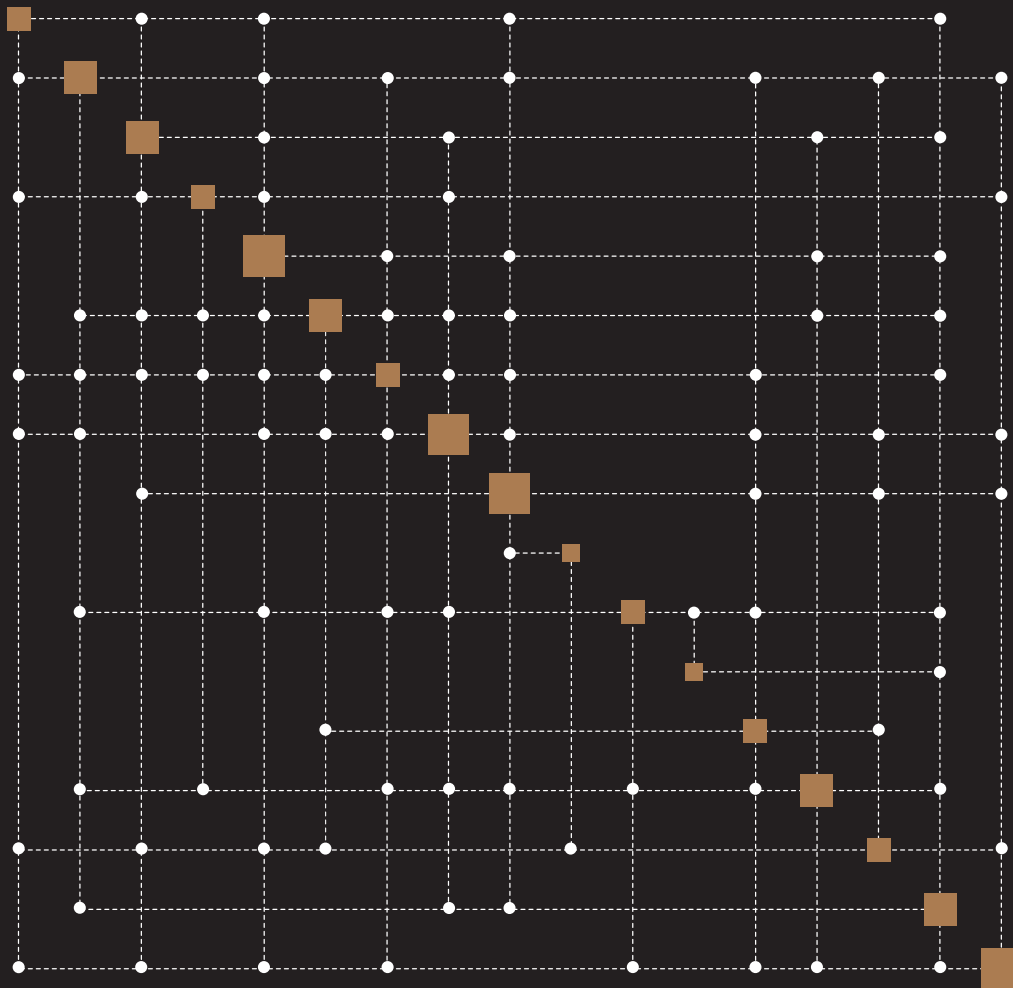




Complexity and Resilience Ratings

New Paradigms in Economics and Finance



A novel rating system,
based on complexity and resilience, engineered specifically for an economy
dominated by shocks, bubbles and instability



Introduction

The Probability of Default (PoD) of a company has been so far the central concept behind a rating and ratings are a key link between the markets and investors. Their importance cannot be overstated. However, the PoD is not a physical quantity and there exist very many ways of computing it. Until today, rating has not been a science. In fact, rating agencies themselves claim that ratings are merely opinions. When all calculations are done, it is always down to the subjective opinion of an expert. In mechanical engineering, for example, things like mass, strength, energy, stiffness or margin of safety are computed according to laws of physics which are the same all over the World. The PoD does not obey any such laws. Given the importance of ratings, the PoD must be replaced by something rational and more relevant. Something that not only has its roots in physics, but which is also more in line with the turbulent character of our times. Let's not forget that the Big Three agencies have conducted ratings since the beginning of the 20-th century. The world was very different a hundred years ago. Traditional ratings have become dangerously outdated and, most importantly, not suited for a turbulent economy. As the complexity of the economy increases, conventional ratings produce results of increasing irrelevance. Mathematically correct but irrelevant. This has become apparent in 2007 when Credit Rating Agencies have misled investors and contributed significantly to the economy meltdown. The new rating concept presented herein has been engineered *specifically* for turbulence and for an economy dominated by shocks, bubbles and instability. Markets are not efficient. In Nature there is no such thing as equilibrium.

Conventional ratings will surely continue to be used in the foreseeable future. However, in order to provide investors with new knowledge and insights we propose a novel, objective *complexity* and *resilience-based*

rating. High complexity is, with all likelihood, the most evident and dramatic characteristic of the economy. It is also the hallmark of our times. Resilience is the capacity to withstand shocks and is a measurable *physical* quantity. A resilience rating is applicable to companies, stocks, portfolios, and funds, systems of companies or national economies. In our turbulent economy, which is fast, uncertain and highly interdependent, extreme and sudden events are becoming quite common. Such events will become more frequent and intense, exposing fragile businesses to apparently unrelated events originating thousands of kilometers away. This mandates that companies and investors focus not just on performance but also on resilience, building less complex, less fragile businesses. Resilience means survival and sustainability. It is science, not opinions.

