PART B Please complete in BLOCK CAPITALS

Student Number _____ **Name** _____ **Signature** _____

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THE UNIVERSITY *of* EDINBURGH

PART A Please complete clearly

Exam Number
as shown on your university card

Advanced Time Series Econometrics
ECNM11049

Saturday 10 May 2025
13:00:00–15:00:00

Number of questions: 4 out of 6
Total number of marks: 100

IMPORTANT PLEASE READ CAREFULLY

Before the examination

1. Put your university card face up on the desk.
2. **Complete PART A and PART B above**. By completing PART B you are accepting the University Regulations on student conduct in an examination (see back cover).
3. Complete the attendance slip and leave it on the desk.
4. This is a closed-book examination. No notes, printed matter or books are allowed.
5. A calculator is permitted in this examination. It must not be a programmable or graphic calculator. It must not be able to communicate with any other device.

During the examination

1. Write clearly, in ink, in the space provided after each question. If you need more space then please use the extra pages at the end of the examination script or ask an invigilator for additional paper.
2. **This exam contains two sections, each of which contains 3 (THREE) questions. Please answer 2 (TWO) questions from Section A and 2 (TWO) questions from Section B**.
3. If you have rough work to do, simply include it within your overall answer – put brackets at the start and end of it if you want to highlight that it is rough work.

At the end of the examination

1. This examination script must not be removed from the examination venue.
2. There are extra pages for working at the end of this examination script. If used, you should clearly label your working with the question to which it relates.
3. Additional paper and graph paper, if used, should be attached to the back of this examination script. Write your examination number on the top of each additional sheet.

Examiners: Prof Luis Candelaria (Chair), Prof Gregory Veramendi (External)

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Section A

ANSWER TWO of the THREE questions in this section!

1. (a) Write down the three-regime Markov switching autoregressive model. This model involves "regimes", "transition probabilities" and "durations". Explain what is meant by each of these concepts and discuss how they relate to one another. [8 marks]

If you have used additional space for working then please tick here: ☐

(b) Write down the time-varying parameter autoregressive (TVP-AR) model and describe how econometric estimation of the TVP-AR model can be done. [7 marks]

If you have used additional space for working then please tick here: ☐

(c) Describe the properties of Markov switching models and TVP-AR models. Compare the two models with respect to how they handle parameter variation and their relative advantages for modeling different types of economic phenomena. **[5 marks]**

If you have used additional space for working then please tick here: ☐

(d) When working with a new, unfamiliar data series, how would you determine whether a linear or nonlinear model is more appropriate? If a nonlinear model seems preferable but you're unsure which type to use, what tool or method can help identify the underlying nonlinear pattern in your data? [5 marks]

If you have used additional space for working then please tick here: ☐

2. Suppose you have monthly data on a macroeconomic variable (y) and daily data on a financial variable (x). You want to build a model which uses x to produce high frequency nowcasts of y.

   (a) Describe what a bridge equation is and how you would use it in a regression model to produce the high frequency nowcasts. **[10 marks]**

If you have used additional space for working then please tick here: ☐

(b) Give an example of a MIDAS model. Discuss its properties and compare them to the properties of the model in part a) of this question. [10 marks]

If you have used additional space for working then please tick here: ☐

(c) How would you compare the point forecast/nowcast performance of the two models proposed in parts a) and b)? In this context, also briefly comment on the main advantage of the MIDAS model compared to the bridge equation. **[5 marks]**

If you have used additional space for working then please tick here: ☐

3. Suppose you have 250 quarterly macroeconomic time series indicators spanning from 1960:Q1 to 2024:Q4 and wish to use all of them in an empirical analysis.

   (a) The lectures for this course covered two main types of factor models: the static and the dynamic factor model. Carefully compare the properties of the dynamic factor model with those of the static factor model. In particular, contrast the serial correlation and persistence of the factors in the two models. (Note: For simplicity, assume there is no autocorrelation in the idiosyncratic errors.) **[10 marks]**

If you have used additional space for working then please tick here: ☐

(b) The lectures for this course covered two methods for estimating factor models. Explain briefly each of these. [8 marks]

If you have used additional space for working then please tick here: ☐

(c) Based on your discussion in parts a) and b): which type of factor model would you use for the "fat" quarterly macroeconomic dataset at hand, and which estimation method would you use? Briefly (but carefully) justify your choices. [7 marks]

If you have used additional space for working then please tick here: ☐

Section B

ANSWER TWO of the THREE questions in this section!

