Market Dynamics: Bridging Security Price Movements and Classical Physics

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Abstract

The subject of security price movements and its possible physical parallel has long remained elusive. Market Dynamics bridges this gap by demonstrating parallelism 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. In doing so, Market Dynamics provides insight into mechanisms responsible for security price movements and their underlying chart patterns. The approach leads to the development of various price indicators representing the security's expected price appreciation and related price movement attributes. Market Dynamics has applicability to a number of fields including investment management through measurement of security price appreciation potential, as well as technical analysis in determining support or resistance price levels and understanding the underlying mechanism behind security price movements and support levels. The linkage with classical sciences enables access to a vast pool of existing scientific knowledge with its potential application to the fields of finance and investment management.

Keywords: Classical, Physics, Fluid, Dynamics, Market, Security, Price, Movement, Analysis, Technical

1. Introduction

It has long been suspected that security price movements resemble a classical particle motion, albeit a clear linkage has remained elusive. One area of concern has been the treatment of intrinsic human factors and their projection into a security's price movements. Market Dynamics bridges this gap by providing a method to estimate security price movements that takes into account observed market influences, and by establishing parallelism between security price indicators and their physical counterparts.

Security prices move in response to various events, including: an earnings surprise, change in growth rate, change in attractiveness of an industry or asset class, shift in market liquidity and availability of buyers and sellers, change in macroeconomic factors such as inflation and interest rate, or other significant security or market development. Existing security pricing models typically utilize fundamental analysis or technical analysis in setting a target price or anticipating a price movement.

Fundamental analysts often measure price by using a discounted cash flow model of future expected earnings. This approach relies on research into basic financial information to forecast profits, supply and demand, industry strength, management ability, and other intrinsic matters affecting a security's market value and growth potential (Thomsett, M. C., 1998). Thus, price evaluation is based on business performance and assumes that a forecasted target price eventually will be reached. However, fundamental analysis often results in differing projections based on growth rate and annuity model assumptions, and suffers from subjective weighting and application of multiple factors affecting price.

Technical analysis relies on chart pattern recognition and attempts to anticipate the direction of a price movement through comparison with similar historical chart patterns. This approach assumes that security prices are determined solely by the interaction of market demand and supply, that prices tend to move in trends, that shifts in demand and supply cause trend reversals that can be detected in charts, and that chart patterns repeat themselves (Edwards, R. D., Magee, J., 2001). Technical analysis utilizes various indicators which typically consist of price and trade volume transformations in order to identify a trend and forecast future price movements. Technical analysis can result in differing predictions depending on the specific indicators or approach that is utilized, and while widely practiced lacks a comprehensive theoretical foundation.

Therefore, it would be desirable to develop a security pricing method that combines the strengths of fundamental analysis and its use of historical and projected data about a security together with the strengths of technical analysis in the form of price movement indicators and charts.

The Market Dynamics method and its accompanying system (Dayanim, J., 2009) provide a mechanism to estimate and project expected security price movements and appreciation potential utilizing fundamental data such as earnings per share, price to earnings ratio, share price, trading volume, and number of outstanding shares. The method applies a time derivative approach to the security price equation and relies on a conservation of capital principal in its formulation. It then develops a security pricing model that takes into account the received data and generates target price and price movement indicators including expected price change, money flow, and support ratio.

Market Dynamics provides needed insight into the underlying mechanisms responsible for observed security price movements. The pursuing discussion provides a theoretical foundation for Market Dynamics with a focus on the observed parallelism between security price movements and classical sciences.

The Market Dynamics method has been applied successfully to securities listed on AMEX, NASDAQ, and New York Stock Exchange as well as their composite indices.

2. Dynamics of Price

The price of a traded security is described by the price equation, $P = EPS \cdot PE$, with price shown as a product of earnings per share (EPS) and price to earnings ratio (PE) (Madura, J., 2008). The expected price change in the aftermath of an event can be determined by applying a time derivative to the price equation, as follows:

$$\Delta P = \Delta EPS \cdot PE_0 + EPS_0 \cdot \Delta PE \tag{1}$$

where EPS_0 and PE_0 represent initial values prior to the onset of the event. Thus, the expected target price is derived by adding the expected price change to the starting price, that is:

$$P_T = P_0 + \Delta P \tag{2}$$

Market Capitalization (MC) represents the intrinsic capital or investment value of a security and is defined as a product of a security's share price (P) and its number of outstanding shares (S), that is, $MC = P \cdot S$. In this manner, the share price acts as a unit of capital investment in the security. A Conservation of Capital principal is now defined stating that the change in a security's market capitalization must equal the amount of new investment or money flow (MF) into the security.