Instituting a new rating system, based on complexity and resilience measures, is based on the following rationale:

- Complexity is the hallmark of our times. It also dominates the dynamics of financial markets and of the global economy. It should be taken into account when analyzing and qualifying a business or an investment.
- Excessive complexity is a formidable source of fragility and vulnerability. Consequently, less experienced investors should avoid investing in highly complex businesses and financial products as they are more risky.
- The economy is characterized by a high degree of interdependency. This mandates the analysis of *systems* of corporation, funds, markets, rather than single entities. Systemic analysis and the rating of systems should be one of the cornerstones of a modern rating system.
- Conventional ratings, based on a Probability of

Introduction

Default (PoD) approach, are not applicable in a turbulent and non-stationary regime in which things change with the speed of the Internet. A more relevant rating scheme is one based on resilience, the capacity to withstand shocks, contagion and intense fluctuations of markets as these are the salient characteristics of the global economy.

- A rating should be available to every single business, not only to listed companies. Ratings must be 'democratized' in favor of a less fragile economy.
- A rating must be available for stocks, portfolios, funds, funds of funds, any financial product, not only for publicly listed corporations. It must be perceived as a dynamic property, not as a constant.
- A rating should indicate how to potentially improve a business or an asset portfolio.

The rationale behind resilience ratings may be postulated as follows:

- *Conventional PoD ratings are irrelevant and misleading in a turbulent economy. Resilience (resistance to shocks and turbulence) is more adequate.*
- *In a turbulent economy one cannot estimate the Probability of Default of a business but it is possible to identify its fragilities and vulnerabilities which may impact negatively its sustainability.*
- *Resilience is a measure which, unlike a Probability*

of Default, can be applied to public and private corporations, stocks, financial products, markets, national economies or systems thereof.

While it is not easy to assign a Probability of Default to a market, an industry sector, a fund or a portfolio, measures of complexity and resilience may always be computed. Therefore, with the new rating methodology it is possible to compare the resilience and rate any of the following:

1. Single companies (private, listed)
2. Stocks, financial products (e.g. derivatives)
3. Portfolios, funds
4. Stock markets
5. Market segments
6. National economies
7. Any data reflecting the functioning of a business (e.g. data contained in an ERP system)
8. Systems of any of the above
9. The entire Global Financial System

At present, Credit Rating Agencies rate public companies and sometimes large private corporations. There are over 40000 public companies listed in the world's stock markets. However, there are also over 200 million private companies. These too should have access to a rating mechanism. One of the missions of Universal Ratings is to offer private businesses, regardless of size, the opportunity to access a rating.

How Complex is the Global Economy?

Resilience is a useful property when one is confronted with a highly complex context. The reason for this is quite simple. High complexity, in particular when speaking of the economy, translates to turbulence, uncertainty, shocks, discontinuities, contagion, interdependency. Under similar circumstance, the dynamics is said to non-stationary. The future is permanently under construction.

It is said that the global economy is complex. This statement appears to be true, but just how complex is that? In order to justify the need for a resilience-based rating system we need to confirm that today the complexity of the global economy is indeed high. Today, this can be done on solid scientific grounds. Complexity represents a key physical property of any

system. Systems which grow or evolve tend spontaneously to become more complex. Good examples are our biosphere, societies or civilizations. Higher complexity implies more potential, more 'vitality' and functionality. But it also implies greater effort in terms of management and, last but not least, more difficulty in comprehending the very nature of the system.

Analyzing data from the World Bank we have measured the evolution of complexity as well as entropy – 'disorder' - of the World as a system. The analysis has been performed on the basis of approximately 250000 parameters, spanning the economy, industry, education, healthcare, energy, transportation, etc. The result is indicated in *Figure 1*.

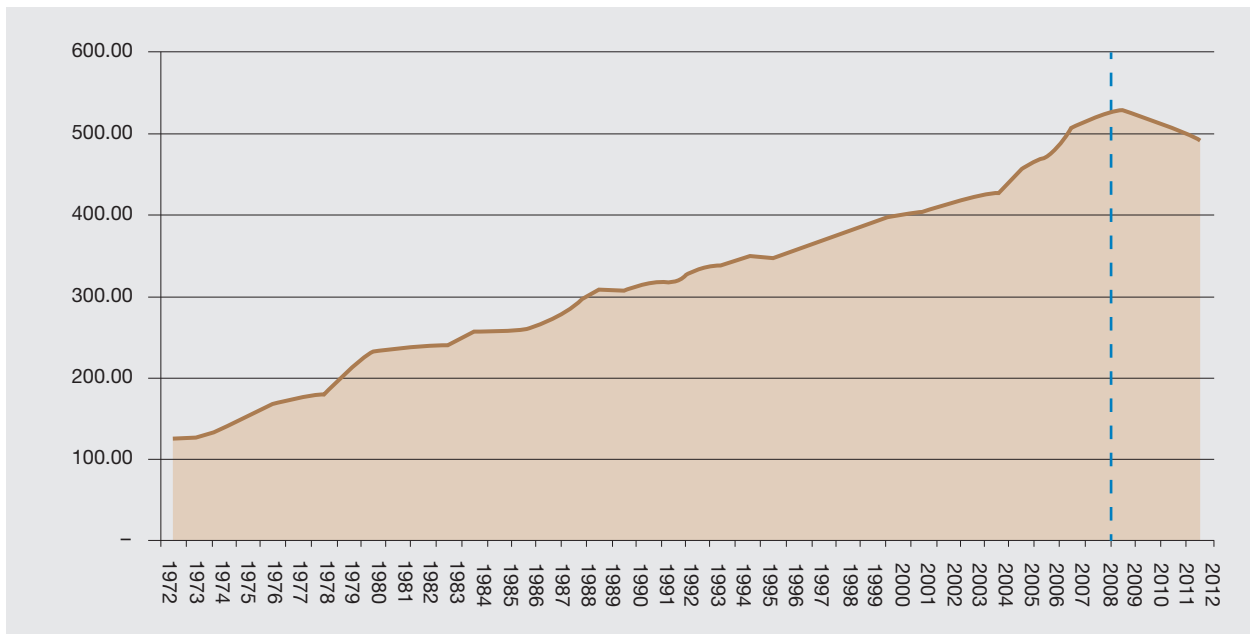


Figure 1. Global complexity in the period 1972-2012. Complexity is measured in cbits.

