THE UNIVERSITY OF TEXAS AT DALLAS
SCHOOL OF MANAGEMENT

HVAC Sales Forecasting

Metin Çakanyıldırım

**Melek C. Aksoy, Andrew J. Royal, Anthony Dsouza, John Beckett, Divakar Rajamani**

C4iSN
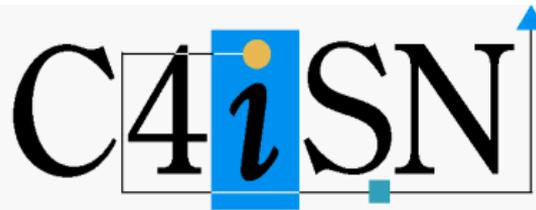
CENTER FOR INTELLIGENT SUPPLY NETWORKS

Typical HVAC Products

- ## Important products:
  Furnace (FR) → Air Conditioner (AC); Coil Blower (CB)→ Heat Pumps (HP)

  - Less important products: Evaporator Coils, Single Package Units
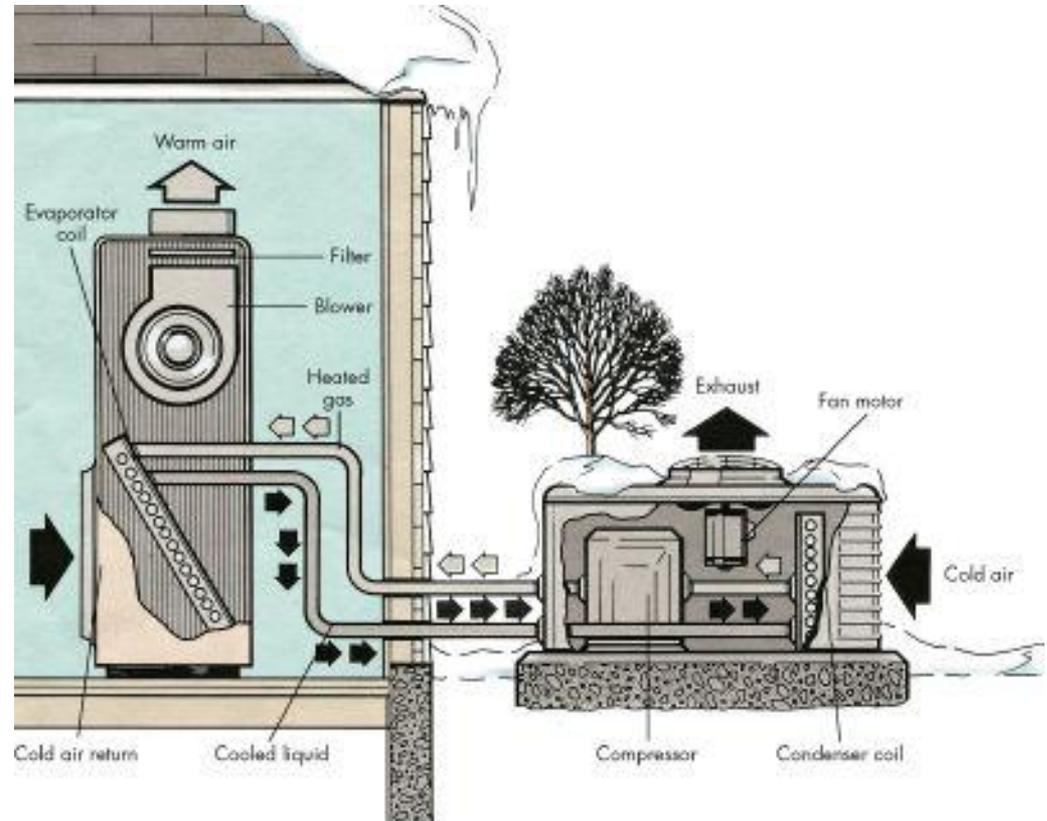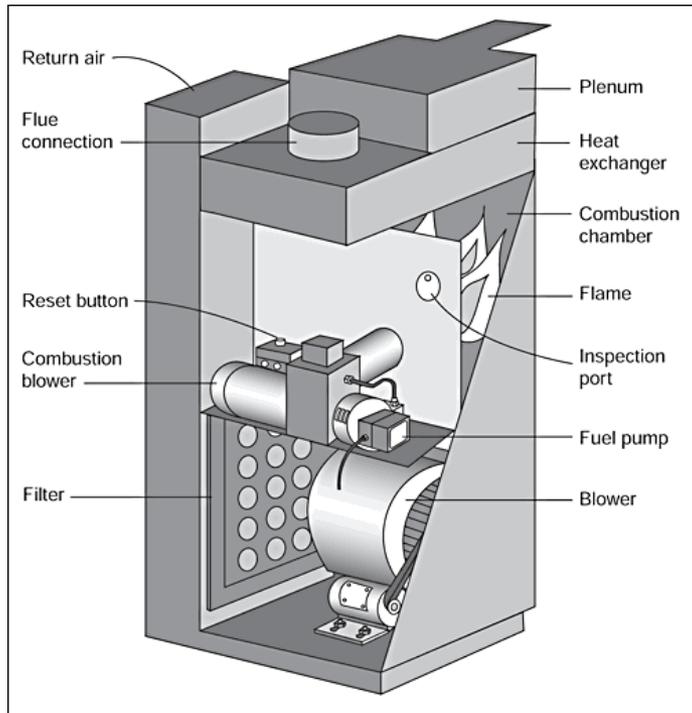
A Typical HVAC Manufacturer named HC-Man

- Make-to-stock process
- Sells directly to the dealers with limited contact with builders
- SC network has about 5-10 regions
    - each with a central warehouse
    - distance from a central warehouse to its dealers usually 1 day
    - aims a SC Network redesign-improvement
- Required level of responsiveness at the manufacturing level
    - 5 days for mix adjustment among the product types (see next page)
    - 4 weeks for volume adjustment
    - workforce is the bottleneck at HC-Man
- Subject to low Brand loyalty
    - Consumers do not know the brand of their ACs.
    - High degree of brand switching to be expected

Air Conditioners at HC-Man

- Types:
  - XC21 – highest cost
  - XC16
  - XC15
  - AC13
  - XC13
  - 13ACX
  - 13ACD – the most sold model

- Sizes (in tons):
  - 1.5
  - 2
  - 2.5
  - 3
  - 3.5
  - 4
  - 5

An SKU is Type x Size.

