# TEST OF THE CHEN-ROLL-ROSS MACROECONOMIC FACTOR MODEL: EVIDENCE FROM CROATIAN STOCK MARKET

**Denis Dolinar**[1]
**Silvije Orsag**
**Paola Suman**

**Abstract**

This paper empirically examines the well-known Chen-Roll-Ross model on the Croatian stock market. Modifications of definitions of the Chen-Roll-Ross model variables showed as necessary because of doubtful availability and quality of input data needed. Namely, some macroeconomic and market variables are not available in the originally defined form or do not exist. In that sense this paper gives some alternative definitions for some model variables. Also, in order to improve statistical analysis, in this paper we have modified Fama-MacBeth technique in the way that second-pass regression was substituted with panel regression analysis. Based on the two-pass regression analysis of returns of 34 Croatian stocks on 4 macroeconomic variables during the seven-and-half-year observation period the following conclusion is made. In contrast to the results of Chen, Roll and Ross (1986) for the U.S. stock market, their model is not successful when describing a risk-return relation of Croatian stocks. Nevertheless, one observed version of the Chen-Roll-Ross model showed certain statistical significance. Namely, two risk factors in that version of the model were statistically significant: default premium, measured as risk premium for the corporate short-term bank loan financing, and term structure premium, measured on short-run basis.

Keywords: Chen-Roll-Ross, macroeconomic factor model, systematic risk, risk-return, stock market.

## INTRODUCTION

During the last sixty years the search for common risk factors in the returns on stocks and bonds has been of great interest for researchers in the field of investment analysis

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[1] **Denis Dolinar**, PhD, Senior Teaching and Research Assistant; **Silvije Orsag**, PhD, Full Professor; **Paola Suman**, MSc., Teaching and Research Assistant, Faculty of Economics and Business, University of Zagreb, Croatia.

and corporate finance. Because of their simple use, development possibilities and easy interpretation, the linear factor models have immediately become very popular in scientific papers when describing securities return-generating process. Up to now a great number of factor models has been developed — primarily for the developed capital markets. Emerging capital markets, like Croatian, bear their own specifics and are characterized by a lower overall level of development. In addition, there is a very small number of researchers and scientific papers that explore return-generating process or develop asset pricing models for those markets. The aim of this paper is to test the well-known Chen-Roll-Ross model of stock returns for Croatia and to give a starting point for development of country-specific macroeconomic factor models.

The remainder of this paper is organized as it follows. The next section in short discusses the position of macroeconomic factor models within the modern portfolio theory. The section after that is the central part of the paper. It gives a quick review of the Croatian stock market and presents the data, data sources, variable definitions, used methods, and results of regression analysis. The last section concludes the paper.

# 1. MACROECONOMIC FACTOR MODELS

## 1.1. About Factor Models

The objective of modern portfolio theory is to provide the means by which an investor can identify his or her optimal portfolio (Sharpe, Alexander, and Bailey 1999, 256). Modern portfolio theory is characterized by the use of wide range of models that imply interaction of both, company business performance and capital market (Orsag 2011, 427). The first task in the investment process is security and market analysis, by which the risk and expected return attributes of the entire set of possible investment vehicles are assessed (Bodie, Kane, and Marcus 2001, 154). Risk reduction through diversification, as a major motive for portfolio creation, is based on the assumption that the total risk of every security can be separated into two parts: the systematic risk and the specific risk. Since the specific risk of individual securities can be significantly reduced or even eliminated through portfolio construction, the systematic risk of a security is the only one relevant and thus determines the expected return of a security.

Factor models are statistical models that assume that the return on a security is sensitive to the movements of various risk factors. A general representation of factor models is given by the following equation (Sharpe 1984, 21):

$$r_{it} = a_i + \sum_{k=1}^{K} b_{ik}F_{kt} + e_{it} \qquad (1)$$

where $r_{it}$ represents the return on security $i$ in period $t$, $F_{kt}$ represents the value of factor $k$ in period $t$, $b_{ik}$ indicates the sensitivity of the return on the security $i$ to the values of factor $k$, and $a_i$ represents the constant non-factor-related return on security $i$. The last term, $e_{it}$, represents the portion of the return of security $i$ that is unrelated to the specified factors and which expected value is taken to be zero. It is often termed the security-specific or the non-factor-related return.

