How Should Indicators be Found for Scenario Monitoring

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Summary: A systematic approach including seven steps to build indicators for scenario monitoring was developed. Factor analysis was used to assign weights to individual indicators. And then individual indicators were aggregated linearly to build composite indicator. Next, the composite indicators were used to assess the changes in the driving forces so as to infer which scenario is likely to come to pass. A set of four scenarios was analyzed. The result showed that the environment in the selected year is more like a "Collaborative World".

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KEY INSIGHTS

1. Building theoretical framework usually is not a waterfall process. The framework should be tested by the data. If the data are not consistent with the framework, the new framework should be proposed until it is not contradicted with data.

2. Compare the value of composite indicators of the monitoring year and that of the starting year. If the change exceeds the boundary, it is certain that the level of the driving force is either high or low. If not, the level of the driving force remains uncertain.

3. Put the levels of driving forces together and compare them with the description of scenarios. The more levels match the description, the higher possibility the corresponding scenario is unfolding.

Introduction

Scenario planning could be one of the most appropriate tools for making long-term decisions. When scenarios are built, it becomes necessary to monitor the progress of the environment to check if it matches the developed scenarios. In doing so, companies can promptly revisit their strategies and make strategic decisions based on those scenarios. Besides, monitoring scenarios can help companies avoid being misguided by ill-developed scenarios and know when to reap the benefits of scenario planning as well.

However, since scenarios are descriptive, it is hard to directly compare the current environment with the developed scenarios. Indicators are good tools to help companies understand underlying development of the environment. Since scenarios are developed from driving forces, which are environmental factors that shape the scenarios, it is plausible to build indicators for each driving force. In order to find out those indicators, the thesis developed a systematic seven-step approach.
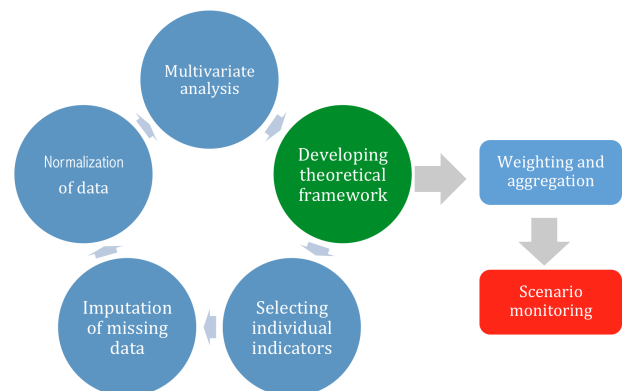

Figure 1 – Steps for Constructing Composite Indicators

Step 1: Developing a theoretical framework

Theoretical frameworks are used to select and aggregate individual indicators. It aims to build a nested structure on top of which is the composite indicator and at the bottom of which are individual indicators. To develop theoretical framework, the

definition of the composite indicator should firstly be given. The second step is to determine sub-groups of multi-dimensional concepts of composite indicator.

The ideas of the frameworks could be from existing literatures or intuition. If there are sophisticated theories or researches that can explain the driving force, their ideas can be used to construct the framework. If such theory or research is not available, brainstorming is a good way to generate original ideas about the theoretical framework. The brainstorming process is to first write down 30 possible indicators and then pick up those that better represent input or output side of the driving force to form the theoretical framework.

Since people usually come up with their theoretical frameworks with minimal perspective or viewpoint, the theoretical framework should be tested by the data. If the data are not consistent with it, the new framework should be proposed until it is not contradicted with data.

Step 2: Selecting individual indicators

This step aims to pick out individual indicators from the data sources. Individual indicators are variables that reflect aspects of "five domains of the environment-Society, Technology, Economy, Environment and Politics"[1]. Those individual indicators are basic elements for constructing composite indicators. They are selected based on four criteria: relevancy, non-repetition, coverage and data-availability.

For each individual indicator, the dimension it belongs to and its objective should be defined. The dimension means the layer under which some indicators are grouped and above which the composite indicator is constructed. The objective is the desired change direction of the indicator.

Step 3: Imputation of missing data

Since scenario monitoring is a constant activity, new data will often be incorporated into original ones. Thus complex imputation methods based on the overall distribution of the data should be avoided. The thesis chose to use the data of the closest previous year from the same country to substitute the missing data, assuming nothing changed during the period.

Step 4: Normalization of data

The original data usually have different measurements. It is necessary to normalize these

data so that different units will not affect the impacts of the individual indicators. The thesis proposed to normalize the data to the base year.

Step 5: Multivariate analysis

The purpose of this step is to use multivariate analysis to group the individual indicators. In doing so, the original theoretical frameworks can be checked by data and revised according to the analysis results. The results of this step are also the base for calculating the weights in the next step.

Among all the available multivariate analysis methods, the thesis chose to use factor analysis. Factor analysis gives weight to each component of composite indicator according to its contribution to the total variance in the data.

There are two reasons for conducting factor analysis. First, the results of factor analysis are based on data. Therefore they are not affected by analysts' subjective opinions in a large extent. Second, the factors can explain the largest part of the variances among indicators. Hence the composite indicators built on them can be well used to compare the changes in each year.

