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CAPM augmented with liquidity and size premium in the Croatian stock market

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This article examines the following models: Capital Asset Pricing Model (CAPM) (Sharpe, 1964), and Liquidity CAPM (Hearn, Piesse and Strange, 2009) in the Croatian stock market. We used daily data for the period 2005–2009. The goal of this article is to examine the impact of an overall market factor, factor related to the firm size, and factor of liquidity risk on expected asset returns in the Croatian stock market. We found that Liquidity Capital Asset Pricing Model (LCAPM) model performs better in explaining stock returns than the standard CAPM. Additionally, LCAPM may indeed be a good tool for realistic assessment of the expected asset returns. The combination of company size and illiquidity in asset pricing in the context of the Fama and French cross-sectional framework can improve the description of equilibrium in the Croatian stock market.

Keywords: Capital Asset Pricing Model (CAPM); Liquidity Capital Asset Pricing Model (LCAPM); Equilibrium; liquidity risk; firm size; zero rates (ZR)

JEL classification: G12

1. Introduction

The Croatian stock market is undeveloped and in transition. This market has low levels of liquidity. The economy expanded in 2002, stimulated by a credit boom led by newly privatised and foreign-capitalised banks, some capital investment, and most importantly road construction, further growth in tourism, and gains by small- and medium-sized private enterprises. Since the start of the decade, Croatia has seen consistent economic growth in gross domestic product (GDP) terms until the economy contracted during 2009. GDP increased by an average of approximately 4.25% in each year over the nine years to 2008 but fell by 5.2% in 2009. Foreign direct investment in the period 2000–2009 totalled over €20 billion. This is somewhat better than comparable small new EU countries such as Slovenia and Slovakia, but remains behind the larger accession countries such as Hungary and the Czech Republic. The largest foreign investors in Croatia are Germany, Italy and Austria.[1] In the financial system of the Republic of Croatia, the banks play a dominant role. They are the most active of all the financial institutions in the country, both in terms of the payment system and their presence on all the three financial markets: money, foreign exchange and the capital markets.[2]

Sajter and Ćorić (2009) found high correlation and co-movements between Croatian and American indices. They explained by three concepts: global factors, contagion and

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irrational escalation. They indentified the downward trend of CROBEX in crises, although the Croatian economy did not offer an economic background for this collapse. Irrational escalation perfectly explains the bear orientation of Croatian investors after the beginning of the crisis. Without domestic economic disturbances, Croatian investors reacted completely irrationally; their behaviour was dependent on the news coming from the US (Sajter & Ćorić, 2009). Benić and Franić (2008) compared the Croatian market liquidity with other markets in the region and then compared those results with the German market in order to perceive differences between developing and developed markets. Minović (2012) showed that the level of Croatian market liquidity is very low. She showed that the least illiquid year was 2007 (the pre-crises year), and most illiquid year for Croatia was 2009. Minović (2012) pointed out that the Croatian market was less illiquid than the Serbian market.

Fama and French (1992, 1993) constructs three-factor model. They identify three common risk factors: an overall market factor (the excess market return), factors related to firm size (Small Minus Big [SMB] factor), and factors (High Minus Low [HML] factor) related to the ratio of book to market value (B/M) of companies (Minović and Živković, 2012). They inferred that risks have to be multivariate in rational assessment of stocks. Fama and French (1992) found that HML factor (related with B/M ratio) has stronger impact on average stock returns than SMB factor related to firm size. The firms with high value of B/M (relatively small stock size versus book value) have tendency to have low earnings. Opposite, low value of B/M (relatively big stock size versus book value) is connected with persistent high earnings (Fama and French, 1993), (Minović and Živković, 2012). However, Fama and French (1992) showed that even for developed markets the CAPM does not perform very well. Pros and cons of the CAPM are presented in Campbell, Lo, and MacKinlay (1997) (Minović and Živković, 2010, 2012). Fama and French's results (1992, 1993) significantly improve the performance of the model compared to the single-factor model (CAPM) (Minović and Živković, 2010, 2012). Halliwell, Heaney, and Sawicki (1999), and Gaunt (2004) tested Fama and French model with Australian data. Haugen (2002) tested Fama and French model with American data for the period 1979–1999. Shum and Tang (2005) examined the application of the Fama and French's (1993) three-factor model in three Asian emerging markets (Hong Kong, Singapore and Taiwan). Bundoo (2006) examined Fama and French's model for African emerging market. Rahim and Nor (2006) compared Fama and French's model and Liquidity-Based Three-Factor Models on stocks traded in the Bursa Malaysia. Their results document that three-factor models outperform CAPM, and predicting returns on stocks traded on the Malaysian stock exchange can be slightly improved by incorporating illiquidity risk in a three-factor model. Chan and Faff (2003) examined the role of liquidity in asset pricing in the context of the Fama and French cross-sectional framework in an Australian setting. Hearn et al. (2009) examined the role of company size and illiquidity in asset pricing in the context of the Fama and French cross-sectional framework in emerging African financial markets (Minović and Živković, 2012). Lieksnis (2011) analysed cross-sectional returns of the stocks in the Baltic stock market (Latvia, Estonia and Lithuania). He used the monthly returns of these company stocks for the period: 2002–2010 using the methodology presented in Fama and French (1996). Minović and Živković (2012) showed that the factor related to the ratio of B/M value of companies did not have an important role in asset pricing in Serbia. They found that Liu's two factor LCAPM model performed better in explaining stock returns than the standard CAPM and the Fama and French three factor model. They pointed out that the combination of the Fama and French model and the LCAPM could improve the understanding of equilibrium in the Serbian equity market.

