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Market Dynamics: A Classical Approach to Security Price Movements

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Market Dynamics: A Classical Approach to Security Price Movements

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Abstract- The recently introduced Market Dynamics method demonstrates parallelisms between security price indicators and their physical counterparts. Specifically, the security price is viewed as a potential energy density, and events such as earnings releases as forces that affect security prices. This dynamic representation of security price movements is extended and applied towards developing an event driven approach for measuring security price movements and the associated price charts. A conservation of capital principal further underlines the central role of capital flow in the formation of support levels. This classical approach to security price movements enables access to a vast pool of existing scientific knowledge and opens new insights into analyzing security price movements with potential applications in the fields of finance and investment management.

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I. Introduction

Historically, various hypothesis have been developed in rationalizing the observed behavior and movements of security prices. The Efficient Market Hypothesis introduced the notion that price fully reflects all available information about a security at its equilibrium state (Fama 1970). This suggests a demand and supply approach to the financial market. The Rational Expectations Hypothesis proposes that market participants act rationally with respect to the available information, possibly without fully realizing their role (Muth 1961). Behavioral finance further considers how various agents act based on social, emotional, and cognitive factors potentially creating market inefficiencies that can be exploited (Shefrin 2005, Kukacha and Barunik 2013).

At the same time, the premise that security prices follow repeating and identifiable patterns has long been a mainstay of technical practitioners in the investment field but this approach has suffered from the lack of a supporting theoretical framework (Edwards and Magee 2001). More recently, behavioral finance appears to signal that such human factors as herding, over-confidence, and market sentiment contribute to irrational behavior and inefficiencies in the financial markets, factors that may contribute to the observed price trends (Shefrin 2005).

It is apparent that a foundational theory describing the movement of security prices is desirable and can lead to a better understanding of factors influencing security price movements as well as support improved prediction of their anticipated future direction. Utilizing concepts from the classical science of motion, Market Dynamics applies a partial differential to the price equation and introduces a conservation of capital principal (Dayanim 2011). The approach incorporates tangible factors such as earnings along with behavioral aspects of various agents in their aggregate form as forces driving price movements. In a manner similar to the efficient market hypothesis the conservation of capital principal leads to an equilibrium condition that is achieved over a span of time as capital from investor trading activities flows into a security. Price uncertainty may be encountered during this transitional period resulting in temporary separation between the stable equilibrium price and the observed market prices, indicating potential market inefficiencies.

The theoretical framework for the dynamics of price movement is first introduced including the price equation, the conservation of capital principle, and several indicators useful in measuring price movements. The methodology is then applied to sample securities demonstrating close match to observed market pricing and highlighting its potential application in analyzing security price movements and identifying market price inefficiencies.

II. Dynamics of Price Movement

a) The Price Equation

Movements in security prices are often attributed to specific events, whether fundamentals based such as earnings surprises, or behavioral such as changes in investor sentiment (Thomsett 1998). The price of a security is defined as a product of it earnings per share (EPS) and Price to Earnings Ratio (PE) as follows:

$$P = EPS.PE \quad (1)$$

The impact of an external event can be measured in terms of changes in a security's Earnings Per Share and Price to Earnings ratio. The expected price change is obtained through a partial differentiation of the price equation with respect to time, that is:

$$\Delta P = \Delta EPS.PE_0 + EPS_0.\Delta PE \quad (2)$$

$$P_T = P_0 + \Delta P \quad (3)$$

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where ΔP is the expected price change resulting from changes in EPS or PE attributed to the event; P_0, EPS_0, and PE_0 are the initial stable values just before the event's onset; and P_T is the new target price.

b) Conservation of Capital

Previously, it has been demonstrated that parallels can be developed between security price movements and the classical science of motion (Dayanim 2011). The Conservation of Capital principal states that changes in market capitalization of a security must be matched by an equal flow of capital from investor trading activities. The change in market capitalization of a security can be written as:

$$\Delta MC = S . \Delta P \tag{4}$$

where ΔMC represents the change in market capitalization and S is the number of issued shares.

