Commercial Mortgages: Energy Factors and Default Risk

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Outline

• Premise: why commercial mortgages?
• DOE scoping study findings

• Energy factors and mortgage default risk: New results!
Premise and Context:
Why Commercial Mortgages?
What about commercial mortgages?

- Commercial mortgages currently do not fully account for energy factors in underwriting and valuation…
- …energy efficiency is not properly valued and energy risks are not properly assessed and mitigated.
- Commercial mortgages are a large lever and could be a significant channel for scaling energy efficiency.
Potential Interventions: 
Results from a Scoping Study
DOE Scoping Study

- Lit review and 40 stakeholder discussions
  - Lenders
  - Owners
  - Service providers
  - Industry orgs

- State-of-the-market
- Potential Interventions

https://cbs.lbl.gov/energy-factors-commercial-mortgages
Potential interventions and outcomes

**Energy / “Green” Impacts on Mortgage Valuation**
- Rental income
- Vacancy rates
- Utility costs
- Utility cost volatility

**Potential Intervention Points**
- Appraisals
- Underwriting methods & requirements
- Property Condition Assessments

**Potential Outcomes**
- Property Valuation
- Interest rates
- Loan-to-Value limit
- Debt Service Coverage limit
Efforts currently underway

1. Demonstrate to lenders why, where, and how much energy factors “move the needle”
   - Focus of today’s presentation

2. Incorporate energy efficiency information in Property Condition Assessments (PCAs)
   - Seeking participants!

3. Incorporate energy efficiency routinely in appraisals
   - DOE working group
Impact of Energy Factors on Mortgage Default Risk
Energy factors that directly affect valuation

- **Energy use volume**
  - Electricity kWh/kW, fuel therms
  - Driven by building features, operations, weather

- **Energy use volatility (+/- %)**
  - Driven by operations, weather

- **Energy price**
  - $/kWh, $/kW, $/therm

- **Energy price volatility**
  - e.g. forward curves

*How much do these factors affect mortgage default risk?*
Ideal analysis approach

- Analysis on an empirical data set that has:
  - Time-variant data on energy factors for specific buildings
  - Loan performance data for the same buildings
  - A representative sample across different market segments

- Challenges:
  - Lack of time-variant consumption dataset that can be matched with loan data
  - Lack of tariff data for individual buildings
Data sources considered

**Loans**
- TREPP
- Dataquick
- Real Capital Analytics

**Energy Price**
- Utility tariff data
- ISO/RTO
- Platts’ forward prices

**Energy Use**
- Bx Disclosure
- BPD
- Simulations
Modeling approach: Estimate the loan-level probability of default

\[ \text{MtgDefaultRate} = f(\text{EUI}, \text{EnergyPriceGap}, \text{CouponGap}, \text{LTVRatio}, \text{Region}) \]
Energy price gap

- Proxy for total unexpected energy expenditures
- Computed by summing monthly deviations of realized electricity prices from expected electricity prices at the time of mortgage origination
- Energy price gap, at time $t$, for a commercial mortgage originated at a time period $t_0$ within ISO zone $k$:

$$pgap_k(t_0, t) = \sum_{s=t_0}^{s=t} lmp_k(s) - hlmp_{k, month(s)}(t_0)$$

- Where:
  - $lmp = \text{monthly average on-peak locational marginal electricity price}$
  - $hlmp = \text{historical monthly average locational marginal price observed at the mortgage origination date.}$
Energy price gap

• Example: Evaluating the Energy Price Gap 22 months after the mortgage origination
## Default risk and source EUI: Office and Retail – Linear probability model

