Bus 701:
Advanced Statistics

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About These Slides

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- The slides were produced using LaTeX and R (the R project; website: www.R-project.org) on a GNU/Linux system.

- R files used for this course are available upon request.

Some Projects

From Our Recent Research

Recent (and ongoing) research projects.

The following slides give an outline of five projects.

- Project 1: OPEC Announcements and Oil Price Volatility
- Project 2: Inventory News and Crude Oil Spot Prices
- Project 3: Currency Carry Trading and Portfolio Optimization
- Project 4: Population Dynamics With Leslie-Type Models
- Project 5: Forecasting Tourist Arrivals in Turkey

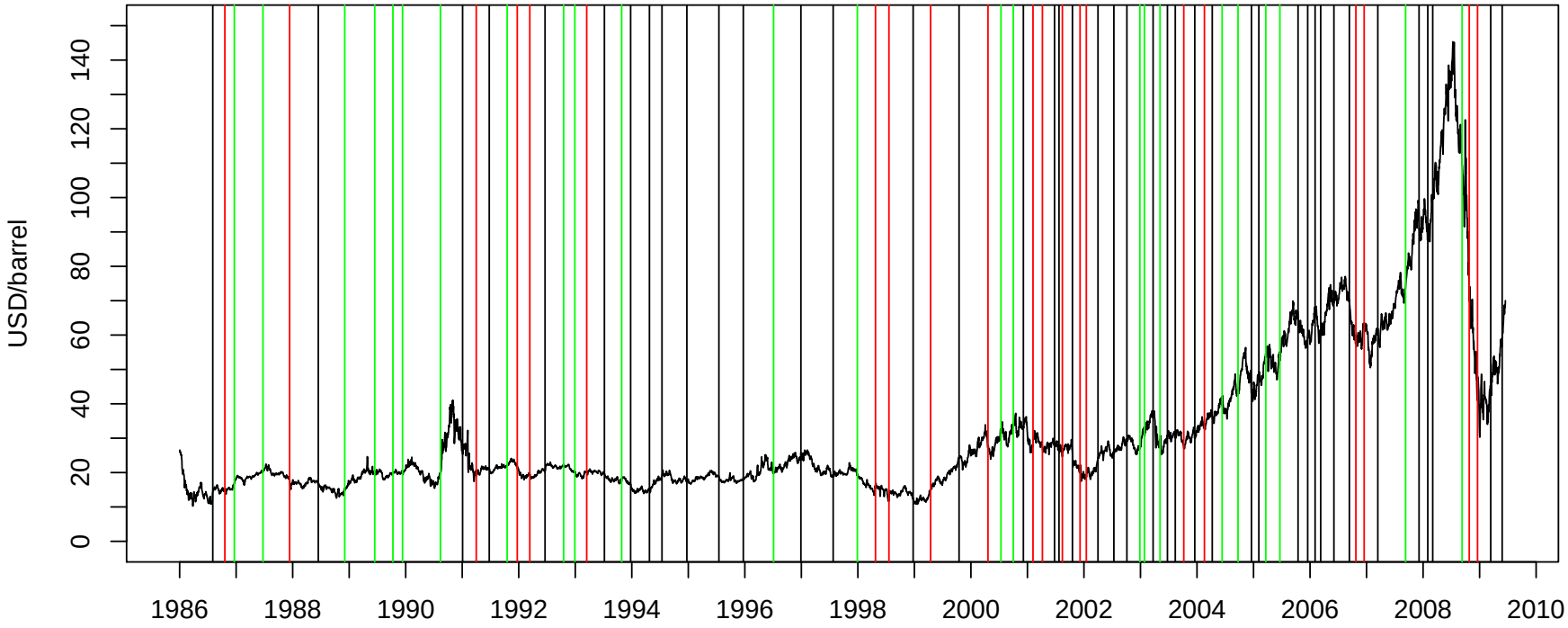
Project 1:
OPEC Announcements and Oil Price Volatility

Crude oil prices and OPEC announcements.

- Impact of OPEC announcements on crude oil prices?
- Impact on the distribution of daily returns, in particular:
  - on the expectation of daily returns?
  - on the variance of daily returns?
- What can be said about expectation and volatility. . .
  - right *before* an announcement will be made (anticipation of the announcement),
  - right *after* an announcement has been made (aftereffect of the announcement)?

Project 1:
OPEC Announcements and Oil Price Volatility

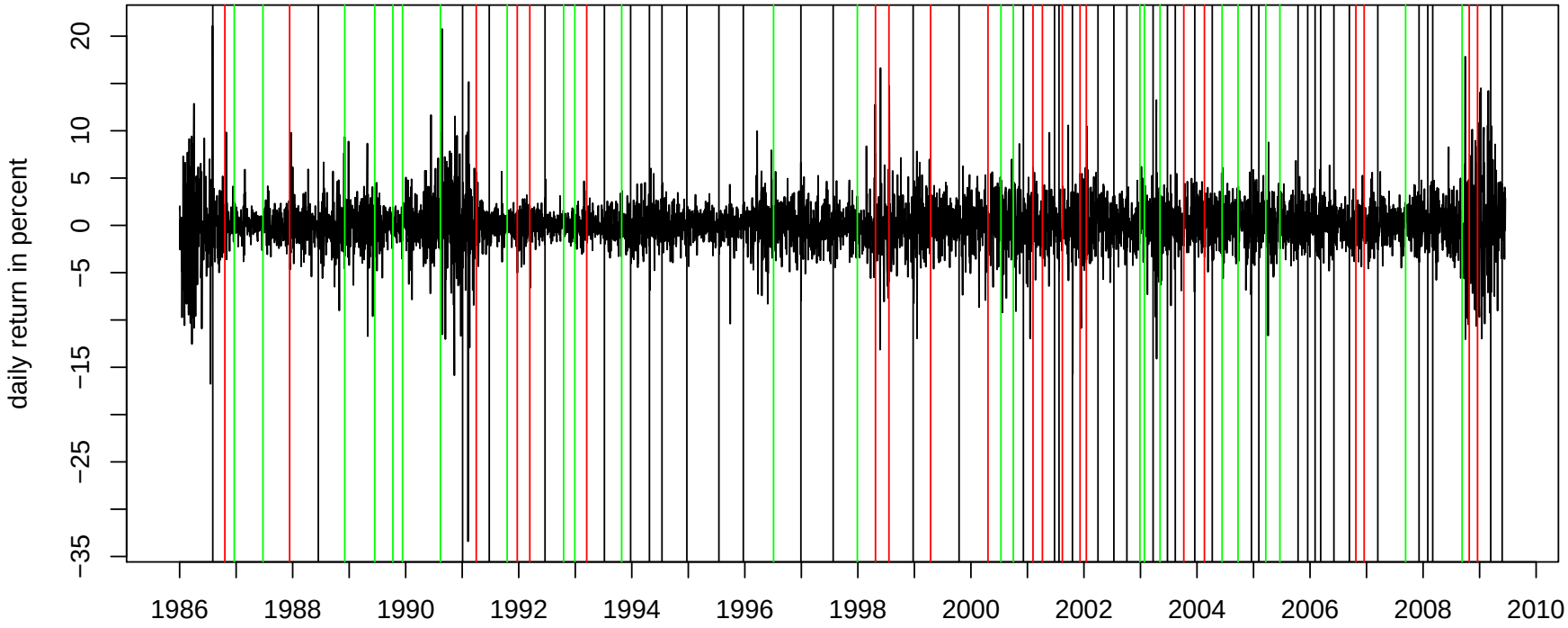
The WTI price series and OPEC announcements.