Customer Types

Replacement Customer

- Replacement, 60% of the revenue dropping
  - Impromptu customers
  - More difficult to forecast

Residential New Customer

- RNC, 40% of the revenue increasing
  - Consist of builders
    - Rates negotiated with builders; actual demand dictated by dealer network
  - Penalty for being wrong is very high
  - Our current focus is the RNC segment

- Goodman Global reports 70% replacement and 30% RNC in 2006.

C4iSN

# Demand Seasonality for RNC + Replacement
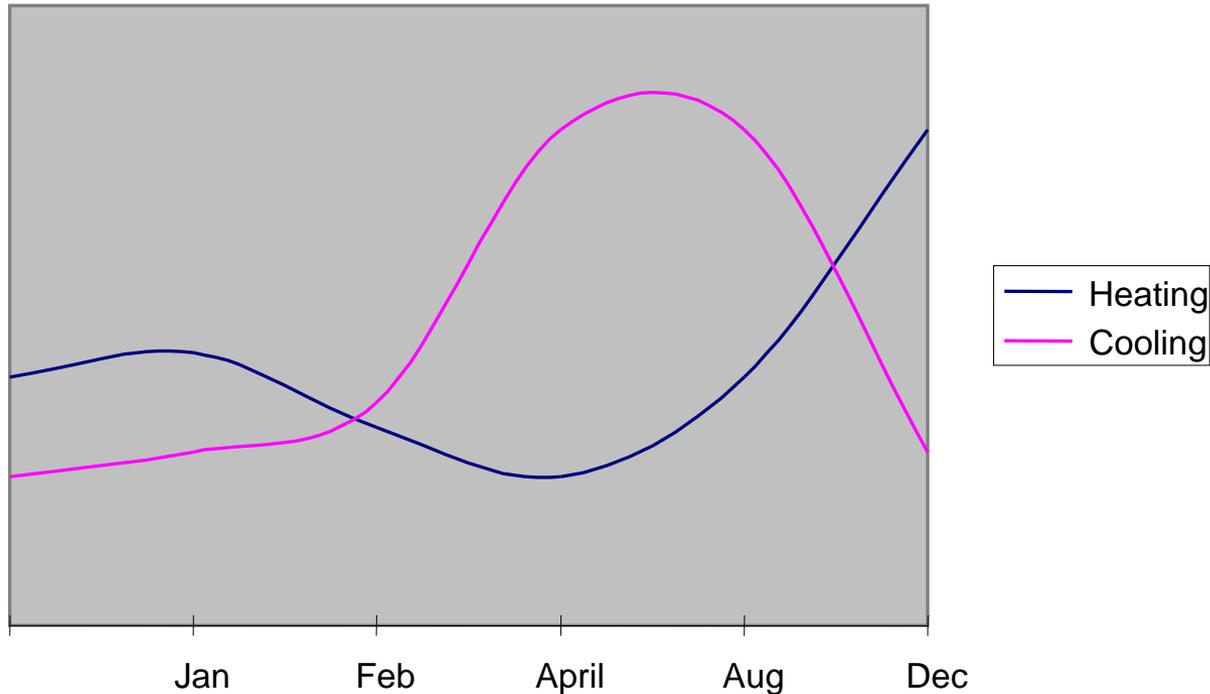
Cooling picks up from May through July; It drops in August when heating increase

Sept to Dec – high heating months

Residential New Customer (RNC)

- Schedule of furnace/AC installation known.
  - But not provided by the builders
  - 98% of the sales orders are from customers who expect same day delivery. But the problem is that there are dealers between HC-Man and the end customers. Sometimes HC-Man cannot supply the requested products
  - Builders provide none of the following: Starting date, progress, estimated completion date, phases of a housing project, the sizes of the houses.

New House Timeline

| Ground breaking | 1 month | 3-4 months | 1 month | Sale |

Furnace → From the same company ← A/C
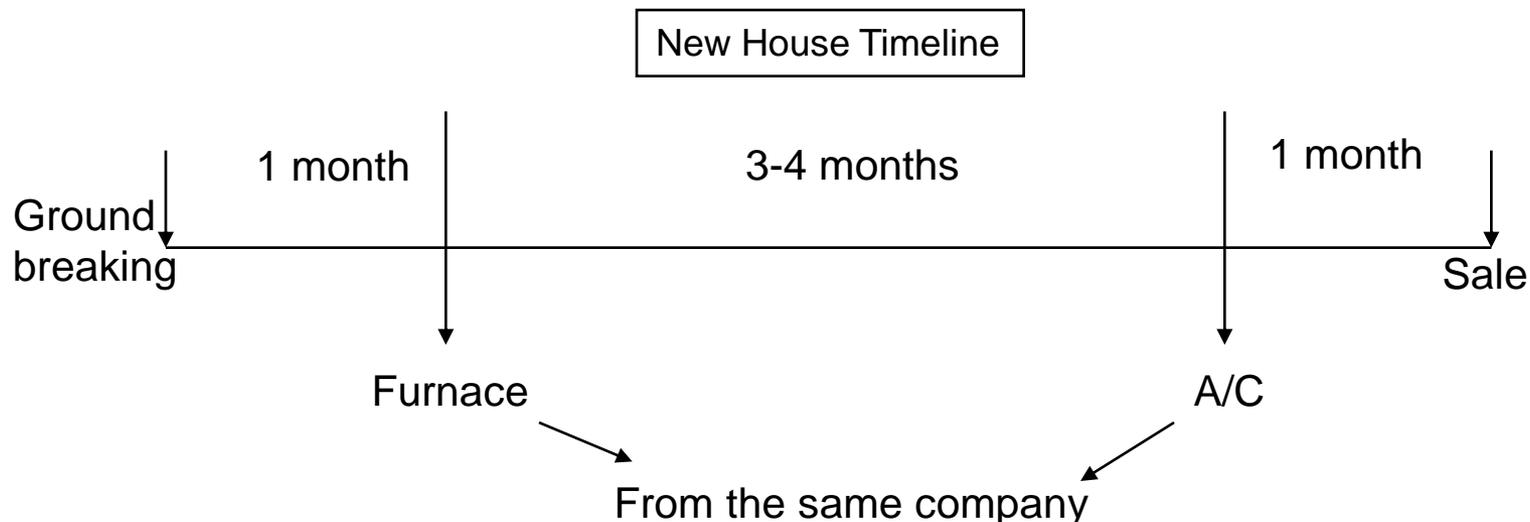
Dealers Stock Inventory

