Ayhan Kapusuzoglu[1]

EMPIRICAL TESTING OF THE SAMUELSON HYPOTHESIS: APPLICATION TO FUTURES MARKET IN TURKEY

The aim of this study is to test whether the Samuelson hypothesis is valid, which proposes that volatility increases as the time to maturity approaches in terms of futures contracts that are traded as based on Istanbul Stock Exchange National 100 Index (ISE 100) in Turkish Derivatives Exchange (TURKDEX). As a result of the conducted analyses, it was found that only 17% of ISE 100 futures contracts supported the Samuelson hypothesis, and the rest 83% of those contracts did not support a relevant hypothesis. In the light of these findings, it can be argued that the Samuelson hypothesis is not valid in terms of futures contracts, which are traded as based on Istanbul Stock Exchange National 100 Index, in other words, its maturity effect does not exist.

Keywords: *Samuelson hypothesis, volatility, futures contract, TURKDEX, ISE 100.*

Айхан Капушуоглу

ЕМПІРИЧНА ПЕРЕВІРКА ГІПОТЕЗИ САМУЕЛЬСОНА СТОСОВНО РИНКУ Ф'ЮЧЕРСІВ У ТУРЕЧЧИНІ

У статті протестовано гіпотезу Самуельсона, згідно з якою волатільність ринку зростає при його переході на стадію зрілості. Гіпотеза застосована до ф'ючерсів 100 кращих компанійСтамбульської фондової біржі і Турецької біржі цінних паперів. Згідно з результатами аналізу, лише 17% ф'ючерсних контрактів відповідають гіпотезі Самуельсона, інші 83% контрактів протирічать даній гіпотезі. Грунтуючись на отриманих результатах, автор робить висновок, що гіпотеза Самуельсона незастосовна до ф'ючерсів наСтамбульській фондовій біржі.

Ключові слова: *гіпотеза Самуельсона; волатильність; ф'ючерсний контракт; TURKDEX; ISE 100.*

Айхан Капушуоглу

ЭМПИРИЧЕСКАЯ ПРОВЕРКА ГИПОТЕЗЫ САМУЭЛЬСОНА ПРИМЕНИТЕЛЬНО К РЫНКУ ФЬЮЧЕРСОВ В ТУРЦИИ

В статье протестирована гипотеза Самуэльсона, согласно которой волатильность рынка возрастает при его переходе на стадию зрелости. Гипотеза применена к фьючерсам 100 лучших компаний Стамбульской фондовой биржи и Турецкой биржи ценных бумаг. Согласно результатам анализа, только 17% фьючерсных контрактов отвечают гипотезе Самуэльсона, остальные 83% контрактов противоречат данной гипотезе. Основываясь на полученных результатах, автор делает вывод, что гипотеза Самуэльсона неприменима к рынку фьючерсов на Стамбульской фондовой бирже.

Ключевые слова: *гипотеза Самуэльсона; волатильность; фьючерсный контракт; TURKDEX; ISE 100.*

1. Introduction. Investigating time pattern of futures price volatility has become one of the most important study areas in futures exchanges. The relationship between volatility and time to maturity for futures prices was first set theoretically by

[1] Assistant Professor, Faculty of Management, Department of Banking and Finance,Yildirim Beyazit University, Ankara, Turkey

Samuelson (1965). In this relationship termed as the Samuelson hypothesis or maturity effect in the relevant literature, it is postulated that the volatility level for the prices of futures contracts should increase as expiration approaches and this relationship is based on the assumption that futures prices and the expected futures spot prices would be equal. The increase in volatility level near expiration is attributed to the increase in futures price variance. Therefore, futures price highly reacts to the ensuing information flow. Thus, the possible profit level to be obtained could be increased because profit level is a positive function of futures price volatility.

Samuelson (1965) argued that spot prices follow the stationary autoregressive method; futures prices are the prices expected in futures contract maturity; and futures price volatility is a negative function of the time to maturity. This means that as a futures contract gets closer to expiration, or in other words, the less the time to maturity, the higher the futures price volatility is. Thus, he claimed that as the expiry date gets closer, more information or news will be obtained about the future, with greater sensitivity to information flow that influences futures prices (Chandra, 2006).