<table>
<thead>
<tr>
<th></th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.19342</td>
<td>0.16448</td>
<td>-0.40444**</td>
<td>0.18466</td>
</tr>
<tr>
<td>Log Source EUI</td>
<td>0.06001*</td>
<td>0.03159</td>
<td>0.07335**</td>
<td>0.03129</td>
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<tr>
<td>Origination Loan-to-Value Ratio</td>
<td></td>
<td></td>
<td>0.00258***</td>
<td>0.00096</td>
</tr>
<tr>
<td>Coupon Spread to 10 Year Treasury</td>
<td></td>
<td></td>
<td>0.02188</td>
<td>0.01565</td>
</tr>
<tr>
<td>Electricity Price Gap</td>
<td></td>
<td></td>
<td>0.00003***</td>
<td>0.00001</td>
</tr>
<tr>
<td>Time to Maturity on Balloon</td>
<td></td>
<td></td>
<td>-0.00189***</td>
<td>0.00060</td>
</tr>
<tr>
<td>Origination Year Fixed Effects</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>N = 492</td>
<td></td>
<td></td>
<td>N = 473</td>
<td></td>
</tr>
<tr>
<td>R2 = .0005</td>
<td></td>
<td></td>
<td>R2 = .1052</td>
<td></td>
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</tbody>
</table>

* p<0.1; ** p<0.05; ***p<0.01
The coefficient estimates for BOTH the *Electricity Price Gap* and *Source EUI* are significant at better than the .05 level of statistical significance.

Both coefficient estimates are also economically meaningful:

- The higher the *Source EUI* (the more energy usage per square foot) the higher the likelihood of default.
- The higher the *Electricity Price Gap*, (the larger the difference between the realized and the expected electricity prices since the loan origination), the higher the likelihood of default.
### Default risk and site EUI: Office and retail – linear prob. model

<table>
<thead>
<tr>
<th></th>
<th>Coefficient Estimate</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.05633</td>
<td>0.07404</td>
<td>-0.10734</td>
<td>0.08375</td>
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<tr>
<td>Log Site EUI</td>
<td>0.03169*</td>
<td>0.01711</td>
<td>0.02685</td>
<td>0.01658</td>
</tr>
<tr>
<td>Origination Loan-to-Value Ratio</td>
<td></td>
<td></td>
<td>0.0015**</td>
<td>0.00034</td>
</tr>
<tr>
<td>Coupon Spread to 10 Year Treasury</td>
<td></td>
<td></td>
<td>-0.00002</td>
<td>0.00014</td>
</tr>
<tr>
<td>Electricity Price Gap</td>
<td></td>
<td></td>
<td>0.00002***</td>
<td>0.00000</td>
</tr>
<tr>
<td>Time to Maturity on Balloon</td>
<td></td>
<td></td>
<td>-0.00048*</td>
<td>0.00028</td>
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<tr>
<td>Origination Year Fixed Effects/Year Fixed Effects</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>N = 535</td>
<td></td>
<td>N = 516</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2 = .002</td>
<td></td>
<td>R2 = .0701</td>
<td></td>
<td></td>
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</tbody>
</table>

* p<0.1; ** p<0.05; ***p<0.01
Default risk and site EUI: Office and retail – linear prob. model

- *Site EUI* is not statistically significantly different from 0 at better than .05 level.
- Electricity Price Gap is significant at better than the .05 level of statistical significance.
- Both coefficients have economically meaningful signs:
  - The higher the *Site EUI* (the more energy usage per square foot) the higher the likelihood of default.
  - The higher the *Electricity Price Gap*, (the larger the difference between the realized and the expected electricity prices since the loan origination), the higher the likelihood of default.
## Default risk and ENERGY STAR Score: Office and retail – linear prob. model

<table>
<thead>
<tr>
<th></th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.18650**</td>
<td>0.05788</td>
<td>0.18383*</td>
<td>0.11046</td>
</tr>
<tr>
<td>Energy Star Score</td>
<td>-0.00102</td>
<td>0.00079</td>
<td>-0.00134*</td>
<td>0.00077</td>
</tr>
<tr>
<td>Origination Loan-to-Value Ratio</td>
<td></td>
<td></td>
<td>0.00183*</td>
<td>0.00099</td>
</tr>
<tr>
<td>Coupon Spread to 10 Year Treasury</td>
<td></td>
<td></td>
<td>-0.00028</td>
<td>0.00021</td>
</tr>
<tr>
<td>Electricity Price Gap</td>
<td></td>
<td></td>
<td>0.00004***</td>
<td>0.00001</td>
</tr>
<tr>
<td>Time to Maturity on Balloon</td>
<td></td>
<td></td>
<td>-0.00166**</td>
<td>0.00054</td>
</tr>
<tr>
<td>Origination Year Fixed Effects/Year Fixed Effects</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>N = 448</td>
<td></td>
<td></td>
<td>N = 432</td>
<td></td>
</tr>
<tr>
<td>R2 = .002</td>
<td></td>
<td></td>
<td>R2 = .071</td>
<td></td>
</tr>
</tbody>
</table>

