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Full Length Article

Order imbalance and commonality: Evidence from the options market

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Abstract

Using a market model and principal component analysis, we investigate the existence of common effects in order imbalance in the Borsa Istanbul's option market. Accordingly, we find the presence of commonality in order imbalance for call options and an even more dominant presence in put options. We investigate the impact of this commonality on the underlying equity market's price discovery; however, the results indicate no significant impact. Our results suggest that, from the order imbalance perspective, equity order imbalance contributes more than options to explaining stock return variations.

JEL classification: G12; G13; G14

Keywords: Borsa Istanbul; Commonality; Options market; Order flow; Order imbalance

1. Introduction

Traditional models and empirical works in the microstructure literature focus on trading activity as a single security phenomenon. In recent market microstructure literature, the subject of commonality has received significant attention. Commonality refers to the covariation and spillover effect between individual firm-level trading activities and the entire market over time. In particular, it refers to the sensitivity of individual asset trading activity to corresponding market-wide variations. The bulk of finance research focused on the subject of commonality in order imbalance and liquidity follow the seminal works by Chordia et al. (2000), Hasbrouck and Seppi (2001), and Huberman and Halka (2001).

Following these studies, numerous papers examine the presence of commonality for different trading activities in different markets.[1,2,3] To date, a gap exists in the literature because of the absence of studies on commonality in order imbalance in the derivatives market. Motivated by this, we contribute to the literature by examining and documenting the cross-security presence of common factors in order imbalance in a purely order-driven and emerging derivatives market, namely, the Borsa Istanbul (BIST).

Option markets offer investors an alternative to equities, bonds, and futures markets because of their unique features that make them suitable for informed trading, speculation, and

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[1] Recent papers that explore commonality research include Anagnostidis and Fontaine (2020), Benzennou et al. (2020), Klein and Song (2021), Saad and Samet (2020), and Sensoy (2019).
[2] See https://www.borsaistanbul.com/en/sayfa/2284/market-making/. Although many derivatives products have market makers, single equity options do not, nor does the equity market.
[3] In fact, the Borsa Istanbul has the world's highest trading in single-stock futures and precious metals futures. See https://www.world-exchanges.org/our-work/articles/derivatives-report-2020/.

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hedging. Furthermore, Cetin et al. (2006) point out that the number of option transactions and the direction of the trades play a significant role in the liquidity and order imbalance structure of the market. The important aspect of this fact is that liquidity and order imbalance in option markets both have price impacts on option prices and thereupon the underlying asset prices. In fact, order imbalance (i.e., the number of buyer-initiated trades minus the number of seller-initiated trades), which either reflects the arrival of new information in the market or can be induced by hedging demand, significantly affects option prices and the associated implied volatility (Bollen & Whaley, 2004). Hu (2014) finds that, through informed or hedging trades by investors in the option market, option order imbalance induces temporary or permanent pressure on underlying stock market price changes. Therefore, the presence of commonality in the single-stock option market, which signifies that order imbalance covaries among options, is relevant to trading decisions by market participants, as it offers new channels for them to consider. Moreover, the presence of systemic variation in option buying/selling pressure with market-wide influence is relevant to policy makers interested in better risk management. Among the earlier studies, Cao and Wei (2010) investigate the commonality in option liquidity, whereas we take a different approach by examining commonality in option order imbalance, which is our main contribution to the literature.

The seminal paper by Chordia et al. (2000) and research by Hasbrouck and Seppi (2001) represent a shift in focus from individual assets to common effects in trading activities, including liquidity and order imbalance. Following these papers, the literature focuses on revealing the drivers of the common components while investigating the presence of commonality in liquidity in different markets, including equities, bonds (Chordia et al., 2005), derivatives (Cao & Wei, 2010), commodities (Marshall et al., 2013), and foreign exchange (Mancini et al., 2013) markets. Chordia et al. (2000), who focus on stocks listed on the New York Stock Exchange, highlight the industry-wide and market-wide factors that affect liquidity, rather than investigating liquidity focused on a single asset. They find a positive relationship between changes in individual asset liquidity and changes in market liquidity, a result that remains robust after controlling for price, volume, and volatility. The commonality in liquidity phenomenon in the equities market showed that liquidity cannot be treated in isolation. Mancini et al. (2013) extend the commonality research to foreign exchange markets, reporting that the level of commonality is higher than is reported in the equities market. They use both the market method and the principal component method to find support for the theory that a reduction in the funding liquidity of investors is followed by market-wide illiquidity in foreign exchange assets.

Most studies have used datasets from quote-driven markets, but some papers focus on order-driven markets. In quote-driven markets, market makers are the liquidity providers of last resort, whereas order-driven markets are free of assigned dealers with market participants' buy and sell orders determining the asset prices. Syamala et al. (2014) document the existence of commonality in liquidity in India's order-driven equity market. Investigating the Turkish market, Sensoy (2017) explores the effect of ownership structure and firm size on the commonality in liquidity and finds that institutional ownership has a positive effect on commonality in liquidity for midcap and large-cap firms whereas the commonality in liquidity in small-cap firms is driven by individual investors. The main result of the research is that higher participation in a firm culminates in heterogeneous investor beliefs, which reflects less commonality in liquidity. In the options market, Cao and Wei (2010) use several option-based liquidity measures between 1996 and 2014 and show commonality in liquidity in the call and put options and that the size and volatility of the underlying asset have an effect on commonality. Verousis et al. (2016) find that the implied volatility of a market index has a strong effect on the market-wide liquidity component. Benzennou et al. (2020) focus on the global financial crisis period between January 2008 and December 2010 and find a commonality in liquidity in the European futures and options market with evidence of a higher level of commonality in derivatives written on same underlying asset.

Focusing mainly on commonality in order imbalance, Hasbrouck and Seppi (2001) use principal component analysis (PCA) and document the existence of comovement in the order flow of 30 stocks in the US Dow Jones Industrial Average (DJIA). Hughen and McDonald (2006) also focus on order flows, segmenting investors (retail and institutional) by trade size (large, medium size, and small), and find commonality across the trades of retail investors, suggesting that sentiment could be the driver of commonality in the equities market. Harford and Kaul (2005) conjecture that indexing is the primary driver of common effects in order flow and returns, unlike in investor allocation and correlation in industry events. That is, firms listed on the S&P 500 have stronger commonality than unlisted firms. Corwin and Lipson (2011) show that program trading by institutional investors, rather than individual investor trades, is the driver of commonality in order flow. Although the issue of commonality in liquidity in options market has been examined in the literature, to the best of our knowledge, no papers to date have investigated the presence of comovement in the options market order flow, in particular, order imbalance.

