ECONOMIC ANNALS, Volume LV, No. 185 / April – June 2010
UDC: 3.33 ISSN: 0013-3264

SCIENTIFIC PAPERS

DOI:10.2298/EKA1085033M

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OPEN ISSUES IN TESTING LIQUIDITY IN FRONTIER FINANCIAL MARKETS: THE CASE OF SERBIA

ABSTRACT: *This paper examines the impact of illiquidity and liquidity risk on expected asset returns in the Serbian stock market. For this market we estimate the conditional Liquidity-adjusted Capital Asset Pricing Model (LCAPM) of Acharya and Pedersen (2005). We use daily data for the period from 2005-2009. While the method developed is applicable in other markets this is the first paper that tests the LCAPM model in the case of Serbia. Liquidity risks are allowed to be time-varying. We find that for the Serbian market as a frontier market illiquidity and liquidity risk significantly impact price formation. For such a market the LCAPM may indeed be a good tool for realistic assessment of the expected asset returns.*

KEY WORDS: *Frontier market, conditional liquidity-adjusted CAPM, illiquidity, liquidity risk.*

JEL CLASSIFICATION: G12, C30

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1. INTRODUCTION

In the parlance of institutional investors there are three major types of markets in the world today: developed markets in North America, Western Europe and Japan, the emerging markets of East Asia and Latin America, and the frontier markets of South East Asia and South Eastern Europe (see Šestović & Latković, 1998). Typical examples of frontier markets are Serbia, Croatia, Bulgaria, Kazakhstan, Nigeria, Sri Lanka and Vietnam. In this paper we focus on liquidity issues in frontier markets and in particular in the Serbian stock market. One of the key difficulties facing an investor in a frontier market is the low level of market liquidity. While such markets typically demonstrate openness and availability for foreign investors, low liquidity often prevents a more serious level of investment by institutional investors. Therefore it is commonly thought that low level of liquidity is one of the key problem areas facing small frontier markets.

Liquidity of a market is characterized by the ability of investors to buy and sell securities with relative ease. Illiquidity arises when an asset or security cannot be converted to cash quickly (Clark, 2008). Put in another way, market liquidity refers to the ability to undertake transactions in such a way as to adjust portfolios and risk profiles without disturbing underlying prices (Crockett, 2008).

The main problems of frontier markets that impact market liquidity are the small number of stocks with significant capitalization, the small number of shares outstanding, infrequent and irregular trading, etc. In addition there are the typically short time series of past trades and the lack of transparency and readily accessible information about traded companies, as well as the appearance of the so-called invisible forms of risk, of which illiquidity is the most important. Due to all these factors frontier markets suffer from an increased level of systematic risk (Latković & Barac, 1999).

In frontier markets liquidity is not only low but also discontinuous: the time period between two subsequent trades can be several weeks. Such a situation is certainly not common for traded securities in developed capital markets

(Latković, 2001). Frontier markets have some specific features that cannot be found in developed markets (Latković & Barac, 1999).

A large portion of the total capitalization in the Serbian frontier market is highly illiquid, i.e. many companies are merely listed on the exchange *de jure* rather than *de facto*. In addition typically only a small fraction of the company is floated. While this is typical of almost all economies in transition the Serbian market may be even more illiquid than many other transition markets.

Before the global economic crisis foreign investors showed an active interest in emerging markets: lured by the promise of higher returns they explored opportunities, with relatively modest success. Chuhan (1994) notes the small size of the frontier markets and their poor liquidity[1] as the main factors impeding interest in frontier markets. In most cases the cause of the dramatic falls and rises in market illiquidity and of increases in the liquidity risk is the growth and fall in the foreign investor's participation.

Standard equilibrium models such as Capital Asset Pricing Model or CAPM (see Sharpe, 1964) have been developed to describe, more or less successfully, pricing of assets in liquid markets. Emerging and frontier capital markets are a modelling challenge and require the creation of new models (Bekaert & Harvey, 2002, 2003).

As is well known, the CAPM focuses on only one factor or risk, namely market risk. Fama and French (1992) show that even for developed markets the CAPM does not perform too well.[2] Therefore they propose to include additional risk factors in the model. In order to explain stock returns in the U.S. market, Fama and French (1993) identify three common risk factors: an overall market factor

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1 Penev and Rojec (2004) find that the main obstacles to foreign direct investment flows into the South-East Europe region are high investment risks, the lack of adequate physical infrastructure, delays in bank restructuring and rehabilitation, underdeveloped financial markets, delays in large–scale privatization and enterprise reform, inadequate development level of institutional infrastructure, administrative barriers to foreign direct investment, and an unfavourable legal environment.

2 Pros and cons of the CAPM model are presented in Campbell, Lo, and MacKinlay (1997).

(the excess market return), factor related to firm size, and factor related to the ratio of book to market value of companies. Fama and French's results (1992, 1993) significantly improve the performance of the model compared to the single-factor model.

Bekaert, Harvey, and Lundblad (2007) examined the impact of liquidity on expected returns in emerging markets. Their results suggest that local market liquidity is an important driver of expected returns in emerging markets, and that the liberalization process has not eliminated its impact. Recently the literature has focused on liquidity as a factor of the overall risk. Many authors believe that liquidity is an important risk factor[3]. For the U.S. market Pástor and Stambaugh (2003) find that securities with outputs more susceptible to market liquidity risk require higher expected returns than securities with a lower sensitivity to liquidity risk. Chan and Faff (2003) examine the role of liquidity in asset pricing in the context of the Fama-French cross-sectional framework in an Australian setting. Martínez, Nieto, Rubio, and Tapia (2005) investigate liquidity risk impact on stock returns on the Spanish stock exchange.[4] Clark (2008) studies history and measurement of liquidity risk in frontier markets. Huberman and Halka (2001) find a systematic time-varying component of liquidity. Acharya and Pedersen (2005) use illiquidity measure as in Amihud (2002). They find that their model significantly improves upon the standard CAPM results.

In this paper, we test the liquidity-adjusted capital asset pricing model (LCAPM) of Acharya and Pedersen (2005). We use data from the Belgrade Stock Exchange - BELEX - for the period October 2005 – July 2009. Risk factors that have primary impact on price formation in the Serbian market are isolated. We use daily data for stocks from BELEX*line* and BELEX15 indices (http://www.belex.rs). To measure illiquidity we choose the price impact measure of Bekaert et al. (2007). We use the Ordinary Least Squares (OLS)

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3 Pástor and Stambaugh (2003), Acharya and Pedersen (2005), Sadka (2006), Lee (2006), and others.

4 Chordia, Roll, and Subrahmanyam (2000) find significant commonality in liquidity across their data, while Hasbrouck and Seppi (2001) find weak commonality in liquidity.

method in order to estimate the conditional version of the LCAPM model. The time variation of the liquidity risk is captured by the multivariate GARCH model. Using estimated conditional time-varying co-variances between corresponding residual series as well as individual conditional time-varying variances, we get the standard market beta and three betas representing different forms of the liquidity risk. These liquidity risks are associated with: commonality in illiquidity with the market illiquidity; return sensitivity to market illiquidity; and illiquidity sensitivity to market returns. We empirically document that illiquidity is persistent[5], and that illiquidity co-moves with contemporaneous returns in the Serbian market[6]. From the estimated LCAPM model we determine four illiquidity premia. Various robustness checks are performed.

