ISE WARRANTS ARBITRAGE OPPORTUNITIES

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- Arbitrage opportunities arising from intra-day price movements ,as well as the risks in terms of warrant seller (market-maker), portfolio constructions in to neutralize the risks of threads.
- The compliance with efficient market hypothesis is tested using intra-day data.
- The model constructed refers to the concept the lower boundary condition which is one of the main components of option theory.

Warrant and ISE I

Warrants, which traded for a long time in developed international markets, became operational with the cooperation of Istanbul Stock Exchange and Deutsche Bank in 2010.

What is Warrant? I

- Warrant is a security giving the holder the right to buy a pre-determined amount of stock at some specified future date at a specified price.
- The warrants, similar to options have call and put warrants.
- There are also European and American type of warrants and they can be issued as vanilla types, or exotic types.
- All warrants have been issued as plain (vanilla) type in Istanbul Stock Exchange, and they directly depend on the price movement of underlying securities.
- The first warrants issued and traded in Istanbul Stock Exchange have a 1:1 leverage ratio, while different leverage ratios are quite common in several markets. Since 2011 index warrants are called as mini-contracts which can be issued with 1:5 leverage ratio.

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- q, Dividend

Features I

- Warrants are securitized option contracts and can be traded following their issuance and listing.
  - Warrants are traded in secondary market and its exchanges are settled like other securities.
  - However, it is not a capital market product which provides capital to its issuer; warrants are completely under the responsibility of the issuer.
- Maturity of warrants can not be less than two months and can not exceed five years.
- Warrants can be issued by different institutions having similar specifications, for the same stock. There may be more than one warrant issuer for basket or ISE index.
- The warrants in terms of issuer, underlying asset, maturity, price and type of processing (providing the right to buy or sell) are similar are treated in the same line.

Features II

- Three types of short code is identified for the warrants which run on the ISE warrant market:
  - Short code on the shares warrants
  - Short code on the basket warrants
  - Short codeon the index warrants
- The first two letters of the code, which consists of a total of seven letters, represents the underlying asset, the issuer is represented by the third letter, fourth and fifth characters determines the warrant property. V is fixed as the sixth character represents the warrant. The seventh character has been left blank. If the fourth and fifth characters are in the range of A to O then the warrant is call warrant; if the characters in the range of P to Z then the warrant is put warrant.

An Example

GADAA:V

Expansion of the stock-based warrant which its short code GADAA:V and long code **GARAN C 311210 0008.00 DBL 001:001NA**, are as follows:

- Underlying asset: GARAN.E

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- Settlement: Cash
- Type: Europe

Black Scholes Model, Warrant Issuer

Among the most common pricing models are used in the warrants, the first one is Black & Scholes:

$$c = Se^{-qT}N(d_1) - Ke^{-rT}N(d_2)$$
$$p = Ke^{-rT}N(-d_2) - Se^{-qT}\left[1 - N(d_1)\right]$$

$$d_1 = \frac{log(S_t/K) + \left(r - q + 0.5\sigma^2\right)\tau}{\sigma\sqrt{\tau}}$$
$$d_2 = d_1 - \sigma\sqrt{\tau}$$

Improving Black Scholes Model, The Warrants Issued by Companies

Foreign companies whose shares traded on other countries' stock exchanges are able to issue warrants. In this case, the following changes proposed for the BS model (Lauterbach and Schultz, 1990) in the previous slide:

- Share price, S, replace the value with $S + \frac{M}{N} W$
- Volatility in the value of σ, should be considered as volatility of $S + \frac{M}{N} W$
- The result should be multiplied with $\frac{N}{M+N}$

W Price of warrant, N outstanding shares, M number of warrants.

Calculation of Leverage

Exploiting the advantage of the leverage effect of warrants to get higher returns and avoiding risks through warrants are the most important issues for the investors to prefer investing in warrants. The leverage of warrants can be calculated by the following formula:

Leverage

$$L_c = e^{-qT} N(d_1) \frac{S}{c}$$

$$L_p = e^{-qT} N(-d_1) \frac{S}{p}$$

Data

In this study, three stock based and ISE-30 index based warrants, which are issued by Deutsche bank in 2010, are used.

