# HMTS: A hedonic multilateral approach for dynamic, low-volume price indices

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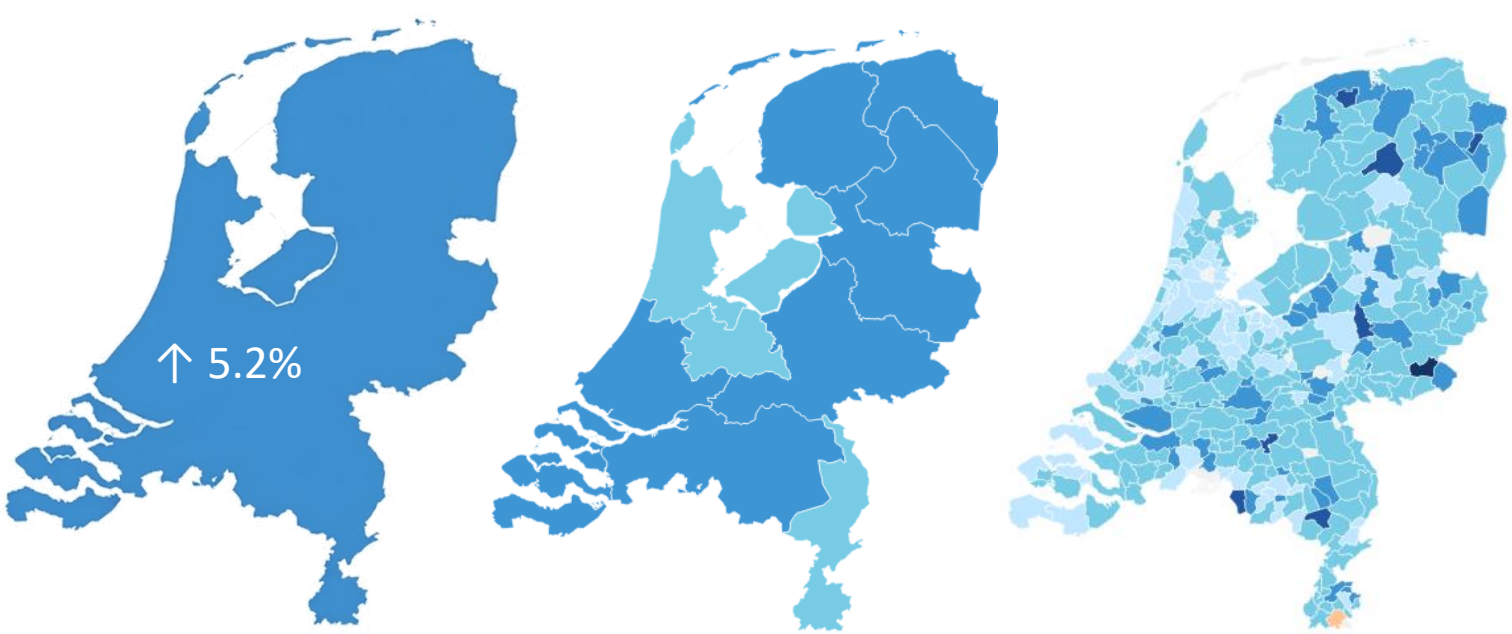
# Today’s content

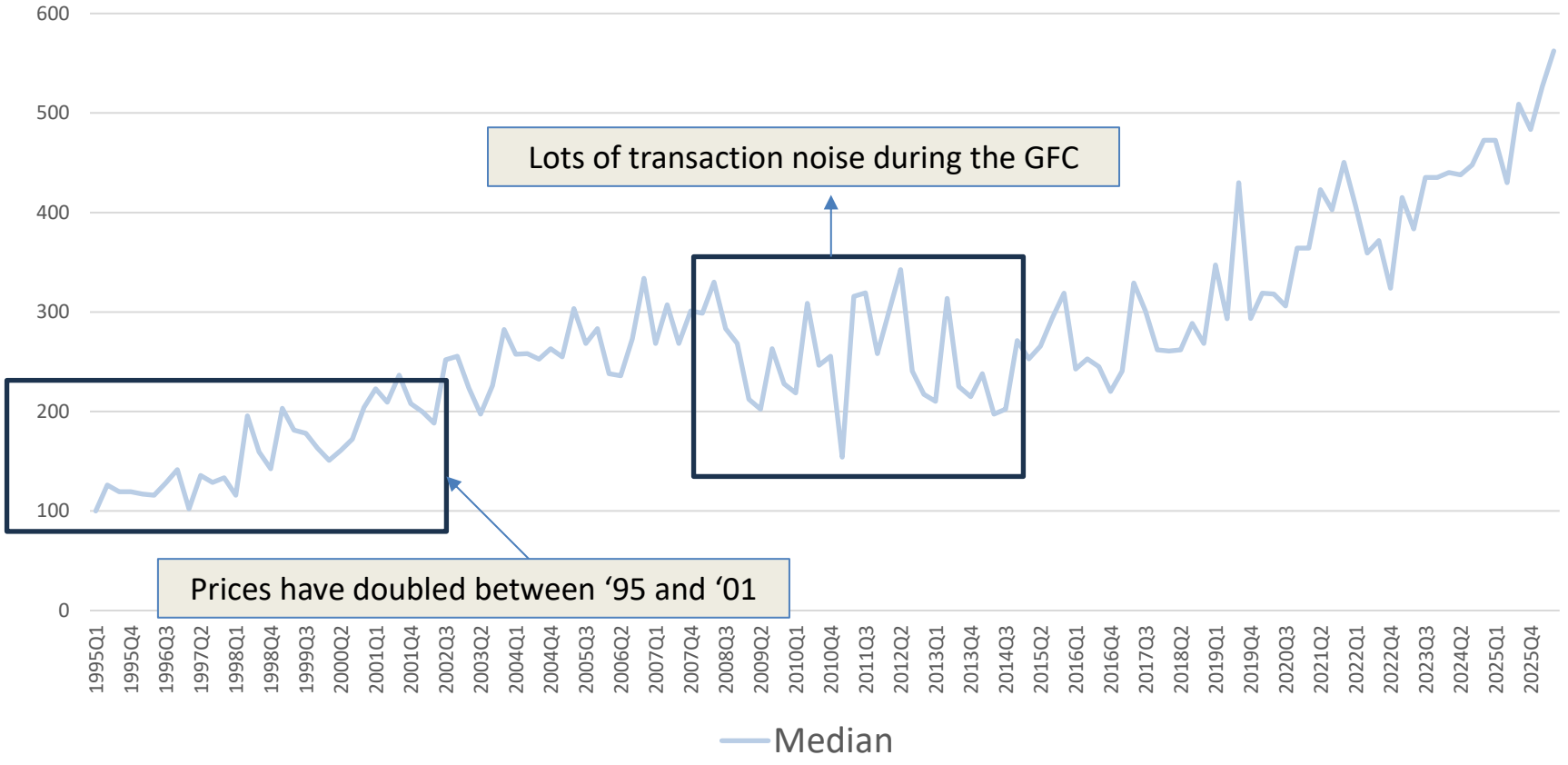
- Growing deed for indicators in small domains
- Accurate estimations are challenging
- Approach that utilizes information in multiple ways: HMTS
- R-package: REPS
- Applied in below statistics:
  - House prices, municipalities
  - Land prices
  - Argiculture prices

