

Appendix A

Additional Tables, Figures and Derivations

A.1 Graphs of the Real Per Capita GDP Series

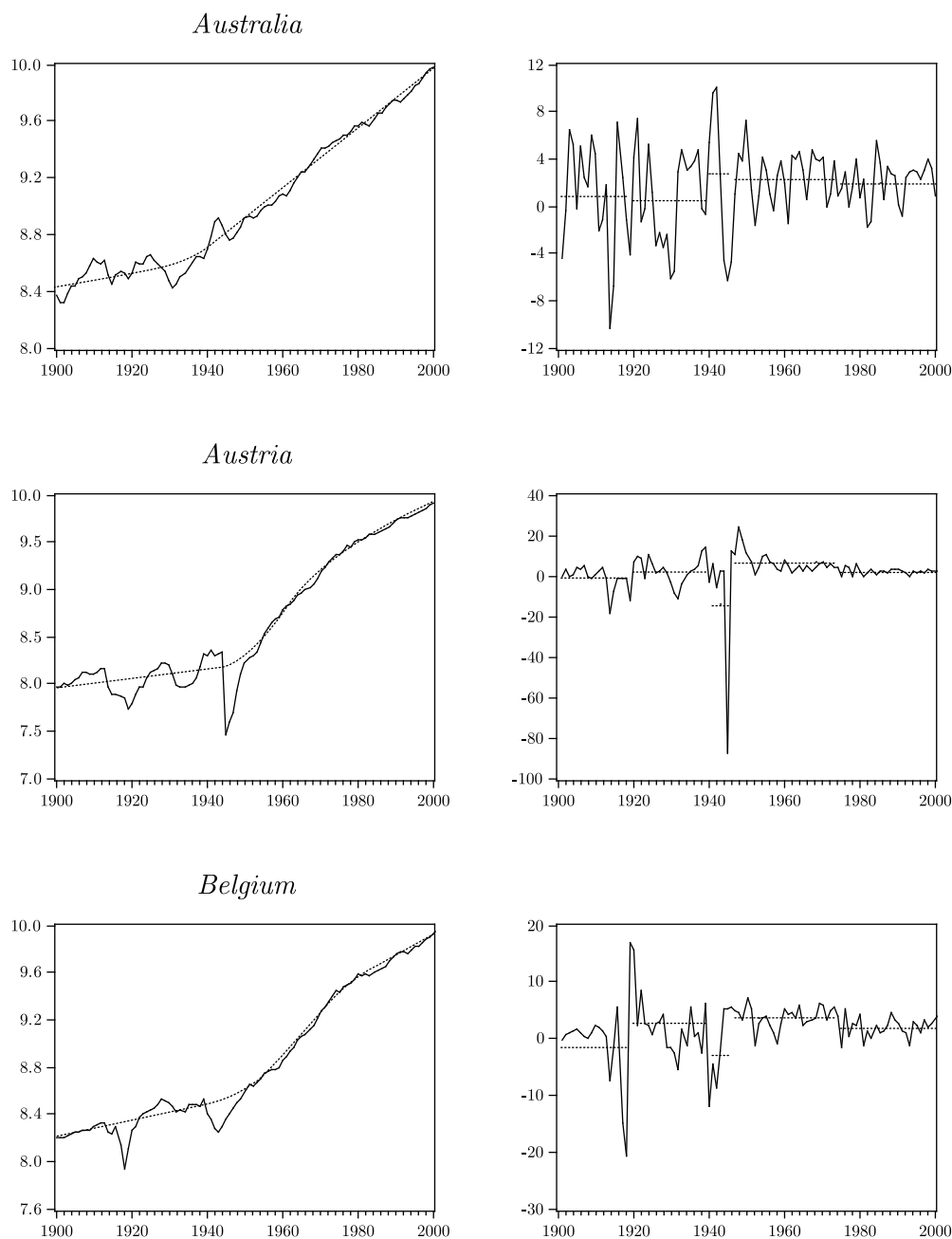
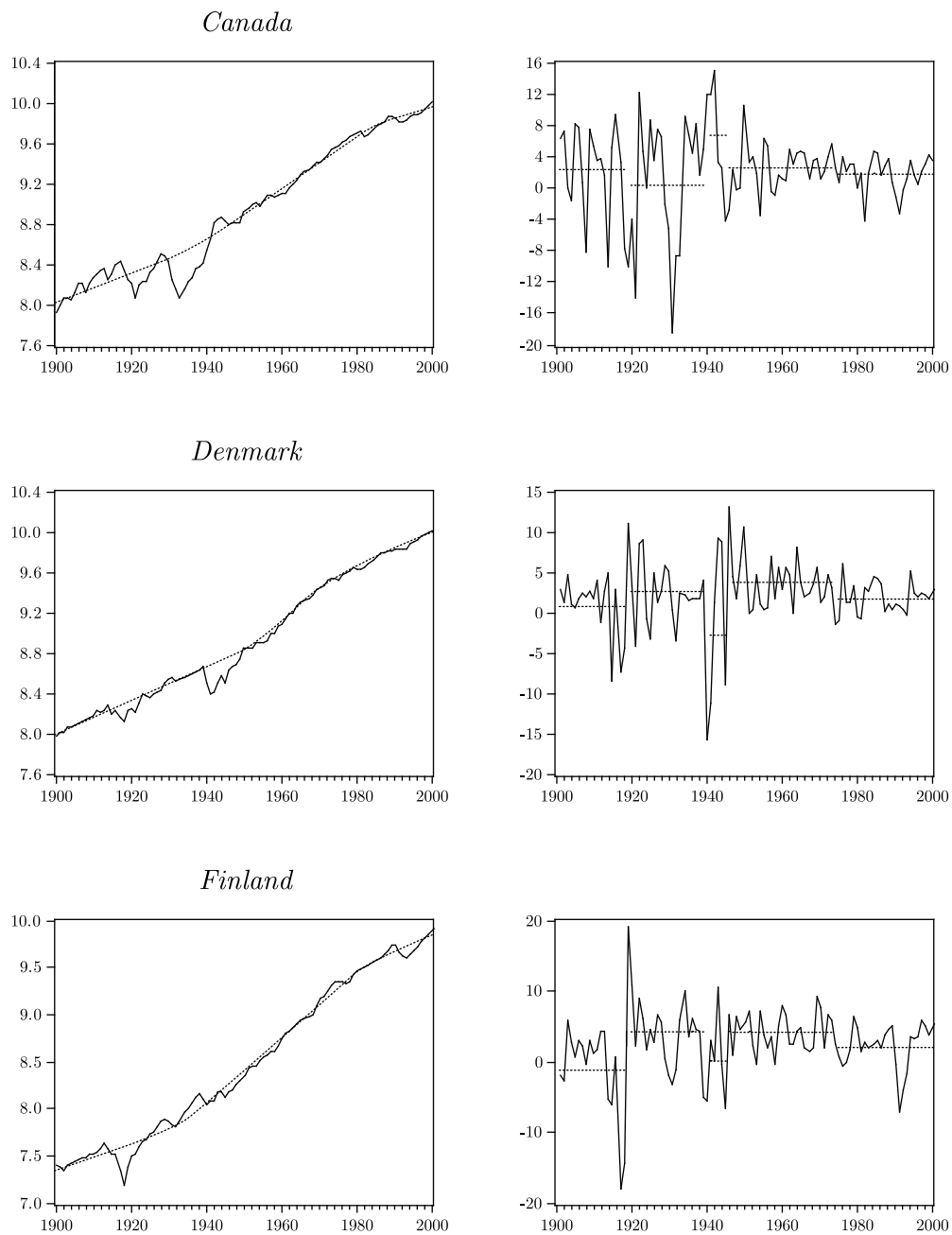