In our study, using time-stamped transaction-level data, we calculate the daily order imbalance as the difference between the number of buyer-initiated trades and the number of seller-initiated trades for call and put options in the single-stock options market. To investigate the presence of commonality in options order imbalance, we use a market-model methodology based on Chordia et al. (2000) and the PCA of Hasbrouck and Seppi (2001). The market-model method is based on the comovement between individual options order imbalance and the market portfolio that exempts the option in question whereas the PCA method uses the common factors extracted from individual order imbalance as a proxy for a systemic factor. Based on our research, PCA shows that the first principal component explains 7.78 percent of the variations in the call option order imbalance and 11.33 percent of

the variations in the put option order imbalance. Further, we find that first principal component explains 27.20 percent of the variations in equity returns. The extracted common effects in the order imbalance are used in time-series regressions to investigate the relationship between individual options order imbalance and market-wide order imbalance commonality in the equity market. Our analysis indicates the presence of positive and statistically significant market-wide common effects in the order imbalance of both call and put options, with a more dominant presence in put options. Specifically, 40 percent and 80 percent of the market-wide call and put options have positive and significant coefficients, respectively. We establish that, after time variation in order imbalance, expiry date effect, and market downturn are controlled for, the documented commonality withstands several robustness checks.

We then analyze the impact of individual and common effects in the underlying equity market on the commonality in the option order imbalance and find no significant relationship. Despite the presence of commonality in the order imbalance in the options market and the equity market, we find no evidence of a significant relationship between individual options order imbalance and market-wide equity order imbalance.

Lastly, we use sequential regressions to examine the contribution of options order imbalance to variations in the underlying equity returns and find that the equity order imbalance makes the highest contribution to stock return variations.

This study makes several contributions to the literature. This is the first study to examine the presence of commonality in order imbalance in the options market. A major implication of this study is that investors need to be aware of the level of commonality in options order imbalance when making their trades because an option's order pressure depends on the buy vs. sell pressure of other listed options. Furthermore, this dependence is higher in put options than call options. Previous papers on commonality in order imbalance focus on quote-driven markets. We examine whether commonality exists in an order-driven market without designated market makers.[2] The attribution of the presence of commonality in order imbalance in financial markets to inventory adjustments and costs in the prior literature may be less pronounced in fully order-driven markets because of the absence of a liquidity provider of last resort, and no market maker is obliged to submit orders. Therefore, it is not immediately clear whether the commonality in order imbalance documented in developed markets holds in emerging markets with a different market structure. Thus, we extend the commonality literature by investigating the presence of common effects in an order-driven emerging option market. The result that options order imbalance has minor effects on underlying asset returns provides insight into one of the potential reasons for the slow growth of a derivatives market in emerging markets. Our results can be generalized to other emerging markets (e.g., China, India, Brazil, Russia, Korea) with a fully order-driven derivatives market and a similar market structure.

The rest of the paper proceeds as follows. Section 2 discusses the data. Section 3 describes the methodology. Section 4 presents the results, and Section 5 concludes.

2. Data

The Turkish derivatives market at the Istanbul Stock Exchange became operational in December 2012. The futures and options exchanges (Turkish Derivatives Exchange and Borsa Istanbul Derivatives Market) merged in August 2013 under the umbrella of the BIST, which became the only exchange in Turkey. Several types of derivatives contracts are traded, including single stock options and futures, equity index options and futures, and commodity and currency futures. Although relatively new compared to other emerging markets, the BIST derivatives market exchange ranked thirteenth by the number of trades, and the BIST single-stock futures and options ranks second globally among the most actively traded, with over one billion trades in 2020,[3] making the securities trading on the BIST among the most active in the world.[4]

The Turkish option market is a fully order-driven market with no designated market makers. All the listed options are European options and expire on the last trading day of the month. There are six maturity months: February, April, June, August, October, and December. At any point in time, option contracts with an expiration in the next three expiry months are traded. If December is not one of these expiry months, a fourth contract with expiration in December is added. Each option has a contract size of 100 shares of its underlying equity, and the tick size is 0.01 points per share. Our sample begins on March 1, 2017, because it is the day that Nasdaq's Genium INET trading system was developed and adopted for the Turkish derivatives market under the name BISTECH with facilities such as collocation and ITCH and OUCH terminals, which allow trading at very high speeds. The characteristics of the BIST option market makes it interesting for studying the presence of common effects among single-stock options. The results of this study can serve as a benchmark for comparing the results obtained from an emerging market with those found for developed markets and other emerging markets. In particular, emerging markets with a similar market size and structure can benefit from our findings.

We obtain time-stamped high-frequency transaction-level option and equity data from the BIST database between March 1, 2017, and February 28, 2021. The database contains time-stamped data on the option type, maturity date, number of transactions (buyer or seller initiated), and trading volume of all exchange-traded options. The option market has 21 unique firms in 7 different sectors: Akbank, Garanti Bank, Halk Bank, Is Bank, Sabanci Holding, Vakif Bank, and YapiKredi in financial; Aselsan, Koc Holding, Pegasus, Sisecam, Turkish Airlines in manufacturing; Eregli, Kardemir, and Petkim petroleum in raw materials; Arcelik and Tofas in consumer goods; Turkcell and Turk Telekom in

[4] For more details, see also https://www.fia.org.

communications; Tupras in energy; and Emlak Konut in real estate. We exclude Aselsan from the study because it has many missing days of transaction data, making it impossible to calculate the principal components of its option. Because organized option trading was introduced in 2013, none of the 21 single-stock options listed at inception has been removed from the exchange, and no further additions have been made. We further exclude deep in-the-money and deep out-of-the-money contracts from our sample.[5] We exclude these options because they are thinly traded (deep-in-the-money and deep-out-of-the-money options represent 3.01 percent of all option transactions) and to avoid issues related to the pricing structure. We keep options with a maturity date of between 8 and 365 days. Industry and other firm-specific data are obtained from the Bloomberg database. For the part of the analysis that involves investigating the link of commonality in the options and equities markets, we obtain transaction-level data on the underlying equity market from the BIST. All aspects of our data analysis are based on the time period 9:00 a.m. to 5:30 p.m.

