

# Feature response analysis



We are working on Moody's dataset with multiple features and responses for each market. It is quarterly data that means, that every quarter, new record come for each market. It is real estate dataset.

I am currently working with feature name `wholesale_trade_employment` and response `vacancy`. Help me understand how it works

Got it! Let's break this down carefully. You're working with Moody's **real estate dataset**, it's **quarterly**, and your feature is `wholesale_trade_employment` with `vacancy` as the response. Here's a thorough explanation:

## 1 Understanding the Feature: `wholesale_trade_employment`

- **Definition:** This feature represents the number of people employed in the wholesale trade sector within a given market (city or metro area) for that quarter. Wholesale trade involves businesses that sell goods in bulk to retailers, industrial, commercial, or institutional users.
- **Units:** Usually in total employment counts (e.g., number of employees) or sometimes as an index.
- **Role in real estate:**
  - Wholesale trade often indicates **commercial activity** in a market.
  - If wholesale trade employment is **growing**, it can suggest economic expansion, more businesses buying and distributing goods, which can lead to **higher demand for industrial or commercial space** (like warehouses, distribution centers).
  - Conversely, a **decline** might signal economic slowdown, potentially increasing **vacancy** rates in commercial/industrial properties.

## 2 Understanding the Response: `vacancy`

- **Definition:** Percentage of available (but unoccupied) real estate space in a market.
- **Connection to wholesale trade employment:**
  - A **high growth in wholesale employment** → potentially **lower industrial/commercial vacancy**.
  - A **drop in employment** → potentially **higher vacancy**, because businesses might be downsizing or closing.

## 3 How They Work Together (Potential Relationships)

Think of it as a **leading/lagging indicator relationship**:



1. **Lagged effect:** Changes in employment might **impact vacancy a quarter or two later**, since construction, leasing, or vacancy adjustments take time.
2. **Correlation intuition:**
  - Positive employment growth → may reduce vacancy (especially for industrial properties).
  - Negative employment growth → may increase vacancy.

#### 4 Feature Engineering Ideas for `wholesale_trade_employment`

Since you have **quarterly data**, you can create more predictive features:

Feature Type	Example
Lag features	<code>wholesale_trade_employment_lag1</code> (previous quarter), <code>lag2</code>
Rolling averages	4-quarter rolling avg: smooth seasonal fluctuations
Quarter-over-quarter growth	$(\text{current\_quarter} - \text{previous\_quarter}) / \text{previous\_quarter}$
Year-over-year growth	$(\text{current\_quarter} - \text{same\_quarter\_last\_year}) / \text{same\_quarter\_last\_year}$
Difference from trend	Difference from 4-quarter moving average (to capture unusual growth/drop)
Employment-to-vacancy ratio	See if local employment levels relate to space demand

These engineered features often **capture signals better than the raw employment number** for predicting vacancy.

#### 5 Real-world insight

- In markets with **high industrial activity**, wholesale trade employment is often a **leading indicator** for industrial vacancy trends.
- In other markets, it may be less relevant, so combining it with other **sector employment** features (like manufacturing, construction, retail) gives a more complete picture.

If you want, I can **draw a full causal diagram showing how wholesale trade employment affects vacancy**, including lagged effects, seasonal patterns, and interaction with other sectors—this is something **top real estate analysts** use to visualize relationships before modeling.

Do you want me to do that?



Help with out of box features engineering for this column.

Perfect! Let's think **beyond the standard lag/rolling/YoY features** and explore **"out-of-the-box" feature engineering** for `wholesale_trade_employment` in a real estate context. These are techniques **top real estate analysts and Moody's-style models** often use:



## 1 Employment Pressure Features

- **Concept:** Capture how changes in wholesale trade employment relate to available space.
- **Examples:**
  - **Employment per vacancy unit:**  $\text{wholesale\_trade\_employment} / \text{vacancy}$  → higher value may indicate stronger demand.
  - **Employment acceleration:** Second derivative of employment:

$$\text{acceleration} = (\text{current\_quarter} - 2 * \text{previous\_quarter} + \text{lag2}) / \text{lag2}$$

→ Shows whether employment growth is speeding up or slowing down.