# Need for regional statistics

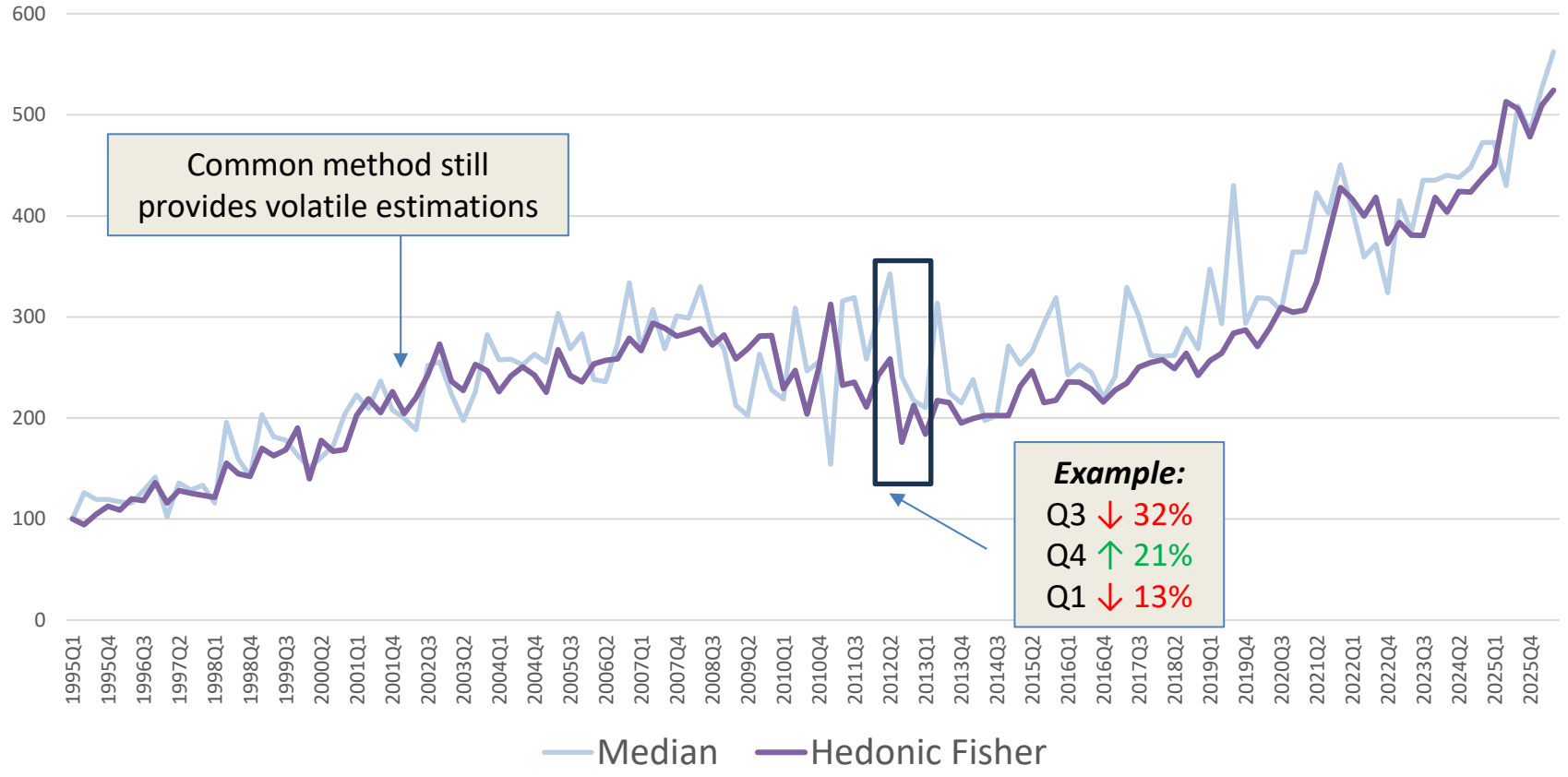
- Markets often show **regional dynamics**
- Users demand figures that **represents** their case
- **Eurostat requests** for more statistics at regional level



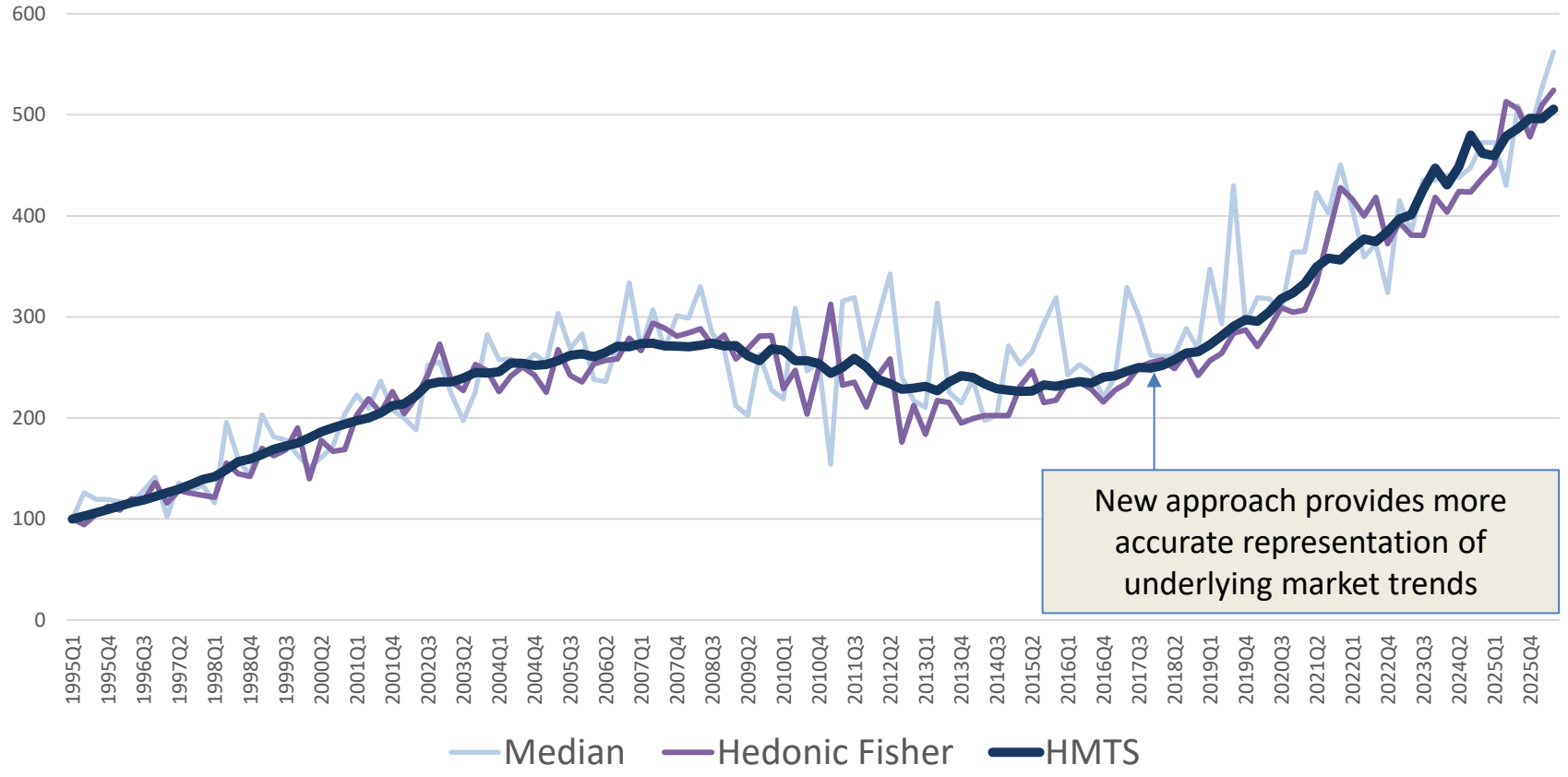
# Adjusting for quality in the mix of sold property is a must