Factor models attempt to capture the major economic forces that systematically move the prices of all securities (Sharpe, Alexander, and Bailey 1999, 256–257). Risk factor selection tends to limit on those factors that seem likely to be important, that is, factors that concern investors sufficiently that they will demand meaningful risk premiums to bear exposure to those sources of risk (Bodie, Kane, and Marcus 2001, 311). Depending on the nature of risk factors Sharpe, Alexander and Bailey (1999, 270–275) point out three statistical approaches when estimating factor models: time-series approaches (mostly related to macroeconomic factors), cross-sectional approaches (mostly related to fundamental factors) and factor-analytic approaches (which use factor analysis). Special forms of factor models like Capital asset pricing model (CAPM) and Arbitrage pricing theory (APT) are models developed from the theories of capital market that assume capital market equilibrium and imply a great number of assumptions (Orsag 2011, 445, 464). Great contribution for the development of the concept of factor models had following researchers: Markowitz (1959), Sharpe (1963), King (1966), Cohen and Pogue (1967), Feeney and Hester (1967), Elton and Gruber (1973), Fama and MacBeth (1973), Farrell (1974), Rosenberg and Marathe (1976), Roll and Ross (1980), Arnott (1980), Chen, Roll and Ross (1986), Fama and French (1993), and many others.

## 1.2. Macroeconomic Risk Factors

In a macroeconomic factor model the systematic risk factors are defined by economic theory and observed externally to the security returns data (Connor 1995, 43). Representation of returns in the macroeconomic factor model assumes that the returns to each asset are correlated with only the surprises in some factors related to the aggregate economy. A factor surprise is the component of the factor return that was unexpected, and the factor surprises constitute the model independent variables (DeFusco et al. 2012, 423). In practice, the usefulness of any factor for explaining asset returns is generally evaluated using historical data. Confidence that a factor will explain future returns increases if we can give an economic explanation of why a factor should be important in explaining average returns (DeFusco et al. 2012, 434).

Macroeconomic indicators that consistently capture significant fractions of common movement of stock prices are of great interest for researchers. Although all macroeconomic indicators are mutually related, Tangjitprom (2012, 105–107) separates them into following four groups: (1) general economic condition and business cycle factors, (2) market related factors, (3) monetary policy related factors and (4) internationally related factors. As the proxy of general economic condition and business cycle the following variables are usually used: employment, GDP, industrial production index, etc. As the market related factors the following variables are used: government bond yield, corporation bond yield, yield on the stock market index, price of commodities (like crude oil), etc. Among the monetary policy related factors the most common are: inflation (presented via consumer price index or some other price index) and money market interest rate. International sections of economy are usually presented throughout the foreign exchange rate. Consequently, the variety of possible combinations of macroeconomic indicators, with different geographical- or time-coverages, and performed with different statistical techniques, result with a huge number of scientific papers, often with inconsistent findings.

### 1.3. Macroeconomic Factor Models in Practice

Macroeconomic factor models gained the biggest attention during the 1980s, especially after the papers of Chan, Chen and Hsieh (1985), and Chen, Roll and Ross (1986). Macroeconomic factor models are the simplest and the most intuitive type of factor models. They use observable economic time-series as a measure of the pervasive factors in security returns. A security's linear sensitivities to the factors are called the factor betas or factor loadings (Connor 1995, 42). Usually, macroeconomic factor models were developed as an extension of the Sharpe's (1963) single-index market model (Zangari 2003, 344). Relevant financial literature emphasizes following macroeconomic factor models: Chen-Roll-Ross (CRR), Burmeister-Roll-Ross (BIRR) and Salamon-Smith-Barney (Salamon RAM). All of them are designed and tested for the U.S. stock market.