Push

Pull

Plant

North American Distributor

FGs

Regional Distributor

Warehouse

Dealer (Hold no inventory)

Dealer (Hold new home inventory)

Dealer (Hold both types of inventory)

Builder

Residential New Customer

Replacement Customer

30% of dealers stock
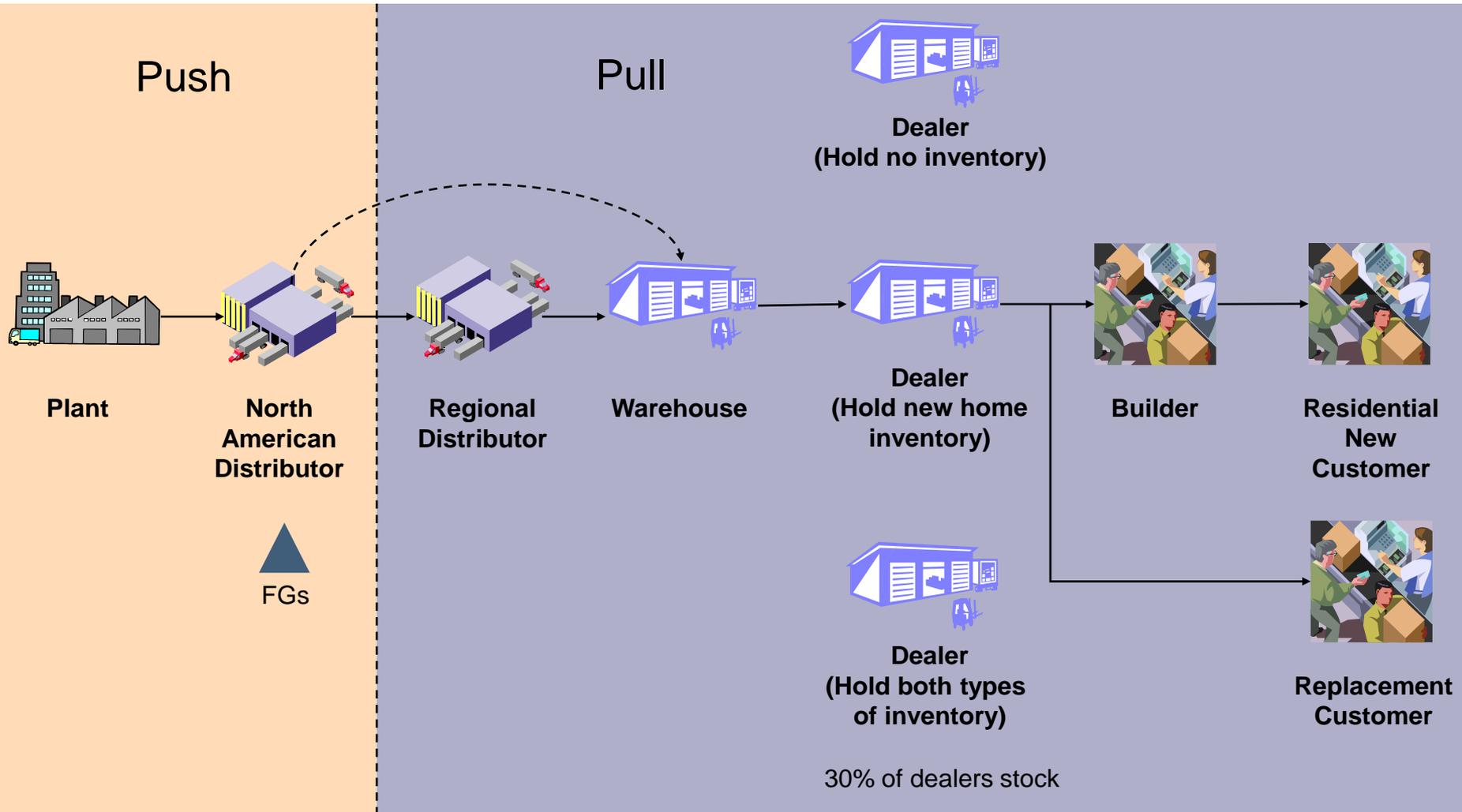
Dealer's Behavior

- If a dealer sells more, it can become a preferred dealer. Preferred dealers buy products from HC-Man at a low price (computed by dealer specific multipliers).

- To become a preferred dealer for a certain manufacturer, dealers may push the products of that manufacturer.

- Some dealers have warranty/maintenance contracts with the consumers, so they prefer to sell/install durable products to minimize after-the-sale service.

Purchasing Behavior of Builders

- Builders are offered a menu of manufacturer rebates at the time of starting their projects. (0301)
- The menu specifies the quantities at which the builder becomes eligible for certain discount price. (0301)
- Builders make no quantity commitments to this menu. However, they specify the type of the AC to be used in their project. (0301)
- Builders stage their orders. (0201)
  - They allow for 1 day of delivery time after they request the delivery of the type of products specified earlier-right after the announcement of the manufacturer rebate. (0222)
- The competition among HVAC manufacturers happens mostly when the builders place their actual orders. (0301)
  - Since the builders do not specify their purchase quantity at the time the manufacturer rebate is announced, there is little competition then.
- At the end of a project, a builder reports the number of ACs purchased and asks for the rebate check.
- It is extremely unlikely for a builder to use different brands of heaters and coolers in the same residential project.

C4iSN

Some Facts

- Regulatory issues by region

- Utility rebates are an important factor for demand

- Rates are market driven

- Heat wave is a factor for the replacement demand
  Seasonality is an important factor for demand

  - Demand during peak season is greater than capacity: Capacity smoothing, Seasonal Inventory

- HC-Man is guessing a lag effect between sales and macroeconomics factors up to three to four months

- The average life of an air conditioner is around 10 to 15 years and a furnace is up to 20 years.