Table: 1

		Underlying Asset			
Type	**Data**	**GARAN**	**ISCTR**	**KCHOL**	**XU030**
CALL	Total Volume (TRL)	35.819.567	28.346.883	1.055.512	14.495.248
	Total Data Amount	14.643	13.369	1.289	20.948
PUT	Total Volume (TRL)	79.725.458	33.077.940	19.096.073	120.348.855
	Total Data Amount	13.376	8.672	9.591	50.526
General Total Volume (TRL)		115.545.025	61.424.823	20.151.585	134.844.103
General Total Data Amount		28.019	22.041	10.880	71.474

Table: 2

Kod	Underlying Asset	First Transaction	Time to Maturity	Type	Exercise Price	Data Amount	Volume
OZDPP	XU030	13.08.2010	31.12.2010	PUT	75000	37387	96.284.105
OZDPR	XU030	12.10.2010	28.02.2011	PUT	85000	13139	24.064.750
OZDAA	XU030	13.08.2010	31.12.2010	CALL	77500	18433	10.151.238
OZDAC	XU030	20.08.2010	28.02.2011	CALL	72500	2515	4.344.010
KCDPR	KCHOL	12.10.2010	28.02.2011	PUT	7	3459	9.576.135
KCDPP	KCHOL	20.08.2010	31.12.2010	PUT	5,5	6132	9.519.938
KCDAB	KCHOL	20.08.2010	28.02.2011	CALL	6,1	756	681.419
KCDAA	KCHOL	20.08.2010	31.12.2010	CALL	5,7	533	374.093
ISDPP	ISCTR	20.08.2010	31.12.2010	PUT	5,25	7271	27.233.132
ISDAB	ISCTR	20.08.2010	28.02.2011	CALL	6	7271	18.584.830
ISDAA	ISCTR	20.08.2010	31.12.2010	CALL	5,5	6098	9.762.053
ISDPR	ISCTR	12.10.2010	28.02.2011	PUT	6,3	1401	5.844.808
GADPP	GARAN	13.08.2010	31.12.2010	PUT	7,5	9603	60.525.692
GADAA	GARAN	13.08.2010	31.12.2010	CALL	8	12854	31.926.655
GADPR	GARAN	12.10.2010	28.02.2011	PUT	8,5	3773	19.199.766
GADAB	GARAN	20.08.2010	28.02.2011	CALL	7,25	1789	3.892.912

Descriptive Statistics

Table: 3

	Average	S.Deviation	Skewness	Kurtosis	Maximum	Minimum
OZDAA.V	-0,001	0,118	-0,459	1,124	0,343	-0,313
XU030	0,001	0,014	-0,423	0,725	0,037	-0,036
OZDAC.V	-0,014	0,118	-2,045	9,201	0,21	-0,683
XU030	0	0,016	-0,011	0,068	0,041	-0,037
OZDPP.V	-0,056	0,196	-0,24	1,333	0,433	-0,693
XU030	0,001	0,014	-0,421	0,79	0,037	-0,036
OZDPR.V	0,012	0,129	0,266	-0,351	0,304	-0,284
XU030	-0,002	0,015	-0,157	-0,119	0,037	-0,036
GADAA.V	-0,037	0,225	-4,588	32,43	0,313	-1,705
GARAN	0,001	0,021	-0,114	-0,367	0,057	-0,046
GADAB.V	-0,036	0,195	-2,816	14,876	0,444	-1,253
GARAN	0	0,023	-0,076	-0,315	0,057	-0,054
GADPP.V	-0,041	0,157	-0,356	1,137	0,368	-0,56
GARAN	0,001	0,021	-0,113	-0,338	0,057	-0,046
GADPR.V	0,01	0,109	-0,292	0,303	0,228	-0,335
GARAN	-0,003	0,022	0,14	-0,185	0,057	-0,046

Table: 3, Cont.