# Common methods don’t deliver accurate estimations



# New approach is more effective in identifying trends



# What makes indices for small domains publishable?

**Practical**

- Stable index
- No continuous revisions
- Early detection of turning points

**Methodological**

- Identity
- Time reversal
- Circularity

# New approach: HMTS

- **H**edonic imputation
- **M**ultilateral calculation
- **T**ime series re-estimation
- **S**plicing
- PRICE INDEX

Article in the Journal of Official Statistics

# Step 1: Hedonic imputation

**What?**

Estimate prices with
one base period

**Why?**

Correct for quality
of sold real estate

| | | Reporting period | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Base period | 0 | $\overline{\hat{p}_{0(0)}}$ | $\overline{\hat{p}_{1(0)}}$ | $\overline{\hat{p}_{2(0)}}$ | $\overline{\hat{p}_{3(0)}}$ |

$$\hat{p}_{1(0)} = \alpha + \beta_a^1 x_a^0 + \beta_a^1 x_a^0 + \beta_n^1 x_n^0$$

Model estimations of **reporting period**

Characteristics of **base period**

**Side effect:**

If observations are few and heterogeneous:
inaccurate estimations

# Step 2: Multilateral calculations

**What?**

Estimate prices with
all possible base periods

**Why?**

Limit the importance
of the first period

**Side effect:**

Revision after adding one period

| | | Reporting period | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Base period | 0 | $\overline{\hat{p}_{0(0)}}$ | $\overline{\hat{p}_{1(0)}}$ | $\overline{\hat{p}_{2(0)}}$ | $\overline{\hat{p}_{3(0)}}$ |
| | 1 | $\overline{\hat{p}_{0(1)}}$ | $\overline{\hat{p}_{1(1)}}$ | $\overline{\hat{p}_{2(1)}}$ | $\overline{\hat{p}_{3(1)}}$ |
| | 2 | $\overline{\hat{p}_{0(2)}}$ | $\overline{\hat{p}_{1(2)}}$ | $\overline{\hat{p}_{2(2)}}$ | $\overline{\hat{p}_{3(2)}}$ |
| | 3 | $\overline{\hat{p}_{0(3)}}$ | $\overline{\hat{p}_{1(3)}}$ | $\overline{\hat{p}_{2(3)}}$ | $\overline{\hat{p}_{3(3)}}$ |

# Step 3: Time series re-estimation

## What?

Improve estimations
with Kalman filter (smoothen)

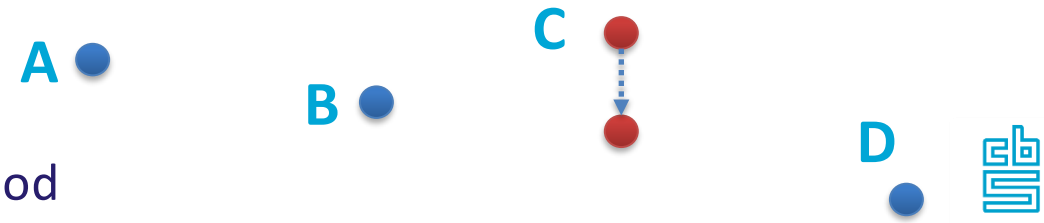
| | | Reporting period | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Base period | 0 | $\widetilde{\hat{p}_{0(0)}}$ | $\widetilde{\hat{p}_{1(0)}}$ | $\widetilde{\hat{p}_{2(0)}}$ | $\widetilde{\hat{p}_{3(0)}}$ |
| | 1 | $\widetilde{\hat{p}_{0(1)}}$ | $\widetilde{\hat{p}_{1(1)}}$ | $\widetilde{\hat{p}_{2(1)}}$ | $\widetilde{\hat{p}_{3(1)}}$ |
| | 2 | $\widetilde{\hat{p}_{0(2)}}$ | $\widetilde{\hat{p}_{1(2)}}$ | $\widetilde{\hat{p}_{2(2)}}$ | $\widetilde{\hat{p}_{3(2)}}$ |
| | 3 | $\widetilde{\hat{p}_{0(3)}}$ | $\widetilde{\hat{p}_{1(3)}}$ | $\widetilde{\hat{p}_{2(3)}}$ | $\widetilde{\hat{p}_{3(3)}}$ |

## Why?

Previous estimations contain
transaction noise

## Side effect:

Revision after adding one period



# Stap 4: Splice

## What?

Use estimations within a window

## Why?

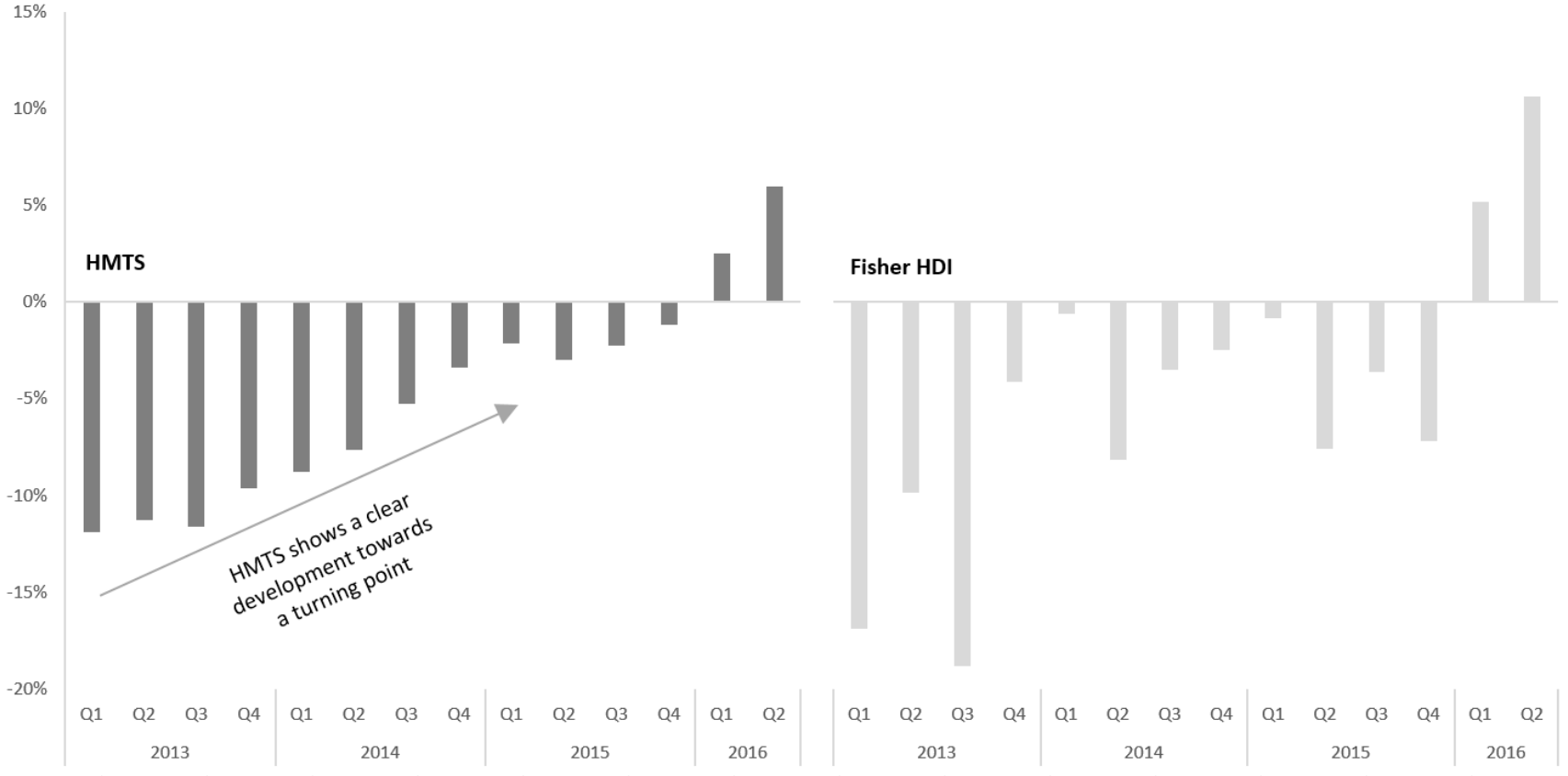
Limit revisions of all periods to just a few periods