A Forecasting Tool

- A forecast for **Sales to Dealers**

    1. Air Conditioners 2. Heat Pumps 3. Furnace 4. Coil Blower

- Significant indicators of the demand

    - Indicators can be products themselves:

        - e.g., Furnace → AC

    - But there are many other indicators, more on this later

- Improve forecast accuracy

    - More proactive planning as opposed to revising the targets based on sales and inventory

C4iSN

Inputs

- Sales
- Housing Starts
- Building Permits
- Temperatures
- Average Sales Price

Input: Sales Data

- Sales to Dealers for months over Jan01-Feb07
    - Months are columns
- Sales are by
    - District
        - U453 for Dallas
    - Product Hierarchy
        - C1C12A4T7J and C1C12A4T7Y
        - Both belong to Hierarchy Description HP29 3PH, which is an Air Conditioner
    - Rows are indexed by (District) X (Product Hierarchy)
   - 30080 Rows

C4iSN

Aggregating Sales Data

- ## By location:

  - Aggregate Districts into Regions, Call them RDNs
    - 'Florida', 'Great Lakes', 'North Central', 'Northeast', 'South Central', 'Southwest', 'Eastern Canada', 'Western Canada'

- ## By product grouping:

  - Aggregate Product Hierarchies into
    - AC: Air Conditioners, FR: Furnaces
    - HP: Heat Pumps, CB:Coil Blowers

AC and
FR
Sales

CB and HP
Sales

Western Canada

Eastern Canada

Northwest

North Central

Great Lakes

Northeast

Southwest
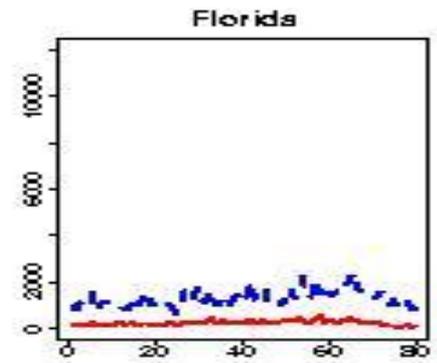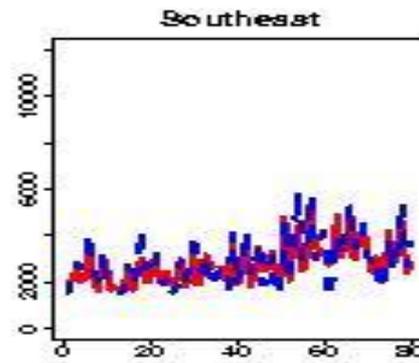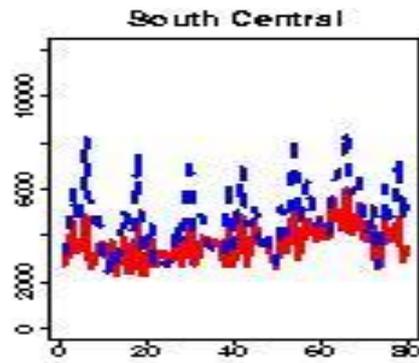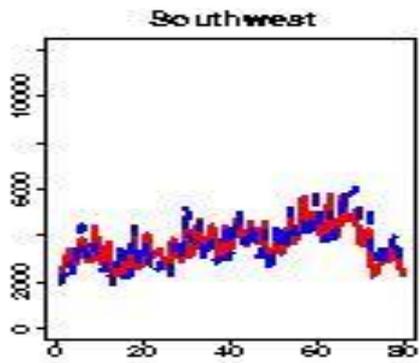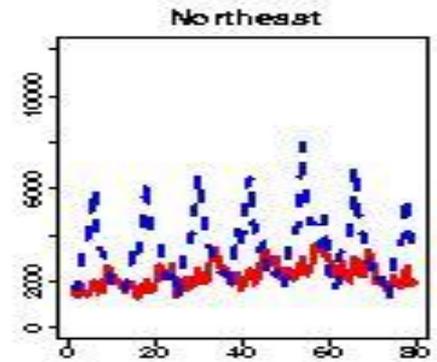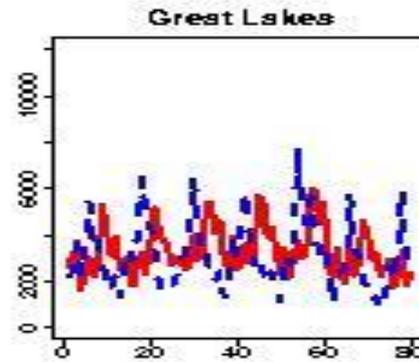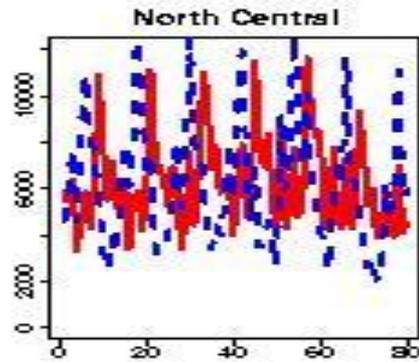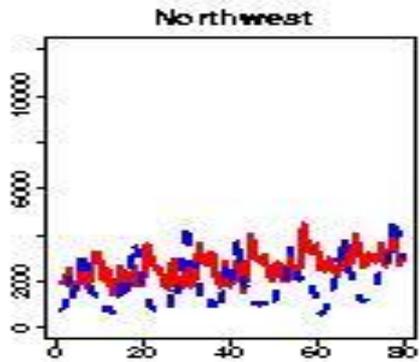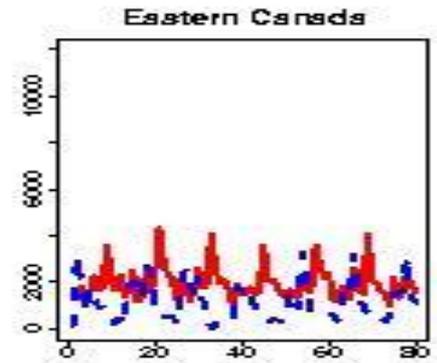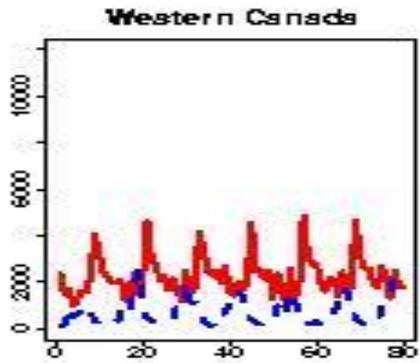
South Central
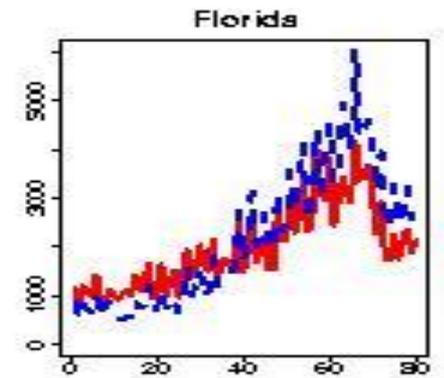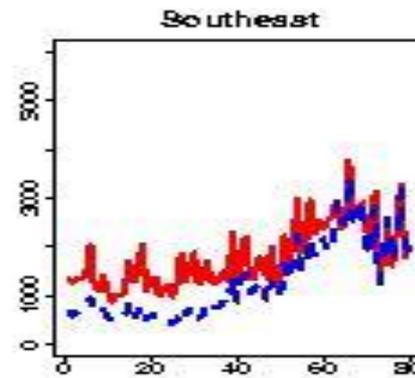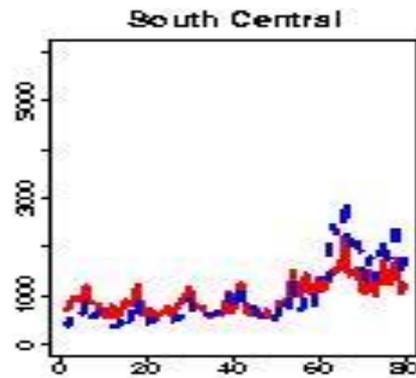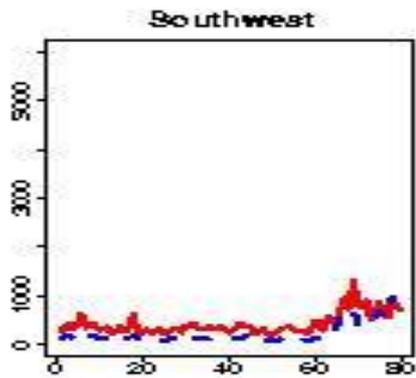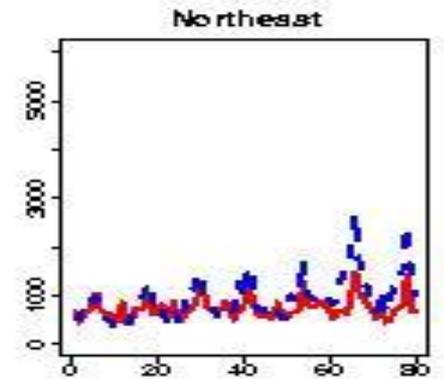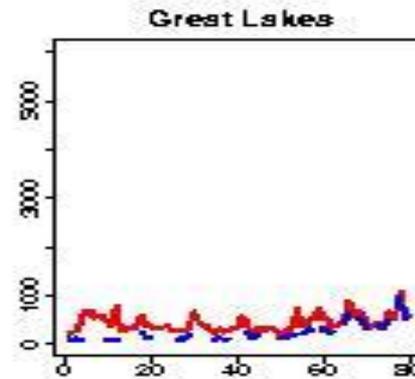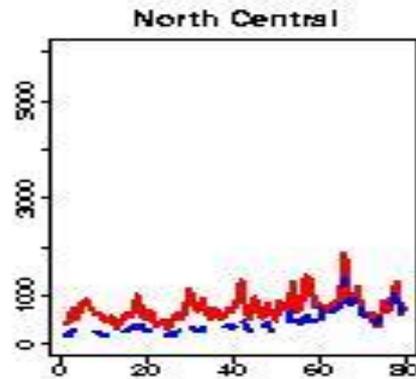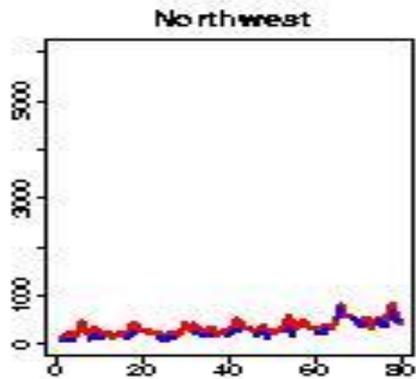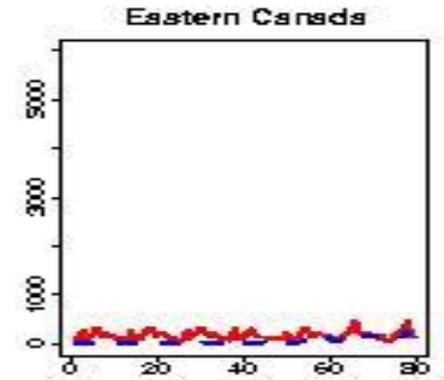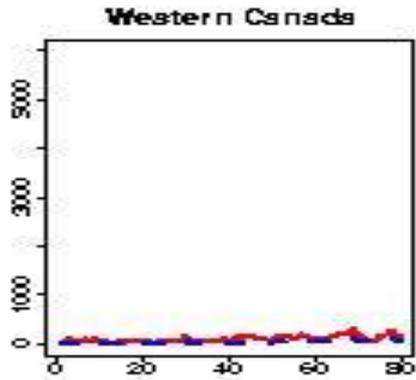
Southeast