In this article we presented the results of testing CAPM by Sharpe (1964), and LCAPM by Hearn et al. (2009) in the Croatian stock market. We used data from the Zagreb Stock Exchange for the period October 14, 2005–December 31, 2009. To measure illiquidity we chose zero rates (ZR) measure given by Lesmond, Ogden, and Trzcinka (1999). We examined the impact of an overall market factor, factor related to firm size, and factor of liquidity risk on expected asset returns in the Croatian stock market. We used the Ordinary Least Squares (OLS) method in regression analysis in order to estimate CAPM and LCAPM. Various robustness checks are performed. We wish to investigate whether investors are compensated for holding undeveloped-markets' assets whose returns are sensitive to liquidity risk. We found that LCAPM performs better in explaining stock returns than the CAPM. Superiority of LCAPM tells us that high liquidity risk (high level of illiquidity) distorts the basic mechanism of price discovering in the Croatian stock market. Consequently, it is impossible to establish long-run equilibrium on this market (Minović and Živković, 2012).

The hypothesis that we set up for this research is as follows: Standard CAPM has to be augmented with factor of liquidity risk, and factor related to firm size in order to achieve equilibrium in undeveloped markets. It gives LCAPM.[3]

The article is structured as follows. Section 2 presents ZR illiquidity measure and LCAPM by Hearn et al. (2009). Section 3 presents the estimation methodology. Section 4 presents our discussion of the results of the estimation CAPM and LCAPM. It explores the impact of an overall market factor, factor related to firm size, and factor of liquidity risk on expected asset returns in the Croatian market. Section 5 concludes.

2. Modelling illiquidity and size company in a CAPM framework

2.1. The zero-return measure (The LOTs measure)

Lesmond et al. (1999) proposed an illiquidity measure based on the portion of zero return days out of possible trading days. The zero-return measure is the ratio of the number of zero-return days to the total number of trading days in a given month (Lee, 2006). The LOTs measure is defined as follows:

$$ZR_{i,t} \equiv \frac{N_{i,t}}{T_t}, \tag{1}$$

where T_t is a number of trading days in month t and $N_{i,t}$ is the number of zero-return days of stock i in month t (Minović and Živković, 2012).

The economic intuition for the zero return measure is derived from simple trade-offs of the cost and benefit of trading for informed investors: when the trading cost is too high to cover the benefit from informed trading, informed investors would choose not to trade and this non-trading would lead to an observed zero return for that day. Importantly, the zero-return measure is defined over zero-volume days as well as positive volume days since this measure assumes that a zero-return day with positive volume is a day when noise trading induces trading volume (Lee, 2006; Minović and Živković, 2012).

Lesmond (2005), and Bekaert, Harvey and Lundblad (2007) found that each countries liquidity is best measured by the LOTs model. A drawback of the LOTs measure is that it requires a long enough period (i.e. longer than one month) in order to estimate parameters. Moreover a lot of zero-returns (i.e. if there are more than 80% for estimation period) make this measure invaluable. Bekaert et al. (2007) employed the LOTs

measure and they indicated that only this measure is applicable as illiquidity measure for emerging markets.

2.2. LCAPM

Hearn et al. (2009) construct a three-factor model similar to the Fama and French (1993) model. They introduced in the standard CAPM two factors related to firm size (SMB factor) and related to liquidity risk (Illiquid Minus Liquid [IML] factor). Hearn et al. (2009) found that premiums associated with size are more prevalent than liquidity although both are highly significant in both valuation and cost of equity estimates. Their evidence suggests that the lowest cost of equity is achieved in the two major international markets of London and Johannesburg while the less advanced North African markets of Morocco and Egypt have higher costs of equity. The small developing market of Kenya has the highest cost of equity.

Three-factor LCAPM (Hearn et al., 2009) is:

$$E(R_t^p) - R_t^f = \beta_{p,M}\left[E(R_t^M) - R_t^f\right] + \lambda_{p,SMB}E(SMB_t) + \lambda_{p,IML}E(IML_t) \tag{2}$$

with

$$\beta^i = \frac{\mathrm{cov}(\mathrm{R_t^i}, \mathrm{R_t^M})}{\mathrm{var}(R_t^M)} \tag{3}$$

The expected return of security/portfolio i and market are $E(R_t^i)$ and $E(R_t^M)$, respectively. R_f is the risk free rate, the risk premium is $E(R_t^m - R_t^f)$, the systematic undiversifiable risk is β^i. Where SMB is the difference between the return on a portfolio of small-size stocks and the return on a portfolio of large-size stocks. IML is the difference between the return on a portfolio of high illiquidity stocks and the return on a portfolio of low illiquidity stocks. $E(SMB_t)$ is the expected value of the firm size factor, $E(IML_t)$ is the expected value of the related to the liquidity factor, λ_{SMB} are λ_{IML} premiums related with these two factors.

Hearn et al. (2009) formed SMB and IML factors in the following way: they sorted stocks according to the value of market capitalisation (MV) on small and big (50:50). Then, they sorted stocks according to the value Amihud's (2002) illiquidity measure into illiquid and liquid stocks group. They classified stocks on illiquid, neutral and liquid (30:40:30) according to the value of illiquidity measure.

