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* Intro & Motivation * Modifications * Bivariate Models

* Constraint for h_t * Empirical Example * Summary

* LM Test * Two Constraints

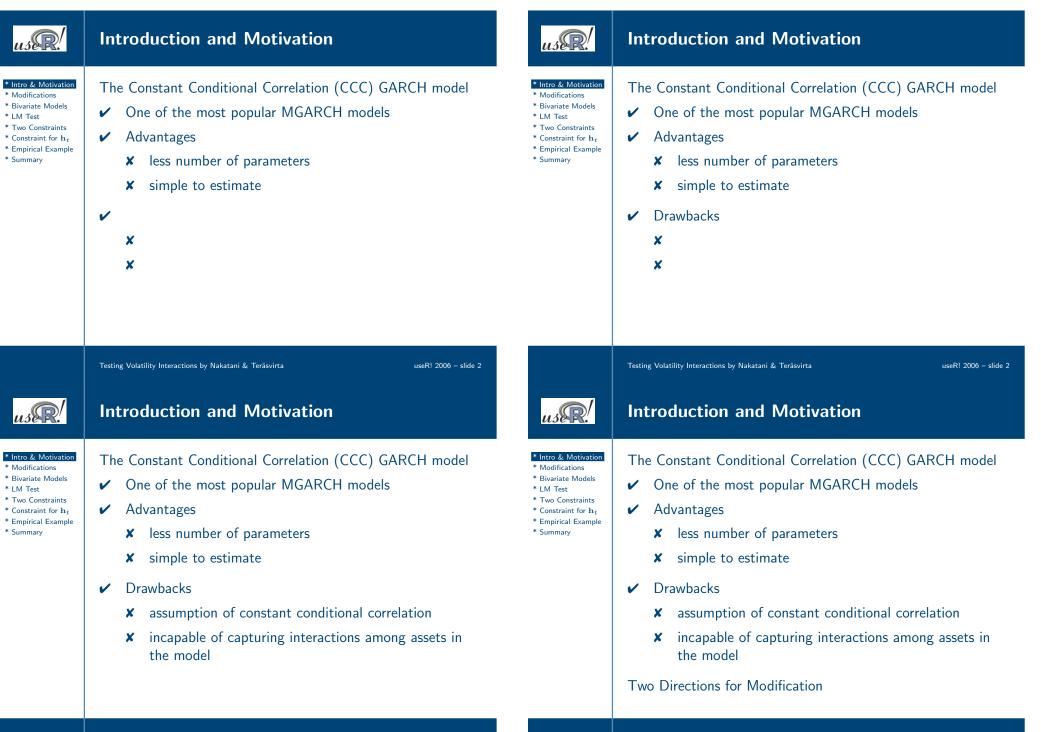
Testing Volatility Interactions in a Cons Conditional Correlation GARCH Mod