Chen, Roll and Ross (1986) pioneered the development of macroeconomic factor models. They found several economic variables to be significant in explaining expected stock returns, most notably, industrial production (MP), changes in the risk premium (URP), twist in the yield curve (UTS), and, somewhat more weakly, measures of unanticipated inflation (UI) and changes in expected inflation (DEI) during periods when these variables were highly volatile. The most striking result of the Chen, Roll and Ross (1986) paper is that even though a stock market index explains a significant portion of the time-series variability of stock returns, it has an insignificant influence on pricing when compared against the economic state variables. Chen, Roll and Ross (1986) also examined the influence on pricing of exposure to innovations in real per capita consumption and changes of an index of oil price. For both variables no overall effect was found. Final representation of the Chen-Roll-Ross model is given by the following equation:

$$r_{it} = a_i + b_{iMP}MP_t + b_{iDEI}DEI_t + b_{iUI}UI_t + b_{iUPR}UPR_t + b_{iUTS}UTS_t + e_{it} \qquad (2)$$

Additional contribution of the the Chen-Roll-Ross model is that it became template for many following papers, e.g. Berry, Burmeister and McElroy (1988), Burmeister, Roll and Ross (1994), and Connor (1995).

### 1.4. Factor Models and Emerging Markets

Up to nowadays a huge number of papers has been published regarding systematic risk factors and factor models. Most of them were focused on developed capital markets. Emerging capital markets bear their own specifics that need to be taken into account. Thus, Beckers et al. (1992) and Serra (2002) find that a country or a local market exposure has significant power when explaining stock returns. Usually specifics of emerging capital markets are explained by the following four circumstances: (1) home bias of the investors (investor myopia), (2) reduced influence of globalisations trends, (3) lower level of market efficiency, and (4) lower level of economic development.

Most of the research on emerging stock markets are recent and have been made on a level of aggregated data. Only a small portion is based on a level of individual stocks. However, according to Serra (2002, 4) systematic risk factors that drive cross-sectional differences in expected stock returns in emerging markets are qualitatively similar to those that have been found in developed markets.

## 2. TESTING THE CHEN-ROLL-ROSS MODEL IN CROATIA

### 2.1. Croatian Stock Market

The Zagreb Stock Exchange (ZSE) represents the central Croatian equities marketplace, where stocks of Croatian companies, as well bonds and commercial bills, are traded. The ZSE was first established in 1907. The modern ZSE in its present form was reestablished in 1991. During the last 20 years the ZSE has experienced huge development in both, technological and trading aspect. As of December 31, 2014, market capitalization of listed companies on the ZSE is 126.22 billion kunas (US\$ 20.03 billion).

From 2005 to 2007 Croatian and regional capital markets were under the influence of investors optimism. Thus, a significant increase was realized in both, turnover and growth sense. After 2007 this equity boom ended and upcoming economic crisis has taken its place. Growing risk aversion among investors struck stock indices and market liquidity. Namely, the CROBEX index declined in 2008 by 67%, while stock market turnover is reduced by more than 3 times on average after 2008. Figure 1 shows strong market contraction in the period from 2007 to 2013.[2]
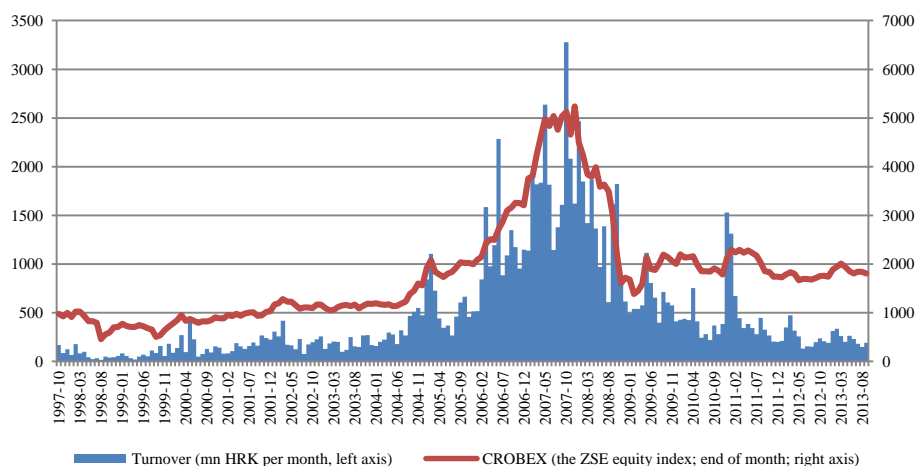


