



## The Basics of Investor Uncertainty: Value and Momentum are Complementary.

How do trends develop in the stock market? How can investors benefit from the undervaluation of a stock? These questions are as old as investing itself. A different way of reasoning – a reasoning which borrows from modern physics – provides new answers to these questions. A surprisingly simple scheme of human information processing shows – in addition to many other interesting insights and conclusions for investors – that certain investment situations are mutually exclusive – value and momentum.

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### The uncertainty of little boys, physicists, stock market experts and other primates

When I was a little boy my three years older brother made an offer to me: „I'll give you my piece of two francs and in return you'll give me your piece of one franc, your piece of fifty centimes and your five pieces of ten centimes!“ I had to be careful with my brother since he was always trying to tease and fool me. This time I had paid attention to his trick: It cannot be that he gives me one coin and I should give him seven in return. My brother still tried a few times to convince me that his offer was fair. I remained firm and refused the exchange.

With a smile on your face, dear reader, you may follow this little story and think to yourself: Every beginning is difficult, especially the dealing with money!

But – hand on heart – does dealing with money really become easier as we grow older? When I was a little boy my brother gave me the information that two certain amounts of money are the same. I did not believe him and did not go ahead with the transaction. Is such behavior only typical for small awkward boys as I used to be? Do not even seasoned market professionals behave like this, time and again? Perhaps even have to behave like this? That this is the case and that this causes interesting

pricing phenomena (like value and momentum - whatever these terms may still mean) is at the center of this essay. I invite you to explore together with me a world of quantum phenomena in order to fathom these.

Surprisingly, quantum phenomena also occur in our daily lives. With every small decision we stumble over these, without being aware of it. I would like to try to introduce you to this world. Don't worry you don't need to be a physicist to understand this, just to be open to a different, unusual style of reasoning.

Let me briefly outline the subject of this essay. Value and momentum are complementary. Value and momentum are terms from the world of stock markets. Ask an expert – let us call her Alice – and she will not hesitate to explain to you: „Value is the undervaluation of a security, momentum is the slope of this' security's price trend.“ If you then ask Alice: „How does such a price trend develop?“, then she will probably be less sure of her answer: „Actually there should be no trends in prices“, she will respond shrugging her shoulders. „Nor should there be any undervaluation of securities, because the standard theory assumes that markets are efficient. This means, any undervaluation, any value situation is so quickly discovered and eliminated by the market participants that nobody can ever make an extra profit out of it“, Alice will continue and then self-consciously add: „But as practitioners we know that this cannot be true. Markets are not

efficient. We are therefore constantly looking for value and momentum situations, and price trends from which we can benefit." Curious and amazed that here practice and theory gape apart so far you keep asking: „When do these so-called value and momentum situations occur in practice?" With this question you stoke Alice' passion. „You can always find stocks which are very undervalued. I constantly watch out for them. If I am alerted to such a stock then I analyze it with regard to its real economic value. I ask for example: How much income can the company generate with its business in the future and what capital costs will arise? With such considerations I then determine the so-called 'fair value' of the stock. If the stock is considerably cheaper than its fair value I buy it. If it is more expensive than its fair value I sell it. Unfortunately I must be patient after such a purchase, until I can realize my profit. The undervaluation, the value, of the purchase typically only vanishes very slowly. This can easily take three to five years. However, there are investors who are shorter term oriented. They then rely on momentum. They wait until a price trend of the stock forms in order to jump on it. They buy stocks which, for example, have exhibited superior returns over the past six months and they then hold these stocks for a certain time, in the hope that this trend continues. Both strategies are subject to risks. If I buy value then I have to wait for my profit. If I buy momentum then I face the risk that the trend may break off after a short time, leaving me with a stock purchased too expensively." „This sounds indeed very exciting", you then say and ask puzzled: „Instead of either buying value or momentum, wouldn't it be safest to just buy stocks which exhibit both, value and momentum?" Alice will respond with a sigh: „Exactly this I try again and again. But I simply do not find the right situation. The undervalued value stocks unfortunately never have momentum, and if I find a stock with an established price trend – a momentum stock – then unfortunately it never happens to me that I can unambiguously state the stock is undervalued. It is like bewitched. Both simply do not occur in the stock market together. Value and momentum seem to exclude each other." After thinking a while you come to the conclusion: „Here we have a very strange situation. In order to achieve an extra profit on the stock exchange an undervaluation is necessary, that is value, and for the undervaluation to disappear momentum is needed. Both seem to be necessary for this extra profit on the stock exchange, but the certainty about being in one or the other situation exclude each other, right?" „An unusual point of view, but I see no reason for objection: therefore you are probably right", Alice will respond to you.

Your fictional dialog with the stock market expert Alice characterizes quite well a situation which modern physics encounters when dealing with so-called complementary quantities – quantities which cannot be precisely measured at the same time.

