# The determinants of stock returns: An analysis of industrial sector indices

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**Abstract**

This paper investigates the determinants of stock returns in a small open economy in an Arbitrage Pricing Theory framework. The analysis is conducted with monthly data from the Swiss stock market over the period 1986-2000. We use data on industrial sector indices, as well as macro-economic data. Both a statistical and a macro-economic implementation of the model are provided. We find that Swiss equity returns are influenced by both global and domestic economic conditions. The results also show that the statistically determined factors yield a better representation of the determinants of stock returns than the macro-economic variables.

Keywords: Arbitrage Pricing Theory, stock returns, principal component analysis
JEL Classification : G12,G15

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## 1. Introduction

Identifying the forces that drive stock returns is a major concern for practice and academic research. This topic has been the focus of numerous studies in empirical finance. From a theoretical perspective, several models are available. Only a few of these can be implemented however. The most widespread model is the Capital Asset Pricing Model (CAPM) that hypothesises that stock returns are driven solely by one factor, the market portfolio. Empirical tests have documented many shortcomings to this theoretical model, in particular the anomalous effect of the market value and book-to-market ratio influences on stock returns. Some authors have suggested using these variables directly as determinants of stock returns without providing any theoretical justification (e.g. Fama and French, 1993).

This paper follows another line of research that has sounder theoretical grounds and aims at finding the determinants of stock returns according to the Arbitrage Pricing Theory (APT). As most of the empirical evidence concerns the U.S. stock market, it is necessary to investigate this issue for other markets to check the robustness of the U.S. results. The analysis of the Swiss market is of particular interest for two main reasons. First, this market has been the focus of little research despite its importance (seventh largest market in the world). Second, the Swiss economy is a small open economy and it is likely that international factors play an important role in explaining domestic equity returns.

This study provides an empirical implementation of the APT for Switzerland. Two versions of the model are investigated and compared: a statistical one and a macro-economic one. This research differs from previous work in a number of ways. Instead of using individual stock returns, we implement the APT on a set of industrial sector portfolios. This has two advantages: (1) the covariance matrix of residual returns is more likely to be diagonal and (2) we avoid the liquidity problems associated with most stocks. Moreover, we use cluster analysis to find out the best set of macro-economic variables rather than using a pre-specified set of variables (as e.g. in Chen *et al.*, 1986). Another feature of this study is that we allow the risk-return relation to vary through time to be as realistic as possible. This implies that we measure changes in macro-economic variables instead of innovations to time-series processes. This allows us to conduct truly out-of-sample tests. We also use an original two-pass method that takes explicitly into account the fact that tests are performed with realised instead of expected returns. Finally, we consider a large number of variables that reflect global and domestic economic conditions.

The statistical implementation of the model yields eight factors. The macro-economic version also includes eight variables and provides interesting insights into the economic determinants of Swiss stock returns. Five of these variables are clearly linked to global economic conditions, in particular to the general level of economic activity, credit conditions and the stock market environment. These results emphasise the importance of international influences on the Swiss stock market. We also find that the statistical model provides a better representation of the determinants of stock returns than the macro-economic variables. We also document the links between the risk premia obtained in both approaches.

The paper is organised as follows. The next section reviews the relevant literature, while section 3 describes the data and methodology. The results are detailed in section 4. Finally we provide some concluding remarks in section 5.

# 2. Literature Review

The Arbitrage Pricing Theory (APT) of Ross (1976) provides a theoretical framework to determine the expected returns on stocks, but it does not specify the number of factors nor their identity. Hence, the implementation of this model follows two avenues: factors can be extracted by means of statistical procedures, such as factor analysis or principal component analysis, or be pre-specified using mainly macro-economic variables.

## *2.1. Statistical APT*

The first test of the APT is conducted by Gehr (1975) who applies factor analysis to U.S. stock returns. This approach is further developed by Roll and Ross (1980) who report a five-factor structure of which two are priced after cross-sectional testing. In a closely related paper, Chen (1983) assumes *a priori* a five-factor structure and finds that the factors change over time. His model is robust to the inclusion of size and specific risk.

Factor analysis has been criticized for many reasons: the factors are not selected in the same order between two different samples, their sign is not reliable and they have scaling problems (Elton and Gruber, 1995, pp. 376-377). Additional problems occur when implementing the APT using factor analysis. The number of factors extracted and priced increases with the number of stocks in the sample (Dhrymes *et al.*, 1984) and the length of the time series (Dhrymes *et al.*, 1985). Further, the estimates of the risk premia are sensitive to seasonality (Cho and Taylor, 1987; Gültekin and Gültekin, 1987) and to the choice of the criteria used to construct portfolios (Lehman and Modest, 1988). They also suffer from the standard error-in-variables problem.

To address these criticisms, Chamberlain and Rothschild (1983) develop an alternative methodology: asymptotic principal component analysis. However, this technique also has several drawbacks: the number of factors increases with the number of stocks included in the analysis (Trzcinka, 1986), this procedure overestimates the number of factors (Brown, 1989) and the estimates are biased unless a very large number of assets are considered (Grinblatt and Titman, 1985). Connor and Korajczyk (1986, 1988) propose an alternative procedure that yields more robust estimates, but also requires a very large number of assets. Formal comparisons of factor analysis and principal component analysis are provided by Shukla and Trzcinka (1990) and Huang and Jo (1995). They do not find a clear dominance of either technique.

Most of the empirical studies performed on the U.S. market conclude that a five-factor structure is appropriate to explain stock returns (e.g. Roll and Ross, 1980; Connor and Korajczyk, 1988). The number of relevant factors differs in studies that have implemented statistical models for other countries. For the French market, Dumontier (1986) uses factor analysis and finds seven factors, but only three have significant risk premia. For Finland, Yli-Olli and Virtanen (1992) report four factors. For the U.K., Morelli (1999) finds six to nine variables according to a factor analysis, but only two to four with a principal component analysis.

### *2.2. Macro-economic APT*

Chen (1983) is the first author to suggest giving an economic interpretation to statistical factors. The idea is that firms' expected cash flows and discount rates, and hence expected returns, are sensitive to various macro-economic influences. In a widely quoted paper, Chen *et al*. (1986) use a six-factor model consisting of market index returns, changes in expected inflation, unexpected inflation, industrial production, the risk premium and the term structure premium. They find that the last three variables are significant determinants of U.S. stock returns. Chan *et al.* (1985) show that the size effect no longer exists in that model because it is captured by the risk premium.