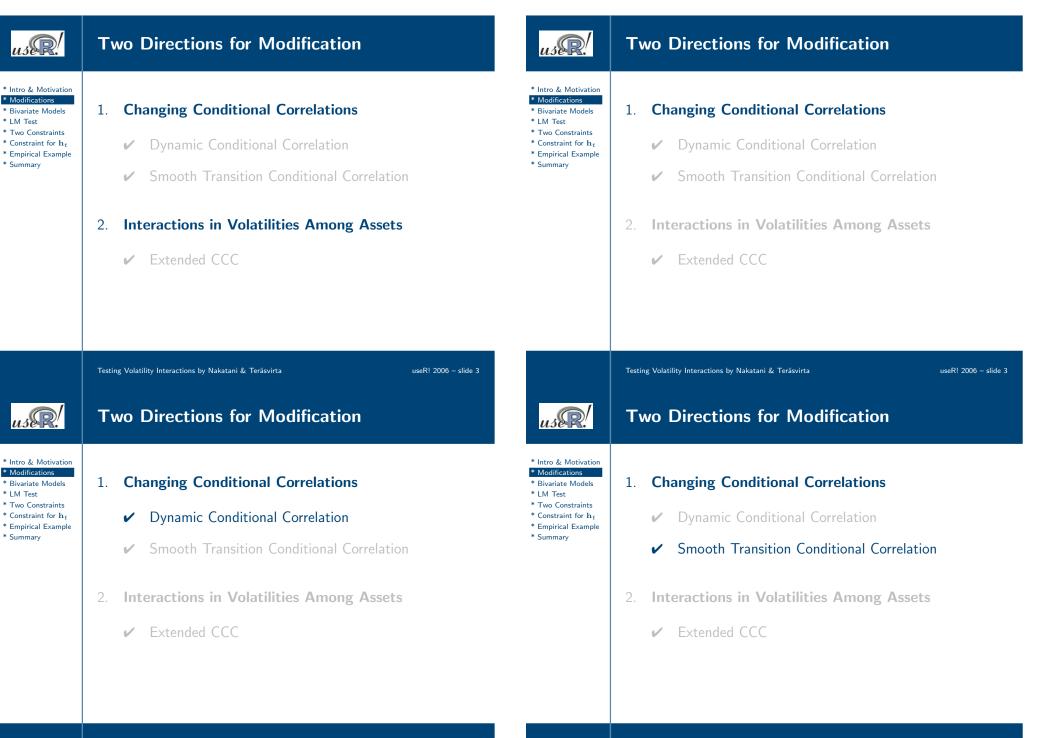


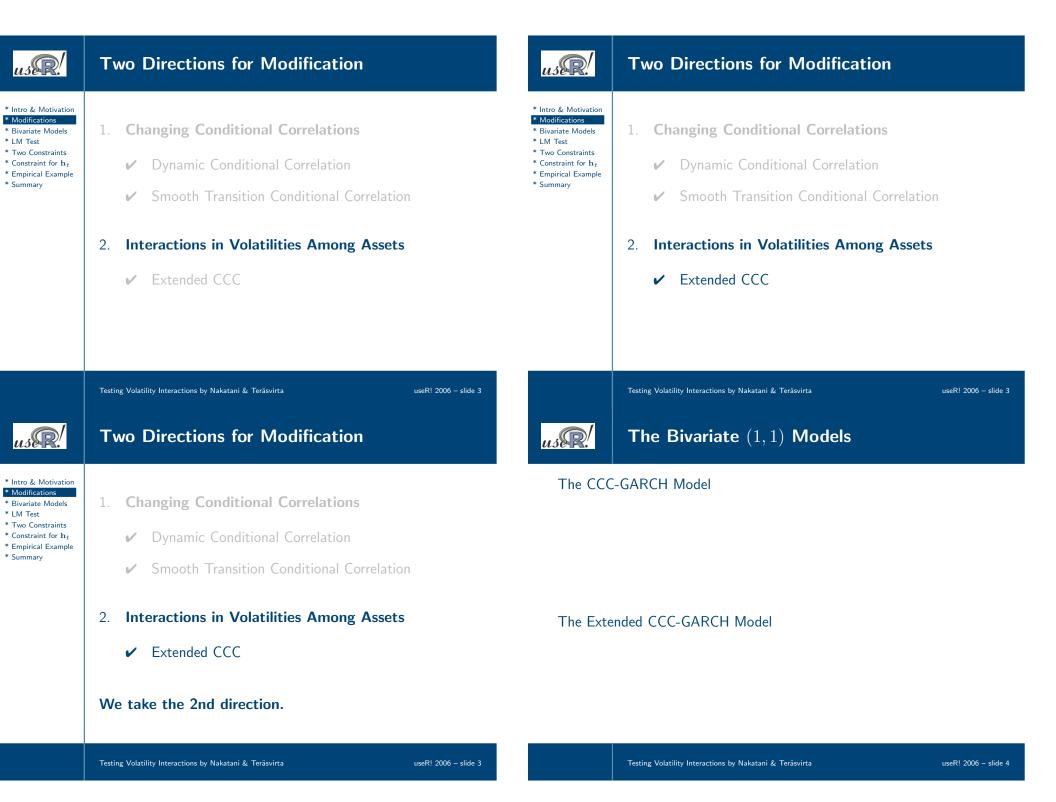
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Introduction and Motivation

sting Volatility Interactions in a Constant Conditional Correlation GARCH Model Tomoaki Nakatani Timo Teräsvirta Department of Economic Statistics, Stockholm School of Economics 15, June 2006	 Intro & Motivation Modifications Bivariate Models LM Test Two Constraints Constraint for h_t Empirical Example Summary 	The Constant Conditional Correlation (CCC) GARCH model
Testing Volatility Interactions by Nakatani & Teräsvirta useR! 2006 – slide 1 Introduction and Motivation	useR!	Testing Volatility Interactions by Nakatani & Teräsvirta useR! 2006 – slide 2 Introduction and Motivation
The Constant Conditional Correlation (CCC) GARCH model C One of the most popular MGARCH models X X X X X X X X X X X X X	 Intro & Motivation Modifications Bivariate Models LM Test Two Constraints Constraint for h_t Empirical Example Summary 	The Constant Conditional Correlation (CCC) GARCH model