Even if you are not an expert, and perhaps never have been interested in physics, a brief look at findings of this discipline can be well worth your while. If we apply these

findings to the financial market we can better understand the uncertainties which we, as investors, face. Let us therefore turn to fundamental physics in order to return from there with a clearer view of our situation as investors.

Modern quantum physics often has to deal with complementary quantities. Imagine, for this purpose, a small physical particle in motion. In order for the particle to achieve an action, it passes through a distance driven by a momentum. Complementary in this case firstly means: the action of the particle can be seen as the distance it passes through together with the momentum it has. The „complementary" quantities distance and momentum, in this sense, make up the „complete" action of the particle. This is almost self-explanatory and not very surprising. Only with the special insight of Werner Heisenberg, one of the most famous physicists of the 20th century, does the term „complementary" become surprising to us. Heisenberg says: we cannot precisely measure complementary quantities at the same time. If we want to accurately measure the distance of an action the momentum becomes fuzzy. And vice versa: If we want to accurately measure the momentum of the action of such a small particle then we lose knowledge of its location. If we want to measure both, distance and momentum, then some degree of uncertainty is therefore natural. We only know „more or less" where the particle in action is and „more or less" what momentum it has. There's even a formula exactly bounding this necessary measure of uncertainty: the Heisenberg uncertainty principle.

$$\Delta x \times \Delta p \geq h$$

The uncertainty about the distance ( $\Delta x$ ) and the momentum ( $\Delta p$ ) of an action cannot be eliminated because of this very same uncertainty relation.

Now, Heisenberg continues: We know exactly why this uncertainty occurs. Physical particles perform actions only in whole quanta – meaning that in nature actions occur in quanta only. There is a minimal quantum of action  $h$  (Planck's constant) which cannot be further divided. For example we can consider a photon, a light quantum, a particle oscillating in space. The higher the momentum and the energy of the light quantum the more (electromagnetic) oscillations it makes per unit of distance it passes through. Because in nature, as stated previously, these oscillations only occur as quanta of action, it appears to an observer as if the action occurs in leaps. These leaps generate the gaps in the observation which are responsible for the uncertainty in the measured physical quantities.

This is the way modern physics views complementary quantities. But let us come back to the stock market and to our fictional dialog with the expert Alice. Alice comes to the conclusion together with you that in the stock market a phenomenon similar to that in quantum physics can be observed. Value and momentum together form the necessary 'action' to make an extra profit. Yet somehow

experts can never determine both quantities at the same time. If experts are certain a stock has value then they are very uncertain about its momentum. As they become more certain that a price trend is developing for the stock – that is that the stock gets momentum – the more uncertain they become about its value, about the state of its undervaluation. Certainty about value and momentum seem to exclude each other.

How is it possible that the stock market exhibits such an amazing quantum phenomenon?

How is it at all possible that such quantum phenomena can occur in our daily lives?

If we follow the reasoning of Werner Heisenberg, we should begin to look out for actions in our daily lives which are not divisible, which occur only in whole leaps, and ask ourselves: Are there such action quanta, such quantum effects, in our daily lives?

As a little boy I had chosen not to trust the information of my brother. I did not believe him that one of his coins should be of equal worth to seven of mine and that I could therefore have confidently exchanged. I could have decided differently. I could also have accepted the information – and not resist it. My decision to follow this information or not was indivisible for me. Either I decided to follow: this action took place. Or I decided not to follow: this action did not take place. A quantum therefore. A leap of action in everyday life.

With the spirit of Werner Heisenberg we may now ask: Might such action leaps – that is decisions to follow information or not – be responsible for value and momentum being complementary in the stock market? An interesting question. How should we proceed? Are value and momentum not price phenomena in the stock market? How can these price phenomena be linked to our decisions about stock market information? And anyway, is it really our decisions about information which are so important? Is it not rather information itself which really matters? For me it is surely only important whether or not I have the information? If I have it I profit, if not I don't. Where do I have to make a decision here?

Our common sense may reject the idea that decisions about information are important. In recent years however, behavioral scientists have researched intensively such questions of our decision making behavior<sup>1</sup>. And they come to a surprising conclusion. If something really matters to us, something important to our life for example, then we humans follow a primary instinct. This primary instinct generates a resistance to any information. It questions any information presented to us. It lets us decide whether we want to follow it or not. To the point: When it comes to life and death, the informant can be an ally but is always a potential rival...

... when it comes to life and death – or to our money!

