Enhancing Efficiency and Flexibility in Audits through Bayesian Optional Stopping

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Audits verify the accuracy of financial statements

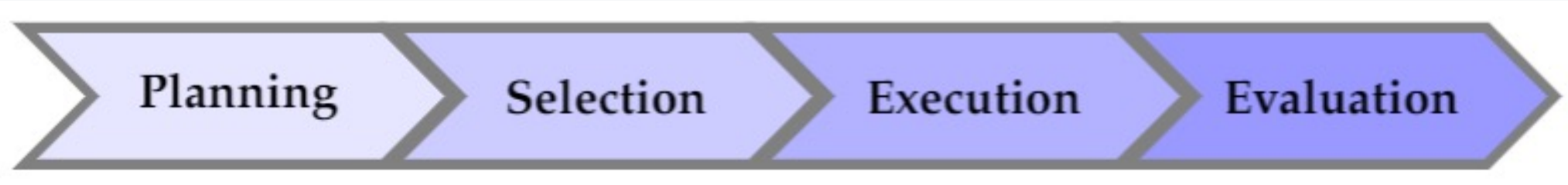
- Financial statements should provide a fair and true overview of the companies' financial state
- Obtain reasonable assurance that the financial statements are free of material misstatement
- Gather audit evidence for assurance

Sampling can be used to gather audit evidence

- However, conclusions contain uncertainty

		True state of the population	
		Population is materially misstated	Population is free of material misstatement
Auditors' conclusion from the sample	Population is materially misstated	Correct decision	Incorrect decision: Risk of incorrect rejection
	Population is free of material misstatement	Incorrect decision: Risk of incorrect acceptance	Correct decision

A typical audit sample follows the sampling workflow



Audit sample size is planned based on three considerations *(PCAOB, 2020)*:

- Tolerable deviation rate (e.g., 3%)
- Allowable risk of incorrect acceptance (e.g., 5%)
- Expected number of deviations in the sample (e.g., 1 deviation)

Auditor calculates minimum required sample size to accept the population

Planning the audit sample can be a challenge

On one hand:

- Existing material misstatement should be detected
- Larger sample size → lower risk of incorrect acceptance

On the other hand:

- Audit should be efficient
- Smaller sample size → higher efficiency

Difficult balancing act!

Wouldn’t it be easier to just monitor the evidence as we go?

Possible solution: **Optional stopping**

Here, we need to take into account:

- Frequentist vs. Bayesian statistical framework
- Frequentist dominant in practice
- Bayesian allows for incorporation of prior knowledge
- Crucially, frameworks differ in their ability to ‘handle’ optional stopping *(Rouder, 2014)*

Frequentist methods obstruct optional stopping

The frequentist framework requires the auditor to plan the sample in advance:

- The number of stages in which the audit evidence is collected affects the outcome of the evaluation of the audit evidence *(Gillett & Peytcheva, 2007)*

If the auditor does want to incorporate interim analyses:

