EXPERIMENTS WITH HIGH-FREQUENCY DATA AND MACHINE LEARNING

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Insights and Lessons

New Tools of the Economists' Trade series

James Fudurich, Jeff Mollins and Naveen Rai

October 31, 2024

Disclaimer: The views expressed are solely those of the researchers and do not necessarily reflect the views of the Bank of Canada.

Three Experiments – Q&A after each session

1. High-frequency consumer survey: *Daily Internet Survey of Confidence (DISC)*

2. Moneris' high-frequency retail payment data

3. Survey Practitioner's use cases for Large Language Models

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High Frequency Consumer Survey: What are the Speed Limits?

Daily Internet Survey of Canadians (DISC)
Objectives, Methods and Outcomes

James Fudurich

ECONOMIST

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BACKGROUND

Daily Internet Survey of Confidence (DISC)

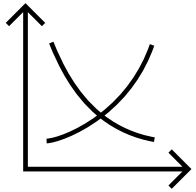
Daily, internet survey conducted between December 2019 and December 2023.

Only daily consumer confidence survey in Canada and one of few internationally.

‘Random intercept’ approach where participants visiting dormant websites are presented with a survey

12-15 closed-ended questions, including demographic information and categorical questions on their macroeconomic expectations, opinions and behaviour

Core questions and special questions

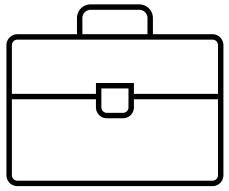


Is right now a good time to make a major purchase?

Right now, the **Canadian economy** in your opinion is?

How much do you think the **value of houses** in your neighbourhood changed in the **last year**?
……over the **next year**?

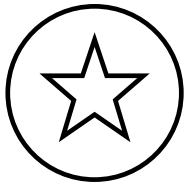
How much do you think the **cost of living** for the average Canadian will change over the **next 12 months**?
….**next two years**?



Do you expect **overall employment** in your community over the next six months will…?

How do you expect **your pay** will change in the next year?

Compared to six months ago, **the likelihood of losing a job** has….?



How often do you expect to **spend on activities outside the home** over the next 12 months?

Compared to last month, how frequently have your purchases been delayed due to items being **out of stock**?

Example questions

How much do you think the cost of living for the average Canadian will change over **the next 12 months?**

Rise substantially (more than 5%)	Rise moderately (4-5%)	Rise a little (1-3%)	Minimal change (±1%)	Fall a little (1-3%)	Fall moderately (4-5%)	Fall substantially (more than 5%)

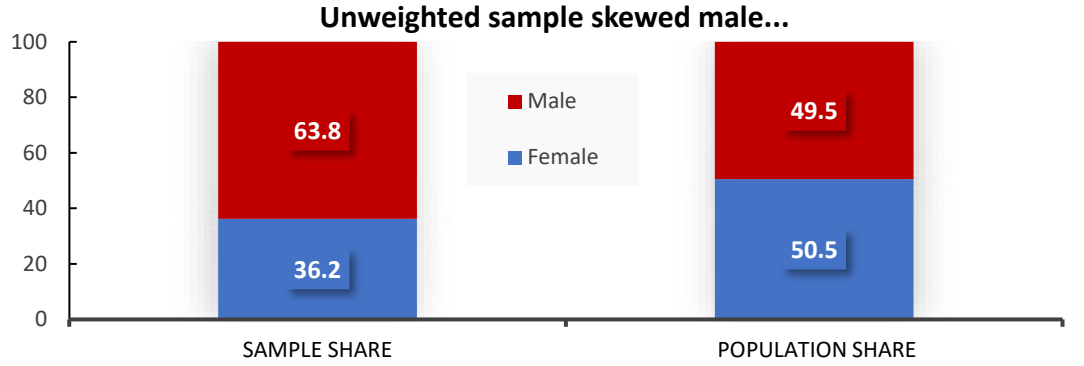
Think about your spending on activities out of home like eating out, entertainment, and recreation in the past 12 months. Now looking forward, how often do you expect to spend on these activities **in the next 12 months?**

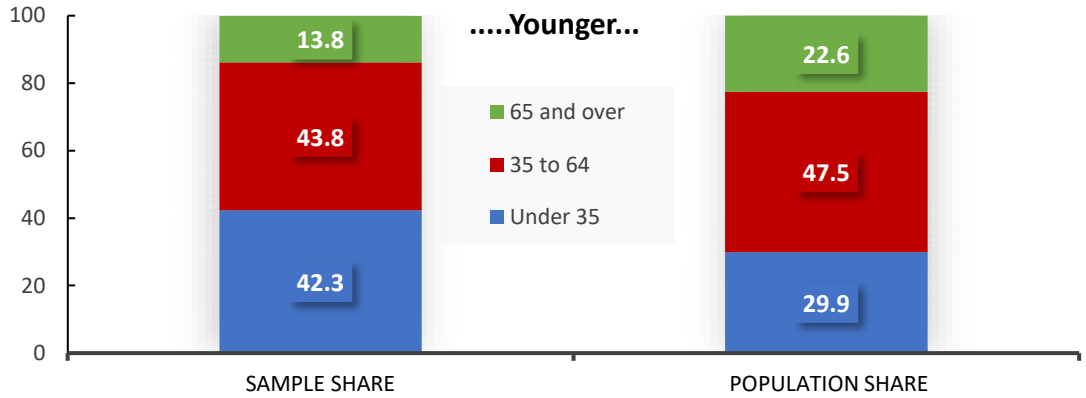
Less often	About as often	More often

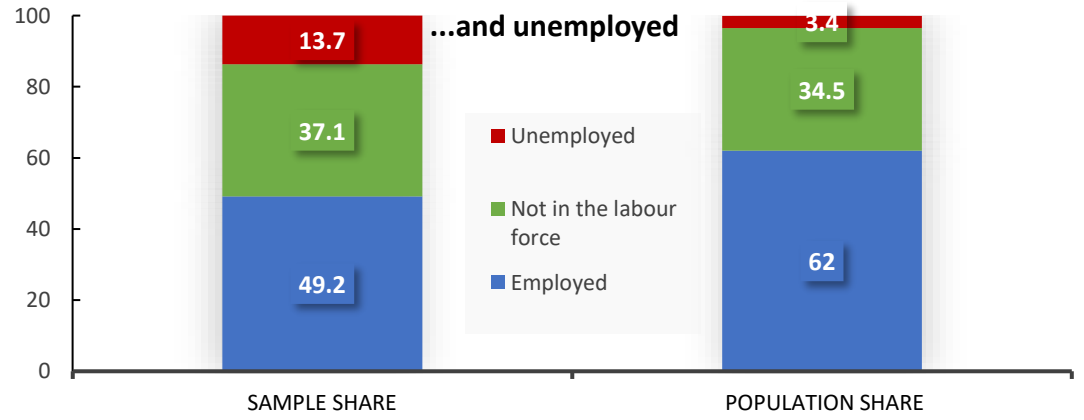
Sample skewed towards young, unemployed males

2,500 monthly observations, weighted by age, gender and region to reflect Canadian population.

Questions presented in **random order**, taking only several minutes to complete.







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EVALUATION

Reliability

Propensity-score matching

Objective: Identify survey ‘mode effects’

Methodology: create two equal sub-samples and compare responses between surveys

Usefulness

Inflection points

Objective: Identify whether DISC inflection points occurred ahead of data releases

Methodology: Segment DISC and official statistics, compare timing of inflection points.

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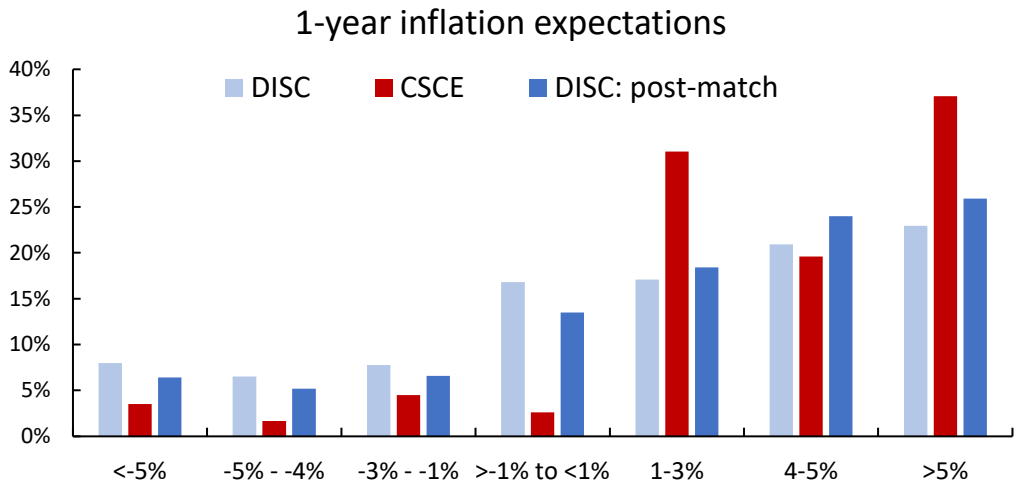
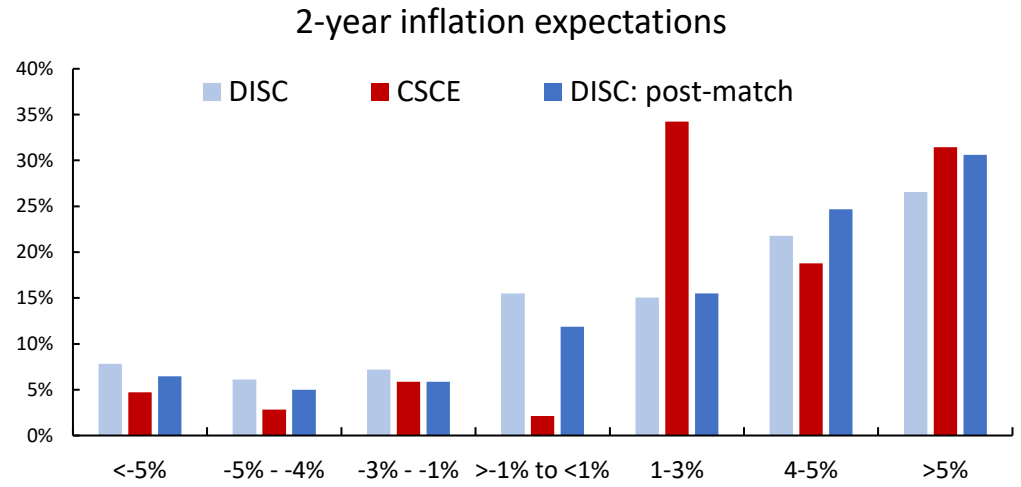
RESULTS