Using an alternative technique based on the generalized method of moments, Zhou (1999) confirms that four out of the six macro-economic variables used by Chen *et al.* (1986) are relevant to explain U.S. stock returns. Other authors estimate the APT equilibrium relationship using non-linear seemingly unrelated regressions. They find that other variables, such as real final sales, the budget deficit and nonfarm employment, are also important in explaining stock returns[1]. As is the case for the statistical implementations, the macroeconomic models also have some important drawbacks. The factor structure is not robust to the portfolio formation criteria (Clare and Thomas, 1994), it changes over time (Chen *et al.*, 1986) and it suffers from the standard error-in-variables problem.

Papers that have implemented macro-economic APT for other countries find that the same types of variables as those used by Chen *et al.* (1986) are priced as well as other more country-specific variables (e.g. the growth rate of money supply, gold prices and exchange rates with various countries)[2].

### *2.3. Comparison between the statistical and the macro-economic APT*

Determining which model provides the best description of stock returns is a crucial question. Given the variety of methods that have been used in the literature, it is difficult to compare the

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[1] See Berry *et al***.** (1988), Caporale and Thorbecke (1993) and Thorbecke and Chisholm (1995).

[2] See van Rensburg (1996) for South Africa, Groenewold and Fraser (1997) for Australia and Antoniou *et al*. (1998) for the U.K.

results of the various studies and hence no clear-cut conclusion about the superiority of one model over the other can be drawn. Based on different samples, Chen and Jordan (1993) find contradictory results: in-sample tests prove the net superiority of a statistical model extracted from a factor analysis over the classical macro-economic relation, whereas out-of-sample results are mitigated and slightly in favour of the macro-economic model. The superiority of the statistical APT over the macro-economic APT in explaining U.S. stock returns is confirmed by Connor (1995) and Chan *et al.* (1998)[3]. On the other hand, Shafiqur *et al.* (1998) and Groenewold and Fraser (1997) provide evidence in favour of the macro-economic APT.

### *2.4. Empirical evidence for Switzerland*

The first paper focusing on the Swiss market analyses the macro-economic version of the APT. Broillet (1991) specifies initially 38 candidate variables that are divided into 13 groups. Using stepwise regressions, he finds that the best factor structure consists of three variables: the change in unexpected inflation, the volume of loans granted and the USD two-month interest rate. Cuenot and Reyes (1992) use an alternative approach that mixes the statistical and macro-economic approaches. In a first step, five variables are selected *a priori* (a long-term interest rate, a term structure premium, a weighted average of three exchange rates, oil prices and a residual market factor). In a second step, the link between these variables and principal components extracted from Swiss stock returns is investigated. They find that all five variables are significantly linearly related to the ten components. Finally, they report that the risk premia on these five variables are significant at the 5% level, except for oil prices whose risk premium is significant at the 10% level only. Beckers *et al.* (1993) extract nine factors from a factor analysis and compare them with a multifactor model based on 8 firm-specific attributes and 12 industry dummy variables. They find that the multifactor model outperforms the statistical model in terms of ex-ante predictions.

As Switzerland is a small open economy, it is reasonable to assume that it is sensitive to foreign factors. For this reason, Gallati (1993) follows a similar approach to Cuenot and Reyes (1992), but he considers a much broader database containing both domestic and international variables. He selects the variables that are the most highly correlated with the

[3] However, both papers find that the statistical APT is dominated by a multifactor model.

first ten principal components. Four of these have a significant risk premium (the Euro-CHF one-month interest rate, the Euro-DEM three-month interest rate, the EFFAS Swiss Government bond Index and the FTSE-100 Index). It is of interest to note that two out of these four variables reflect purely foreign influences.

In a recent contribution, Vessereau (2000) applies a new methodology, independent component analysis (InCA), to extract factors for the Swiss market. He compares his results to those of the traditional principal component analysis. While the traditional technique leads to one to four factors being priced, InCA always results in a two-factor model. He suggests that these factors are related to the market and a liquidity premium.

# 3. Data and methodology

### *3.1. Data*

Despite the small size of the Swiss economy, the Swiss stock market is the seventh largest equity market in the world (USD 792 billion as of the end of 2000). The number of Swiss companies listed amounts to 252. As is the case with most European markets, the Swiss market is highly concentrated with the eight largest companies accounting for almost 70% of the total market capitalisation. As a result, the remainder of the market suffers from severe liquidity problems, with some stocks being traded on a very irregular basis. This can help explain the results of Vessereau (2000) who finds that liquidity is a priced factor when tests of the APT for the Swiss market are implemented on individual stocks.

To avoid this issue we focus on portfolios representing various industries. For this purpose, we use the most disaggregated sub-sector indexes as provided by *Datastream International* (aggregation level 6). The sample contains monthly continuously compounded returns for the period 1986-2000. We cannot use prior data, as several macro-economic variables are not available before 1986. The dataset encompasses 24 industrial portfolios weighted by market capitalisation and a 25th portfolio that contains all sub-sectors indexes for which no complete performance history is available. Table 1 presents summary statistics for the 25 portfolios.

[Insert Table 1]

Over the whole period, the market index yielded an average monthly return of 1.06% and a standard deviation of 5.23%. Table 1 shows that these parameters vary quite substantially across industries. The skewness and kurtosis statistics are in line with those reported in previous research and they show that return distributions are slightly asymmetric and have fatter tails than the normal distribution.

As the paper investigates the determinants of Swiss stock returns, a database of potential explanatory macro-economic variables is needed. The Swiss economy being small and heavily involved in international trade, both domestic and foreign factors should impact on the expected cash-flows and discount rates of Swiss companies and therefore on stock returns. As the U.S. economy is the leading economy, we hypothesise that most of the foreign influences on the Swiss economy can be captured by U.S. variables.

The macro-economic variables are extracted from *Datastream International* and can be classified into four broad groups. The first group represents variables that are linked to the general level of activity. These include the growth rate of the following variables: unemployment (both in Switzerland and in the U.S.), Swiss retail sales, Swiss exports, American industrial production[4] and Swiss loans and mortgages granted. As Switzerland does not produce oil, it is forced to import this resource; we assume therefore that oil prices have an impact on the Swiss economy and include them in our sample. For this purpose, we use the change in two oil price indexes: the Brent oil index and a composite index which is constructed by weighting the prices from different types of oil[5] by the quantities of each type which are imported in Switzerland. Finally, this group of variables also contains the influence of currency markets. We choose exchange rates of the Swiss Franc against the currencies of the four main trade partners of Switzerland: Germany, France, Italy and the U.S.