- Still needs to be planned in advance
- Total sample size is higher

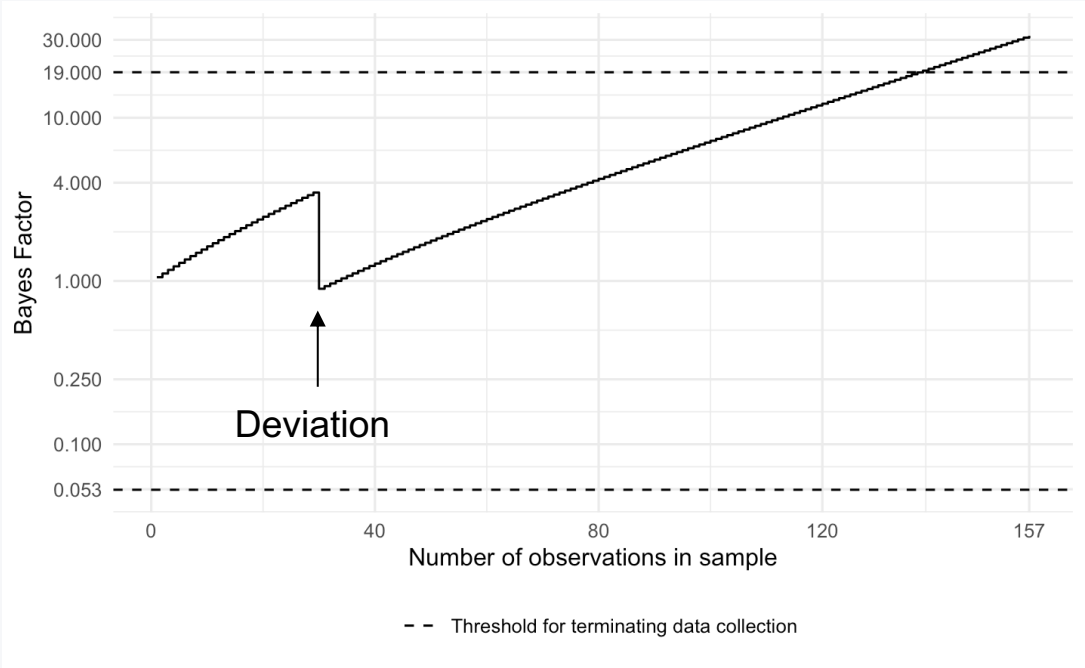
Bayesian methods do allow for optional stopping

No planning necessary

- The number of stages in which the audit evidence is collected does not affect the outcome of the evaluation of the audit evidence *(Berger & Wolpert, 1988)*:
- Monitor the Bayes factor (BF)
- Terminate evidence collection whenever the Bayes factor is high enough

Bayes factor can be monitored during data collection

BF = 10:
The data are 10 times more likely under the hypothesis that there is no material misstatement than under the hypothesis that there is material misstatement



Example: Compliance audit

Suppose an auditor is charged to do an audit to ensure that a population of invoices is compliant with the regulations:

- Tolerable deviation rate: 3%
- Allowable risk of incorrect acceptance: 5%
- Expected number of deviations in the sample: 1

But what happens after the data has been collected? Three scenarios:

- 1 deviation found
- 0 deviations found
- 2 deviations found

Example: 1 deviation found

Frequentist sampling workflow:

- Plan sample size based on considerations: 157 invoices
- Collect sample

Bayesian optional stopping

- Formulate prior
- Just start sampling
- Monitor the Bayes factor
- Stop data collection when reaching threshold, after 134 invoices

More efficient!

Example: 0 deviations found

Frequentist sampling workflow:

- Plan sample size based on considerations: 157 invoices
- Collect sample
- Although evidence shows no deviations, don’t stop before 157 is reached

Bayesian optional stopping

- Formulate prior
- Just start sampling
- Monitor the Bayes factor
- Stop data collection when reaching threshold, after 81 invoices

Almost twice as efficient!

Example: 2 deviations found

Frequentist sampling workflow:

- Two-stage test required *(Akresh & Finley, 1979)*
- Expand planned sample size upon observing 1 error in interim analysis
- Various combinations possible: 209 - 310 invoices

Bayesian optional stopping

- Formulate prior
- Just start sampling
- Monitor the Bayes factor
- Stop data collection when reaching threshold, after 185 invoices

Again, more efficient!

Summary of the relative efficiency gains

Relative efficiency gain that results from collecting audit samples with Bayesian optional stopping when compared to frequentist audit samples

		Expected number of errors		
		0	1	2
Observed	0	-23.2%	-48.4%	-59.1%
number	1	[-49.4, -14.6]%	-12.1%	-32.7%
of errors	2	[-59.3, -11.1]%	[-39.4, -9.6]%	-8.2%

Bayesian optional stopping enhances efficiency in audits

- Also provides practical benefits
- More flexibility
- To be implemented in the user-friendly open-source software program JASP
- More details, see paper

References

Akresh, A., & Finley, D. R. (1979). Two-step attributes sampling in auditing. *The CPA Journal*, *49*(000012), 19.

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Rouder, J. N. (2014). Optional stopping: No problem for Bayesians. *Psychonomic Bulletin & Review*, *21*(2), 301–308. https://doi.org/10.3758/s13423-014-0595-4

Thank you for your attention

Are there any questions?