In our daily lives we are swamped with information. We blindly believe the statements of the news presenter on television, the lady at the information desk or the delay message of station staff. With advertising we are already more cautious: Does the night cream presented really make my skin younger and is it really worth my money? When it comes to investing our money on the basis of information from a stockbroker, then it is completely over with blindly trusting the information. Instinctively we then ask the fundamental question: Should we go along with the informant or not? No matter how trustworthy the information is we know instinctively: If we use the information then we cooperate with our informant on a mutually understood goal. Do we want this or not? If we want it then we cooperate. The good news is: Only we humans are capable for conscious cooperation. It is a behavior that distinguishes us from other advanced primates. Gorillas or chimpanzees, for example, primarily view any informant as a rival<sup>1</sup>. Of course, the bad news is: If we choose, however, not to cooperate with our informant, then we are not further than the little boy who does not believe his brother, and then we have not made more progress than our primeval ancestors, who were not able to make use of information of others.

We summarize briefly. In physics there are complementary quantities like distance and momentum which together result in an action. In nature action appears only in whole quanta ( $h$ ). These action leaps generate the uncertainty in the complementary quantities. They are responsible for the fact that a complementary quantity can only be determined at the expense of the determination of the other one. At the stock market we have considered a price phenomenon with which value and momentum appear as complementary quantities, just as in quantum physics. We have searched, inspired by Heisenberg, after a quantum of action with which we could perhaps understand this phenomenon. A quantum of action which we have found is our instinctive decision to follow or not information in the stock market. That such a decision is necessary is contrary to our common conception of information, which sees it as a fact not subject to being questioned. When it comes to our own money, however, we question any information, no matter how factual it appears.

We still do not know how this questioning, this kind of information processing, is taking place. And, we still do not know how this is related to value and momentum. As we will see, we, very naturally, use for this purpose an uncertainty relation in information processing, the simple, but very effective „basics of investor uncertainty“.

### The basics of information risk

Imagine you are a portfolio manager. You get a phone call of an unknown stockbroker – let us call her Beatrice – who provides you with following information:

*„The South Pacific islands state Vanuatu opens up for foreign investors. There are a number of new, very interesting, completely undervalued investment opportunities in Vanuatu which you could invest in.“*

You speculate what Beatrice's intentions are. Quite possible that she only recommends Vanuatu shares in order to make a profit for herself. Beatrice and her company are paid transaction fees on your purchase of the shares, or they are already in the possession of Vanuatu shares and want to mobilize now as many as possible investors to do the same, so that their own stocks rise faster. Quietly, you hope that Beatrice has also altruistic intentions and simply wants to help: If the information helps you then Beatrice is happy just for you, if the information does not help and you maybe even lose money because of it, then Beatrice would feel sorry having „seduced“ you to something bad. Despite all your hopes for the good intentions of Beatrice, you know of course that there is much competition in the securities business. You are swamped with calls from stockbrokers with buy recommendations for „attractive“ stocks – more than you can invest in and also more that you want to. Thus, you have a natural resistance towards stock market information.

After weighing up the motives of the information you see the goal of the attractive yields of Vanuatu shares and you are now asking yourself whether you want to participate in this goal. You have to decide whether you want to follow the information or not. This decision may be easy for you or very difficult. If the decision is easy for you then you maybe decide to buy a large number of Vanuatu shares. If it is difficult then you maybe decide to buy fewer or even no shares. You cannot buy less than a single share because stock exchange does not allow for it. As a portfolio manager it makes no sense for you to enter a stock position which is less than a certain percentage of the investor assets entrusted to you. Thus, there are a minimum number of Vanuatu shares what your decision is about. Maybe you discuss and agree with an investment committee and your clients before making the decision, but ultimately your decision is either: Yes, I follow the information and buy the position in Vanuatu shares or no, I won't. This „quantum“ of decision making – let us call it  $h_{dec}$  – is irreducible for you. It is there for you only as an indivisible single whole or not at all.

You know with your decision you join all those who already bought Vanuatu shares. So you join Beatrice (most likely she has the shares already) and everyone else whom Beatrice convinced already and all others who joined the Vanuatu trend from another source. The number of Vanuatu trend followers will increase with your decision by the number of people,

$$\Delta Investors,$$

with whom you will have coordinated your decision. You suspect that you will hardly be the first who is banking on the Vanuatu trend. But you also don't know either how many will follow you. You don't know the actual potential, the actual value the information still has.

With this decision you enter the following uncertainty situation: On one hand, increasing the number of the Vanu-

atu trend followers by  $\Delta Investors$  reduces the potential – that is the value – for all subsequent investors and, on the other hand, increases the realization of values for all previous investors in the Vanuatu trend. Most of all you fear the possibility that no one buys after you, that the existing number of investors will no longer grow after an increase by  $\Delta Investors$ , that the information has no value anymore. We write for this current uncertainty<sup>2</sup>:

$$\Delta Investors \sim \Delta Value$$

Beatrice, your caller, is confronted, however, by a different kind of uncertainty.

She just got the job from her boss, the head of an investment firm, to place as many Vanuatu shares in the market as possible in order for them to recover from their undervaluation. The investment firm got the exclusive right to emit Vanuatu shares, but had to take much of the emission on its own account, because they could not be placed in the market. Unfortunately the shares fell strongly already on the first day of the going public, making them appear very interesting and cheap. After Beatrice got the job from her boss she starts thinking about how to best proceed.