4. This question uses quarterly data for a macroeconomic variable US GNP year-on-year growth (labelled y_t). Table 1 provides information and summarises the estimation results for two state space models: the local level model and the local linear trend model.

   (a) Write down the local level model in the form of a state space model, using the information and estimates shown in Table 1. [5 marks]

If you have used additional space for working then please tick here: ☐

(b) Table 1 also provides information and estimates for a local linear trend model. Write down the local linear trend model. Show that the local linear trend model exhibits I(2) behaviour (i.e., the variable must be differenced twice to achieve stationarity). [5 marks]

If you have used additional space for working then please tick here: ☐

(c) Based on the two BICs provided in Table 1, which model (local level model or local linear trend model) would you choose? Does your answer to this question indicate that the variable is I(1) or I(2)? Carefully explain! **[8 marks]**

If you have used additional space for working then please tick here: ☐

(d) For this question, we focus on the local linear trend model only. With this model, we wish to test the null hypothesis that y_t is I(1) against the alternative that y_t is I(2). Which coefficient in this model allows us to test this hypothesis? In the following, the p-value associated with this coefficient is 0.25. Using a significance level of 5%, does this p-value indicate that y_t is I(1) or I(2)? Carefully discuss! **[7 marks]**

If you have used additional space for working then please tick here: ☐

Table 1: Two simple state space models for US GNP year-on-year growth

	Dependent variable: y_t	
	Local Level Model	**Local Linear Trend Model**
	Observation equation	
σ^2_ϵ	13.66	9.67
	State equation	
σ^2_u	5.42×10^{-3}	
$\sigma^2_{1,u}$		1.51
$\sigma^2_{2,u}$		3.77×10^{-10}
Observations	291	291
AIC	-1932	-2058
BIC	-1925	-2047

5. This question uses monthly data for a macroeconomic variable US CPI inflation (labelled y_t). Table 2 summarises the estimates for three models. **Model 1** is an AR model and results for this model are given in the first column (labelled Model 1). **Model 2** is a TAR model and results for this model are given in the second column (labelled Model 2). **Model 3** is based on two regressions. These two regressions are based on different sub-samples of y_t, and the results are given in the third and fourth columns (labelled Model 3).

   (a) AR stands for Autoregressive and TAR stands for Threshold Autoregressive. Define what a TAR model is. **[5 marks]**

If you have used additional space for working then please tick here: ☐

(b) The estimate for **Model 2** is based on a regression which contains the lag of a dummy variable, D_{t-1}. The dummy variable equals zero ($D_t = 0$) for periods in which y_t is smaller than three and equals one ($D_t = 1$) in other periods. Show how this regression leads to a TAR of the form you defined in part (a). What threshold is being used in the TAR model?

[5 marks]

If you have used additional space for working then please tick here: ☐

(c) The results for **Model 3** are based on two regressions. One regression is based on the sub-sample for which the lag of the dummy variable $D_{t-1} = 0$ and the other regression is based on the sub-sample defined by $D_{t-1} = 1$. The models in parts (b) and (c) are both TAR models, but differ in one important aspect. Carefully discuss this aspect! **[8 marks]**

If you have used additional space for working then please tick here: ☐

(d) Using the information criteria provided as model selection criteria, discuss which of the three models (i.e., the AR and the two versions of the TAR model) you would use to report empirical results in a project. [7 marks]

If you have used additional space for working then please tick here: ☐

Table 2: Regime switches in US CPI inflation

	Dependent variable: y_t			
	Model 1	**Model 2**	**Model 3**	
			$D_{t-1}=0$	$D_{t-1}=1$
y_{t-1}	0.621^{***}	0.573^{***}	0.573^{***}	0.703^{***}
	(0.028)	(0.066)	(0.064)	(0.049)
D_{t-1}		-0.758^{**}		
		(0.361)		
$D_{t-1}y_{t-1}$		0.130		
		(0.081)		
Intercept	1.382^{***}	1.539^{***}	1.539^{***}	0.782^{**}
	(0.145)	(0.163)	(0.157)	(0.333)
Observations	791	791	377	414
σ^2	8.63	8.6	7.96	9.19
AIC	3955	3951	3949	
BIC	3964	3960	3965	

Note: *p<0.1; **p<0.05; ***p<0.01

6. Suppose we have monthly data on US interest rates from January 2000 to December 2023. We have $M = 10$ different constant-maturity Treasury yields (i.e., interest rates), with yearly maturities ranging from one-year, denoted by $i_t(1)$, to ten-year, denoted by $i_t(10)$, for each period t. The interest rates are shown in a time series plot below.

