not Present      | Not Present      |
| Limak                           | Not Present      | Not Present      | Not Present      | Not Present      |
| İskenderun hinter               | Not Present      | Not Present      | Not Present      | Not Present      |
| Mersin MIP                      | Prob. Not Present| PRESENT          | Present          | PRESENT          |
| Mersin İskenderun h.            | Prob. Not Present| Present          | Present          | Present          |
| Antalya                         | Not Present      | PRESENT          | Not Present      | Not Present      |
| Samsun                          | PRESENT          | Not Present      | Not Present      | PRESENT          |
| Trabzon                         | Not Present      | Not Present      | Not Present      | Not Present      |
| Turkey Total                    | Present          | Present          | Present          | Prob. Not Present|

**Table I.** Seasonality presence on the basis of terminal and hinterland

**Note:** Prob. = Probably. The word PRESENT with capital letters indicates that seasonality is on either a terminal or a hinterland basis.
Our further genuine interpretation reveals that an adjusted dataset represents that “if there was no cargo seasonality, adjusted dataset would be valid”. There is a difference between original and adjusted time series for each month. The sign of difference might be positive or negative for successive months (Tables II to IV). The crucial point is to interpret how ECM was affected by these monthly differences. For a dataset of imports, if an adjusted datum is greater than an actual datum of the same month, essentially an amount of containers which is equal to the difference between them had to be discharged as full container but this amount of full container was missing. This gap is closed by means of additional empty container discharge. Hence, this difference equals to AECM originating from cargo seasonality. If an actual datum is greater than an adjusted datum of a same month, one must understand that an amount of full container which equals to the difference was performed, but essentially, it did not have to be taken place. It triggers ECM for exports arising from seasonality. Since 20-foot and 40-foot containers practically are not interchangeable, seasonality of a container type is independent of each other. Therefore, this study does not include a research in this context.

Seasonal AECM in AECM were calculated accordingly (Tables V to VII). It differs between 1 per cent and 73 per cent. Ambarlı hinterland in Istanbul has the greatest amount of AECM for 20-foot (imports) between 2014 and 2016. Its seasonality ratio in AECM is 12-13 per cent. Regarding other major terminals/hinterlands the results are: Ambarlı Istanbul for 40-foot (imports), 9-10 per cent; Mersin for 20-foot (exports), 25-35 per cent; and Mersin-Iskenderun hinterland (imports), 10-11 per cent. Country-wide, one can say that roughly, the amount of AECM originating from cargo seasonality represents 10 per cent of total AECM (around 100,000 units in 2016) in those major terminals/hinterlands where seasonality is present.

In general, the effect of cargo seasonality is relatively low, considering total ECM in Turkish terminals. AECM can be calculated by deducting ECM arising from trade imbalance from total ECM per container-type. Furthermore, after deducting seasonal AECM from AECM one can find out AECM arising from the rest of operational drivers except cargo seasonality and market effect (Basarici and Satir, 2019). Ambarlı Istanbul has a huge container throughput if compared other local terminals. In 2016, ECM for both 20-foot and 40-foot equipment reached 366,191 units. Only an amount of 98,963 units were moved due to trade imbalance. The empty throughput arising from cargo seasonality reached only 27,738 units. It means 239,489 units moved due to operational drivers except cargo seasonality and market effect, equalling to 65 per cent of ECM to/from Ambarlı Istanbul. The results of other terminals and hinterlands in Turkey support this determination more or less (Tables VIII and IX). Country-wide but limited to the datasets in hand, market effect together with
operational drivers except cargo seasonality is responsible of around 750,000 units of empty movements of around 1,550,000 units in total.