**Figure 1.** The ZSE trading statistic
*Source:* Zagreb stock exchange

### 2.2. Data selection and data sources

This paper focuses on the stocks that are (or were) listed on the Zagreb Stock Exchange in the period from January 2007 till June 2014. Not all stocks were chosen for the factor model testing. 34 stocks were selected as an intersection of four criteria during the pre-observed period (from October 2004 till October 2013): (1) stock is common; (2) stock issuer is nonfinancial company; (3) stock has trading history of at least 24 quarters and more, and (4) stock liquidity is in the top 50. This way the research is exclusively focused

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[2] Bogdan, Baresa, and Ivanovic (2010), Bogdan, Baresa, and Ivanovic (2012) and Ivanovic, Baresa, and Bogdan (2013) give broader insight of the Croatian stock market.

on the segment of stocks that define stock market in its true meaning, and whose observation can enable identification of systematic risk factors. Selected stocks altogether account only 13% of total number of stocks, but around 50% of total market capitalization and more than 75% of total turnover of stocks on the ZSE.

Main data sources for this research were: Zagreb Stock Exchange (ZSE), Central Depository & Clearing Company (SKDD), Croatian National Bank (HNB), Croatian Bureau of Statistics (DZS) and Ministry of Finance of the Republic of Croatia (MFRH). Exact data source for every variable of the model is clearly noted in the text below.

## 2.3. Definition of variables and necessary modifications

Unlike Chen, Roll and Ross (1986), this paper uses monthly returns when estimating factor sensitivities (betas) and quarterly returns when estimating factor premiums. There are two reasons for switching to quarterly observations: (1) quarterly returns correspond with realises of certain macroeconomic indicators, and (2) the Croatian stock market liquidity is not on the level of developed stock markets, thus monthly returns could be perceived less relevant. Observed stock returns are total returns and defined as an excess return (ie. stock return above the risk free rate).

In relation to the originally defined Chen-Roll-Ross model several major modifications had to be made to the sources and definitions of variables (ie. factors), mainly because of the country specifics. Table 1 consolidates necessary modifications and observed alternatives of definitions of variables. Used data, data sources and definitions of variables are noted in the Table 2.

**Table 1.** Necessary modifications and observed alternatives in the process of establishing a time-series of the Chen-Roll-Ross model variables

|  | Original paper (Chen, Roll, and Ross 1986) | Necessary modifications and observed alternatives in this paper | Reason(s) for modification |
|---|---|---|---|
| **Inflation as risk factor** | Two risk factors: unanticipated inflation (UI) and changes in expected inflation (DEI). | Alternative A1 – Estimated inflation for some time period (INFM). Alternative A2 – Change in inflation between two time periods (INFCM). | It is not possible to include originally defined variables (UI and DEI) in this research, since their time-series is not known (not estimated) in Croatia. In spite of this, inflation as a risk factor is incorporated in the model through one of the two alternatives. |
| **Risk (default) premium** | An unanticipated changes in risk premium (URP) is estimated as a difference between the low-grade ("Baa and under") corporate bond return and the return on a portfolio of long-term government bond. | Alternative B1 – Risk premium for the corporate long-term bank loan financing (DPLKM). Alternative B2 – Risk premium for the corporate short-term bank loan financing (DPSKM). Alternative B3 – Risk premium for the corporate long-term bank loan financing denominated in foreign currency (DPLEM). | Croatian capital market is poorly developed in respect of corporate bonds financing. Thus realised corporate bond prices and yields could not be taken as relevant indicators of investor's sentiment. On the contrary, bank loan financing is well developed. Namely, bank loan is the primary instrument of corporate debt financing in Croatia. |