   (a) Factor models are a popular tool for summarising information from many time series into a small number of factors. 1) Sketch the observation equation of a factor model. 2) Explain why it might be a useful tool for summarising the different interest rates shown in the time series plot below. **[10 marks]**

If you have used additional space for working then please tick here: ☐

(b) We obtain the following estimate for the first factor using PCA:

$$\widehat{f}_{1t} \approx \sum_{\tau=1}^{10} 0.3 \; i_t(\tau).$$

Here, $i_t(\tau)$ denotes the interest rates with maturity τ in period t, and each maturity is assigned an equal weight of 0.3. How would you interpret the first principal component (the first factor) $\widehat{f}_{1t}$ in general? Specifically, how would you interpret it in the context of the yield curve? **[8 marks]**

If you have used additional space for working then please tick here: ☐

(c) In the following, we use principal component analysis (PCA) to estimate the unobserved factors. We obtain the following scree plot shown below. Carefully interpret the output below. In addition, explain in detail what a scree plot shows and what it is typically used for. [7 marks]

If you have used additional space for working then please tick here: ☐

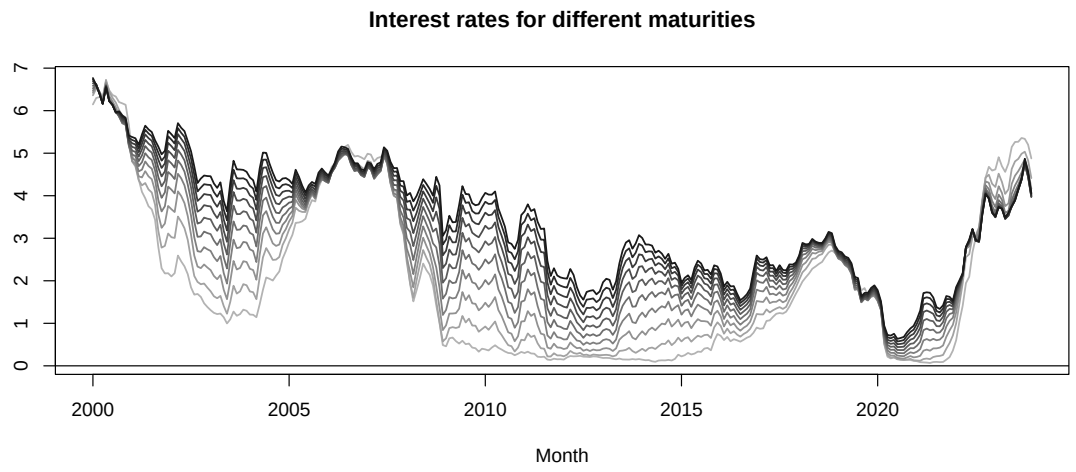

Figure 1: Interest rates for different maturities.