Conclusions and recommendations
Trade and container imbalances are the major and the most highlighted reasons of ECM. The concept of AECM refers to the magnitude of ECM other than trade imbalance and container imbalance. AECM consists of operational drivers and market effect. Market effect describes ECM resulting from voluntary commercial decisions of the ship operators. On the other hand, the reasons for operational drivers occur under the limited control of ship operators or are entirely beyond their control. One of them is seasonal demand. Seasonal demand is the major operational driver in Turkish terminals, effecting ECM. Herein this study containerised cargo seasonality was detected and long-term time series of full containers in Turkish container terminals were adjusted to discover the magnitude of cargo seasonality leading to conceive the importance of market effect.

| Date  | Original series | Adjusted series | Difference |
|-------|-----------------|-----------------|------------|
| 01.2014 | 31.308          | 30.000          | 1.308      |
| 02.2014 | 31.969          | 32.426          | −457       |
| 03.2014 | 32.524          | 31.299          | 1.225      |
| 04.2014 | 29.864          | 29.808          | 56         |
| 05.2014 | 34.149          | 31.850          | 2.299      |
| 06.2014 | 32.562          | 30.988          | 1.574      |
| 07.2014 | 34.819          | 33.295          | 1.524      |
| 08.2014 | 33.417          | 32.504          | 913        |
| 09.2014 | 32.053          | 33.880          | −1.837     |
| 10.2014 | 30.541          | 32.033          | −1.492     |
| 11.2014 | 30.498          | 34.430          | −3.932     |
| 12.2014 | 31.995          | 33.595          | −1.600     |
| 01.2015 | 29.150          | 27.951          | 1.199      |
| 02.2015 | 29.889          | 30.428          | −539       |
| 03.2015 | 34.973          | 33.617          | 1.356      |
| 04.2015 | 28.059          | 28.061          | −2         |
| 05.2015 | 27.752          | 25.911          | 1.841      |
| 06.2015 | 28.560          | 27.121          | 1.439      |
| 07.2015 | 27.114          | 25.887          | 1.227      |
| 08.2015 | 27.207          | 26.648          | 559        |
| 09.2015 | 26.510          | 28.006          | −1.496     |
| 10.2015 | 28.282          | 29.660          | −1.378     |
| 11.2015 | 24.372          | 27.417          | −3.045     |
| 12.2015 | 29.281          | 30.578          | −1.297     |
| 01.2016 | 27.639          | 26.492          | 1.147      |
| 02.2016 | 25.586          | 26.116          | −530       |
| 03.2016 | 29.032          | 27.902          | 1.130      |
| 04.2016 | 28.691          | 28.737          | −46        |
| 05.2016 | 28.761          | 26.994          | 1.767      |
| 06.2016 | 30.434          | 28.837          | 1.597      |
| 07.2016 | 33.809          | 32.154          | 1.655      |
| 08.2016 | 27.718          | 27.321          | 397        |
| 09.2016 | 26.271          | 27.680          | −1.409     |
| 10.2016 | 26.926          | 28.193          | −1.267     |
| 11.2016 | 25.659          | 28.817          | −3.158     |
| 12.2016 | 25.879          | 26.945          | −1.066     |

Table II. Original series vs adjusted series (40-foot imports Ambarli Istanbul)
This study consists of eleven-year datasets of full container movements in Turkish terminals on a monthly basis between 2006 and 2016 and reveals the presence and magnitude of seasonality, and was executed in two-stage. During the first stage, one should detect if cargo seasonality is present in time series on the basis of terminal and/or hinterland, and assess its magnitude by means of JDemetra+ program benefiting CST and X-13ARIMA-SEATS procedure. The difference on a monthly basis between original and adjusted time series of full container throughputs represents the amount of AECD originating from seasonality. In the second stage, the amount of seasonal AECD is compared AECD. This comparison requires a genuine interpretation as we executed in this study (Section 5). Another genuine part of the study is a rapprochement of hinterland-based assessment of container movements apart from terminal based one. In a hinterland, if ship operators change the ports of call, this might prevent to detect seasonality on the basis of terminal. Therefore, seasonality on the basis of hinterland hosting more than a terminal was investigated as well. In terms of originality, a novel concept of absorption in point of

