RESILIENCE RATING OF CORPORATIONS, FINANCIAL PRODUCTS AND MARKETS

TECHNICAL NOTE

ONTONIX

1. SCOPE

The present Technical Note has the scope of illustrating the logic behind the Resilience Rating process which has been established by Ontonix.

2. INTRODUCTION

In the current economic context, characterized by turbulence, and high complexity, new analytics, business intelligence, risk assessment, risk management and rating techniques, which would reflect the nature of our times, are needed. This is precisely the motivation behind resilience rating. Resilience is the capacity of systems to withstand shocks and extreme events. Because the economy is and will become even more turbulent in the future, resilience is a fundamental characteristic which business should pursue in order to survive. Moreover, given that in our globalized economy events spread very quickly, a dynamic and near-real time rating system is in demand. The Resilience Rating methodology developed by Ontonix satisfies this fundamental property – it is a dynamic rating system.

Given the non-stationary and turbulent nature of the economy, what one would expect from a modern rating system is not only a measure of its capacity to survive in a similar environment. In fact, Resilience Rating establishes a formidable per-alarm mechanism which can provide those who resort to it with a fundamental resource – time. Time to react to crises is of paramount importance in a turbulent regime.

3. MEASURING RESILIENCE AND RESILIENCE RATING

Resilience is a characteristic to which economists refer with increasing frequency. Resilience is a physical quantity which can be measured and in engineering, in particular, there exists specific machines which enable one to measure the resilience of materials which corresponds to the capacity of withstanding impacts (shocks). This important property may also be measured for generic systems or artifacts, including corporations, asset portfolios, markets and national economies.

The computation of resilience for a given systems is based on the concept and measure of complexity. Complexity is a fundamental physical characteristic of every system that may be found in Nature. Its importance is similar to that of energy. The functionality of a given system is proportional to its complexity. More complex systems are able to perform more functions, a characteristic which is evident in our biosphere. However, high complexity implies also an increase of management effort and energy. When taken to extremes, excessive complexity becomes a formidable source of exposure. This is because excessively complex systems are inherently fragile. This last statement becomes clear after we will have introduced the concept of critical complexity.

The complexity of a system having state vector {**x**} of N components, is defined as a function of *Structure* and *Entropy*.

$$C = f(\mathbf{S} \circ \mathbf{E})$$

where **S** represents an N × N adjacency matrix, **E** is an N × N entropy matrix, ○ is the Hadamard matrix product operator and f is a norm operator. Given that **S** has no units and entropy is measured in bits the units of C are also bits. The above equation represents a formal definition of complexity and it is not used in its computation. Instead, the adjacency matrix is determined via a patented multi-dimensional approach which is used to determine if entry S_{ij} is 0 or 1. This establishes the structure of the system in question.

Structure is represented by means of graphs (maps) such as the one illustrated below. There exist numerous means of representing graphs or maps. A common approach is illustrated in Figure 1.

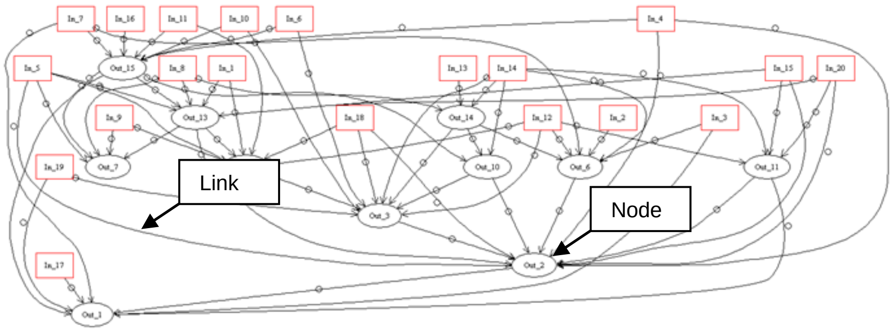

Figure 1 Conventional representation of a map, composed of nodes and links.

A conventional map representation becomes quickly unreadable as the number of nodes and links increases. An alternative approach to displaying maps is depicted in Figure 2. The great advantage is that maps with a very large number of nodes and links are still easily readable.