The Bivariate $\left(1,1\right)$ Models

The CCC-GARCH Model

$$\mathbf{h}_{t} = \begin{bmatrix} h_{1,t} \\ h_{2,t} \end{bmatrix} = \mathbf{a}_{0} + \mathbf{A}_{1} \boldsymbol{\varepsilon}_{t-1}^{(2)} + \mathbf{B}_{1} \mathbf{h}_{t-1}$$
$$= \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t-1}^{2} \\ \varepsilon_{2,t-1}^{2} \end{bmatrix} + \begin{bmatrix} b_{11} & 0 \\ 0 & b_{22} \end{bmatrix} \begin{bmatrix} h_{1,t-1} \\ h_{2,t-1} \end{bmatrix}$$

The Extended CCC-GARCH Model



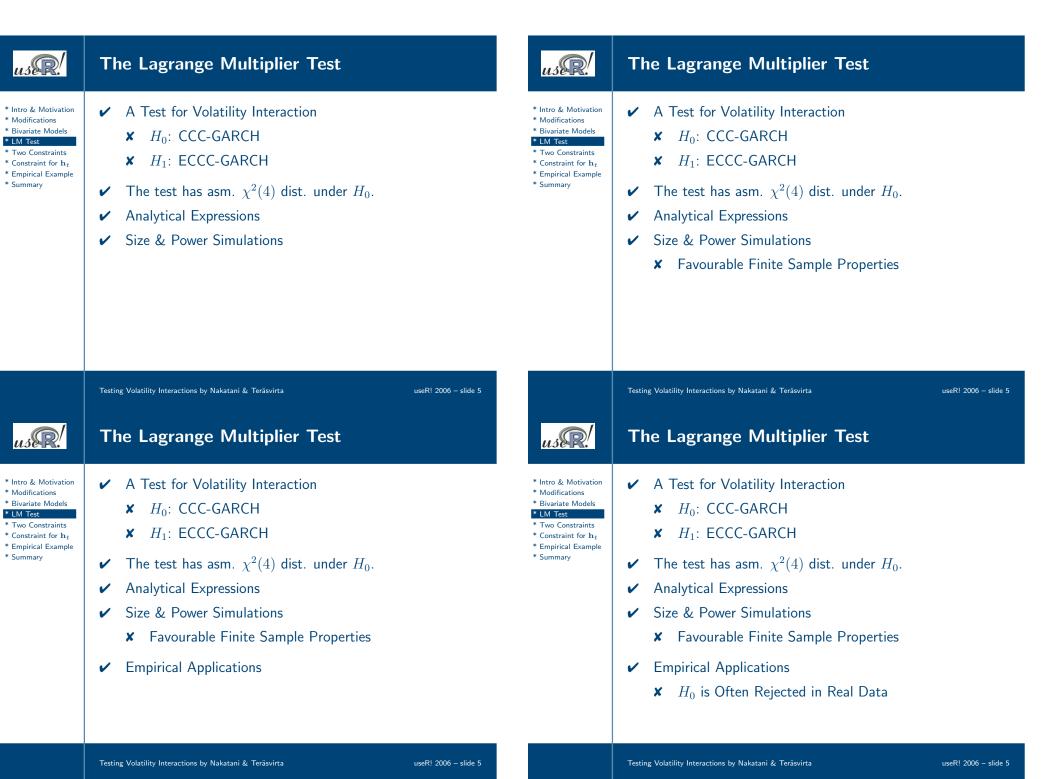
The CCC-GARCH Model

$$\mathbf{h}_{t} = \begin{bmatrix} h_{1,t} \\ h_{2,t} \end{bmatrix} = \mathbf{a}_{0} + \mathbf{A}_{1} \boldsymbol{\varepsilon}_{t-1}^{(2)} + \mathbf{B}_{1} \mathbf{h}_{t-1}$$
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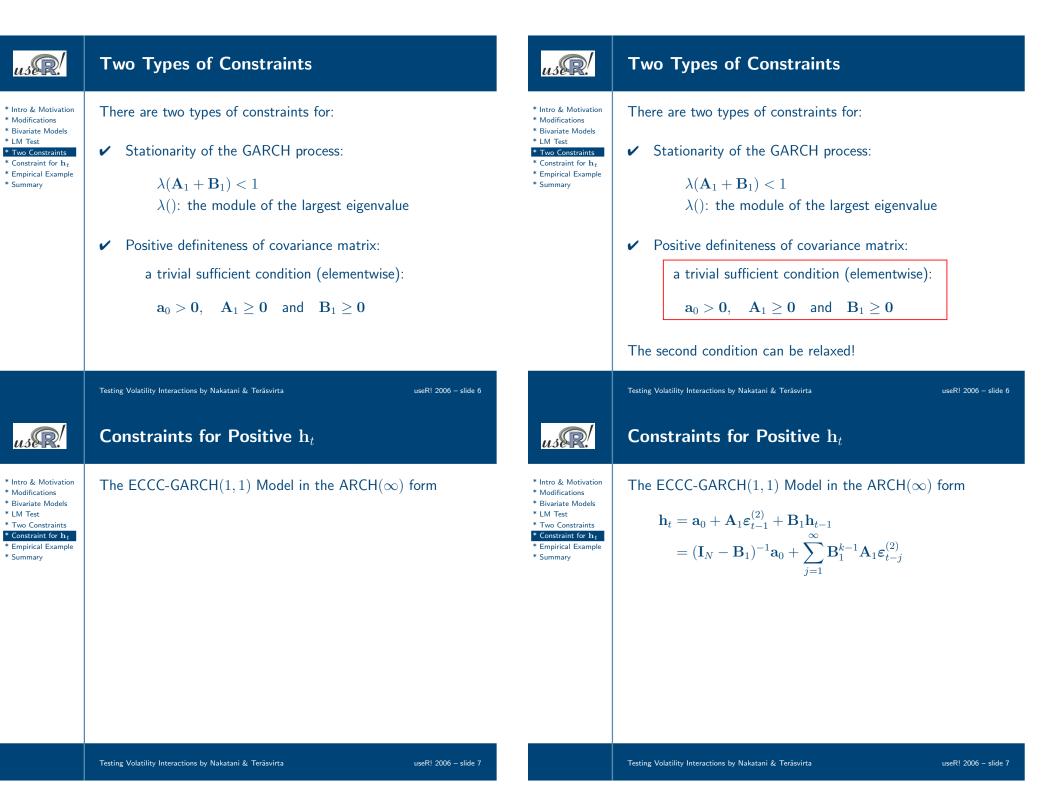
The Extended CCC-GARCH Model

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useR!	The Lagrange Multiplier Test	useR!	The Lagrange Multiplier Test