A positive event, such as a rise in earnings, results in an infusion of new investment into the security as buyers purchase shares of a security at a higher price than a sellers' cost basis, that is the original purchase price paid by the seller to acquire the traded shares. The amount of new investment can be measured by adding the incremental new investment from each transaction, as follows:

$$MF = \sum_{n=1}^{N} \{s(n) \cdot P_n\} \tag{3}$$

where s(n) is the number of traded shares in transaction n, $P_n = P_B - P_S$ is the difference between the buyer and the seller's per share cost basis, $\{s(n) \cdot P_n\}$ represents the incremental new investment for transaction n, and N is the number of trade transactions before the security price reaches its target price. The calculation assumes a stable initial price and no startup money flow.

The conservation principle requires that the aggregate amount of new investment generated by the event equals the observed change in market capitalization of the security, that is:

$$MF = \Delta MC = \Delta P \cdot S \tag{4}$$

As new investment accumulates over time with each trade transaction, a Support ratio may be defined as the ratio of new investment at time t to the expected change in Market Capitalization for the event, as follows:

$$Support = \frac{MF}{\Delta MC} \ \ (no\ unit) \tag{5}$$

The Support ratio is an indicator of current progress in reaching the target price, starting at 0 at the event's onset and reaching 1 as price approaches the target price where a fully supported price level is established. The expected price at time t can be estimated assuming a linear relationship as:

$$P_E = P_0 + Support \cdot \Delta P \ \ (\$/share) \tag{6}$$

A possible starting point for establishing physical parallelism between security price movements and Classical Physics is the concept of energy. Classically, Work (W) performed on an object by an external force is the product of force and displacement (Benenson, W., 2002), or for a fluid counterpart (Saleh, J., 2002) the product of change in pressure and volume. For a lossless system and in the presence of a potential field, work performed by an external force is stored in the form of potential energy E_P as the objects returns to rest. This is a result of the Conservation of Energy principal. The foregoing can be stated as:

$$W = \Delta E_P = Force \cdot Distance = \Delta Pressure \cdot Volume \tag{7}$$

A comparison of equations (4) and (7) governed by the corresponding conservation laws yields the following parallelisms or equivalencies:

$$Volume \leftrightarrow S \ \ (no\ unit) \tag{8}$$

$$\Delta Pressure \leftrightarrow \Delta P \ \ (\$/share) \tag{9}$$

$$E_P \leftrightarrow MC \ \ (\$) \tag{10}$$

with the latter relying on the initial condition that $E_P\ (P = 0) = MC\ (P = 0) = 0$. The number of outstanding shares therefore represents volume, while price of a traded security may be viewed as a potential energy density, $P = MC/S$. Changes in earnings per share and price to earnings ratio in equation (1) can now be viewed as external forces contributing to the change in price, or in an alternative fluid view as a pressure differential. These forces reflect the human and market factors involved in pricing a security.

Classically, an external force results in acceleration and generates kinetic energy of motion. In the presence of a potential field the kinetic energy is transferred into potential energy and stored in the object as it returns to rest. The change in potential energy is then equal to the amount of transferred kinetic energy, $\Delta E_P = -\Delta E_K$. Using equation (4) and the classical formulation of kinetic energy in terms of mass and velocity, this equality may be rewritten as a time variant equation, assuming a final rest condition $v_T = 0$ and a stable target price, as follows:

$$E_P(T) - E_P(t) = E_K(t) - E_K(T) \tag{11}$$

$$\Delta P_T \cdot S = \frac{1}{2} m v^2 \tag{12}$$

where $\Delta P_T = P_T - P$ represents the remaining potential price appreciation for a share of the security at time t, and v the velocity at time t. This leads to:

$$\frac{v^2}{2} = \frac{S}{m} \Delta P_T = \frac{\Delta P_T}{\rho} \equiv \frac{\Delta P_T}{P} \tag{13}$$

The above assumes a new equivalency between price and mass density:

$$\rho \leftrightarrow P \ \ (\$/share) \tag{14}$$

which in turn leads to an equivalency between mass and potential energy. The ratio in the right hand side of equation (13) is known as Divergence, measuring the ratio of remaining price spread ΔP_T over price at time t, and is an indicator of a security's price appreciation potential or separation from its target price.

The above derivation assumes a positive movement in price where ΔP_T is positive. In the event of a price drop ΔP_T will be negative resulting a negative velocity directed towards the lower target price. The velocity can now be stated as:

$$v = \pm \sqrt{\frac{2|\Delta P_T|}{P}} \ \ (no\ unit) \tag{15}$$

where its sign indicates the direction of price movement and points towards the target price.

