Estimating Consumer Default Sensitivities to Financial Stress Factors Through Counterfactual Analysis

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Senior Principal Scientist, FICO
Agenda

Objective and Concept

Methodology and Insights
Objective

Financial stress factors:

* **Tough economy**
  * Growing balances

are likely to increase default rates…

But not all consumers may be equally affected

- **Financial stress-resistant**
- **How will each individual respond if these stresses arise?**
- **Financial stress-vulnerable**

- Understand individuals’ sensitivities to financial stresses arising from
  - Recessionary economies
  - Increasing credit card balances
Concept

- Developed new indices, based on credit bureau data, to rank order consumers according to default sensitivities
  - Economic Sensitivity Index
  - Balance Change Sensitivity Index

<table>
<thead>
<tr>
<th>Consumer ID</th>
<th>FICO® Score</th>
<th>Economic Sensitivity</th>
<th>Balance Change Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>671</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>#2</td>
<td>689</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>#3</td>
<td>730</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Mitigate Cycle Sensitivity

In Times of Economic Uncertainty, Prefer Consumers Who Are Less Sensitive to the Economy

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<tbody>
<tr>
<td>#1</td>
<td>674</td>
<td>Low</td>
</tr>
<tr>
<td>#2</td>
<td>682</td>
<td>High</td>
</tr>
<tr>
<td>#3</td>
<td>739</td>
<td>Medium</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

- Consumer #1 is preferred over consumer #2—despite marginally lower risk score
- Swap sets:
  - Lend more to stress-resistant consumers and less to more sensitive ones at similar risk scores
### Account for Affordability In Credit Card Limit Decisions

When Managing Card Limits, Prefer Consumers With Low Balance Sensitivity

<table>
<thead>
<tr>
<th>Consumer ID</th>
<th>FICO® Score</th>
<th>Balance Change Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>683</td>
<td>High</td>
</tr>
<tr>
<td>#5</td>
<td>732</td>
<td>Low</td>
</tr>
<tr>
<td>#6</td>
<td>746</td>
<td>High</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

- Allowing consumer #5 to grow her credit card balance is preferred over allowing consumer #6 to grow his balance—despite marginally lower risk score.

More aggressive limits

More conservative limits
Admiring Stress Situations Part I: The Great Recession

Economic Cycle Sensitivity Example (US)

- FICO® Score is designed to rank order credit risk
- Odds to Score relation:
  - In a “normal” economic period expect the relation to be stable
  - In a period of economic stress expect the line to shift and/or rotate downwards

![Graph showing FICO Score and economic cycle sensitivity](attachment:image.png)
But Not All Consumers Are Equally Sensitive to a Recession

- Consumers with low economic sensitivity maintained stable Odds during the last US recession – they are decoupled from the economy
- Odds drop substantially for the most sensitive consumers

There are consumers with varying economic sensitivities in any risk score band
90+ DPD Rates (Worst Performance on Any Trade Line) for FICO® Score 680 Consumers

Solid Versus Trough Economy

<table>
<thead>
<tr>
<th>90+ DPD Rate</th>
<th>All @ FICO® Score ~680</th>
<th>20% Most Sensitive @ FICO® Score ~680</th>
<th>20% Least Sensitive @ FICO® Score ~680</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Economy</td>
<td>12.5%</td>
<td>14.0%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Trough Economy</td>
<td>20.7%</td>
<td>29.3%</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

- Bad rate more than doubles during stressed economic period for the 20% most sensitives in this score band
- Bad rate hardly varies across economic conditions for the 20% least sensitives in this score band
Admiring Stress Situations Part II: Credit Card Balance Overextension

Longitudinal Study Design to Analyze Effects of Rapid Balance Increases on Default Likelihood

Natural A/B experiments play out all the time

- Non-Increaser (A) Bal. change < $100
- Increaser (B) Bal. change > $2,000

Performance period

Scoring date, outset of experiment
Measure balance change
Define Increasers and Non-Increasers

Generate performance

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# 90+ DPD Rates (Worst Performance on Any Trade Line) for Consumers @ 610-710

Non-Increasers Versus Increasers

<table>
<thead>
<tr>
<th>90+ DPD Rate*</th>
<th>All @ FICO® Score 610-710</th>
<th>20% Most Sensitive @ FICO® Score 610-710</th>
<th>20% Least Sensitive @ FICO® Score 610-710</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Increasers</td>
<td>14.3%</td>
<td>14.2%</td>
<td>16.4%</td>
</tr>
<tr>
<td>Increasers</td>
<td>20.2%↑</td>
<td>22.8%</td>
<td>17.1%↑</td>
</tr>
</tbody>
</table>

*During performance period subsequent to balance change period

- Bad rate varies considerably across balance stress conditions for the 20% most sensitives in this score band
- Bad rate hardly varies across balance stress conditions for the 20% least sensitives in this score band
Agenda

Objective and Concept

Methodology and Insights
Understanding Effects of Stress Factors on Future Performance

Credit bureau data
Application information
Transaction data …

Entity’s current observable attributes

Change to economy
Change to balance

Stress Factors

Causality?