The second group is composed of variables related to the general level of prices. We use two inflation measures: (1) the unexpected inflation rate which is proxied by the residuals of an ARIMA(0;1;1) process on the Swiss inflation rate, and (2) changes in expected inflation calculated as the difference between observed and unexpected inflation between period *t* and

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[4] Data on the Swiss industrial production are only available on a quarterly basis and therefore cannot be used in this study.

[5] These types are : Crude oil Africa Bonny Light, Crude oil Arab Light and Crude oil North Sea Forties.

period *t-1*. We also use two alternative variables that represent the evolution of monetary aggregates: the growth rate of the narrow money supply (M1) for Switzerland and for the U.S.

The third group is related to general credit conditions in Switzerland and in the U.S. We use variables that represent the default premium, i.e. the spread between risky debt and riskless debt, and the term premium, i.e. the spread between long term and short term debt.

The last category relates to the general evolution of the stock market. Indeed, according to Wei (1988), using a market residual[6] as an additional factor guarantees an exact factor-pricing model. Therefore, we use two different market indexes: the Swiss and the World Datastream price index.

Table 2 presents the macro-economic variables and gives further information concerning their construction and the underlying time-series we used.

[Insert Table 2]

### *3.2. Methodology*

#### *3.2.1. The two-pass methodology*

As the objective of the paper is to test and compare the predictive ability of both types of APT implementations, we use a methodology that permits out-of-sample cross-sectional validation. This is one of the reasons why we do not employ Seemingly Unrelated Regressions (SUR) techniques which simultaneously estimate sensitivities and risk premia and by essence do not permit a cross-sectional validation of the model for subsequent periods. The other reason for not using SUR methods is that they imply fixed risk premia through time, whereas we prefer to work under the more realistic assumption of time-varying risk premia.

These reasons lead us to test the validity of the two fundamental pricing relations with the well-known technique initially proposed by Fama and MacBeth (FM, 1973) to test the CAPM. To implement this type of test, we first divide the period January 1986-December

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[6] The market residual is the part of the market returns that is orthogonal to the other variables included in the APT equation.

1999 into ten overlapping periods of five years to estimate the factor sensitivities. Each period contains 60 monthly returns on the 25 industrial portfolios. The first period begins in January 1986 and ends in December 1990. The second also covers a five-year interval but begins (and ends) one year later (January 1987-December 1991). The last period begins in January 1995 and ends in December 1999.

The first step of the FM method involves the estimation of the portfolio sensitivities (risk coefficients) to each factor. This is done for every five-year period and the sensitivities are the coefficients obtained from a time-series regression of the portfolio returns on the factor realizations as described in equation (1). In our specific case, we have sensitivities to either macro-economic variables or to statistical factors depending on the type of APT model that we implement.

$$r_{pt} = b_{p0} + \sum_{j=1}^{K} b_{pj} F_{jt} + e_{pt} \qquad (1)$$

where $r_{pt}$ is the observed return on industrial portfolio $p$ in month $t$ ($p$=1…25 and $t$=1…60), $b_{p0}$ represents the constant term, $b_{pj}$ symbolizes portfolio $p$ sensitivity to factor $j$ which is either a factor loading or a macroeconomic variable, $F_{jt}$ is the observed value of factor $j$ in month $t$ and $e_{pt}$ represents the residual error term that is assumed to be normally, identically and independently distributed.

In the second step, we use the estimates of the sensitivities as independent variables in the cross-sectional regression described in equation (2). This procedure yields estimates of the risk premia for the different factors for month $t$.

$$r_{pt} - r_{ft} = l_{ot} + \sum_{j=1}^{K} l_{jt} \hat{b}_{pj} + u_{pt} \qquad (2)$$

where $r_{ft}$ is the risk free rate proxied by the one-month interbank offered rate, $\hat{b}_{pj}$ symbolizes portfolio $p$ estimated sensitivity to factor $j$, $l_{ot}$ represents the intercept, $l_{jt}$ is the estimated risk premium for factor $j$ in month $t$, $u_{pt}$ represents the residual error term with usual assumptions.

We run this regression on the portfolios excess returns[7] for each month of the year following the five-year period over which the sensitivities are estimated. For instance, we obtain risk premia for each month of 1991 on the basis of the sensitivities estimates of the five-year period from January 1986 to December 1990. We iterate this process up until the last period that yields the 12 risk premia for 2000. We obtain a time-series of 120 estimates of the risk premia (from 1991 to 2000) for each factor included in the model. We then test if the mean of this series is statistically different from zero. If this is indeed the case, it indicates that the considered risk factor is priced.

As always, the cross-sectional regressions test for a relationship between sensitivities and *realised* returns, whereas the APT is expressed in terms of *expected* returns. Most of the empirical literature on the CAPM reports the absence of a statistical relationship between risk and realised return. Several authors have advocated that this is due to the use of realised *in lieu* of expected returns. This distinction leads to a testing procedure that distinguishes between bull and bear markets, hypothesising a positive risk-return relationship in upward markets and a negative relationship in downward markets. This approach was initially developed by Pettengill *et al.* (1995) who found conclusive evidence for the U.S.[8] The discrepancy between tests using realised returns and expectation-based theoretical models also exists for APT-type models. For this reason we propose to extend the Pettengill *et al.* approach to the multifactor framework and estimate the following relationship between portfolio excess returns ($r_{pt}$-$r_{ft}$) and factor sensitivities ($b_{pt}$):

$$r_{pt} - r_{ft} = l_{ot} + \sum_{j=1}^{K} l^{+}_{jt} d_{j} \hat{b}_{pj} + \sum_{j=1}^{K} l^{-}_{jt} (1 - d_{j}) \hat{b}_{pj} + u_{pt} \qquad (3)$$

where $l_{ot}$ represents the intercept, $l^{+}_{jt}$ ($l^{-}_{jt}$) is the estimated risk premium for factor $j$ conditional on a positive (negative) realisation of factor $j$ in month $t$, $d_{j}$ is a dummy variable equal to 1 when factor $j$ is positive and equal to 0 otherwise and $u_{pt}$ represents the residual error term with usual assumptions.

[7] Lehmann and Modest (1988) suggest that the excess-return version of the APT should be preferred to the raw-return version when testing the model empirically.