Separately, the investor trading activities can be measured as the accumulated flow of capital into a security as follows:

$$MF = \sum_{n=1}^{N} \{s_n . \Delta P_n\} \tag{5}$$

where Money Flow MF is the change in accumulated flow of capital attributed to investor trading activities, s_n is the number of shares exchanged in an individual trade transaction, ΔP_n is the difference between a buyer and a seller's per share cost for such transaction, and N is the number of completed transactions during the observation period. Contributions from individual trade transactions are added in order to obtain the accumulated change in investor capital. This analysis ignores any transaction related costs in the form of ask-bid spread or trade execution fees.

Assuming an initial stable price point, an equality is defined between the left hand sides of equations (4) and (5) framing the conservation principal for the event simply as:

$$\Delta MC = MF \tag{6}$$

The latter effectively states that a change in market valuation of a security should be supported by a corresponding level of investor trading activities or flow of investor capital that fully accounts for the observed price movement.

Of particular interest to this discussion is the nature of capital and its relationship to investor activities. As a security's price rises or falls, its market capitalization can fluctuate greatly in a relatively short span of time due to trading activities in a small portion of its shares. There appears to be an imbalance between the level of investment capital flow due to trading activities and the observed movement in the security's market valuation. This leads to the notion of an event's Time Horizon, or the elapsed time after an event's onset until such time when sufficient investor capital has been accumulated to account for the corresponding change in market capitalization. At that time a new equilibrium point is reached at the target price level.

c) Superposition of Events

It is not unusual to encounter multiple events with separated or overlapping time horizons such as consecutive earnings releases, or earnings releases combined with PE movements reflecting changes in investor behavior. As equation (2) demonstrates, the change in price is additive and proportional to the change in the underlying force such as earnings thus indicating a linear system. Using the Superposition principal of linear systems the individual contributions from multiple events can then be added to obtain the aggregate impact (Serway and Jewett 2013). The outcome from two independent events remains the same whether they are separated in time or partially overlapping. In this manner, contributions to price from each event is individually added over time to the original starting price in order to measure and track expected and target prices throughput the observation period.

d) Aggregate Securities

The approach can be extended to a group of securities such as an exchange or industry index by aggregating the individual results from each listed security in the group. Hence, market capitalization values and earnings of the underlying securities are grouped and added in order to obtain the price and earnings data for the aggregate security. For example, the aggregate money flow starting from a stable initial price point for the aggregate security is measured by summing the individual contributions as follows:

$$MF = \sum_{m=1}^{M} MF_m \tag{7}$$

where M is the list of underlying securities in the index.

e) Dynamic Indicators

Markets frequently over- or under-react to an event resulting in changes in market capitalization that materially diverge from the observed flow in investor capital. In order to analyze the price behavior, several indicators are defined that are useful in measuring the expected price and the accumulated flow of investor capital for an event over time.

The Support indicator is a ratio of the accumulated investor capital at time t over the observed change in market capitalization, and is measured as follows:

$$Support(t) = \frac{MF}{\Delta MC} \tag{8}$$

As the support ratio approaches 1 an equilibrium state is attained and a stable and fully supported price level is formed at the target price level. These points correspond to the observed price resistance or support levels in technical analysis which describe levels at which price is stabilized in the aftermath of a decline or rise in a security's price (Murphy 1999).

The event's Time Horizon can be estimated by measuring the progress rate towards the equilibrium state by dividing the elapsed time t into the current support ratio, that is:

$$T(t) = \frac{t}{Support\ (t)} \tag{9}$$

This estimation assumes a linear change in the Support ratio over time, although alternative non-linear estimations may also be used. The event time horizon may vary widely in duration with shorter intervals indicative of a broader level of investor interest and higher trading volumes.