**Table 1.** (*continued*)

|  | Original paper (Chen, Roll, and Ross 1986) | Necessary modifications and observed alternatives in this paper | Reason(s) for modification |
|---|---|---|---|
| **Term structure premium** | An unanticipated changes in term structure premium (UTS) is estimated as a difference between the return on a portfolio of long-term government bond and the Treasury-bill rate. | Alternative C1 – Long-run term structure premium (TPLKM). Alternative C2 – Short-run term structure premium (TPSKM). Alternative C3 – Long-run term structure premium based on financial instruments denominated in foreign currency (TPLEM). | Croatian capital market is poorly developed in respect of government bond market liquidity. Thus term structure premium is not possible to estimate as usual. Alternatives 1 and 3 are based on yield curve modelling, while alternative 2 is focused on observing shorter time periods. |

**Table 2.** Used data, data sources and definitions of variables

| Symbol | Variable / Factor | Source / Definition |
|---|---|---|
| | *Basic Series* | |
| PPS | Price per share (end of month/quarter) | ZSE |
| DPS | Dividends per share | ZSE, SKDD |
| TB03 | Three-month treasury-bill rate (yield at the moment of issuing; proxy for the risk free rate) | MFRH, HNB |
| TB12 | Twelve-month treasury-bill rate (yield at the moment of issuing) | MFRH, HNB |
| EBOR | Three-month Euribor rate | EMMI |
| IPI | Industrial production volume index (seasonally adjusted) | HNB, DZS |
| CPI | Consumer price index (seasonally adjusted) | HNB, DZS |
| LELD | Interest rate on long-term bank loans to enterprises (domestic currency) | HNB |
| SELD | Interest rate on short-term bank loans to enterprises (domestic currency) | HNB |
| LELF | Interest rate on long-term bank loans to enterprises (loans denominated in foreign currency (Euro)) | HNB |
| YCD012 YCD120 | Estimate of yield curve for government securities (12 month and 120 month yield rate; denominated in domestic currency; Nelson-Siegel model) | Zoricic and Badurina (2013), Zoricic and Orsag (2013) |
| YCF012 YCF120 | Estimate of yield curve for government securities (12 month and 120 month yield rate; denominated in foreign currency (Euro); Nelson-Siegel model) | Zoricic and Badurina (2013), Zoricic and Orsag (2013) |
| | *Derived Series* | |
| $R_{i,t}$ | Monthly/quarterly return of stock i (dependent variable) | $((DPS_{i,t}+PPS_{i,t})/PPS_{i,t-1}-1)-TB03_t$ |
| $INDM_t$ | Industrial production (monthly growth) | $IPI_t/IPI_{t-1}-1$ |
| $INFM_t$ | Inflation (change of CPI on a monthly level; Alternative A1) | $CPI_t/CPI_{t-1}-1$ |
| $INFCM_t$ | Change of inflation (on a monthly level; Alternative A2) | $INFM_t-INFM_{t-1}$ |
| $DPLKM_t$ | Default risk premium (Alternative B1) | $LELD_t-TB03_t$ |
| $DPSKM_t$ | Default risk premium (Alternative B2) | $SELD_t-TB03_t$ |
| $DPLEM_t$ | Default risk premium (Alternative B3) | $LELF_t-EBOR_t$ |
| $TPLKM_t$ | Term structure premium (Alternative C1) | $YCD120_t-YCD012_t$ |
| $TPSKM_t$ | Term structure premium (Alternative C2) | $TB12_t-TB03_t$ |
| $TPLEM_t$ | Term structure premium (Alternative C3) | $YCF120_t-YCF012_t$ |

## 2.4. Methodology

To ascertain whether the macroeconomic variables are related to the underlying factors that explain pricing in the Croatian equity market, like Chen Roll and Ross (1986), a

version of the Fama-MacBeth (1973) technique was employed. The procedure has two phases: first- and second-pass regression analysis. First-pass regressions examine the significance of factor sensitivities (betas), by regressing time-series of stock returns on the macroeconomic variables. Second-pass regressions examine the significance of factor risk premiums, by regressing cross-section of stock returns on the resulting estimates of factor sensitivities (betas) from the first-pass regressions.