First, Beatrice begins to daydream. She imagines figuratively her success with her job. How her customers will buy Vanuatu shares and how her boss will reward her when she has placed all of the shares in the market and the price of the shares will have risen enough. Beatrice is thinking how nice it would be if she could place all excess Vanuatu shares with a single transaction. Then, she would have reached her goal with her first customer already – or maybe not? No, actually she wouldn't have reached her goal then yet, Beatrice begins to doubt. Because the shares are undervalued, she could sell them to a single client only at a very low price. The undervaluation would still be there. But her boss expects the valuation gap to close and share prices to rise to normal levels. Many individual purchases in Vanuatu shares must be made that this can be accomplished, Beatrice considers further. Beatrice imagines all those people who will be involved, all investors who will participate. Quite a few will be necessary. How many will it be at the end? Some ten thousand perhaps? She imagines how these people will decide to participate. Surely, not all participants will decide alone. Hardly. Rather, Beatrice thinks, they will come to an agreement within more or less larger groups. How many decisions will have been taken at the end when Beatrice has achieved her goal? Fifty perhaps? No, she thinks, fifty is too low. With fifty investment decisions, groups of two hundred investors each would have to join, if it is to be ten thousand participants at the end. In that case only larger asset managers would participate. In order to develop a solid trend in favor of Vanuatu shares, many smaller asset managers and even private investors must also participate, Beatrice realizes. On average, Beatrice is expecting, there will be about one hundred participating groups of about one hundred associated investors.



Now, Beatrice visualizes not only the fantastic salary she will have in case of success, but also the work that lies ahead of her. So go on, she says to herself, a hundred money managers of an average of one hundred investors need to be convinced!

Beatrice informs herself extensively about all details of the Vanuatu stocks: the political environment of Vanuatu, the reasons for the opening of the small state, the quality of the companies, their economic potential, etc. She contemplates arguments to convince potential investors. She asks for example: Will I rather point to the political stability of Vanuatu, to the economic potential of the South Seas region or simply to the undoubtedly attractive valuation of Vanuatu stocks? Beatrice thinks to herself she could make a few test calls with some private investors in order to see how they react. Only then, once she has found the best reasoning, she will approach professional money managers.

With private investors usually only one person decides whether or not to buy. The number of Vanuatu investors increases, with every private investor Beatrice calls, by one investor or, if Beatrice is not successful, by zero. We write for this current uncertainty in the number of investors:

$$\Delta Investors = 1 \text{ Investor}$$

With private investors Beatrice has a relatively low uncertainty about the change in the number of Vanuatu trend followers. However, she must overcome a relatively high „information resistance“ in this investor group in order to keep the trend going. Information resistance is a key figure which is particularly important for the work of Beatrice. She asks herself: How many successful calls do I need per additional investor into the Vanuatu shares? And she denotes this number information resistance. Beatrice would like to win as many investors as possible with as few successful calls as possible. Thus, she is interested in an information resistance which is as low as possible. A call is successful if the corresponding investor group decides to purchase the Vanuatu shares. Beatrice denotes this decision activity of her customers  $h_{dec}$ . (Because there are no three-quarters or half decisions,  $h_{dec}$  is an irreducible quantum of action.) If Beatrice only needs one successful call to win one hundred additional investors at a time then:

$$\text{Information Resistance} = \frac{1 \times h_{dec}}{100 \text{ Investors}}$$

In comparison, this number is a hundred times smaller than the information resistance Beatrice receives when calling only private investors. With private investors, she needs a successful call for each additional investor in order to keep the trend going:

$$\text{Information Resistance} = \frac{1 \times h_{dec}}{\text{Investor}}$$

This is the hurdle Beatrice has to overcome with each of her calls to private investors. Thus, her current uncertainty with each of these calls is: Can I surpass the hurdle or not? We write for this current uncertainty in information resistance:

$$\Delta \text{Information Resistance} = \frac{1 \times h_{dec}}{\text{Investor}}$$

Let us briefly summarize this trial run of Beatrice's. For testing purposes Beatrice only calls private investors. On one hand, she has got the advantage of a low uncertainty about the change in the number of investors. If her arguments are not convincing at a call she only loses one single potential investor. On the other hand, she is confronted in this test run with a high current uncertainty in information resistance. She needs one successful call for each additional investor into the Vanuatu shares.

