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Efficient Market Hypothesis (EMH) description: EMH is a very popular topic among academicians and practitioners nowadays, and there are many researches about it, but the origins of EMH can go as far as the theoretical work of Bachelier (1900) and the empirical research of Cowles (1933). One can not forecast market price changes in an informationally efficient market if the expectations and information of all market participants are fully taken in (Samuelson, 1965). Fama defines the notion of informational efficiency in his survey this way: “A market in which prices always ‘fully reflect’ available information is called ‘efficient’ ” (1970).

However categorized, the possibility that market inefficiency can exist independently of price dependence can be traced to definitions originally associated with Roberts (1959, 1967), and Fama (1970), i.e. ‘weak form’, ‘semi-strong form’ and ‘strong form’ efficiency. The existence of market efficiency may best be examined in terms of three distinct types of test, each subjecting the efficient markets hypothesis to different levels of strictness.

Fama considered the tests in terms of the information subset relevant to changes in security prices.

- **weak form efficiency** - if prices fully reflect the information included in past price movements: they do not follow patterns which repeat and it is not possible to trade profitably solely on the basis of historical price information. The information subset includes only the history of prices or returns themselves;

- **semi-strong form efficiency** – if prices fully reflect all publicly available information: market participants cannot make extra returns by the information from publicly available sources, since the information are already incorporated in security prices. The information subset includes all information known to all market participants (publicly available information).

- **strong form efficiency** - if prices fully reflect all relevant information (publicly available or not): no investor could ever earn systematically extra returns (even with insider information). The information subset includes all information known to any market participant (private information).
Sometimes people get confused by the idea, that in an informationally efficient market security price should be random. Thus, in that type of market there are no profits to be made by the people who do not have private information, because the price adjusts rapidly as the information becomes available. The confusion might be the result of the fact that security price are determined by discounting future cash flows. For better understanding, Law of Iterated Expectations are presented below\(^1\).

Let \(I_t\) and \(J_t\) be information sets (these sets contain all the information available at time \(t\)) such that all the information in \(I_t\) is incuded in \(J_t\), \(I_t \subseteq J_t\). If one has limited information \(I_t\), the best forecast can be made of a random variable \(X\) is the forecast of the forecast one could make of \(X\) if had superior information \(J_t\):

\[
E(X \mid I_t) = E(\{E(X \mid I_t) \mid J_t\} \leftrightarrow E(X - E(X \mid I_t) \mid J_t) = 0.
\]

Now, suppose \(P_t\) is the security price at time \(t\) and let \(V\) be fundamental value (or intrinsic value). Then, \(P_t = E(V \mid I_t) \equiv E_t(V)\), \(E_t(P_{t+1} - P_t) = E_t(E_{t+1}(V) - E_t(V)) = 0\), because \(I_t \subseteq I_{t+1}\) and by the Law of Iterated Expectations \(E_t(E_{t+1}(V)) = E_t(V)\). Therefore, the realized changes in prices cannot be forecasted given the information set \(I_t\).

There are some obstacles for markets to be informationally efficient\(^2\):

- Information price,
- Trading costs,
- Excluding arbitrage opportunities.

**Testing weak form efficiency and evolving efficiency:** Although, the tests for market efficiency differentiate from a technical point of view, they have one similarity - they look at the long-run market characteristics\(^3\). To sum sum up the methodology of empirical studies, there are two types of tests:

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\(^3\)Abdmoulah W., Testing the Evolving Efficiency of 11 Arab Stock Markets, Economist at The Arab Planning Institute, Kuwait, April 2009.
tests of asset pricing models and tests of market efficiency. The first seeks to determine whether security price behavior conforms to the CAPM, the second seeks to determine whether the pattern of changes in the security price is consistent with the notion of an efficient equity market, i.e. whether the market is informationally efficient.

In this framework two tests will be discussed below. Let $r_t$ be the return (or logreturn - $\ln \frac{P_t}{P_{t-1}}$) of considered market index at time $t$. In the financial literature is well documented that the financial securities' returns are often time series with volatility clustering. Therefore, we will say that a market is weak-form efficient when there is no profit opportunity based on the past movement of asset prices. It can be tested with GARCH-M (Generalized Autoregressive Conditionally Heteroskedastic in Mean) model:

$$r_t = \beta_0 + \sum_{i=1}^{p} \beta_i r_{t-i} + \delta \sigma_t + \epsilon_t, \epsilon_t \sim N(0, \sigma_t)$$

$$\sigma_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i \sigma_{t-i} + \sum_{i=1}^{m} \gamma_i \epsilon_{t-i}^2$$

*If the market is informationally efficient, all the $\beta_i, i=1,\ldots,p$ coefficients should be zero.* The problem of choosing $p, n, m$ can be solved by Akaike Information Criterion (AIC). But, in practice, mostly $p = n = m = 1$ is chosen, avoiding useless complexity.