Rahim and Nor (2006) clearly document that market factor alone cannot capture other risks in stocks. The implication on investment is that instead of merely relying on the market factor, investors particularly in this equity market must also be concerned with firm-specific factors like the distress and liquidity levels. They pointed out that investors require additional premiums to compensate risks due to distress and illiquidity, rather than just to compensate risks due to being small. Rationally, being small by itself does not make a company riskier. Rather, it is the company's risk of being in distress and risk of losing liquidity that trigger investors to demand higher than market risk premiums (Minović and Živković, 2012).

3. Estimation methodology

In order to estimate LCAPM (Hearn et al., 2009) and standard CAPM we used the OLS method in regression analysis. In regression analysis we included Heteroskedasticity and

Autocorrelation Consistent Covariances (HAC) method for consistent standard error estimates. The HAC method gives consistent estimates of standard errors in presence strange form of heteroskedasticity and autocorrelation (Minović and Živković, 2012).

As in Minović and Živković (2012), various robustness checks are performed. To check adequacy of the models we used: R^2 determination coefficient, F-test for regression significance, *t*-test for parameters significance in model, Chow's tests of stability parameters[4], tests of residuals analysis of estimated model (Jarque-Bera test and Breusch-Godfrey test) (Mladenović and Petrović, 2002). We have chosen model that best describes equilibrium of the Croatian stock market.

3.1. Data

We have daily data[5] for all stocks[6] listed at the Zagreb Stock Exchange for the period 2005–2009. Daily returns are calculated as difference in log price at closing, as follows:

$$R_t^i = \log(P_t^i) - \log(P_{t-1}^i) = \log\left(\frac{P_t^i}{P_{t-1}^i}\right) \tag{4}$$

where $\log(P_t)$ is log value of stock price on day *t*, and $\log(P_{t-1})$ is log value of stock price on day *t* - 1.

We got data for Croatian Stock Exchange Index (CROBEX)[7]) and for its structure for period 2005–2009, from the Zagreb Stock Exchange (http://zse.hr/). The value-weighted return of this index is calculated using equation (4). In Figure 1 we can see significant decreasing value of this index in the crisis period. Decreased value is the most dominant in the fourth quarter 2008 and the first quarter of 2009.

Treasury Bills (T-bills) are issued by the Republic of Croatia, and observed on the website of the Croatian National Bank[8]. The Republic of Croatia's T-bills are used as the risk-free rate, and they represent the averaged weighted rate[9] for each month (in percent) on an annual basis.[10]

After calculating returns for each stocks and index, we calculated liquidity measures for each stock in each particular month of the observed period. We used ZR return by Lesmond et al. (1999) as a measure of stock illiquidity. In order to obtain and apply the

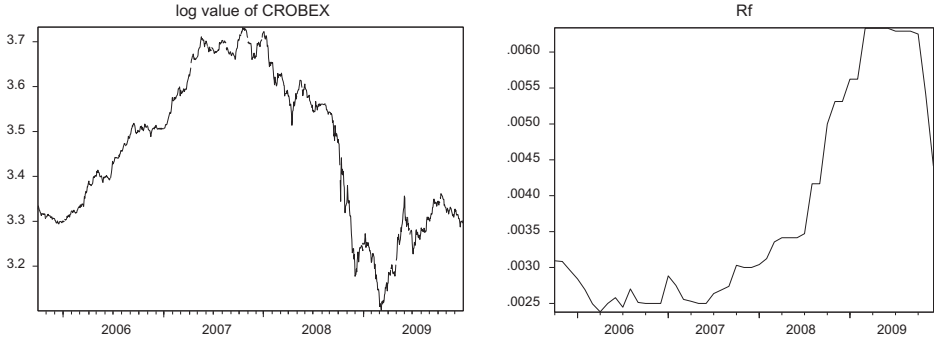

Figure 1. Daily log values of CROBEX index, and average monthly risk free rate or the Republic of Croatia's T-bills (in percent).
Source: Prices data from ZSE and Croatian National Bank. Authors' calculation.

corresponding illiquidity measure, we have written a programme within Microsoft Access package. ZR is calculated for each stock in each particular month. Then, we sorted all stocks in each particular month according to value of ZR in ascending order, using programme. For further analysis we rejected stocks that had ZR in over 80% cases, in each month.[11] The stocks would be grouped in two portfolios. This would be two equally-weighted portfolios consisted of the 20 most liquid and the 20 least liquid stocks. These two portfolios are rebalanced monthly. Daily log returns for CROBEX index, and for both portfolios are presented in Figure 2.

To calculate two factors, SMB and IML we needed data about the number of issued shares and the number of trading days for each shares listed at the Zagreb Stock Exchange in the observed period 2005–2009. We hand-collected the number of issued shares in the Croatian market from ZSE (http://zse.hr/), from annual reports for each stock's ticker.

We could not follow Fama and French's (1993) methodology, because of unavailable book values for all Croatian stocks. We could not find 1/3 of data for book value[12]. Therefore, we see a big problem with empirical analysis in emerging and undeveloped markets, the lack of transparency reports. However Fama and French (1993) factors would not calculate, for that reason we follow the methodology of Hearn et al. (2009). The SMB factor was calculated in a similar way to Fama and French (1993).