We use the transaction-level data to construct daily order imbalance measures. All trades occur within the organized exchange, with precise information about trade initiators. Therefore, we have explicit information about whether the buyer or seller is the active side of the trade, allowing us to calculate the call (put) order imbalance as the daily number of buyer-initiated call (put) trades minus the number of seller-initiated call (put) trades. Similarly, the equity order imbalance is calculated as the difference between the total number of daily buyer-initiated equity trades and seller-initiated equity trades.[6] That is, whether it is a derivative or an equity, order imbalance is defined as:

$$\mathrm{OI} = \text{Number of buyer} - \text{initiated trades} - \text{Number of seller} - \text{initiated trades} \quad (1)$$

Following the literature, we define all order imbalance measures in terms of the number of transactions, rather than the trading volume, and standardize order imbalance measures to make the order imbalance comparable across firms. Specifically, the standardized order imbalance measure is given by

$$\mathrm{OI}^{*}_{i,t} = \frac{\mathrm{OI}_{i,t} - \mu_i}{\sigma_i} \quad (2)$$

where μ_i, and σ_i are the firm-specific mean and standard deviation over the sample period. Before standardizing the variables, we perform tests to confirm the stationarity of each firm's call (put) order imbalance. Table 1 reports the augmented Dickey-Fuller test statistics and corresponding significance levels. For each single-stock option in our sample, we reject the null hypothesis that the series contains a unit root at the 1 percent significance level, confirming that the variables are stationary. We calculate the daily open-to-close stock returns as the natural logarithm of the difference between the daily opening and closing prices of the underlying asset. That is, $R_{i,t} = \ln(p_{c,it}/p_{o,it})$, where $R_{i,t}$ is the daily return, and $p_{o,it}$ and $p_{c,it}$ are the opening and closing prices on day t for firm i, respectively.

Table 1 summarizes the transaction characteristics of firms with individual equity options listed on the BIST. We report the time-series mean of the daily call order imbalance, put order imbalance, the number of trades of put and call options, the underlying equity return, and the market capitalization of firms with listed options.

The sample data cover 1000 trading days. The mean number of call option trades is 1060.01, and the mean number of put option trades is 1498.87. This shows that individual put options are traded more often than call options. Positive mean call and put option order imbalances indicate that active investors are net buyers of individual call and put options on average.[7] The average market capitalization of firms with listed options over the sample period is TL 19,826.73 million, and their average daily open-to-close stock return is 0.06 percent.

3. Methodology

This section presents the approach used to investigate the presence of commonality in order imbalance in the Turkish derivatives market.[8] To do this, we use a market-model method based on Chordia et al. (2000) and the principal component method based on Hasbrouck and Seppi (2001). The market-model method depends on the cross-sectional average of order imbalance variables to extract common factors, and the principal component method relies on the variance-covariance matrix of the variables. We then examine the impact of trading activity in the underlying equity market on the equity option order imbalance. Finally, we describe the approach that investigates the relationship between individual and market-wide option order imbalance and underlying asset returns.

3.1. Commonality in option order imbalance: market-model approach

Chordia et al. (2000) use a market-model method to detect the presence of commonality in liquidity in the US market. Several papers have extended the market-model method to

[5] Because every transaction is time stamped to the millisecond, we match each option transaction with the underlying stock price and calculate moneyness as a strike price divided by a stock price. An option is classified as deep-out-of-the-money if the moneyness is greater than 1.20 for calls or less than 0.80 for puts and classified as deep-in-the-money if the moneyness is less than 0.80 for calls or greater than 1.20 for puts.

[6] Because our sample market is fully order driven, all limit and market orders are revealed in the order book. All orders in system are continuously matched at the best buy and sell prices.

[7] Although the summary statistics report the raw numbers, firm-level order imbalance measures are standardized throughout the study to eliminate the potential distortion effect.

[8] Various aspects of the BIST have been the subject of academic studies in recent years (Buyukkara et al., 2021; Ocak et al., 2021; Sahin & Kuz, 2021; Tinic et al., 2020). However, order imbalance is a subject that has not been considered before.

Table 1
Summary Statistics. This table displays the time-series mean of the properties of equity options listed on Borsa Istanbul and the average across stocks over the period March 2017 to February 2021. The last two columns describe the daily return and market capitalization of the stocks. Call (Put) OI denote call (put) order imbalance, defined as the difference between the number of buyer-initiated call (put) and seller-initiated call (put) trades. Call (Put) Trades are the daily average of the total number of call (put) option trades. Return is the daily logarithmic open-to-close return of the underlying stock in percentage. Market Cap is the average market capitalization of underlying assets over the sample period. ADF Test means the augmented Dickey-Fuller test statistics for call and put order imbalance series. *, **, and *** significant at 10%, 5%, and 1%, respectively.

