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Non-hierarchy forecasting

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Research Background

- Objectives of the research
  1. Gather data on the extent to which various factors influence a firm's choice of forecasting level (the hierarchy level at which a forecast is initially produced)
  2. Better understand the business process, if any, for choosing the forecasting level
- Research need
  - Much of the past literature proposes new techniques and methods for forecasting and disaggregation.
  - Some articles focus on the business process of forecasting (Moon, IJF, 2003), (Fildes and Goodwin, Foresight, 2007).
  - There is little literature available on the factors which drive a choice of level

Research need: Forecasting Principles*

- Principle 2.2: Tailor the level of data aggregation (or segmentation) to the decisions
  - Description: One can make forecasts for various components that can then be aggregated or disaggregated to fit the decision needs. Thus, the analyst can focus on the level of aggregation that yields the most accurate forecasts.
  - Purpose: Improve accuracy
  - Conditions: Sufficient data must exist to enable different levels of aggregation
  - Strength of Evidence: Common Sense
  - Assumption:
    - The business needs can be satisfied by aggregating or disaggregating a forecast.

*From the second subject area of the Forecasting Principles (Armstrong, 2001) entitled "Structuring the Problem"

Research need: Forecasting Principles*

- Principle 2.3: Decompose the problem into parts
  - Description: Use a bottom-up approach. That is, forecast each component and then combine them.
  - Purpose: Improve accuracy by improving reliability
  - Conditions: It is helpful to decompose the problem in situations involving high uncertainty and extreme numbers. Disaggregation will not improve accuracy if the components cannot be measured reliably.
  - Strength of evidence: Received wisdom and strong empirical evidence
  - Assumption:
    - A combined, bottom-up, forecast is sufficient to satisfy the decision needs of the firm.

*From the second subject area of the Forecasting Principles (Armstrong, 2001) entitled "Structuring the Problem"

Research need

- Hierarchy level assumption
  - According to Principles 2.2 and 2.3, there is no need for analysis on factor effects because forecasts are produced at the bottom and then aggregated to the level of need. This research assume that not all firms use bottom-up forecasting
- Alternative forecasting levels
  - Middle out: Forecasts are produced at a middle hierarchy level and disaggregated for lower level forecasts and aggregated for higher level forecasts
  - Top down: Forecasting are produced at the highest level in the hierarchy and disaggregated for use at lower levels

Anticipated results of the research

- Analyze the extent to which various factors influence a firm's choice of forecasting level
  - Are the business needs satisfied by aggregating or disaggregating a forecast?
  - The factors will be related to aggregation ability (software, accuracy goals, and disaggregation method)
  - Principle 2.2 does holds providing sufficient data exists

- Determine if there is a rational business process for choosing the forecasting level
  - Do bottom-up forecasts support the business needs (including those beyond forecast accuracy)?
  - An explicit part of the business process will describe bottom-up forecasting to allow aggregation to any hierarchy level
  - An implicit part of the business process will shows that the business needs only require forecasts for levels in the hierarchy
  - Principle 2.3 holds provided the components of the bottom level data series can be measured reliably

Survey

- Background information
  - Industry, job description, main forecasting responsibilities
  - Elements in the product and customer hierarchies
  - Description of the time hierarchy
- Types of forecasts produced and used
  - Departments producing forecasts, levels of forecasts, uses of forecasts
  - Time horizon of forecasts, time groupings of forecasts
  - Departments using forecasts, how forecasts are used, involvement in production of forecasts
  - Communication between producers and end users of forecasts, process for reconciliation of forecasts

Factors affecting forecasting levels

- Labor/time/forecasting responsibilities
  - Objective: Understand the extent to which forecasting is a priority in the firm. Companies that don't support forecasting may find little value in bottom level forecasts.
    - Number of products forecasted/person and multiple responsibilities
    - Forecasters as a percent of workforce
- Forecast accuracy goals
  - Objective: Understand how accuracy goals vary between departments and if the priority on accuracy is correlated with the hierarchy level where accuracy is measured.
    - Types of measurements and hierarchy level measured
- Focus products
  - Objective: Explore if forecasting focus products/customers is a priority. If focus products are a priority, the firm should be forecasting at these levels which may not be the lowest levels
    - Focus products within the hierarchy (concept or finished products)
    - Method of forecasting (statistical, manual)