Florida

Input: Publicly Available Housing Starts

- **By Regions**
  - Northeast, Midwest, South, West
- **By Months**

- **Issues:**
  - These regions are larger than desired.
    - South covers several RDNs Florida, South Central, Southwest
  - Housing starts themselves are estimates.
  - The time from housing start until purchasing Furnace and Air Conditioner varies.

Input: Available Building Permit Data

- ## By RDNs
    - 'Florida', 'Great Lakes', 'North Central', 'Northeast', 'South Central', 'Southwest', 'Eastern Canada', 'Western Canada'
- ## By Months

- ## Issue: There is a significant lag between building permit issuance and the housing start. This lag becomes longer when housing market slows down.

# Input: Temperatures

- ## By Cities
  - Toronto, Orlando, Detroit, Chicago, New York, Dallas, Los Angeles, Calgary
- ## By Day

- ## Issue: Multiple cities in a single region.
  - Toronto and Montreal are both in Eastern Canada, which city to use?

C4iSN

Input: Average Sales Price

- By Product
  - AC, FR, HP, CB
- By Cities
  - Toronto, Orlando, Detroit, Chicago, New York, Dallas, Los Angeles, Calgary, many more
- By Month

- Issue: Prices are very variable.
 - They change with the product mix.

AC Prices in Dallas

Over Jan 01 – May 07
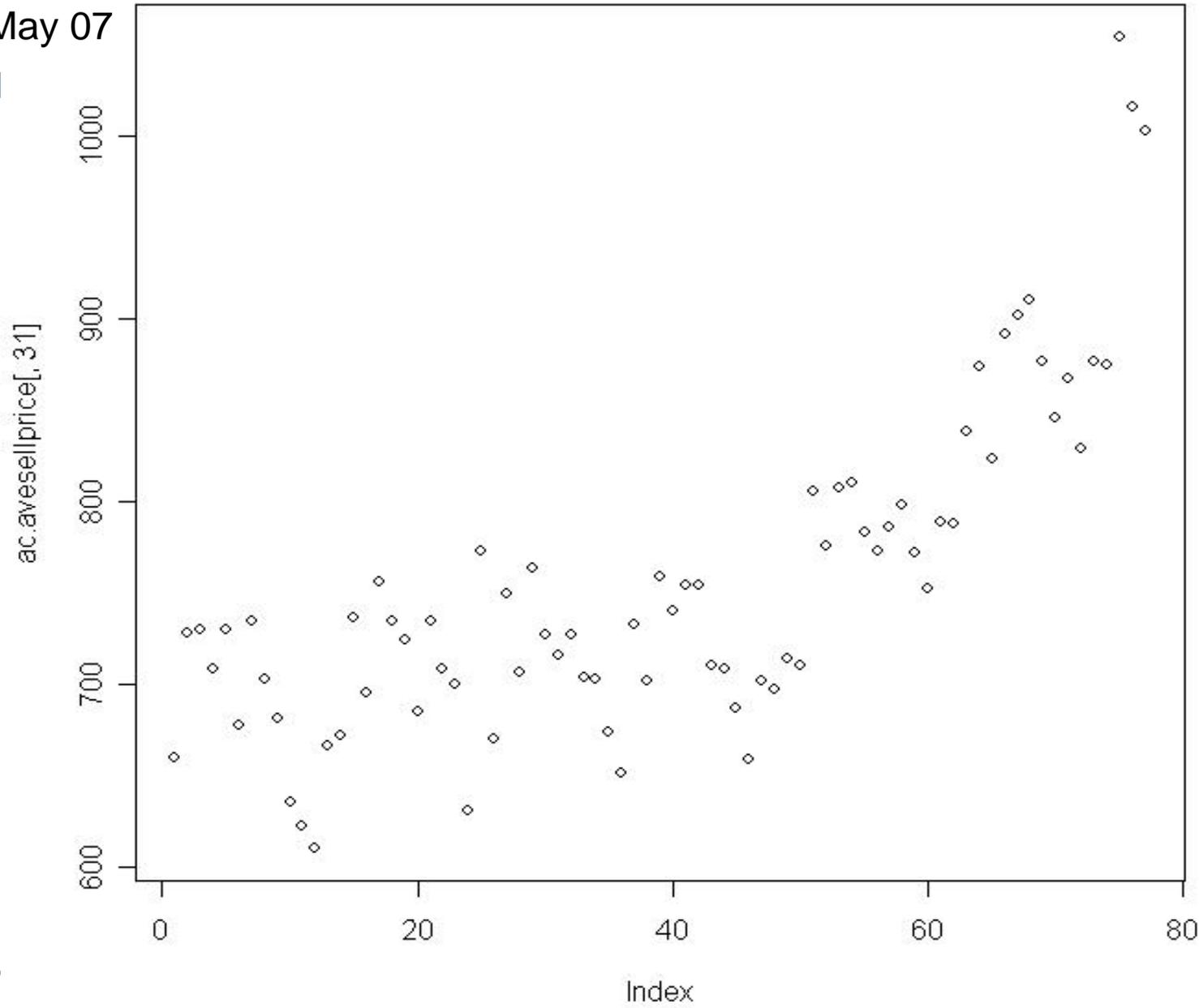
AC Prices in Orlando
Over Jan 01 – May 07
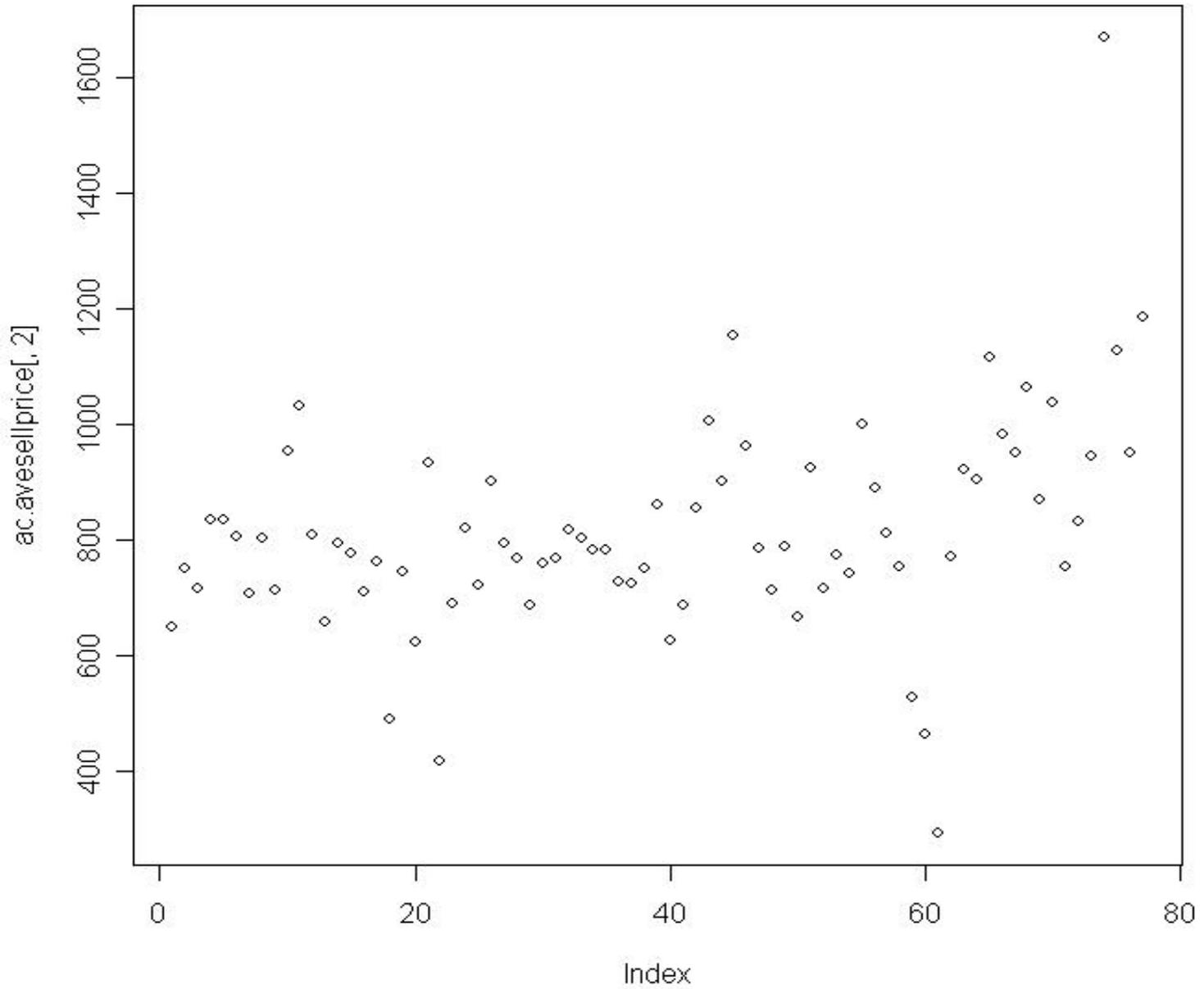
Forecasting: Preprocessing