(black: quantity unchanged; green: quantity increased; red: quantity reduced)

Project 1:
OPEC Announcements and Oil Price Volatility

The daily WTI return series and OPEC announcements.



(black: quantity unchanged; green: quantity increased; red: quantity reduced)

Project 1:
OPEC Announcements and Oil Price Volatility

Regression: conditional expectation; GARCH: conditional variance.

$$r_t = c + \sum_{s \geq 1} a_s r_{t-s} + \sum_i b_i d_{it} + \epsilon_t, \tag{1}$$

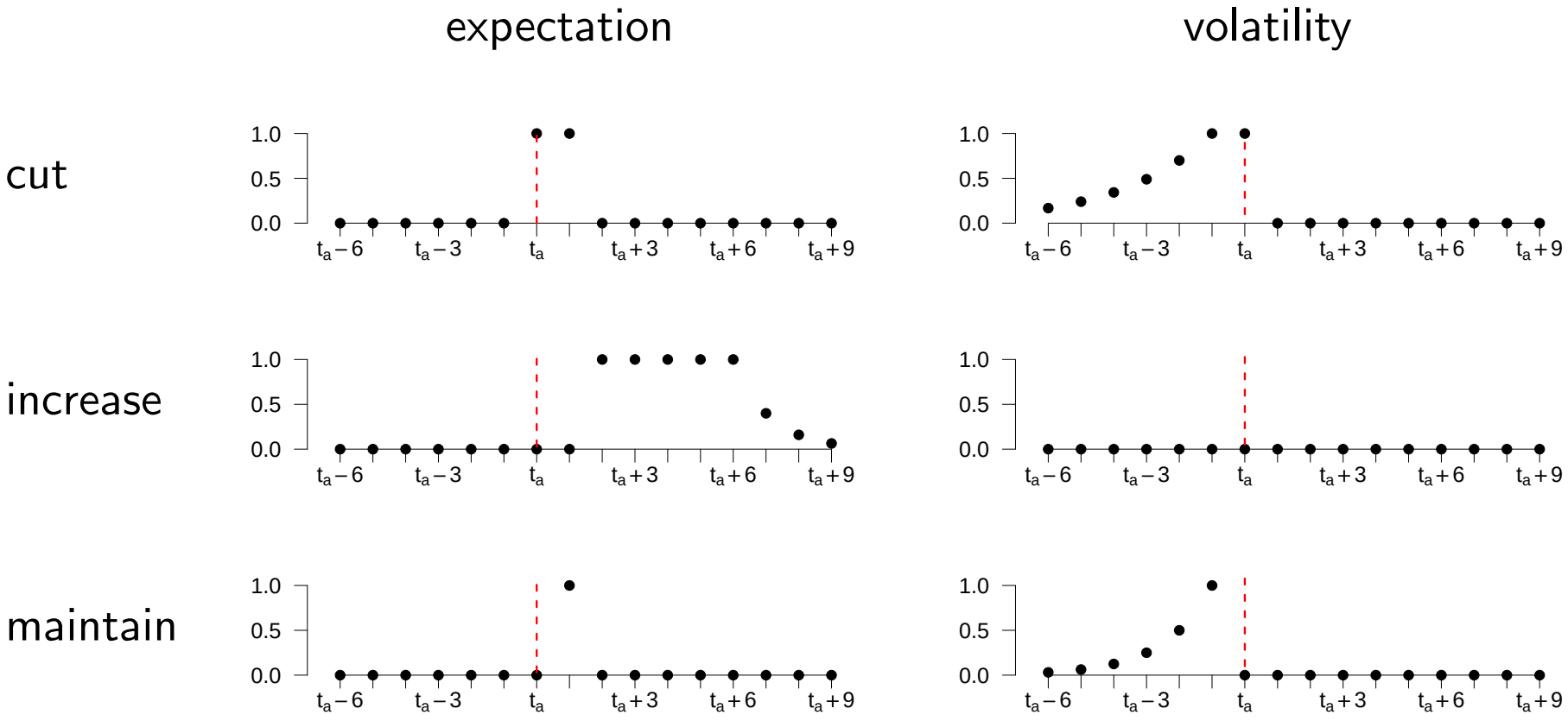
$$\epsilon_t = \nu_t \cdot \sqrt{h_t}, \tag{2}$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1} + \sum_i \gamma_i d_{it}. \tag{3}$$

- (r_t): series of daily returns on WTI crude oil price
- (d_{it}): (modified) dummy variables for announcements of kind i
- (ν_t): Gaussian white noise with $\mathrm{var}(\nu_t) = 1$
- b_i, γ_i: parameters (impact of an announcement of kind i)

Project 1:
OPEC Announcements and Oil Price Volatility

Summary: The optimal model structure.