Momentum of a particle is described as a product of its mass and velocity, and momentum density or momentum per share of a security may be measured as:

$$Momentum\ Density = \frac{m}{S}v = \rho v = \pm P\sqrt{\frac{2|\Delta P_T|}{P}} = \pm\sqrt{2P\,|\Delta P_T|}\ \ (\$/share) \tag{16}$$

and can be shown to be equivalent to another physical measure, Intensity (I), defined as a product of energy density and velocity:

$$Intensity\ (I) = P \cdot v = \pm P\sqrt{\frac{2|\Delta P_T|}{P}} = \pm\sqrt{2P\,|\Delta P_T|}\ \ (\$/share) \tag{17}$$

Impulse is a product of force and impact duration or equivalently a product of mass and change in velocity. Impulse density for an event can be measured as:

$$Impulse\ Density = \frac{m\Delta v}{S} = \rho\Delta v = P_0 v_0 = \pm\sqrt{2P_0\,|\Delta P_0|} = I_0 \tag{18}$$

The above equation assume that the security price is stable and at rest prior to the application of force, and v_0 is the resultant velocity of the object pursuant to the application of force. As shown, the impulse density equals the starting intensity measured in the immediate aftermath of the applied force. The underlying assumption is that the transfer of kinetic energy into potential energy starts after the impulse force is removed and that the time duration of the impulse is negligible.

Other classical measures such as acceleration can similarly be derived:

$$a = \frac{\Delta v}{\Delta T} = \pm\frac{\sqrt{2}}{2}\left(\frac{|\Delta P_T|}{P}\right)^{\frac{-1}{2}} \cdot \left(\frac{\Delta P_T}{P}\right)' = \pm\frac{1}{\sqrt{2}}\left(\frac{P}{|\Delta P_T|}\right)^{\frac{1}{2}} \cdot \frac{-P_T}{P^2} \tag{19}$$

$$= \mp\frac{P_T}{\sqrt{2|\Delta P_T|}P^{\frac{3}{2}}}\ \ (share/\$) \tag{20}$$

Acceleration is negative as price climbs towards the target price, lowering the velocity until the object comes to rest at the target price.

Approaching from an alternative fluid dynamics view, Volume Flow Rate (VFR) is classically defined as a product of area A by the effective flow velocity across the area, $VFR = A \cdot v$. Since volume is represented by the number of outstanding shares the flow rate is the rate of trading activity, leading to a new equivalency between VFR and the number of traded shares s, that is:

$$VFR \leftrightarrow s\ \ (shares/day) \tag{21}$$

where an optional daily measure of time is utilized. Similarly, Energy Flow Rate (EFR) is defined as a product of area and intensity. Combining with the above equations, this yields:

$$EFR = A \cdot I = \frac{VFR}{v} \cdot I = \frac{s}{v} \cdot Pv = s \cdot P\ \ (\$/day) \tag{22}$$

stating that EFR is simply the total value of traded securities during the observed time period. Mass Flow Rate (MFR) is classically written in terms of density, area, and velocity, and is shown to be identical to EFR:

$$MFR = \rho Av = PAv = P\frac{s}{v}v = P \cdot s\ \ (\$/day) \tag{23}$$

Fluid viscosity (R) is defined in relation to volume flow rate and change in pressure as follows:

$$VFR = \frac{\Delta Pressure}{R} \tag{24}$$

By substituting change in pressure and VFR with their equivalent terms, viscosity may be measured as:

$$R = \frac{\Delta Pressure}{VFR} = \frac{\Delta P_T}{s}\ \ (\$/share) \tag{25}$$

indicating that viscosity is a ratio of the remaining price appreciation potential and the rate of trading activity at time t. This effectively states that the lower the trade volume, the higher the viscosity, and the slower the progress towards reaching the target price.

3. Potential of Market Dynamics

Through the application of a conservation of capital principal and postulation of several equivalencies, a parallelism emerges between the price movement of traded securities and the classical sciences of motion. Such approach relies on an abstraction of market and human forces in terms of changes in observed corporate earnings and price to earnings ratios. A further assumption is made that sufficient market liquidity exists and that prices are free to move in response to exerted forces.

The Market Dynamics method provides needed insight and understanding into the mechanisms responsible for security price movements and their underlying chart patterns. By utilizing a classical superposition principal, price movements resulting from consecutive earnings releases or changes in a security's price to earnings ratio can be aggregated to provide a target price trajectory for a security. An expected price may also be calculated by factoring in the support ratio. The resultant price channel separating the expected price and target price provides an acceptable price range for the security. The price channel is depicted graphically in Figure 1 for shares of Amazon for the period of May 2009 through October 2010. Point markers are also used to note fully supported price levels. Where observed security prices move outside the price channel a potential price correction may be expected.