In this research first-pass regressions are based on three-year time-series of monthly observations. These regressions enable multivariate estimation of factor sensitivities (betas) for each stock, each time period (quarter) and each risk factor (variable) in the model. In other words, for each stock and each risk factor time-series of factor sensitivities were estimated. Differences in factor sensitivities between stocks and time periods point out the fact that different stocks react differently to market changes and that systematic risk of some stock can change over time.

In this research second-pass regression analysis is based on quarterly observations. Also, Fama-MacBeth technique was modified in the way that second-pass regression was substituted with panel regression analysis.[3] We find three reasons for doing so: (1) estimated factor sensitivities from first-pass regression can take a form of a panel, (2) panel analysis has numerous statistical advantages,[4] and (3) it is easier to test statistical significance of factor premiums since panel analysis also incorporates time dimension of observations.[5] In addition, special care was taken when defining the form of a panel model. Finally, the fixed effect panel model was chosen, whereby the time is a panel variable. This form of a panel model is consistent with theoretical background of the Fama-MacBeth technique and with the nature of data in the analysis. This way, the constant parameter of the model changes in every time period, but is fixed in relation to observed entities (ie. stocks). Equation 3 presents a general form of a panel model in this research.

$$y_{it} = \alpha_t + \sum_{k=1}^{K} \beta_k x_{itk} + \varepsilon_{it} \tag{3}$$

Significance of risk factors within the Chen-Roll-Ross factor model is based on the absolute values of t-statistic of factor premiums (ie. estimated parameters in the second-pass regression).[6] Thus, the Chen-Roll-Ross factor model could be perceived as valid if all risk factors (macroeconomic variables) within the model are statistically significant.[7]

## 2.5. Empirical results

Since we use several indicators as alternatives for some model variables and since there is a great number of possible combinations of these indicators, in this research we have focused only on six alternative representations of the Chen-Roll-Ross model for the

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[3] Similar approach was used by Amihud, Christensen and Mendelson (1992). They called it AM methodology.

[4] Andreß, Golsch and Schmidt (2013) give detail explanations of these advantages.

[5] Thus it is sufficient to rely on standard t-statistic of estimated parameters (ie. factor premiums).

[6] Higher absolute value of t-statistic is indication of higher absolute value of the estimated factor premium (coefficient) and/or lower value of its standard error.

[7] In this research 90% confidence level is assumed.

Croatian stock market. Equations 4 to 9 present these observed alternatives and were the base for doing the first-pass regressions.

$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFM\,t}INFM_t + b_{i\,DPLKM\,t}DPLKM_t + b_{i\,TPLKM\,t}TPLKM_t + e_{it} \quad (4)$$
$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFCM\,t}INFCM_t + b_{i\,DPLKM\,t}DPLKM_t + b_{i\,TPLKM\,t}TPLKM_t + e_{it} \quad (5)$$
$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFM\,t}INFM_t + b_{i\,DPSKM\,t}DPSKM_t + b_{i\,TPSKM\,t}TPSKM_t + e_{it} \quad (6)$$
$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFCM\,t}INFCM_t + b_{i\,DPSKM\,t}DPSKM_t + b_{i\,TPSKM\,t}TPSKM_t + e_{it} \quad (7)$$
$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFM\,t}INFM_t + b_{i\,DPLEM\,t}DPLEM_t + b_{i\,TPLEM\,t}TPLEM_t + e_{it} \quad (8)$$
$$r_{it} = a_{it} + b_{i\,INDM\,t}INDM_t + b_{i\,INFCM\,t}INFCM_t + b_{i\,DPLEM\,t}DPLEM_t + b_{i\,TPLEM\,t}TPLEM_t + e_{it} \quad (9)$$

Here $b_{ikt}$ represents the sensitivity of the security $i$ in month $t$ to some risk factor $k$ and $a_{it}$ represents the constant non-factor-related return on security $i$ in month $t$. Since second-pass regression analysis is on quarterly basis, factors sensitivities were not estimated for all twelve months in a year, but only for the last month in the quarters (ie. for March, June, October and December).