The rest of the paper is organized as follows. Section 2 explores illiquidity in a CAPM framework. Section 3 presents the estimation methodology. Section 4 presents our discussion of the final results of the empirical calculation of the LCAPM, and explores liquidity risk impact on portfolio returns in the Serbian stock market. Section 5 concludes.

2. MODELLING ILLIQUIDITY IN A LCAPM FRAMEWORK

An important issue for the empirical analysis of this paper is the choice of an appropriate measure of liquidity for frontier capital markets. Many of the more sophisticated measures of (il)liquidity[7] could not be used for estimation of the liquidity of the Serbian frontier market because of the lack of data and specific features of these markets. Lesmond (2005) points out that it is very important to choose an appropriate measure of liquidity because these measures are

5 It should be noted that persistence of liquidity is empirically documented by Amihud (2002), Chordia, Roll, and Subrahmanyam (2000, 2001), Hasbrouck and Seppi (2001), Huberman and Halka (2001), Pástor and Stambaugh (2003), Acharya and Pedersen (2005), and others.

6 Acharya and Pedersen (2005) showed that persistence of liquidity implies that liquidity predicts future returns and co-moves with contemporaneous returns.

7 Some of the most common measures of (il)liquidity are as follows: Turnover, Bid-Ask spread, Roll's model (1984), Kyle's measure (1985), LOT's model (named by Lesmond, Ogden, and Trzcinka, 1999), Amihud's measure (2002), Pástor-Stambaugh factor (2003), and others.

necessary for an adequate estimation of the market efficiency. As a measure of illiquidity for the Serbian market we use the price impact measure as in Bekaert et al. (2007)[8]. This measure aims to incorporate potential price impact by using the length of the non-trading (or zero return) interval (Bekaert et al., 2007).

2.1. The Illiquidity Measure

The daily price impact (PI) measure is defined as follows (Bekaert et al., 2007):

$$\mathrm{PI}_{i,t} = \frac{\sum_{j=1}^{N} \omega_j \delta_{j,t} \left| R_{j,t,\tau} \right|}{\sum_{j=1}^{N} \omega_j \left| R_{j,t,\tau} \right|}, \tag{2.1}$$

where ω_j represents the weighting of the stocks in the market index[9]. N is number of stocks, each indexed by j. We also compute a capitalization-weighted price impact measure as a robustness check. Coefficient $\delta_{j,t}$ indicates no trade days (as proxied by zero return days) and the first day after a no trade interval when the price impact is felt.

$$\delta_{j,t} = \begin{cases} 1, & \text{if} \quad R_{j,t} \text{ or } R_{j,t-1} = 0 \\ 0, & \text{otherwise} \end{cases} . \tag{2.2}$$

Also,

$$R_{j,t,\tau} = \begin{cases} R_{j,t}, & \text{if} \quad R_{j,t-1} \neq 0 \\ \prod_{k=0}^{\tau-1} \left(1 + R_{M,t-k}\right) - 1, & \text{if} \quad R_{j,t-1} = 0 \end{cases} \tag{2.3}$$

8 These authors used this illiquidity measure for emerging markets, and it turned out to be reliable in estimation of the illiquidity of these markets.

9 In our case it is the BELEX*line* index.

Here τ represents the number of days the stock has not been trading and $R_{j,t,\tau}$ is an estimate of the return that would have occurred if the stock had traded. Because in frontier markets market-wide factors may dominate return behaviour with respect to idiosyncratic factors, we use the value-weighted market return $R_{M,t}$ as our proxy for the unobserved return. Note that when a stock does not trade for a lengthy interval, $R_{j,t,\tau}$ may become quite large and the price impact illiquidity measure (PI_t) may move to 1.0 (Bekaert et al., 2007). We are now ready to present the LCAPM model.

2.2. LCAPM by Acharya and Pedersen (2005)

One of the key problems facing small frontier markets is the low level of liquidity. Recent literature gives more attention to liquidity risk. Many studies argue that investors require higher expected returns (a liquidity premium) as compensation for holding less liquid securities. There is widespread evidence that liquidity (both in terms of a security's individual characteristics and its systematic risk) is priced in the security market (Panyanukul, 2009). Therefore it is necessary to introduce additional factors that measure liquidity risk in order to perform a more realistic assessment of the expected asset returns in frontier markets. Acharya and Pedersen (2005) show how the CAPM in an imaginary economy translates into a CAPM in net returns for the original economy with illiquidity costs (Panyanukul, 2009).

The standard equilibrium Capital Asset Pricing Model (CAPM) is a one-period, static model with one factor, namely market risk. This model has been developed to describe pricing of assets in liquid markets. In order to capture some of the salient features of the frontier markets we consider an extension of the CAPM called Liquidity-adjusted CAPM (LCAPM), introduced by Acharya and Pedersen (2005). This model is derived from a framework similar to the CAPM. In it the risk-averse investors maximize their expected utility under a wealth constraint by replacing the cost-free stock price $P_{i,t}$ with a stochastic trading-cost-adjusted stock price $P_{i,t} - \psi_{i,t}$. Here, $\psi_{i,t}$ is the level of trading cost in an overlapping-generations economy (Lee, 2006). Acharya and Pedersen (2005) develop a unified equilibrium model including both liquidity level and liquidity risk. In addition to expected liquidity cost and the traditional CAPM market beta (beta1), this new model captures three possible different forms of liquidity risk for an asset. These are: commonality in illiquidity with the market illiquidity (beta2)[10], the portfolio's return sensitivity to market illiquidity (beta3), and sensitivity of the portfolio's illiquidity to market returns (beta4). These authors identify three different sources of premia associated with liquidity risk.

In reality neither market nor liquidity risk are constant in time, so the testing of static models gives unrealistic results. As risk is not time invariant, we test the conditional version of the LCAPM. For this reason we test the dynamic LCAPM and CAPM, and conditional versions of these models. Testing the conditional LCAPM gives us an opportunity to investigate the effect of illiquidity on asset prices through four forms of various undiversifiable risks over time.

Bollerslev, Engle, and Wooldridge (1988) and Harvey (1989) analyse the standard CAPM with time-varying covariance. The evidence in Harvey (1989) indicates that the conditional covariance does change through time. The patterns of the pricing errors through time suggest the model's inability to capture the dynamic behaviour of asset returns. Hafner and Herwartz (1998) use the CAPM with betas that are time varying with the assistance of the two-dimensional "GARCH in Mean" model. Watanabe and Watanabe (2008) study dynamic features of liquidity betas and liquidity risk premium. They construct a conditional liquidity factor and examine whether the cross-sectional pricing of liquidity risk strengthens in the high liquidity-beta state. These authors did not use the conditional LCAPM of Acharya and Pedersen (2005). Thus we did not find that any of the authors used a conditional version of this model for testing.