How Complex is the Global Economy?

It is interesting to note how the World as a system has been becoming more complex at an essentially steady rate. Fluctuations correspond to destabilizing events (conflicts, energy crises, etc.). The 2008 crisis – so far the most intense in the period under study – is indicated by the vertical dashed line. The build up

of complexity commenced in approximately 2004, peaking in 2007-2008. The subsequent drastic drop of complexity corresponds to destruction of the global economy. It is interesting to consider the evolution of disorder in the same period, see *Figure 2*.

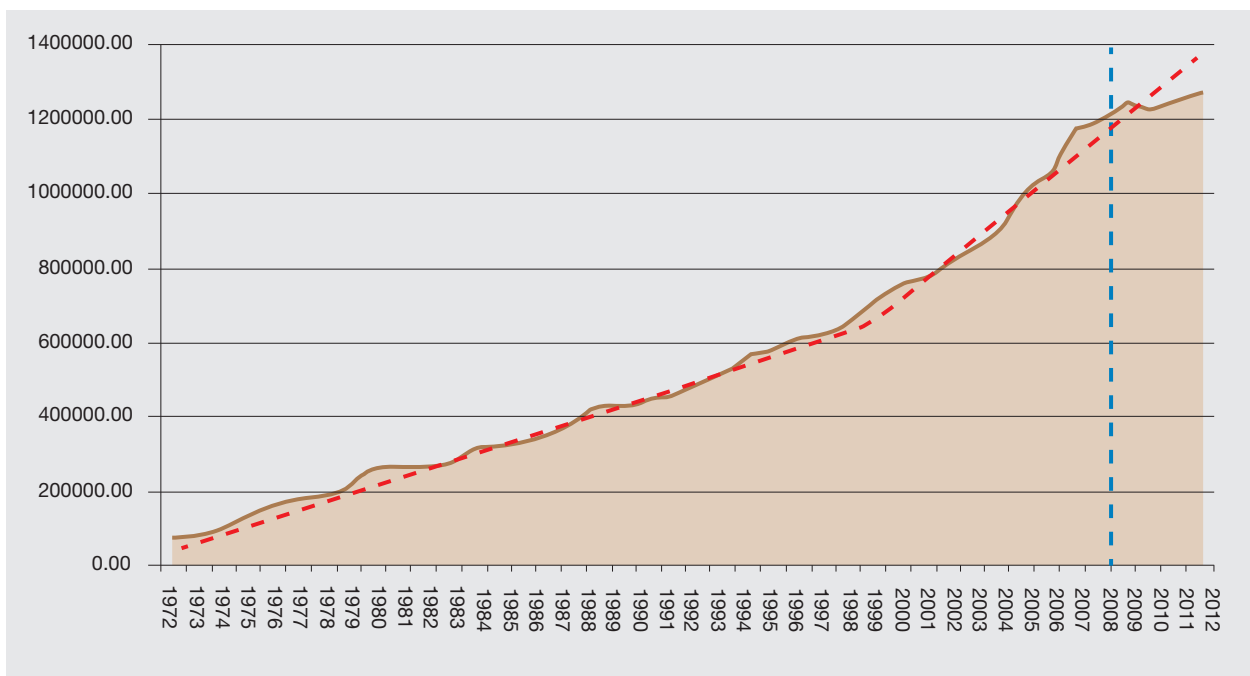


Figure 2. Global 'disorder' (entropy) in the period 1972-2012.

It is clear how, over the past four decades the levels of complexity and disorder have increased by a factor of 5 and 15 respectively. Evidently, high levels of complexity and disorder (uncertainty) translate to difficulty in doing business, to exposure, to even more turbulence. In such a context, what value can one attribute to a Probability of Default over horizons of

three or five years? As complexity and disorder increase - the above graphs hint that the trend is bound to continue - conventional risk assessment, management and rating techniques will have become increasingly irrelevant and should be replaced along the lines presented in this White Paper.



A New Rating Paradigm

The rating system developed by Universal Ratings (see [1] and [2]) relies on the following data:

- Market indices and stock performance (of public companies).
- Fundamentals (of public and private companies).
- Performance of financial products (bonds, funds, derivatives, commodities, etc.).
- Macroeconomic indicators.

Such data is available via commercial platforms such as Bloomberg, Thomson Reuters, capital IQ, etc. and is retrieved automatically by the Universal Rating system. With the exception of fundamentals, data can be obtained with basically arbitrary frequency (real-time, daily, weekly, quarterly, etc.). Universal Ratings' integrated platform provides short/mid/long-term complexity and resilience ratings of all of the above. In addition to standard products, i.e. pre-computed ratings of single stocks, companies or markets, the system allows users to construct on-demand portfolios (systems) of items and rate these on the same grounds. For example, in addition to it is possible to obtain a complexity and resilience rating of:

- All companies belonging to a particular sector and/or geography (e.g. telcos, oil & gas, automotive, banks, etc.).
- All companies listed at a particular stock exchange (e.g. all companies listed on Wall Street and treated as a single super-system).
- An arbitrary stock portfolio.
- A system of national economies (e.g. all G7 countries, the Eurozone, Mercosur, etc.).
- A system of stock markets (e.g. all stock markets of the G7 countries).

The ability to analyze and rate (large) systems of companies or portfolios proves invaluable to institutional investors who manage assets spanning various sectors, markets and geographies and whose concern is sustainability. The ability to know quickly which assets or markets are contributing increasing fragility to a given portfolio cannot be overstated.