	Average	S.Deviation	Skewness	Kurtosis	Maximum	Minimum
ISDAA.V	-0,041	0,196	-3,638	21,236	0,22	-1,299
ISCTR	0	0,02	-0,464	1,165	0,041	-0,062
ISDAB.V	-0,041	0,154	-0,578	4,625	0,47	-0,693
ISCTR	-0,001	0,023	0,587	2,833	0,094	-0,062
ISDPP.V	-0,035	0,174	-0,036	0,842	0,442	-0,511
ISCTR	0	0,019	-0,64	1,699	0,041	-0,062
ISDPR.V	0,014	0,099	0,328	0,151	0,316	-0,234
ISCTR	-0,003	0,021	-0,065	0,538	0,057	-0,062
KCDAA.V	0,019	0,104	0,29	3,301	0,377	-0,288
KCHOL	0,005	0,027	1,348	5,131	0,113	-0,045
KCDAB.V	-0,004	0,126	-0,327	1,588	0,382	-0,381
KCHOL	0,001	0,021	-0,104	0,308	0,053	-0,055
KCDPP.V	-0,045	0,161	-0,857	3,866	0,405	-0,693
KCHOL	0,003	0,016	-0,14	0,963	0,049	-0,045
KCDPR.V	-0,003	0,179	0,081	1,721	0,531	-0,616
KCHOL	-0,001	0,019	-0,355	0,637	0,052	-0,055

Efficient Market Hypothesis Test Findings

- The basic point of departure for the study is the discussion of the level of significance of the information obtained from various models for these new and popular products.
- Data is analysed based on the of efficient markets hypothesis (Fama, 1970). Efficient market hypothesis, was carried out using the method lower boundary described in the article of Black and Scholes (1973).
- The formula for this method are as follows:

$$C_{min} = max(S - Ke^{-rt}; 0)$$
$$P_{min} = max(Ke^{-rt} - S; 0)$$

Following the analysis warrants violations for efficient markets hypothesis has been detected only in index based warrants and it is showed in table-4.

Table: 4

Time	Warrant	Price	Amount	Index	VKG	Min Value	Percentage
11.10.2010 14:27	OZDAA	11.210	1	87385,6	80	11239,246	0,26%
13.10.2010 10:08	OZDAA	13.130	1	89314,6	79	13137,919	0,06%
13.10.2010 10:11	OZDAA	13.000	124	89179,9	79	13003,191	0,03%
13.10.2010 10:18	OZDAA	12.960	10	89325,2	79	13148,358	1,43%
13.10.2010 10:25	OZDAA	13.090	70	89333,7	79	13156,84	0,51%
13.10.2010 11:30	OZDAA	13.160	69	89451,6	79	13273,926	0,86%
13.10.2010 12:01	OZDAA	13.550	63	89738,3	78	13560,306	0,08%
14.10.2010 09:59	OZDAA	13.960	20	90177,9	78	13984,6	0,18%
14.10.2010 10:11	OZDAA	14.220	130	90541,1	78	14347,722	0,89%
14.10.2010 10:12	OZDAA	14.220	10	90496,9	78	14303,43	0,58%
14.10.2010 10:12	OZDAA	14.220	50	90514,6	78	14321,137	0,71%
14.10.2010 10:20	OZDAA	14.180	35	90490,5	78	14297,005	0,82%
14.10.2010 10:20	OZDAA	14.180	250	90492,9	78	14299,332	0,84%
14.10.2010 10:24	OZDAA	14.310	10	90616,9	78	14423,289	0,79%
14.10.2010 10:31	OZDAA	14.110	35	90469,5	78	14275,841	1,16%
14.10.2010 10:31	OZDAA	14.110	1100	90469,5	78	14275,841	1,16%
14.10.2010 10:32	OZDAA	14.030	35	90380,4	78	14186,748	1,11%
14.10.2010 10:39	OZDAA	13.980	35	90307,5	78	14113,764	0,95%

Table: 4, Cont.