 Intro & Motivation Modifications Bivariate Models LM Test Two Constraints Constraint for h_t Empirical Example Summary 	 ✓ A Test for Volatility Interaction ✗ H₀: CCC-GARCH 	* Intro & Motivation * Modifications * Bivariate Models * LM Test * Two Constraints * Constraint for h _t * Empirical Example * Summary	 ✓ A Test for Volatility Interaction ✗ H₀: CCC-GARCH ✗ H₁: ECCC-GARCH
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		useR!	The Lagrange Multiplier Test







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Empirical Example

	Partial Results of Bivariate GARCH Models				
Model	Stock	В	1	—LogLik	LM
	NEC	0.910		23833.11	82.97
CCC		(0.009)			[0.00]
	Toshiba		0.898		
			(0.011)		

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Empirical Example

	Partial Res	ults of Biv	ariate GA	RCH Models	
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	Partial Results of Bivariate GARCH Models				
Model	Stock	В	1	—LogLik	LM
	NEC	0.910		23833.11	82.97
CCC		(0.009)			[0.00]
	Toshiba		0.898		
			(0.011)		
	NEC	0.888	1E-8	23799.10	
ECCC		(0.011)	(9E-6)		
w. C	Toshiba	7E-8	0.869		
		(2E-5)	(0.013)		



Empirical Example

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*	Environt and and a	E
	Empirical	Example