Universal rating's system provides complexity and resilience measures and ratings for each of the classes of items and systems thereof. Complexity quantifies the degree of sophistication and the intricacy of the dynamics of a stock, a portfolio, a public company's fundamentals or a market index. Less complex and less convolute dynamics are easier to comprehend. In the presence of high complexity it is more difficult to make predictions and forecasts as to how a given stock or portfolio will perform. Consequently, highly complex financial items are inherently more risky and their behavior may often be non-intuitive. Therefore, highly complex assets should be avoided by less experienced investors. Complexity is stratified into five classes: Very Low, Low, Medium, High and Very High.

Resilience is the capacity to absorb shocks or destabilizing events, such as financial contagion, stock market collapses, market bubbles, natural disasters or geopolitical events. Opposite of fragility, resilience provides an indication of how stable a portfolio or market is and how it will react in the presence of the said events. It is therefore important to measure the resilience of corporations, portfolios and markets as well as that of the global economy. In a turbulent and complex economy driven by uncertainty and discontinuities, resilient portfolios provide the basis for more sustainable investments. Resilience ranges from 0% to



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100%. Higher values correspond to a better resilience rating, which ranges from one to five stars, while low values point to fragility.

Examples of complexity and resilience ratings of the following entities shall now be illustrated in the sequel.

- Stocks
- Stock portfolio
- Public company
- Market indices
- System of national economies (G7 countries belonging to the EU)

STOCKS

In general, high complexity implies intricate and convolute dynamics - this may not be visible to the naked eye - and indicate that 'surprising behavior' may be possible. In the case of scandal-stricken Volkswagen, a medium value of complexity suggests that the stock will not surprise investors any time soon. Similar statements may be made in the case of Exxon Mobile. Stock complexities are computed based on their closing value and are updated every day. Computations are based on a default horizon of 50 trading days.

SYMBOL	NAME	COMPLEXITY	LEVEL
IBM	International Business Machines	45	High
VOW3.DE	Volkswagen VZ	31	Medium
GS	Goldman Sachs Group, Inc. (the)	16	Low
XOM	Exxon Mobil Corporation Common	17	Low
FB	Facebook, Inc.	51	High
GOOG	Alphabet Inc.	57	Very High

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STOCK PORTFOLIO

A portfolios containing stocks of major pharmaceutical companies has been analyzed based on close values of the corresponding stocks. A resilience of 68% has been obtained, which corresponds to a two-star resilience rating. The portfolio *Complexity Map* illustrated below reflects the structure of stock interdependencies, see [Figure 3](#).

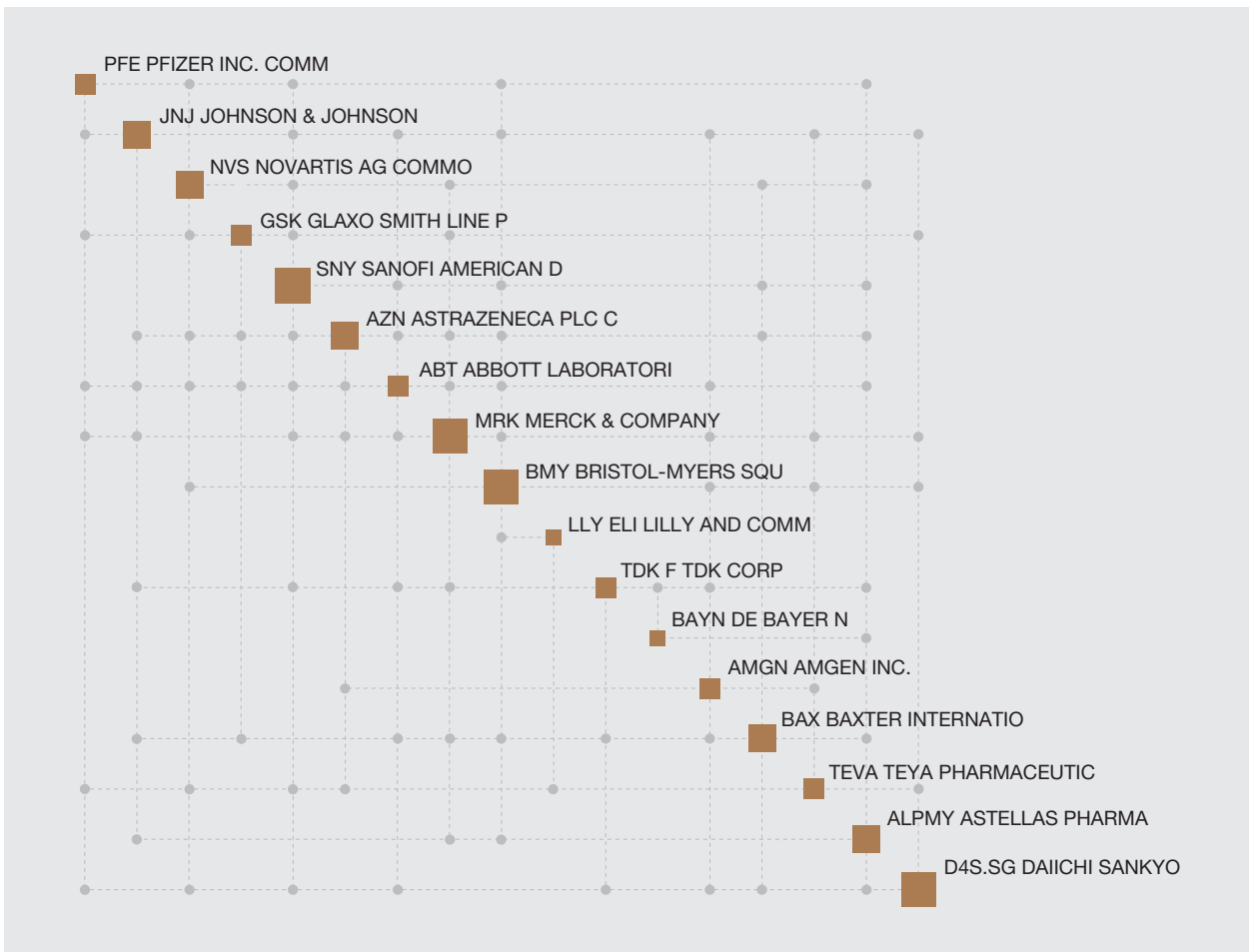


Figure 3. Complexity Map of portfolio of major pharmaceutical companies (1/1/2016).