* p<0.1; ** p<0.05; ***p<0.01
Default risk and ENERGY STAR score: Office and Retail – Linear Prob. Model

- *Energy Star Score* is not statistically significantly different from 0 at better than .05 level.
- Electricity Price Gap is significant at better than the .05 level of statistical significance.
- Both coefficients have economically meaningful signs:
  - The higher the *Energy Star Score* (the more energy efficient the building) the lower the likelihood of default.
  - The higher the *Electricity Price Gap*, (the larger the difference between the realized and the expected electricity prices since the loan origination), the higher the likelihood of default.
What are the impacts on specific cases? – Scenario analysis

- Develop range of scenarios that have different energy factor risks
  - Range of locations, building features, operations, etc.

For each scenario:
- Determine energy consumption and price volatility.
  - Use combination of empirical and simulation approaches
- Use hazard model coefficients to determine impact on default risk
### Asset types

<table>
<thead>
<tr>
<th>Use</th>
<th>Size</th>
<th>Climate</th>
<th>Asset eff</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>500,000</td>
<td>4A</td>
<td>High</td>
<td>~ 90.1-2013</td>
</tr>
<tr>
<td>Office</td>
<td>500,000</td>
<td>4A</td>
<td>Medium</td>
<td>~ 90.1-2004</td>
</tr>
<tr>
<td>Office</td>
<td>500,000</td>
<td>4A</td>
<td>Low</td>
<td>Pre-1980 envelope</td>
</tr>
<tr>
<td>Office</td>
<td>500,000</td>
<td>2A</td>
<td>High</td>
<td>~ 90.1-2013</td>
</tr>
<tr>
<td>Office</td>
<td>500,000</td>
<td>2A</td>
<td>Medium</td>
<td>~ 90.1-2004</td>
</tr>
<tr>
<td>Office</td>
<td>500,000</td>
<td>2A</td>
<td>Low</td>
<td>Pre-1980 envelope</td>
</tr>
<tr>
<td>Office</td>
<td>200,000</td>
<td>4A</td>
<td>Medium</td>
<td>~ 90.1-2004</td>
</tr>
<tr>
<td>Office</td>
<td>25,000</td>
<td>4A</td>
<td>Medium</td>
<td>~ 90.1-2004</td>
</tr>
</tbody>
</table>

...
A wide range of factors affect year-to-year energy use variations

### Facilities management
- Economizer settings
- VAV box minimum flow setting
- Supply air temperature reset
- Static pressure reset
- Chilled water/Hot water supply temperature reset
- Condenser water temperature reset
- Chiller /boiler sequencing

### Occupant behavior
- Lighting controls
- Window operation
- Thermostat setpoints/setback
- Local heating/cooling equipment
- Plug in equipment