Time	Warrant	Price	Amount	Index	VKG	Min Value	Percentage
14.10.2010 10:48	OZDAA	14.070	10	90406,7	78	14212,886	1,01%
14.10.2010 10:55	OZDAA	14.030	12	90467,9	78	14273,984	1,71%
14.10.2010 11:03	OZDAA	13.980	1	90176,3	78	13982,301	0,02%
18.10.2010 15:34	OZDAA	13.420	5	89740,6	73	13476,611	0,42%
18.10.2010 15:35	OZDAA	13.470	100	89749,6	73	13485,565	0,12%
28.12.2010 09:59	OZDAA	4.970	259	82436,8	3	4980,6899	0,22%
28.12.2010 15:34	OZDAA	4.130	15	81606,5	2	4146,4542	0,40%
28.12.2010 15:43	OZDAA	4.270	103	81751,5	2	4291,3091	0,50%
28.12.2010 15:53	OZDAA	4.360	103	81859	2	4398,6849	0,88%
28.12.2010 16:01	OZDAA	4.450	10	81930,8	2	4470,3553	0,46%
28.12.2010 16:01	OZDAA	4.450	46	81925,8	2	4465,4037	0,35%
13.10.2010 09:53	OZDAC	19.190	50	89697,3	138	19350,992	0,83%
13.10.2010 10:02	OZDAC	19.060	40	89737,7	138	19391,287	1,71%
13.10.2010 10:02	OZDAC	19.060	9	89808,4	138	19461,966	2,07%
13.10.2010 10:03	OZDAC	19.010	5	89602,9	138	19256,458	1,28%
13.10.2010 10:11	OZDAC	18.750	3	89237,1	138	18890,637	0,74%
13.10.2010 11:40	OZDAC	19.150	50	89519,6	138	19172,167	0,12%
14.10.2010 09:52	OZDAC	19.780	20	90228,7	137	19866,966	0,44%

Findings-Evaluation

- Based on the results the arbitrage opportunities are occured in very limited periods of time and creating an active arbitrage portfolio does not seem appropriate for a risk-free profit.
- Violations can be seen from Table-4, only for the index based warrants for very short durations and low volumes realized.
- Arbitrage opportunities that are arised by call warrant, evaluated within the moneyness criteria with respect to definition of Cox and Rubinstein and shown in Table-5. According to the table among 36 intrinsic value, 7 data in the money and the rest were observed as deep in the money.

Table: 5

Spot/Exercise price				
0,75-0,85	0,85-0,95	0,95-1,05	1,05-1,15	>1,15
Deep Out of the Money	Out of the Money	At the Money	In the Money	Deep In the Money

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- Any arbitrage opportunity is not detected for stock based call warrants. Yet, these warrants meet with much more demand from investors with respect to index based warrants and stay above of the minimum value.
- There is no violation with respect to efficient markets hypothesis in terms of index based and stock based put warrants.

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  - Calculations are realized for 10.000 long warrant.
  - Transaction commissions are assumed as 2bps.

Findings of Delta-Hedge Strategy

The findings are summarized in Table 6.

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- OZDAA warrant had 14, and OZDAC warrant had 4 points of time for a profit.

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- OZDPP warrant had a total of 209 points,
- OZDPR warrant had a total of 13055 points,
- OZDAA warrant had 14, and OZDAC warrant had 4 points of time for a profit.
- While OZDPR warrant has the highest profit potential among all warrants, OZDAC warrant has the highest loss potential.

Table: 6

VARANT	Tip	Vade	Strike	En Yüksek Kar	En Yüksek Zarar	Karda Olunan Fiyat	Toplam Veri Sayysy
OZDPP	P	31.12.2010	75000	2.351	-22.312	209	37387
OZDPR	P	28.02.2011	85000	10.345	-869	13055	13139
OZDAA	C	31.12.2010	77500	925	-46.019	14	18433
OZDAC	C	28.02.2011	72500	5.318	-51.602	4	2515

Stable Volatility Delta Protection - Portfolio Substitution

- In this part of the study, portfolio substitution is constructed by calculating implied volatility through high frequency data.
- As summarized in Table 7 to be invested equally in all the portfolios are likely to profit at a certain point, but ratio of profits to losses is low.
- Hence, the investor have a very limited profit even, where he/she makes a delta-hedge the amount of loss is more frequent could be even higher.
- The above lines have dealt with in terms of the investor can consider the situation in the opposite direction in terms of the issuer. The issuer, clearly has an advantage against investors.

Delta Protection with Low Frequency Data

- Alongside high frequency data, portfolio substitution is realized by using closing prices.
- Closing datas are provided from the firm FİNNET.
- At the analysis which contains daily datas, it is assumed that the transaction price occurred from the closure of the first trading day. The implied volatility which is calculated according to this value has been kept constant during the process in order to stick with the classic argument of BS.
- Results are summarized in Table 7.