Board and Sutclife (1990) noted that maturity/volatility relationship is important in three respects. First, it is important in margin arrangements since margin calls are related to futures price volatility; so if futures price volatility increases as the contract maturity gets closer, as is postulated in the Samuelson hypothesis, then cash balance should be stabilized to meet margin cost.

Secondly, they argued that the relationship between volatility and time to maturity is significant for hedging strategies, and depending on whether this relationship is positive or negative, hedgers will have to select futures contracts with short or long time to their expiry dates in order to minimize price volatility. For the Samuelson hypothesis to be valid, they noted that traders will consider exchanging contracts with those that are more distant to expiration; otherwise, they would face high volatility and the need for high risk premium.

Finally, they also stated that the volatility of an asset in a contract is a significant input for option pricing and the volatility/maturity relationship needs to be considered in pricing of futures options. They noted that high volatility for an asset in a contract will yield high-potential returns, which means an increase in prices of futures options if the Samuelson hypothesis applies, and will force option dealers to pay for the risk (Duong and Kalev, 2008).

Presenting a new interpretation of maturity effect, Anderson and Danthie (1983) proposed the state variable hypothesis, in which time to maturity falls short of defining volatility and instead, information flow into the market should be considered. A great deal of information flow will result in expanded volatility, and if this flow of information can eliminate the uncertainties for a futures contract, then volatility will also rise within the life cycle of a contract (Verma and Kumar, 2010).

Bessembinder et al. (1996) developed a model of economic analysis to demonstrate why maturity effect applies to some markets and does not apply to others. Also called negative covariance or BCCS hypothesis, this model assumes that maturity effect results from the negative covariance between the changes in spot prices and net carry cost, and that maturity effect is high in real assets and low in financial futures contracts. This hypothesis was confirmed by the results obtained by Bessembinder et al. (1996) and Duong and Kalev (2008). On the other hand, the results of Daal et al. (2006) offer weak evidence for the validity of this hypothesis (Gurrola and Herrerias, 2010).

In order to demonstrate the relationship between maturity and volatility for the contracts traded in the National-100 Index at the Turkish Derivatives Exchange, the present study analyzes the presence of the Samuelson (maturity effect) hypothesis in 46 futures contracts traded in the ISE National-100 Index at the Turkish Derivatives Exchange for the period between 2005 and 2010. Thus, the second part of the study presents the results of other relevant studies, the third part discusses the data set and the methodology used in the analysis process, and the fourth part deals with the analysis results obtained. The final part presents the evaluation of the obtained results.

2. Literature Review. The empirical literature contains numerous studies examining the presence of the Samuelson hypothesis (maturity effect) with different findings. Most of these studies concluded that the Samuelson hypothesis applies more to the agricultural futures market than to other markets (Duong and Kalev, 2008). One of the first studies to examine the effects on futures prices was conducted by Segall (1956), who argued that the interest rate factor is effective on futures prices but speculative effects and uncertainties also have significant impacts.

Moosa and Bollen (2001) provided some evidence of the maturity effect in futures contracts. Volatility in futures contracts usually increases as the time to maturity draws nearer because a greater information flow causes high price fluctuations. This approach holds that increased level of information results in increased volatility. The authors presented two conclusions about the hypothesis of maturity effect in futures contracts. First, periodicity is more important in agricultural futures contracts than maturity. Secondly, maturity effect plays a significant role in revealing the volatility in commodities futures contracts (Floros and Vougas, 2006).

Rutledge (1976) investigated the presence of maturity effect in futures contracts traded for cocoa, silver, wheat and soy oil. The study provided evidence that maturity does not have an effect in the contracts for soy oil and wheat, but maturity effect applies to contracts for silver and cocoa. Dusak-Miller (1979), on the other hand, investigated maturity effect for livestock cattle futures and observed that the Samuelson hypothesis was valid.