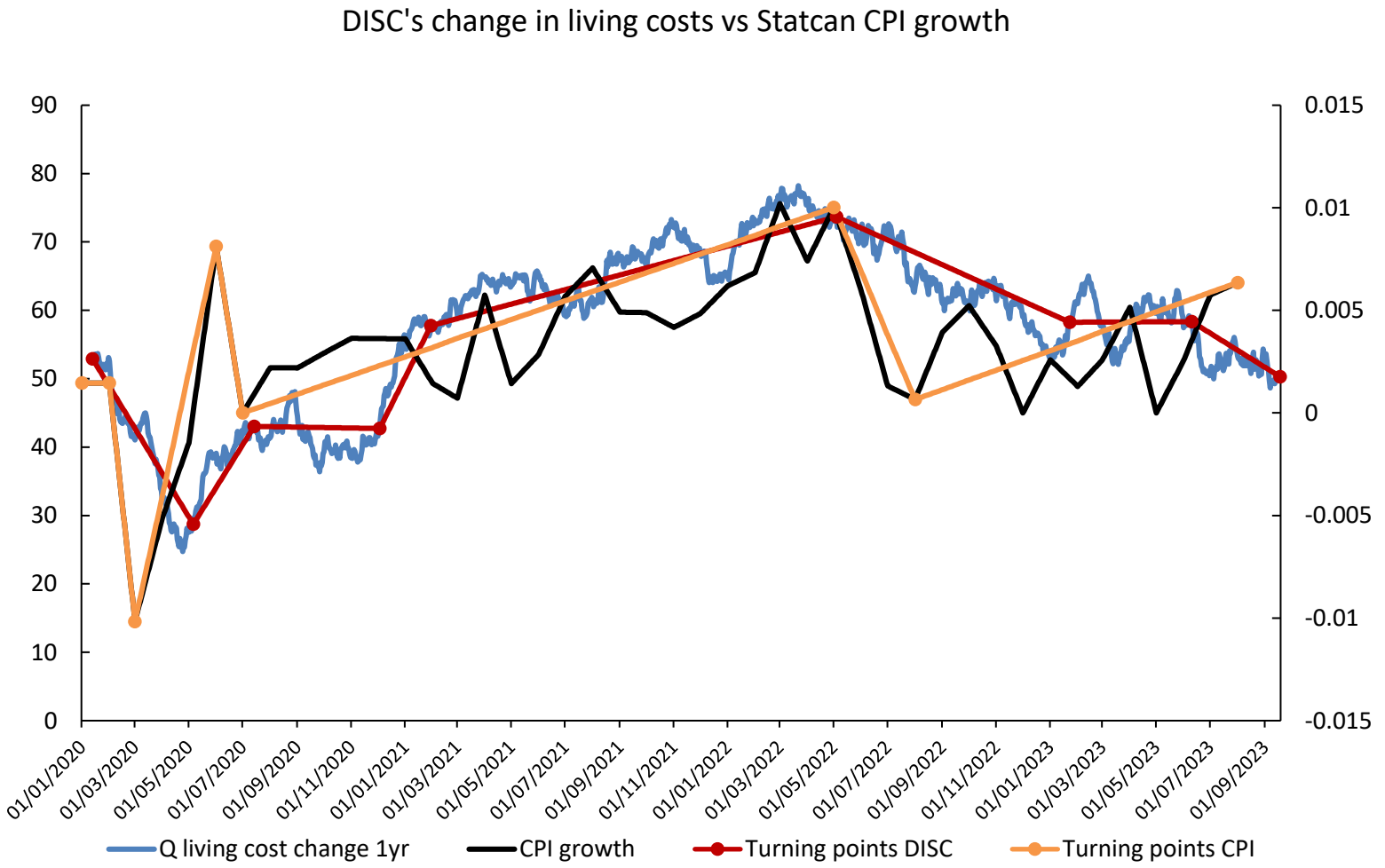
PS Matching: Phrasing and order matter





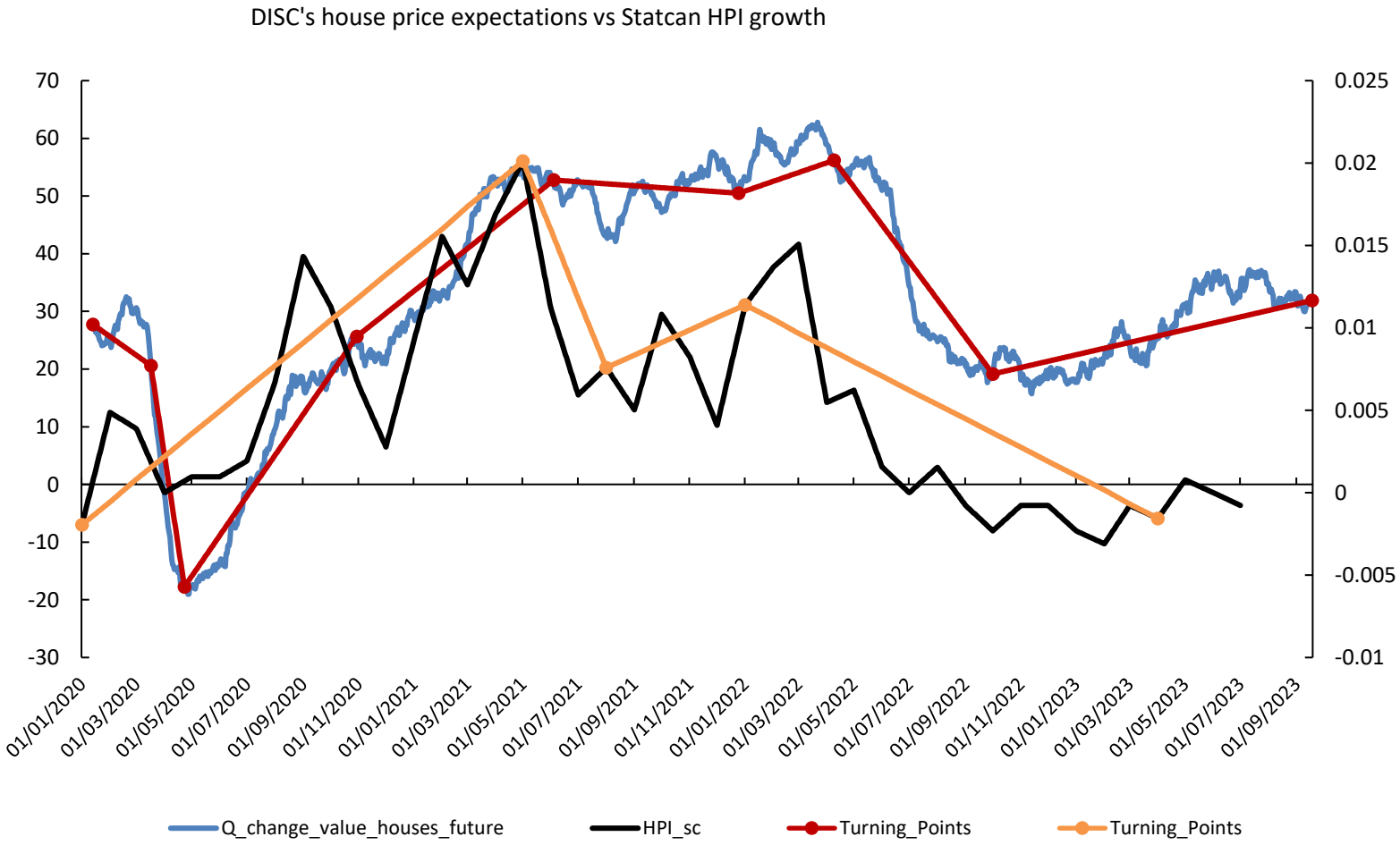
- Point-estimates make it more likely to elicit *higher* inflation expectations
  - Point-estimates are less ‘extreme’ compared to categorical response options
- When presented with different time horizons in random order, 1- and 2-year inflation expectations were similar
  - Survey order is important; best to stick to one time horizon on short surveys

Survey predicted turning points in inflation…….