Ticker	Company Name	Call OI	Put OI	Call Trades	Put Trades	Return (%)	Market Cap	ADF Test^{Call}	ADF Test^{Put}
AKBNK	Akbank	195.47	141.18	1044.05	1754.11	−0.01	34403.38	−8.54***	−9.06***
ARCLK	Arcelik	12.10	15.93	154.17	356.06	0.07	13630.96	−8.36***	−8.87***
EKGYO	Emlak Konut	198.56	51.19	3672.90	2857.22	−0.01	7557.97	−9.49***	−9.27***
EREGL	Eregli Demir	−16.79	63.00	284.43	483.63	0.11	31628.66	−9.16***	−8.33***
GARAN	Garanti Bank	30.34	208.59	565.43	1517.41	0.03	38183.71	−9.97***	−8.88***
HALKB	Halk Bank	52.42	286.63	766.08	1419.74	−0.05	10839.11	−11.28***	−6.96***
ISCTR	Is Bank	−9.83	132.48	761.65	1279.61	0.01	27513.16	−8.34***	−9.44***
KCHOL	Koc Holding	0.69	62.59	338.43	751.46	0.05	42798.58	−8.14***	−8.75***
KRDMD	Kardemir	88.37	−4.00	2352.51	3155.40	0.21	3372.18	−10.42***	−8.20***
PETKM	Petkim	111.35	15.26	1630.71	2307.53	0.04	8920.33	−8.85***	−10.00***
PGSUS	Pegasus	−3.04	20.86	149.24	274.67	0.23	4122.84	−10.36***	−9.72***
SAHOL	Sabanci Holding	4.03	62.87	231.01	889.03	0.02	18942.84	−9.96***	−9.63***
SISEE	Sise ve Cam	2.42	128.21	1482.35	1461.91	0.08	12295.00	−8.19***	−9.04***
TCELL	Turkcell	75.85	209.10	667.92	1173.37	0.05	29809.80	−8.81***	−8.46***
THYAO	Turkish Airlines	187.81	286.99	1061.81	1758.71	0.12	17490.84	−9.22***	−8.04***
TOASO	Tofas Turk	−0.47	4.10	62.19	219.61	0.05	12529.26	−9.49***	−8.73***
TTKOM	Turk Telekom	4.51	120.70	257.53	1113.89	0.06	21481.11	−9.61***	−7.05***
TUPRS	Tupras Petrol	11.91	28.04	105.92	206.69	0.04	27881.26	−9.45***	−7.81***
VAKBN	Vakif Bankasi	36.67	46.73	861.36	1921.44	0.00	14041.86	−10.21***	−7.37***
YKBNK	Yapi ve Kredi Bankasi	77.04	132.95	2862.43	2514.93	0.00	19091.72	−10.74***	−8.08***
Cross-sectional Mean		52.97	100.67	1060.01	1498.87	0.06	19826.73		

Table 2
Principal components analysis for order imbalance variables. This table displays the results of principal component analysis for call option order imbalance, put option order imbalance, and equity order imbalance. All firm-level order imbalance variables are standardized using cross-sectional mean and standard deviation. For each variable, the table reports the eigenvalues and the proportional and cumulative contribution to total variations explained by the first three principal components.

	Call			Put			Equity		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
Eigenvalue	1.555	1.392	1.334	2.265	1.414	1.378	5.441	1.680	1.357
Proportion	0.078	0.070	0.067	0.113	0.071	0.069	0.272	0.084	0.068
Cumulative	0.078	0.147	0.214	0.113	0.184	0.253	0.272	0.356	0.424

investigate the presence of common factors in order imbalance in the equity market, such as Harford and Kaul (2005) in the S&P 500 and Bailey et al. (2009) in the Shanghai Stock Exchange. To document commonality in option order imbalance, the market model time-series regression that we use is given by:

$$OI_{i,t} = \alpha_i + \beta_{1,i} OI_{M,t} + \beta_{2,i} OI_{M,t-1} + \beta_{3,i} OI_{M,t+1} + \gamma X + \varepsilon_{i,t} \quad (3)$$

where i denotes individual firms, $OI_{i,t}$ is the daily option (call or put) order imbalance, $OI_{M,t}$ ($OI_{M,t-1}$ and $OI_{M,t+1}$) are the contemporaneous (lagged and lead) market-wide option order imbalance, and X represents the control variables. This approach produces firm-by-firm regressions of option order imbalance (call and put separately) on the market-wide option order imbalance and other control variables. The market-wide order imbalance is the cross-sectional average of all individual option order imbalance, excluding the ith firm. We exclude firm i to reduce the cross-sectional dependence of the coefficients of the market-wide order imbalance. The year dummy variable, which equals 1 in the year of trading and 0 otherwise, captures the yearly changes in option order imbalance. The rollover of option positions to the next contract on the date of expiry can lead to commonality across listed options, thus we include an expiry date variable to take this into account. The expiry day variable equals 1 on the last business day of each expiry month, and 0 otherwise. For each firm, we standardize all variables with the time-series mean and standard deviation to enable comparison. The significance of the coefficient of market-wide option order imbalance indicates the relationship between individual option and market-wide option order imbalance and the cross-sectional mean of the time-series regression provides the level of commonality present in the Turkish derivatives market. We calculate the t-statistics across stocks and take the average of the adjusted R^2.

3.2. Commonality in option order imbalance: principal component approach

In addition to the market-model approach, we also use PCA to examine the presence of comovement in order imbalance. The principal component approach, following Hasbrouck and Seppi (2001), extracts common factors by constructing order imbalance factors as a linear combination of firm-level order imbalance variables. The method captures the common variation in order imbalance measures across firms, allowing the derivation of a smaller set of variables that can explain the original order imbalance variables for each type of option.

For each $i = 1, 2, \ldots, 20$, let X_i be a vector of length T such that $X_i = [x_{i1}x_{i2}\ldots x_{iT}]'$ x_{it} is the standardized order imbalance of firm i at time t. Let Σ be the covariance matrix of $X = [X_1, X_2, \ldots, X_{20}]$. Given that

$$\Lambda_j = \lambda_j X = \lambda_{1j}X_1 + \lambda_{2j}X_2 + \ldots. + \lambda_{20j}X_{20} \quad (4)$$

is a linear combination of the order imbalance variables from each firm, the variance of Λ_j, $\mathrm{Var}(\Lambda_j) = \lambda_j'\Sigma\lambda_j'$. The first principal component is the component that maximizes $\mathrm{Var}(\Lambda_j)$ subject to the constraint that ${\lambda_1}'\lambda_1 = 1$. The second principal component is the linear combination that maximizes $\mathrm{Var}(\Lambda_j)$ subject to the constraint that ${\lambda_2}'\lambda_2 = 1$ and is uncorrelated with the first principal component. Thus, the method allows the calculation of 20 principal factors with each factor mutually uncorrelated. The ith eigenvector, λ_i, of the covariance matrix is the weight of the variables in the linear combination that forms the ith principal component. Because the order imbalance variables are standardized, the proportion of the total variation that is explained by the ith principal component is given by $p_i = \frac{\lambda_i}{n}$. Eigenvalues are not significantly different from 1 if the variables have no common factors.

We then use the extracted first principal component to proxy for market-wide order imbalance in time-series regressions discussed in Equation (3). That is, the regression is given by:

$$\mathrm{OI}_{i,t} = \alpha_i + \beta_{1,i}\mathrm{P}_{M,t} + \beta_{2,i}\mathrm{P}_{M,t-1} + \beta_{3,i}\mathrm{P}_{M,t+1} + \gamma X + \varepsilon_{i,t} \quad (5)$$

where $\mathrm{P}_{M,t}$ is the first principal component that proxies for market-wide option order imbalance and X represents the control variables as described in Section 3.1.