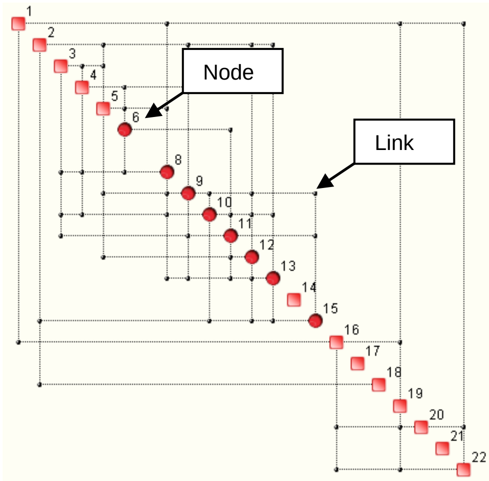

Figure 2 Modern representation of a map. The nodes (state-vector components) are aligned along the diagonal. Such maps are known as System or Process Maps.

The intensities of the relationships between pairs of state-vector components are obtained via a model-free approach, in which the corresponding scatter plots are first transformed into 2D images via a pixelization process.

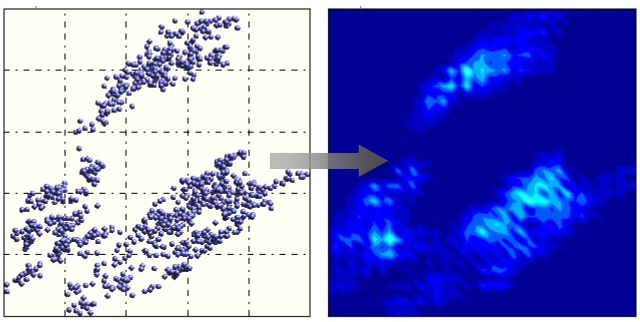

Figure 3 Scatter plot pixelization transforms a scatter-plot of discrete data points into an image.

Once the image has been obtained, its entropy becomes the corresponding entry of the entropy matrix **E**. The intensity of the corresponding relationship, the so-called *generalized correlation*, is computed based on this value of entropy and mutual entropy. This approach has been chosen because it avoids the drawbacks of conventional model-based techniques whereby one attempts to describe data via regression models, cluster analysis or other methods. The huge advantage of our approach is that it is independent of numerical conditioning of the data and its ability to identify the existence of structures where conventional methods fail. Examples of images and corresponding entropies are illustrated in Figure 4.

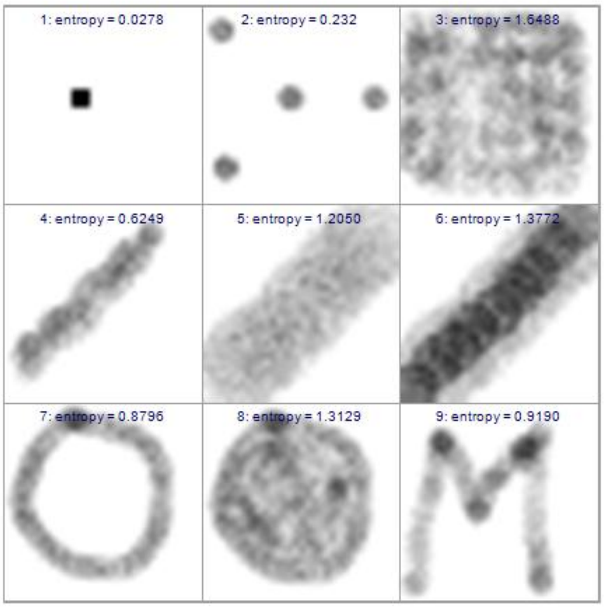

Figure 4 Examples of images with the corresponding entropy measures.

Once the entropy matrix and the adjacency matrix have been obtained, one may compute the complexity of a given system as the following matrix norm:

$$C = \left\| \mathbf{S} \circ \mathbf{E} \right\|$$

A fundamental property of systems related to complexity is the so-called *critical complexity*, C_U which corresponds to the upper bound of the complexity metric . Critical complexity may be defined formally using the above expression,

$$C = \left\| \mathbf{S} \circ \mathbf{E}_{max} \right\|$$

where $\mathbf{E}_{max}$ is the entropy matrix in which the entries correspond to entropies of “saturated” 2D images. Saturated images are obtained from the original images via a process in which noise is added to the image until loss of structure, hence useful information.

In a similar fashion, the lower bound of complexity, C_L, may be computed as $C = \left\| \mathbf{S} \circ \mathbf{E}_{min} \right\|$.

In proximity of the lower complexity bound, the system in question is almost totally deprived of entropy and functions in a deterministic *structure-dominated* fashion. In proximity of the upper complexity bound the system in question is uncertainty-dominated and relationships between the various state vector entries are fuzzy and therefore characterized by very low generalized correlations. Both situations are illustrated in Figure 5.