The shame of forming factors is similar as French explained on his website[13]. In order to calculate risk factors related to the SMB, we used MV [14] as a proxy to measure size of the companies. Then we sorted all of the sample companies by market capitalisation in each particular month. We formed two portfolios with equal number of stocks (50:50): small size portfolio and big size portfolio, in each month (Minović and Živković, 2012). In order to calculate factor related to liquidity risk (IML factor), we sorted all companies from the sample by ZR measure[15] of stocks within two portfolios based on the market capitalisation (30:40:30).

After that we formed three portfolios based on ZR (illiquid, neutral, and liquid portfolios). In order to calculate MV of stock in year t, we take the number of issued shares[16] in year t -1. Finally, we constructed the six portfolios formed on size and illiquidity measure. In order to obtain SMB and IML factors we have written a programme within Microsoft Access package for sorting stocks according to the value of market capitalisation and according to the ZR measure. In Table 1 we give mean value and standard deviation of the equally-weighted daily portfolio returns formed on size and illiquidity measure.

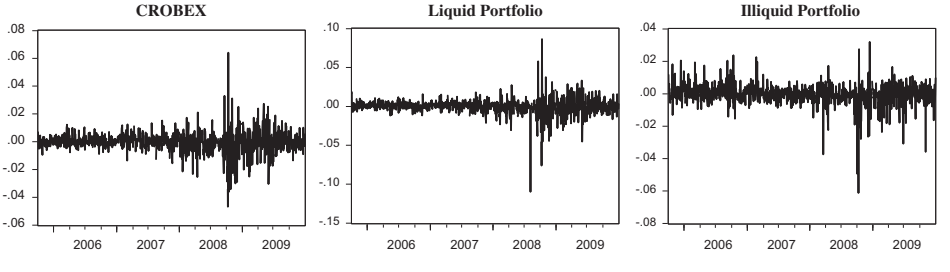

Figure 2. Daily log returns for CROBEX index, liquid, and illiquid portfolio for observed period.
Source: Prices data from ZSE and QuoteStation. Authors' calculation.

Table 1. The mean value and standard deviation of the six equally-weighted daily portfolio returns formed on size and ZR measure. Factors SMB and IML.

(%)	$R^{Small}_{Illiquid}$	$R^{Small}_{Neutral}$	R^{Small}_{Liquid}	$R^{Big}_{Illiquid}$	$R^{Big}_{Neutral}$	R^{Big}_{Liquid}	SMB	IML
$E(R)$	−0.0005	−0.0002	−0.0003	0.0001	−0.0001	0.0000	−0.0003	−0.0000
	0.0073	0.0066	0.0101	0.0071	0.0075	0.0097	0.0057	0.0085

Notes: $E(R)$ = the mean value of returns; σ = the standard deviation. SMB is the factor related to firm size, and it is the average return on the three small portfolios minus the average return on the three big portfolios. IML is the factor of liquidity risk, and it is the average return on the two illiquid portfolios minus the average return on the two liquid portfolios.
Source: Authors' estimation.

From Table 1 we can see that small firms have negative and significantly lower average returns than big firms. The average returns of big firms (liquid and illiquid) have smaller standard deviations than small firms. This can be interpreted in a mean that big companies are potentially less risky than small one.

3.2. Regression factors

We performed regression analysis of the standard CAPM by Sharpe (1964), and LCAPM by Hearn et al. (2009) represented by equations (5) and (6), respectively. Before regression analysis, we tested stationarity of all time-series variables (see Table A2 in Appendix). After determining stationarity of all time-series, regression analysis followed. All regressions were estimated with daily time-series. Results of regressions for investor's liquid and illiquid portfolio are summarised in Table 2.

Models	*Regression equation of static models*	
CAPM	$R^p_t - R^f_t = \alpha_p + \beta_{p,M}(R^M_t - R^f_t) + \varepsilon_{p,t}$	(5)
LCAPM(Hearn et al., 2009)	$R^p_t - R^f_t = \alpha_p + \beta_{p,M}(R^M_t - R^f_t) + \lambda_{p,SMB}SMB_t + \lambda_{p,IML}IML_t + \varepsilon_{p,t}$	(6)

Regression factors are:

R^M_t- The return of the market index CROBEX.

R^p_t- The equally-weighted return of portfolio consisted of 20 liquid and 20 illiquid stocks.

R^f_t- The risk-free rate or the Republic of Croatia's T-bills.

$R^M_t - R^f_t$- The risk premium (the excess market return)

$R^p_t - R^f_t$- The investor's premium (the excess return of liquid or illiquid portfolio)

β- The slope coefficient. In standard CAPM it is systematic risk, and calculates by equation (2).

α- The coefficient of intercept, Jensen's αor abnormal return.

$\varepsilon_{p,t}$- The error term, innovation, shock.

λ_{SMB}, λ_{IML}- The premiums related with market risk factors SMB, and IML, respectively.

SMB_t- Small Minus Big - the factor related to firm size. SMB is the average return on the three small portfolios minus the average return on the three big portfolios. We formed 6 portfolios that are rebalanced in each particular month. SMB factor is calculated by equation:

Table 2. Regression results with daily data for liquid and illiquid portfolio. For market return we used return of CROBEX index.