| | | Reporting period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| Base period | 0 | $I_{0,0(0)}$ | $I_{0,1(0)}$ | $I_{0,2(0)}$ | | | |
| | 1 | $I_{0,0(1)}$ | $I_{0,1(1)}$ | $I_{0,2(1)}$ | $I_{0,3(1)}$ | | |
| | 2 | $I_{0,0(2)}$ | $I_{0,1(2)}$ | $I_{0,2(2)}$ | $I_{0,3(2)}$ | $I_{0,4(2)}$ | |
| | 3 | | | | $I_{0,3(3)}$ | $I_{0,4(3)}$ | $I_{0,5(3)}$ |
| | 4 | | | | | $I_{0,4(4)}$ | $I_{0,5(4)}$ |
| | 5 | | | | | | $I_{0,5(5)}$ |
| Final index | | $I_{0,0}^{MHIT-3}$ | $I_{0,1}^{MHIT-3}$ | $I_{0,2}^{MHIT-3}$ | $I_{0,3}^{MHIT-3}$ | $I_{0,4}^{MHIT-3}$ | $I_{0,5}^{MHIT-3}$ |

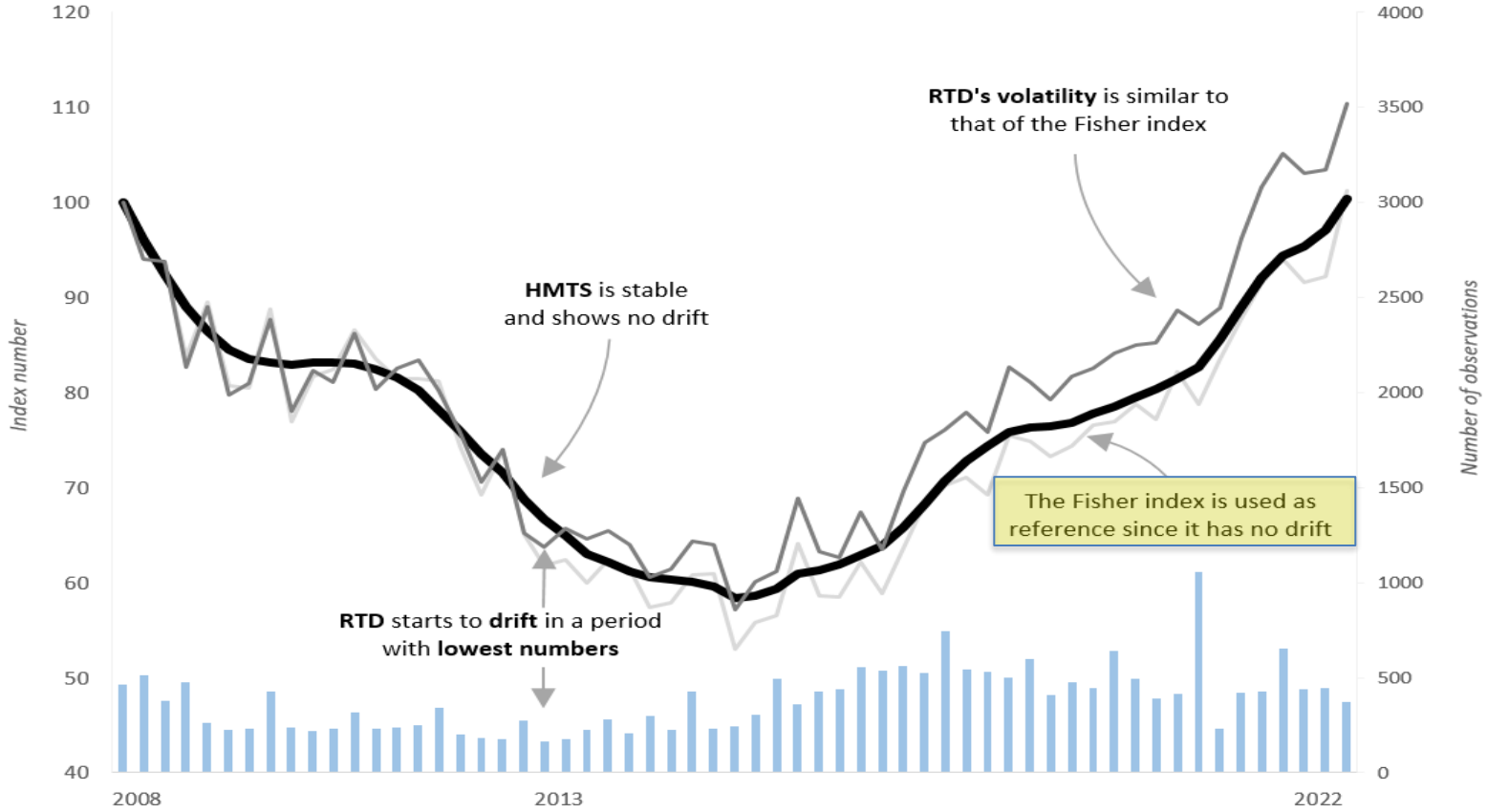
## Side effect:

Index does not formally pass all methodological tests

# Earlier detection of turning points



# HMTS not subject to drift



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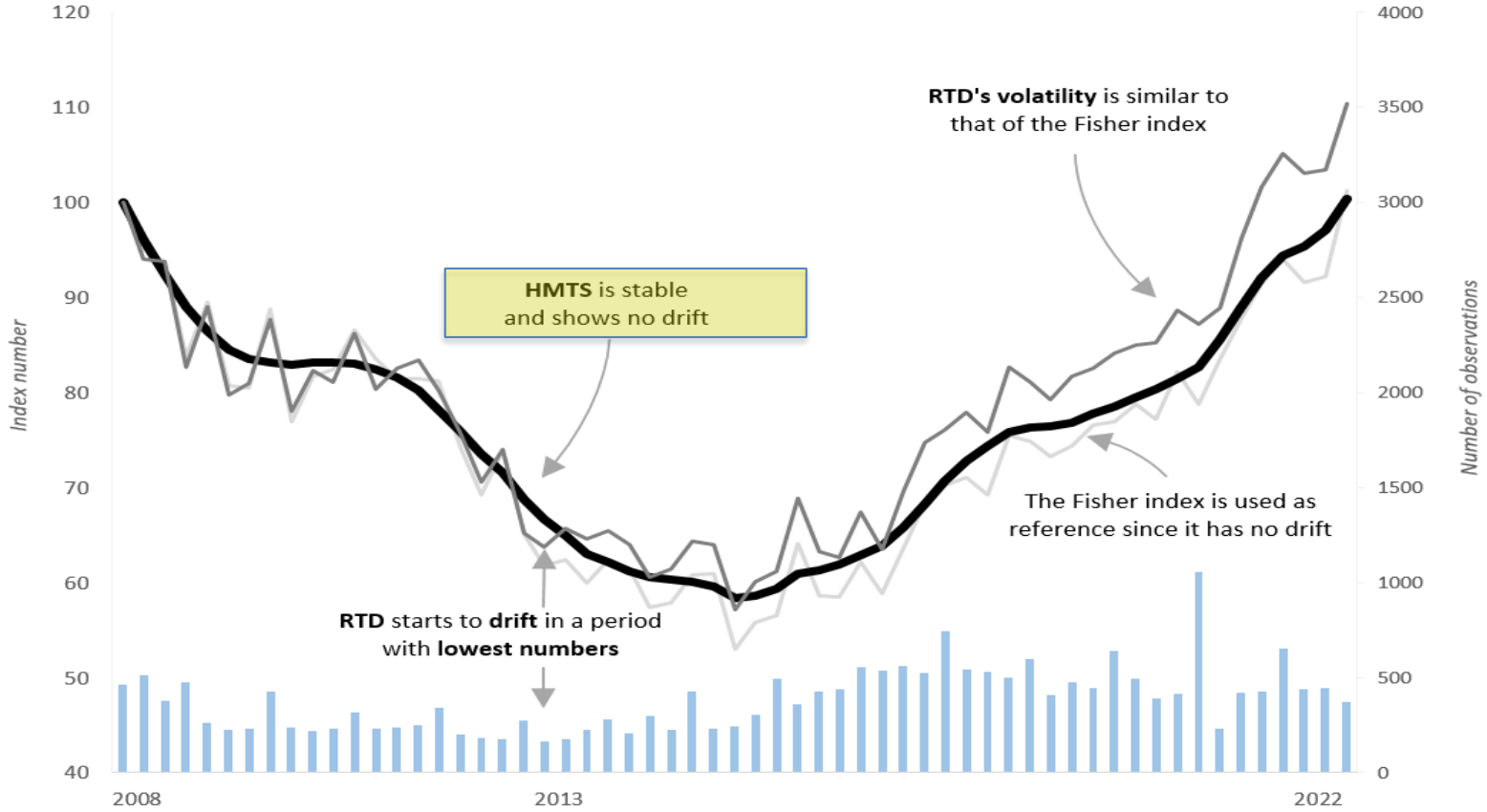

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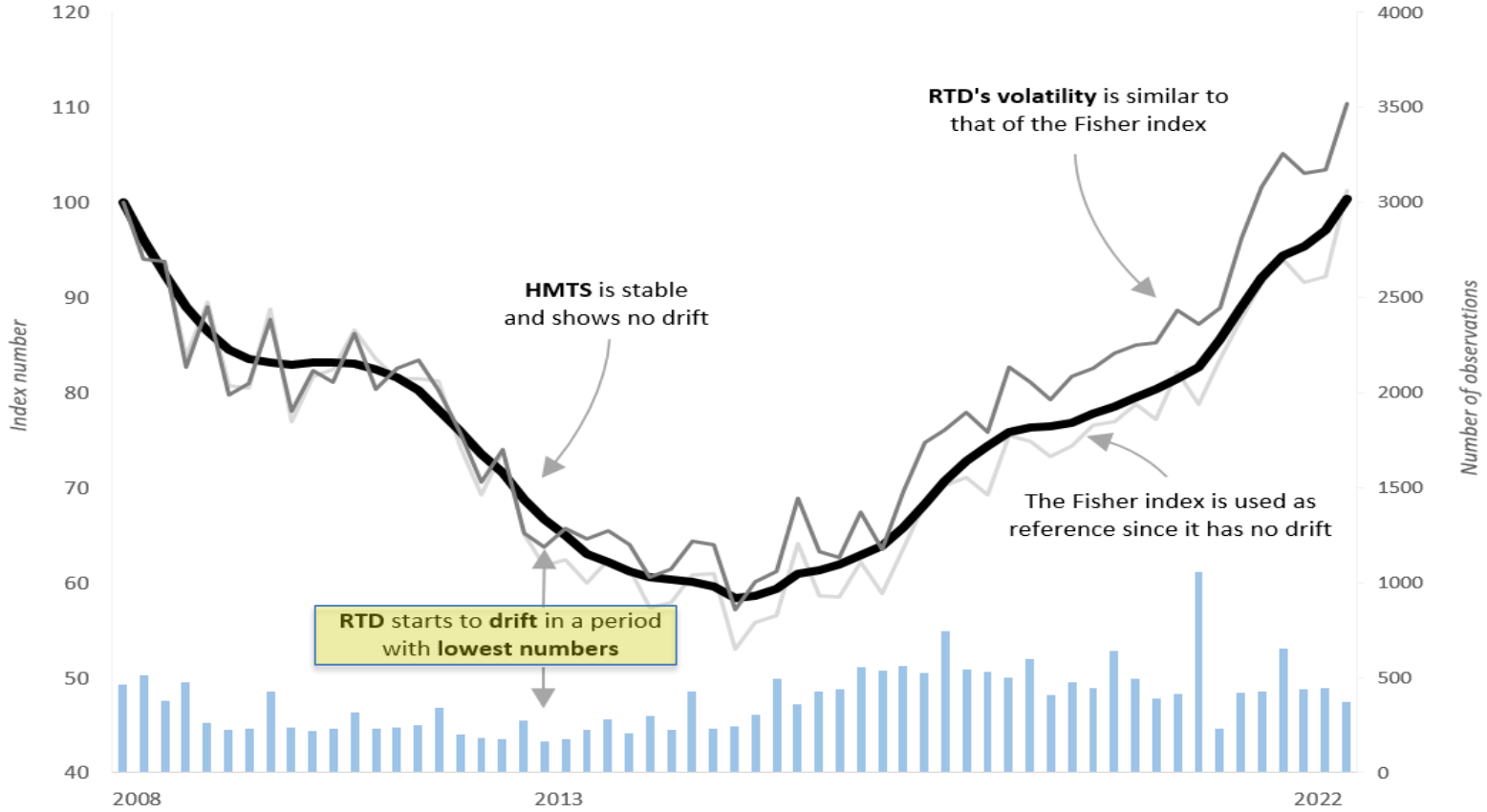