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The size of the nodes in the complexity map reflects the percentage footprint of each stock on the complexity of the entire portfolio. This is illustrated in the so-called *Complexity Profile* of the portfolio in *Figure 4*.

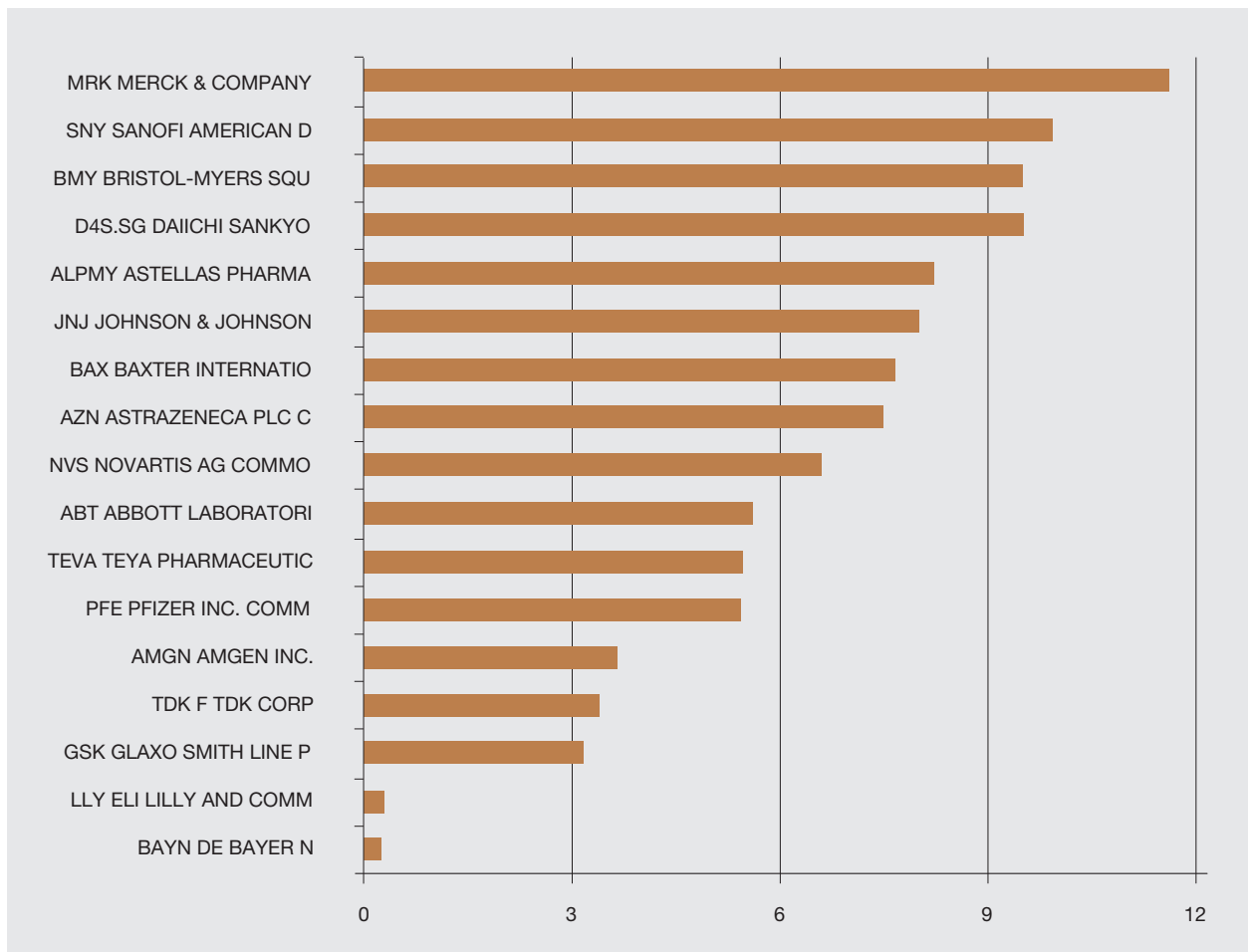


Figure 4. Complexity Profile of portfolio of major pharmaceutical companies (1/1/2016).

The stocks situated at the top of the chart in *Figure 4* are those that contribute the most to the complexity of the portfolio: MRK (11.7%), SNY (9.9%), BMY (9.6%). Stocks situated at the bottom, on the other hand, have a low impact on the portfolio's complexity: GSK (3.2%), LLY (0.3%) and BAYN (0.2%). As mentioned, high-complexity portfolios should be avoided by inexperienced investors.

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PUBLIC COMPANY

A major chemical company has been analyzed based on its quarterly fundamentals. The complexity and resilience rating of the business is illustrated below, along with that of its Financial Statements, Economics, Business Volume and Market Value, see *Figure 5*.

ITEM	COMPLEXITY	RESILIENCE	RR™
Overall	198	65%	★★
Financial Statements	43	68%	★★
Economics	48	67%	★★
Business Volume	95	73%	★★★
Market Value	21	76%	★★★

The dashboard below puts the various measures into perspective.