	α	β	λ_{SMB}	λ_{IML}	(%)	F	BG(6)
Liquid portfolio							
CAPM	0.000[0.000](0.680)	1.151[0.046](0.000)	–	–	71.14	2,595(0.000)	2.248(0.037)
LCAPM (Hearn et al., 2009)	0.000[0.000](0.862)	0.926[0.072](0.000)	−0.008[0.144](0.953)	−0.358[0.121](0.003)	77.09	1,179(0.000)	0.914(0.484)
Illiquid portfolio							
CAPM	−0.000[0.000](0.038)	0.210[0.057](0.000)	–	–	5.99	67.10 (0.000)	3.554 (0.002)
LCAPM (H,P,S,2009)	−0.000 [0.000] (0.275)	0.705 [0.076] (0.000)	0.610 [0.063] (0.000)	0.506 [0.048] (0.000)	47.96	322.9 (0.000)	1.949 (0.100)

Notes: Standard errors of estimated parameters are given in square brackets, and p-values are in parenthesis. Values of determination coefficient (R^2), F-test for regression significance, and Breusch-Godfrey's (BG) test of serial correlation of sixth order are given.
Source: Authors' estimation.

$$SMB = \frac{1}{3}(R^{Small}_{Illiquid} + R^{Small}_{Neutral} + R^{Small}_{Liquid}) - \frac{1}{3}(R^{Big}_{Illiquid} + R^{Big}_{Neutral} + R^{Big}_{Liquid}) \quad (7)$$

IML_t- Illiquid Minus Liquid - the factor of liquidity risk. IML is the average return on the two illiquid portfolios minus the average return on the two liquid portfolios. Portfolios are rebalanced in each particular month. IML factor is calculated by equation:

$$IML = \frac{1}{2}(R^{Illiquid}_{Small} + R^{Illiquid}_{Big}) - \frac{1}{2}(R^{Liquid}_{Small} + R^{Liquid}_{Big}) \quad (8)$$

4. Empirical results

From Table 2 we can see that the coefficient of determination (R^2) for all examined models is significantly higher for LCAPM than for CAPM for both portfolios. All regressions are statistically significant according to F-test. Thus we choose model according to values of R^2, and Breusch-Godfrey (BG) test of serial correlation in residuals. It is evident that only LCAPM (Hearn et al., 2009) has no autocorrelation of sixth order in residuals. This model is only adequate, for both portfolios. In CAPM residuals have autocorrelation at the confidence level of 5%.

According to the values R^2 and BG-test statistic, standard CAPM cannot explain equilibrium of the Croatian stock market. However, useful model for describing equilibrium of this market could be LCAPM (Hearn et al., 2009). The coefficient of determination for this model, for liquid portfolio is about 77%. It means that major part of liquid portfolio return can be explained with variations in the market risk-premium, liquid risk-premium (by the IML factor), while risk-premium of size (by the SMB factor) is not statistically significant. The remaining 23% of variation cannot be explained by this model. In case of illiquid portfolio, risk-premium of size is statistically significant. In both case, dominant factor on returns, in addition to the market risk-premium, has liquid risk-premium.

Estimated equations of selected model are as follows (in parenthesis standard errors of estimated parameters are given):

$$\begin{aligned} &R^p_t - R^f_t = 0.926_{(0.072)} \\ \textit{Liquid portfolio} \quad &\cdot (R^M_t - R^f_t) - 0.358_{(0.121)} \cdot IML_t + \varepsilon_{p,t} R^2 = 0.77; \\ &\mathrm{CBT} = 88.10(0.00);\ \mathrm{CFT} = 1.72(0.00) \end{aligned} \quad (9)$$

$$\begin{aligned} &R^p_t - R^f_t = 0.705_{(0.076)} \\ \textit{Illiquid portfolio} \quad &\cdot (R^M_t - R^f_t) + 0.610_{(0.063)} \cdot SMB_t + 0.506_{(0.048)} \cdot IML_t + \varepsilon_{p,t} R^2 = 0.48; \\ &\mathrm{CBT} = 17.53(0.00);\ \mathrm{CFT} = 1.56(0.00) \end{aligned} \quad (10)$$

Since estimation period cover period of global economic crises, on October 2008, we tested stability of parameters for chosen model using Chow's tests.[17] The results of these two tests are presented in equations (9) and (10). In Chow's tests we entered breakpoint on 1 October 2008.

Value of Chow Breakpoint Test (CBT) for LCAPM tell us that the parameters of estimated function of excess liquid and illiquid portfolio returns are unstable in the whole observed period. The value of Chow Forecast Test (CFT) tells us on the fact that

LCAPM cannot adequately forecast observations in the post-crisis period, until December 2009. This model is estimated again, but for two separated sub-periods, to October 2008, and after October 2008. Results are presented in Table 3.

In Table A3 in Appendix we give results of testing CAPM for two separated sub-periods. Liquid portfolio value of R^2 in the pre-crisis period is about 39%, while in the post-crisis period it is about 93%. Our findings about high value of R^2 in CAPM in the pre-crisis period for liquid portfolio are consistent with evidence by Morck, Yeung and Yu (2000), Jin and Myers (2006). This high value of R^2 is usual in countries with smaller GDP, less developed financial systems and poorer corporate governance (Morck et al., 2000). Moreover an increase in opaqueness (lack of transparency), combined with capture by insiders, leads to lower firm-specific risk for investors and to the higher R^2 (Jin and Myers, 2006). This confirms the fact that in the Croatian stock market insider information has a huge influence on investor's decisions.[18] However, another test-statistics (Q and JB tests) of CAPM suggest about wrong specification of this model (see Table A3). Illiquid portfolio value of R^2 in the both sub-periods is about 6%. Our results confirms fact that classical CAPM have not been developed for to describing pricing of assets (equilibrium) in undeveloped and low liquid markets.