Grammatikos and Saunders (1986) carried out a study on maturity effect in foreign exchange futures contracts, but found no evidence for the validity of this hypothesis. Castelino and Francis (1982) examined whether maturity effect applies to wheat, corn, soybean, soybean meals, soy oil and copper futures contracts, and most of their findings demonstrated the validity of the hypothesis. In their study, Barnhill et al. (1987) provided some support for maturity effect in financial futures contracts for the US treasury bonds.

Using the data they obtained from 11 futures markets, Bassembinder et al. (1996) concluded in their study that agricultural and crude oil futures contracts strongly supported the Samuelson hypothesis; metal futures contracts provided less support; and financial futures contracts did not support the Samuelson hypothesis. In their study, Galloway and Kolb (1996) investigated the presence of maturity effect in 45 commodities futures contracts. The researchers found that the maturity effect applied to all agricultural, energy, and copper contracts, but did not have a significant effect in contracts for valuable metals.

Investigating the validity of the Samuelson hypothesis in futures contracts based on the NIKKEI 225 index, Chen et al. (1999) provided support for the fact that volatility is reduced with closer time to maturity. Daigler and Wiley (1999) demonstrated by their research that volatility in financial futures markets increases as the result of participation of ordinary investors and decreases due to participation of stock market experts, which they attributed to the fact that stock market experts interpret market signals much better than ordinary investors and thus take better positions.

In their study, Adrangi et al. (2001) examined the presence of maturity effect. As a result, they obtained supporting evidence for the Samuelson hypothesis in crude oil, fuel oil, and gas oil contracts. Investigating the maturity effect for 61 commodities, Daal et al. (2003) revealed the maturity effect at various levels in energy, agricultural, metal, interest, and index futures contracts, an effect which was shown to be the highest in energy futures contracts. Pati (2006) investigated the presence of maturity effect in Indian Futures Exchange and found no evidence for maturity effect, or the Samuelson hypothesis.

In their study, Duong and Kalev (2008) examined the presence of the Samuelson hypothesis in 6 different futures markets for 20 industries. As a result, they obtained strong evidence for the validity of the hypothesis in agricultural futures contracts, but found no evidence in other industries. Ripple and Maosa (2009) investigated whether the Samuelson hypothesis applies to crude oil futures contracts traded at the New York Mercantile Exchange. Their findings supported the presence of the Samuelson hypothesis, particularly revealing that trading volume levels play a significant role. In a study investigating the presence of the maturity effect in the ISE, Gok (2009) found very little support for the Samuelson hypothesis; in other words, the study concluded that a very small increase is observed in volatility as the time to maturity gets closer.

3. Data Set and Methodology. The data set used in this study covers the period between December 2005 and November 2010 and consists of 46 futures contracts traded on the basis of ISE 100-Istanbul Stock Exchange within the Turkish Derivatives Exchange (TURKDEX). Based on the day-end settlement prices and times to maturity for futures contracts, a total of 1270 cases were analyzed by the regression method. The data used in the analysis were retrieved from the Data Center of Turkish Derivatives Exchange (http://www.vob.org.tr).

Linear regression analysis was based on the day-end settlement prices for each contract at TURKDEX, and volatility was calculated by the following formula. In the formulation, (Vol_t) is volatility on day t, ($ln\ P_t$) is the natural logarithm of the settlement price on day t, and ($ln\ P_{t-1}$) is the natural logarithm of the day-end settlement price on day $t-1$:

$$Vol_t = ln\ P_t - ln\ P_{t-1} * 100 \qquad (1)$$

The regression equation used to measure maturity effect is presented below, where (Vol_t) is volatility on day t, α is the constant, $ln\ D_t$ is the natural logarithm of the number of days to maturity, and ε_t is the error term:

$$Vol_t = \alpha + \beta\ ln\ D_t + \varepsilon_t \qquad (2)$$

This equation assumes that there is maturity effect in contracts whose constant is positive and significantly different from zero, and β coefficient is negative and significantly different from zero. T-test was used to demonstrate that the constant and β-coefficient are significantly different from zero, and regression analyses were performed for each futures contract.