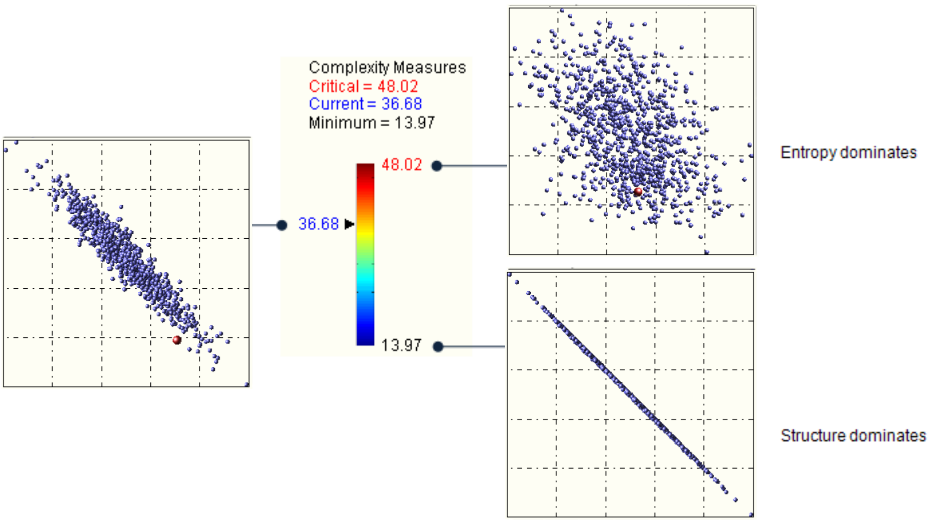

Figure 5 Illustration of lower and upper complexity bounds and examples of typical relationships at these limits. Without loss of generality linear relationships have been used to convey the concepts.

At this point the measure the resilience of a system may be defined. Since a system Maps represents the structure of a given system (corporation) it is of interest to measure how well will the structure of the map withstand the presence of endogenous and exogenous disturbances and/or shocks. Resilience is defined as follows:

$$R = f(C_L; C; C_U)$$

where C_L, C and C_U represent, respectively, the lower complexity bound, the current system complexity and the upper complexity bound. The function f in the above equation is a second-order polynomial function such that:

$$\text{if } C = C_L \rightarrow R = 1$$

$$\text{if } C = C_U \rightarrow R = 0$$

An example situation is illustrated in Figure 6, in which $C_L = 13.97$, $C = 36.68$ and $C_U = 48.02$. Resilience in this case is 74.5%.

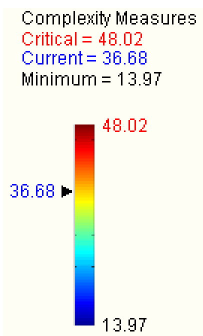

Figure 6 Example of measure of resilience of a system based on its current, lower and upper complexities.

The resilience function is illustrated in Figure 7.

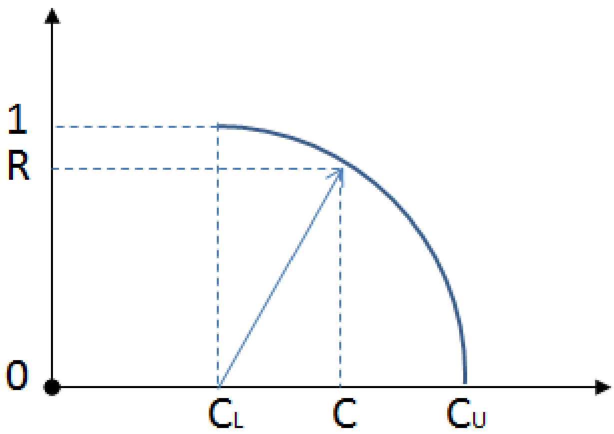

Figure 7 Definition of the resilience function of a system based on its current, lower and upper complexities.

A second order function has been chosen so as to penalize strongly situations in which complexity is close to critical complexity. The choice has been dictated by the fact that when a system finds itself in proximity of its critical complexity the following facts may be observed:

- Most relationships (correlations) between the state vector entries are close to "saturation". This means that they are very fuzzy and therefore weak. Information transmission becomes unreliable.
- A small increase in entropy (uncertainty) can cause these relationships to actually vanish.
- Managing a system in which the variables are linked via fuzzy and weak relationships is generally risky.
- Systems close to criticality cannot grow unless drastic measures are taken (e.g. spin-off, restructuring, merger, massive entropy dumping, etc.).
- Once the point of criticality is passed, the system continues to decay and loses functionality. For a closed system the process is irreversible.
- Close to criticality, no single variable may be expected to govern the behaviour of the system.