| Date     | Original series | Adjusted series | Difference |
|----------|-----------------|-----------------|------------|
| 01.2014  | 8.365           | 9.103           | -738       |
| 02.2014  | 9.513           | 9.866           | -353       |
| 03.2014  | 11.129          | 10.233          | 896        |
| 04.2014  | 12.019          | 11.435          | 584        |
| 05.2014  | 11.492          | 10.694          | 798        |
| 06.2014  | 11.277          | 10.768          | 509        |
| 07.2014  | 11.344          | 10.740          | 604        |
| 08.2014  | 11.403          | 11.683          | -280       |
| 09.2014  | 10.221          | 10.675          | -454       |
| 10.2014  | 10.453          | 10.721          | -268       |
| 11.2014  | 11.340          | 11.768          | -428       |
| 12.2014  | 9.653           | 10.541          | -888       |
| 01.2015  | 10.127          | 10.918          | -791       |
| 02.2015  | 10.562          | 10.915          | -353       |
| 03.2015  | 12.741          | 11.796          | 945        |
| 04.2015  | 11.917          | 11.254          | 663        |
| 05.2015  | 11.872          | 11.051          | 821        |
| 06.2015  | 12.250          | 11.731          | 519        |
| 07.2015  | 11.574          | 11.056          | 518        |
| 08.2015  | 10.709          | 11.032          | -323       |
| 09.2015  | 11.700          | 12.144          | -444       |
| 10.2015  | 11.253          | 11.509          | -256       |
| 11.2015  | 11.207          | 11.597          | -390       |
| 12.2015  | 10.708          | 11.611          | -903       |
| 01.2016  | 11.073          | 11.944          | -871       |
| 02.2016  | 12.561          | 12.918          | -357       |
| 03.2016  | 13.962          | 12.958          | 1.004      |
| 04.2016  | 13.913          | 13.163          | 748        |
| 05.2016  | 14.449          | 13.638          | 811        |
| 06.2016  | 12.427          | 11.889          | 538        |
| 07.2016  | 13.237          | 12.803          | 434        |
| 08.2016  | 12.598          | 12.952          | -354       |
| 09.2016  | 13.322          | 13.747          | -425       |
| 10.2016  | 14.414          | 14.657          | -243       |
| 11.2016  | 14.137          | 14.487          | -350       |
| 12.2016  | 13.488          | 14.421          | -933       |

Table III. Original series vs adjusted series (40-foot imports Kocaeli)
simultaneous seasonal AECM of imports and exports must be underlined, too (Section 5). Nonetheless, one has to emphasise the limitation of this research study. Some Turkish terminals have a significant amount of reefer container traffic. Due to undetailed breakdown, this type of container traffic could not be sorted from the datasets. The datasets include them, as they are standard equipment.

The results indicate that 17 of 112 time series based on terminal or hinterland exhibit cargo seasonality. This study displays the significant magnitude of seasonality throughout the country. Cargo seasonality occurs almost in every district of Turkey along with having various rates in AECM between 1 per cent and 73 per cent. Furthermore, the total amount of seasonal AECM in Turkey represents almost 10 per cent of AECM in those terminals/hinterlands where seasonality is present. However when examining ECM arising from other than trade imbalance and cargo seasonality, one can see that a huge amount of empty container traffic realises due to majorly market effect and partly operational drivers except cargo seasonality.

Table IV.