After these sample calls to close private investors, Beatrice knows how to best convince her customers. She starts to approach professional investors, first many smaller ones, and later also the larger asset managers. Each such call involves on average an investor group of about one hundred:

$$\Delta Investors = 100 \text{ Investors}$$

Now the stakes are higher. One hundred investors more or one hundred potential investors less. However, with these investors the information resistance to overcome is much smaller than for private investors. Beatrice only needs one positive investment decision per hundred investors and no longer one positive decision for each individual investor. Her risk in information resistance has decreased substantially (hundredfold):

$$\Delta \text{Information Resistance} = \frac{1 \times h_{dec}}{100 \text{ Investors}}$$

Or, written differently:

$$\Delta \text{Information Resistance} = \frac{h_{dec}}{\Delta Investors}$$

And again, written differently:

$$\Delta Investors \times \Delta \text{Information Resistance} = h_{dec}$$

*The current uncertainty about the growth of the number of investors times the current uncertainty in the information resistance equals the minimal unit of decision  $h_{dec}$  to follow the information.*

As Beatrice not only approaches investor groups of the same size, but investor pools which vary in size, this uncertainty equation does not apply strictly. With a little mathematics (which I would like to spare you here) it can be shown that, instead of this uncertainty equation, a more general „uncertainty relation of information processing in the stock market“ applies to Beatrice:

$$\Delta Investors \times \Delta \text{Information Resistance} \geq h_{dec}$$

*The current average uncertainty about the growth of the number of investors times the current average uncertainty in the information resistance is greater than or equal to the minimal unit of decision  $h_{dec}$  to follow the information.*

You have put yourself in the shoes of a portfolio manager who received from an unfamiliar stockbroker, Beatrice, a piece of information. You have gotten to know Beatrice as dreamy, ambitious, but also coolly calculating stockbroker and seller of Vanuatu shares.

The current risk of the seller Beatrice is a relationship of uncertainty between the number of investors and the information resistance with regard to the information she wants to pass to customers. Beatrice faces a fundamental uncertainty in both, the number of buyers and in the information resistance for buy decisions. She can reduce the current uncertainty in the number of buyers by confining herself to small investor groups only, but then she must expect a higher uncertainty in the information resistance, because more purchase decisions per investor are necessary. If she wants to reduce the current uncertainty in the information resistance, then she has to approach larger investor groups, which, in turn, increases the uncertainty in the number of investors.

Let us summarize. Or, to put it in more precise terms, let us add together the individual steps of the dissemination of information in the stock market to a single whole – to a complete absorption of the information in the stock market. Let us string together all the steps, the steps Beatrice takes, starting from the first investor she convinces to the second one, to the third one and further on to the bigger investor groups, until she has reached her goal or has to give up. Until the Vanuatu stocks have recovered from their undervaluation and Beatrice is rewarded by her boss or she has to give up. What is the uncertainty for the whole enterprise to place the information in the market? The „small“ uncertainties of every single phone call of Beatrice add up to a „big“ uncertainty relation.

If Beatrice wants to make sure that a certain number of investors will buy Vanuatu shares, if, for example, she wants to ensure that ten thousand investors will buy Vanuatu shares, then she cannot confine herself to speaking with investor groups of a certain size only. She must, in that case, not speak only with large pension funds, for example. The number of necessary decisions, i.e.: the information resistance, is indefinite. If she has no luck with large pension funds she has to approach smaller investor groups and vice versa.

If, however, Beatrice wants to focus on investor groups of a certain size only, if for example she wants to speak with large pension funds only, then she wants certainty in information resistance. In that case she doesn't know how many groups she can convince, how many pension funds will participate and how many investors at the end will have followed her.

Certainty about the number of investors and the information resistance of stock market information are mutually exclusive.

The same principle that applies to Beatrice as employee of an investment firm, also applies to investors of their own money. It applies to portfolio managers of large assets as well as to small money managers. It applies to all market participants.

*Certainty about the number of investors and the information resistance of stock market information are mutually exclusive for all market participants.*

*The number of investors and the information resistance of stock market information are complementary.*

### **How information risk is related to value and momentum and the consequences for investors**

Beatrice, the stockbroker, and her customers worry about the number of investors who already have followed her information in the stock market, and what the decision-making mechanisms are for a transaction that is made on the basis of the information itself. Beatrice concludes, one cannot know the number of investors and the information resistance at the same time.

If you remember the fictional dialog between you and the investment expert Alice, then you were talking about something else, namely about the value of a stock and its momentum. In this fictional dialog, you and Alice raised the conjecture that certainty about both cannot prevail at the same time. A stock either has value, then its momentum is uncertain, or it has momentum, then its value is uncertain.

Now, how do both interrelate? The stockbroker Beatrice knows: The number of investors and the information resistance are complementary. The stock market expert Alice and you have suspected: value and momentum could be complementary. Can the knowledge of Beatrice help corroborate this conjecture or even prove it?

Let us listen to a further fictional dialog about this issue. The dialog between the investment expert Alice and the stockbroker Beatrice.