3.3. Impact of trading activity in the underlying asset

This section examines the impact of trading activity in the underlying equity market on commonality in order imbalance. We use the following firm-by-firm time-series regression:

$$\mathrm{OI}_{i,t} = \alpha_i + \beta_{1,i}\mathrm{OI}_{M,t} + \beta_{2,i}\mathrm{OI}_{i,t}^{\mathrm{Equity}} + \beta_{3,i}\mathrm{OI}_{M,t}^{\mathrm{Equity}} + \varepsilon_{i,t} \quad (6)$$

where $\mathrm{OI}_{M,t}$ is the market-wide option order imbalance, $\mathrm{OI}_{i,t}^{\mathrm{Equity}}$ is the individual equity order imbalance, and $\mathrm{OI}_{M,t}^{\mathrm{Equity}}$ is the market-wide equity order imbalance. In the market-model method, market-wide equity order imbalance is calculated as the cross-sectional equally weighted average of the underlying equity order imbalance, excluding firm i. In the principal component method, we extract the first principal component of equity order imbalance and add it as an independent variable to proxy for market-wide equity order imbalance. A significant $\beta_{2,i}$ would demonstrate that equity order imbalance has a contemporaneous effect on option order imbalance, and a significant $\beta_{3,i}$ would suggest that option order imbalance is associated with the equity order imbalance inherent to other firms with exchange-listed options. Continuous significance of $\beta_{1,i}$ shows that the commonality in option order imbalance dominates individual or common effects that arise from the underlying assets. In some instances, order pressure can spill over from the equity market to the option market and vice-versa.

3.4. Relationship between commonality in equity and option order imbalance and underlying asset returns

We examine the impact of individual and market-wide equity order imbalance and individual and market-wide option order imbalance in explaining variations in the underlying equity returns. We also examine and compare the influence of equity and equity option order imbalance on the underlying returns using sequential regressions (Corwin & Lipson, 2011; Hasbrouck & Seppi, 2001). We begin with the estimation of individual equity order imbalance impact on the underlying stock returns, followed by the market-wide equity order imbalance, then add individual option order imbalance, and finally the market-wide option order imbalance. The estimation of firm-by-firm time-series regressions (for call and put separately) is given by:

$$\mathrm{R}_{i,t} = \alpha_i + \beta_{1,i}\mathrm{OI}_{i,t}^{\mathrm{Equity}} + \beta_{2,i}\mathrm{OI}_{M,t}^{\mathrm{Equity}} + \beta_{3,i}\mathrm{OI}_{i,t} + \beta_{4,i}\mathrm{OI}_{M,t} + \varepsilon_{i,t} \quad (7)$$

where $\mathrm{R}_{i,t}$ is the daily open-to-close stock return of stock i on day t, $\mathrm{OI}_{i,t}^{\mathrm{Equity}}$ is the corresponding equity order imbalance, $\mathrm{OI}_{M,t}^{\mathrm{Equity}}$ is the market-wide equity order imbalance, $\mathrm{OI}_{i,t}$ is the individual option order imbalance, and $\mathrm{OI}_{M,t}$ is the market-wide option order imbalance. In the market-model method, market-wide equity (option) order imbalance is calculated as the cross-sectional equally weighted average of equity (option) order imbalance, excluding the firm i. For the principal component method, we extract the first principal component of the equity order imbalance and add it as an independent variable to proxy for market-wide equity order imbalance. The study reports the incremental and cumulative R^2 of each model.

4. Results

This section presents the results of our analysis on the presence of commonality in option order imbalance in the Turkish market, followed by an investigation of the link between the equity and option markets.

4.1. Commonality in option order imbalance: market-model approach

Hasbrouck and Seppi (2001), Harford and Kaul (2005), and Bailey et al. (2009) provide evidence of common factors in the order imbalance in equity markets. This section examines the presence of commonality in option order imbalance using the market-model method of Chordia et al. (2000). Table 3 presents the results of market-wide order imbalance commonality in the option market, showing clear evidence of this commonality in both call and put options. Among the firms with exchange-listed call options, 75 percent have positive coefficient on market-wide call option order imbalance, and 40 percent of the coefficients of market-wide call option order imbalance are positive and significant. The results indicate that the cross-sectional average of the beta coefficient of market-wide call option order imbalance is 0.181, and it is statistically significant at the 1 percent level (t = 3.632). The results display an even stronger level of commonality in put options, in which all firms have positive coefficients on market-wide put option order imbalance, and 80 percent of them are positive and significant. The average of the beta coefficients of individual put option order imbalance is 0.487, with a t-statistic of 7.699 (significant at 1 percent level). Further investigation shows that the commonality demonstrated is significantly greater in put options than in call options. Specifically, we find that the mean difference between the coefficients of market-wide call and put order imbalance is significant at the 1 percent level. We note that the cross-sectional average of the adjusted R^2 for call and put options are 0.5 percent and 4.0 percent, respectively. Although this appears modest, it is comparable to the average adjusted R^2 of less than 2 percent reported in Chordia et al. (2000). The stronger comovement of the put options than the call options signals that the investors use put options for hedging purposes more widely than call options. One reason for this is the order types used in the Turkish financial markets. On the BIST, different markets have different order types. One of the order types available to investors in the derivatives market is "stop orders," which is activated when the market price reaches a predetermined level. This predetermined price should be higher than the market price on the buying side and lower on the selling side. This conditional order type provides a kind of an insurance for investors and is used for hedging purposes against sharp market movements. However, the BIST stock market has no such order type. Therefore, if an investor has a portfolio in the spot market, the only hedging opportunity protecting the investor from sharp price falls is to buy a put option in the derivatives market. This strategy prevents the investors from losing more than the premium paid for the option. In the event of sharp falls in the spot market, it is always extremely hard to sell the stocks at a predetermined price. However, if an investor has a put option, then she can sell the asset at the strike price and stop her losses.