Entity’s future payment performance

Credit risk score
Potential Outcomes Framework for Defining Individual Sensitivity to Stress

Rubin Causal Model

- Sensitivity is defined on the individual, as a comparison
  - Difference in potential payment performance under unstressed versus stressed conditions

\[ Y^U_{Joe} \]

Joe’s potential payment performance under unstressed condition

\[ Y^S_{Joe} \]

Joe’s potential payment performance under stressed condition

\[ X_{Joe} \]

Joe’s attributes

\[ U \]

Joe’s attributes

\[ S \]

Joe’s attributes

Unstressed condition

\[ C < $100 \]

Stressed condition

\[ C > $2,000 \]
Counterfactual Analysis

Estimation strategy:

1. Generate matched data set, by pairwise matched sampling of stressed and unstressed individuals based on non-parametric propensity score.

2. On matched, develop non-parametric regression model to predict performance, allowing for interactions between stress indicator and attributes (so effect of stress can depend on individual).

Counterfactuals can be estimated s.t. to common support and unconfoundedness.

Idea: Find individuals similar to Joe, but subsequently running through his path not taken, to obtain an estimate of Joe’s performance under counterfactual conditions.
Machine Learning Approach
Learns Optimal Mapping from Consumer Attributes to Stress Sensitivity Index

Stochastic Gradient Boosting

Matched sample
- Unstressed condition
- Stressed condition

Performance
Consumer attributes

Tree 1

Tree 2

Tree M

Combine predictions from 1000's of trees

Sensitivity Index

New index value

New attribute value
Empirical Findings

- In each FICO® Score band we find substantial variation in estimated sensitivities.
- Joint frequencies:

<table>
<thead>
<tr>
<th>Quartiles of Balance Change Sensitivity Index</th>
<th>FICO_300to650</th>
<th>FICO_650to700</th>
<th>FICO_700to750</th>
<th>FICO_750toInf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least sensitive</td>
<td>2.34</td>
<td>1.23</td>
<td>2.47</td>
<td>18.95</td>
</tr>
<tr>
<td></td>
<td>4.29</td>
<td>2.21</td>
<td>3.39</td>
<td>15.12</td>
</tr>
<tr>
<td></td>
<td>8.13</td>
<td>3.50</td>
<td>4.39</td>
<td>8.98</td>
</tr>
<tr>
<td>Most sensitive</td>
<td>10.56</td>
<td>5.67</td>
<td>5.65</td>
<td>3.11</td>
</tr>
</tbody>
</table>

\[ \sum = 100\% \]

(qualitatively similar results for Economic Sensitivity Index)

- Two consumers can have the same FICO® Score yet very different sensitivities.
- Higher FICO® Scores tend to be less sensitive, but association isn’t too strong.
Economic Stress Sensitive FICO® Score 680 Consumers … … More Actively Search for Credit

Avg. number of inquiries last year

<table>
<thead>
<tr>
<th>Least Sensitive 20%</th>
<th>Most Sensitive 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Economic Stress Sensitive FICO® Score 680 Consumers … … Have Higher Total Balances
Economic Stress Sensitive FICO® Score 680 Consumers …
… More Recently Opened a New Trade Line

Avg. months since most recent trade line opened
Economic Stress Sensitive FICO® Score 680 Consumers … … Have Experienced Fewer Delinquencies
Balance Change Sensitive FICO® Score 680 Consumers … … Are Less Mature

Avg. months since oldest trade line opened

Least Sensitive 20%  Most Sensitive 20%
Balance Change Sensitive FICO® Score 680 Consumers … … Have Higher Revolving Balances
Balance Change Sensitive FICO® Score 680 Consumers …
… More Recently Opened a New Trade Line

![Bar Chart]

Avg. months since most recent trade line opened

- Least Sensitive 20%:
  - Avg. months: 35

- Most Sensitive 20%:
  - Avg. months: 10
Balance Change Sensitive FICO® Score 680 Consumers …
… Paid Down Less on Installment Loans

$10^5$ Avg. amount paid down on Installment Loans

- Least Sensitive 20%
- Most Sensitive 20%
Balance Change Sensitive FICO® Score 680 Consumers …
… Have Experienced Fewer Delinquencies
Many Consumers Share the Same Risk Score But Respond Differently to Stresses

- We can now separate stress-sensitive from robust consumers and use this knowledge to mitigate risks related to economic cycle and affordability of card debt
  - By factoring our novel sensitivity indices into marketing and lending policies
Thank You

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