Project 2:
Inventory News and Crude Oil Spot Prices

Inventories and the price series.

- US Energy Information Administration:
  Reports on US ending stocks of crude oil and petroleum products.
  Usually released on Wednesdays.

- Effect of inventory data release on crude oil spot prices?

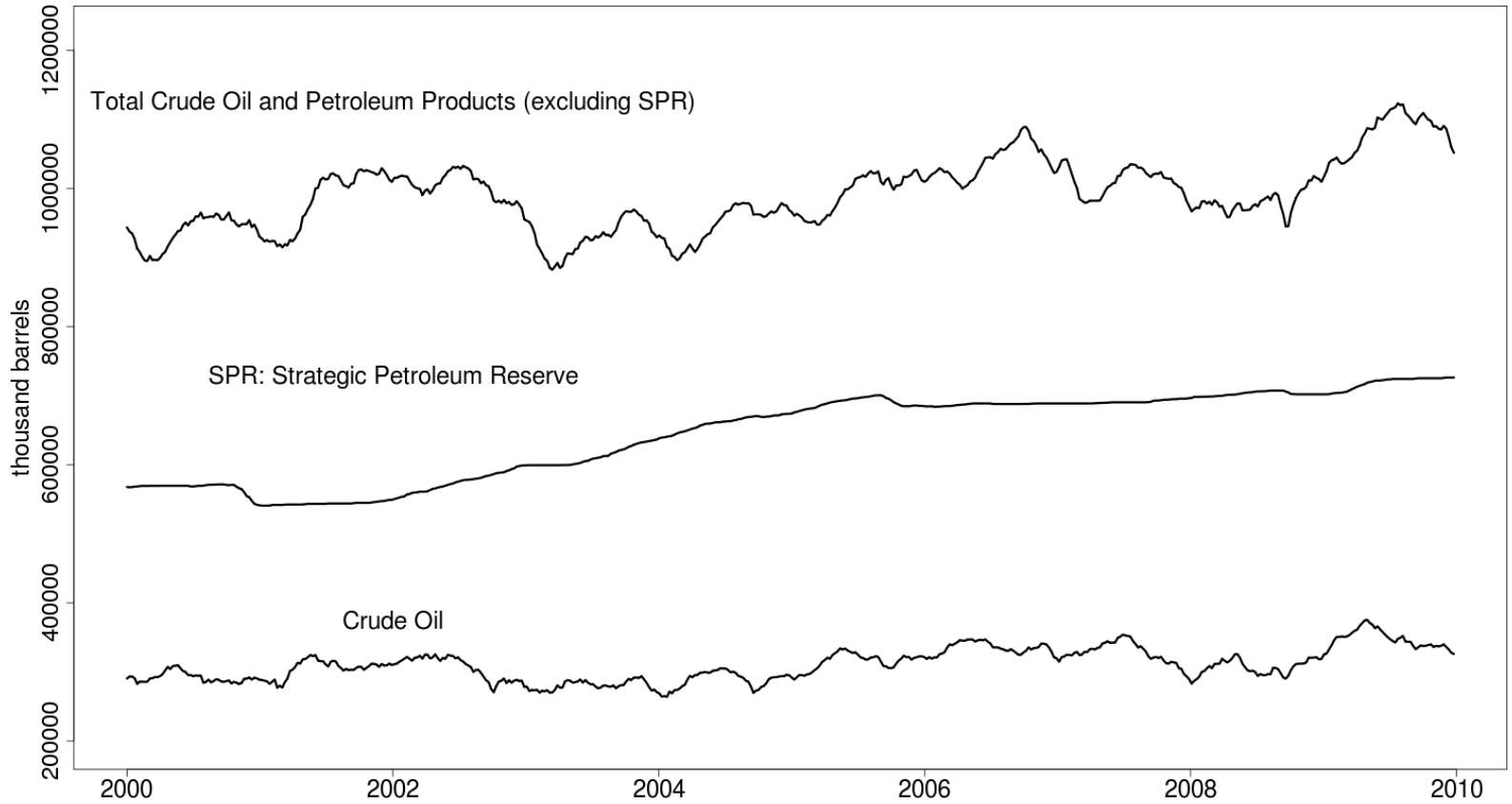
- Response of prices to deviation from inventory forecast?

- Effect on price level / volatility?

Project 2:
Inventory News and Crude Oil Spot Prices

Weekly release data.