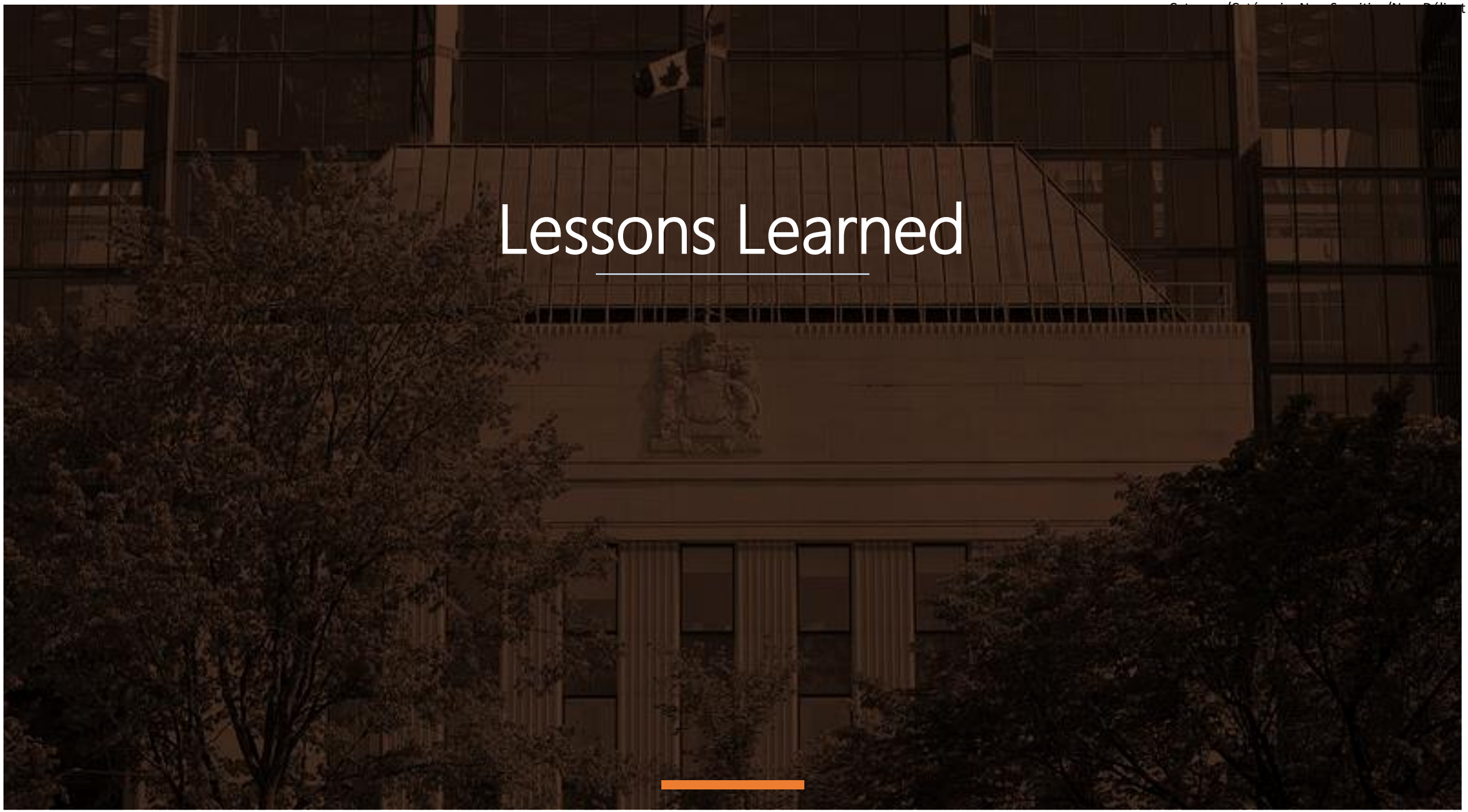


- Consumers update cost of living expectations daily
    - High frequency data captures updated expectations *ahead* of official data releases

.....but not in other indicators



- Consumers probably don't update home price expectations regularly
  - High frequency data reflects updated expectations *after* official data is released


Lessons Learned

Value of high-frequency survey

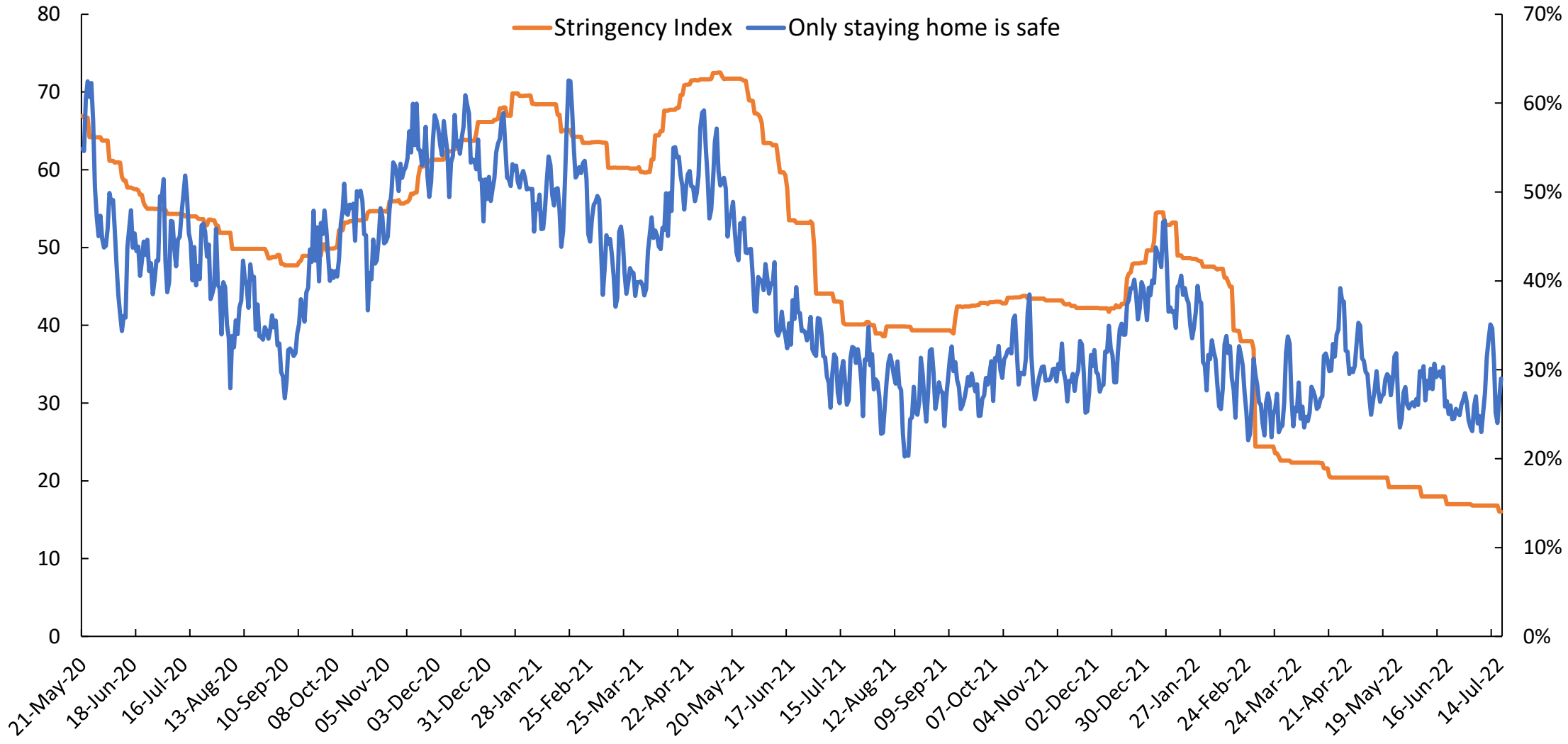
1. Unique survey, with more rich demographic detail than comparable surveys

   Important when considering sub-national dynamic; flexibility in changing demographics when needed