[8] These results have been confirmed for other countries (see e.g. Fletcher, 1997, for the U.K., Isakov, 1999, for Switzerland, Hodoshima *et al*. for Japan, 2000 and Elsas *et al*., 2002, for Germany).

As in the standard FM method, we obtain time-series for the $l_{ot}$, $l^{+}_{jt}$, $l^{-}_{jt}$ coefficients. We then test whether $l_{ot}$ is on average equal to zero, $l^{+}_{jt}$ is on average positive and $l^{-}_{jt}$ is on average negative. Finally, we test if the positive mean is statistically different from the negative one in absolute value to check if the risk premia behave symmetrically.

### *3.2.2. Statistical APT*

Among the various methodologies that are available to extract the factors underlying asset returns, we use the standard principal component analysis, as it does not suffer from a scaling issue or from a rotation problem, contrary to what is the case with factor analysis. This means that we can use standard t-tests to check for the statistical significance of each risk premium.

To find the relevant number of statistical factors, we use the methodology developed by Trzcinka (1986). This test is based on the work by Chamberlain and Rothschild (1983) who demonstrate that a market admits a $K$-factor structure if and only if $K$ eigenvalues of the $NxN$ covariance matrix of returns increase without bound, whereas the $N$-$K$ other eigenvalues are bounded. In fact, they show that it is sufficient to determine the number of unbounded eigenvalues to estimate how many factors are priced. As the $N$ eigenvalues are ranked in decreasing order, if the first $K$ eigenvalues are unbounded, then the remaining $N$-$K$ eigenvalues are negligible and can be considered as being equal. This statement underlies Trzcinka's (1986) approach that provides a formal way to test the hypothesis that the last $N$-$K$ eigenvalues are equal (and therefore if a $K$-factor structure is present in the data). This is achieved with the following Chi-square statistic:

$$c^2 = -(T-1)\sum_{j=K+1}^{N} \ln(l_j) + (T-1)\ln[(N-K)\sum_{j=K+1}^{N} l_j] \qquad (4)$$

where $T$ is the number of observations ($T$=180 as we consider the asset returns over the whole period January 1986-December 2000), $l_j$ represents the $j^{th}$ eigenvalue of the covariance matrix of returns and $N$ is the number of portfolios (equal to *25* in our case). Under the null hypothesis of equality between the $N$-$K$ last eigenvalues, the statistic follows a Chi-square distribution with $\frac{1}{2}(N-K+1)(N-K)$ degrees of freedom for large $T$s.

Once the number of factors $K$ has been determined statistically, a principal component analysis is performed to extract the factor loadings from the covariance matrix of returns. This technique yields factors that are linear combinations of the initial variables and that best explain the covariance matrix. This methodology creates the same number of principal components as there are assets. According to the results obtained with the Trzcinka (1986) test, we take the first $K$ linear combinations as estimates of the true return generating factors. These principal components are then used as inputs in the two-pass FM technique described above to test formally the statistical version of the APT.

*3.2.3. Macro-economic APT*

As is the case with the statistical model, we need to determine the number and identity of relevant pre-specified factors before estimating the pricing model. The method proposed by Mei (1993) is used to find out the number of factors. He shows that a $K$-factor model can be transformed into a $K$-lag autoregressive model. Therefore, if $K$-lagged returns are sufficient to explain the cross-section of asset returns, we can conclude that the factor structure consists of $K$ factors. To implement this test, we estimate models containing from one to ten lags on each of the 25 portfolios. For each lag examined, we compute the sum of squared residuals and aggregate them cross-sectionally to obtain a generalized sum of squared residuals ($Q_K$ where $K$ represents the number of lags considered). Then, we compute the difference ($L_{K,K+1}$) between $Q_K$ and $Q_{K+1}$ (which contains one more lag). This difference measures the reduction of the generalized sum of squared residuals that results from including an additional lag. Under the null hypothesis that $L_{K,K+1}$ is not reduced by an additional lag, $L_{K,K+1}$ follows a Chi-square distribution. The number of degrees of freedom is equal to the difference between the number of parameters estimated in the model with $K$ lags and the model with $K+1$ lags (25 in our case). The number of factors is equal to the highest $K$ for which the null hypothesis is rejected. This test is performed over the whole period (1986-2000).

To determine the identity of the factors, we have to choose $K$ macro-economic variables from our initial database. The empirical literature on the APT measures the macro-economic variables in two different ways: it either considers innovations in a time-series process (e.g. Chen and Jordan, 1993) or it simply measures the changes in the levels of the variables (e.g. Chen *et al.*, 1986). We use the latter method because it allows for more realistic out-of-sample tests. Obviously some variables (e.g. inflation measures and market residuals) cannot be measured in this way and require the estimation of a model over the entire sample period.

The variable selection is undertaken using cluster analysis. This statistical technique permits to group data in such a way that observations belonging to the same cluster present similarities, whereas observations in separate clusters exhibit substantial differences. We use an agglomerative hierarchical clustering algorithm that starts with as many groups as there are variables and that computes dissimilarities between groups in terms of Euclidean distance. We select a procedure that merges groups at a distance that is the mean between initial distances. This technique allows us to determine $K$ groups of variables from which the factors needed for the implementation of the macro-economic model are selected. We assume that variables that belong to the same group are substitutes to one another, which means that any variable within each cluster can be considered to be representative of that cluster. As a result, several alternative macro-economic versions of the APT are investigated.

All macro-economic models are then estimated through the FM two-pass methodology. To find which model best fits the cross-section of returns, we combine two criteria: the model explanatory power ($R^2$) and the stability of this measure through time. Our idea is that the best macro-economic model should be able to explain the cross-section of portfolio returns not only a few times, but in a consistent way. We establish the ranking of the model by means of a synthetic index $I = \frac{1}{2}\left(I_{R^2} + I_{R_A^2}\right)$. The component $I_{R^2}$ is the ratio of the average $R^2$ of the macro-economic model over the standard deviation of the $R^2$:

$$I_{R^2} = \frac{\overline{R}^2}{s_{R^2}} \qquad (5)$$

$I_{R_A^2}$ is constructed in the same way using the adjusted $R^2$ ($R_A^2$) instead of the $R^2$ in equation (5). We combine these two measures as they do not yield the same ranking of models and as both provide reasonable measures of the fit of the model.