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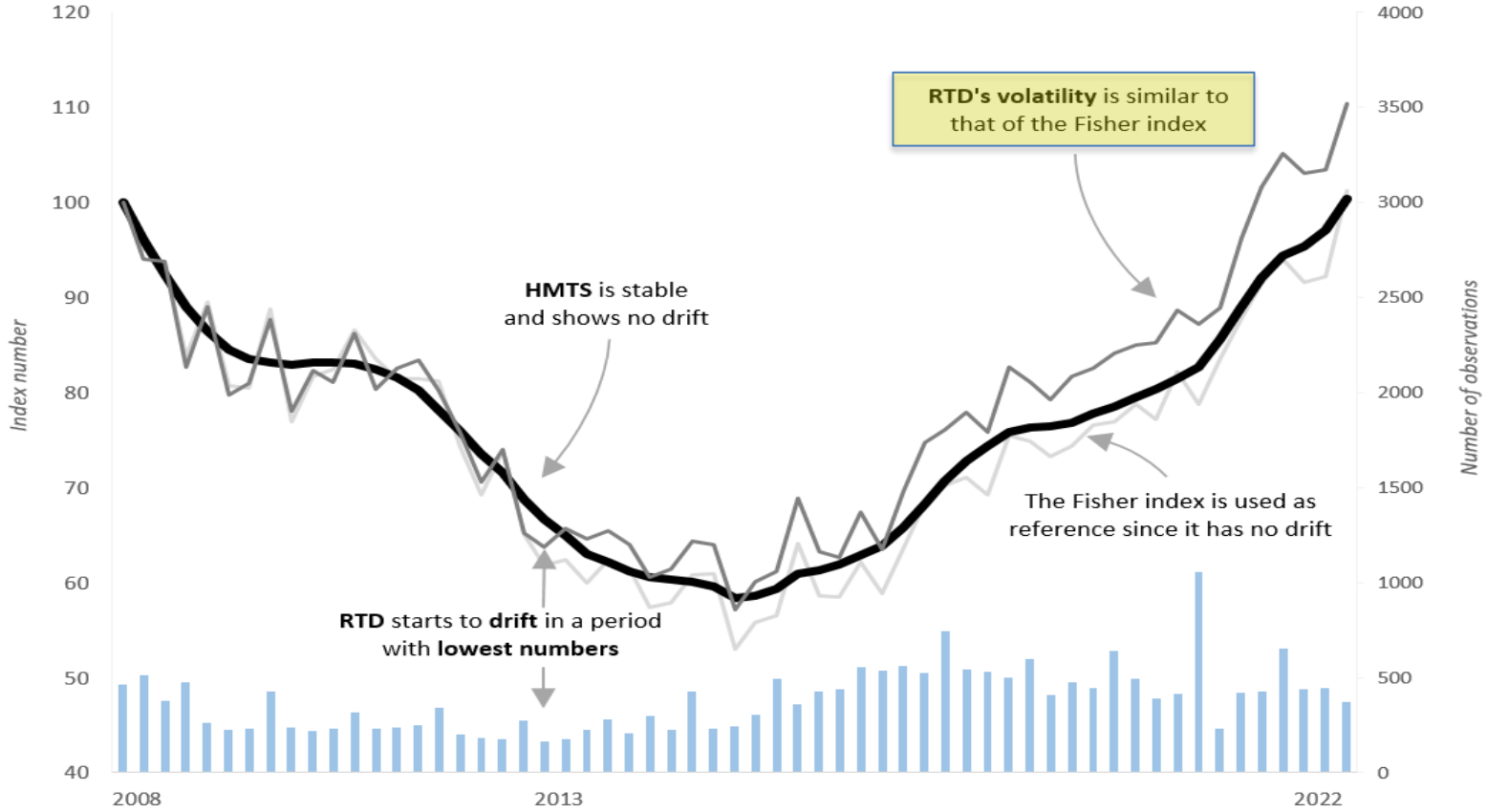
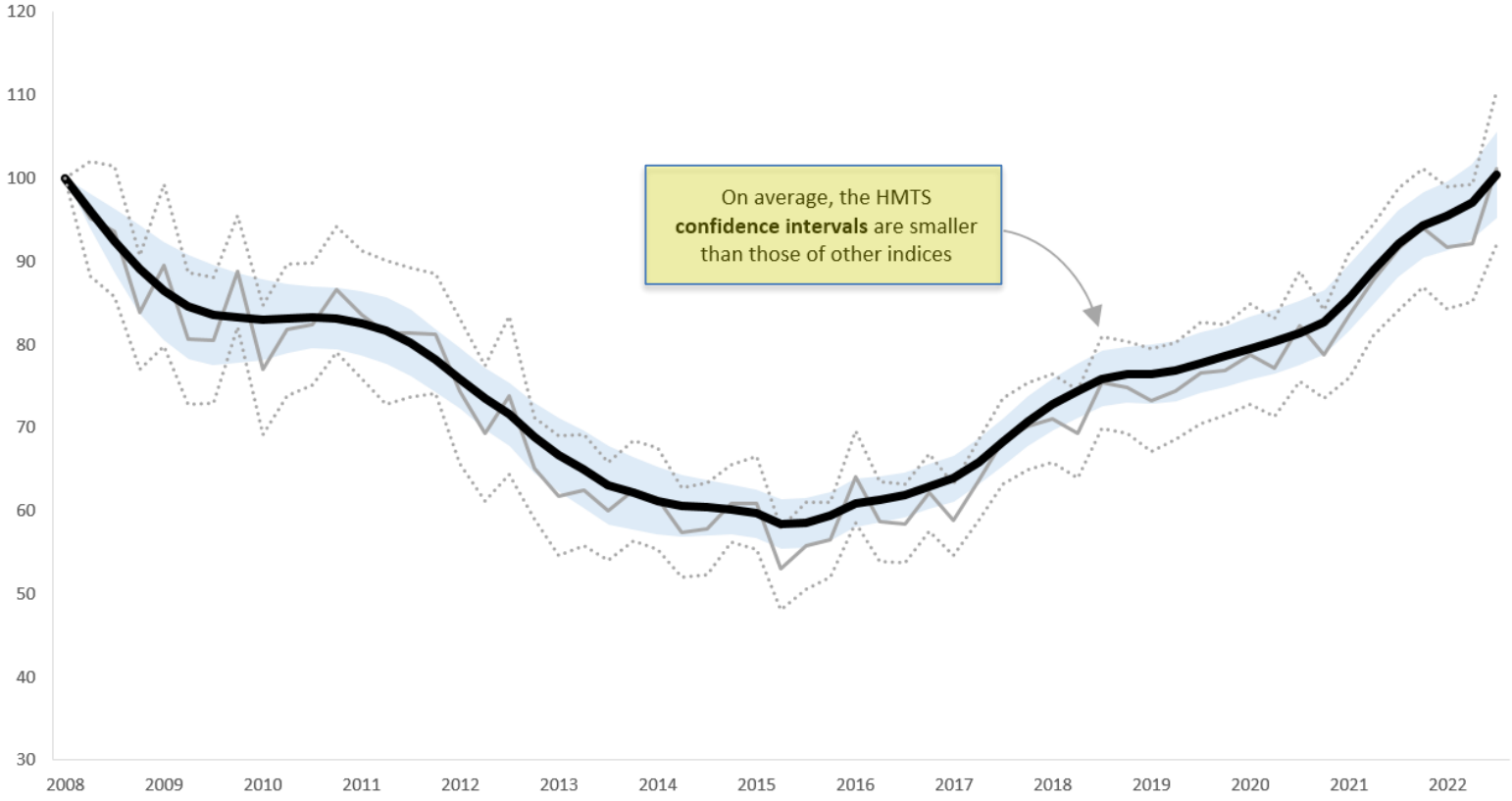


