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Chapter XVIII

The Analytic Network Process – Dependence and Feedback in Decision-Making: Theory and Validation Examples

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Abstract

Simple multi-criteria decisions are made by deriving priorities of importance for the criteria in terms of a goal and of the alternatives in terms of the criteria. Often one also considers benefits, opportunities, costs and risks and their synthesis in an overall outcome. The Analytic Hierarchy Process (AHP) with its independence assumptions, and its generalization to dependence among and within the clusters of a decision — the Analytic Network Process (ANP), are theories of prioritization and decision-making. Here we show how to derive priorities from pair-wise comparison judgments, give the fundamental scale for representing the judgments numerically and by way of validation illustrate its use with examples and then apply it to make a simple hierarchic decision in two ways: pair-wise comparisons of the alternatives and rating the

alternatives with respect to an ideal. Network decisions are discussed and illustrated with market share examples. A mathematical appendix is also included.

Introduction

The material in this chapter is an outgrowth of the author's work over a long period of time in multi-criteria decision-making. It contains some of the basic ideas together with a modicum of the mathematics of the Analytic Hierarchy Process (AHP) with a structure that descends from a goal to criteria, subcriteria, stakeholders and their objectives, the groups affected and the alternatives of the decision. It also contains information about the generalization of the AHP to dependence and feedback, the Analytic Network Process (ANP), along with some elementary applications to determine the market share of different companies in relative form. In the ANP one identifies clusters of elements that influence each other and influence and are influenced by elements in other clusters. The ANP allows considerable flexibility (but requires more work) and frees us from having a fixed structure to follow, as in a hierarchy. In addition the ANP makes it possible to analyze influence separately according to many factors: political, economic, social, business and trade, etc., and then combine them into a single outcome. It can even include interdependence among these factors themselves according to higher order values. Numerical priorities are derived from comparisons made mostly on intangible attributes used to study the influences of individuals, companies or governments with respect to these attributes. The outcome is then compared with the actual money market shares for validation purposes so the method can be applied with greater confidence to cases where the answers are not already known.

Decision-making involves criteria and alternatives to choose from. The criteria usually have different importance and the alternatives in turn differ in our preference for them on each criterion. To make such trade-offs and choices we need a way to measure. Measuring needs a good understanding of methods of measurement and different scales of measurement. Figueira, Greco, and Ehrgott (2005), in their overview of decision-making, include a chapter on the AHP/ANP. This approach differs from other theories of decision-making in that, instead of interval scale numbers normally used by other theories, the AHP/ANP approach uses absolute scale numbers (invariant under the identity transformation). These numbers cannot be changed to other numbers to have any meaning, like Fahrenheit to Celcius as interval scale numbers or pounds to kilograms as ratio scale numbers. It is primarily a descriptive (rather than a prescriptive) psychophysical theory. There are two ways to deal with the measurement of intangibles. One relies on questioning a person relative to his/her preferences among things and deriving a general utility function for that person to be used as representative of their values in general. The assumption is that people have a utility function which many people question. The other is to rely on people's *tacit knowledge* about a problem and use pairwise comparisons to determine numerically, according to the strength of feelings or judgments, as to what may be more preferred, more important or more likely for that particular decision and then derive priorities from these judgments. To have confidence