- **Normalized employment:** Compare against historical maximum/minimum for the market:

$$\text{norm\_employment} = (\text{current} - \text{min}) / (\text{max} - \text{min})$$

## 2 Cross-sector Interaction Features

- Combine wholesale trade with other employment sectors to capture **market dynamics**.
- **Examples:**
  - $\text{wholesale\_trade} / \text{manufacturing\_employment}$  → shows trade vs production balance.
  - $\text{wholesale\_trade} + \text{retail\_employment}$  → total commerce employment indicator.
  - $\text{wholesale\_trade} * \text{construction\_employment}$  → potential new demand for warehouses/distribution centers.

## 3 Seasonality & Timing Features

- **Concept:** Wholesale trade often follows **seasonal cycles** (e.g., holiday seasons, Q4 peak).
- **Features:**
  - Quarter indicator × employment →  $\text{employment\_Q4}$ ,  $\text{employment\_Q1}$ , etc.
  - Seasonal index:  $\text{employment} / \text{average\_same\_quarter\_last\_3\_years}$  → detect unusual growth.
  - Employment deviation from 4-quarter rolling mean → capture short-term spikes.

## 4 Lagged Leading Indicators

- Instead of using only 1-quarter lag, create **lagged sequences**:
  - **Cumulative lag:** Sum of last 4 quarters:

$$\text{cumulative\_employment\_4q} = \text{lag1} + \text{lag2} + \text{lag3} + \text{lag4}$$

→ Captures sustained employment growth/decline.

- **Weighted lag:** Recent quarters more important:

$$\text{weighted} = 0.5 * \text{lag1} + 0.3 * \text{lag2} + 0.2 * \text{lag3}$$



## 5 Market Relative Features

- Compare employment in a market to the national or regional trend:
  - $\text{relative\_employment} = \text{market\_employment} / \text{national\_wholesale\_employment}$
  - Z-score normalization:

$$z\_score = (\text{market\_employment} - \text{mean\_national}) / \text{std\_national}$$

- Can reveal **overheated or underperforming markets** in terms of trade activity.

## 6 Volatility & Risk Features

- Measure **stability of employment** as a predictor of vacancy:
  - Standard deviation over last 4 or 8 quarters → **employment\_volatility\_4q**
  - Max-min range → **employment\_range\_4q**
  - Quarter-to-quarter absolute change → **employment\_change\_abs**

## 7 Ratio Features for Property Type

- If you have vacancy by property type (industrial, office, retail):
  - $\text{wholesale\_trade\_employment} / \text{industrial\_vacancy}$
  - $\text{wholesale\_trade\_employment} / \text{office\_vacancy}$
  - Useful because wholesale trade employment mostly drives **industrial demand**, but cross-effects are possible.

## 8 Shock/Trend Detection Features

- Detect unusual jumps or drops:
  - Employment change outside  $1.5 \times \text{IQR}$  of last 4 quarters → binary flag **employment\_spike**
  - Rolling percentile rank → shows if current employment is unusually high or low.

### Pro tip from top analysts:

Instead of blindly feeding all lagged and derived features, **combine them using dimensionality reduction** (PCA, autoencoders) or **interaction terms**, which captures **hidden signals** between sectors and vacancy. This often **beats plain regression with raw features**.

If you want, I can **make a full feature engineering “recipe” table** for **wholesale\_trade\_employment**, showing **25–30 advanced features**, categorized by type, with formulas ready for implementation in Python or R.

Do you want me to do that next?





Sorry I was asking can you look for some more top notch features engineering which top real estate industry use

Ah! Got it—you want **industry-grade, advanced feature engineering** for `wholesale_trade_employment` that **top real estate analysts or Moody's-style models** would actually use, not just basic lags or ratios. Let's go deep:

## 1 Economic Pressure & Demand Signals

- **Employment Elasticity Feature:**

Estimate how sensitive vacancy is to wholesale trade employment changes:

$$elasticity = \frac{\%change\ in\ vacancy}{\%change\ in\ wholesale\_employment}$$

→ Useful as a dynamic market stress indicator.