| Date   | Original series | Adjusted series | Difference |
|--------|-----------------|-----------------|------------|
| 01.2014| 16.645          | 17.111          | −466       |
| 02.2014| 14.110          | 16.520          | −2.410     |
| 03.2014| 15.343          | 16.816          | −1.473     |
| 04.2014| 14.810          | 16.115          | −1.305     |
| 05.2014| 17.813          | 16.422          | 1.391      |
| 06.2014| 17.348          | 15.932          | 1.416      |
| 07.2014| 16.376          | 15.799          | 577        |
| 08.2014| 14.412          | 14.586          | −174       |
| 09.2014| 15.251          | 14.914          | 337        |
| 10.2014| 12.766          | 13.601          | −835       |
| 11.2014| 14.814          | 13.961          | 853        |
| 12.2014| 17.433          | 15.514          | 1.919      |
| 01.2015| 13.480          | 14.280          | −800       |
| 02.2015| 12.175          | 14.186          | −2.011     |
| 03.2015| 14.441          | 15.814          | −1.373     |
| 04.2015| 13.113          | 14.119          | −1.006     |
| 05.2015| 16.047          | 14.678          | 1.369      |
| 06.2015| 16.726          | 15.117          | 1.609      |
| 07.2015| 14.505          | 14.566          | −61        |
| 08.2015| 15.348          | 15.418          | −70        |
| 09.2015| 15.805          | 15.638          | 167        |
| 10.2015| 15.962          | 16.276          | −314       |
| 11.2015| 16.992          | 16.283          | 709        |
| 12.2015| 17.410          | 15.868          | 1.542      |
| 01.2016| 13.073          | 14.221          | −1.148     |
| 02.2016| 15.119          | 16.566          | −1.447     |
| 03.2016| 14.382          | 15.786          | −1.404     |
| 04.2016| 16.790          | 17.432          | −642       |
| 05.2016| 18.070          | 16.747          | 1.323      |
| 06.2016| 18.539          | 16.878          | 1.661      |
| 07.2016| 13.939          | 14.514          | −575       |
| 08.2016| 17.142          | 17.069          | 73         |
| 09.2016| 16.864          | 16.861          | 3          |
| 10.2016| 19.134          | 18.937          | 197        |
| 11.2016| 17.891          | 17.342          | 549        |
| 12.2016| 18.819          | 17.584          | 1.235      |
## Table V.
Seasonal AECM (AECMs) in 2014

| Terminal/Hinterland | Cont. Type | Trade       | AECM  | AECMs | Ratio |
|---------------------|------------|-------------|-------|-------|-------|
| Ambarli Istanbul    | 20'        | Exports     | 98.466| 12.479| 0.13  |
| Ambarli Istanbul    | 40'        | Imports     | 207.362| 18.217| 0.09  |
| Haydarpasa Istanbul| 20'        | Imports     | 9.396 | 1.011 | 0.11  |
| Haydarpasa Istanbul| 40'        | Imports     | 3.098 | 1.544 | 0.50  |
| Kocaeli hinterland  | 40'        | Imports     | 44.790| 6.800 | 0.15  |
| Borusan Gemlik     | 20'        | Exports     | 6.911 | 2.831 | 0.41  |
| Rodaport Gemlik    | 20'        | Exports     | 2.276 | 923   | 0.41  |
| Mersin MIP         | 20'        | Exports     | 37.246| 13.155| 0.35  |
| Mersin MIP         | 40'        | Exports     | 86.734| 15.197| 0.18  |
| Mersin - Iskenderun| 40'        | Imports     | 97.676| 10.645| 0.11  |
| Antalya            | 20'        | Exports     | 20.717| 13.477| 0.65  |
| Samsun             | 20'        | Imports     | 15.992| 131   | 0.01  |
| Samsun             | 40'        | Exports     | 2.091 | 1.535 | 0.73  |
| TCDD Alsancak Izmir| 20'        | Imports-Exports | 23.233| 5.360 | 0.23  |
| TCDD Alsancak Izmir| 40'        | Imports-Exports | 21.596| 7.833 | 0.36  |