4. Empirical Findings. Table 1-a and Table 1-b (see appendix) present the findings obtained in the regression analysis. According to the analysis results given in Table 1-a and Table 1-b, the findings about the futures contracts traded on the basis of the ISE National-100 index at the Turkish Derivatives Exchange revealed that among 46 futures contracts, there are 21 contracts whose constant (α) is positive and significantly different from zero (June 2006, October 2006, December 2006, February 2007, April 2007, August 2007, October 2007, June 2008, July 2008, January 2009, April 2009, July 2009, August 2009, October 2009, February 2010, April 2010, May 2010, June 2010, August 2010, October 2010 and November 2010), which account for 45.60% of all the futures contracts.

In the view of the maturity coefficient (β) values for the futures contracts, the maturity coefficient assumed a negative value in the total of 22 contracts (June 2006, August 2006, October 2006, December 2006, February 2007, April 2007, August 2007, October 2007, May 2008, June 2008, July 2008, October 2008, November 2008, January 2009, April 2009, July 2009, October 2009, February 2010, April 2010, August 2010, October 2010 and November 2010), which account for 47.82% of all the futures contracts. Within these 22, the maturity coefficient is both negative and significantly different from zero in 8 contracts (October 2006, December 2006, February 2007, April 2007, August 2007, June 2008, July 2008 and October 2009), which account for 17% of all the futures contracts.

As it is shown by the examination of the significance of the overall model, there are 8 futures contracts in total which meet both the requirements of $\alpha>0$ and $\beta<0$, which again account for 17% of all the futures contracts. In the light of these results, the hypothesis postulating that volatility increases with decreasing time to maturity is supported by 17% of the ISE National-100 futures contracts, and not supported by 83%.

5. Conclusion. Using the regression method, the present study analyzed the validity of the Samuelson hypothesis (maturity effect) in 46 futures contracts traded on the basis of the Istanbul Stock Exchange (ISE) National-100 index at the Turkish Derivatives Exchange during the period between 2005 and 2010. The analyses performed for each contract revealed the presence of maturity effect in the financial futures contracts dated October 2006, December 2006, February 2007, April 2007, August 2007, June 2008, July 2008 and October 2008; meaning that they met the requirements of $\alpha>0$ and $\beta<0$; and that maturity does not have any effect in the remaining 38 contracts, meaning that they did not meet the requirements of $\alpha>0$ and $\beta<0$. The result obtained for these 8 contracts accounts for 17% of all the contracts, while the result concerning the remaining 38 contracts accounts for 83%.

The obtained results demonstrate that there is no strong and inverse relationship between volatility and time to maturity in the contracts traded within the ISE National-100 index at the Turkish Derivatives Exchange in Izmir, meaning that these contracts do not support the Samuelson hypothesis (83%), and that there was a very small increase in volatility with decreasing number of days to maturity in the contracts. The results obtained in the study are in parallel to the results of other studies carried out both in the ISE and in other markets (Grammatikos and Saunders, 1986; Barnhill et al., 1987; Chen et al., 1999; Adrangi et al., 2001; Pati, 2006; Gok, 2009). These findings can be helpful to risk managers dealing with Istanbul Stock Exchange National-100 Index futures.

References:

Adrangi, B., Chatrath, A., Dhanda, K. K. and Raffiee, K. (2001), Chaos in Oil Prices? Evidence from Futures Markets, Energy Economics, 23(4): 405-425.

Anderson, R. and Danthine, J. (1983). The Time Pattern of Hedging and The Volatility of Futures Prices, Review of Economic Studies, 50: 249-266.

Barnhill, T. M., Jordan, J. V. and Seal, W. E. (1987). Maturity and Refunding Effects on Treasury-Bond Futures Price Variance, Journal of Financial Research, 10: 121-131.

Bessembinder, H., Coughenour, J. F., Seguin, P. J. and Smoller, M. M. (1996). Is There a Term Structure of Futures Volatilities? Reevaluating the Samuelson Hypothesis, Journal of Derivatives, 4: 45-57.