After all factor sensitivities had been estimated,[8] the starting point for second-pass regression analysis was established. Equations 10 to 15 present the base for estimation of factor premiums, $\lambda_k$, within the Chen-Roll-Ross model. Panel regression analysis (estimated parameters and test values) for all six observed modifications of the Chen-Roll-Ross model are presented in table 3.

$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFM}b_{i\,INFM\,t-1} + \lambda_{DPLKM}b_{i\,DPLKM\,t-1} + \lambda_{TPLKM}b_{i\,TPLKM\,t-1} + e_{it} \quad (10)$$
$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFCM}b_{i\,INFCM\,t-1} + \lambda_{DPLKM}b_{i\,DPLKM\,t-1} + \lambda_{TPLKM}b_{i\,TPLKM\,t-1} + e_{it} \quad (11)$$
$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFM}b_{i\,INFM\,t-1} + \lambda_{DPSKM}b_{i\,DPSKM\,t-1} + \lambda_{TPSKM}b_{i\,TPSKM\,t-1} + e_{it} \quad (12)$$
$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFCM}b_{i\,INFCM\,t-1} + \lambda_{DPSKM}b_{i\,DPSKM\,t-1} + \lambda_{TPSKM}b_{i\,TPSKM\,t-1} + e_{it} \quad (13)$$
$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFM}b_{i\,INFM\,t-1} + \lambda_{DPLEM}b_{i\,DPLEM\,t-1} + \lambda_{TPLEM}b_{i\,TPLEM\,t-1} + e_{it} \quad (14)$$
$$r_{it} = \lambda_{0t} + \lambda_{INDM}b_{i\,INDM\,t-1} + \lambda_{INFCM}b_{i\,INFCM\,t-1} + \lambda_{DPLEM}b_{i\,DPLEM\,t-1} + \lambda_{TPLEM}b_{i\,TPLEM\,t-1} + e_{it} \quad (15)$$

**Table 3.** Estimated parameters and test values for all six observed modifications of the Chen-Roll-Ross model

| Risk factors (macroeconomic variables) | | | | Estimated parameters (factor premiums; $\hat{\lambda}$) | | | | | No. of obs. | $R^2$-within |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 1. | 2. | 3. | 4. | $\hat{\lambda}_0$ | | |
| INDM | INFM | DPLKM | TPLKM | 0.009 | -0.002 | 0.000 | -0.001 | -0.033 | 861 | 0.009 |
| INDM | INFCM | DPLKM | TPLKM | 0.010 | -0.001 | 0.000 | -0.001 | -0.034 | 861 | 0.006 |
| INDM | INFM | DPSKM | TPSKM | 0.008 | -0.002 | 0.002 | 0.001 | -0.006 | 966 | 0.011 |
| INDM | INFCM | DPSKM | TPSKM | 0.008 | -0.002 | 0.002 | 0.001 | -0.010 | 966 | 0.008 |
| INDM | INFM | DPLEM | TPLEM | -0.002 | -0.001 | 0.002 | 0.001 | -0.022 | 956 | 0.005 |
| INDM | INFCM | DPLEM | TPLEM | -0.002 | 0.000 | 0.002 | 0.001 | -0.025 | 956 | 0.003 |