In the pre-crises period, size premium has no role in explaining variation of liquid portfolio return. In this period, market premium and liquidity risk premium have dominant role in explaining variation of liquid portfolio return. After October 2008, the impact of market risk premium is the most dominant, and the impact of size premium increased on the moving prices of liquidity portfolio, while the impact of liquidity risk premium decreased. This is confirmed by the increase of the determination coefficient from 65% to 94% when SMB factor is statistically significant in the post-crisis period, for liquid portfolio. In both sub-periods, all three risk-premiums have significant impact in explaining variation of illiquid portfolio return. All risk factors increased in the post-crisis period on the moving prices of illiquid portfolio. In this period, market risk premium increased for 38%, size premium increased for 30%, and liquidity risk premium increased for 20%. This is confirmed by the increase of the determination coefficient from 31% to 67% when all risk factors increased in the post-crisis period, for the illiquid portfolio.

Table 3. Results of testing LCAPM for two sub-periods, October 2005–September 2008, and October 2008–December 2009.

	Period	α	β	λ_{SMB}	λ_{IML}	(%)	F
Liquid portfolio	04/10/2005-30/09/2008	0.000	0.687	0.225	−0.710	65.31	464.418
		[0.000]	[0.067]	[0.192]	[0.161]		(0.000)
		(0.618)	(0.000)	(0.243)	(0.000)		
	01/10/2008-31/12/2009	0.000	1.171	−0.071	−0.099	93.78	1541.670
		[0.000]	[0.061]	[0.038]	[0.036]		(0.000)
		(0.412)	(0.000)	(0.063)	(0.006)		
Illiquid portfolio	04/10/2005-30/09/2008	0.000	0.514	0.456	0.412	31.14	111.549
		[0.000]	[0.066]	[0.086]	[0.066]		(0.000)
		(0.551)	(0.000)	(0.000)	(0.000)		
	01/10/2008-31/12/2009	−0.000	0.891	0.759	0.615	66.97	207.477
		[0.000]	[0.090]	[0.063]	[0.054]		(0.000)
		(0.025)	(0.000)	(0.000)	(0.000)		

Notes: In square brackets are standard errors of estimated parameters, and in parenthesis are p-values. Values of determination coefficient (R^2), and F-test for regression significance are given.
Source: Authors' estimation.

The parameters of estimated LCAPM by Hearn et al. (2009) are presented with equations (in parenthesis are standard errors of estimated parameters):

Liquid portfolio		
Pre-crisis	$R_t^p - R_t^f = 0.687_{(0.067)} \cdot \left(R_t^M - R_t^f\right) - 0.710_{(0.161)} \cdot IML_t + \varepsilon_{p,t}, R^2 = 65\%$	(11)
Post-crisis	$R_t^p - R_t^f = 1.171_{(0.061)} \cdot (R_t^M - R_t^f) - 0.071_{(0.038)} \cdot SMB_t - 0.099_{(0.036)} IML_t + \varepsilon_{p,t}, R^2 = 94\%$	(12)
Illiquid portfolio		
Pre-crisis	$R_t^p - R_t^f = 0.514_{(0.066)} \cdot (R_t^M - R_t^f) + 0.456_{(0.086)} SMB_t + 0.412_{(0.066)} \cdot IML_t + \varepsilon_{p,t}, R^2 = 31\%$	(13)
Post-crisis	$R_t^p - R_t^f = 0.891_{(0.090)} \cdot (R_t^M - R_t^f) + 0.759_{(0.063)} \cdot SMB_t + 0.615_{(0.054)} \cdot IML_t + \varepsilon_{p,t}, R^2 = 67\%$	(14)

In the post-crisis period, market risk increased (higher value of beta coefficient) for both portfolios. Moreover, in the post-crisis period liquid stocks are risky, because their return rate fluctuate more than average market return rate (the beta coefficient is greater than one). In a post-crisis period, growth return rate of liquid stocks is greater than average return rate, while decline return rate of liquid stocks is pronounced than average return rate. In this period the representative investor who holds the liquid portfolio, has to pay size risk premium of 7.1% (λ_{SMB}) that it was not significant in pre-crises period, has to pay illiquidity risk premium of 10% (λ_{IML}). Negative sign of SMB and IML factors means that big (firms with high capitalisation) and liquid firms impact on liquid segment of the Croatian market. The excess of liquid portfolio returns is decreasing function of market illiquidity (IML factor), in both sub-periods.

In the post-crisis period, the factor of the market risk premium is the most dominant, then SMB factor has the greatest impact as the second one, and then the factor of liquidity risk premium as the third one, on the moving prices of illiquid portfolio. In cases when the representative investor holds the illiquid portfolio, in the post-crisis period, all three risk factors are greater than in pre-crisis period. However, all risk factors significantly increased in the crisis period. Positive signs of SMB and IML factors mean that small and illiquid firms impact on illiquid segment of the Croatian stock market. In the post-crisis period, SMB factor has the greatest impact than illiquidity risk premium (IML factor) on moving stock prices of illiquid stocks.[19]

Kovačević (1998) pointed out the importance of different sized firms in the process of development in Croatia. He told that the process of development is significantly determined by different firm types. Smaller firms are one of the most efficient mechanisms that influence changes in the operative characteristics of the firms on the market. The task was successfully accomplished by small Croatian firms.