Step 6: Weighting and aggregation

In this step, the weight assigned to each individual indicator and dimension is determined and all the components were aggregated.

The thesis used the rotated component matrix got from the factor analysis as a start point to calculate weight for each indicator. The factor loading was first squared and scaled into unity sum. And then the individual indicators are put into factors in which they have the highest factor loading. The thesis then multiplied the squared factor loading of each indicator by the percent of variance explained by the factor that includes the indicator. The weight for each indicator can be derived by scaling the result of the multiplication so as to make them add up to one.

Table 1 – Loading Matrix of Political Stability

	Factor loadings		Squared loadings		Squared loadings (scaled to unity sum)	
	CMPT 1	CMPT 2	CMPT 1	CMPT 2	CMPT 1	CMPT 2
Intentional homicides (per 100,000 people)	0.96	-0.1	0.93	0.01	**0.26**	0.01
Armed forces personnel (% of total labor force)	0.95	-0.13	0.91	0.02	**0.25**	0.01
Arms imports (constant 1990 US$)	0.94	-0.23	0.89	0.05	**0.25**	0.05
Foreign direct investment, net inflows (BoP, current US$)	-0.92	-0.31	0.85	0.09	**0.24**	0.08
Military expenditure (% of GDP)	-0.07	0.99	0	0.98	0	**0.85**
Explained Variance	3.58	1.15	3.58	1.15		
Explained Variance/ Total Variance	0.76	0.24				

After getting the weights, all the components should be put together to construct composite indicators.

[1] Phadnis, S., Caplice, C., Singh, M., & Sheffi, Y. (2012). *Axiomatic foundation and a structured process for developing firm-specific intuitive logics scenarios*. Unpublished manuscript.

The individual indicators are firstly aggregated to dimensions and then dimensions are aggregated to composite indicators. In order to keep the aggregation straightforward, the thesis used linear aggregation.

Step 7: Scenario Monitoring

The last step aims to use composite indicators to monitor the environment. The following definitions are used in this step.

1. *Starting year:* the year in which scenarios are developed.

2. *Monitoring year*: the year in which the environment is monitored.

3. *Boundary*: a number that helps to judge whether the trend in the driving force is certain. If the difference between the composite indicator of the monitoring year and the composite indicator of the starting year exceeds the boundary, the trend can be considered determined. The value of the boundary could be various for each composite indicator. To be simple, the thesis chose 0.5 as the uniform boundary.

To monitor the environment, first calculate the composite indicator of the starting year and the monitoring year in the same area.

Second, compare the value of composite indicators of the monitoring year and that of the starting year. If there is an increase higher than the boundary, then it is certain that the level of the driving force in the monitoring year is high. If there is a decrease goes beyond the boundary, then it is certain that the level of the driving force in the monitoring year is low. If the difference is within the boundary, then the trend of the driving force is still uncertain.

Third, put these levels together and compare them with the description of scenarios. Count the number of levels that match the scenario. The scenario that the most driving forces match is most likely to unfold.

Conclusions

The advantages of this approach are as follows:

1. The data are easy to get. The approach only concerns about five aspects that are used to construct scenarios. They are society, economy, technology, environment and politics. Many international organizations collect the data in those five areas regularly and make the data available to the public.

2. The most part of the process can be automated. Once the individual indicators are selected, the rest part of the calculation and comparison can be fully done by artificial intellectual without any human interference. Hence, the routine cost of implementing this approach will be very low.

3. The result is simple and easy to understand. This approach is originally designed to satisfy the needs of supply chain managers. The composite indicator is just one number and the scenario monitoring results are also simple numbers which are easy to be compared.

To improve the process, first, experts' opinions could be imported when building theoretical frameworks. Second, sensitivity analysis could be applied. Although sensitivity analysis is not a must step in finding indicators for scenario monitoring, using sensitivity analysis can give the companies more confident in adding or subtracting indicators from the structure.

By and large, scenario monitoring will not replace scenario planning in terms that the process of scenario planning is actually a practice for decision makers to change their mind-sets. Although scenario planning usually follows a qualitative approach, it does not mean scenario monitoring cannot follow a quantitative approach. The quantitative approach introduced in this paper is a direct and convenient way for scenario monitoring. Moreover, this approach can serve as an economic tool to improve the implementation of the strategies after the scenarios are developed.

Table 2 – Scenario monitoring dashboard

Driving Forces	Collaborative World High	Collaborative World Low	Lean World High	Lean World Low	Demanding World High	Demanding World Low	Low Cost World High	Low Cost World Low
Political stability	x		x		x		x	
TCF	x		x		x		x	
Stability of financial systems	x		x		x		x	
Availability of qualified employees	x		x		x		x	
Investment in transportation infrastructure	x		x		x		x	
Transfer and application of global knowledge		x		x		x		x
Awareness towards sustainability of the society	x		x		x		x	
Energy costs								
Environmental regulation	x		x		x		x	
Mobility of people	x		x		x		x	