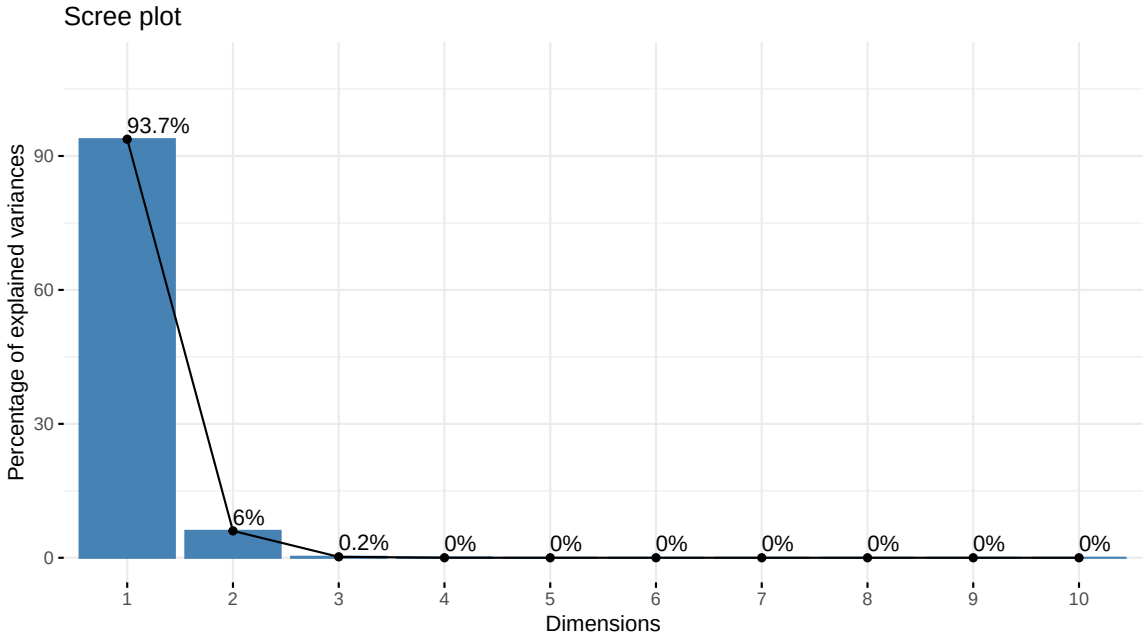

Figure 2: A scree plot.

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Exam Hall Regulations

The following is a copy of a Notice which is displayed in Edinburgh University Examination Halls for the information of students and staff.

The University of Edinburgh Exam Hall Regulations

1. An examination attendance sheet is laid on the desk for each student to complete upon arrival. These are collected by an invigilator after thirty minutes have elapsed from the start of the examination. Students are not normally allowed to enter the examination hall more than thirty minutes after the start of the examination.
2. Students arriving after the start of the examination are required to complete a “Late arrival form” which requires them to sign a statement that they understand that they are not entitled to any additional time. Students are not allowed to leave the examination hall less than thirty minutes after the commencement of the examination or within the last fifteen minutes of the examination.
3. Personal belongings e.g. coats, jackets, any form of headwear (with the exception of headwear worn for religious reasons) electronic equipment, bags, books, papers, briefcases and cases must be left at the front/back or sides of the examination room. No coats or jackets are permitted on the back of chairs. It is a breach of the Code of Student Conduct for a student to have in their possession in the examination any material relevant to the work being examined unless this has been authorised by the examiners.
4. Students must take their seats within the block of desks allocated to them and must not communicate with other students either by word or sign, nor let their papers be seen by any other student.
5. Students are prohibited from deliberately doing anything that might distract other students. Students wishing to attract the attention of an invigilator shall do so without causing a disturbance. Any student who causes a disturbance in an examination room may be required to leave the room, and shall be reported by the invigilator.
6. An announcement will be made to students that they may start the examination. Students must stop writing immediately when the end of the examination is announced. Students who continue to write after the end of the examination will be reported to their School.
7. Answers should be written in ink (unless otherwise instructed) in the script book provided. Rough work, if any, should be completed within the script book and subsequently crossed out. Script books must be left in the examination hall.
8. Dictionaries, reference books, computers, calculators, electronic devices or any other material are NOT permitted.
   The only exceptions are:-
   - If such is specified in a student’s Learning Profile as assessed by the Student Disability Service, or K:\Reg\SAS\Examinations\Exam Hall Regulations
   - For all students taking courses where the provision of a dictionary, reference books, computers, calculators, electronic devices or any other material is an integral part of the assessment process. Such exceptional arrangements requires authorisation by the examiners for use by all students and is recorded in the exam’s instructions.
9. The use of mobile devices/personal electronic equipment is not permitted. Mobile devices must be switched off during an examination. These should be placed in your bag and should not be on your person. Mobile devices are those which store/display data or connect to the internet, such as a mobile telephone, smart watches, smart glasses or any other communications equipment.
10. It is a breach of the Code of Student Conduct for any student knowingly
    - to make use of unfair means in any University examination
    - to assist a student to make use of such unfair means
    - to do anything prejudicial to the good conduct of the examination, or

- to impersonate another student or allow another student to impersonate them

11. Students will be required to display their University Card on the desk throughout all written degree examinations and certain other examinations. If a card is not produced, the student will be required to make alternative arrangements to allow their identity to be verified before the examination is marked.
12. Smoking (including the use of e-cigarettes) and eating is not permitted inside the examination hall. Only students who can provide a letter from Student Disability Services, that grants them permission to eat, will be allowed to do so. Students who have received this letter of permission are required to show the letter to the invigilator.
13. If an invigilator suspects a student of cheating, they shall impound any prohibited material and shall inform the Examinations Office as soon as possible. A report will be sent to the relevant School.
14. Cheating is an extremely serious offence, and any student found by the University to have cheated or attempted to cheat in an examination may be deemed to have failed that examination or the entire diet of examinations, or be subject to such penalty as the University considers appropriate.

Timetabling and Examinations Services
September 2023