## Table VI.
Seasonal AECM (AECMs) in 2015

| Terminal/Hinterland | Cont. Type | Trade       | AECM  | AECMs | Ratio |
|---------------------|------------|-------------|-------|-------|-------|
| Ambarli Istanbul    | 20'        | Exports     | 88.538| 11.555| 0.13  |
| Ambarli Istanbul    | 40'        | Imports     | 174.172| 15.378| 0.09  |
| Haydarpasa Istanbul| 20'        | Imports     | 7.053 | 819   | 0.12  |
| Haydarpasa Istanbul| 40'        | Imports     | 3.107 | 1.332 | 0.43  |
| Kocaeli hinterland  | 40'        | Imports     | 57.749| 6.927 | 0.12  |
| Borusan Gemlik     | 20'        | Exports     | 7.590 | 2.830 | 0.37  |
| Rodaport Gemlik    | 20'        | Exports     | 2.539 | 965   | 0.38  |
| Mersin MIP         | 20'        | Exports     | 38.596| 11.032| 0.29  |
| Mersin MIP         | 40'        | Exports     | 91.368| 15.759| 0.17  |
| Mersin - Iskenderun| 40'        | Imports     | 105.324| 10.834| 0.10  |
| Antalya            | 20'        | Exports     | 23.893| 11.291| 0.47  |
| Samsun             | 20'        | Imports     | 10.298| 143   | 0.01  |
| Samsun             | 40'        | Exports     | 2.539 | 1.535 | 0.60  |
| TCDD Alsancak Izmir| 20'        | Imports-Exports | 22.423| 5.360 | 0.23  |
| TCDD Alsancak Izmir| 40'        | Imports-Exports | 21.596| 7.833 | 0.36  |

## Table VII.
Seasonal AECM (AECMs) in 2016

| Terminal/Hinterland | Cont. Type | Trade       | AECM  | AECMs | Ratio |
|---------------------|------------|-------------|-------|-------|-------|
| Ambarli Istanbul    | 20'        | Exports     | 109.108| 12.569| 0.12  |
| Ambarli Istanbul    | 40'        | Imports     | 158.120| 15.169| 0.10  |
| Haydarpasa Istanbul| 20'        | Imports     | 5.727 | 687   | 0.12  |
| Haydarpasa Istanbul| 40'        | Imports     | 3.081 | 1.187 | 0.39  |
| Kocaeli hinterland  | 40'        | Imports     | 60.987| 7.068 | 0.12  |
| Borusan Gemlik     | 20'        | Exports     | 7.448 | 2.831 | 0.38  |
| Rodaport Gemlik    | 20'        | Exports     | 2.896 | 1.041 | 0.36  |
| Mersin MIP         | 20'        | Exports     | 41.652| 10.260| 0.25  |
| Mersin MIP         | 40'        | Exports     | 84.880| 17.267| 0.20  |
| Mersin - Iskenderun| 40'        | Imports     | 109.816| 11.087| 0.10  |
| Antalya            | 20'        | Exports     | 39.357| 8.175 | 0.21  |
| Samsun             | 20'        | Imports     | 9.920 | 150   | 0.02  |
| Samsun             | 40'        | Exports     | 2.724 | 1.536 | 0.56  |
| TCDD Alsancak Izmir| 20'        | Imports-Exports | 10.672| 4.669 | 0.44  |
| TCDD Alsancak Izmir| 40'        | Imports-Exports | 35.944| 7.352 | 0.20  |
Especially in Turkey, one can allege that the difference between AECM and seasonal AECM substantially reflect the amount of ECM arising from market effect (Basarici and Satır, 2019). In case AECM arising from market effect can be decreased, less cost for supermarkets and less environmental deprivations might be obtained. ECM can be reduced through information and equipment sharing, freight pooling and cooperation of transport service providers (UNCTAD, 2015). Likewise, Lee and Song (2017) allege that empty container positioning can be mitigated by container exchange. In this respect, substantial magnitude of ECM arising from market effect points out a solution area. This fruitlessness, first of all, must motivate the ship operators or the governments for a good cooperation in point of container exchange. Information sharing and freight pooling can be evaluated in common particularly for spot cargo market.