The unconditional LCAPM can be obtained assuming the independence over time of returns and illiquidity measures and constant conditional covariance of innovation in illiquidity and returns. Lee (2006) uses the unconditional version LCAPM. He performs cross-sectional regression for each month using the individual stock returns and the estimated betas. He does not consider the

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[10] This is liquidity risk arising from the co-movement of individual portfolio illiquidity with market illiquidity.

impact of different holding periods on liquidity in his empirical tests. By using monthly returns and liquidity he implicitly assumes that the investors' holding period is one month, which is a very strong assumption. Panyanukul (2009) extends the unconditional LCAPM to the bond market. He assumes that the risk premium for all four betas is the same. For this model he found that it was difficult to distinguish empirically the effect of each liquidity beta. Fang, Sun, and Wang (2006) test the unconditional LCAPM in the Japanese stock market.

In order to overcome problems linked with the use of the unconditional version of the LCAPM with one risk premium, we test the conditional LCAPM with four risk premiums. In this way we want to investigate how all forms of liquidity risk affect portfolio return. In this model a representative investor, in addition to expected excess return over the risk-free rate in the form of market risk premium (denoted $+\lambda_1$), expects to receive a premium for holding a portfolio that becomes illiquid when the market in general becomes illiquid (denoted $+\lambda_2$). Then the investor pays a premium for a portfolio with high return in times of market illiquidity (denoted $-\lambda_3$), and pays a premium for a portfolio with low illiquidity in states of poor market return (denoted $-\lambda_4$) (Acharya and Pedersen, 2005).

One-beta CAPM in net returns, derived by Acharya and Pedersen (2005), can be re-written in terms of gross returns. It introduces three liquidity betas:

$$E_{t-1}\left(R_t^p - PI_t^p\right) = R_t^f + \lambda_{t-1}\frac{\operatorname{cov}_{t-1}\left(R_t^p - PI_t^p, R_t^M - PI_t^M\right)}{\operatorname{var}_{t-1}\left(R_t^M - PI_t^M\right)}, \tag{2.4}$$

where R_t^f is the risk free rate, PI_t is the price impact illiquidity measure, and λ_{t-1} is the risk premium defined as $\lambda_{t-1} = E_{t-1}\left(R_t^M - PI_t^M - R_t^f\right)$. Liquidity risk premium is calculated as the market risk premium as in the standard CAPM, but corrections to the level of illiquidity are introduced. Superscripts *p* and *M* represent the portfolio *p* and aggregate market respectively.

Expected excess return over the risk-free rate (portfolio's risk premium) is a function of both the expected illiquidity ($E_{t-1}\left(PI_t^p\right)$) and four systematic risk variables: the market return beta $\beta_{1,t-1}^p = \frac{\text{cov}_{t-1}\left(R_t^p, R_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)}$, and three other liquidity betas: $\beta_{2,t-1}^p = \frac{\text{cov}_{t-1}\left(PI_t^p, PI_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)}$, $\beta_{3,t-1}^p = \frac{\text{cov}_{t-1}\left(R_t^p, PI_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)}$, $\beta_{4,t-1}^p = \frac{\text{cov}_{t-1}\left(PI_t^p, R_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)}$. Thus, in a LCAPM investor portfolio (assets) risk is determined by four covariance terms, unlike in the CAPM where only one covariance term exists.

In particular the conditional version of the LCAPM can be expressed as follows:

$$E_{t-1}\left(R_t^p - R_t^f\right) = E_{t-1}\left(PI_t^p\right) + \lambda_{t-1}\frac{\text{cov}_{t-1}\left(R_t^p, R_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)} + \lambda_{t-1}\frac{\text{cov}_{t-1}\left(PI_t^p, PI_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)} - \lambda_{t-1}\frac{\text{cov}_{t-1}\left(R_t^p, PI_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)} - \lambda_{t-1}\frac{\text{cov}_{t-1}\left(PI_t^p, R_t^M\right)}{\text{var}_{t-1}\left(R_t^M - PI_t^M\right)} \tag{2.5}$$

Let R_t^M and PI_t^M be the daily log return series and daily illiquidity series of a value-weighted market index (i.e. BELEX*line*) respectively. R_t^p and PI_t^p are the daily log return series and daily illiquidity series of a value-weighted portfolio of the most liquid stocks (i.e. BELEX15) respectively. Acharya and Pedersen (2005) have one risk premium and we have four risk premiums. However we allow that conditional variances and covariances vary over time, but we assume that all illiquidity premiums are constant and different. Hence liquidity risks (betas) will be time-varying. This model is:

$$E_{t-1}\left(R_t^p - R_t^f\right) = E_{t-1}\left(PI_t^p\right) + \lambda_1\beta_{1,t-1}^p + \lambda_2\beta_{2,t-1}^p - \lambda_3\beta_{3,t-1}^p - \lambda_4\beta_{4,t-1}^p. \tag{2.6}$$

Where $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ are the risk premia.

It is clear that without the illiquidity measure terms PI_t^p and PI_t^M the LCAPM in (2.4) is equivalent to the traditional CAPM. The standard CAPM model in the conditional version is:

$$E_{t-1}\left(R_t^p - R_t^f\right) = \lambda_1 \beta_{1,t-1}^p \text{, where } \beta_{1,t-1}^p = \frac{\operatorname{cov}_{t-1}\left(R_t^p, R_t^M\right)}{\operatorname{var}_{t-1}\left(R_t^M\right)}. \tag{2.7}$$

If we compare equations (2.6) and (2.7) we can see that there is a big difference in the number of coefficients. In the case where securities are illiquid, investors can require higher expected returns (different sources of liquidity premiums) in order to compensate for holding less liquid securities. On the other hand when securities are liquid, and when the standard CAPM is applicable, investors can require only one-risk premiums for holding risk assets with high beta.

3. ESTIMATION METHODOLOGY

It is known that financial markets are characterized by random fluctuations over time, which is particularly important because the value of shares, options and other financial instruments depends on the risk. Analysis of the pricing of assets or estimates of portfolio risk is unthinkable without the concept of conditional heteroscedasticity explained by the GARCH model (by Bollerslev, 1986). Determining the price of risk is one of the basic functions of financial markets. Any investment is risky, and careful investors compare the expected return of assets to risk where they are exposed. It is not possible to estimate this risk without measuring a time variable conditional variance (volatility) of asset returns (Engle, 2004). Since time series in financial markets often have unstable variances, modelling the behaviour of variances and covariances throughout time represents a necessary step in the analysis of financial econometrics.

This section describes data, presents summary statistics, constructs factors and a portfolio for regression analysis, and describes estimation methodology for the conditional version of the LCAPM. It is therefore important to rely on an assumption of time-varying conditional covariance of innovation in illiquidity and returns. Specifically, we used the multivariate GARCH model in order to capture the time variation of the liquidity risk, because this model specifies equations for how the covariances move over time. Our focus is on modelling time-varying betas explicitly. We investigate the impact of illiquidity and liquidity risk in explaining price formation. We wish to find out whether investors are compensated for holding frontier-market assets, the returns of which are sensitive to both market risk and liquidity risk. This is the first paper that tests the conditional LCAPM model in the case of Serbia. The method developed is applicable to other markets.