Our analysis demonstrates that classical CAPM have been developed to describe pricing of assets (equilibrium) in developed and liquid markets. As the Croatian market is undeveloped and illiquid, we had to add some of the factors in this model, in order to capture some of the characteristics of this market (Minović and Živković, 2012). The results showed that LCAPM by Hearn et al. (2009) could well explain the mechanism of price discovering and equilibrium of the Croatian stock market. Our analysis demonstrates that liquidity risk and size premium have significant impact on price formation in Croatia. Results showed that there is significant impact of liquidity risk (IML factor) on price formation in the Croatian market. Thus, hypothesis that CAPM has to

be augmented with factor of liquidity risk, and factor related to firm size in order to achieve equilibrium in undeveloped markets cannot be rejected.[20]

5. Conclusion

In this article we tested standard CAPM by Sharpe (1964) and Liquidity CAPM by Hearn et al. (2009) in the Croatian stock market. We used data from the Zagreb Stock Exchange for the period from October 14, 2005 to December 31, 2009. To measure illiquidity we choose ZR returns by Lesmond et al. (1999). We examined the impact of an overall market factor, factor related to the firm size, and factor of liquidity risk on expected asset returns in the Croatian market. We used the OLS method in regression analysis in order to estimate factor models. Our results showed that LCAPM performs better in explaining stock returns than the CAPM. It is because classical CAPM does not capture liquidity risk that is the key problem on such small and undeveloped markets. As in Minović and Živković (2012), superiority of LCAPM tells us that high liquidity risk (high level of illiquidity) distorts the basic mechanism of price discovering in the Croatian stock market. Consequently, it is impossible to establish long-run equilibrium on this market. Our results showed that liquidity risk and firm size have significant impact on price formation in Croatia. This finding coincides with finding by Minović and Živković (2012) for Serbia. Results showed that excess liquid portfolio return is decreasing function of market illiquidity, while excess illiquid portfolio return is increasing function of market illiquidity. In the pre-crisis period, market premium and liquidity risk premium have dominant role in explaining variation of liquid portfolio return. After October 2008, the impact of market risk premium is the most dominant, and the impact of size premium increased on the moving prices of liquidity portfolio, while the impact of liquidity risk premium decreased. In both sub-periods, all three risk-premiums have significant impact in explaining variation of illiquid portfolio return. All risk factors increased in the post-crisis period on the moving prices of illiquid portfolio. Results showed that excess liquid portfolio return is decreasing function of firm size (in the post-crisis period), while excess illiquid portfolio return is increasing function of firm size. Two factors (SMB and IML) significantly improve ability of model to explain asset returns variations. As a conclusion we can say that the combination of company size and illiquidity in asset pricing in the context of the Fama and French cross-sectional framework can improve the description of disequilibrium in the Croatian stock market. Recently, Minović and Živković (2012) showed similar findings for the Serbian stock market.

Future research should examine the impact of time-varying liquidity risks on expected asset returns in the Croatian stock market (conditional version of LCAPM)[21]. Testing the dynamic LCAPM should give to us an opportunity to investigate the effect of illiquidity on asset prices through four forms of various undiversifiable risks over time. It is interesting to consider the impact of different holding periods on liquidity, too.

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Notes

1. http://emergingmarketproperty.co.uk/aboutcroatia.pdf (accessed December 1, 2011).
2. http://www.hnb.hr/financijska_stabilnost/efinancijka_sustav.htm (accessed December 1, 2011).
3. A similar hypothesis is tested by Minović and Živković (2012) in the Serbian stock market, and with another type of LCAPM.
4. Chow's tests of stability parameters applied because observed sample period cover period of global economic crises. The changes in economic environment are reflected on the value of parameters in regression models. The analysis of stability parameters is required to check reliability in forecasting (Mladenović and Petrović, 2002).
5. Prices got on request from QuoteStation, http://www.quotestation.com/ (accessed January 25, 2010).
6. In the period October 14, 2005–December 31, 2009 at the Zagreb Stock Exchange listed about 350 stocks.
7. CROBEX is the official Zagreb Stock Exchange share index. The ZSE started publishing it on September 1, 1997. CROBEX is weighted by free float adjusted market capitalisation. The weight of any individual issuer in CROBEX is limited to 15% of the index capitalisation. If a stock was not traded on the given day, the previous last price is used (http://www.zse.hr/default.aspx?id=10,924) (accessed November 25, 2011).
8. http://www.hnb.hr/publikac/prezent/spf-tablice/t-bill_and_bnd_yield.xls (accessed July 20, 2010).
9. For months without given data we have carried out extrapolation between two points in months when the data was available.
10. Aiming at evaluation of different factor models with daily data we have divided the observed T-bills rate by 360.
11. A lot of ZRs (i.e. if there are more than 80% for estimation period) make this measure invaluable.
12. The book value data for 2/3 stocks are hand collected from the Zagreb Stock Exchange (http://zse.hr/) from annual reports for each ticker of stocks. Data were requested at the court register of the Ministry of Justice of the Republic of Croatia (https://sudreg.pravosudje.hr/Sudreg/index.jsp). None of all necessary data, as firms are not timely submitted their data.
13. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html
14. Share price × number of shares outstanding.
15. We sorted stocks according to value of ZR that had zero returns in smaller 80% cases, while for further analysis we rejected stocks that had zero returns in over 80% cases, in each month.
16. Data about number of share outstanding are hand collected from website of the Zagreb Stock Exchange (http://zse.hr/) from annuly reports for each ticker of stocks.
17. Chow's tests of stability parameters are applied on CAPM. This model showed extreme instability of the parameters, and this model could not forecast observation in the post-crisis period.
18. These findings coincide with findings for Serbian stock market by Minović and Živković (2012).
19. Hearn et al. (2009) acquired similar result for four major emerging African markets: South Africa, Kenya, Egypt and Morocco.
20. Minović and Živković (2012) acquired similar results for the Serbian stock market, but with different factors and models.
21. Minović and Živković (2010) examined conditional LCAPM of Acharya and Pedersen (2005) in the Serbian stock market. As the measure of illiquidity they used the price impact measure suggested by Bekaert et al. (2007).

