Going Back to the Basics – Rethinking Market Efficiency

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The purpose of this paper is to promote discussions and the exchange of ideas. Comments on the concepts presented are gratefully received.

1 Introduction

The real-life experience of our customers shows that we successfully forecast foreign exchange (FX) price movements for short to medium-term time horizons. This is substantiated by a positive forecast quality and high trading model returns (Dacorogna et al., 1992; Pictet et al., 1992).

We have to ask ourselves why O&A is able to forecast. Are we successful in capturing the inefficiencies of the FX market? Since this market is widely held to be the most efficient of the financial markets, we should ask a more pertinent question: Does our success not conflict with the theory of efficient markets, which precludes the ability to forecast and denies the existence of profitable trading models?

The present *discussion paper* explains why, in contrast to the statement of the efficient market theory, we have been able to develop successful forecasting and profitable trading models. We believe that there are a number of reasons, which are all associated with market dynamics. We emphasize that such explanations are highly tentative. In particular, we think that many years of hard investigation will be needed to prove scientifically that the claims made here are actually valid. To facilitate this research, we suggest some ideas for a new definition of market efficiency at the end of the paper.

2 Definition of efficient markets

In conventional economics, markets are assumed to be efficient if all available information is reflected in current market prices (Fama, 1970; Fama, 1991). Economists have embarked on weak, semi-strong and strong-form efficiency tests. The weak-form tests investigate whether market prices actually reflect all available information. The semi-strong tests are based on so-called event studies, where the degree of market reaction to "news announcements" is analyzed. The strong-form tests, finally, analyze whether specific investors or groups have private information to take advantage of. By and large, most studies conclude that the major financial markets are efficient and that all information is reflected in current prices. However, the conclusions of such studies have been bogged down by methodological questions; in particular, whether any observed departures from market efficiency are due to any genuine market inefficiency or a deficiency of the market pricing model being used as a yardstick to compare actual with theoretical prices.

The inference that in an efficient market no excess return can be generated with trading models is based on the assumption that all investors act according to the rational expectation model (see, for example, the introduction to Robert Shiller's book on market volatility (Shiller, 1989) or the review article by Eugene Fama, 1970). If this assumption is wrong, the conclusion that forecasting is impossible is also questionable. The assumption of rational expectations has been called into question by many economists. The idea of heterogeneous expectations has become of increasing interest to specialists. Shiller, for example, argues that most participants in the stock market are not "smart investors" (following the rational expectation model) but rather follow trends and fashions. On the FX market, there is much investigation of "speculative bubbles" and the influence of technical analysis on the dealer's strategy (see, for example, Frankel and Froot, 1990). More recently, the attention of researchers has been caught by the possibility of time varying expectation, which is closer to our view of the market. Bekaert and

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Hodrick (1992), for example, write in a paper investigating the predictability of equity and foreign exchange returns:

> Variation over time in expected returns poses a challenge for asset pricing theory because it requires an explicit dynamic theory in contrast to the traditional static capital asset pricing model (CAPM).

This is really the research challenge of the next years.

3 Dynamic markets and relativistic effects

We mentioned that conventional economics makes its inferences on efficient markets on the basis of a model in which economic agents are entities that act according to the rational expectation strategy. Any differences in planning horizons, frequency of trading or institutional constraints are neglected. This contrasts with O&A's direct experience. Besides, there is substantial evidence that investors have heterogeneous expectations. Surveys on the forecasts of participants in the FX market reflect the wide dispersion of expectation at any point in time. The huge volume of FX trading[1] is another indication reinforcing this idea since it takes differences in expectation among market participants to explain why they trade.

There are many ways to describe these heterogeneous expectations. We believe that the most promising approach is to differentiate the expectations according to their time dimension because we consider the *different time scales* of the market participants the key characteristic of the market. Some trade short-term, others have long-term horizons with market makers at the short-term end of the scale and central banks at the long-term end. Contrary to the usual assumption, there is no privileged time scale in the market. The broad set of market agents with different time horizons lends a *fractal* structure to the market. The differences in "relevant" time scales lead to effects which we term *relativistic*[2]. The interaction of components with different time scales gives rise to characteristically relativistic effects such as certain properties of volatility clusters (see below), trend persistence, lag between interest rate adjustment and FX rate adjustment. The latter is a good example of what conventional theory considers an inefficiency while we see it as an effect arising from the different time scales involved in the market. To take advantage of the lag in adjustment between interest rate and exchange rate moves, an investor needs to tie up his money for months or even years. This is a very long time for a forex trader. Some investors will thus tend to ignore these profit opportunities while others invest in them, as is testified by the development of managed currency funds based on this property. The combination of all these effects ultimately enables us to build successful forecasting and trading models.