The Expected Price for a security can be similarly stated from equation (3) by using the Support ratio as a progress indicator, as follows:

$$P_E(t) = P_0 + \Delta P.Support(t) \tag{10}$$

The Expected Price can be viewed as a moving Support Line and represents the price level currently supported by the accumulated flow of investor capital. The support line touches the security's target price line at the equilibrium point where the change in market capitalization equals the accumulated investor capital flow.

Divergence represents the gap or spread between the target price and the current market price. In this manner, the Divergence indicator measures the remaining appreciation potential in price using the following equation;

$$Divergence(t) = \frac{P_T - P(t)}{P(t)} = \frac{\Delta P_T}{P} \tag{11}$$

As the price moves towards the target level, the divergence approaches 0. A negative divergence value indicates an expected price drop, while a positive value indicates an expected rise. Divergence may also be viewed as the current rate of price change representing the upward price pressure.

Conversely, Expectance is defined as the separation gap between the expected price and the current market price. The Expectance indicator can be measured as follows:

$$Expectance(t) = \frac{P_E - P(t)}{P(t)} = \frac{\Delta P_E}{P} \tag{12}$$

Expectance represents the potential price exposure due to a lack of sufficient investor capital flow. It often acts as a retarding price pressure and a counter-balance to the investor enthusiasm that is driving the change in market capitalization. In contrast, a positive Expectance value may indicate a cooling condition where the price has temporarily dropped below the support line.

After an event's onset the price is expected to move along the support line during the event's time horizon as investor capital flow continues to accumulate. Price then reaches the target price at the equilibrium point. However, investors may react to the event by pushing the price to near or past its target level in a short span of time. This can create a negative price pressure and result in price volatility caused by a lack of sufficient accumulated investor capital. For securities with a high level of trading activity and investor interest this period may be short in duration, while for others it may span many months.

III. Estimation Methods

a) Money Flow

The calculation of investor capital flow poses a clear challenge due to the complexity involved in gathering all historical trade transactions for a security, obtaining the buyer's original purchase cost, and summing up the individual capital flow contributions. However, this activity can be estimated by summing the product of daily trade volume and price change over the covered period, as follows:

$$MF = \sum_{t=1}^{T} V(t).\{P(t) - P_0\} = \sum_{t=1}^{T} V(t).\Delta P_0 \tag{13}$$

where V(t) is the daily trade volume, P(t) is the daily close price, P_0 is a stable starting price, and T is the number of elapsed days. This approach effectively uses the stable starting price as the cost basis for all trade transactions during an event's time horizon. The estimation relies on a capital flow transfer or leveling process where the accumulated capital flow from individual trade transactions are distributed across all issued shares of a security.

b) Price to Earnings Ratio

Historical PE values may be used in measuring expected price change by using averaged or weighted PE values for a set number of days, for example by using a 30 day running average. This approach while straight forward and reasonably adequate for most analysis suffers from a delayed response to changes in PE. While there is currently no method of modeling PE using its underlying behavioral factors, an alternative dynamic estimation is available by using equation (2) as follows:

$$\Delta PE = \frac{\Delta P - PE_0.\Delta EPS}{EPS_0} \tag{14}$$

$$\Delta PE = \frac{\Delta MC/S - PE_0.\Delta EPS}{EPS_0} \tag{15}$$

which uses the relationship between price and market capitalization where S represents the number of outstanding shares in the security. The conservation of capital principle states that the money flow attributed to an event must equal the change in market capitalization of the security once a stable and supported price level is established. As new investment accumulates over time

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with each trade transaction, the expected change in PE at time t following an event may be restated using a time variant money flow allowing its direct measurement, as follows:

$$\Delta PE_E(t) = \frac{MF(t)/S - PE_0.\Delta EPS}{EPS_0} \qquad (16)$$

c) Earnings Per Share

Earnings data is typically available for each financial reporting quarter for each traded security. Since earnings data may not be publicly available for some time after the end of the covered earnings period, it can impact or delay the earnings event's timing.