3.1. Data

We have daily and monthly returns for individual stocks that enter into BELEX*line*[11] and BELEX15[12] indices, trading in the Serbian market from October 2005 through July 2009 (http://www.belex.rs).

A large portion of the total capitalization in the Serbian frontier market is highly illiquid. Many companies are listed on the exchange merely *de jure* rather than *de facto*. In addition typically only a small fraction of the company is floated. The weighting of both indices is based on market capitalization. The change in the level of capitalization is not a representative measure of a frontier market's liquidity. Due to the illiquidity of belonging securities the index composition is often modified, and that is the reason why both indices are not the best choice for the market proxy. However we do not have a better market proxy, and we use BELEX15 and BELEX*line* indices.

Daily returns are estimated for over 200 companies companies in Serbia and on both indices (daily returns are calculated as difference in log price at closing).

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11 The Belgrade Stock Exchange has calculated and published the BELEX*line* index since April 2, 2007, as a benchmark for monitoring broad market movements. The BELEX*line* index is descriptive, in the statistical sense, and not investible. The index weighting is based on market capitalization.

12 BELEX15 is a free-floating market capitalization weighted price index, which follows the movements of the most liquid shares traded by the continuous method and fulfilling criteria for inclusion in the index basket. This index is not a perfect proxy for the market.

The returns of the market are a value-weighted index, BELEX*line*, comprised of all stocks available either in a given month or on a particular day in the sample. To diversify a part of returns specific to each company as well as to get more precise estimations of beta coefficients, stocks would be grouped in a portfolio. This would be a value-weighted portfolio consisting of the 15 most liquid stocks (which is actually the second index of the Belgrade Stock Exchange, BELEX15)[13].

As a measure of illiquidity in the Serbian frontier market the chosen measure is the price impact (PI) measure, as in Bekaert et al. (2007). It is not possible to use more delicate measures of illiquidity due to the lack of data in this frontier market. We also computed a value-weighted[14] illiquidity measure of BELEX*line* and BELEX15 indices. Hence we modelled illiquidity as a stochastic price impact process. Each group of series of log returns and illiquidity measures in the Serbian case are considered separately, in order to get its individual dynamics over time.

Treasury Bills (T-bills) are issued by the Republic of Serbia, and observed on the website of the National Bank of Serbia (http://www.nbs.rs). The Republic of Serbia's T-bills are used as the risk-free rate, and they represent the averaged weighted rate[15] for each month (in percents) on an annual basis.[16]

A selected illiquidity measure value ranges in intervals between 0 and 1, with the value closer to 1 denoting extremely high market/portfolio illiquidity. Figures 3.1 and 3.2 plot the daily log return and daily illiquidity measure of the market

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13 The portfolio is rebalanced after each revision of the BELEX15 index.

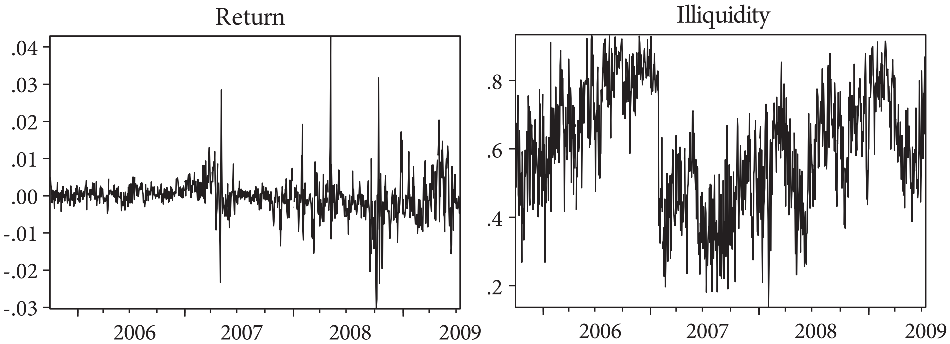
14 Amihud (2002), Pástor and Stambaugh (2003), Acharya and Pedersen (2004), Sadka (2006) and others used an equal-weighted illiquidity measure. Computing the market illiquidity as an equal-weighted average is perhaps more appropriate than a value-weighted average because liquid firms are over represented in the sample. A value-weighted average would further worsen this problem because it would heavily represent the largest of firms in the sample (Sadka, 2006; Acharya and Pedersen, 2003).

15 For months without given data we have carried out extrapolation between two points in months when the data was available.

16 Aiming at evaluation of the LCAPM with daily data we have divided the observed T-bills rate by 360. For estimation of the LCAPM with monthly data we have divided the observed T-bills rate by 12.

index (BELEX*line*) and the portfolio of the most liquid stocks (BELEX15) respectively.

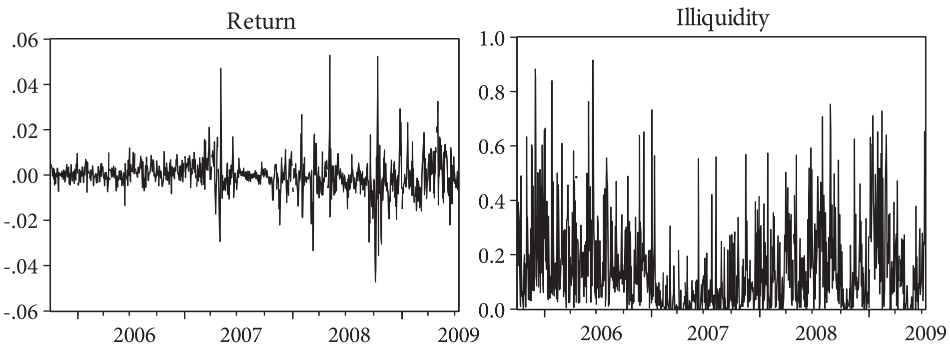
Figure 3.1: Graphs of daily log return and daily illiquidity measure of BELEX*line* index, respectively.



Source: authors' estimation

By comparing the plots of return with the plots of illiquidity in Figures 3.1 and 3.2 one can observe that illiquidity is significantly less stable than returns. However we empirically document that time-varying illiquidity is highly unstable and persistent in the Serbian market. According to findings about illiquidity behaviour it can be claimed that the key risk factor in the frontier market is illiquidity.

Figure 3.2: Graphs of daily log return and daily illiquidity measure of the BELEX15 index, respectively.