In long time intervals, market price changes are "flatter" and have fewer relevant movements (trend changes) than in short-term intervals. The higher the resolution and the smaller the intervals, the larger the number of relevant price movements. The long and the short-term traders thus have different trading opportunities: the shorter the trading horizon, the greater the opportunity set. A market participant's response to outside events should always be viewed as relative to his intrinsic opportunity set. A short-term trader does not react in the same way as a long-term trader. Economic decision makers, such as traders, treasurers and central bankers, interpret the same information differently. The variation in perspective has

[1]Over 740 billion US$ is traded every day in the different centers like Tokyo, London and New York according to the 3-yearly survey of the Bank of International Settlements (1990) .

[2]We chose this term by analogy to physics, where relativistic effects arise due to the absence of a universal time clock.

the effect that specific price movements cannot lead to a uniform reaction; rather they result in individual reactions of different components. In turn, these reactions give rise to secondary reactions, with the different components reacting to their respective initial response. Watching the intraday price movements, one clearly sees the sequences of secondary reactions triggered by the initial events (see, for example, the recent work by Goodhart *et al.* on news effects on the sterling-dollar exchange rate (1991)). The delay with which the secondary reactions unfold is called the *relaxation time*.

If diverse components with different time scales interact in the market, there is typically a mixture of long and short relaxation times following the impact of outside events. If different relaxation times are combined, the resulting autocorrelation decays hyperbolically. Our study of the autocorrelation function for short-term absolute price changes (Dacorogna et al., 1993) confirmed the hyperbolic decay and revealed that volatility clusters tend to have a longer memory than assumed by other studies of the subject.

There is yet another phenomenon: Financial markets are spread worldwide. Economic and political news and trading activity are not stationary. They have a clear-cut pattern of moving around the world in a 24-hour cycle. The price data of foreign exchange rates reflects this in terms of a 24-hour seasonality in market volatility (Müller et al., 1990). O&A's model accounts for this seasonality by introducing a *business time scale* (Dacorogna et al., 1993). The 24-hour cycle implies that market reactions to an event cannot be simultaneous and that there are distinct relaxation times following the event. Geographical components related to the business hours of the different trading centers must be added to the time components.

4 Impact of the new technology

Will the impact of the new technology be a passing phenomenon or will it have a long-term effect? As O&A's technology is based on the relativistic phenomena arising from the interaction of components with different time scales, it will remain appropriate as long as heterogeneous expectations continue to exist in the market. The interaction process may become more complex, but it cannot disappear.

O&A's technology enables users to identify additional trading opportunities to increase their profits. This quickens their pace of trading and contributes to higher market volume and liquidity. The improved liquidity lowers the spreads between bid and ask prices. Lower spreads reduce transaction costs, which in turn increases the opportunity horizon for profitable trading. The new technology introduces a shift in perspective, with components starting to focus on increasingly more numerous short-term time intervals. In terms of the component time horizon, this will introduce a time shift.

It is unlikely – at least for the foreseeable future – that this time shift will have the effect that all components acquire the same time scale. To the extent that it is possible to develop *specific* trading models which are optimized for the risk profile, institutional constraints and specific trading history of the respective components, a large diversity of components will continue to participate in the market.

As components become increasingly short-term in their focus, the spectrum of short-term components increases. This has the effect that relativistic differences among components become more significant and the relativistic effects more pronounced. Contrary to accepted notions assuming that sufficient buying power can "trade away" any phenomenon, the increased buying power will have the overall effect of enhancing the relativistic effects. Thus the very basis of our ability to forecast and build profitable trading models will be enhanced. This statement must be qualified in the sense that the reaction patterns will become increasingly diversified and, therefore, more complex.

5 Zero-sum game or perpetuum mobile?

Conventional thought has it that financial markets must be a zero-sum game. This is true if we take a static view. Because reality is dynamic, however, it is more complex.