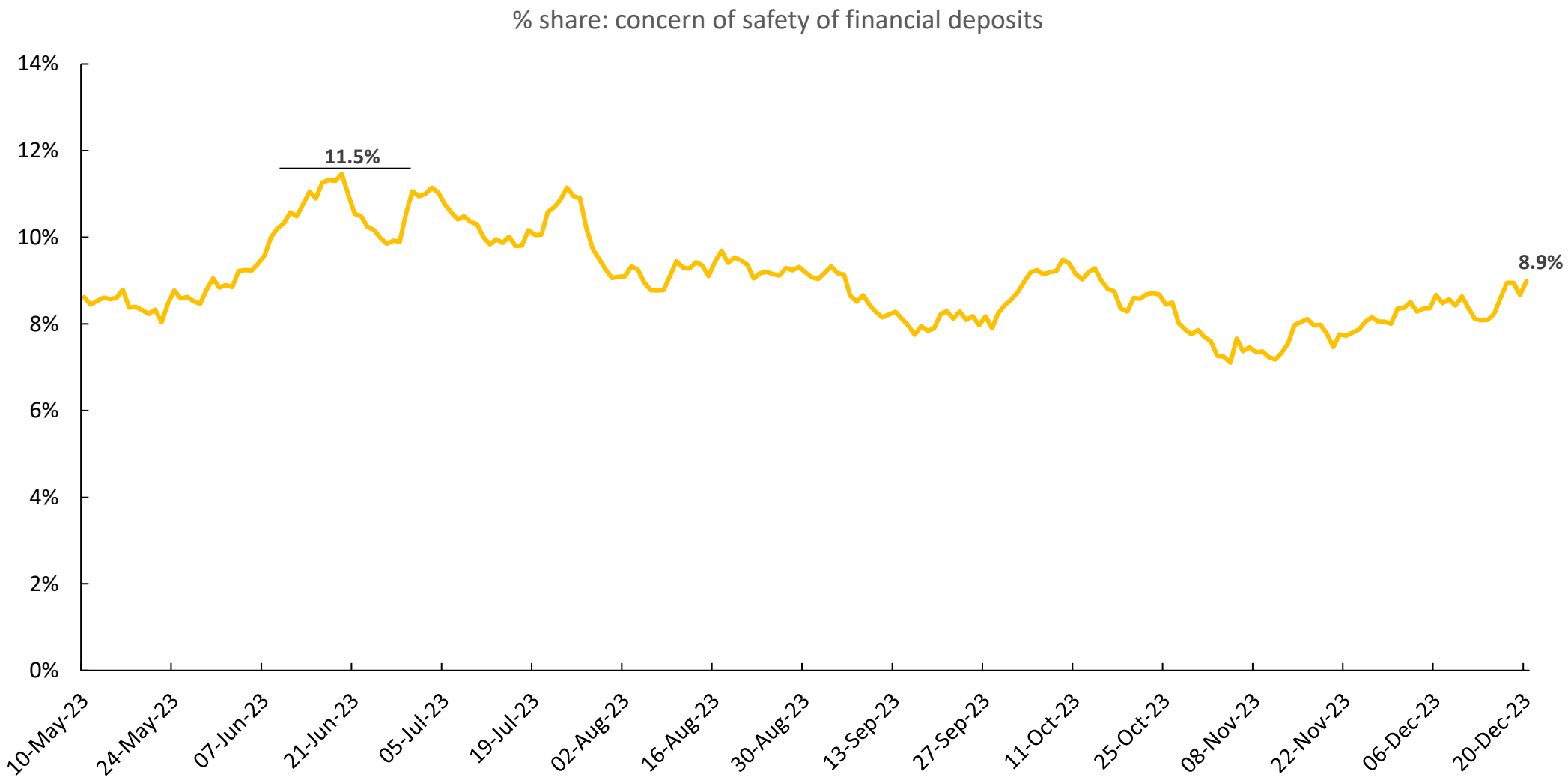
2. Useful to fill information gaps in response to unexpected events

   Introduced new questions following COVID-19 pandemic, supply chain disruptions and SVB collapse

Special topics also tracked similar indicators



Concern over deposits waned months after SVB collapse



Rich demographics reveal diverging trends

Limited predictive power and flexibility in question design

1. Higher frequency not always necessary – useful when consumers *update information frequently*

   For example: cost of living, pressing concerns, daily behaviours

2. Questions should be simple – avoid growth *rates* and different horizons.

   Categorical questions are not well-suited to magnitudes of growth;

   Stick with a single horizon

Untapped potential

- Event studies measuring strength and persistence of policy announcements:
  - How does consumer confidence, expectations respond to monetary/fiscal policy announcements? How persistent are these impacts?
- Digging deeper into household behaviour:
  - Track changes in use of debt/credit cards?
  - Understand how consumers prioritize spending (i.e. which of these items do you intend to purchase in the next month [vehicle, vacation, dining out, new clothes etc.])
- Offloading burden from other surveys:
  - If multiple surveys are being run, consider what's best suited for daily vs. monthly/quarterly surveying.

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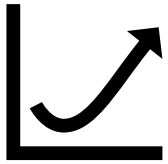
High-frequency data and nowcasting