* Summary

Partial Results of Bivariate GARCH Models					
Model	Stock	E	B ₁	—LogLik	LM
	NEC	0.910		23833.11	82.97
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	Toshiba		0.898		
			(0.011)		
	NEC	0.888	1E-8	23799.10	
ECCC		(0.011)	(9E-6)		
w. C	Toshiba	7E-8	0.869		
		(2E-5)	(0.013)		
	NEC	0.897	-0.033	23789.37	
ECCC		(0.017)	(0.010)		
w.o. C	Toshiba	-0.031	0.900		
		(0.012)	(0.016)		

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Empirical Example

 Intro & Motivation Modifications Bivariate Models LM Test Two Constraints Constraint for h_t Empirical Example Summary 	$\begin{tabular}{ c c c c c } \hline Partial Results of Bivariate GARCH Models \\ \hline \hline Model & Stock & B_1 & -LogLik & LM \\ \hline NEC & 0.910 & 23833.11 & 82.97 \\ \hline CCC & (0.009) & [0.00] \\ \hline Toshiba & 0.898 & \\ & (0.011) & \\ \hline NEC & 0.888 & 1E-8 & 23799.10 \\ \hline ECCC & (0.011) & (9E-6) & \\ w. C & Toshiba & 7E-8 & 0.869 & \\ & (2E-5) & (0.013) & \\ \hline NEC & 0.897 & -0.033 & 23789.37 \\ \hline ECCC & (0.017) & (0.010) & \\ w.o. C & Toshiba & -0.031 & 0.900 & \\ & (0.012) & (0.016) & \\ \hline The estimated B_1 does not satisfy $B_1^{k-1}A_1 \ge 0$ for all $k \in \mathbb{N}$. \end{tabular}$	 * Intro & Motivation * Modifications * Evaluation Models * Two Constraints * Constraint for h_c * Empirical Example * Summary 	
user!	Testing Volatility Interactions by Nakatani & Teräsvirta useR! 2006 – slide 8 Summary & Remarks	Testing Volatility Interactions by Nakatani & Teräsvirta	useR! 2006 – slide 9
 Intro & Motivation Modifications Bivariate Models LM Test Two Constraints Constraint for h_t Empirical Example Summary 	 Analytical Expressions are derived The LM test often rejects the null of CCC-GARCH 	 * Intro & Motivation * Modifications * Bivariate Models * LM Test * Two Constraints * Constraint for h_ℓ * Empirical Example * Summary 	CCC-GARCH

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Summary & Remarks

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ntro & Motivation Aodifications Bivariate Models M. Test Two Constraints Constraint for \mathbf{h}_t Impirical Example Summary	 Analytical Expressions are derived The LM test often rejects the null of CCC-GARCH need to estimate ECCC-GARCH Estimation without constraint on B₁ 	 * Intro & Motivation * Modifications * Bivariate Models * LM Test * Two Constraints * Constraint for h_t * Empirical Example * Summary 	 ✓ Analytical Expressions are derived ✓ The LM test often rejects the null of CCC-GARCH ✓ need to estimate ECCC-GARCH ✓ Estimation without constraint on B₁ ✓ ending up with negative off-diagonal elements
useR!	Testing Volatility Interactions by Nakatani & Teräsvirta useR! 2006 – slide 9 Summary & Remarks	useR!	Testing Volatility Interactions by Nakatani & Teräsvirta useRI 2006 – slide s Summary & Remarks
ntro & Motivation Modifications Bivariate Models M Test Two Constraints Constraint for h _t Empirical Example Summary	 ✓ Analytical Expressions are derived ✓ The LM test often rejects the null of CCC-GARCH ✓ need to estimate ECCC-GARCH ✓ Estimation without constraint on B₁ ✗ ending up with negative off-diagonal elements ✗ but does not satisfy B₁^{k-1}A₁ ≥ 0 	 * Intro & Motivation * Modifications * Bivariate Models * LM Test * Two Constraints * Constraint for h_t * Empirical Example * Summary 	 ✓ Analytical Expressions are derived ✓ The LM test often rejects the null of CCC-GARCH ✓ need to estimate ECCC-GARCH ✓ Estimation without constraint on B₁ ✓ ending up with negative off-diagonal elements ✓ but does not satisfy B₁^{k-1}A₁ ≥ 0 ✓ How can we control them in codes?



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