Source: authors' estimation

We examined volatility of both return series and both illiquidity series.[17] In other words we estimated univariate Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models, within software package Eviews, Version 6.0, in order to get the estimated conditional volatility of the corresponding series of residuals. From Table 1 in the Appendix we see that the log return follows the ARMA(1,3)-IGARCH(1,1) model, and the illiquidity measure of the BELEX*line* index follows the ARMA(4,2)-GARCH(1,1) model. From Table 2 in the Appendix we see that the log returns follows the ARMA(0,2)-IGARCH(1,1) model, and the illiquidity measure of the portfolio of the most liquid stocks (BELEX15) follows the ARMA(1,1)-GARCH(1,1) model. The results in Tables 1 and 2 for both series show that all GARCH coefficients are statistically significant. The sum of ARCH and GARCH coefficients is close to one for the log return on BELEX*line* and BELEX15 indices. This suggests the persistence of ARCH effects in the datasets and hence implies that current information remains important for forecasts of conditional variances on all horizons.[18] The fitted models were checked by using the standardized residuals of returns and illiquidity and its squared process (see Table 3 in the Appendix). The values of Q-statistics with significantly low *p*-values (less than 10%) of the standardized residual series for log returns of both BELEX*line* and BELEX15 indices imply that there is autocorrelation. It suggests that we have less associated liquidity equilibrium[19]. However the Ljung-Box statistics of standardized residuals and those squared for each analyzed series show that the models are adequate for describing the heteroscedasticity of the data (see Table 3 in the Appendix). We applied the ARCH test on the standardized residuals of all analyzed series to see if there are any ARCH effects left. Both the F-statistic and the LM-statistic are very insignificant, suggesting no ARCH effect for each analyzed series of log

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17 Summary statistics, which have been calculated before volatility examination, such as descriptive statistics, test statistics for a unit root - Augmented Dickey Fuller test (ADF), Ljung-Box tests of residuals for ARMA models, and the Lagrange multiplier (LM) tests, are available by request.

18 This special type of GARCH model is termed Integrated GARCH (IGARCH). It means that if the residual of log return follows an IGARCH process, then the unconditional variance of residuals is infinite.

19 Grossman and Miller (1988) found that the less the autocorrelation value of stock return, the higher the associated liquidity equilibrium.

returns and illiquidity measures, up to order 5 or 10 (see Table 3 in the Appendix).

In order to estimate betas for the LCAPM model we also had to estimate the variance of difference in market return and market illiquidity measure (i.e. $\text{var}_{t-1}\left(R_t^M - PI_t^M\right)$). The same procedure was applied as for all previous series so far. From Table 4 in the Appendix we see that this difference fulfils the ARMA(4,2)-GARCH(1,1) model. Table 4 also reports the Ljung-Box statistics of standardized residuals and squared standardized residuals, as well as the ARCH-LM test.

3.2. Regression factors and LCAPM estimation

Next we prepared the return-illiquidity series for constructing factors for LCAPM regression. Liquidity risks (measured by beta coefficients) were estimated using the multivariate GARCH model (version: bivariate diagonal VECH, DVECH model initially due to Bollerslev et al., 1988) within the Eviews software package Version 6.0. Using residuals from ARMA models for each series of returns and illiquidity, we estimated the conditional covariances on a daily and monthly basis, utilizing the DVECH model. The main empirical contribution of this paper is that allowed conditional variances of innovations in illiquidity and returns, as well as conditional covariances between these series, are time varying, and estimated on a daily basis. The method for estimation parameters in DVECH models that we used is maximum log-likelihood. This estimator is suitable for models that specify conditional covariances and variances, because it correctly specifies the conditional mean and the conditional variance. The number of iteration was 500 and the convergence criterion is $1 \cdot 10^{-5}$, which suggests high precision.

Let $r_t^M = R_t^M - E_{t-1}\left(R_t^M\right)$ and $r_t^p = R_t^p - E_{t-1}\left(R_t^p\right)$ be the log return series corrected for autocorrelation in the mean of BELEX*line* (market index) and of BELEX15 (portfolio of the most liquid stocks) respectively. Let $pi_t^M = PI_t^M - E_{t-1}\left(PI_t^M\right)$ and $pi_t^p = PI_t^p - E_{t-1}\left(PI_t^p\right)$ be the illiquidity series corrected for autocorrelation in the mean of BELEX*line* and of BELEX15 respectively.

Utilizing the DVECH model we have four risks in LCAPM as defined by Acharya and Pedersen (2005):

1. $\operatorname{cov}_{t-1}\left(r_t^p, r_t^M\right)$: the conditional covariance between the portfolio's return and the market return.
2. $\operatorname{cov}_{t-1}\left(pi_t^p, pi_t^M\right)$: the conditional covariance between the portfolio's illiquidity and the market illiquidity.
3. $\operatorname{cov}_{t-1}\left(r_t^p, pi_t^M\right)$: the conditional covariance between the portfolio's return and the market illiquidity.
4. $\operatorname{cov}_{t-1}\left(pi_t^p, r_t^M\right)$: the conditional covariance between the portfolio's illiquidity and the market return.

For diagnostic checking we analyzed correlograms of the cross product of standardized residuals from DVECH models. We did not observe any ARCH effects left in the cross product of standardized residuals. So the autocorrelations were not significant in covariance equations of DVECH models. Thus the check of the models showed that the models are appropriate and adequate for describing the conditional heteroscedasticity of the return and illiquidity series.

Dividing estimated covariances by variance of difference in market returns and market illiquidity measures gives us all four betas - a systematic (market) risk and 3 liquidity risks. Acharya and Pedersen (2005) defined betas as follows:

$$\beta_{1,t-1}^{p} = \frac{\text{cov}_{t-1}\left(R_t^p - E_{t-1}\left(R_t^p\right), R_t^M - E_{t-1}\left(R_t^M\right)\right)}{\text{var}_{t-1}\left(R_t^M - E_{t-1}\left(R_t^M\right) - \left[PI_t^M - E_{t-1}\left(PI_t^M\right)\right]\right)}, \tag{3.1}$$

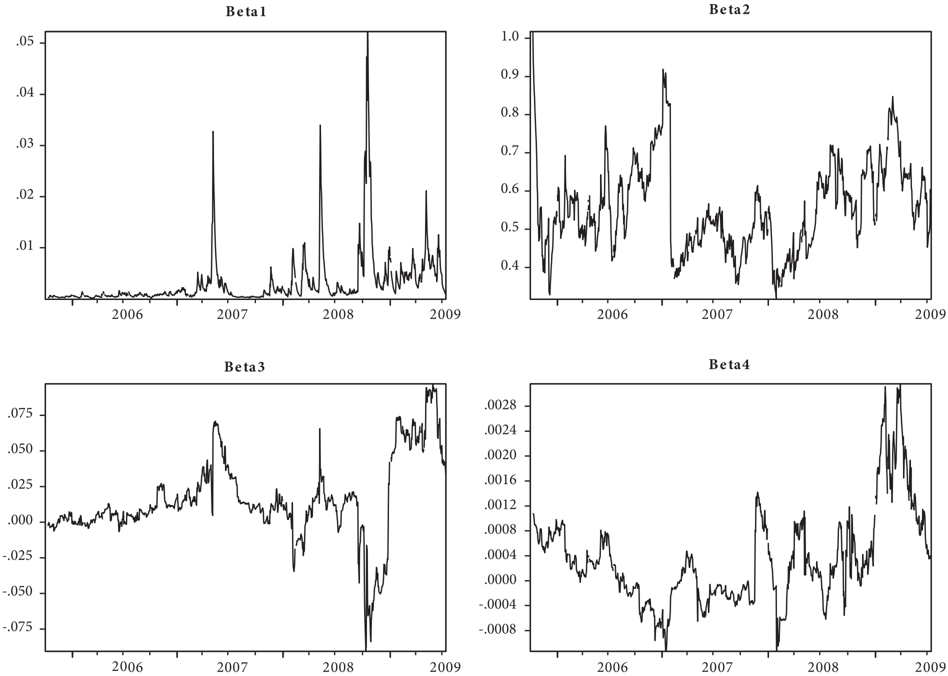
$$\beta_{2,t-1}^{p} = \frac{\text{cov}_{t-1}\left(PI_t^p - E_{t-1}\left(PI_t^p\right), PI_t^M - E_{t-1}\left(PI_t^M\right)\right)}{\text{var}_{t-1}\left(R_t^M - E_{t-1}\left(R_t^M\right) - \left[PI_t^M - E_{t-1}\left(PI_t^M\right)\right]\right)}, \tag{3.2}$$