*3.2.4. Comparison of models*

We use the tests proposed by Chen and Jordan (1993) and Chen *et al.* (1997) to investigate the similarities between the risk premia from statistical and macro-economic models and to compare the explanatory power of both types of models.

An analysis of the similarities between macro-economic and statistical risk premia allows us to check if the selected macro-economic factors correspond to factor loadings and therefore to provide an economic content to statistically generated factors. For this purpose, two methods are used: multiple regression analysis and correlation analysis. We regress each statistical risk premium on all macro-economic risk premia and analyse the significance of coefficients. We also provide evidence on univariate dependences between the various risk premia by analysing the correlation matrix of all risk premia (statistical and macro-economic)[9].

Our second concern is to determine which model provides the most accurate description of Swiss stock returns by comparing the cross-sectional adjusted $R^2$s by means of a Wilcoxon matched-pairs signed-rank test. The null hypothesis is that the median of the distribution of the difference between both time-series of adjusted $R^2$s is equal to zero. As the distribution of the adjusted $R^2$s is unknown, we use a non-parametric procedure that relies on the Wilcoxon z-statistic. As our sample contains 120 observations, the test compares the z-statistic to a normal distribution.

The Davidson and MacKinnon procedure (1981) is another procedure to assess which model has more power in explaining the cross-section of portfolio returns. To perform the test, we use time-series of forecasted returns for each portfolio. The forecasted series are obtained with estimates of the statistical model and with estimates of the macro-economic model. For each month $t$ of the validation period (1991-2000), we use a cross-section of forecasted returns as regressors:

$$r_{P,t} = q_t \hat{r}_{S,t} + (1 - q_t)\hat{r}_{M,t} + e_t \qquad (6)$$

where $\hat{r}_{S,t}$ is a cross-section of returns forecasted with the statistical model at time $t$ and $\hat{r}_{M,t}$ is a cross-section of returns forecasted with the macro-economic model at time $t$. After having estimated this equation for the 120 months of the validation period, we compute the mean of the regression coefficient $\bar{\hat{q}}$ and its standard deviation to formally test with a t-test if $\bar{\hat{q}} = 0.5$, i.e. if one model explains the portfolio returns better than the other. Note that the sign of this statistic indicates which model dominates the other. In this particular case, if the t-statistic, i.e. $\left(\bar{q} - 0.5\right) \Big/ \hat{s}\left(\bar{q}\right)$, is positive, it means that the macro-economic model is less powerful than

[9] Canonical correlations were also considered but yielded similar conclusions.

the statistical one. On the contrary, a negative t-statistic indicates that the macro-economic version of the APT is a better model.

# 4. Results

### *4.1. Statistical APT*

We first determine the relevant number of statistical factors by using the methodology developed by Trzcinka (1986). This is achieved by using the Chi-square statistic described in equation (4). The number of factors is equal to the number of unbounded eigenvalues in the covariance matrix of returns. Table 3 reports the values of this statistic for different numbers of factors. For a number of factors between one and seven, the null hypothesis of having $K$ factors is rejected at the significance level of 5%. All tests with a number of factors greater than seven cannot reject the null hypothesis. Therefore, we consider that the relevant factor structure contains eight factors.

[Insert Table 3]

Based on these results, we run a principal component analysis and keep the first eight components as the statistical factors that drive Swiss stock returns. The first factor explains 50.34% of the variance, the second factor 6.65%, the third 4.38%, while the eight synthetic variables together explain 77.26% of the variance of the industrial portfolio returns. We then perform Fama and MacBeth (FM, 1973) two-pass tests to determine the risk premia on these eight factors for each month of our test period (1991-2000). Table 4, Panel A presents the average risk premia of each statistical factor and their level of significance.

[Insert Table 4]

Our statistical model explains well the cross-sectional returns as the average adjusted $R^2$ is equal to 29.37% and the average cross-sectional $R^2$ is 52.91%. These levels of explanatory power are very high for cross-sections of stock returns. As the cross-sectional regressions are performed on portfolio excess returns, the constant term should be equal to zero. Table 4 indicates that the average risk premium on the intercept is close to zero and cannot be statistically distinguished from this value, which shows that the cross-sectional variation in excess returns is fully captured by the sensitivities to the eight factors.

As far as the factor risk premia are concerned, we notice that none of them is statistically significant at the 5% level. This may be attributed in part to the error-in-variable problem that biases downward the risk premia estimates and to the numerous possibilities for measurement error in the first step of the FM methodology. The most likely explanation however is that there are positive and negative occurrences of the risk premia and hence that their average is not significantly different from zero. To test this conjecture we employ an extension to the APT of the Pettengill *et al.* (1995) methodology (described in 3.2.1). The results are displayed in Table 4, Panel B. We find that all but three positive and negative average risk premia are statistically significant at the 5% level. We also find that all but one pair of positive and negative risk premia are not significantly different from one another in absolute value. Based on these results, we find that there are significant relationships between the returns on Swiss industrial portfolios and the sensitivities to statistical factors.

### *4.2. Macro-economic APT*

For the implementation of the macro-economic version of the model, we also need to determine the relevant number of factors in a first stage. This is achieved by using the autoregressive test of Mei (1993) that is performed on the whole sample period (1986-2000). Table 5 contains the values of the statistic $L_{K,K+1}$ that tests the null hypothesis that the generalized sum of squared residuals of a model with $K$ lags is equal to the generalized sum of squared residuals of a model with $K+1$ lags. The relevant number of factors is equal to the highest $K$ for which the null hypothesis is rejected.

[Insert Table 5]

For the whole sample period, we find that eight pre-specified factors are relevant. On the basis of these results, we have to select eight macro-economic variables from our initial database. This is achieved using cluster analysis. We use the results of the cluster analysis at a level where the variables are gathered into eight groups. One of these groups is composed of five variables, but as we work in the framework proposed by Wei (1988), we need to use a market residual instead of a market factor to obtain an exact pricing relationship. Therefore, we keep both market indices residuals in the sixth cluster and discard other variables (three exchange rates with the Swiss Franc).

[Insert Table 6]

This methodology yields seven groups containing two, three or four potential candidates, respectively, for our macro-economic model and one group with one clearly identified variable. The composition of these groups is given in Table 6. To choose among the candidate variables in each of the seven groups, we implement 576 different macro-economic models[10]. For each of these 576 alternatives, we run FM tests and select the best model according to the index $I$ that combines two measures of the explanatory power of the model, $I_{R^2}$, described in equation (5).