Jeff Mollins

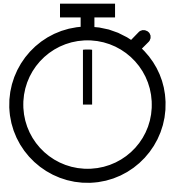
ECONOMIST

Typical benefits of high-frequency data

Additional detail



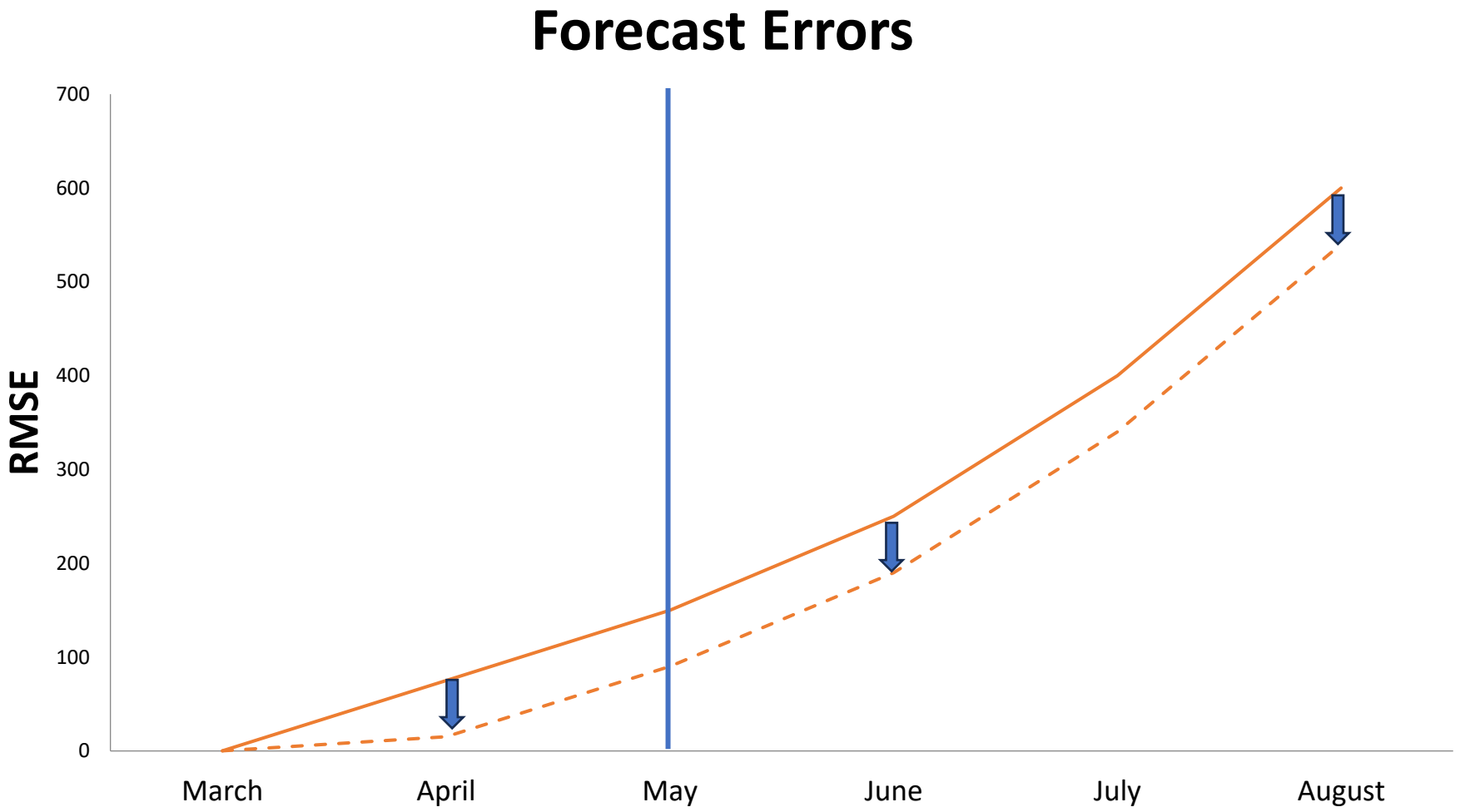
Isolate shocks



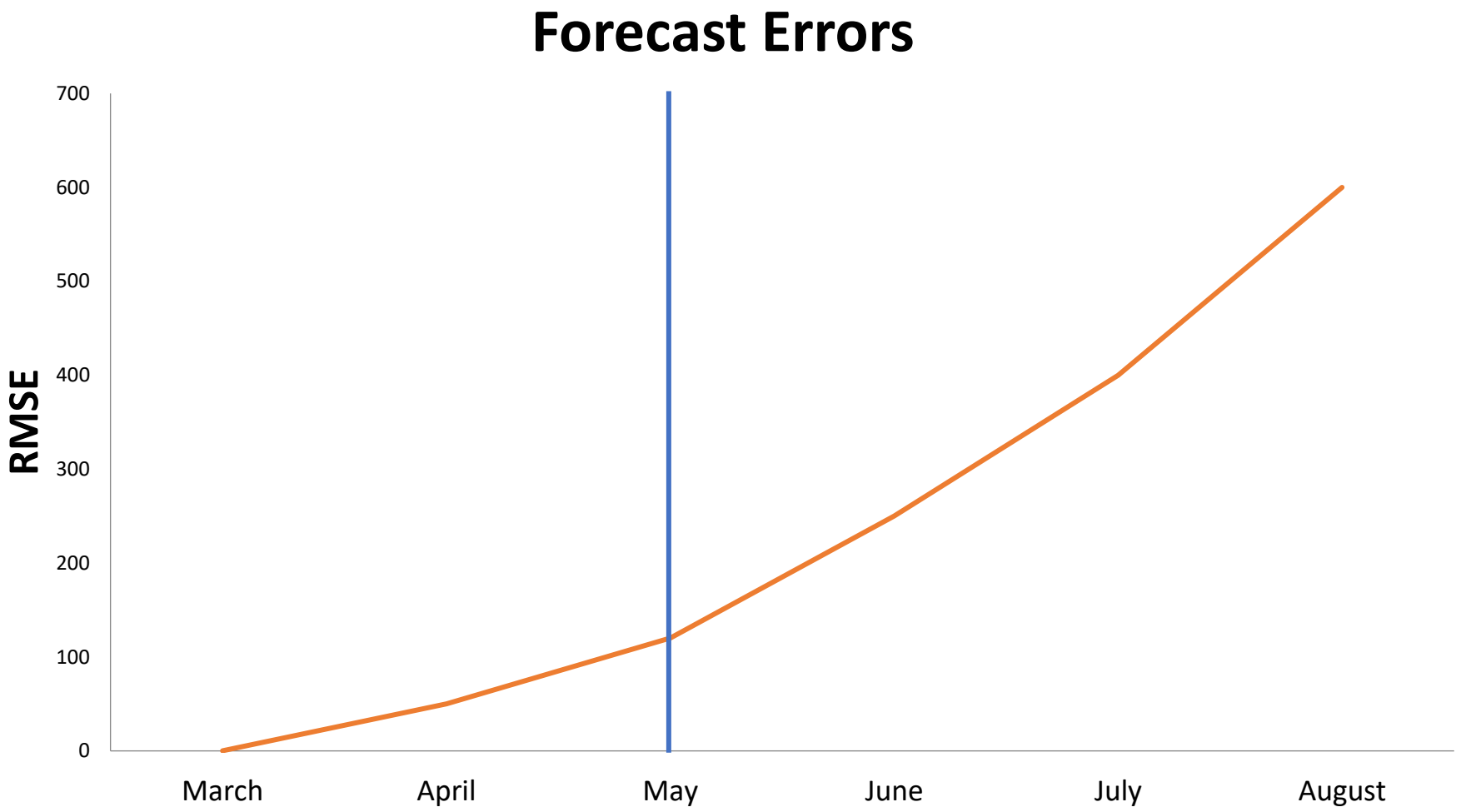
Timeliness

HF data can shift the entire RMSE curve

HF data can shift the entire RMSE curve



HF data can move us forward along RMSE curve



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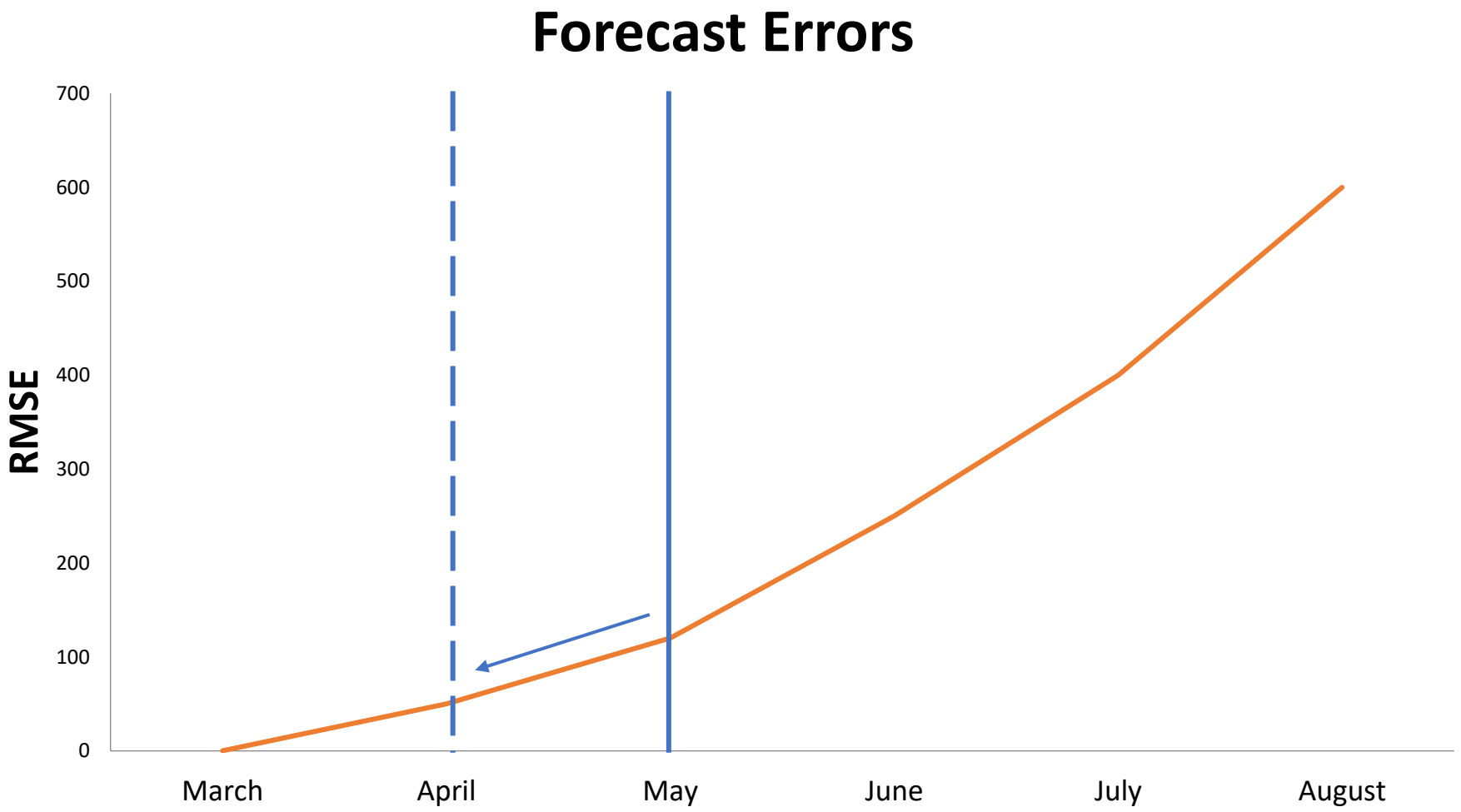


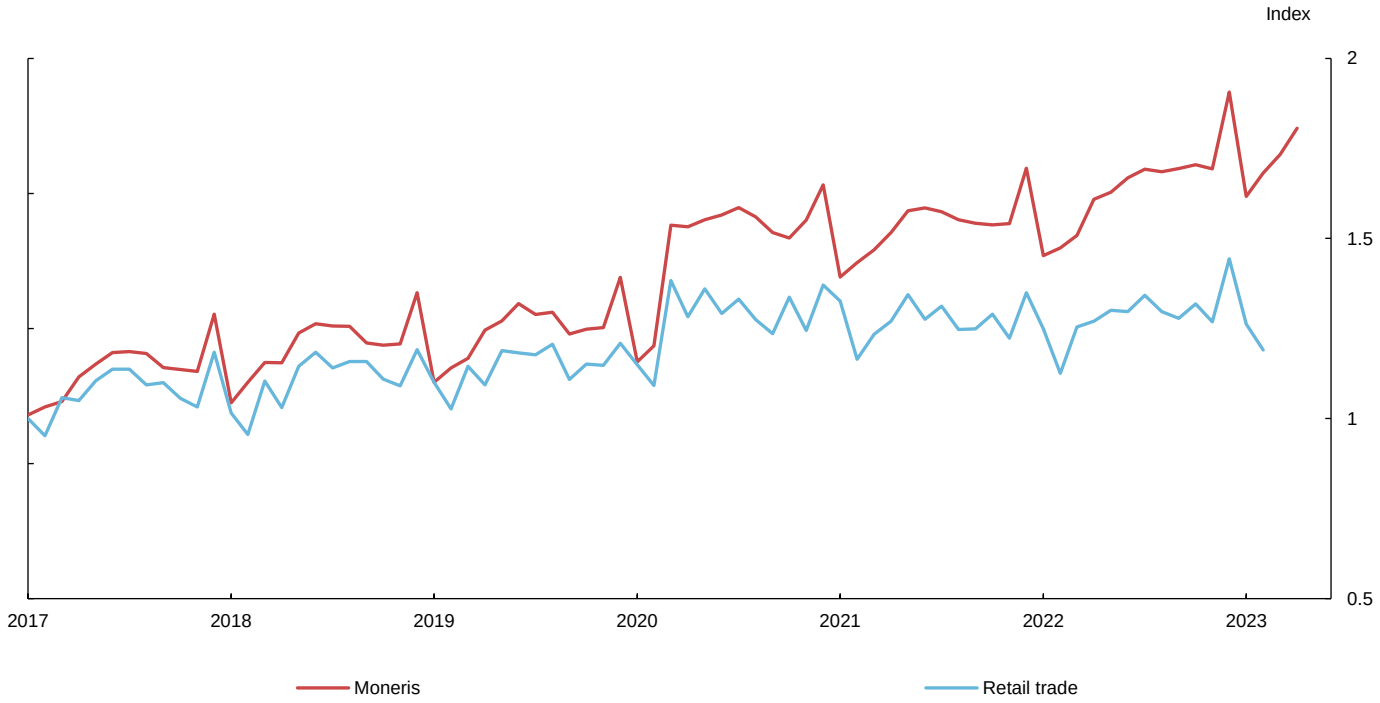
Moneris payment data

- Moneris is a Canadian payment processor that accepts both **credit and debit payment methods**
- **Market share of 30-40 percent** of credit and debit transactions
- Broken down by merchant category
- **History starts in January 2017** and has weekly frequency with a lag of about 2 weeks
- The data is **naturally occurring**, and therefore is not revised