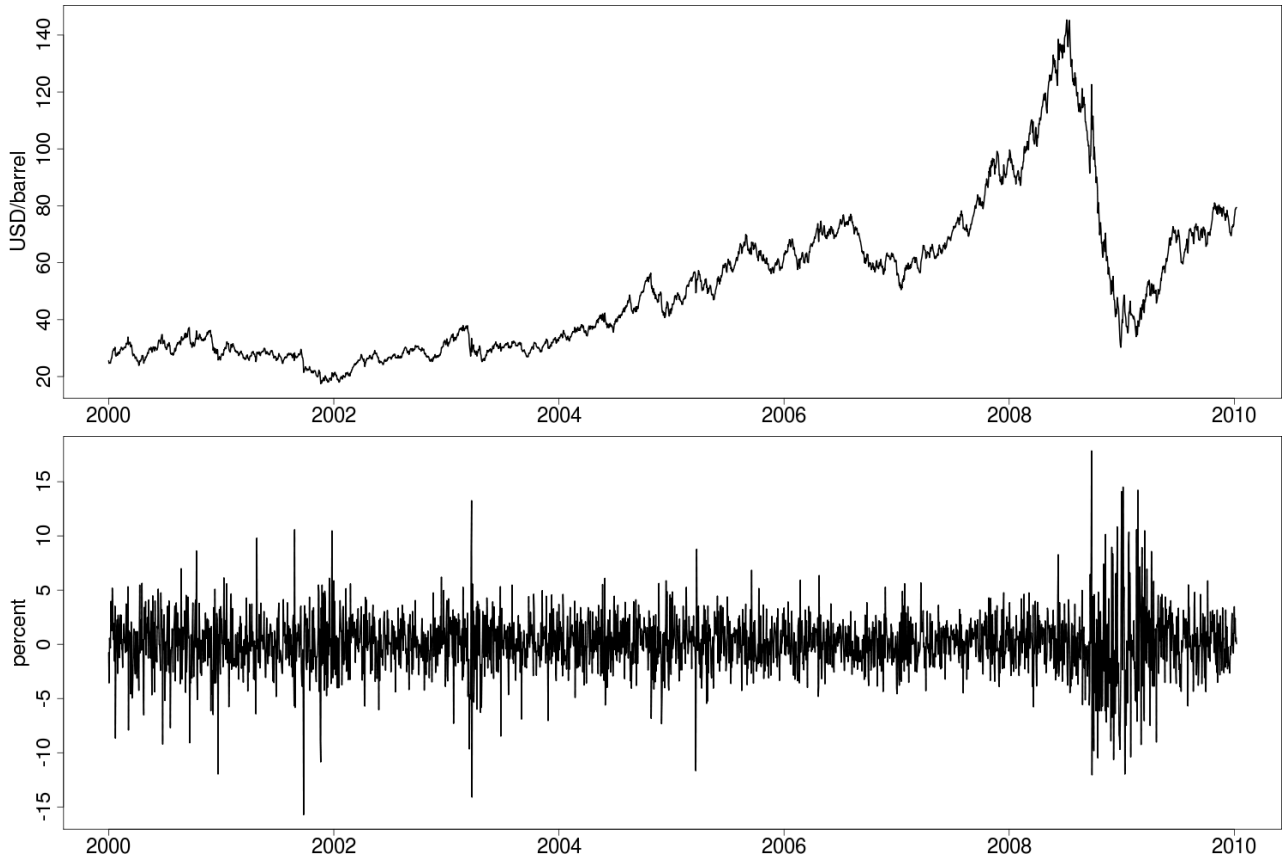
(Crude oil: WTI = West Texas Intermediate)



Project 2:
Inventory News and Crude Oil Spot Prices

Daily price data.

(Crude oil: WTI = West Texas Intermediate)



Project 2:
Inventory News and Crude Oil Spot Prices

Model-building in three steps.

1. Obtain weekly deviations from expected inventory data.
   ("Forecast error" in ARIMA-based forecast.)

2. Regress daily crude oil price returns on inventory deviations.
   (Model for return expectation.)

3. Fit GARCH with inventory deviation covariates to regression residual series.
   (Model for return volatility.)

Project 2:
Inventory News and Crude Oil Spot Prices

Some results for two periods.

time period	impact on. . .			
	expectation		volatility	
	inventory deviation:		inventory deviation:	
	positive	negative	positive	negative
2000 – 2004	*			
2005 – 2009	*	*	*	*

Project 3:
Currency Carry Trading and Portfolio Optimization

The Case of a Single Currency.

- USD investor contracting in a 1 month USD-BRL forward every four weeks.
- On the date of maturity:
  - Buy BRL at the contracted forward price.
  - Immediately sell them at the observed spot price.
- Realized gross profit / loss:

$$\frac{\text{contracted forward price}}{\text{observed spot price on the day of maturity}}$$

- Investment criterion?

Project 3:
Currency Carry Trading and Portfolio Optimization

A Portfolio of Currency Contracts.

- For each currency:
  Carry of the contract at decision date t.

$$c_{i,t} = \frac{\text{contracted forward price}}{\text{spot price at the beginning of the contract}}$$

- Construct the portfolio which maximizes Carry-to-Risk:

$$\frac{\text{carry of the portfolio}}{1 + \text{portfolio volatility forecast}/100} = \frac{1 + \phi' \cdot \mathbf{c}_t/100}{1 + \sqrt{\phi' \cdot \hat{\mathbf{H}}_{t+4} \cdot \phi}/100},$$

  w.r.t. weights $\phi = (\phi_1, \phi_2)$ under the constraints

$$|\phi_1| + |\phi_2| = 1, \quad -1 \leq \phi_1, \phi_2 \leq 1.$$

Project 3:
Currency Carry Trading and Portfolio Optimization

Models to Obtain the Covariance Matrix.

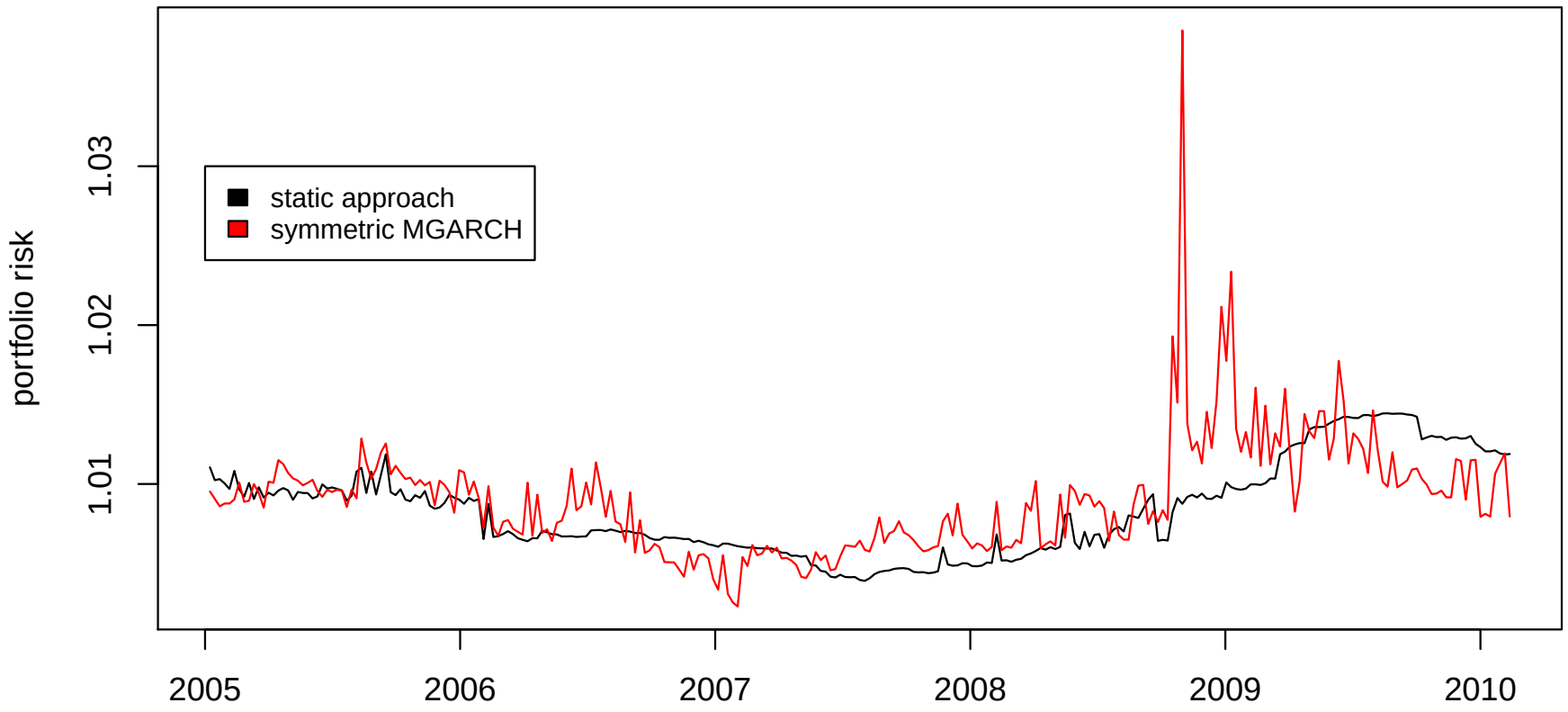
- Rolling estimation (50 weeks); "static approach"
- Conditional covariance matrix; "dynamic approach" (here: symmetric MGARCH)
- Full title of this project:

  "Currency Carry Trading with MGARCH-based Carry-to-Risk Portfolio Optimization"

Project 3:
Currency Carry Trading and Portfolio Optimization

Estimated portfolio risk.

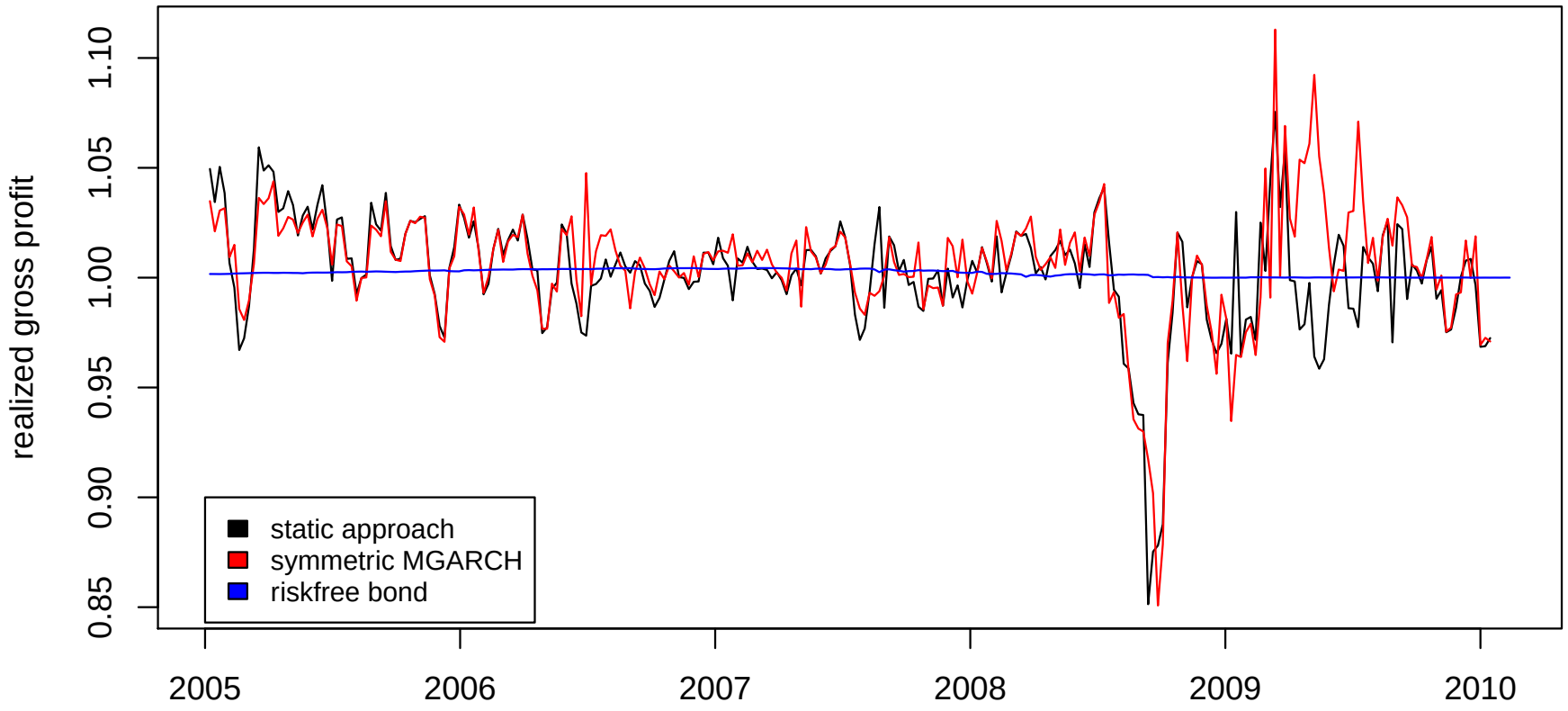
Static vs. dynamic approach.



Project 3:
Currency Carry Trading and Portfolio Optimization

Realized gross profit.

Realized gross profit (monthly), as compared to 1 month US treasury bonds.



Project 4:
Population Dynamics With Leslie-Type Models

The classical Leslie model.

- Leslie model:
  a discrete, age-structured model of population growth
- time-constant age-specific fertility and mortality rates
- population is closed to migration
- only females considered
- three 15-year intervals of age covering ages 0 to 45

Project 4:
Population Dynamics With Leslie-Type Models

The classical Leslie model.