# Smaller error margins

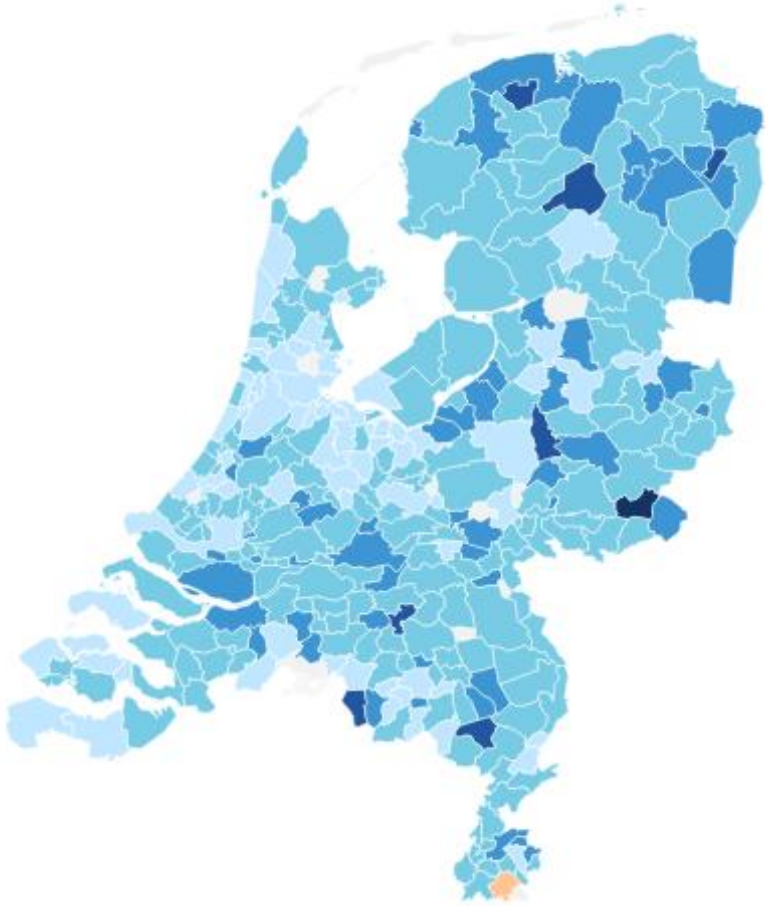


# Use of HMTS in official statistics

- House price indices for municipalities
- Land price indices
- Agriculture price indices

*Soon:*

- Commercial real estate price indices



# Calculation with R-package REPS

- REPS: Real Estate Price Statistics
- Published by CBS on CRAN
- Calculates multiple methods
- Calculates diagnostics, necessary to assess model quality