Markets are a platform for components to take advantage of the diversity of interests. They are able to match their opposing objectives; that is, when one component buys, there is another component that sells. The lower the friction, the easier a counterpart for a particular transaction is found and the larger, therefore, is the particular component's opportunity set. By being able to go ahead with a particular transaction, the flexibility of the respective components is increased and their profit potential improved.

The new technology fosters the market's ability to provide an environment for the generation of wealth. As explained, interaction within the market gives rise to relativistic effects and relaxation times. To the extent that these relativistic effects are understood and incorporated into forecasting and trading model technology, market participants have the opportunity to generate additional profit or limit their losses. In our terminology, the profit which is generated is energy extracted from the market. Improved efficacy of component interaction generates additional energy and reduces the friction associated with buying and selling within the market. The process may be compared to the search for more efficient engines in the automobile industry: in the long term, everybody gains from it.

Have we achieved a *perpetuum mobile*? The answer is clearly no. Like any other technological innovation, the new technology does not generate energy from nothing, but it does take advantage of the energy potential existing in the financial markets. Besides, a lot of energy has been put into the new technology in form of extensive research and development work. As the relativistic reaction patterns become increasingly diversified, research and development efforts will have to increase. Money spent in terms of subscription fees to make the new technology available to the decision makers will contribute to that end.

6 Discussion of the conventional definition of efficient markets

As the markets consist of a diversity of components, there are different relaxation times, occurring because of the underlying relativistic effects between different components. It follows that the weak form of efficiency coupled with the rational expectation model cannot be attained: because of the presence of different time components with heterogeneous expectations, current market prices cannot reflect all available information. Why, then, did this not show up more clearly in previous scientific investigations?

There are several reasons:

- Extensive computing power is needed to show that financial markets can be forecast. Access to reasonably priced computing power has become available only recently.
- High-frequency data is also a prerequisite. We have been collecting tick-by-tick market maker quotes since the beginning of 1986 and thus possess a high-quality database for

the investigation of relativistic phenomena.

- Another reason may be linked to the traditional notion that free markets must generate fair prices with no additional gains to be made. In part, this may have been inspired by the political message of the founders of economics such as Adam Smith, who wanted to free the markets from state control. If their theories had concluded that the so-called invisible hand was indeed visible – that is, that forecasting was feasible and that some individuals could take an unfair advantage thereof – this would have been a strong argument against free markets, and a strong argument for keeping the status quo.
- Last but not least, it is only in the last few decades that an increasing awareness for dynamic and nonlinear processes has been gained. Such an awareness, however, is crucial for the development of applied economics focusing on relativistic effects.

The presumption of conventional economics that forecasting is impossible per definition has had a powerful impact on the research on market efficiency. Economists have focused on structural studies which were hamstrung by a lack of high-frequency data and theoretical shortcomings. Little research has been invested in actually trying to forecast shorter-term price movements and build successful trading models. The few studies that have been made focused on relatively simple strategies, which are ill-suited to understanding dynamic phenomena.

7 Suggestions for an improved definition of "efficient markets"

Although the current definition of efficient markets has shortcomings, we do not think that this concept should be abandoned; rather, we believe, it should be adapted to the new findings. It is important to find a good measure of how well a market operates. This is why, in view of our results, we would like to suggest some ideas for a redefinition of "efficient markets".

From a dynamic perspective, the notion of reduced friction should be central to the notion of efficiency. We consider an efficient market to be a market where any investor can find a matching partner for any transaction any time at a price which is not biased by information hidden from any partner. In other words, a market may be termed efficient if the following two requirements are met: First, all market information must be available to the decision makers. Second, there must be participants with different time scales and heterogeneous expectations trading with each other to ensure a minimum of friction in the transaction costs. This latter requirement would not be met in an oligopoly or monopoly, where the market is dominated by one or a few market components only.

A quantitative measure of efficiency might be derived from the bid-ask spreads (those between real bid and ask prices being more appropriate for such a measure than the nominal spreads quoted in information systems). Spreads are not only a measure of "friction", they also contain a risk component. The volatility or, more precisely, the probability of extreme price changes within short time intervals has to be considered together with the spread in the quantitative measure of market efficiency to be proposed.

Contrary to the accepted opinion, efficient markets as newly defined are a requirement for relativistic effects and thus for developing successful forecasting and trading models. This is a surprising result – it indicates that with increasing globalization of financial markets and growing trading volume the potential for successful forecasting will increase, too. From this we conclude that we are seeing the start of a new technology whose full potential remains to be discovered.

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