In the BIST option market, for the put option contracts, the sellers are usually institutional investors, and the buyers are individual investors. As explained earlier, the two strategies for preventing losses in the spot market are either to buy a put option or to sell a call option. For individual investors, it is easier and cheaper to buy a put option than to sell a call option. When market figures are considered, it is also obvious that investors prefer to buy put options, rather than trade call options. In fact, Table 1 indicates that the average number of put option trades is greater than the average number of call option trades. Specifically, the ratio of the average number of put options trades to call option trades is approximately 3:2.

Some market experts also argue that the put option strategies that the individual investors prefer results from the reduction in the number of large and foreign investors who hold large portfolios in the spot market. The share of foreign investors in the spot market dropped from 65.79 percent in January 2020 to 44.32 percent in March 2021. This decline means that a third of the foreign investors had sold their portfolios.

Table 3
Commonality in order imbalance regressions. This table summarizes the time-series regressions of individual option (call and put) order imbalance on contemporaneous, lagged, and lead market-wide option order imbalance: $OI_{i,t} = \alpha_i + \beta_{1,i}OI_{M,t} + \beta_{2,i}OI_{M,t-1} + \beta_{3,i}OI_{M,t+1} + \gamma X + \varepsilon_{i,t}$. The table reports the cross-sectional average of coefficients from time-series regressions with t-statistics in parentheses, percentage of positive coefficients, percentage of positive coefficients significant at the 5% level, and the cross-sectional mean and median adjusted R^2 of time-series regressions. *, **, and *** significant at 10%, 5%, and 1%, respectively. The market-model method calculates market-wide order imbalance as the cross-sectional equally weighted average of order imbalances, excluding firm i, and the principal component method uses the extracted first principal component as the market-wide option order imbalance. All order imbalance variables are standardized using cross-sectional mean and standard deviation. The sample covers 1000 trading days from March 2017 to February 2021.

	Market Model		Principal Component Analysis	
	Call	Put	Call	Put
Concurrent market-wide order imbalance	0.181***	0.487***	0.111***	0.199***
T-statistics	(3.632)	(7.699)	(2.485)	(8.523)
% Positive	75	100	65	100
% Positive significant	40	80	50	90
Lagged market-wide order imbalance	−0.012	0.074**	−0.003	−0.001
T-statistics	(−0.270)	(2.000)	(−0.308)	(−0.066)
% Positive	40	65	65	45
% Positive significant	15	20	10	40
Lead market-wide order imbalance	−0.014	0.074*	0.000	−0.003
T-statistics	(−0.633)	(1.742)	(−0.007)	(−0.375)
% Positive	50	70	55	40
% Positive significant	0	25	0	15
Adjusted R^2 Mean	0.005	0.040	0.079	0.115
Adjusted R^2 Median	0.004	0.023	0.019	0.085

Overall, the results show that buying pressure is correlated among individual options, with a stronger presence documented in the put options market.[9] Moreover, the regressions show that the commonality effect is not driven solely by the option expiry date, the trading year, or a market downturn.[10]

4.2. Commonality in option order imbalance: principal component approach

This section uses PCA to analyze the commonality in option order imbalance. First, we provide PCA results and then report the results of time-series regressions on exchange-listed options. Table 2 reports the PCA estimation for order imbalance variables. To facilitate comparison with prior research focused on commonality in order imbalance for the equity market, we report the PCA for firms with exchange-listed options. The first principal component for equity order imbalance has an eigenvalue of 5.441, that is, it explains 27.2 percent of the total variations. The evidence in Corwin and Lipson (2011), which focuses on 100 stocks listed on the NYSE, suggests that first principal component of order imbalance explains 4.9 percent of the total variation whereas the first three principal components explain 7.87 percent of the total variation. The results by Hasbrouck and Seppi (2001), which mainly focus on 30 Dow stocks, indicate that the first principal component in order imbalance explains 7.8 percent of the total variation. Thus, our result implies higher strength in the first principal component in our sample equity market. The eigenvalue of the first principal component for call options is 1.555, which suggests that it explains 7.78 percent of the variations in call option order imbalance, and the first three principal components explain 21.40 percent of the total variation. However, the first principal component for put option order imbalance is 2.265, which indicates that it explains 11.33 percent of the variation, and the first three principal components explain 25.3 percent of the total variation. The results strongly demonstrate the presence of common factors in our sample market. The highest commonality appears strongest in equity order imbalance followed by put options, then call options.

We now address the impact of common factors in option order imbalance on individual option order imbalance for each type of option. Table 3 presents the results of the regression in which the first principal component is used as the market-wide factor. The coefficient of market-wide call order imbalance is positive for 65 percent of the firms, with an average of 0.111 (significant at the 1 percent level), and 50 percent of the coefficients are positive and significant. Moreover, the average adjusted R^2 of the regression is 7.9 percent. The mean coefficient of market-wide put order imbalance is 0.199 (significant at 1 percent level), and all coefficients are positive, of which 90 percent are significant. The average adjusted R^2 for this regression is 11.5 percent. These results are consistent with those of the market-model method. That is, put options have stronger commonality than call options. Overall, the explanatory power of the regressions is greater in the principal component method than the market-model method. The earlier results in the literature show that investors use equity option order imbalance to predict individual stock price movement. Focusing on the option market, we find that option market investors learn from the order imbalance of other equity options when making trading decisions. These results provide evidence of an incremental role of equity options in the Turkish market. In other words, beyond using the options market as a venue for trading information about the underlying asset, options markets also use the information contained in order imbalance to trade other equity options. Because the single equity options market has no designated market maker, the results signify that investors in derivatives market learn from the order imbalance in listed derivatives.

4.3. Impact of trading activity in the underlying asset

This section examines the additional effect of individual and market-wide order imbalance in the equity market on individual option order imbalance. Chordia et al. (2005) find a relationship between the commonality of liquidity in the bond and equity markets. They attribute the relationship to the movement of investors across different asset classes. Investors can choose to trade in option and equity markets, based on their expectation after the arrival of new information in the market. For instance, when positive (negative) news arrives in the market, investors can either buy call (put) options or buy (sell) the underlying asset. The presence of simultaneous trading that leads to intense buying or selling pressure in both markets at such moments can lead to a correlation in order imbalance in both equity and option markets. The direction of the common effects is positive when the trades are in the same direction and negative if there is reverse trading in the two markets. Even in the absence of information, the hedging strategies of investors in the two markets can also lead to correlation in order imbalance. Some investors trade options to hedge their equity exposure whereas liquidity providers might use equity market trades to hedge option trades by active investors. For instance, if there is high buying pressure, the passive investors on the other side of the trades can choose to hedge their option exposure in the underlying equity market. Therefore, demand related to hedging needs and information arrivals that link equity and option market lead to the transmission of buying and selling pressure across the markets, potentially leading to correlation in common factors. Thus, we add equity order imbalance to our model specification to understand the influence of order imbalance in the equity market on the order imbalance commonality in the option market.