IV. Applied Market Dynamics

a) A Dynamic Model

The dynamic pricing method has been implemented using a computer system for securities listed on U.S. exchanges including New York Stock Exchange (NYSE), NASDAQ, and American Exchange (AMEX) for which historical price, volume, and earnings data was readily available. Figure 1 demonstrates the price movement for a sample security, Agilent Technologies, for a nine month period beginning on July 1, 2010 and ending June 1, 2011. Starting at a relatively stable price level, an upwards pattern emerges as corporate earnings increase starting around September 1, 2010. The PE ratio remains relatively consistent and hovers in the 18 to 21 range. The target price is regularly revised due to movements of EPS and PE values and appears as a stepped ladder, while the expected price forms a smooth line and is calculated using the accumulated investor capital flow and trends up until it finally reaches the target price and forms a stable point in the first quarter of 2011 as shown by the diamond marker.

Fig. 1: Agilent Technologies Price Channel

Figure 2 displays the price to earnings ratio for the same time period that is calculated monthly by averaging the prior 30 day values. Earnings values are also recorded at the end of each quarterly release period without consideration for when the data was actually reported.

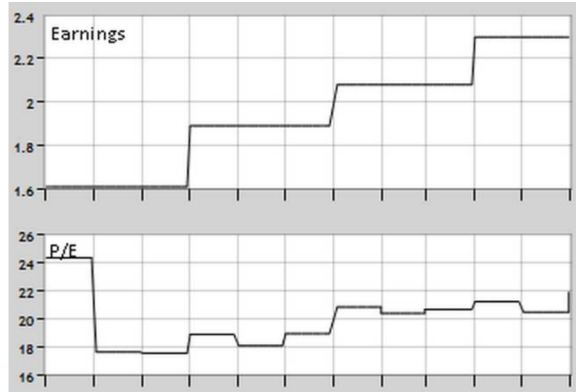


Fig. 2: Agilent Technologies Earnings and PE

As viewed in Figure 3, Expectance is negative during much of the price trajectory and reaches zero once the target price is reached. This negative pressure counter-balances the investor enthusiasm that is driving the change in market capitalization. A Price Channel is formed in the area between the Expected and Target prices wherein one would expect to observe the market price line. A rising price channel indicates a bullish pattern, while a dropping channel indicates a bearish sentiment. In a bearish pattern the Target and Expected price lines switch positions with the Target price forming the lower boundary of the price channel. In such case, the Expectance value tends to be positive and pointing towards the support line.

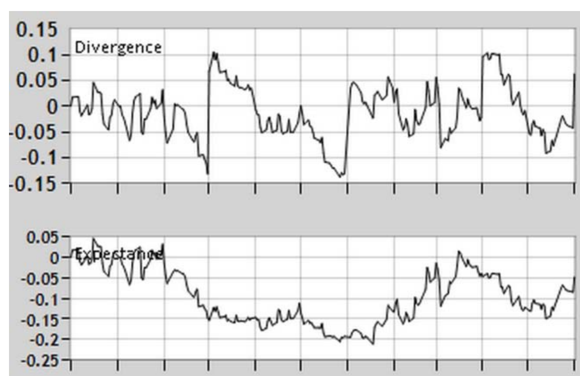


Fig. 3: Agilent Technologies Divergence and Expectance

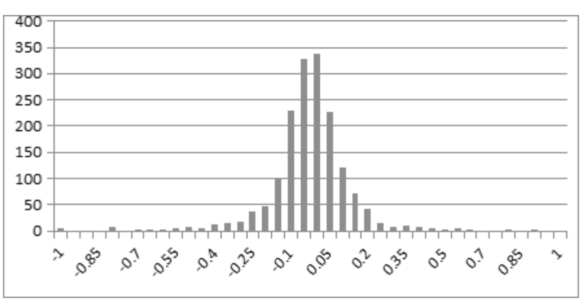
The model is extended by aggregating the results for the NYSE listed securities. In total around 1,650 securities were used for which earnings data was readily available. For this analysis market capitalization values and corporate earnings of the underlying securities are separately grouped and added in order to obtain the price and earnings data for the aggregate security. The investor capital flow is also estimated by using equation (13) and summing the product of daily trade volume and price change for each underlying security, as follows:

$$MF = \sum_{t=1}^{T} \sum_{m=1}^{M} V_m(t).\Delta P_{m0} \qquad (17)$$

where M represents the number of underlying securities and t is the elapsed days from a stable initial price point for the aggregate security. Figure 4 displays the related price chart using a two year observation time period.