Table: 7

WARRANT	Premium	Delta P/L	Amortization P/L	Expiration Date Without Delta Protection Total P/L	With Delta Protection Expiration Date Total P/L	Highest Profit	Highest Loss	Average Profit/Loss	Beginning Volatility	Realized Volatility
KCDPR	-4.400	1.475	3.000	-1.400	75	1.008	-238	403	34,46%	30,29%
KCDPP	-3.900	2.814	-	-3.900	-1.086	24	-1.087	-725	47,07%	25,77%
KCDAB	-7.300	-2.429	6.000	-1.300	-3.729	-56	-4.966	-2.486	41,17%	33,80%
KCDAA	-7.800	-9.403	18.200	10.400	997	3.156	-1.033	587	41,83%	43,27%
ISDPR	-3.600	-8.862	13.200	9.600	738	1.632	-263	663	38,04%	33,46%
ISDPP	-4.200	2.107	-	-4.200	-2.093	477	-2.093	-765	48,85%	29,83%
ISDAB	-6.500	3.000	-	-6.500	-3.500	-202	-3.401	-2.365	45,53%	36,00%
ISDAA	-7.500	-112	-	-7.500	-7.612	-1	-7.613	-2.558	48,66%	31,97%
GADPR	-5.500	-8.633	14.200	8.700	67	1.858	-33	717	37,53%	35,02%
GADPP	-9.300	6.604	-	-9.300	-2.696	59	-2.696	-849	49,30%	33,80%
GADAB	-11.500	5.113	-	-11.500	-6.387	40	-5.660	-2.806	48,18%	36,47%
GADAA	-5.800	481	-	-5.800	-5.319	-215	-4.967	-2.276	46,04%	33,98%

Delta Protection with Stock Based Warrants

- At the analysis which is completed by the use of stocks, one of the factors that we ignored is ability for borrowing and its cost.
- It can not be easy to find stocks for short-sell, the cost may not be satisfactory.
- To eliminate the problem, with the use of the betas of the stocks. A replicating portfolio can be constructed as follows:

$$VK = \beta \frac{\Delta S V_p}{F}$$

VK, number of future contracts, β, beta coefficient, S, spot price of stock, V_p nominal amount of warrant portfolio, F price of future contract.

Delta Protection with VIS -Results

The delta protection results with the use of VIS on stock based warrants are shown in Table-8.

Table: 8

				Expiration Date	With Delta Protection								
WARRANT	Premium	Delta P/L	Amortization P/L	Without Delta Protection Total P/L	Expiration Date Total P/L	Highest Profit	Highest Loss	Average P/L	Beginning Volatility	Volatility Stock	Realized Volatility Index	Correlation	R^2
KCDPR	-4.400	-3.589	3.000		-4.989	980	-3.836	-1.923	34,46%	30,29%	23,87%	64,92%	42,10%
KCDPP	-3.900	2.220	-	-1.400	-1.680	-21	-1.681	-1.180	47,07%	25,77%	22,70%	66,30%	44,00%
KCDAB	-7.300	4.761	6.000	-3.900	3.461	8.112	-3.752	2.990	41,17%	33,80%	27,69%	66,04%	43,60%
KCDAA	-7.800	-2.738	18.200	-1.300	7.662	10.184	-375	4.351	41,83%	43,27%	42,67%	85,25%	72,70%
ISDPR	-3.600	-7.181	13.200	10.400	2.419	5.536	-219	2.470	38,04%	33,46%	24,76%	90,67%	82,20%
ISDPP	-4.200	3.247	-	9.600	-953	1.043	-953	-101	48,85%	29,83%	22,35%	88,23%	77,80%
ISDAB	-6.500	-2.157	-	-4.200	-8.657	-542	-8.558	-5.883	45,53%	36,00%	28,03%	92,29%	85,20%
ISDAA	-7.500	-3.235	-	-6.500	-10.735	-303	-10.735	-4.188	48,66%	31,97%	24,02%	88,76%	78,80%
GADPR	-5.500	-9.331	14.200	-7.500	-631	3.314	-737	1.465	37,53%	35,02%	24,04%	90,05%	81,10%
GADPP	-9.300	6.270	-	8.700	-3.030	184	-3.030	-1.194	49,30%	33,80%	21,76%	86,56%	74,90%
GADAB	-11.500	2.580	-	-9.300	-8.920	1.403	-10.084	-4.960	48,18%	36,47%	24,43%	88,30%	78,00%
GADAA	-5.800	-3.386	-	-11.500	-9.186	1.016	-8.848	-3.615	46,04%	33,98%	21,92%	86,43%	74,70%
OZDPR	-32.201	-65.904	103.479	-5.800	5.374	14.320	-430	8.284	25,72%		24,04%		
OZDPP	-56.823	41.291	-	-56.823	-15.532	25.743	-23.395	-1.949	35,80%		26,25%		
OZDAC	-92.705	29.424	21.521	-71.184	-41.760	-934	-42.202	-22.216	31,42%		25,60%		
OZDAA	-48.309	-22.621	38.381	-9.928	-32.549	-607	-32.269	-17.808	30,10%		22,01%		