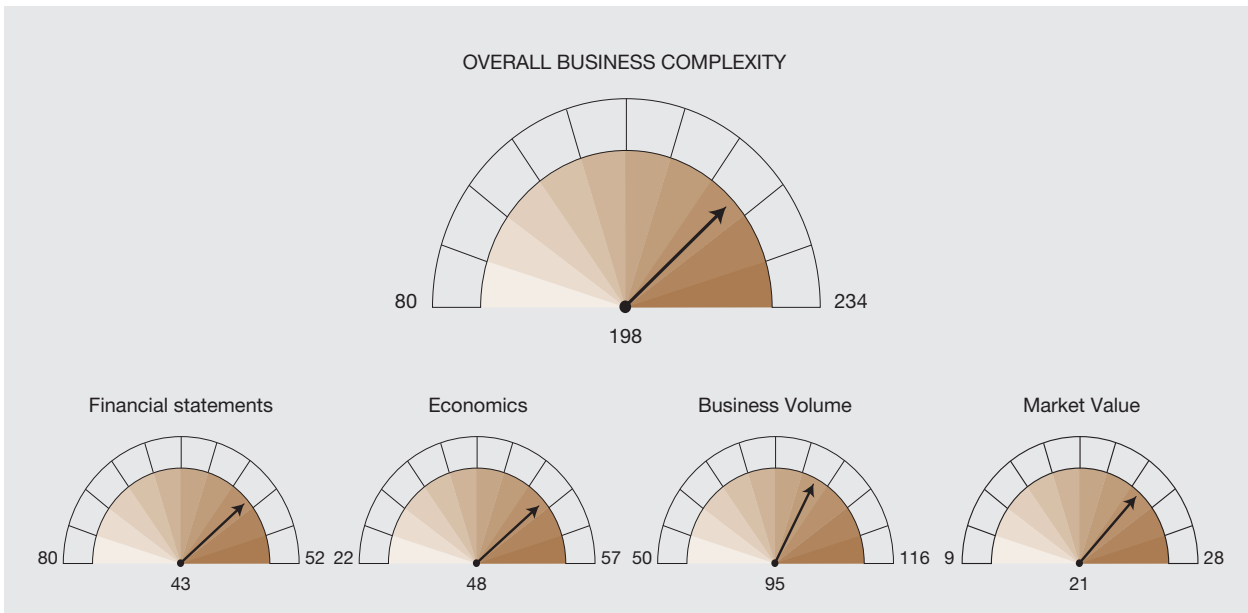


Figure 5. Complexity and Resilience Rating dashboard of a large chemical company.

As an example, the highest and lowest contributors to the complexity of the company's Balance Sheet are ranked and indicated below.

A New Rating Paradigm

TOTAL ASSETS	6,89	SHORT-TERM BORROWINGS	1,03
TOTAL LIABILITIES AND SHAREHOLDERS EQUITY	6,52	LIABILITIES ASSOC WITH ASSETS HELD FOR SALE	1,03
TOTAL LIABILITIES	5,77	ASSETS HELD FOR SALE	0,70
INVENTORIES	5,29	NET INCOME/LOSS (Stockholders Equity)	0,66
OTHER RECEIVABLES (Short-Term)	5,20	MARKETABLE SECURITIES	0,52
OTHER PROVISIONS FOR LIABILITIES AND CHARGES	4,88	OTHER NONCURRENT LIABILITIES	0,47
RETAINED EARNINGS (Accumulated Deficit)	4,87	TOTAL CURRENT ASSETS	0,47
CURRENT INCOME TAX ASSET	4,80	TOTAL CURRENT LIABILITIES	0,47
PROPERTY PLANT & EQUIPMENT - NET	4,22	OTHER NONCURRENT ASSETS	0,42
CASH AND EQUIVALENTS	4,12	SHORT-TERM PROVISIONS	0,10
TOTAL SHEREHOLDERS EQUITY	3,98	OTHER CURRENT LIABILITIES	0,06
ACCUMULATED OTHER COMPREHENSIVE INCOME	3,87	OTHER CURRENT ASSETS	0,00
EQUITY INVESTMENTS IN ASSOCIATES/AFFILIATES	3,75		
MINORITY/NON CONTROLLING INT (Stckhldrs Eqty)	3,12		

Figure 6. Complexity and Resilience Rating dashboard of a large chemical company.

From the above table one may infer that the *fluctuations* of ‘Total Assets’ (6.89%), ‘Total Liabilities and Shareholders Equity’ (6.52%) and ‘Total Liabilities’ (5.77%) are responsible for nearly 20% of the overall complexity of the company’s Balance Sheet, see [Figure 6](#). As complexity impacts resilience, the quarterly evolution of these entries drives a significant portion of the company’s resilience. Similar information is obtained for Economics, Business Volume and Market Value.

It is interesting to observe how the company in question is positioned with respect to all other chemical companies that operate today. The constellation of these companies is illustrated below in the Resilience-Complexity plot, in which the horizontal line indicates the resilience of the sector, which is just under 70%. This value is not the result of statistical averaging and has been obtained based on a systemic analysis, whereby all interactions between the companies have been taken into account, see [Figure 7](#).