Alice begins: „I recently read an interesting article on this subject by a famous scientist – Joseph Stiglitz.“

„Is that Stiglitz, who in 2001 was awarded the Nobel Prize for economics, along with George Akerlof and Michael Spence, for his work on the relationship of information and markets?“

„Yes exactly. Stiglitz wrote this article already in 1976 together with Sanford Grossman<sup>2</sup>. He associates value – that is the value of information – with the number of those investors who already have the information. 'Since when no one is informed...', so Grossman and Stiglitz, 'then the value of

information... is high; when almost everyone is informed, the price system is very informative, so the value of knowing ... [the information] precisely is low.'"

„If so,“ Beatrice picks up the thread, „then a direct link between the number of investors and the value of information can be established. When I convinced another group of a hundred investors to buy shares of Vanuatu, then on average the price rose a little and the value decreased a little:

$$\Delta \text{Investors} \sim \Delta \text{Value}$$

„Precisely, which means nothing other than: The current uncertainty about the change of the value was always roughly the same with this homogeneous group of investors, which comprised always about hundred investors. And by the same token the uncertainty in information resistance was always about the same, wasn't it?“

„Yes, every conversation with an asset manager in this homogeneous group was about the same: Do a hundred investors decide to participate or do they decide against it?“

„But you did not only approach this homogeneous group of investors which comprised always hundred investors? The size of asset managers who participated in the theme certainly varied greatly over time? As did the uncertainty in information resistance?“

„Unfortunately yes,“ Beatrice replies with some regret, „as the Vanuatu stocks had fallen dramatically after going public, not much has happened. At the beginning I could not convince many of the larger investor pools, the pension funds and institutional investors, only later. They indeed bought Vanuatu shares, now and again, to fill their quota for Pacific shares, but only if they themselves had received more money to invest. But these investors were not chasing Vanuatu shares. If another party made a better offer, they let go of the shares offered to them, and bought other stocks in the Pacific region.“

„But who were the active buyers of Vanuatu shares at this time?“

„At the beginning, after the shares had fallen sharply, some hedge funds and certain, very specialized asset managers were convinced of my arguments. Interestingly, they would not have bought if I had told them that several of the larger investor pools already had participated. These specialized asset managers were looking for information which is as exclusive as possible.“

„So at the beginning these specialized asset managers had a high certainty about the value of the Vanuatu stocks. But they were very worried and uncertain about what other investors were doing?“

„Exactly, yes they were!“

„Which means nothing other than: They were very uncertain about the information resistance of the others?“

„Exactly, and for me it was very tedious at the beginning, too. I had to talk to many people in order to succeed. Many could not believe that the efforts for opening up the South Seas islands were serious. Others did not believe that in the South Sea inhabitants work hard enough to succeed economically. Yet others objected that other investment firms had rated Vanuatu shares as 'sell' precisely because of the poor showing of going public, and therefore did not want to buy. It was completely unclear whether any and which of the investor groups would follow the information.“

„And of course, it was then also completely open and unclear how, and whether at all, a price trend would develop?“

„Oh absolutely!“ says Beatrice, already slightly agitated. „The initial investors all worried that I had, by this time, informed and convinced many competitors. They told me: If many competitors want to do the same thing at the same time, i.e. to buy, then the price can adjust very quickly and with high momentum. Conversely, they could live with a low momentum, namely, if the information still not is in the market at all, if it is not taken seriously there, even later, or rejected. These early investors could deal well with this high uncertainty. As long as they have value, uncertainty in the momentum doesn't matter, they said.“

„Do I sum up correctly?“ Alice attempts to analyze soberly. „At the beginning, after the strong price collapse, only a few knew about the high value of the stocks. The number of investors, which comprised these insiders, was initially small and the value was high. There was hardly any uncertainty among these specialists about the value and about the number of these very few investors. At the same time, these specialists were highly uncertain about the information resistance of other investor groups as well as about the momentum, right?“

„Exactly, yes they were!“

Alice analyzes further: „Thus, at the beginning of the distribution of information the following is true:

$$\Delta \text{Investors} \sim \Delta \text{Value}$$

and

$$\Delta \text{Information Resistance} \sim \Delta \text{Momentum},$$

isn't it?“

„If we look at it like this, then yes it is. If I understand you correctly, then, at the beginning, the number of investors is comparable with the value of the stock as well as the uncertainty in information resistance is comparable with the uncertainty in the momentum.“

„If you now consider that the basics of investor uncertainty always applies. That certainty about the number of investors and about information resistance are always mutually exclusive. In particular, at the beginning of the information distribution. Then ...“

„...I think I know what you are getting at. Then, at the beginning of the information distribution, the same applies to value and momentum as applies to the uncertainty about the number of investors and the information resistance ...“

„...exactly, certainty about both cannot prevail at the same time either!“

„Bingo!“ cries Beatrice, now completely enthusiastic. „Value and momentum are complementary at the beginning of the information distribution.“

„Of course, the question arises“, Alice is still somewhat skeptical, „whether this is so only at the beginning of the information distribution or whether this is always the case. Tell me what happened next!“