| Risk factors | | | | t-statistic | | | | | F-test | prob. (F-test) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 1. | 2. | 3. | 4. | $\hat{\lambda}_0$ | | |
| INDM | INFM | DPLKM | TPLKM | 1.288 | -0.975 | -0.344 | -0.636 | -7.424 | 1.503 | 0.232 |
| INDM | INFCM | DPLKM | TPLKM | 1.561 | -0.355 | -0.224 | -1.319 | -7.537 | 1.132 | 0.364 |
| INDM | INFM | DPSKM | TPSKM | 0.766 | -1.639 | 2.395 | 2.032 | -0.749 | 3.234 | 0.026 |
| INDM | INFCM | DPSKM | TPSKM | 0.731 | -0.931 | 1.679 | 1.179 | -1.354 | 2.250 | 0.088 |
| INDM | INFM | DPLEM | TPLEM | -0.217 | -1.069 | 1.445 | 0.891 | -2.715 | 1.151 | 0.353 |
| INDM | INFCM | DPLEM | TPLEM | -0.236 | -0.201 | 1.450 | 0.637 | -3.528 | 0.843 | 0.509 |

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[8] Estimated factors sensitivities are not presented in this paper, but are available upon request. Namely, in total 22,360 factors sensitivities was estimated.

Estimated parameters and test values show that for observed time period modifications of the Chen-Roll-Ross model that were analysed did not show very useful when explaining stock returns on the Croatian equity market. Namely, almost all estimated factor premiums showed as statistically insignificant. Nevertheless, the third combination of macroeconomic indicators (ie. the third observed version of the model) shows statistical significance (90% confidence level) of two risk factors within the model: default premium, measured as risk premium for the corporate short-term bank loan financing (DPSKM), and term structure premium, measured on short-run basis (TPSKM). Naturally, this version of the Chen-Roll-Ross model showed the highest $R^2$-within value among other observed versions of the model. Finally, we can conclude that the Chen-Roll-Ross model solely cannot adequately capture common movement of stock prices on the Croatian equity market.


## CONCLUSION

This paper shows that pricing models built for the developed capital markets, like the U.S. stock market, can be applied to an emerging capital market, like Croatian. However, their success in explaining a risk-return relation cannot be so easily copied from one market to another. Emerging capital markets bear their own specifics that need to be taken into account when applying existing or developing new pricing models. In that context the Chen-Roll-Ross model has imposed as a logical starting point when testing macroeconomic factors.

Modifications of definitions of the Chen-Roll-Ross model variables showed as necessary because of doubtful availability and quality of input data needed. Namely, some macroeconomic and market variables are not available in the originally defined form or do not exist. In that sense this paper gives some alternative definitions for some model variables (inflation, risk premium and term structure premium). Also, in this paper, in order to improve statistical analysis, we modified Fama-MacBeth technique in the way that second-pass regression was substituted with panel regression analysis.

Based on the two-pass regression analysis of returns of 34 Croatian stocks on 4 macroeconomic variables during the seven-and-half-year observation period (30 quarters) the following conclusions have been made. (1) In contrast to the results of Chen, Roll and Ross (1986) for the U.S. stock market, their model was not successful when describing a risk-return relation of Croatian stocks. Namely, for most observed versions of the model almost all estimated factor premiums showed as statistically insignificant. (2) One observed version of the Chen-Roll-Ross model showed certain statistical significance. That version of the model had two risk factors that were statistically significant: default premium, measured as risk premium for the corporate short-term bank loan financing, and term structure premium, measured on short-run basis.

Several reasons can be named why the Chen-Roll-Ross model for the Croatian stock market has not showed statistical significance that it has in Chen, Roll and Ross paper. One of the reasons for such result is an inadequate informational background. Other reasons can be found in the specifics of emerging capital markets. Lower liquidity in general is the result of a lower level of knowledge and experience of capital market participants, huge influence of commercial banks on overall financial system, and a small

number of institutional and individual investors. Further research will focus on incorporating these issues when developing a new stock pricing model for emerging markets. Finally, many combinations of macroeconomic and market factors are left open for the future research. Therefore the aim and purpose of new findings are in some degree intended to improve today's financial industry practice when analyzing emerging markets.

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