- Preprocessing:
  - Additive and Multiplicative models (log-based)
  - Compute heating and cooling degreed days
    - CDD(month)=Average max{0,temp(day)-65} over days
    - HDD(month)=Average max{0,65-temp(day)} over days

Forecasting: Models

- From simple to complex
  - Trend and Seasonality
  - Add terms to capture correlation between AC - FR.
  - Add Cooling Degree Days.
  - Add Housing Starts.
  - Add unemployment in Michigan to explain sales.
  - Replace Housing Starts with Building Permits.
  - Add Average Selling Price

- Show the results in *Summary.xls*

Forecasting: Suggestions

- Primary Factors
  - Seasonality
  - Trend

- Secondary Factors
  - Correlation between products
  - Cooling degree days
  - Housing starts

- Tertiary Factors
  - Average sales prices

- 3 levels of factors call for 3 models

Forecasting: Software

- 3 Forecasting Models are in Predictions3.R

- Show the code *Predictions3.R*

- Run to obtain the predictions for the coming months for 3 models

- The code runs in (Open Source) R environment

- Because of the difficulty of importing/exporting data in/out of SAP, we did not attempt to use SAP modules. Moreover, SAP is unlikely to have forecasting modules that can deal with the very specifics of the forecasting requirements.

- Because of our limited knowledge about Excel, we did not attempt to use Excel. Moreover, Excel is not a statistics software and hence is unlikely to have the vector regression capability exploited in Predictions.R.

C4iSN

Software Architecture

HC-Man

sales_phd.csv
product_phd.csv
RDN.csv

AvePriceData.xls
InputPrices.xls

salesformater.r

Intermediate
Files

sales_csv

AvePriceData.xls
InputPrices.xls

Housing.csv

Census Bureau

Housing.csv

forecaster.r

Output
File

predictionfromR.csv

Temperature Archive

ssccccc.txt

chddcalculater.r

Memory

tcccccc.avecdd

C4iSN
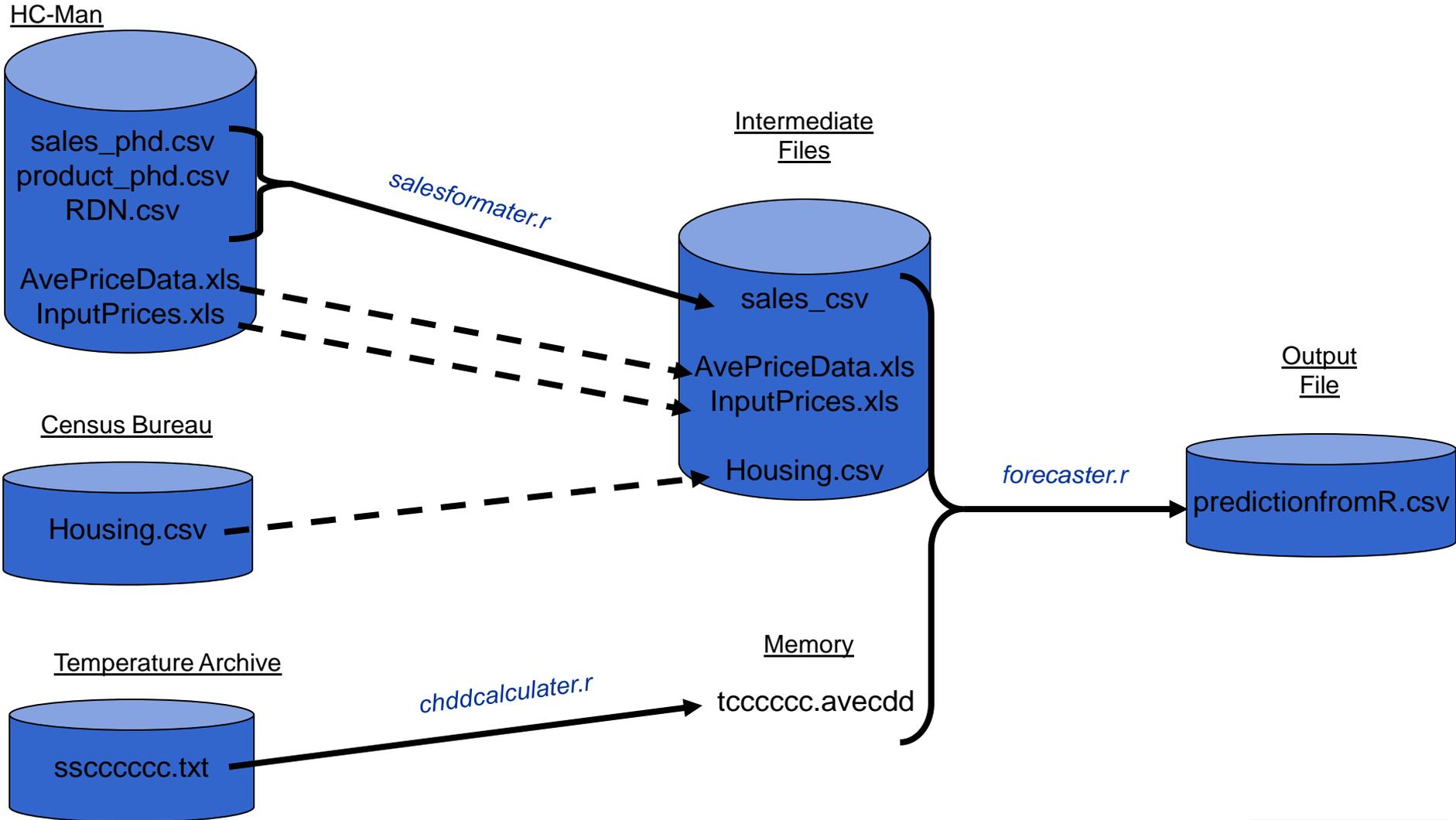
# Forecasting: Comparison with Existing