Board, J. L. G. and Sutcliffe, C. M. S. (1990). Information, Volatility, Volume and Maturity: An Investigation of Stock Index Futures, Review of Futures Markets, 9; 532-549.

Castelino, M. G. and Francis, J. C. (1982). Basis Speculation in Commodity Futures: The Maturity Effect, Journal of Futures Markets, 2: 195-206.

Chandra, P. P. (2006). Maturity and Volume Effects on the Volatility: Evidence from NSE Nifty Futures, Available at: http://ssrn.com/abstract=962319, [Accessed June 2011].

Chen, Y. J., Duan, J. C. and Hung, M. W.(1999). Volatility and Maturity Effects in the Nikkei Index Futures, Journal of Futures Markets, 19: 895-909.

Daal, E., Farhat, J. and Wei, P. P. (2006). Does Futures Exhibit Maturity Effect? New Evidence from an Extensive Set of US and Foreign Futures Contracts, Review of Financial Economics, 15: 113-128.

Daigler, R. T. and Wiley, M. K. (1999). The Impact of Trader Type on the Futures Volatility-Volume Relation, Journal of Finance, 54(6): 2297-2316.

Duong, H. N. and Kalev, P. S. (2008). The Samuelson Hypothesis in Futures 20 Markets: An Analysis Using Intraday Data, Journal of Banking and Finance, 32(4): 489-500.

Dusak-Miller, K. (1979). The Relation between Volatility and Maturity in Futures Contracts, 1979, Leuthold, R. M. (ed.) Commodity Markets and Futures Prices, Chicago Mercantile Exchange, 25-36.

Floros, C. and Vougas, D. V. (2006). Samuelson's Hypothesis in Greek Stock Index Futures Market, Investment Management and Financial Innovations, 3(2): 154-170.

Galloway, T. M. and Kolb, R. W. (1996). Futures Prices and the Maturity Effect, Journal of Futures Markets, 7: 809-828.

Grammatikos, T. and Saunders, A. (1986). Futures Price Variability: A Test of Maturity and Volume Effects, Journal of Business, 59: 319-330.

Gok, I. Y. (2009). Testing of Validity for Samuelson Hypothesis in Futures Markets by Linear Regression and Garch Models: An Application of Turkish Derivatives Exchange, M.Sc. Thesis (Unpublished), Suleyman Demirel University, Isparta.

Gurrola, P. and Herrerias, R. (2010). Inverse Maturity Effects in Short Term Interest Rate Futures Markets, Instituto Tecnologico Autonomo de Mexico, Research and Working Papers, No: 005-10-FINM-TP.

Moosa, I. A. and Bollen, B. (2001). Is There a Maturity Effect in the Price of the S&P 500 Futures Contract?, Applied Economics Letters, 8: 693-695.

Pati, P. C. and Kumar, K. K. (2006). Maturity and Volume Effect on the Volatility: Evidences from NSE Nifty Futures, The ICFAI Journal of Derivatives Markets, 4(4): 44-63.

Ripple, R. and Moosa, I. (2009). The Effect of Maturity, Trading Volume and Open Interest on Crude Oil Futures Price Range-Based Volatility, Global Finance Journal, 20: 209-219.

Rutledge, D. J. S. (1976). A Note on the Variability of Futures Prices, Review of Economics and Statistics, 58: 120-123.

Samuelson, P. A. (1965). Proof that Properly Anticipated Prices Fluctuate Randomly", Industrial Management Review, 6: 41-49.

Segall, J. (1956). The Effect of Maturity on Price Fluctuations, Journal of Business, 29: 202-206.

Verma, A. and Kumar, C. V. R. S. V. (2010). An Examination of the Maturity Effect in the Indian Commodities Futures Market, Agricultural Economics Research Review, 23: 335-342.