Moneris data and retail trade

Chart 1: **Spending on groceries**

Monthly data, index: 01-2017 = 1



Sources: Moneris and Statistics Canada

Last observations: Moneris, April 2023; Retail trade, February 2023

Seasonal adjustment is difficult for HF data

- Seasonal adjustment is the first problem that one encounters when working with high-frequency data
- When using the native frequency, we use Prophet complimented by hyperparameter tuning
- For monthly comparisons, we use the standard X-13

Method

- We use real-time forecast databases compiled by our monitoring teams
  - Consumption
  - Retail trade
- We calculate correlation and regressions with Moneris
  - At monthly frequency
  - With only partial month data
  - At native frequency
  - Using principal component analysis on Moneris categories

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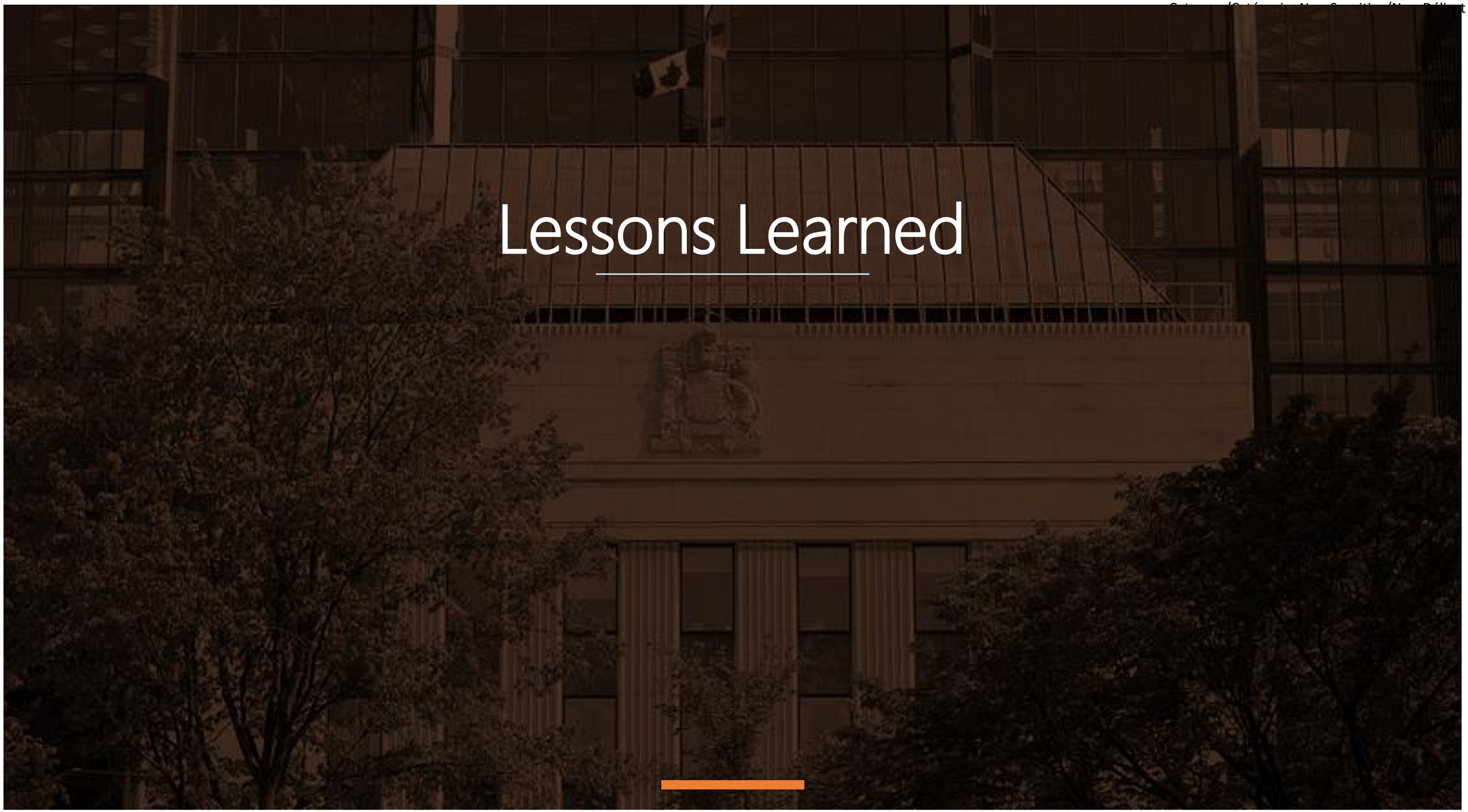
RESULTS

Moneris nowcasts well for Y/Y, but not M/M

	M/M		Y/Y	
	Relative RMSE	R-squared	Relative RMSE	R-squared
AR(1)	1	-0.21	1	0.31
Moneris	0.9	0.02	0.52	0.81
Moneris with AR(1)	0.97	-0.13	0.49	0.84
Principal Component	0.92	-0.02	0.47	0.85

Additional findings

- Moneris can help predict the signal and size of retail trade revisions
- Moneris (seasonally adjusted) weekly data is representative of the full month once at least one third of the month is observed
- Using Moneris' native frequency met with limited success
- Correlations by industry seem to be better for industries with lower cash usage (e.g. gasoline stations)


Lessons Learned

Lessons learned

- Developing data cleaning and processing pipelines should always be the first step
- Understanding the data is crucial
  - Timing effects
  - Category misalignment
- More sophisticated models might be helpful
  - Extracting the extra information

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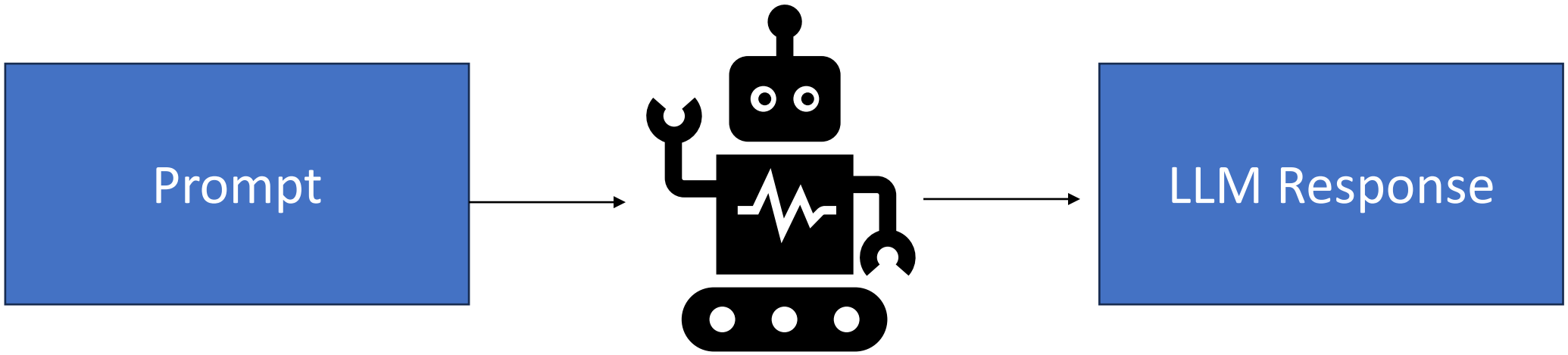
Survey Practitioner's use cases for Large Language Models

Naveen Rai

ECONOMIST

What are LLMs?



CloudResearch®

Hi

Earlier this morning, CloudResearch launched a truly transformative online research tool: Virtual Recruitment of AI participants. Drawing on the power of large language models like Chat GPT 4, CloudResearch has engineered billions of different simulated human personalities that can be used for behavioral research. The benefits of this technology include:

- Perfect data quality
- The ability to reach any sample, any demographic
- Instantaneous data collection
- Studies that can be conducted for pennies

Check out our latest blog for all the details of this newest product!

Happy April Fool's Day!