- **Employment Pressure Index:**

Combine multiple sectors into a single index for industrial/commercial demand:

$$pressure = w_1 * wholesale\_trade + w_2 * manufacturing + w_3 * construction$$

Weights can be learned from historical correlations to vacancy.

## 2 Lagged & Lead Features

- **Forward-looking “Lead” Features:** Sometimes, **vacancy reacts to employment 1–2 quarters later**, so create features like:

- `employment_lag1`, `employment_lag2`
- **Cumulative employment growth over last year** (sum of 4 lags) → captures sustained demand.

- **Dynamic Growth Rates:**

- Quarter-over-quarter, year-over-year, 4-quarter rolling growth.
- Weighted recent growth: recent quarters weigh more than older ones.

## 3 Market Relative & Comparative Features

- **Market Share / Concentration:**

- Compare a market's wholesale trade employment to the **national or regional level**:

$$market\_share = \frac{market\_employment}{total\_regional\_employment}$$



→ High share may indicate strong local industrial hub, low vacancy pressure.

- **Deviation from Historical Trend:**

- Z-score of current quarter vs last 8–12 quarters.
- Percentile rank: Is the market above the 80th percentile historically?

## 4 Volatility & Risk Features

- **Employment Stability Index:** Standard deviation or coefficient of variation over past 4–8 quarters.
- **Shock Detection Flags:**
  - Spike/drop beyond  $1.5 \times \text{IQR}$  or  $2\sigma$  from rolling mean → captures unusual events.
  - Binary “shock” features often have strong predictive power for vacancy jumps.

## 5 Interaction & Cross-sector Features

- **Sector Ratios:**
  - `wholesale_trade / manufacturing` → trade vs production balance.
  - `wholesale_trade / construction` → potential for new warehouse/industrial demand.
- **Employment Multiplicative Signals:**
  - `wholesale_trade * retail_employment` → combined effect on commercial demand.

Top analysts **never look at single sectors in isolation**—they model interaction effects between employment sectors.

## 6 Seasonality & Timing Signals

- **Quarterly Seasonal Adjustment:**
  - `employment_current / avg_employment_same_quarter_last_3_years` → seasonal anomaly detection.
- **Employment Acceleration:**
  - Measures the change in growth:

$$acceleration = lag0 - 2 * lag1 + lag2$$

→ Indicates whether employment growth is speeding up/slowing down.

## 7 Leading Indicators for Vacancy

- Wholesale trade employment is often a **leading indicator** for industrial vacancy. Advanced features can include:
  - **Lag-weighted sum:**



$$weighted\_lag = 0.5 * lag1 + 0.3 * lag2 + 0.2 * lag3$$

- **Cumulative growth over multiple quarters** → captures trend momentum.

## 8 Advanced Composite Indices

- **Industrial Demand Score:** Combine multiple employment features, construction activity, and past vacancy trends into a **single predictive score**.
- **Normalized Market Signal:** Z-score of market relative to national trend, then combine with sector interactions:

$$signal = z\_market * (manufacturing\_employment + wholesale\_trade)$$

### ✓ Industry Insights:

Top real estate analytics models don't just feed raw numbers—they engineer features to capture:

1. **Trend strength** (growth rates, acceleration)
2. **Market position** (relative to region/nation)
3. **Volatility / shock detection** (spikes, drops)
4. **Cross-sector interactions** (commerce + production + construction)
5. **Lagged/leading signals** (employment leads vacancy by quarters)

This is exactly what Moody's and other top analysts do for **forecasting vacancy in industrial and commercial real estate**.

If you want, I can **create a complete "out-of-the-box feature set" table for `wholesale_trade_employment` with 30+ features**, including formulas ready for Python/R implementation—covering **lags, growth, interactions, seasonality, shocks, and market-relative indices**.

Do you want me to do that next?



So me some more features engineering with `wholesale_trade_employment`

Absolutely! Let's go beyond the obvious and explore **advanced and creative feature engineering specifically for `wholesale_trade_employment`** in a real estate context. I'll break them into categories with practical examples.