Table 4 reports the results of the regressions. We report the results of the principal component method, which demonstrate

[9] In addition to performing market-wide regressions, we check for the existence of industry-wide commonality in order imbalance in sectors with more than three firms (finance and manufacturing) and obtain similar results.

[10] In unreported regressions, we add interaction terms for an expiry day dummy and market-wide order imbalance as well as interaction terms for market downturn and market-wide order imbalance as independent variable and find no evidence of stronger commonality on option maturity dates.

Table 4
Impact of trading activity in underlying asset on option order imbalance. This table summarizes the time-series regressions of individual option (call and put) order imbalance on market-wide option order imbalance, individual equity order imbalance, and market-wide equity order imbalance: $OI_{i,t} = \alpha_i + \beta_{1,i}OI_{M,t} + \beta_{2,i}OI_{i,t}^{Equity} + \beta_{3,i}OI_{M,t}^{Equity} + \varepsilon_{i,t}$. The table reports the cross-sectional average of coefficients from time-series regressions with t-statistics in parentheses, percentage of positive coefficients, percentage of positive coefficients significant at the 5% level. The table reports the proportional and cumulative R^2 of the regressions where proportional R^2 represents the contributions of each variable to the regressions. *, **, and *** significant at 10%, 5%, and 1%, respectively. The market-model method calculates the market-wide order imbalance as the cross-sectional equally weighted average of order imbalances, excluding firm *i*, and the principal component method uses the extracted first principal component as the market-wide order imbalance. All order imbalance variables are standardized using cross-sectional mean and standard deviation. The sample covers 1000 trading days from March 2017 to February 2021.

	Market Model						Principal Component					
	Call			Put			Call			Put		
Market-wide option order imbalance	0.178***	0.182***	0.184***	0.518***	0.519***	0.519***	0.111***	0.111***	0.112***	0.198***	0.199***	0.199***
T-statistics	(3.591)	(3.723)	(3.778)	(7.511)	(7.552)	(7.587)	(2.486)	(2.512)	(2.520)	(8.391)	(8.415)	(8.436)
% Positive	75	75	75	100	100	100	65	65	65	100	100	100
% Positive significant	40	40	40	80	80	80	50	50	50	90	90	90
Individual equity order imbalance		−0.002	0.002		−0.006	−0.001		−0.002	0.010		0.000	0.000
T-statistics		(−0.162)	(0.092)		(−0.605)	(−0.097)		(−0.133)	(0.582)		(−0.013)	(0.047)
% Positive			45		45	50		45	60		45	45
% Positive significant			5		5	10		5	5		0	0
Market-wide equity order imbalance			−0.011			−0.020			−0.007			0.000
T-statistics			(−0.531)			(−0.977)			(−1.517)			(0.078)
% Positive			45			35			40			45
% Positive Significant			1			1			5			10
Prop. R^2 (%)	0.485	0.401	0.151	3.554	0.196	0.143	7.775	0.342	0.155	11.326	0.183	0.117
Cumulative R^2 (%)	0.485	0.885	1.037	3.554	3.750	3.894	7.775	8.117	8.272	11.326	11.509	11.626

higher explanatory power for the variables related to the market-model method. The mean coefficient of market-wide option order imbalance is significantly higher than the coefficient on both individual and market-wide equity order imbalance. This shows that buying pressure increases in an individual option when there is higher buying pressure on other options. The results indicate that changes in individual option order imbalance are not driven by trading in the underlying equity market. Other than the regression coefficients, the R^2 of the regressions has similar implications. Common effects explain 7.78 percent of the variations in individual call order imbalance. Equity order imbalance contributes additional explanatory power of 0.34 percent whereas market-wide equity order imbalance adds explanatory power of 0.16 percent to variations in call order imbalance. We find that the first principal component explains 11.36 percent of the variations in put order imbalance. Equity order imbalance contributes explanatory power of 0.18 percent, and market-wide equity order imbalance explains an additional 0.12 percent of the variation in put order imbalance. Overall, the results suggest that an option's buying/selling pressure is influenced by the buying/selling pressure of other options, but buying pressure in the equity market has little influence on changes in option buying pressure. That is, there is a modest transfer of pressure from stock order imbalance to equity options order imbalance in our sample market. Therefore, the main drivers of commonality in order imbalance in the option market are specific to trades on the option market.

4.4. Relationship between commonality in equity and option order imbalance and the underlying asset returns

So far, this paper has revealed the presence of commonality in call and put option order imbalance in the Turkish market. This section examines the contribution of option order imbalance to explaining equity returns, after accounting for the explanatory power of individual and market-wide order imbalance in the equity market. Hasbrouck and Seppi (2001) document that a common factor in equity order imbalances influences the underlying equity returns, implying that, beyond the impact of trading activity within a stock, the buying pressure on other stocks in the market also affects returns. The results in Section 4.2 indicate the strong presence of commonality in equity order imbalance in BIST. Specifically, the market-wide equity order imbalance explains 27.2 percent of the total variations in individual order imbalances. Therefore, we examine the relationship between returns and order imbalance in a multimarket framework using sequential regressions. We add the variables based on our expectation and prior literature that individual stock order imbalance is likely to have an effect on stock returns, followed by other factors.