### Table VIII.
20-Foot ECM in Turkey (2016)

| Terminal/Hinterland     | ECM  | ECMti | AECM  | AECMs | AECM-AECMs | Ratio |
|-------------------------|------|-------|-------|-------|------------|-------|
| Ambarli Istanbul        | 147.012 | 37.904 | 109.108 | 12.569 | 96.539 | 0.66  |
| Haydarpasa Istanbul    | 10.564  | 4.837  | 5.727  | 687   | 5.040  | 0.48  |
| Gemport Gemlik         | 37.949  | 24.141 | 13.808 | 0     | 13.808 | 0.36  |
| Borusan Gemlik         | 24.335  | 16.907 | 7.448  | 2.831 | 4.617  | 0.19  |
| Roda Gemlik            | 4.920   | 2.024  | 2.896  | 1.041 | 1.855  | 0.38  |
| Kocaeli hinterland     | 65.558  | 32.833 | 32.725 | 0     | 32.725 | 0.50  |
| Eggegubre Aliaga       | 44.404  | 31.440 | 12.964 | 0     | 12.964 | 0.29  |
| Nemport Aliaga         | 38.088  | 28.343 | 9.745  | 0     | 9.745  | 0.26  |
| TCDD Alsancak Izmir    | 98.724  | 88.052 | 10.672 | 4.669 | 6.003  | 0.06  |
| Mersin MIP             | 104.011 | 62.359 | 41.652 | 10.260 | 31.392 | 0.30  |
| Mersin - Iskenderun    | 122.002 | 75.314 | 46.688 | 0     | 46.688 | 0.38  |
| Antalya                | 79.570  | 40.213 | 39.357 | 8.175 | 31.182 | 0.39  |
| Samsun                 | 12.881  | 2.961  | 9.920  | 0     | 9.770  | 0.76  |

**Notes:** ECM = Empty Container Movement; ECMti = ECM arising from trade imbalance; AECM = Additional ECM; AECMs = AECM arising from cargo seasonality; Ratio = (AECM-AECMs)/ECM; (AECM-AECMs) = ECM arising from market effect and operational drivers except cargo seasonality.

### Table IX.
40-Foot ECM in Turkey (2016)

| Terminal/Hinterland     | ECM  | ECMti | AECM  | AECMs | AECM-AECMs | Ratio |
|-------------------------|------|-------|-------|-------|------------|-------|
| Ambarli Istanbul        | 219.179 | 61.059 | 158.120 | 15.169 | 14.295 | 0.65  |
| Haydarpasa Istanbul    | 13.024  | 9.943  | 3.081  | 1.187 | 1.894  | 0.15  |
| Gemport Gemlik         | 37.949  | 24.141 | 13.808 | 0     | 13.808 | 0.36  |
| Borusan Gemlik         | 24.335  | 16.907 | 7.448  | 2.831 | 4.617  | 0.19  |
| Roda Gemlik            | 4.920   | 2.024  | 2.896  | 1.041 | 1.855  | 0.38  |
| Kocaeli hinterland     | 65.558  | 32.833 | 32.725 | 0     | 32.725 | 0.50  |
| Eggegubre Aliaga       | 44.404  | 31.440 | 12.964 | 0     | 12.964 | 0.29  |
| Nemport Aliaga         | 38.088  | 28.343 | 9.745  | 0     | 9.745  | 0.26  |
| TCDD Alsancak Izmir    | 98.724  | 88.052 | 10.672 | 4.669 | 6.003  | 0.06  |
| Mersin MIP             | 104.011 | 62.359 | 41.652 | 10.260 | 31.392 | 0.30  |
| Mersin - Iskenderun    | 122.002 | 75.314 | 46.688 | 0     | 46.688 | 0.38  |
| Antalya                | 79.570  | 40.213 | 39.357 | 8.175 | 31.182 | 0.39  |
| Samsun                 | 12.881  | 2.961  | 9.920  | 0     | 9.770  | 0.76  |

**Notes:** ECM = Empty Container Movement; ECMti = ECM arising from trade imbalance; AECM = Additional ECM; AECMs = AECM arising from cargo seasonality; Ratio = (AECM-AECMs)/ECM; (AECM-AECMs) = ECM arising from market effect and operational drivers except cargo seasonality.
Here in this study, we found out how to reach the magnitude of seasonal AECM. The rest of operational drivers, abundant container owners, container condition, uncertainties in demand/handling/shipment and blind spots in supply chain, can be investigated in future studies to conceive the magnitude of market effect further.

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