„After a certain period of time the shares began to rise, which of course was exciting for the first investors, the hedge funds and the specialized asset managers. Thereafter, I had an easier game. Suddenly, I realized that my conversations were getting easier with certain asset managers. Often they were willing to buy Vanuatu shares in no time ...“

„...each small step in overcoming the information resistance led to a transaction and thus on average to a small step in the momentum and therefore the prices increased,“ Alice adds, „but tell me: Which were the asset managers you could suddenly convince so easily?“

„In the case of the Vanuatu stocks it was the large investor pools, the pension funds and institutional investors, bringing me to a breakthrough. Because they had a fixed rate for Pacific equities in their investment strategy, they could not avoid dealing with Vanuatu shares with their increasing success. For many of these large investor pools Vanuatu stocks became a fixed part of their investment strategy“, Beatrice remembers. „I must add however that the trend is not always set by these large pension funds and institutionals. At other jobs, where I had to place other shares, it was for example the funds for small investors which helped break through the price trend.“

„I'm trying to combine your experience with my thoughts.“ Alice now is getting increasingly excited, too. „Later you could convince some investor groups – in this case that large pension funds and institutionals – more easily. This meant that the number of investors grew more rapidly, and with it the price rose and the value fell. The uncertainty about the increase of investors and thus the uncertainty about the value increased. At the same time the

uncertainty in the information resistance of these investor groups decreased and with it also the uncertainty about the momentum, right?“

„You can put it like this, yes!“

„So, later, and towards the end of the information distribution, the uncertainty in the information resistance is linked to the uncertainty in the momentum by the same close relationship as in the beginning?“

„Yes, of course! And our good Professor Stiglitz ...“

„...already explained to us that we should always compare the number of investors with the value of the information...“

„...also later and towards the end of the information distribution. Now we have everything together: ...“

„... Uncertainty about value and momentum always compare to uncertainty about the number of investors and the information resistance ...“

„... which means nothing other than: Certainty about the value and the momentum of stock market information are mutually exclusive in each phase of the information distribution.“

„Value and momentum are always complementary!“

Both, Alice' and Beatrice' faces are beaming now.

„Once again, Bingo! This finding alone is already worth something“, says Beatrice after a while, „but can you make money out of it, Alice?“

Alice thinks for a while and finally responds: „The knowledge that value and momentum are complementary is not like winning the lottery making me or my clients rich at a single stroke. It is not knowledge which has a special news value. But it has the advantage that it is always true, thus timeless. In our investment business it is, in the long run, often more important to avoid errors than to have novel investment ideas. How often have I looked for stocks which have value and momentum at the same time. And how often did I fall on 'my proverbial face' with this quest. Now I will no longer do so, based on this knowledge. If I invest in value, I will look only at the criteria characterizing value stocks. I will be patient with these investments and not additionally require them to have momentum at the same time for a putatively faster success. And if I invest in momentum, I will, from now on, confine myself to the criteria of the momentum. I will act short term, decisively and quickly. With momentum stocks I will no longer also look at the valuation, making me putatively certain, that in the long run there is still value would the trend break down. I will no longer make the mistake to require value and momentum at the same time. Because I now know value and momentum are mutually exclusive. If I avoid



just this mistake in the future, then – I am sure – over time there will be some more profit per year for me and for my customers.”

„Then everything is ok, Alice.“ Beatrice smiles all over her face. „But the ideas for your investment decisions you will continue to get from me.“

### The edification which lies in the fact that we humans are inferior to the machine

Dear reader, as a critically analytical person you may think: May be that with this different reasoning, which borrows from modern quantum physics, certain phenomena of the stock market can be better understood. The physics of subatomic world cannot determine distance and momentum of a particle at the same time, because there is an indivisible quantum of action. By the same reasoning, value and momentum of a stock cannot be determined at the same time in the market place. Either I have value and I have to wait in order to realize my profit, or I have momentum, then the value of the stock which can be achieved in the long term is so uncertain that I have to lock in my profit soon. My Swiss franc cannot have at the same time both, value and momentum, because it is impossible. I understand, you may think, that this is so because investors too are exposed to a certain quantum of action: Investors must (alone or in groups) take the indivisible decision to follow information or not. They must decide to buy or not. They have an innate information resistance. I agree with that, you could argue, but I still cannot see why my very own decisions should be so important! Do I really have to decide, with or without coordinating with other people, by myself? Can't I just delegate it to someone else? And also this person, at the end, is not obliged to necessarily decide by herself. Aren't most investment decisions already taken automatically? Transactions done from computer to computer? And don't these computers have the advantage to act completely without emotions? Aren't we ourselves, all too often, misdirected by our own emotions. We sell because of fear when the stock is cheapest, and buy with greed when it is expensive. Isn't it better, to leave our investment decisions to the computer? Can't I then spare myself from my own (often all too) human decision to follow stock market information?