Calculation of Theoretical Advantage, GARCH(1,1)

- For the relationship between initial volatilities and real calculated volatilities and to understand being over/under, the volatility is calculated by GARCH(1,1).
- If the initial volatility is less than the volatility found by GARCH(1,1) theoretical advantage can be mentioned, otherwise theoretical advantage may not be valid.
- Parameters of GARCH(1,1) are shown in Table-9. The graphs of the volatility, which is calculated with GARCH(1,1), and underlying asset are stated in Annex 2.

GARCH(1,1) Parameters

Table: 9

Volatility Model	XU030	GARAN	ISCTR	KCHOL
GARCH:				
Volatility	24,70%	37,60%	34,10%	29,80%
Long term forecast	34,20%	48,00%	45,60%	41,50%
Exponential Weighted - EWMA	23,10%	34,80%	31,20%	25,40%
Equally weighted Closure-Closure	33,60%	47,50%	46,00%	41,40%
Sample				
Numer of Observation	2.004	2.004	2.004	1.998
Frequency	Daily	Daily	Daily	Daily
The first sampling date	02-Jan-03	02-Jan-03	02-Jan-03	02-Jan-03
The last sampling date	31-Dec-10	31-Dec-10	31-Dec-10	31-Dec-10
Last price	81338,13	7,69	5,33	7,31
SKEW	-0,1	-0,07	0,03	-0,03
Excess kurtosis	3,64	2,75	2,69	3,39
EWMA correction	0,94	0,97	0,95	0,95
Constant (λ=lambda)				
GARCH Parameters:				
ω	1,21E-05	1,11E-05	3,64E-05	4,41E-05
α	0,086	0,043	0,077	0,097
β	0,888	0,945	0,879	0,838

Results and Discussion I

- This study was conducted under the assumption that the absence of any study on this subject, with Turkish data is thought to contribute to the literature.
- The basic point of departure for the study is the discussion of the level of significance of the information obtained from various models for these new and popular products. By using EMH (Fama, 1970) analysis of all available data is made.
- According to the results no significant profit opportunity is available.
- During the dynamic delta protection, the severity and the frequency of the fluctuation on underlying asset can be rise possibility to get profit.

Results and Discussion II

- Under the assumption that warrant delta protection is used by both buyer and seller the total value of the game think of it as a zero or near zero. The issuer, against clearly advantageous to investors.
- In this study, as well as high-frequency data, the replacement has started as portfolios using daily data. All warrants for a period of maturity are examined, and 8 of them potential profit created by passing the land. Significant profit potential in creating profitable warrants ($>$ 200TL) as the number of observations drops to 5.
- For the relationship between initial volatilities and real calculated volatilities and to understand being over/under, the volatility is calculated by GARCH(1,1). According to the result of the analysis in terms of initial volatility and realized volatility, among all warrants just KCDAA has higher realized volatility compare to its initial volatility.

Results and Discussion III

- Because the study covers the warrants issued in ISE, in the context of advanced practice, the studies about the comparison of warrants and OTC options can be done. In addition the differences with exchange markets can be explored.