The final macro-economic model is composed of the following factors: the growth rate of U.S. unemployment, Swiss exports, U.S. industrial production, the U.S. term premium, the Swiss term premium, the Swiss default premium, unexpected inflation and the World market index residual. These variables originate from all of our four broadly defined groups (level of economic activity, price levels, credit conditions and stock market conditions). We observe that five out of eight variables are related to global economic conditions, which reflects the international nature of the Swiss economy. This is confirmed by the level of activity variables that are all strongly related to international economic conditions. U.S. unemployment and industrial production are tightly linked to the world business cycle and Swiss exports depend strongly on the level of activity in partner countries. It is also of interest to note that domestic conditions are represented only by unexpected inflation and credit conditions (default and term premia). The latter are also sensitive to the U.S. term structure.

Compared to the exogenously determined variables of Chen *et al.* (1986) our results provide a different perspective. Firstly, the variables are chosen endogenously and confirm some of the choices of Chen *et al.* (1986). However, our results highlight the importance of international factors for pricing the stocks in a small open economy. Also, we do not find changes in expected inflation to be an important influence on Swiss stock returns.

The risk premia relative to these variables and their level of significance are presented in Table 7, Panel A. As for the statistical case, we find that the average risk premium on the intercept is close to zero and cannot be distinguished statistically from this value, which shows that the cross-sectional variation in excess returns is fully captured by the sensitivities to the macro-economic variables. We also find that one of the macro-economic variables presents a significant risk premium: the Swiss term structure premium is negative and statistically different from zero at the 5% level. The other seven macro-economic variables do

[10] 576 corresponds to the number of different possible combinations of the variables ($3\times4\times2\times2\times2\times2\times3$).

not have significant risk premia. The explanatory power of the model is also high for the cross-section of stock returns as it amounts to an average $R^2$ of 46.54% (19.81% in adjusted terms). It is slightly lower however than the average $R^2$ that is obtained for the statistical model.

[Insert Table 7]

As for the statistical model, we also distinguish between periods with positive and negative occurrences of the variables to further assess the link between portfolio returns and risk sensitivities. The results of these tests are presented in Table 7, Panel B. Contrary to what is the case with the statistical model, only a few risk premia are statistically different from zero. These results may indicate that these macro-economic variables are only proxies for the underlying forces that drive stock returns, despite the fact that our set of eight variables obtained from a cluster analysis makes sense from an economic point of view. Another explanation for these results is that these variables are imperfect proxies for the evolution of true macro-economic conditions due to the use of monthly data and to the unavoidable measurement errors.

### *4.3. Comparison of models*

The above results suggest that a statistical model may be more appropriate in explaining equity returns. To test this assertion, we analyse the links between the risk premia of both types of models and compare their explanatory power. Table 8 provides the results, for each statistical factor, of a multiple regression of the statistical factor risk premia on the risk premia of the macro-economic variables, while Table 9 presents the pairs of statistical and macro-economic risk premia that exhibit the highest correlation. The risk premium on the most important statistical factor (i.e. factor 1) is strongly related to the world market residual premium and the Swiss term structure premium. The importance of the link between factor 1 and the world market residual is confirmed by the high degree of correlation between their risk premia. In general, we observe that all of the statistical risk premia show significant links with at least two macro-economic risk premia. Moreover, each macro-economic risk premium has significant links with at least two statistical factor risk premia. These results indicate that the risk premia from both types of models are clearly linked. However, the $R^2$s of the eight regressions in Table 8 never exceed 50% which indicates that the risk premia of statistical factors are influenced by other forces as well.

[Insert Table 8]

[Insert Table 9]

Formal comparisons of both models confirm the superiority of the statistical version of the model over the macro-economic version. The result of the Wilcoxon signed-rank test is clearly in favour of the statistical model with a z-statistic equal to –3.5054 and a p-value close to zero (0.0005). This provides evidence that the statistical APT is superior to the macro-economic APT in terms of the adjusted $R^2$. The same conclusions prevail when the Davidson and MacKinnon procedure (1981) is used. Indeed, the mean of the regression coefficient $\bar{\hat{q}}$ is equal to 0.63 and the value of the t-statistic testing the null hypothesis that $\bar{\hat{q}}$ =0.5 is equal to 6.16 (significant at any level). This confirms that the cross-sections of returns forecasted from a statistical model have a better explanatory power than those forecasted from a macro-economic model.

## 5. Conclusions

This paper provides an analysis of the determinants of stock returns in a small open economy in an APT framework. Knowledge of such determinants is of particular interest as similar factors should prevail in several factors around the world. The results give insights into the forces that drive stock returns in such a situation, in particular it addresses the issue of the importance of international factors on domestic equity returns.

This research differs from previous work in a number of ways. Firstly, we implement the APT on a set of industrial sector portfolios, rather than using individual stock returns, mainly to avoid the liquidity problems associated with a large fraction of the securities traded on the Swiss market. Secondly, we extend the approach of Pettengill *et al.* (1995) developed for the two-pass tests of the CAPM to the APT framework. This method provides a better assessment of the empirical risk-return relationship. Thirdly, to be as realistic as possible we allow the risk-return relation to vary through time. This implies that we measure changes in macro-economic variables instead of innovations to time-series processes. This allows us to conduct truly out-of-sample tests. A further contribution of this paper is that we do not select macro-economic variables *a priori* but use a cluster analysis to find the most relevant set of variables. Finally, our paper provides the most comprehensive examination of the Swiss market in an APT framework to date.

Two types of implementations of the model are investigated and compared: a statistical one and a macro-economic one. We use monthly returns on 25 industrial sector portfolios over the period 1986-2000. The statistical implementation of the model yields eight factors. The macro-economic version also includes eight variables, five of which are clearly linked to global economic conditions, in particular to the general level of economic activity, credit conditions and the stock market environment. These results confirm the identity of the relevant factors chosen by Chen *et al.* (1986) for the U.S. market, but emphasise the importance of international influences.

The two-pass standard FM tests show that neither the statistical nor the macro-economic versions display significant relations between risk and return. However, when positive and negative realisations of the factors are taken into account, the risk-return relationship becomes highly significant for the statistical model, but only weakly for the macro-economic model. This result suggests that the statistically determined factors yield a better representation of the determinants of stock returns than the macro-economic variables. This is confirmed by formal comparisons of the explanatory power of both types of models. Finally, an analysis of the links existing between risk premia generated by the statistical model and those of the macro-economic model shows that both types of premia are significantly related. However the macro-economic risk premia explain at best 50% of the variance of statistical risk premia, which suggests that other forces are at work.