Market Dynamics is a valuable tool for estimating and forecasting security prices, and identifying short term price disparities represented by the Divergence indicator. When combined with a decision support system, the method can be used as an investment strategy tool that lists securities with the greatest price appreciation opportunity for a selected investment style. Figure 2 depicts the Divergence chart for the same security and time period.

The demonstrated parallelism with classical sciences provides further 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 market with an orderly clearance of trade transactions, provided that intrinsic values can be associated with the underlying traded commodities or goods. The valuations should follow a price equation that factors in the underlying market and human elements.

References

Benenson, W., Harris, J. W., Stocker, H. & Lutz, H. (2002). *Handbook of Physics*. (4th ed.). New York: Springer-Verlag.

Dayanim, J. F. (2011). Market Dynamics: Modeling Security Price Movements and Support Levels. *(*IFTA Journal), 50-53.

Edwards, R. D., Magee, J. (2001). *Technical Analysis of Stock Trends*. (8th ed.). AMACOM.

Madura, J. (2008). *Financial Markets and Institutions*. (8th ed.). Mason OH: Thomson South-Western, (Chapter 1).

Saleh, J. (2002). *Fluid Flow Handbook*. New York: McGraw-Hill.

Thomsett, M. C. (1998). *Mastering Fundamental Analysis*. Kaplan Publishing.

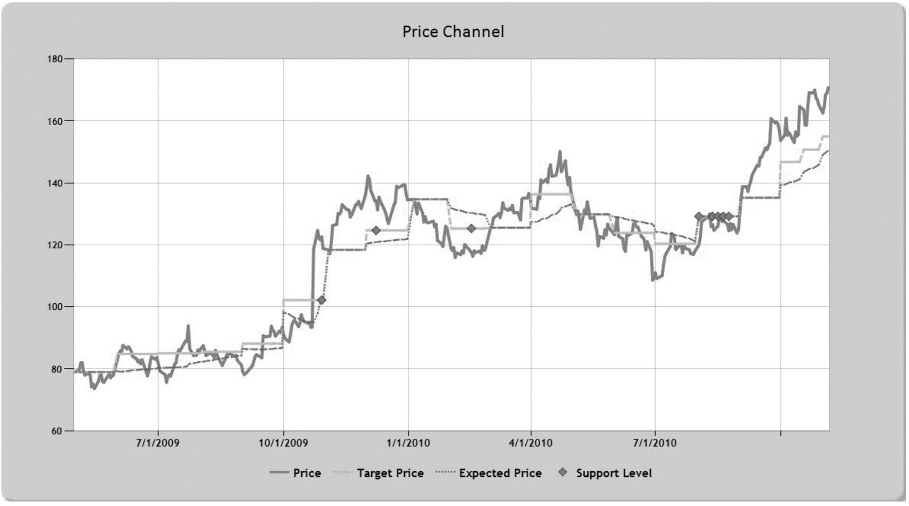

Figure 1.

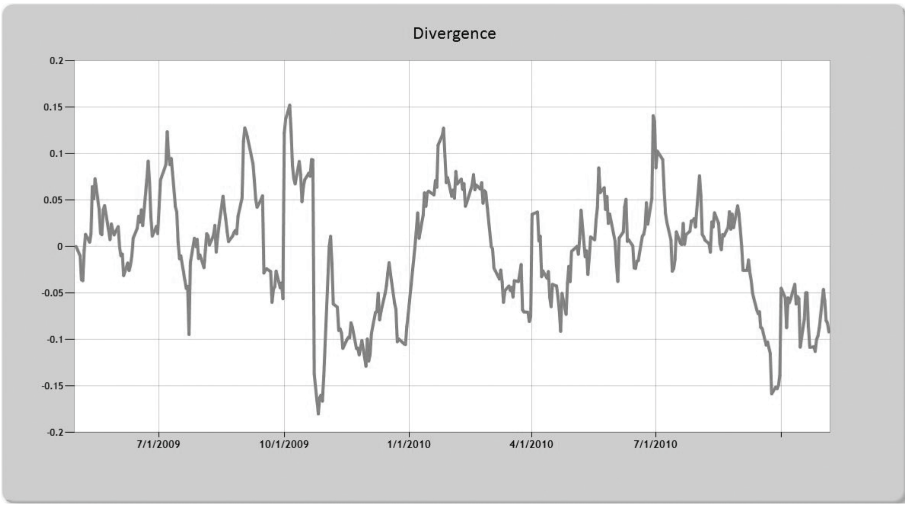

Figure 2.