$$\beta_{3,t-1}^{p} = \frac{\text{cov}_{t-1}\left(R_t^p - E_{t-1}\left(R_t^p\right), PI_t^M - E_{t-1}\left(PI_t^M\right)\right)}{\text{var}_{t-1}\left(R_t^M - E_{t-1}\left(R_t^M\right) - \left[PI_t^M - E_{t-1}\left(PI_t^M\right)\right]\right)}, \tag{3.3}$$

$$\beta_{4,t-1}^{p} = \frac{\text{cov}_{t-1}\left(PI_t^p - E_{t-1}\left(PI_t^p\right), R_t^M - E_{t-1}\left(R_t^M\right)\right)}{\text{var}_{t-1}\left(R_t^M - E_{t-1}\left(R_t^M\right) - \left[PI_t^M - E_{t-1}\left(PI_t^M\right)\right]\right)}. \tag{3.4}$$

Figure 3.3 plots betas on a daily level.

Figure 3.3: The estimated daily betas from the MGARCH process (version DVECH) in the case of a value-weighted portfolio of the most liquid stocks with a value-weighted market index (i.e. BELEX15–BELEX*line*).



Notes: The betas are: market beta (beta1), commonality in illiquidity with the market illiquidity (beta2), return sensitivity to market illiquidity (beta3), and illiquidity sensitivity to market returns (beta4).

Source: authors' estimation

Figure 3.3 shows that beta1 and beta2 always have a positive value in the course of the inspected period, while beta3 and beta4 sometimes take negative values. Beta2 has the highest recorded values of all evaluated betas. From Figure 3.3 we see the negative peak of return sensitivity to market illiquidity (beta3) during autumn 2008 (the onset of world economic crisis), which means that when the market is illiquid, returns significantly decrease. In the same period (during the autumn of 2008) we observe an increase in market (systematic) risk (beta1). On the other hand we observe the peak of illiquidity sensitivity to market returns (beta4) in February 2009 (the peak of the crisis in Serbia).

Aiming at evaluation of liquidity premiums on a daily basis, the following cross-sectional regression is performed using the daily portfolio's return and illiquidity measure, as well as daily estimated betas.

$$R_t^p - R_t^f = a + bPI_t^p + \lambda_1 \ddot{\beta}_{1,t}^p + \lambda_2 \ddot{\beta}_{2,t}^p - \lambda_3 \ddot{\beta}_{3,t}^p - \lambda_4 \ddot{\beta}_{4,t}^p + \varepsilon_t \,. \qquad (3.5)$$

The intercept *a* is the excess return earned by trading based on liquidity risks, and ε_t is an iid disturbance term.

On the other hand we tested the conditional standard CAPM model against the LCAPM using equation (2.7), i.e. we performed the following regression analysis:

$$R_t^p - R_t^f = a + \lambda_1 \ddot{\beta}_{1,t}^p + \varepsilon_t \,. \qquad (3.6)$$ [20]

The method for estimation of parameters in conditional versions of LCAPM and CAPM models that we used are Ordinary Least Squares (OLS). A popular method for showing the importance of liquidity risks in asset pricing is time-series tests. These tests provide an easy interpretation of the economic magnitude of liquidity risks (Lee, 2006). We have therefore used these tests in this paper as well.

4. RESULTS

As a final check, we have considered results from Tables 4.1 and 4.3. In the case of the conditional LCAPM with daily data (Table 4.1) our liquid portfolio tends to have a lot of return sensitivity to market returns (beta1), a lot of return sensitivity to market illiquidity (beta3), and a lot of illiquidity sensitivity to market returns (beta4). Additionally the portfolio's illiquidity is negative and

[20] Beta1 from the standard CAPM is calculated by formula (2.7), and it is not the same as beta1 in the LCAPM.

significant at the 5% level. It means that the expected portfolio return is a decreasing function of its expected illiquidity.[21] The market risk (beta1) is negative and significant at the 10% level. From Table 4.1 it can be observed that liquidity risk is priced, and liquidity risk has a higher risk premium than market risk. The beta3 is negative and significant at the 5% level. This means that investors pay a premium ($\lambda_3 = 2.3\%$ at daily level) for an asset/portfolio with a high return in times of market illiquidity.[22] From Table 4.1 we have that illiquidity premium by beta4 is positive and significant at the 10% level ($\lambda_4 = 67\%$ at daily level). In other words when the liquidity risk is higher (beta4) returns are significantly lower (according to equation 3.5) for the portfolio composed of the 15 most liquid stocks. This effect on the required return is due to the co-variation between a portfolio's illiquidity and the market return (beta4). Hence an investor is willing to accept a discounted return on a liquid portfolio in states of poor market return.

Table 4.1: The estimation results from regressions of liquidity-adjusted CAPM and standard CAPM with time-varying betas and with daily data.

daily	**cond. LCAPM**				**cond. CAPM**			
Variable	Coeff.	S.E.	t-Stat	Prob.	Coeff.	S.E.	t-Stat	Prob.
a	-0.0004	0.0013	-0.2976	0.7660	-0.0001	0.0010	-0.1160	0.9077
PI_p	-0.0034	0.0016	-2.0506	0.0406	-	-	-	-
Beta1	-0.0871	0.0492	-1.7711	0.0769	-0.0004	0.0007	-0.6369	0.5244
Beta2	0.0006	0.0023	0.2557	0.7983	-	-	-	-
-Beta3	-0.0232	0.0099	-2.3454	0.0192	-	-	-	-
-Beta4	0.6730	0.4032	1.6690	0.0955	-	-	-	-
R^2	0.0172				0.0004			
Adj. R^2	0.0119				-0.0006			
F-stat	3.2758 (0.0061)				0.4056 (0.5244)			

Notes: *a* is constant or intercept; PI_p is the monthly illiquidity series of a value-weighted portfolio of the most liquid stocks (i.e. BELEX15); the betas are: market beta (beta1), commonality in

[21] Amihud (2002) found the opposite, that the expected stock return is an increasing function of its expected illiquidity.