Sincerely,
The CloudResearch Team
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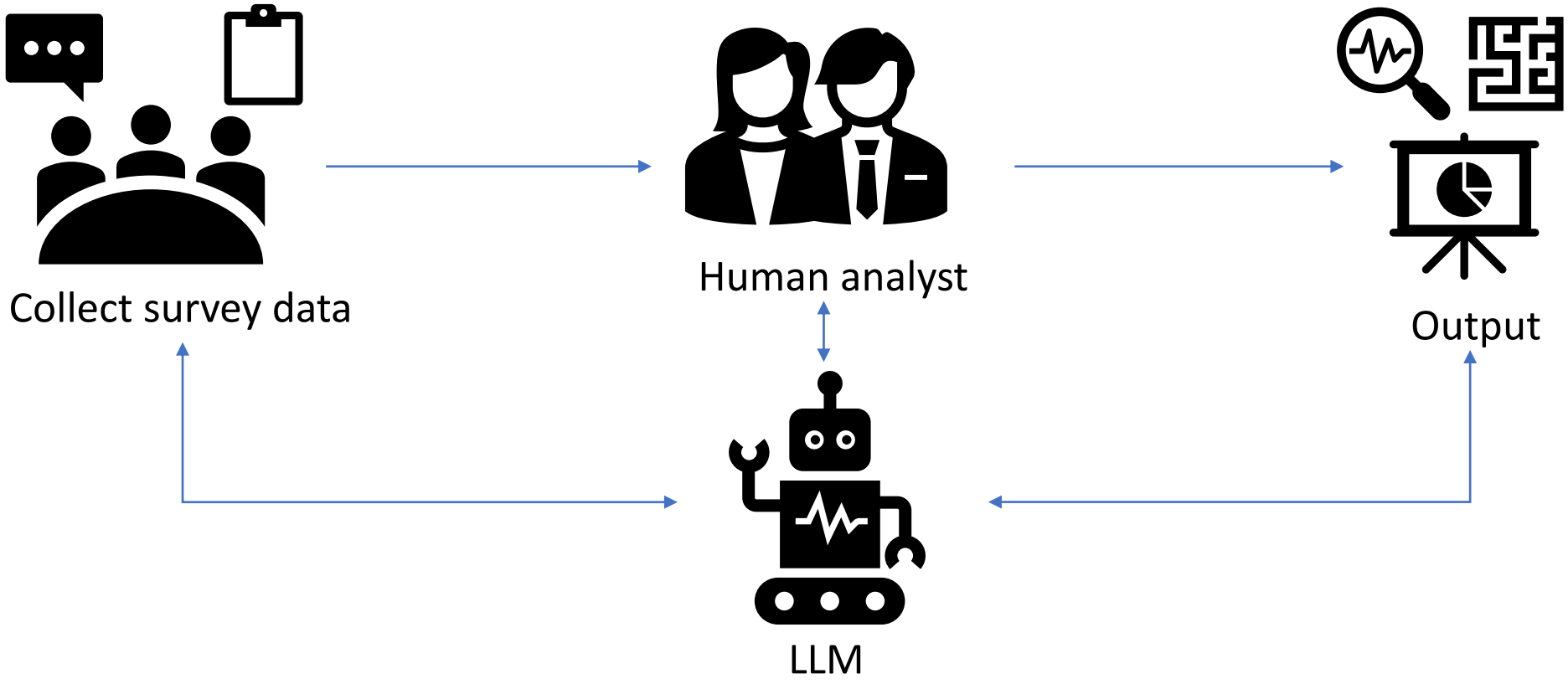
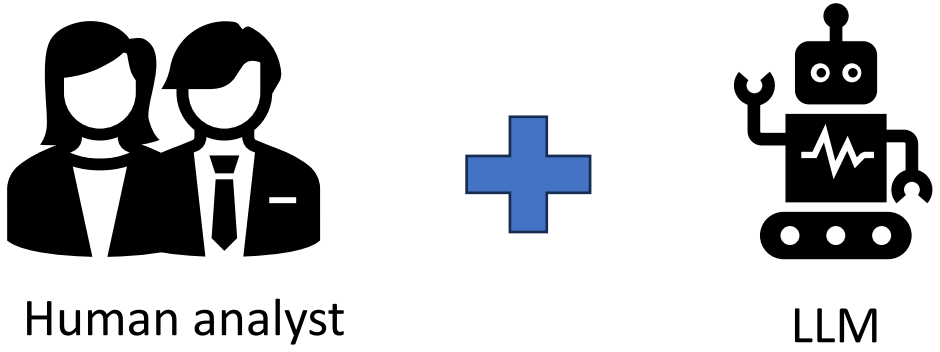
How can we use LLMS in survey work?



Collect survey data

- Data imputation and non-response
- **Survey question design**

LLMs can help with survey question design



Human analyst + LLM

- Some best practices
  - Be precise! (Buskirk et al, 2024 AAPOR presentation)
  - Reference the works of survey methodologists (Kreuter, IASS Webinar)
  - Use the prompt sandwich cookie

Prompting is important

Can you design a question to ask presentation participants how good the presentation was?

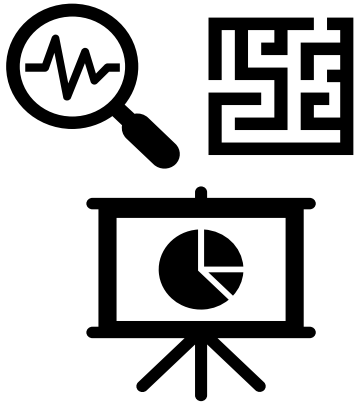
“On a scale from 1 to 5, where 1 is 'Not at all effective' and 5 is 'Extremely effective,' how would you rate the effectiveness of this presentation?”

Prompting is important

I would like to understand what participants thought of a presentation. Can you create a close ended survey question that asks respondents about the quality of the presentation using best practices from Schumar and Presser? Keep the reading level to a grade 7 level. Feel free to add any clarifications to the question as parentheticals.

Thinking about the presentation you just attended, how well do you feel it helped you understand the key concepts discussed?"

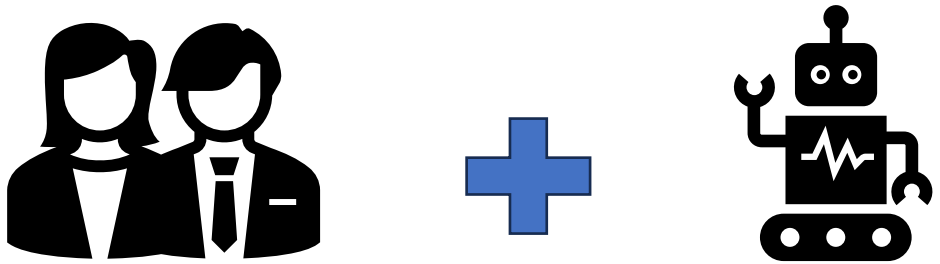
- Extremely well
- Very well
- Moderately well
- Slightly well
- Not well at all



Analysing Survey Output

- Sentiment analysis
- Translation
- Topic extraction
- **Summarization**

LLMs can be efficient in summarization



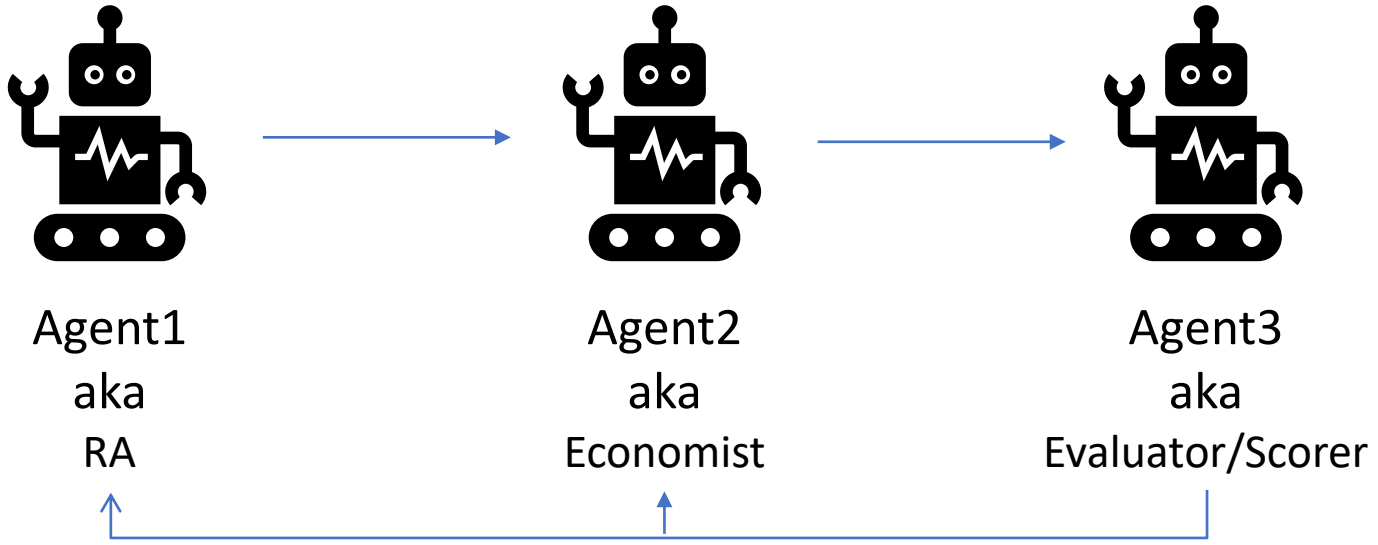
Human analyst

LLM

Some best practices

- Keep the temperature low
- Break the task up!
- Use evaluation metrics to make sure the LLM is on the right track