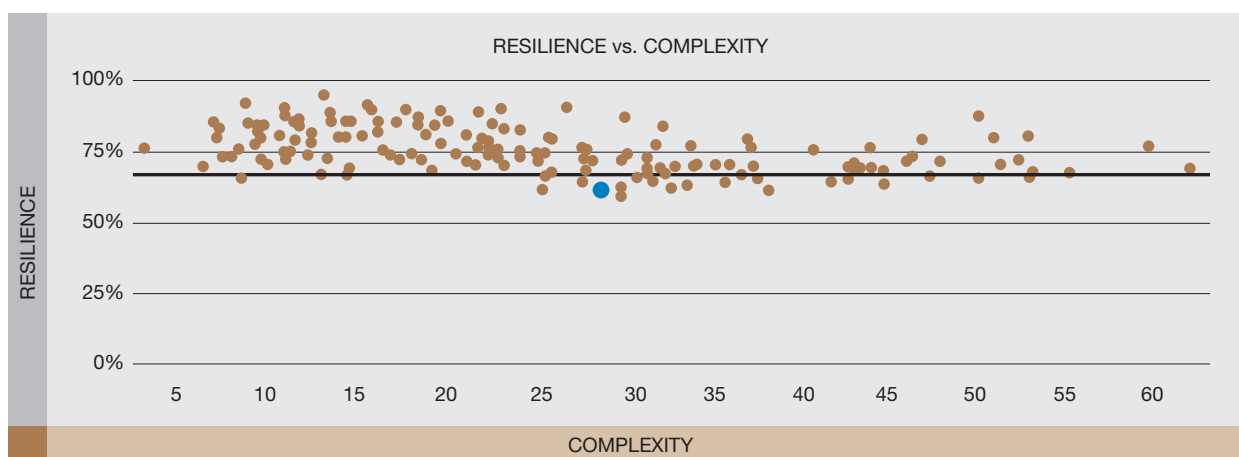


Figure 7. Resilience-complexity plot indicating company’s position (black dot) with respect to the market segment.

The above example illustrates how a complexity and resilience rating becomes more than just a simple reflection of the state of health of a business. In fact, it is a tool for managers that contains actionable information, indicating in a *quantitative* manner which areas of the business require more attention as potential sources of fragility.

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MARKET INDICES

The resilience and corresponding resilience rating of market indices is updated on a daily basis. Examples of ratings of certain major indices are illustrated below.

INDEX	DESCRIPTION	RESILIENCE	RATING
CAC40	CAC 40, Paris	46,51%	★
DAX30	Deutsche Boerse, Frankfurt	71,38%	★★★★
DJA	Don Jones Composite Average	54,95%	★★
DJI	Don Jones Industrial Average	57,13%	★★
FTSE	FTSE 100, London	64,34%	★★
FTSE.ITALIA.STAR	FTSE ITALIA STAR, Borsa Italiana	43,94%	★
FTSE.MIB	FTSE MIB, Borsa Italiana Milano	70,02%	★★★★
HANG SENG	HANG SENG, Hong KONG	68,62%	★★
NDX	NASDAQ 100	63,55%	★★
OEX	Standard & Poors 100 Index	53,90%	★★
STI	Straits Time Index, Singapore	78,69%	★★★★
SSMI	Swiss Market Index, Zurich	81,60%	★★★★

In general resilience is independent of performance. It is in fact possible to witness low resilience in the presence of high performance - which will of course be fragile - and vice versa. Formula 1 cars provide a good example of the concept.

The above information is computed based on a window of 50 trading days. The window may of course be changed to suit particular needs.

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MACRO REGION

A system of four G7 countries belonging to the EU - France, Germany, Italy and the United Kingdom - has been rated from a complexity and resilience perspective, yielding the results indicated in the table below. The analysis is relative to Q4 of 2014 and is based on GDP-specific macroeconomic data provided by Eurostat (a total of 26 parameters per country).

COUNTRY	GDP (billion)	Complexity	Resilience	RR™
France	546,65	30,35	76%	★★★
Germany	737,08	27,34	73%	★★★
Italy	423,35	19,44	84%	★★★★★
United Kingdom	577,85	30,82	77%	★★★★★

It is interesting to note that the resilience of this system, i.e. taking into account the interaction between the various economies, is a mere 53%, yielding a two-star rating, significantly below the values of each country when analyzed in isolation. This fact alone is sufficient to underscore the importance of systemic analyses. In fact, systems often behave in ways which cannot be deduced from the behavior of components. The complexity profile illustrated in *Figure 8* shows how for the system in question the biggest contributors to complexity (and resilience) are parameters such as 'Gross domestic product', 'Final consumption expenditure' or 'Exports of services'.

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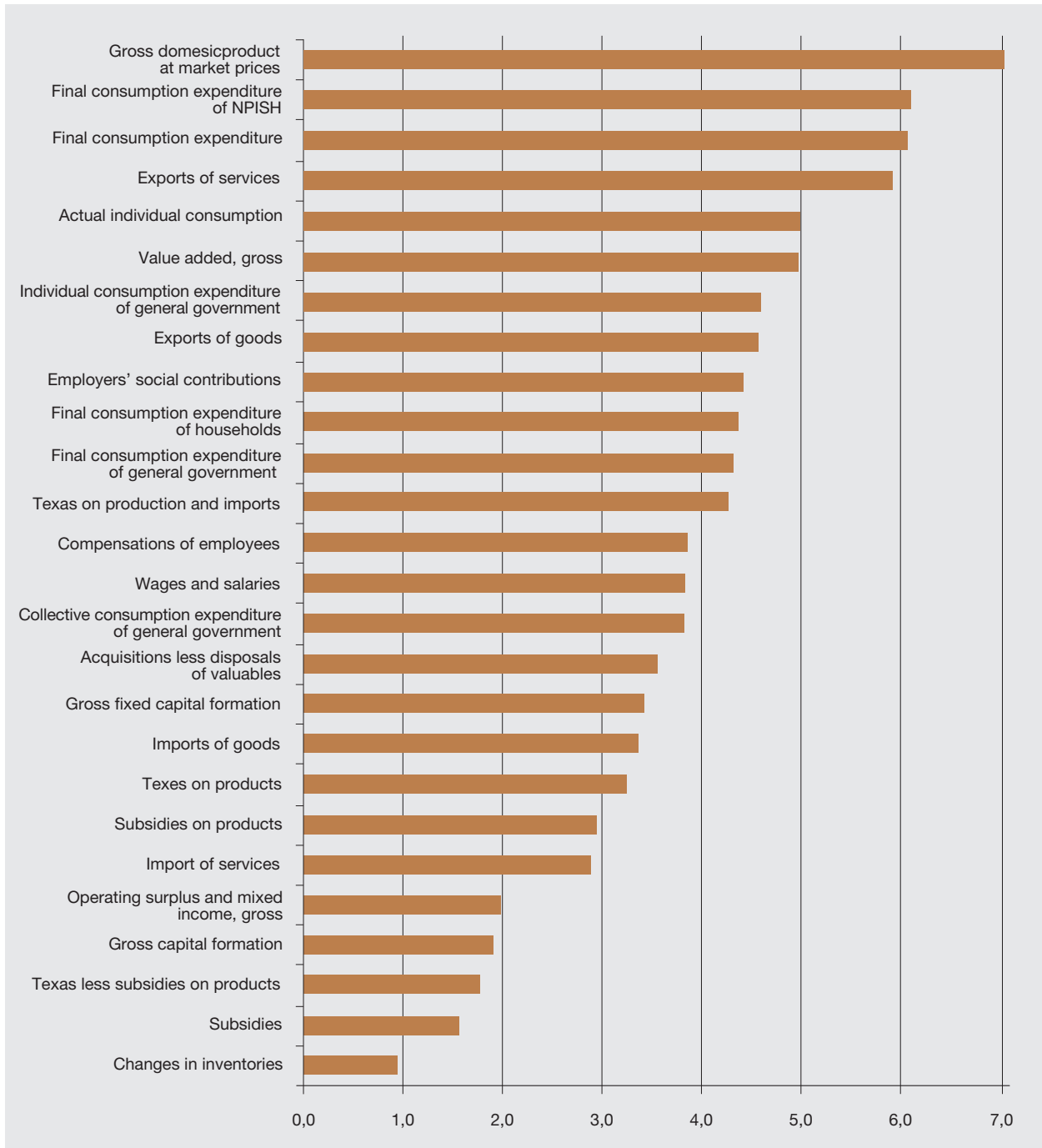