[22] Pástor and Stambaugh (2003) present empirical evidence for this effect of liquidity risk on expected stock returns.

illiquidity with the market illiquidity (beta2), return sensitivity to market illiquidity (beta3), and illiquidity sensitivity to market returns (beta4).

Source: authors' estimation

The first measure of correlation among three significant daily betas is reported in Table 4.2. The results suggest that we have a negative correlation between market risk (beta1) and illiquidity risk described by beta3 (portfolio's return sensitivity to market illiquidity) on a daily basis. Hence an increase in market risk leads to a decrease in susceptibility of the most liquid stocks portfolio returns to the market illiquidity. This effect is particularly present in the autumn of 2008 in Figure 3.3, comparing beta1 and beta3. We may see from Table 4.2 that there is a positive correlation between beta1 and beta4, as well as between beta3 and beta4, on a daily basis. Increase in liquidity risk (especially beta4) will result in increase of systematic risk (beta1).

Table 4.2: The correlation coefficients between three daily betas, beta1, beta3, and beta4.

daily	Beta1	Beta3	Beta4
Beta1	1.00	-0.05	0.16
Beta3		1.00	0.42
Beta4			1.00

Notes: beta1 is market beta, beta3 is return sensitivity to market illiquidity, and beta4 is illiquidity sensitivity to market returns.

Source: authors' estimation

All daily liquidity risks (beside beta2) are statistically significant, according to the results of test statistics for the LCAPM on a daily basis (Table 4.1). It turns out to be senseless to examine the equilibrium of the Serbian market at the daily level, because the value of coefficient R^2 is very low (about 2%). Although we intuitively suppose that liquidity risk is harder to estimate with monthly data, we will nevertheless use that data to present LCAPM results on a monthly basis. Daily return, illiquidity, and beta series have been averaged by months in order to obtain series on a monthly level.

Table 4.3: The estimation results from regressions of liquidity-adjusted CAPM and standard CAPM with time-varying betas and with monthly data.

monthly	**cond. LCAPM**				**cond. CAPM**			
Variable	Coeff.	S.E.	t-Stat	Prob.	Coeff.	S.E.	t-Stat	Prob.
a	-0.0008	0.0024	-0.3299	0.7432	-0.0113	0.0036	-3.1363	0.0030
PI_p	-0.0220	0.0070	-3.1265	0.0033	-	-	-	-
Beta1	-0.1199	0.1177	-1.0189	0.3144	0.0021	0.0025	0.8203	0.4165
Beta2	-0.0058	0.0045	-1.3145	0.1962	-	-	-	-
-Beta3	-0.0077	0.0186	-0.4143	0.6809	-	-	-	-
-Beta4	1.7573	0.8392	2.0940	0.0426	-	-	-	-
R^2	**0.5246**				**0.0151**			
Adj. R^2	0.4652				-0.0073			
F-stat	8.8285 (0.0000)				0.6729 (0.4165)			

Notes: *a* is constant or intercept; PI_p is the monthly illiquidity series of a value-weighted portfolio of the most liquid stocks (i.e. BELEX15); the betas are: market beta (beta1), commonality in illiquidity with the market illiquidity (beta2), return sensitivity to market illiquidity (beta3), and illiquidity sensitivity to market returns (beta4).

Source: authors' estimation

In the case of the conditional LCAPM with monthly data (Table 4.3) our liquid portfolio tends to have a lot of illiquidity sensitivity to market returns (beta4). As the coefficient by portfolio's illiquidity is negative and significant at the 1% level (*b*=-2.2% at monthly basis), it means that high illiquidity predicts low future returns of the liquid portfolio. We claimed that illiquidity is an important driver of expected returns in frontier markets. One of the liquidity risk factors (beta4) dominates other risk factors in its impact. The liquidity premium (λ_4) by beta4 is large, positive and significant at the 5% level. It is empirically shown that the covariance between the portfolio's illiquidity and the market returns (beta4) affects the portfolio's expected return. This effect stems from investors' willingness to accept a lower expected return on a portfolio that is liquid when the market is down. This effect is economically important. Thus, we find consistent evidence of this effect in the Serbian frontier financial market.

Comparing the results of conditional versions of the standard CAPM and the LCAPM models in the Serbian market, one may draw a conclusion that LCAPM has much better performances than a standard CAPM (according to R^2) on a monthly basis. Hence in the case of a value-weighted portfolio of the most liquid stocks, $R^2 = 52.5\%$ for LCAPM, and $R^2 = 1.5\%$ for CAPM. Overall the evidence appears to be supportive of the LCAPM model.

The results highlight the importance of illiquidity and liquidity risk for asset/portfolio prices in the Serbian market. In addition to this a significant contribution of this paper is that measurement of illiquidity is adjusted to frontier market characteristics and its time-series variation, for individual stocks/portfolios as well as for the market.

According to the results (Tables 4.1, and 4.3) of F-statistics and of R^2 coefficient, the standard CAPM does not hold in frontier markets, and it cannot be used for asset pricing or for description of disequilibrium in these markets. Results (Table 4.3) from estimation of the LCAPM implies that intercept *a* is zero for this model. The proposed model fits the Serbian stock market data rather well.

Table 4.4: Diagnostic checking of LCAPM and standard CAPM with time-varying betas, with monthly data; the Ljung-Box statistics of residuals, and Breusch-Godfrey Serial Correlation LM Test of order 5.

The Ljung-Box statistics			*Breusch-Godfrey Serial Correlation LM(5) Test*	
montly series	**Q(10)**	**Q(20)**	**F-stat**	**Obs*R^2**
LCAPM	22.575 (0.012)	36.493 (0.013)	3.040 (0.022)	13.930 (0.016)
CAPM	75.079 (0.000)	132.22 (0.000)	12.033 (0.000)	27.909 (0.000)

Notes: The number in parentheses denotes *p*-value.

Source: authors' estimation

Table 4.4 reports results of diagnostic checking of residuals of conditional versions of the LCAPM and the standard CAPM models, with monthly data. So, the *Q*-statistics are significant at all lags, indicating significant serial correlation in the residuals of both models. The Breusch-Godfrey Test also rejects the hypothesis of no serial correlation up to order five for both models. The results of both test-statistics indicate that the residuals of both models are serially correlated. Thus the relatively low value of the R^2 coefficient indicates that the Serbian market is a special type of emerging market, i.e. a frontier one, and that even the LCAPM model is not sufficient to give a realistic description of disequilibrium in frontier financial markets. An increase in illiquidity and illiquidity sensitivity to market returns (liquidity risk, beta4) causes disequilibrium of this market, and a relatively low value of the R^2 coefficient (52.5%), with monthly data. We anticipate that the introduction of the Fama-French factors (SMB and HML) in the LCAPM should improve the R^2 coefficient.

5. CONCLUSION

This paper examines the role of illiquidity and liquidity risk in explaining portfolio returns in the Serbian market using the Liquidity-adjusted Capital Asset Pricing Model (LCAPM) of Acharya and Pedersen (2005). We test the model for one of the frontier markets, namely the Serbian stock market, over the period October 2005-July 2009. As the measure of illiquidity we use the price impact measure suggested by Bekaert et al. (2007). We find that the proposed model fits rather well with the Serbian stock market data.