- Equation of the Leslie model:

$$\begin{pmatrix} n_{1,t} \\ n_{2,t} \\ n_{3,t} \end{pmatrix} = \begin{pmatrix} f_1 & f_2 & f_3 \\ p_1 & 0 & 0 \\ 0 & p_2 & 0 \end{pmatrix} \cdot \begin{pmatrix} n_{1,t-1} \\ n_{2,t-1} \\ n_{3,t-1} \end{pmatrix}$$

$$\vec{n}_t = \mathtt{M} \cdot \vec{n}_{t-1}$$

Project 4:
Population Dynamics With Leslie-Type Models

A Leslie-type model for a population with constant immigration.

$$\left(\begin{array}{c} n_{1,t} \\ n_{2,t} \\ n_{3,t} \\ \hline n^*_{1,t} \\ n^*_{2,t} \\ n^*_{3,t} \\ \hline R \end{array}\right) = \left(\begin{array}{ccc|ccc|c} f_1 & f_2 & f_3 & f^*_1 & f^*_2 & f^*_3 & 0 \\ p_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & p_2 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 & r_1 \\ 0 & 0 & 0 & p^*_1 & 0 & 0 & r_2 \\ 0 & 0 & 0 & 0 & p^*_2 & 0 & r_3 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{array}\right) \cdot \left(\begin{array}{c} n_{1,t-1} \\ n_{2,t-1} \\ n_{3,t-1} \\ \hline n^*_{1,t-1} \\ n^*_{2,t-1} \\ n^*_{3,t-1} \\ \hline R \end{array}\right)$$

(Schmidbauer & Rösch, 1995)

Project 4:
Population Dynamics With Leslie-Type Models

A Leslie-type model with two populations.

$$
\begin{pmatrix}
n_{c1,t} \\ n_{c2,t} \\ n_{c3,t} \\ \hline
n^*_{c1,t} \\ n^*_{c2,t} \\ n^*_{c3,t} \\ \hline
n_{v1,t} \\ n_{v2,t} \\ n_{v3,t} \\ \hline
n^*_{v1,t} \\ n^*_{v2,t} \\ n^*_{v3,t}
\end{pmatrix}
=
\left(\begin{array}{ccc|ccc|ccc|ccc}
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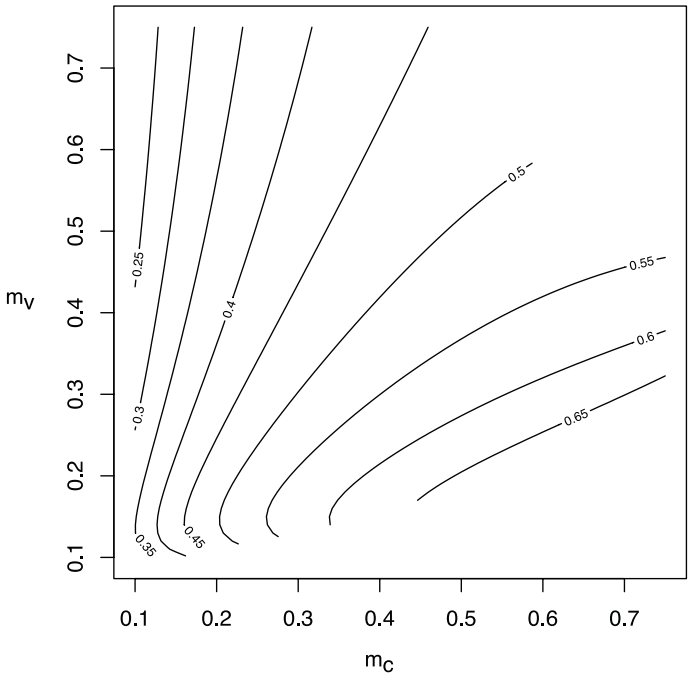
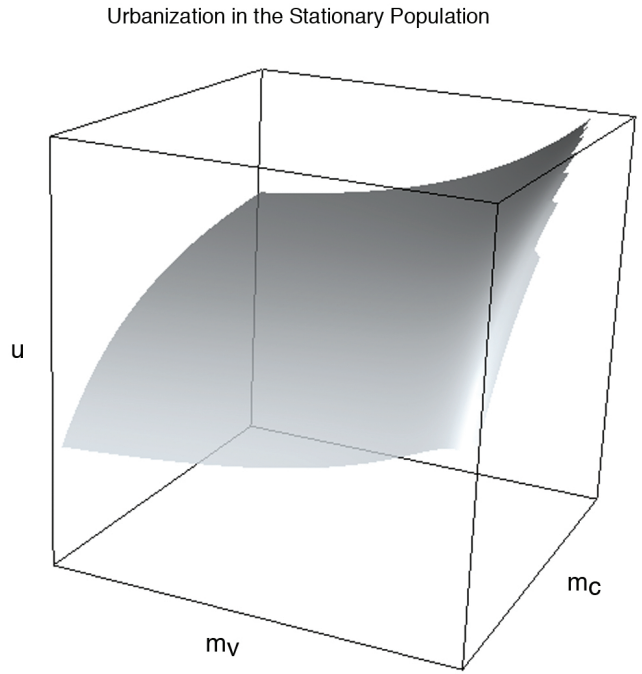
0 & \spadesuit & 0 & 0 & \spadesuit & 0 & 0 & 0 & 0 & 0 & \spadesuit & 0
\end{array}\right)
\cdot
\begin{pmatrix}
n_{c1,t-1} \\ n_{c2,t-1} \\ n_{c3,t-1} \\ \hline
n^*_{c1,t-1} \\ n^*_{c2,t-1} \\ n^*_{c3,t-1} \\ \hline
n_{v1,t-1} \\ n_{v2,t-1} \\ n_{v3,t-1} \\ \hline
n^*_{v1,t-1} \\ n^*_{v2,t-1} \\ n^*_{v3,t-1}
\end{pmatrix}
$$

Project 4:
Population Dynamics With Leslie-Type Models

Long-run urbanization.