## Table 1 : Summary statistics for the 25 industrial portfolios

| | Industry | Mean | Std dev | Skewness | Kurtosis |
|---|---|---|---|---|---|
| 1 | Building & Construction Materials | 0.71% | 6.32% | -1.00 | 7.40 |
| 2 | Paper | 0.85% | 10.45% | -0.34 | 6.65 |
| 3 | Diversified Industrials | 0.39% | 5.93% | -0.99 | 6.49 |
| 4 | Electrical Equipment | 1.20% | 8.42% | -0.58 | 5.12 |
| 5 | Electronic Equipment | 1.35% | 7.94% | -1.53 | 14.28 |
| 6 | Engineering Contractors | 0.87% | 8.45% | -0.74 | 5.34 |
| 7 | Engineering General | 0.62% | 7.22% | -1.28 | 8.16 |
| 8 | Brewers | 0.36% | 5.77% | 0.88 | 7.89 |
| 9 | Food Processors | 1.11% | 5.73% | 0.05 | 6.18 |
| 10 | Packaging | 1.16% | 9.00% | -0.44 | 4.94 |
| 11 | Pharmaceuticals | 1.54% | 5.60% | -1.18 | 7.87 |
| 12 | Retailers Multi Department | 0.02% | 8.62% | -0.08 | 5.61 |
| 13 | Hotels | 0.35% | 7.82% | -0.20 | 4.69 |
| 14 | Education, Training | 0.11% | 13.15% | -1.48 | 7.96 |
| 15 | Security & Alarm | 0.43% | 8.91% | -1.46 | 10.76 |
| 16 | Airlines & Airports | -0.05% | 8.29% | 0.09 | 3.98 |
| 17 | Food & Drug Retailers | 0.42% | 8.01% | 0.13 | 8.58 |
| 18 | Electricity | 0.37% | 4.53% | 0.74 | 7.27 |
| 19 | Telecom Equipment | 0.02% | 11.12% | -0.04 | 5.89 |
| 20 | Banks | 0.55% | 7.46% | -1.92 | 15.16 |
| 21 | Insurance Non-Life | 0.69% | 6.88% | -0.55 | 13.91 |
| 22 | Re-Insurance | 1.38% | 7.60% | -0.23 | 3.98 |
| 23 | Other Insurance | 1.07% | 7.69% | -0.45 | 5.55 |
| 24 | Investment Companies | 0.87% | 6.80% | -1.48 | 10.69 |
| 25 | Miscellaneous | 0.55% | 6.72% | -2.43 | 16.22 |

Note: These statistics are computed from monthly continuously compounded returns over the period 1986-2000.

## Table 2: Definitions of macroeconomic variables

| Description | Definition |
|---|---|
| Swiss unemployment growth rate | UNEMP_CH = $\ln(UCH_t/UCH_{t-1})$ with $UCH_t$: Swiss unemployment rate* |
| U. S. unemployment growth rate | UNEMP_US = $\ln(UUS_t/UUS_{t-1})$ with $UUS_t$: U.S. unemployment rate* |
| Swiss retail sales growth rate | RETAIL = $\ln(RS_t/RS_{t-1})$ with RS: Swiss retail sales* |
| Swiss exports growth rate | EXPORTS = $\ln(X_t/ X_{t-1})$ with X: Value of Swiss exports* |
| U.S. industrial production growth rate | INDPROD_US = $\ln(IP_t/IP_{t-1})$ with $IP_t$: U.S. total production index |
| Swiss loans and mortgages growth rate | MORT = $\ln(M_t/M_{t-1})$ with M: Swiss loans and mortgages granted* |
| Brent oil price changes | BRENT = $\ln(B_t/B_{t-1})$ with B: Brent crude oil price |
| Composite oil price changes | SWOIL = $\ln(SCPI_t/SCPI_{t-1})$ with SCPI: Swiss composite oil price index |
| Change in CHFDEM exchange rate | DEM = $\ln(CD_t/CD_{t-1})$ with CD: CHFDEM exchange rate |
| Change in CHFFRF exchange rate | FRF = $\ln(CF_t/CF_{t-1})$ with CF: CHFFRF exchange rate |
| Change in CHFITL exchange rate | ITL = $\ln(CI_t/CI_{t-1})$ with CI: CHFITL exchange rate |
| Change in CHFUSD exchange rate | USD = $\ln(CU_t/CU_{t-1})$ with CU: CHFUSD exchange rate |
| Unexpected inflation | UI = Residuals from an ARIMA (0;1;1) process fitted on ?=$\ln(CPI_t/CPI_{t-1})$ with CPI: Swiss consumer price index* |
| Change in expected inflation | CEI = $(?_t\text{-}UI_t)\text{-}(?_{t-1}\text{-}UI_{t-1})$ |
| Change in Swiss M1 | M1_CH = $\ln(M1CH_t/M1CH_{t-1})$ with M1CH: Swiss narrow money supply* |
| Change in U.S. M1 | M1_US = $\ln(M1US_t/M1US_{t-1})$ with M1US: U.S. narrow money supply* |
| Swiss default premium | DEFAULT_CH = yield on Swiss corporate bonds minus yield on Swiss government bonds |
| U.S. default premium | DEFAULT_US = BAA: yield on U.S. BAA corporate bonds minus yield on U.S. AAA corporate bonds |
| Swiss term premium | STRUCT_CH = yield on Swiss 10-year government bonds minus the yield CHF 1-month interbank offered rate |
| U.S. term premium | STRUCT_US = yield on U.S. 10-year government bonds minus the yield on 1-month interbank offered rate |
| Return on Swiss market index | MARK_CH = $\ln(SM_t/SM_{t-1})$ with SM: Datastream Swiss stock market index |
| Return on World market index | MARK_W = $\ln(WM_t/WM_{t-1})$ with WM: Datastream World stock market index |

Note: A * indicates that a variable is adjusted for seasonal variations

## Table 3: Test of the number of statistical factors

| Number of factors | Chi-squared statistic |
|---|---|
| 1 | 243,77* |
| 2 | 236,00* |
| 3 | 227,99* |
| 4 | 219,58* |
| 5 | 210,69* |
| 6 | 201,74* |
| 7 | 192,60* |
| 8 | 183,13 |
| 9 | 173,47 |
| 10 | 163,62 |