Let me ask this question differently. Stock market computers are nothing other than machines which, without our intervention, process information and then decide to buy or sell. So actually the question is: Does the machine render us humans superfluous? This question is not new. We have posed it since the Industrial Revolution of the 18<sup>th</sup> and 19<sup>th</sup> century, with slight variations over and over again. Was it initially the steam engines which were superior to us in certain respects, so it was later the steam locomotives, again later a variety of electric machines, automobiles and flying machines. Today we have 3D-print-machines, soon it will be nano-robots. And on the stock market, it is ultrafast computers. Computers make buy and sell decisions in milliseconds. So quickly, that no hu-

man intervention is possible in between. Because I, as human being, can't keep up with this speed, I must define in advance all the operating instructions for the computer in a program. I must define in advance what the computer shall do when there is positive news for a stock. I must define in advance what the computer shall do if a purchased stock drops 30% within five minutes. I must define in advance what the computer shall do if shares were sold which only spuriously appeared in my inventory. But can I define in advance what the computer shall do when it turns out that it is given a wrong instruction? How can the computer distinguish, within milliseconds, correct instructions from wrong ones? And very basically: Can I define in advance what the computer shall do if on September 11, 2001 two aircrafts fly into the New York World Trade Center leaving a shocked world standing still?

I can program the computer only according to a list of typical, imaginable to me situations, but not to an unforeseen specific case, not to what makes the future event singular. Each piece of information, every piece of news has something typical and something unique. Stock prices fell a lot on September 11. Maybe this was the typical aspect of this attack. I can already instruct the computer in advance to buy or sell in such a case. But on September 11 something very unique also happened. Something which makes this day a historically unique case – a historical event. The computer does not address this unique aspect which is a component of every information. Even as I, as a responsible human being, would, in this very specific case, have acted differently, due to my conscience, my mind, my feelings or even my subconscious. A computer can ease the burden of uncertainty of a decision in a particular case and then, because we no longer sense the uncertainty we have the feeling that it doesn't exist. But the uncertainty is still there. As you might recall, the basics of investor uncertainty is that each additional group of investors has to decide whether or not to follow information. About how this decision is made the basics of investor uncertainty does not give any insights. The group may also delegate the decision to someone else. Or to a computer. The computer cannot address, as we have seen, the very unique aspect which the information represents. It cannot address the very particular situation, here and now. It will respond only to the typical part of the information. To what makes the information similar to the past. This may lead, very often and for a long time to very good investment results. And perhaps very rarely to huge disasters. And here the question of our responsibility arises. The responsibility for the consequence of this decision cannot be delegated to the machine. It never can be delegated. To delegate decisions to a machine is to delegate them to something which in an isolated particular case is unaware of any responsibility towards you. Decide for yourself whether you want this or not.

Modern quantum physics abandoned the idea of separating the measuring apparatus and the object of a physical measurement. The observer, the measuring apparatus,

always affects the measurement itself. Shouldn't we too, as stock market investors, abandon the idea that information works alone and separated from us in the stock markets – and get used to thinking that more important than pure information is our decision, as market participants, to follow it or not? Should we not also get used to thinking that we can delegate this decision, but we ourselves must bear the consequences? This fundamental law of human action cannot be outsmarted by any computer, no matter how fast. Just like the Heisenberg uncertainty principle cannot be outwit by the most precise measurement apparatus. We cannot escape the basics of investor uncertainty in the stock market: not in cyberspace, not in Vanuatu and not anywhere else in the world.

But honestly: Do we really want this? How can we seriously want to escape this investor uncertainty? Is it not this very uncertainty of how we deal with information which gives crucial weight to our own decision? Only we can decide, here and now, whether and how we follow information. Is it not this very decision which gives us a unique responsibility as human beings and thus that a dignity which elevates us above our phylogenetic ancestors and also definitely above any no matter how fast and powerful machine?

<sup>1</sup> M. Tomasello, M. Carpenter, J. Call, T. Behne and H. Moll, „Understanding and sharing intentions: The origins of cultural cognition“, Behavioral and Brain Sciences (2005) (28), 675-735. [http://email.eva.mpg.de/~tomas/pdf/BBS\\_Final.pdf](http://email.eva.mpg.de/~tomas/pdf/BBS_Final.pdf)

<sup>2</sup> S. J. Grossman and J. E. Stiglitz, „Information and Competitive Price Systems“, The American Economic Review (1976), Vol. 66, No. 2, 246-253. [www.jstor.org/stable/1817229](http://www.jstor.org/stable/1817229)

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<sup>3</sup> I would like to thank Dr Natalie Knapp, Prof Dr Thomas Breuer and Hanspeter Oehri for their valuable comments, remarks and suggestions for improvements of the text. A special thank goes to Dr Marie-Christine Mikl who was very helpful for the English translation.