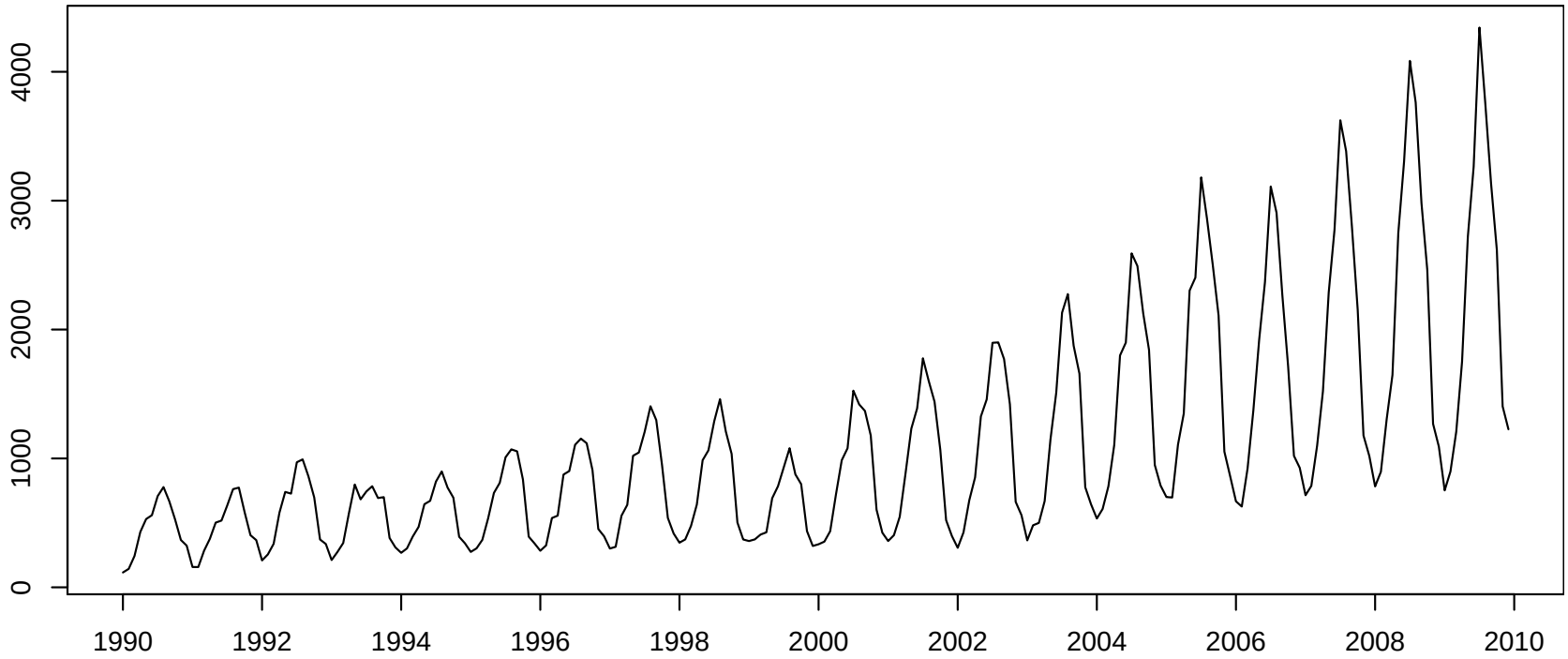
Project 5:
Forecasting Tourist Arrivals in Turkey

Our Goals.

- Forecast monthly tourist arrivals in Turkey!
- Amount of information / variability in this series?
- Importance of deterministic vs. non-deterministic components?
- Two methods:
  - ARIMA
  - STL (seasonal decomposition by local regression)

Project 5:
Forecasting Tourist Arrivals in Turkey

Monthly tourist arrivals to Turkey (1000).



All data downloaded from the website of the Turkish Statistical Institute (TurkStat; www.turkstat.gov.tr) in April 2010.

Project 5:
Forecasting Tourist Arrivals in Turkey

Measuring forecasting accuracy.

- Mean Absolute Percentage Error (MAPE):

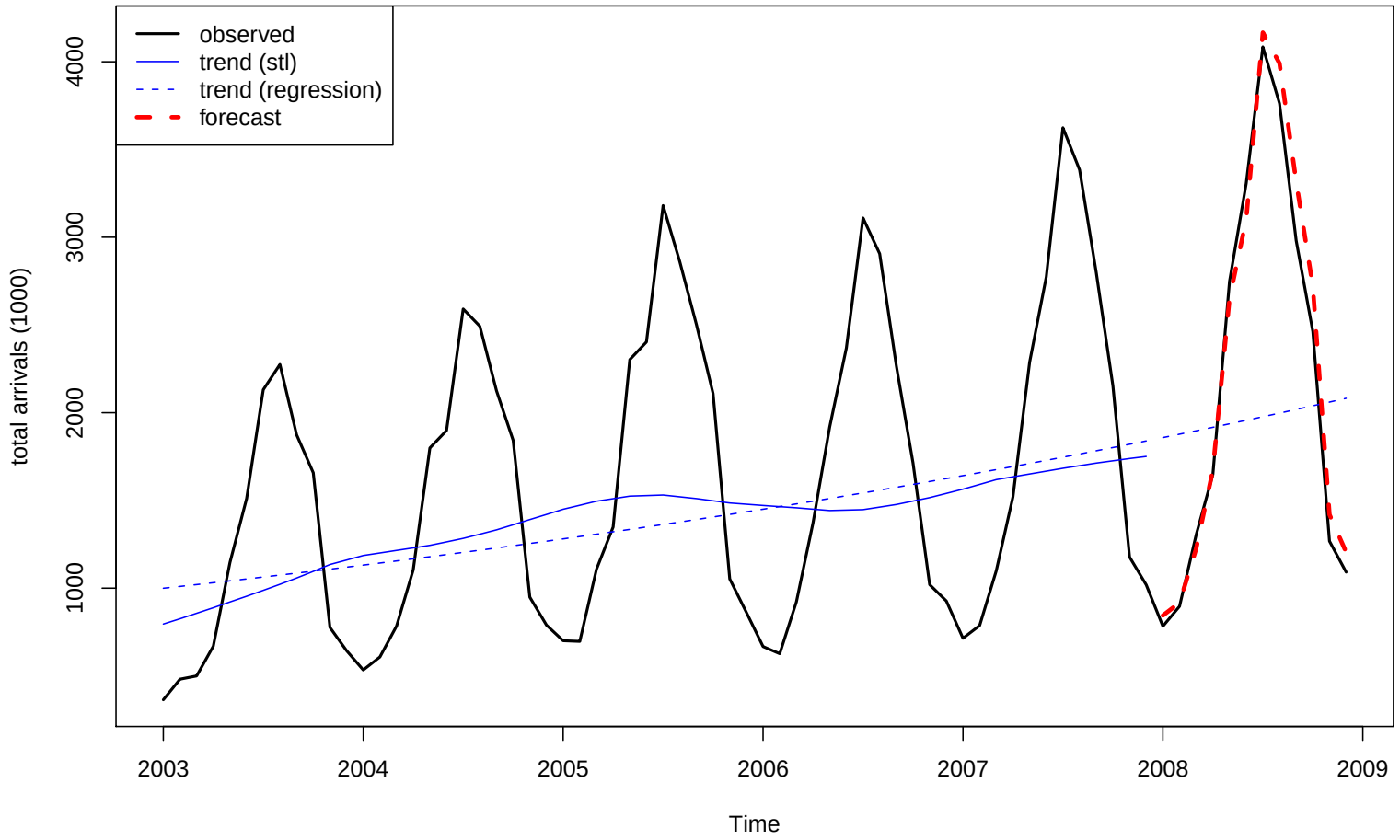
$$\text{MAPE} = \frac{1}{12}\sum_{t=1}^{12}\frac{|A_t - F_t|}{A_t}$$