Factors affecting forecasting levels

- Data availability
  - Objective: Understand the availability of data. Lack of data may lead to higher level forecasting. Intermittent demand may lead to more judgment forecasting
    - Intermittent demand
    - Selection algorithms and combination forecasts
- Software constraints
  - Objective: How software and IT constraints influence the forecasting process. Highly volatile demand may lead to higher level forecasting. Lack of IT resources may lead to higher level forecasting
    - Software used for forecasting
    - Full or part time IT resource availability
    - Software capability for intermittent or high volatility demand

Main Results

- Data collection
  - Main discussion point: “Is your product-customer hierarchy based on market segments, technical application, resource consumption or a combination?”
    - Respondents had trouble describing hierarchy
    - Similar to unscientific questioning at business forecasting conferences
- Focus on definition and elements of product hierarchies
  - Product hierarchies were not bounded on the same subject matter
    - For instance, lower level is build technology and the next higher is costing properties
  - New products could be considered outside of the general statistical forecasting and reconciliation process

Main Results

- Business process was not always clearly defined
  - In some cases, forecast users requested forecasts for elements not in the hierarchies
  - Reconciliation process for forecasters and forecast users varied between formal meetings and no process
  - Often disputes between departments on the appropriate hierarchy levels for calculating forecast accuracy
    - Definition of business needs for the forecast changed between departments
- Question:
  - Could the issues on hierarchy definition and forecasting business process be related through an underlining set of assumptions?

Extensions

- Appeal to Consumer Preference Theory
  - Four assumptions on consumer preferences when comparing possible consumption bundles
    - Complete, Reflective, Transitive, Continuity
  - If the assumptions on preference can be used to establish that consumers will order sets of bundles, can something similar be used for constructing hierarchies?

Properties of hierarchies

- Hierarchies are complete:
  - For each level of the hierarchy, all aspects of the company are contained within that level
  - For instance, if the lowest level is SKU and includes all final good products, than any higher level includes all final goods
  - Violation: New products not fully defined down to the SKU level
- Hierarchy levels are defined by exclusive subsets
  - Each member within a given hierarchy level has an exclusive and unique subset of the elements in the next lowest level and is contained in exactly one element in the next highest level
  - All elements of the lower levels are only contained within the higher levels
  - Each level has a one to many relationship with the levels under it
  - Violation: Hierarchies having a many to many relationship
    - Use the DP hierarchy to show this violation of many to many

Properties of hierarchies

- Hierarchies are continuous:
  - Up the hierarchy leads to great aggregation of current level and down leads to more detail of current level
  - Each level of the hierarchy is a more detailed grouping than the next highest level
  - Each level of the hierarchy is a less detailed grouping than the next lowest level
  - Violation: One level is defined by a subject matter (cost) not used to define the next highest level (production technology) or the next lowest level (end market segment)
- Hierarchy levels are transitive.
  - If a is above b and b is above c, then a is above c

Conclusions / Further research

- Failure of hierarchy properties
  - If levels are defined on different subject matters, aggregation and disaggregation may not yield forecasts satisfying the business needs (2.2)
  - If some levels of the hierarchy do not include all elements of lower levels (new products), then bottom-up forecasts may not be sufficient to satisfy the decision needs of the firm (2.3)
- Further research areas
  - More statistically robust testing of the existence of hierarchy properties
  - Relationship between the hierarchy properties and the extent to which a general forecasting business process is defined
  - Methods for addressing issues arising from the properties not holding
  - More comprehensive analysis of factors affecting the choice of forecasting levels and the associated business process for choosing the levels
  - Forecasting methodology consisting of producing forecasts at the levels where they are used when those levels do not occur in the hierarchy (even one satisfying all four properties)