### Maintenance
- Damper/ valve check
- Filter change
- Coil cleaning

### Weather

### Vacancy rates
## Range of practice for each factor

<table>
<thead>
<tr>
<th>Factor</th>
<th>Good practice</th>
<th>Average practice</th>
<th>Poor practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting controls</td>
<td>Daylight-dimming + occ</td>
<td>Occ only</td>
<td>Timer only</td>
</tr>
<tr>
<td>Plug load controls</td>
<td>Turn off when occupants leave</td>
<td>Sleep mode by itself</td>
<td>No energy saving measures</td>
</tr>
<tr>
<td>HVAC schedule</td>
<td>optimal start</td>
<td>2hr +/- Occupant sch</td>
<td>n/a</td>
</tr>
<tr>
<td>Thermostat settings</td>
<td>68°F for heating and 78°F for cooling</td>
<td>70°F for heating and 76°F for cooling</td>
<td>72°F for heating and 74°F for cooling</td>
</tr>
<tr>
<td>Supply air temp reset</td>
<td>SAT reset base on warmest zones</td>
<td>SAT reset based on the stepwise function of outdoor air temperature</td>
<td>Constant supply air temperature</td>
</tr>
<tr>
<td>VAV box min flow settings</td>
<td>15% of design flow rate.</td>
<td>30% of design flow rate.</td>
<td>50% of design flow rate.</td>
</tr>
<tr>
<td>Economizer controls</td>
<td>Enthalpy</td>
<td>dry bulb</td>
<td>none/broken</td>
</tr>
<tr>
<td>Chilled water supply temp reset</td>
<td>Reset chilled water temperature based on cooling demand.</td>
<td>Linear relationship with outside air temp (OAT).</td>
<td>No reset with constant year-round.</td>
</tr>
<tr>
<td>Chiller sequencing</td>
<td>Kick on the lag chiller when the lead chiller reaches its peak efficiency.</td>
<td>Kick on the lag chiller when the chilled water temperature cannot be maintained.</td>
<td>Always running two chillers</td>
</tr>
<tr>
<td>Hot water supply temp reset</td>
<td>Reset the hot water supply temperature according to heating load.</td>
<td>Linear relationship with OAT.</td>
<td>No reset with constant year-round.</td>
</tr>
<tr>
<td>Boiler sequencing</td>
<td>Kick on the lag boiler when lead boiler reaches its peak efficiency.</td>
<td>Kick on the second boiler based on OAT.</td>
<td>No sequencing and always running two boilers.</td>
</tr>
<tr>
<td>Plug load intensity</td>
<td>0.4 W/sf</td>
<td>0.75 W/sf</td>
<td>2.0 W/sf</td>
</tr>
<tr>
<td>Occupant density</td>
<td>400 sf/per</td>
<td>200 sf/per</td>
<td>130 sf/per</td>
</tr>
<tr>
<td>Occupant schedule</td>
<td>8 hour WD</td>
<td>12 Hr WD</td>
<td>16 Hr WD</td>
</tr>
</tbody>
</table>
Range of variation due to operation factors
Range of variation due to weather: 2000-2015
## Net impacts on default risk - illustrative

<table>
<thead>
<tr>
<th>Case</th>
<th>Source EUI (kBtu/sf.yr)</th>
<th>Change in default risk (absolute)</th>
<th>% Change in default risk (relative to TREPP avg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Poor operational practice</td>
<td>260 (+30%)</td>
<td>+0.0084</td>
<td>+ 10.5%</td>
</tr>
<tr>
<td>Good operational practice</td>
<td>180 (-10%)</td>
<td>-0.0034</td>
<td>- 4.25%</td>
</tr>
</tbody>
</table>
Limitations of these results

- Limited to CMBS.
- Uses proxies for energy cost i.e. source EUI and wholesale energy price gap.
- Source EUI data is only an annual "snapshot".
- Matched data scope is limited by location, building types, and size.
Looking ahead

- **Analysis**
  - Default risk analysis using RCA bank loan data.
  - Actuarial-style “look up” of energy risks based on key asset and operational characteristics.

- **Disseminate analysis results**
  - Primary audience: Lenders and owners
  - via webinars, conferences, technical reports

- **Engage lenders and owners to:**
  - Develop methods and procedures to fully incorporate energy factors in mortgage valuation.
  - Apply these methods and procedures in commercial mortgages and document results in case studies.

*Please let us know if you would like to participate!*

*Contact Cindy Zhu (DOE): Cindy.Zhu@ee.doe.gov*
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Appendix
$2.5 trillion market
Key CMBS sectors: Office, Retail, Hotel, Multi-family
Challenges and opportunities…1

- Energy efficiency is generally not a motivating factor for lenders.
- Very limited awareness and analysis of energy cost impacts in underwriting.
- Underwriting is not standardized across the industry.
Challenges and opportunities...2

- Property Condition Assessment (PCA) generally does not include energy efficiency information.

- Most appraisals do not consider energy efficiency features in property valuation.
Many owners have not seen impact of energy factors on building value in their own portfolios.

Context matters: all real estate is local. The impact of energy factors on valuation varies significantly by location, building type, quality, and market conditions.