- Here:

$$A_t = \text{actual value, month } t$$
$$F_t = \text{forecast for month } t$$

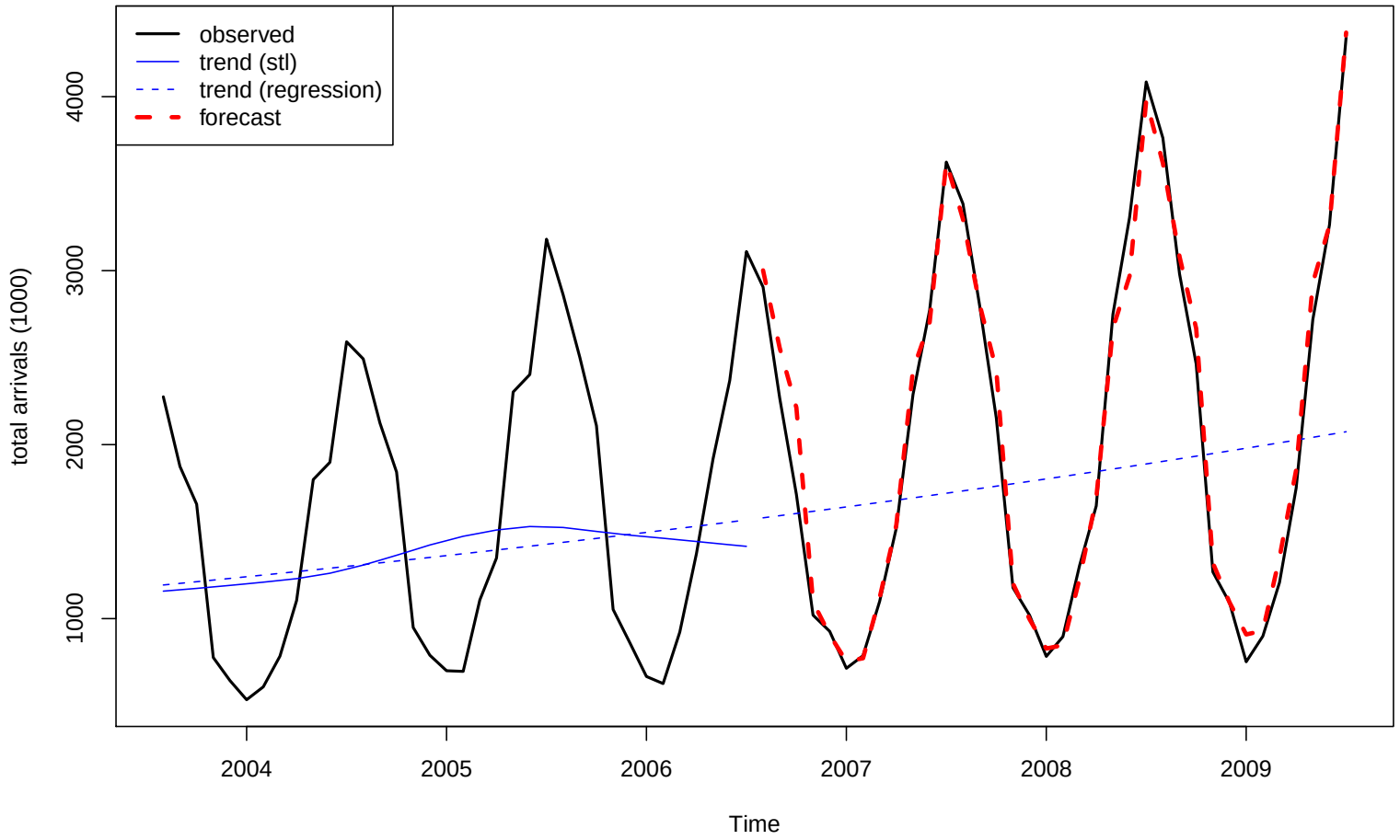
Project 5:
Forecasting Tourist Arrivals in Turkey

Forecasting tourist arrivals for 2008. (MAPE: ca. 6.6%)



Project 5:
Forecasting Tourist Arrivals in Turkey

Forecasting 36 months, using 36 months' data. (MAPE: ca. 5.5%)



Project 5:
Forecasting Tourist Arrivals in Turkey

Conclusions, requirements, suggestions.

- Parts of the series have very strong $deterministic$ components.
- Deterministic components have become stronger in recent years.
- No point in developing more sophisticated forecasting methods?!
- Official statistics agencies: Please reveal all methods used.
  (Otherwise, "forecasting" amounts to identifying the
  raw data processing method.)
- Variability may mean information —
  smoothing destroys information.
- Establish a variance monitoring system.