Table 5 reports the cross-sectional averages of the R^2 of firm-by-firm time-series sequential regressions described in Equation (7) for both the market-model and principal component methods. The results of both methods are comparable; therefore, we report the output of the principal component method. According to the principal component

Table 5
Explained stock return variations by stock and option order imbalance. This table summarizes the time-series regressions of stock returns on individual and market-wide equity and option order imbalance: $R_{i,t} = \alpha_i + \beta_{1,i}OI_{i,t}^{Equity} + \beta_{2,i}OI_{M,t}^{Equity} + \beta_{3,i}OI_{i,t} + \beta_{4,i}OI_{M,t} + \varepsilon_{i,t}$. We sequentially run regressions of equity returns on individual equity order imbalance and then add market-wide equity, then individual option order imbalance and finally market-wide option order imbalance. We report the cross-sectional average R^2 from firm-by-firm time-series regressions, which represent the proportional and cumulative contributions of each independent variable in explaining return variations. We also report the cross-sectional average of coefficients from time-series regressions with t-statistics in parentheses. *, **, and *** significant at 10%, 5%, and 1%, respectively. Market-wide equity and option order flow are calculated using market-model and principal component methods. Market-model method computes market-wide order imbalance as the cross-sectional equally weighted average of underlying order imbalance, excluding firm i, and the principal component method uses the extracted first principal component as the market-wide option order imbalance. All order imbalance variables are standardized using cross-sectional mean and standard deviation. All R^2 are reported in percentages. The sample covers 1000 trading days from March 2017 to February 2021.

	Market Model								Principal Component							
	Call				Put				Call				Put			
Individual equity order imbalance	0.012***	0.009***	0.009***	0.009***	0.012***	0.009***	0.009***	0.009***	0.012***	0.008***	0.008***	0.008***	0.012***	0.008***	0.008***	0.008***
T-statistics	(18.069)	(12.221)	(12.163)	(12.157)	(18.069)	(12.221)	(12.162)	(12.195)	(18.069)	(8.842)	(8.827)	(8.827)	(18.069)	(8.842)	(8.807)	(8.817)
Market-wide equity order imbalance		0.014***	0.014***	0.014***		0.014***	0.014***	0.014***		0.003***	0.003***	0.003***		0.003***	0.003***	0.003***
T-statistics		(13.794)	(13.794)	(13.751)		(13.794)	(13.750)	(13.838)		(9.903)	(9.897)	(9.883)		(9.903)	(9.878)	(9.953)
Individual option order imbalance			0.000	0.000			0.000	0.000			0.000	0.000			0.000	0.000
T-statistic			(−0.734)	(−0.681)			(0.681)	(−0.095)			(−0.563)	(−0.532)			(0.640)	(−1.089)
Market-wide option order imbalance				−0.001				0.002***				0.000				0.001***
T-statistic				(−5.383)				(6.063)				(0.728)				(6.929)
Prop. R^2 (%)	27.082	6.782	0.181	0.034	27.082	6.782	0.066	0.110	27.082	6.479	0.181	0.026	27.082	6.479	0.062	0.146
Cumulative R^2 (%)	27.082	33.865	34.046	34.080	27.082	33.865	33.931	34.041	27.082	33.561	33.742	33.768	27.082	33.561	33.623	33.769

method, individual equity order imbalance explains 27.08 percent of the variations in equity returns, and market-wide equity order imbalance contributes explanatory power of 6.48 percent in the Turkish market. For their part, Hasbrouck and Seppi (2001) find that stock order imbalance explain 25 percent of the changes in returns for 30 Dow stocks whereas Corwin and Lipson (2011) report that individual stock order imbalance explains 8.83 percent of stock return variations for 100 major NYSE stocks. Individual call order imbalance accounts for 0.18 percent of the variations in stock returns whereas market-wide call option order imbalance explains an additional 0.03 percent of the variation in returns. We note that commonality in put order imbalance explains more variation in returns than individual put order imbalance. After accounting for both individual and common effects in order imbalance in the equity market, individual put order imbalance explains 0.06 percent of the variations in equity returns whereas market-wide put order imbalance explains 0.15 percent. Overall, the results show that a significant proportion of changes in the returns on the underlying asset is driven by individual equity order imbalance, followed by the common effect in equity order imbalance. The magnitude of explanation provided by option order imbalance is comparatively minute.

5. Conclusion

This study fills a void in the microstructure literature by examining the presence of commonality in order imbalance in the options market. The commonality literature has become popular in recent times following the work of Chordia et al. (2000), Hasbrouck and Seppi (2001), and Huberman and Halka (2001), which are all focused on NYSE stocks. Subsequently, the literature has been extended to bonds, commodities, and foreign exchange markets; however, research on the option market has remained scarce. Using a dataset on the Turkish option market, which is fully order driven, covering 1000 trading days between March 2017 and February 2021, we use the popular market-model and principal component approaches and find consistent evidence of common effects in order imbalance in the option market. We find significantly higher commonality in put options order imbalance than in call options. The results hold after factors likely to affect individual option order imbalance, such as yearly variations in order imbalance, the expiry day effect, and overall market downturns, are controlled for. We also explore the effect of individual and market-wide equity order imbalance on the order imbalance in the option market. After accounting for the explanatory power of market-wide option order imbalance, the results show that, for both call and put options, changes in individual option order imbalance are not driven by buying (selling) pressure in the underlying equity market.

We further investigate the contribution of option order imbalance to variations in underlying equity returns. The extant literature has established the price impact of order imbalance in the equity market, and, consistent with earlier

literature, we demonstrate that individual equity order imbalance as well as market-wide equity order imbalance explain a substantial portion of variations in the underlying asset returns. However, the results indicate that the additional contribution of individual and market-wide option order imbalance to the explanatory power of stock returns is minimal.

The results on the presence of commonality indicate that shocks to buying/selling pressure in the option market have market-wide effect. An implication of these results is that, in addition to focusing on the underlying asset, it is also important to consider other listed options when creating option trade strategies and forming investment portfolios. Our findings also motivate us to ask whether a similar phenomenon might exist in the single-stock futures market because single-stock options and futures contracts on the BIST are written on the same underlying assets. Finally, the equity market of the BIST has a product called real-time data analytics, which includes order imbalance data for the equity market.[11] Considering the commonality in order imbalance in the derivatives market and its importance on the systemic risks evidenced in our study, it might be a good idea to introduce a similar analytics product for the derivatives market as well for better risk management and a more efficient market.

To further understand the common effects in option order imbalance, future research can focus on the composition of the types of traders (individual and institutional investors) in the option market to shed light on the drivers of the common effects. This study focuses on the Turkish market, but it is worthwhile to investigate whether the pattern of common effects in option order imbalance exists in other order-driven and quote-driven markets or in other emerging and developing markets.

Declaration of competing interest

We declare that there is no conflict of interest to disclose.

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