- Out of 24 accuracy measures in Summary.xls existing method beats us slightly 3 times
  - 1 month-out for AC in last 3 years and last year.
  - 1 month-out for Coil Blower in last 3 years
- We are confident with 10-15% forecast accuracy of our models.
- Inaccuracy in input data hinders our efforts to increase the accuracy.
- We believe that there still is some institutional knowledge/expertise that we have not captured.

C4iSN

Benefits of Our Method

- No requirement of institutional expertise/knowledge
- Streamlined
- Objective

- Provides distribution of the future sales rather than just a forecast
  - This is important when weighing in whether to produce exactly at the forecast, or slightly more, or much more.
  - The likelihood of slightly more sales versus much more sales than forecast can be obtained.

Uncertainty of Sales via Distributions
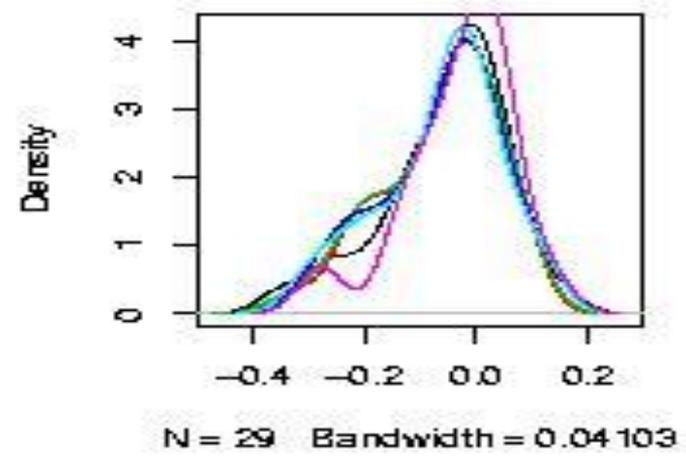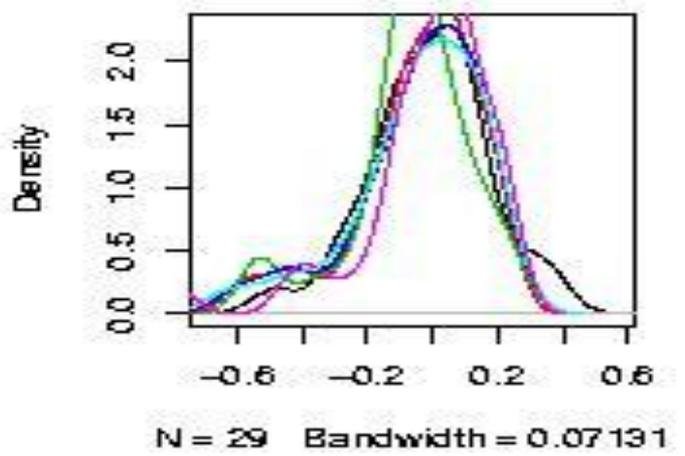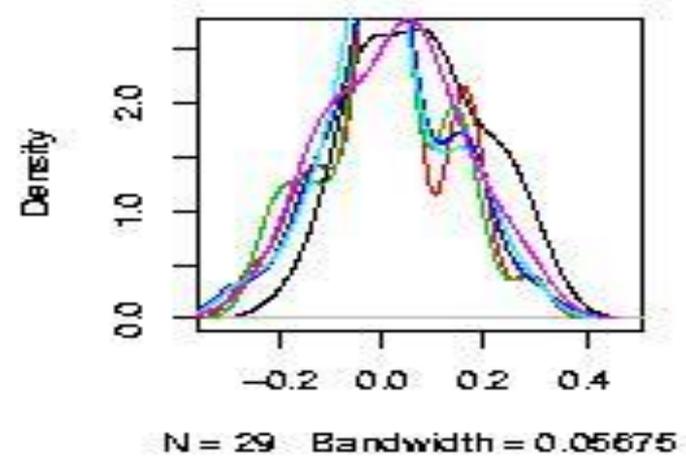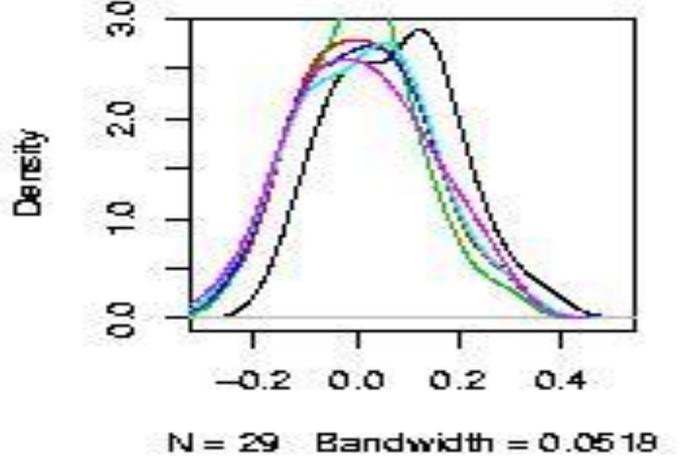
Near Future

- We shall update the input data files to make forecasts from the end of August 2007

Recommendations

- Gather data separately for RNC and Replacement market
  - Identify the idiosyncrasies of RNC and Replacement
    - Hypothesis: RNC driven by Housing starts
    - Hypothesis: Replacement driven by Heat wave
- More accurate input data helps
  - But comes at a cost
- Personal opinion: 10-15% accuracy is good. Next issue is to

  ## optimally plan

C4iSN