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Appendix

Table A1. Descriptive statistics for daily log data, then for daily log returns of the CROBEX index, liquid, and illiquid portfolio. Descriptive statistics for daily time series of SMB and IML factors.

	Series	*E(R)*	Max	Min	σ	*S*	K	JB	Prob.
CROBEX	$P_{M,t}$	3.456	3.732	3.101	0.167	−0.025	1.777	65.887	0.000
	$R_{M,t}$	−0.000	0.064	−0.047	0.008	−0.096	12.345	3840.854	0.000
Liquid portfolio	$R_{p,t}$	0.000	0.087	−0.110	0.010	−1.232	24.781	21120.44	0.000
Illiquid portfolio	$R_{p,t}$	−0.000	0.032	−0.061	0.006	−1.604	17.366	9524.918	0.000
Factors	SMB_t	−0.000	0.033	−0.073	0.006	−3.011	38.136	55915.69	0.000
	IML_t	−0.000	0.103	−0.057	0.009	2.104	32.268	38470.01	0.000

Notes: $P_{M,t}$ = logCROBEX, $R_{M,t}$ = dlog(CROBEX); $R_{p,t}$ is log portfolio return of the most 20 liquid and the 20 illiquid stocks. SMB_t is the factor related to firm size, and it is the average return on the three small portfolios minus the average return on the three big portfolios. IML_t is the factor of liquidity risk, and it is the average return on the two illiquid portfolios minus the average return on the two liquid portfolios. $E(R)$ = the mean value; σ = the standard deviation, S = the coefficient of skewness; K = the coefficient of kurtosis; JB = the Jarque-Bera test.
Source: Authors' estimation.

Table A2. The results of testing a unit root in daily time series for log data, log returns of the CROBEX index, the liquid and illiquid portfolios, SBM and IML factors, respectively. The null hypothesis H_0: unit root exists in the process (for example $R_{M,t}$~I(1)); the alternative hypothesis: the process is stationary (for example $R_{M,t}$~I(0)).

	Series	ADF Test	level	Critical Value	H_0
CROBEX	$P_{M,t}$	−1.30	5%	−3.41	accepted
	$R_{M,t}$	−16.53	5%	−3.41	*rejected*
	$R_{M,t}$-$R_{f,t}$	−16.53	5%	−3.41	*rejected*
Liquid portfolio	$R_{p,t}$	−17.40	5%	−3.41	*rejected*
	$R_{p,t}$-$R_{f,t}$	−17.41	5%	−3.41	*rejected*
Illiquid portfolio	$R_{p,t}$	−32.22	5%	−3.41	*rejected*
	$R_{p,t}$-$R_{f,t}$	−32.23	5%	−3.41	*rejected*
Factors	SMB_t	−26.02	5%	−3.41	*rejected*
	IML_t	−26.18	5%	−3.41	*rejected*

Notes: $P_{M,t}$ = logCROBEX, $R_{M,t}$ = dlog(CROBEX); $R_{p,t}$ is log portfolio return of the most 20 liquid and the 20 illiquid stocks. SMB_t is the factor related to firm size, and it is the average return on the three small portfolios minus the average return on the three big portfolios. IML_t is the factor of liquidity risk, and it is the average return on the two illiquid portfolios minus the average return on the two liquid portfolios.
Source: Authors' estimation.

Table A3. Results of testing CAPM for two sub-periods, October 2005–September 2008, and October 2008–December 2009.

CAPM	Period	α	β	R^2(%)	F	Q (36)	JB
Liquid portfolio	04.10.2005-30.09.2008	0.004 [0.000] (0.857)	0.919 [0.082] (0.000)	39.19	478.121 (0.000)	55.773 (0.002)	779,046 (0.000)
	01.10.2008-31.12.2009	0.000 [0.000] (0.150)	1.267 [0.036] (0.000)	93.37	4,349 (0.000)	59.130 (0.009)	42.584 (0.000)
Illiquid portfolio	04.10.2005-30.09.2008	0.001 [0.000] (0.683)	0.246 [0.045] (0.000)	5.99	47.300 (0.000)	73.362 (0.000)	737 (0.000)
	01.10.2008-31.12.2009	−0.002 [0.000] (0.025)	0.184 [0.084] (0.030)	5.81	19.065 (0.000)	50.297 (0.006)	1,136 (0.000)

Notes: Standard errors of estimated parameters are in square brackets and p-values are in parentheses. Values of determination coefficient (R^2), F-test for regression significance, Ljung-Box (Q-test) statistics of residuals, and Jarque-Bera (JB) test of normality of residuals are given.
Source: Authors' estimation.