Figure 8. Complexity Profile of the system of EU G7 countries.



Independence, Transparency and Objectivity

Credit rating agencies have been accused of conflict of interest and of assigning gold-plated AAA ratings to complex products that proved to be junk. According to the Financial Crisis Inquiry Committee (January 2011): ‘The three credit rating agencies were the key enablers of the financial meltdown’. Basically, they offered overly favorable evaluations of insolvent financial institutions exacerbating the financial crisis and defrauding investors. Both the United States and Europe have taken steps to regulate the three main agencies and ensure more transparency. The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act and the European Securities and Markets Authority (ESMA), created in 2011, have sought to hold agencies accountable and protect investors. Meanwhile, agencies have faced intense legal scrutiny of their practices, with S&P paying a record \$1.37 billion in a 2015 settlement with state and federal prosecutors, and Moody’s coming under investigation by the U.S. Justice Department. However, according to critics, the fundamental business model of the Big Three—and their market dominance —remains intact.

Credit rating agencies play a pivotal role in the economy. They process, filter, and funnel information from the financial industry and economy in the form of ratings to investors. Markets and investors rely heavily on this information. However, ratings are:

- Expensive – ratings are issued mainly to (rich) listed companies who pay for being rated
- Subjective
- Opaque, unregulated

It is not difficult to imagine how conflict of interest fits into the picture. In fact rating agencies are mainly controlled by huge investment funds. This makes them tremendously powerful. A downgrade of a country’s economy by a single notch means billions of losses for that country. It is argued that negative evaluations

accelerated the European sovereign debt crisis as it spread through Greece, Ireland, and Portugal, and Spain—all of which received EU-IMF bailouts.

Ultimately, ratings have become a key factor in shaping the global economy. Until we can break the above scheme, there is no real reason to believe that situation will change. A different approach is necessary and this is where Universal Ratings comes in. The cornerstones of our philosophy are the following:

- Independence. Universal Ratings is a private company. We do not respond to banks or fundmanagement companies.
- Transparency. Any user can verify the results of any of our ratings as the computational engine which powers them is accessible online. This because the platform provides an on-demand service which allows users to upload fundamentals, or any other data reflecting the business of a company, and process them in a matter of minutes. This leads to the following fundamental point.
- Democratization of ratings. The on-demand capability means that even the tiniest of business can have a rating as the service is offered at an accessible cost. Basically, rating is no longer a luxury.
- Objectivity. Our ratings are not based on subjective weights or scoring methods. We offer science, not opinions.
- High-frequency. We rate stocks, portfolios and generic financial products on a daily basis. Listed companies are rated on a quarterly basis based on fundamentals. The goal is to capture the dynamics of the economy.

The highlight of our rating system is the online availability the main algorithm. This has several implications:

- Any listed company can verify its rating by simply

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uploading their fundamentals and acquiring an on-demand analysis.

- The system provides always the same results with the same input data. Today, it is not uncommon that two credit rating agencies provide different ratings for the same company. But more than that, two analysts working at a given rating agency can also differ in their opinions on the rating of a given company.
- The above guarantee that the algorithm which powers our ratings cannot be manipulated. Any attempt to do so would be noticed immediately, becoming quickly public domain.

A long-term implication of this new rating science lies in the fact that it may lead to a general improvement of the resilience of the global economy. If investors

start focusing on low-complexity and favour resilient products it may lead to the progressive withdrawal of 'toxic' products of high complexity in a natural manner. The market will decide which products flourish and which don't. Doing this 'manually' may introduce distortions and ultimately lead to new bubbles.

The dynamics global finance is so fantastically complex that it is no longer advisable to rely on sensations, experience or opinions when seeking sustainable long-term investments. It is necessary to resort to science. Our complexity and resilience-based ratings appear to be the right antidote for a super-complex and fragile economy and may prove useful not only to investors, traders and private enterprises, but also to regulators and governments.

Reference

- [1] Marczyk, J. *A New Theory of Risk and Rating*, Editrice Uniservice, 2009.
- [2] Marczyk, J. *Complexity and Resilience Rating: New Paradigms in Finance, Economics and Sustainable Investment*, Edizioni del Faro., 2015.
- [3] UNI Standard 11613 (VACO) *Business Complexity Assessment guidelines*

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