# Calculation with R-package REPS

REPS script.R

```r
## This script demonstrates the possibilities of the package REPS (Real Estate Price Statistics).
## The package contains test data, which below script uses.
## To calculate indices, replace test data for real data and run below functions!

# Install and load package
install.packages("REPS")
library(REPS)

# Show package information
?REPS

# Load data
Tbl_data = REPS::data_constraxion

# Calculate price indices
Tbl_indices = REPS::calculate_price_index(
  method = c("fisher","hmts", "laspeyres", "paasche", "repricing", "timedummy", "rolling_timedummy"),
  dataset = Tbl_data,
  period_variable = "period",
  dependent_variable = "price",
  numerical_variables = c("floor_area", "dist_trainstation"),
  categorical_variables = c("neighbourhood_code", "dummy_large_city"),
  reference_period = "2015",
  number_of_observations = FALSE
)

# Plot price indices
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Console | Terminal | Background Jobs

R 4.4.3 · ~/

Environment | History | Connections | Tutorial

Import Dataset | 246 MiB | List

Global Environment

Data

| | |
|---|---|
| Tbl_data | 7800 obs. of 6 variables |
| Tbl_diagnostics | 52 obs. of 6 variables |
| Tbl_indices | List of 7 |

Files | Plots | Packages | Help | Viewer | Presentation

R: REPS: Hedonic and Multilateral Index Methods for Real Estate...

REPS-package {REPS} R Documentation

## REPS: Hedonic and Multilateral Index Methods for Real Estate Price Statistics

### Description

Compute price indices using various Hedonic and multilateral methods, including Laspeyres, Paasche, Fisher, and HMTS (Hedonic Multilateral Time series re-estimation with splicing). The central function calculate_price_index() offers a unified interface for running these methods on structured datasets. This package is designed to support index construction workflows across a wide range of domains — including but not limited to real estate — where quality-adjusted price comparisons over time are essential. The development of this package was funded by Eurostat and Statistics Netherlands (CBS), and carried out by Statistics Netherlands. The HMTS method implemented here is described in Ishaak, Ouwehand and Remoy (2024) doi:10.1177/0282423X241246617. For broader methodological context, see Eurostat (2013, ISBN:978-92-79-25984-5, doi:10.2785/34007).

### Author(s)

**Maintainer**: Vivek Gajadhar v.gajadhar@cbs.nl

Authors:

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- Pim Ouwehand
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R 4.4.3 · ~/

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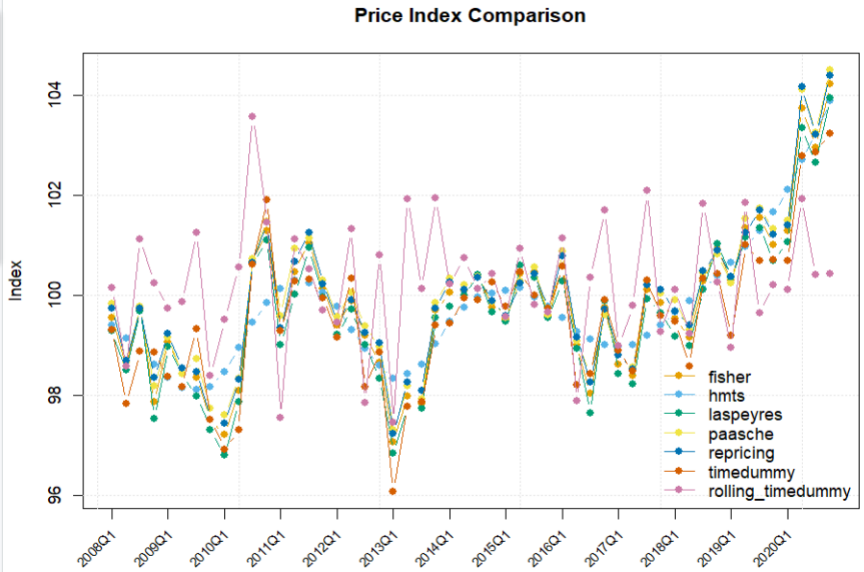
Zoom | Export | Publish



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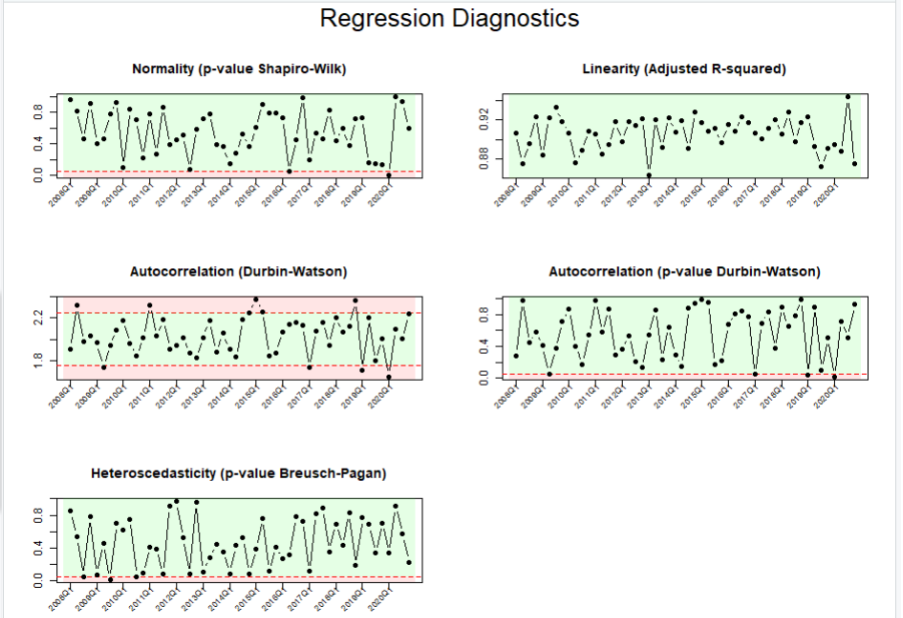

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## This script demonstrates the possibilities of the package REPS (Real Estate Price Statistics).
## Below script uses test data that is included in the package.
## To calculate indices, replace test data for real data and run below functions!

# Install and load package | Show package information
install.packages("REPS")
library(REPS)
?REPS

# Load data
Tbl_data = REPS::data_constraxion

# Calculate price indices
Tbl_indices = REPS::calculate_hedonic_index(          method = c("fisher","hmts", "laspeyres", "paasche", "repricing",
                                                              "timedummy", "rolling_timedummy"),
                                                    dataset = Tbl_data,
                                                    period_variable = "period",
                                                    dependent_variable = "price",
                                                    numerical_variables = c("floor_area", "dist_trainstation"),
                                                    categorical_variables = c("neighbourhood_code", "dummy_large_city"),
                                                    reference_period = "2015",
                                                    number_of_observations = FALSE,
                                                    periods_in_year = 4,
                                                    number_preliminary_periods = 3,
                                                    window_length = 5)
# Plot price indices
REPS::plot_price_index(Tbl_indices)

# Calculate regression diagnostics
Tbl_diagnostics = REPS::calculate_regression_diagnostics(  dataset = Tbl_data,
                                                           period_variable = "period",
                                                           dependent_variable = "price",
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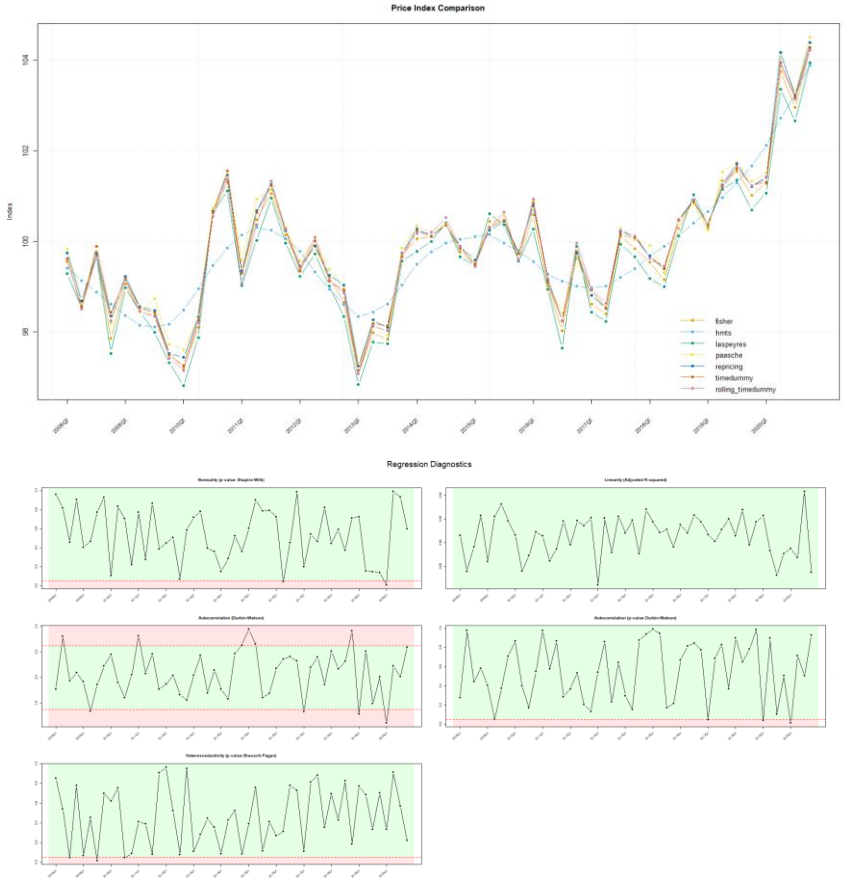
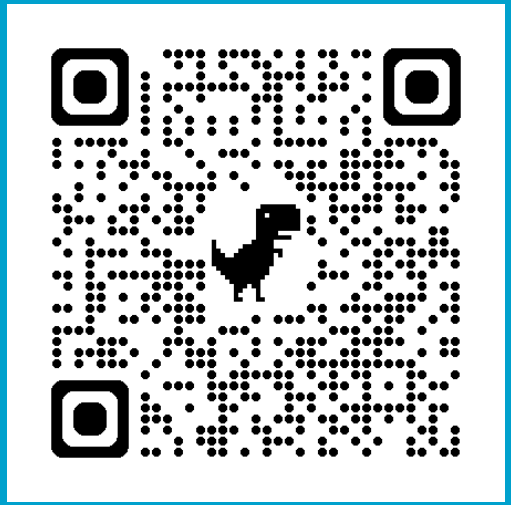


# Conclusions

- HTMS **balances all needs** for official statistics
- HMTS is **already used** for house prices, land prices and agriculture prices and will soon be used for commercial real estate prices
- However, method could be **difficult to implement**
- Therefore, our **REPS package** is published on CRAN

# Questions?



**dr. Farley Ishaak**

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