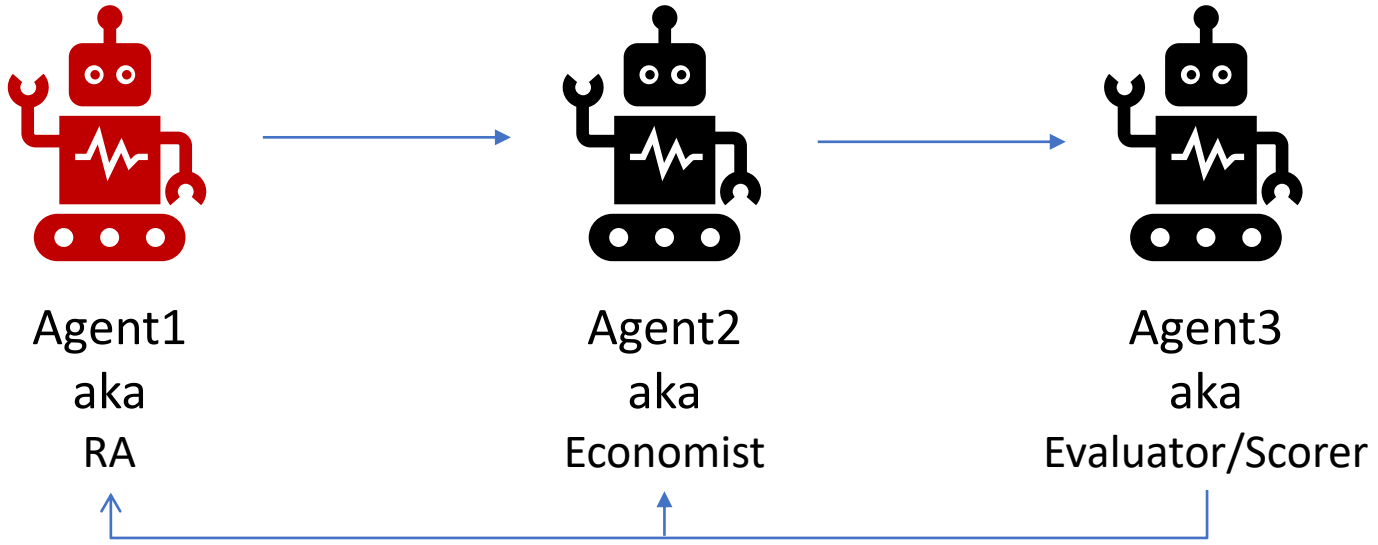
Role or agent-based prompting



Benefits of agent-based prompting

- Improved accuracy
- Helpful output structure
- Computational benefits

Role or agent-based prompting



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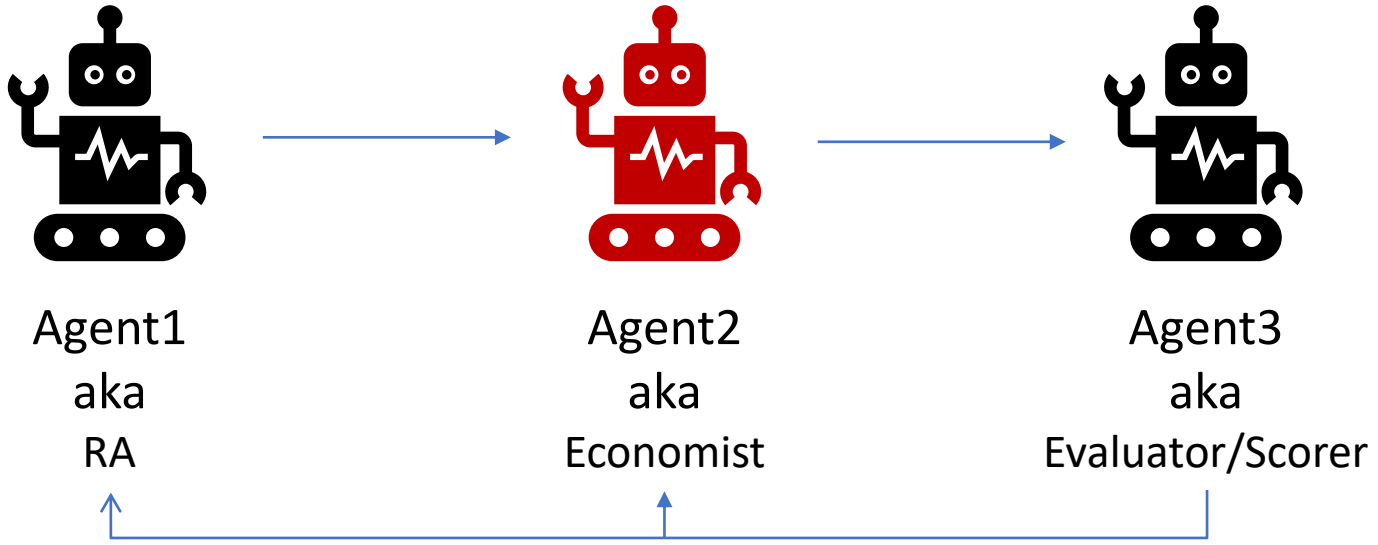

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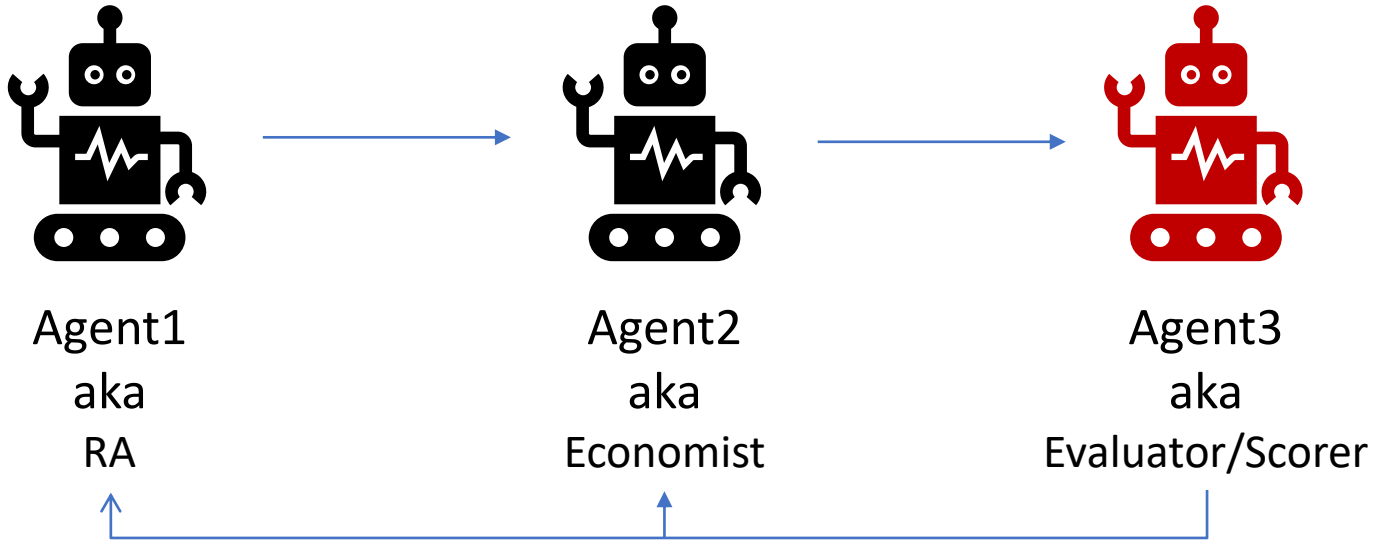

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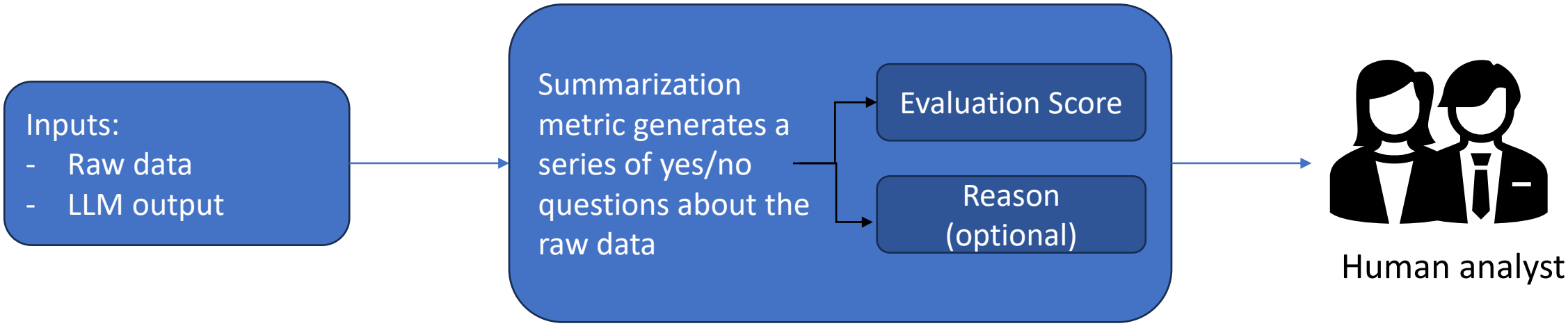
Output evaluation metrics



Agents can evaluate LLM output

- Can test the prior agent's output against the input, generating scores for hallucination, accuracy, and other metrics
- LLMs produce similar scores to other evaluation metrics (Liu et al, 2023)
- Can be used to evaluate hyperparameters

Summary

- LLMs have many uses for survey practitioners
  - These include questionnaire design and summarizing results
- Prompting is important
- Agent-based design can improve results
- Humans are still needed
- Evaluation metrics help us trust the output

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