Resilience rating stratification is operated on five levels: Very Low, Low, Medium, High and Very High. To each level a number of start, ranging from 1 to 5 is assigned. In highly turbulent environments, such as our global economy, attempting to define more classes of risk is of little relevance. Examples of systems with 1 to 5-star ratings are illustrated in Figure 8.

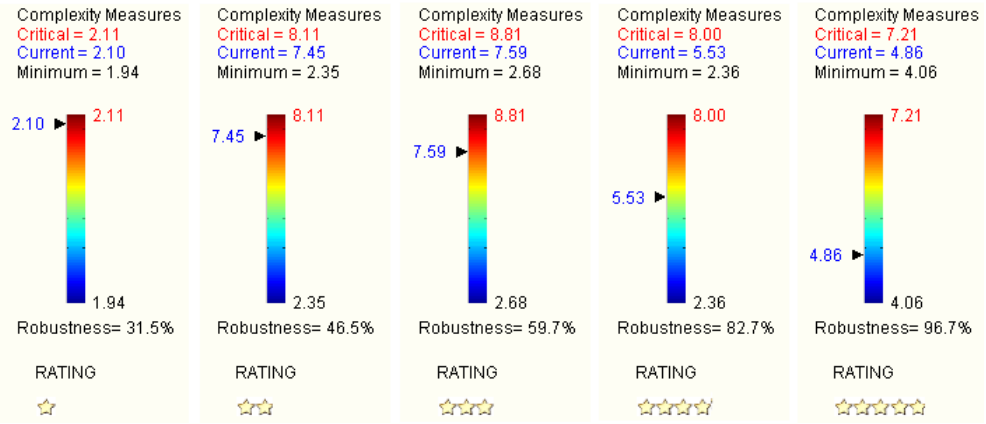

Figure 8 Example of five-level complexity-based rating stratification. The system on the far left operates close to its critical complexity and its System Map is entropy-dominated, indicating imminent loss of structure. The system on the far right operates close to its lower complexity bound and therefore behaves in a nearly deterministic fashion.

The five resilience rating classes correspond to systems (businesses) with the following salient characteristics:

Business resilience is very low. The business structure is weak. It is unsustainable and very fragile. Exposure is very high and the business is inefficient and difficult to manage. It is impossible to make forecasts. The business is a *candidate for default*.

Resilience: 0-50% - Rating: ★

Business resilience is low. The business is difficult to manage and control. Exposure is high as well as inefficiency. The structure of the business is fragile hence vulnerable. It is difficult to make forecasts.

Resilience: 50%-70% - Rating: ★★

Business resilience is medium. The structure of the business is fairly robust. Performance predictability is acceptable. Exposure is moderate.

Resilience: 70%-80% - Rating: ★★★

Business resilience is high. This indicates a robust business structure. Predictability is high, exposure is low. Business sustainability and efficiency are quite high.

Resilience: 80%-90% - Rating: ★★★★

Business resilience is very high. This business structure is very strong. Exposure is very low. The business is manageable and it is possible to make credible forecasts. The business is potentially highly sustainable and efficient.

Resilience: 90%-100% - Rating: ★★★★★

The so-called *Complexity Profile* constitutes an important by-product of a resilience rating process. The profile provides a quantitative breakdown of the total system complexity per variable. An example is depicted in Figure 9.