* indicates that the Chi-squared statistic is significant at the 5 % significance level

## Table 4: Results of the cross-sectional tests of the statistical APT

Panel A : classical test

| | constant term | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 |
|---|---|---|---|---|---|---|---|---|---|
| **average risk premia** | 0,0036 | 0,2813 | -0,1338 | -0,1339 | -0,0645 | -0,0661 | 0,0882 | -0,0232 | 0,0485 |

* indicates that the average risk premium is significant at the 5 % significance level

adjusted $R^2$ : 0,2937 $R^2$ : 0,5291

Panel B : test according to Pettengill et al. approach

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 |
|---|---|---|---|---|---|---|---|---|
| **positive risk premia** | 0,6257 | 0,1374 | 0,3763* | 0,2334* | 0,2329* | 0,2144* | 0,2888* | 0,3552* |
| **negative risk premia** | -0,1691 | -0,8489* | -0,4984* | -0,4285* | -0,2948* | -0,2903* | -0,3458* | -0,3020* |
| **risk premia difference** | 0,4565 | -0,7115° | -0,1221 | -0,1951 | -0,0618 | -0,0759 | -0,0570 | 0,0531 |

* indicates that the average risk premium is significant at the 5 % significance level

° indicates that the difference between positive and negative risk premia is significant at the 5 % significance level

## Table 5: Test of the number of macro-economic factors

| **Number of lags *K*** | **$L_{K,K+1}$** |
|---|---|
| 5 | 85,29* |
| 6 | 45,79* |
| 7 | 84,58* |
| 8 | 40,44* |
| 9 | 29,07 |

* Null hypothesis rejected at the 5 % significance level

## Table 6: Cluster analysis results

| **Group** | **Final composition** |
|---|---|
| **1** | UNEMP_CH |
| | FRF |
| | STRUCT_US |
| **2** | MORT |
| | M1_US |
| | DEFAULT_CH |
| | DEFAULT_US |
| **3** | UNEMP_US |
| **4** | RETAIL |
| | INDPROD_US |
| **5** | EXPORTS |
| | CEI |
| **6** | MARK_CH |
| | MARK_US |
| **7** | M1_CH |
| | STRUCT_CH |
| **8** | BRENT |
| | SWOIL |
| | UI |

## Table 7: Results of the cross-sectional tests of the macro-economic APT

Panel A : classical test

| | constant term | STRUCT _US | DEFAULT _CH | UNEMP _US | INDPROD _US | EXPORTS | STRUCT _CH | UI | MARK_W |
|---|---|---|---|---|---|---|---|---|---|
| **average risk premia** | 0,0085 | -0,5320 | 0,0543 | 0,0041 | 0,0036 | -0,0024 | -0,8078* | 0,0002 | -0,0031 |

* indicates that the average risk premium is significant at the 5 % significance level

adjusted $R^2$ : 0,1981 $R^2$ : 0,4654

Panel B : test according to Pettengill et al. approach

| | STRUCT _US | DEFAULT _CH | UNEMP _US | INDPROD _US | EXPORTS | STRUCT _CH | UI | MARK_W |
|---|---|---|---|---|---|---|---|---|
| **positive risk premia** | -0,6804* | 0,0532 | 0,0136 | 0,0089 | -0,0047 | -0,3312 | 0,0003 | 0,0114 |
| **negative risk premia** | 0,1293 | 0,0835* | -0,0037 | -0,0036 | 0,0001 | -1.7608* | 0,0002 | -0,0196* |
| **risk premia difference** | -0,5511 | 0,1367° | 0,0099 | 0,0052 | -0,0046 | -2,0921° | 0,0005 | -0,0082 |

* indicates that the average risk premium is significant at the 5 % significance level

° indicates that the difference between positive and negative risk premia is significant at the 5 % significance level

## Table 8: Determinants of statistical factor risk premia

| | STRUCT_US | DEFAUTL_CH | UNEMP_US | INDPROD_US | EXPORTS | STRUCT_CH | UI | MARK_W | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Factor 1 | -0,03 | -0,20 | -7,48 | -0,37 | 5,08 | 0,27* | -73,97 | 34,35* | 0,49 |
| Factor 2 | 0,00 | 1,03* | 4,13* | 5,71* | 8,92* | 0,13* | 3,53 | 3,89* | 0,35 |
| Factor 3 | 0,14* | -0,08 | 5,84* | 2,51 | 0,03 | 0,00 | 27,81 | -1,92 | 0,30 |
| Factor 4 | -0,08* | -0,41 | -3,51 | 3,63 | 3,03 | 0,03 | -8,02 | -2,04 | 0,16 |
| Factor 5 | -0,09* | 0,06 | 1,26 | -3,09* | -3,77 | 0,12* | -46,02* | -0,38 | 0,38 |
| Factor 6 | 0,02 | -0,19 | 5,57* | -2,80 | -6,36* | -0,05* | -56,92* | -0,65 | 0,29 |
| Factor 7 | -0,03* | -0,63* | 3,11* | 0,94 | 10,19* | -0,06* | 6,76 | -2,02* | 0,44 |
| Factor 8 | 0,00 | 0,19 | 4,12* | -1,21 | 9,73* | -0,01 | 25,68* | -2,26* | 0,41 |

* indicates that the coefficient is significant at the 5 % significance level

## Table 9: Correlation analysis of risk premia

| Statistical factor | Macro-economic variable | Coefficient of correlation | Macro-economic variable | Statistical factor | Coefficient of correlation |
|---|---|---|---|---|---|
| Factor 1 | MARK_W | 0,63* | STRUCT_US | Factor 3 | 0,34* |
| Factor 2 | DEFAULT_CH | 0,30* | DEFAULT_CH | Factor 2 | 0,30* |
| Factor 3 | STRUCT_US | 0,34* | UNEMP_US | Factor 8 | 0,43* |
| Factor 4 | UNEMP_US | -0,23* | INDPROD_US | Factor 5 | -0,36* |
| Factor 5 | STRUCT_CH | 0,42* | EXPORTS | Factor 7 | 0,45* |
| Factor 6 | UI | -0,28* | STRUCT_CH | Factor 5 | 0,42* |
| Factor 7 | EXPORTS | 0,45* | UI | Factor 6 | -0,28* |
| Factor 8 | EXPORTS | 0,45* | MARK_W | Factor 1 | 0,63* |

* indicates that the correlation coefficient is significant at the 5 % significant level

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