## 1 Lagged and Growth Features

- **Quarter-over-quarter growth:**

$$QoQ\_growth = \frac{employment_t - employment_{t-1}}{employment_{t-1}}$$



- **Year-over-year growth:**

$$YoY\_growth = \frac{employment_t - employment_{t-4}}{employment_{t-4}}$$

- **Cumulative growth over past 4 quarters:**

$$cumulative\_growth = \sum_{i=1}^4 (employment_{t-i+1} - employment_{t-i})$$

- **Employment acceleration** (change in growth rate):

$$acceleration = (employment_t - 2 * employment_{t-1} + employment_{t-2}) / employment_{t-2}$$

## 2 Volatility and Risk Features

- **Rolling standard deviation** over 4 or 8 quarters: captures instability in employment trends.
- **Rolling range:** difference between max and min employment over last 4-8 quarters.
- **Absolute change:**  $|employment_t - employment_{t-1}|$
- **Shock flag:** binary feature if quarter-to-quarter change exceeds historical threshold (e.g.,  $1.5 \times IQR$ ).

## 3 Market-relative Features

- **Relative to national or regional level:**

$$relative\_employment = \frac{market\_employment}{national\_wholesale\_employment}$$

- **Z-score:** compares market to historical mean and standard deviation:

$$z\_score = \frac{market\_employment - mean\_historical}{std\_historical}$$

- **Percentile rank** of current employment in historical distribution.

## 4 Sector Interaction Features

- **Ratios with other sectors:**
  - Wholesale vs manufacturing:  $wholesale\_trade\_employment / manufacturing\_employment$
  - Wholesale vs construction:  $wholesale\_trade\_employment / construction\_employment$
  - Wholesale vs retail:  $wholesale\_trade\_employment / retail\_employment$
- **Multiplicative interaction:**  $wholesale\_trade\_employment * manufacturing\_employment \rightarrow$  captures synergistic growth for industrial/warehouse demand.



## 5 Seasonality & Timing

- **Quarteral adjustment:**
  - `employment_Q1`, `employment_Q2`, etc. → detect seasonal spikes.
- **Employment deviation from same quarter average:**

$$seasonal\_anomaly = employment_t - mean(employment_{t-4, t-8, t-12})$$

- **Rolling seasonal ratio:** current quarter / average of same quarter in past 3 years.

## 6 Leading / Lagged Features for Vacancy Prediction

- **Weighted lag sum:**

$$weighted\_lag = 0.5 * lag1 + 0.3 * lag2 + 0.2 * lag3$$

- **Lagged growth rates:** use past 1–4 quarters' growth as predictors.
- **Cumulative lag features:** sum of last 2–4 quarters' employment → captures sustained trends.

## 7 Composite Index Features

- **Employment Pressure Index:** combine multiple sectors to capture overall industrial/commercial demand:

$$pressure = w_1 * wholesale\_trade + w_2 * manufacturing + w_3 * construction$$

- **Market signal score:** Z-score of market employment × sum of other sectors → identifies over/underperforming markets.

## 8 Advanced Ideas Used by Top Analysts

- **Volatility-adjusted growth:** growth divided by historical standard deviation → captures “risk-adjusted” trend.
- **Spike/dip detection:** flag quarters with unusual employment changes that could trigger vacancy changes.
- **Interaction with vacancy trends:** e.g., `wholesale_trade_employment` / `rolling_vacancy` → leading signal of tightness or slack in the market.
- **Trend momentum features:** e.g., sign of acceleration × magnitude → helps models capture “speeding up” or “slowing down” markets.

### Summary:

By combining **lags**, **growth**, **volatility**, **market-relative signals**, **sector interactions**, **seasonality**, and **composite indices**, you can create **20–30+ powerful features** from `wholesale_trade_employment` that capture **demand pressure**, **market dynamics**, and **leading signals for vacancy**.



If you want, I can make a **ready-to-use table of 30+ advanced features for** `wholesale_trade_employment`, with **exact formulas and types** (lag, growth, volatility, interaction, etc.)—ready to implement in Python or R for real estate modeling.

Do you want me to do that?