Fig. 4: NYSE 8/15/2012-9/20/2014

The price values are normalized for display purposes by dividing into the initial market capitalization value. The chart exhibits a similar price channel to that observed for an individual security. Figure 5 shows a histogram of Divergence values for the covered securities on NYSE with a possible Divergence range between -1 and +1. The simulation results indicate a mean value close to zero and a standard deviation of 0.153 for November 15, 2013. Divergence appears evenly split on both sides of the market price line forming an approximate bell curve distribution. A 10% average deviation is observed between the securities' market and target price points with over 95% falling within a 30% range of their target as prices continue along their individual movement paths. The aggregate market price line continues to stay reasonably close to the price channel after the iterative application of the model over a 2 year time period. As may be expected, the price movement chart is sensitive to the choice of the start date due to the differential nature of the dynamic pricing method and reliance on a stable starting price point.



Mean	Median	Standard Deviation	Average Deviation
-0.026	-0.022	0.153	0.099

Fig. 5: NYSE Divergence 11/15/2013

Observations of the individual and aggregate charts appear to confirm the effectiveness of the dynamic pricing method in modeling expected and target prices using historical price, volume, and earnings data. The method also identifies inefficiencies between expected and observed security prices with potential application in optimizing investment portfolios.

b) *Forecasting Price Movements*

The discussion thus far has focused on investigating historical prices based on known information about a security. However, the dynamic pricing method can also be applied towards forecasting future price movements by utilizing projections of quarterly earnings and PE values. Since such forecasts depend upon future estimates they are subject to a greater level of risk and uncertainty.

V. Conclusion

This study expands on recent classical approach to security price movements by presenting an event driven dynamic pricing method. The approach starts with the price equation and introduces a conservation of capital principle. This leads to a key finding that changes in market capitalization must be matched by an equal flow of investor capital which accumulates over time with successive investor trade transactions. Once the flow of investor capital matches the observed change in market capitalization an equilibrium condition is reached representing a stable and fully supported price level.

Several dynamic price indicators are developed for measuring the level of price support due to accumulated capital flow, the target and expected prices over time, and the separation gap from observed market prices. The time based aspect of the formulation results in a window of time where price can fluctuate between the expected and target price lines until it converges to a stable price at the equilibrium point. The event driven aspect of the formulation creates an opportunity to take into account the available data about the security such as price, volume, and earnings, as well as less tangible aspects such as investor sentiment and behavior. While a model for the latter behavioral factors was not presented here, their contribution was aggregated into a single factor that directly influences the price movement. The Market Dynamics method was further applied to actively traded securities and exchanges demonstrating it closely tracks the observed market price movements over a long span of time.

The method provides needed insight and understanding of the mechanisms responsible for security price movements. The classical approach enables access to a vast pool of existing scientific knowledge with its potential application to the fields of finance and investment management. The Market Dynamics method may be extended to any security or market with an orderly clearance of trade transactions, where intrinsic price values can be associated with the underlying traded commodities and goods. The valuations should follow a linear price equation that factors in the underlying market and human elements.

Biography

Joshua Dayanim is the founder of Market Dynamix, a website dedicated to providing investor information and education on Market Dynamics. As an independent investor, he has studied various approaches to security pricing analysis and investment management. This eventually led to the development of Market Dynamics, providing a model for security pricing movements and formation of support and resistance levels. He holds Masters degrees in Business Administration and Electrical Engineering, with an undergraduate focus in Physics. He can be reached at jdayanim@mdynamix.com.

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