Our results suggest that illiquidity is an important driver of the expected returns in the Serbian market, and that it is persistent. Furthermore, illiquidity co-moves with contemporaneous returns. It has been shown that one of the liquidity risk factors (beta4) dominates other risk factors in its impact. A number of other empirical findings are obtained.

Future research should focus on the combination of the Fama-French model and the LCAPM model. We hope that such a model would improve the description of disequilibrium in the Serbian market, and improve the value of the R^2 coefficient.

ACKNOWLEDGEMENTS

The authors wish to thank dr. Miloš Božović from the Centre for Investments and Finance for valuable comments. All remaining errors are ours alone.

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APPENDIX

Table 1: A joint estimation of the mean and volatility equations for daily series of BELEX*line* return and BELEX*line* illiquidity.

BELEX*line*	**log return**				**PI measure**			
				Mean Equation				
	Coeff.	S.E.	z-Stat	Prob.	Coeff.	S.E.	z-Stat	Prob.
C	0.0005	0.0004	1.1012	0.2708	0.6416	0.0594	10.8028	0.0000
AR(1)	0.9823	0.0106	92.4447	0.0000	0.2522	0.0505	4.9931	0.0000
AR(2)	-	-	-	-	1.0700	0.0451	23.7190	0.0000
AR(3)	-	-	-	-	-0.2519	0.0481	-5.2336	0.0000
AR(4)	-	-	-	-	-0.0873	0.0433	-2.0160	0.0438
MA(1)	-0.6858	0.0353	-19.4320	0.0000	0.1536	0.0365	4.2131	0.0000
MA(2)	-0.0208	0.0427	-0.4877	0.6258	-0.8398	0.0365	-23.0181	0.0000
MA(3)	-0.1855	0.0345	-5.3745	0.0000	-	-	-	-
				Variance Equation				
C	0.0000	0.0000	5.8984	0.0000	0.0003	0.0004	0.8779	0.3800
ARCH(1)	0.3169	0.0758	4.1803	0.0000	0.0344	0.0159	2.1610	0.0307
GARCH(1)	0.7026	0.0429	16.3947	0.0000	0.9343	0.0409	22.8509	0.0000
R^2	0.1991				0.6636			
Adj. R^2	0.1932				0.6603			
S.E. of reg.	0.0047				0.1013			
Sum sq. resid	0.0205				9.5812			
Mean dep. var	-0.0003				0.6047			

Source: authors' estimation

Table 2: A joint estimation of the mean and volatility equations for daily series of BELEX15 return and BELEX15 illiquidity.

BELEX15	**log return**				**PI measure**			
Mean Equation								
	Coeff.	S.E.	z-Stat	Prob.	Coeff.	S.E.	z-Stat	Prob.
C	0.0002	0.0002	1.0906	0.2754	0.1523	0.0254	6.0065	0.0000
AR(1)	-	-	-	-	0.9704	0.0121	80.1471	0.0000
MA(1)	0.2949	0.0331	8.8994	0.0000	-0.8485	0.0257	-32.9664	0.0000
MA(2)	0.2028	0.0375	5.4048	0.0000	-	-	-	-
Variance Equation								
C	0.0000	0.0000	5.0824	0.0000	0.0008	0.0006	1.5110	0.1308
ARCH(1)	0.4461	0.0811	5.5014	0.0000	0.0490	0.0174	2.8129	0.0049
GARCH(1)	0.5888	0.0445	13.2455	0.0000	0.9150	0.0344	26.6124	0.0000
R^2	0.1506				0.1602			
Adj. R^2	0.1461				0.1557			
S.E. of reg.	0.0073				0.1534			
Sum sq. resid	0.0502				22.1229			
Mean dep. var	-0.0003				0.1559			

Source: authors' estimation

Table 3: The Ljung-Box statistics of standardized residuals and squared standardized residuals of daily log returns and of daily illiquidity measures from GARCH models and ARCH-LM test of order 5 and 10.

The Ljung-Box statistics			*ARCH-LM(5)*		*ARCH-LM(10)*	
series	**Q(36)**	**Q^2(36)**	**F-stat**	**Obs*R^2**	**F-stat**	**Obs*R^2**
$R_{M,t}$	57.566 (0.013)	44.320 (0.161)	0.763 (0.576)	3.826 (0.575)	0.593 (0.821)	5.957 (0.819)
$R_{p,t}$	79.915 (0.000)	42.042 (0.226)	0.633 (0.674)	3.177 (0.673)	0.578 (0.833)	5.809 (0.831)
$PI_{M,t}$	34.328 (0.548)	18.248 (0.994)	0.900 (0.481)	4.505 (0.479)	0.539 (0.863)	5.423 (0.861)
$PI_{p,t}$	35.109 (0.511)	33.308 (0.597)	0.565 (0.727)	2.834 (0.726)	0.705 (0.721)	7.076 (0.718)

Notes: $R_{M,t}$ = dlog(BELEX*line*); $R_{p,t}$ = dlog(BELEX15); $PI_{M,t}$ = PI_BELEX*line*; $PI_{p,t}$ = PI_BELEX15. The number in parentheses denotes *p*-value.

Source: authors' estimation

Table 4: A joint estimation of the mean and volatility equations for $R_{M,t}$ - $PI_{M,t}$; The Ljung-Box statistics of standardized residuals and squared standardized residuals and ARCH-LM test of order 5 and 10.

$R_{M,t}$ - $PI_{M,t}$	**GARCH model**			
Mean Equation				
	Coeff.	S.E.	z-Stat	Prob.
C	-0.6413	0.0593	-10.8172	0.0000
AR(1)	0.2563	0.0507	5.0566	0.0000
AR(2)	1.0746	0.0451	23.8189	0.0000
AR(3)	-0.2558	0.0483	-5.2972	0.0000
AR(4)	-0.0919	0.0432	-2.1264	0.0335
MA(1)	0.1517	0.0366	4.1489	0.0000
MA(2)	-0.8417	0.0366	-23.0100	0.0000
Variance Equation				
C	0.0003	0.0004	0.8646	0.3873
ARCH(1)	0.0332	0.0156	2.1245	0.0336
GARCH(1)	0.9357	0.0414	22.6020	0.0000

R^2	0.6629
Adj. R^2	0.6596
S.E.	0.1018
S.S.R.	9.6661
The Ljung-Box statistics	
Q(36)	34.021 (0.280)
$Q^2(36)$	17.470 (0.966)
ARCH-LM(5) test	
F-stat	0.9092 (0.4743)
Obs*R^2	4.5530 (0.4728)
ARCH-LM(10) test	
F-stat	0.5360 (0.8653)
Obs*R^2	5.3925 (0.8635)

Notes: The number in parentheses denotes *p*-value.

Source: authors' estimation

Received: *December 10, 2009*
Revised: *March 1, 2009*
Accepted: *September 15, 2010*