Table 1-a. Regression Results of Futures Contracts

Contract	α	t	Sig	β	t	Sig.	Obs.
December 2005	0.529	1.517	0.137	0.109	0.995	0.326	41
February 2006	0.504	0.785	0.438	0.250	1.230	0.227	37
April 2006	0.678	1.185	0.243	0.151	0.846	0.402	42
June 2006	2.763**	2.455	0.018	-0.319	-0.918	0.364	43
August 2006	1.333	1.209	0.234	-0.211	-0.627	0.534	42
October 2006	3.012***	7.736	0.000	-0.798***	-6.824	0.000	39
December 2006	0.542**	2.398	0.021	-0.136*	-1.928	0.061	42
February 2007	3.147***	3.165	0.003	-0.625*	-1.991	0.054	39
April 2007	5.132***	3.771	0.001	-1.243***	-3.015	0.004	41
June 2007	-0.122	-0.113	0.910	0.341	1.021	0.313	43
August 2007	5.511***	3.472	0.001	-0.968**	-2.004	0.052	43
October 2007	2.565*	1.829	0.075	-0.290	-0.677	0.502	40
December 2007	0.747	0.571	0.571	0.283	0.716	0.478	40
February 2008	0.538	0.578	0.567	0.469	1.613	0.115	42
April 2008	0.538	0.578	0.567	0.469	1.613	0.115	42
May 2008	2.064	1.237	0.240	-0.169	-0.221	0.829	14
June 2008	3.334***	3.231	0.005	-0.765*	-1.937	0.069	20
July 2008	5.290**	2.666	0.015	-1.699**	-2.229	0.037	22
August 2008	0.062	0.091	0.929	0.349	1.263	0.223	20
September 2008	0.250	0.136	0.893	0.474	0.674	0.509	20
October 2008	5.366	1.684	0.110	-0.899	-0.715	0.484	19
November 2008	3.937	1.272	0.221	-0.178	-0.140	0.890	19
December 2008	0.623	0.388	0.703	0.586	0.918	0.372	18

*,**,*** represent the statistical significance level of 10%, 5%, 1% respectively.

Table 1-b. Regression Results of Futures Contracts

Contract	α	t	Sig.	β	t	Sig.	Obs.
January 2009	2.143*	1.842	0.082	-0.094	-0.200	0.843	20
February 2009	0.530	0.450	0.658	0.628	1.300	0.211	19
March 2009	1.239	0.795	0.436	0.078	0.131	0.897	21
April 2009	3.382***	2.976	0.008	-0.571	-1.296	0.211	20
May 2009	1.822	1.230	0.237	0.161	0.265	0.795	18
June 2009	1.356	1.587	0.129	0.012	0.035	0.972	21
July 2009	1.744**	2.267	0.035	-0.240	-0.805	0.431	22
August 2009	1.381*	1.975	0.064	0.126	0.471	0.643	20
September 2009	0.684	1.484	0.156	0.178	1.015	0.324	19
October 2009	3.049***	3.221	0.005	-0.663*	-1.812	0.087	20
November 2009	0.586	1.062	0.304	0.160	0.700	0.494	18
December 2009	0.801	1.134	0.270	0.124	0.458	0.652	22
January 2010	0.307	0.623	0.542	0.228	1.124	0.277	19
February 2010	2.137**	2.658	0.017	-0.296	-0.895	0.383	19
March 2010	0.660	1.639	0.117	0.146	0.955	0.351	22
April 2010	1.581**	2.426	0.026	-0.146	-0.572	0.574	20
May 2010	1.643*	1.986	0.063	0.072	0.227	0.823	19
June 2010	1.009**	2.210	0.040	0.008	0.046	0.964	21
July 2010	0.758	1.299	0.210	0.156	0.675	0.508	21
August 2010	1.068*	2.076	0.053	-0.134	-0.700	0.493	20
September 2010	0.676	1.301	0.211	0.009	0.042	0.967	19
October 2010	1.829**	2.613	0.019	-0.291	-1.014	0.326	18
November 2010	3.193***	3.295	0.009	-0.621	-1.702	0.123	11

*,**,*** represent the statistical significance levels of 10%, 5%, 1% respectively.

Стаття надійшла до редакції 24.02.12