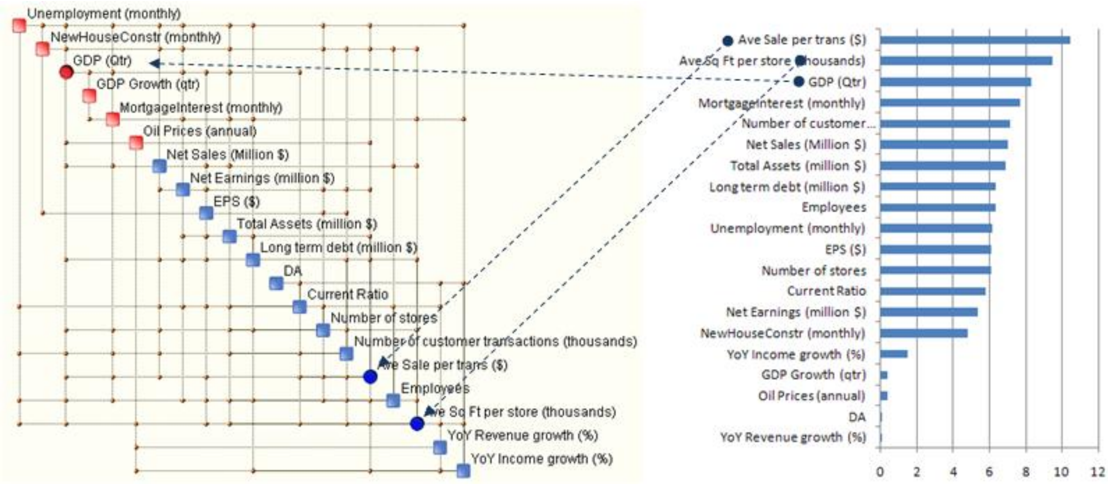

Figure 9 Example of Complexity Profile of a corporation. The bar chart indicates how much in percentage terms each parameter contributes to the total system complexity.

Complexity profiling is computed using the so-called knock-out technique. The procedure is as follows. The total system complexity is computed. Then, each variable is removed from the system and the complexity is recomputed. The difference between the two values of complexity is confronted with the original value of complexity. The variable is then reintroduced into the data set and the next variable is removed. Because of this specific process used in quantifying the impact of each variable on the total complexity, the sum of all the single percentage contributions does not always add up to 100%. In the example shown in Figure 9, the quarterly GDP – an exogenous variable - has a strong impact (8%) on the complexity of the corporation in question.

A possible correspondence between conventional rating stratification and complexity-based resilience rating is illustrated in Figure 10. Resilience values ranging from 0% to 50% are assigned one star, while values above 50% are assigned one additional star per every 10% increment.

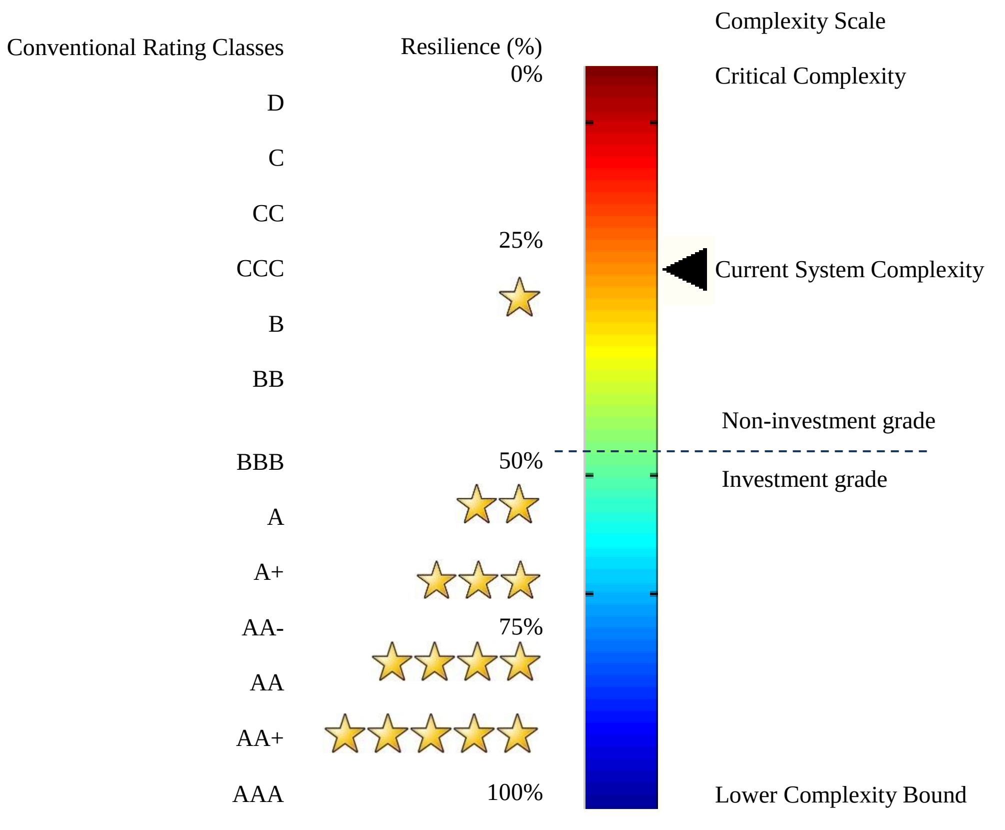

Figure 10 Correspondence between conventional rating stratification and resilience ratings. Resilience values of 50% or less can be regarded as non-investment grade.

The correspondence indicated in Figure 10 is merely indicative.

The Resilience Rating process described herein is available to the public on-line at www.rate-a-business.com