For testing evolving market efficiency we need a model which will allow us do the following:

- it will allow us to check for weak form efficiency,
- it will allow us to detect possible changes in efficiency over time.

Consider dynamic model presented below:

$$r_t = \beta_{0t} + \sum_{i=1}^{p} \beta_{it} r_{t-i} + \delta \sigma_t + \epsilon_t, \epsilon_t \sim N(0, \sigma_t)$$

$$\sigma_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i \sigma_{t-i} + \sum_{i=1}^{m} \gamma_i \epsilon_{t-i}^2$$

$$\beta_{it} = \beta_{it-1} + w_{it}, i = 0, p, w_{it} \sim N(0, \sigma_i^2)$$
This dynamic model may be estimated using the standard Kalman Filter approach, but we will do the following: we will use the technique of “slowly” moving windows of a certain length and in this way divide the whole period in question into a finite number of sub-periods. Then one might estimate all the parameters required by equations for each sub-period individually. In this approach, however, the length of a window is crucial and significant for the power of the estimated values. Moreover, we should note that such an approach causes the loss of some observations at the beginning and at the end of the investigated period.

Data: In this paper we will discuss questions associated with Armenian Treasury Bond Market. There are five Treasury Bond indexes published by Central Bank of Armenia:

- **G03** - coupon bond index with maturity 0-3 years,
- **G05** - coupon bond index with maturity 0-5 years,
- **G5I** - coupon bond index with maturity greater than 5 years,
- **GMI** - coupon bond index with all maturities,
- **TBI** - discount bond index.

For our research framework, we will discuss only **GMI** and **TBI**. We will use time series of current price returns of **GMI** and **TBI**:

\[
CPR_t = \frac{\sum_{i=1}^{m} (P_{it} - P_{it-1}) N_{it-1}}{\sum_{i=1}^{m} (P_{it} + A_{it}) N_{it} + C_t} \times 100
\]

\(CPR_t\) — current price return of index,
\(P_{it}\) — clean price of bond \(i\) at time \(t\),
\(A_{it}\) — accrued interest of bond \(i\) at time \(t\),
\(C_t\) — cash and reinvestment income,
\(N_{it}\) — market value of bond \(i\) at time \(t\),
\(m\) — number of bonds included in index.

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1[https://www.cba.am/AM/panalyticalmaterialsresearches/Treasury%20Indexes-Description%20and%20Application.pdf](https://www.cba.am/AM/panalyticalmaterialsresearches/Treasury%20Indexes-Description%20and%20Application.pdf)

[https://www.cba.am/Storage/AM/downloads/karger/Index%20methodology%201l740L.pdf](https://www.cba.am/Storage/AM/downloads/karger/Index%20methodology%201l740L.pdf)
There are two main purposes for using current price return:

1. It excludes the effect of accrued interest in time series and will not add extra distortion to $\beta$’s estimators.
2. It takes into account daily change of index, contrary to current total return.

**Results:** Below the results of our research are presented. Testing weak form of efficiency we have come to the conclusion that both markets (bond and bill) are not efficient. We estimated $\beta_{GMI}^1 \approx 0.49, \beta_{TBI}^1 \approx 0.93$ (Fig. 1). All coefficients are statistically.

Fig. 1. GARCH estimation for GMI and TBI
As stated above, market efficiency may change with the time: It can be seen from time series of CMEs (Fig. 2.). The most interesting question is to test existence of evolving efficiency in considered markets. Here are the results of the tests (Fig.3)

We can notice that both markets informational efficiency is changing over time. There are periods (especially for bill market) that markets are getting efficient, but it is highly volatile.
INFORMATIONAL EFFICIENCY OF ARMENIAN TREASURY BOND MARKET

Key words- weak form efficiency, evolving efficiency, bond market index, time varying parameters.

In this article we consider the informational efficiency of Armenian treasury bond market from 2013 to 2017. We give a concise hint on the idea of efficiency and historical development of Efficient Market Hypothesis, then describe the types of informational efficiency and estimation principles. A new approach is offered for testing evolving efficiency. The selection of data is described in details. The results are worked out with statistical software R.