Figure A.1: Real per capita GDP series of 17 advanced industrialized countries.

Notes: In the left panels, the logarithmic levels (solid lines) and the visually estimated long-run growth paths (dashed lines) of the series are shown, whereas in the right panels, we show the corresponding growth rates in percentage terms (solid lines) and the average growth rates over five subperiods of the century (dashed lines).

Figure A.1 (*continued*)

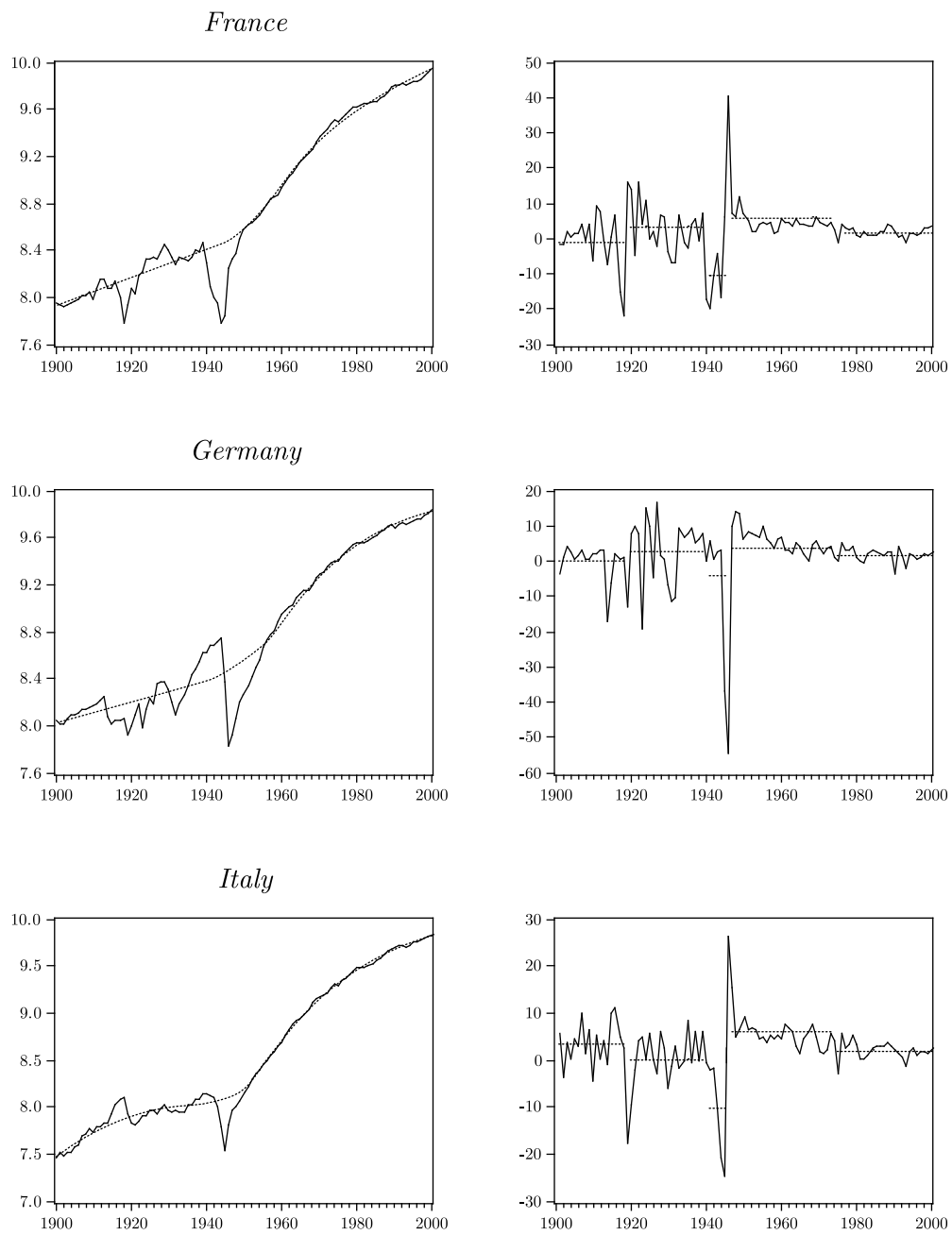
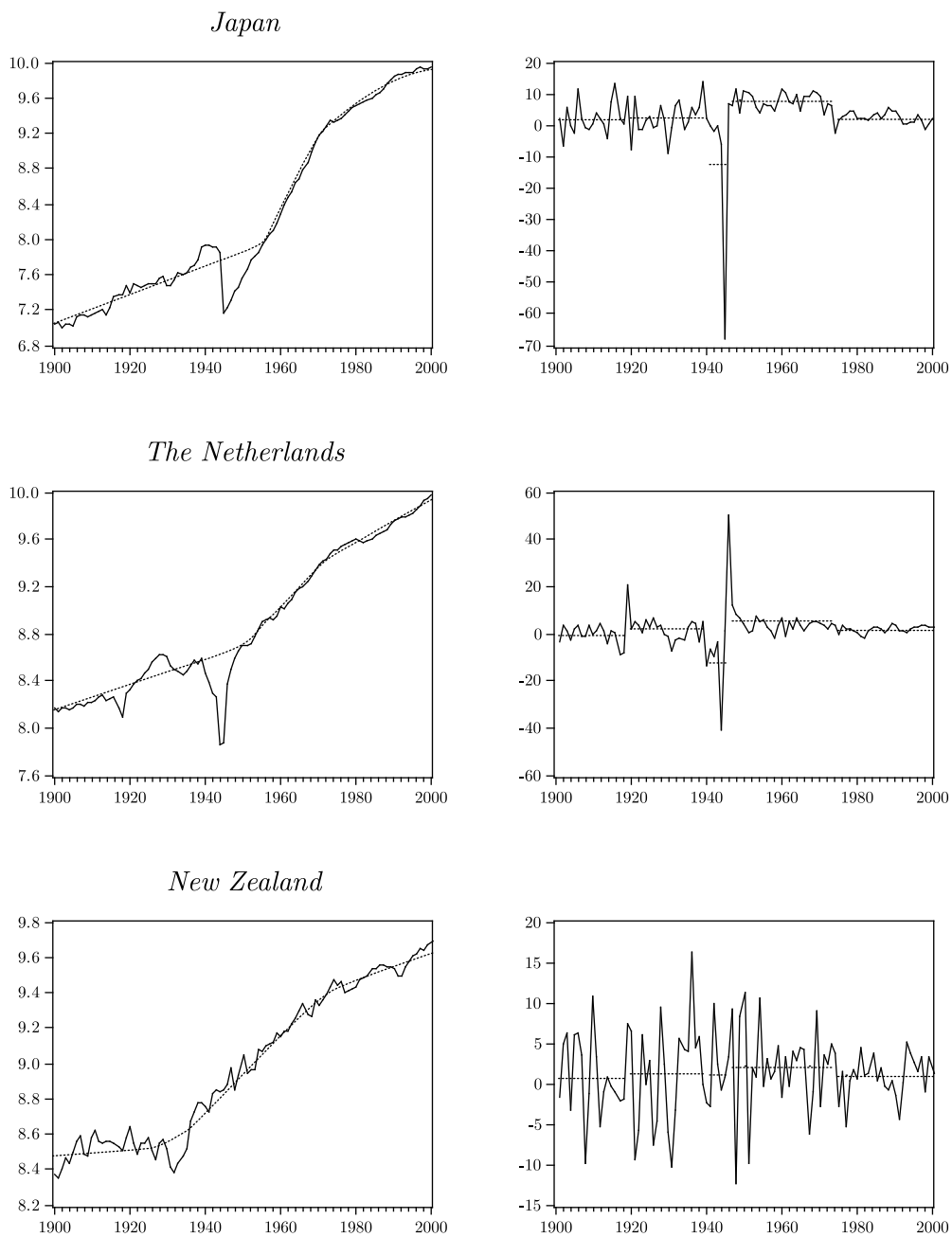


Figure A.1 (continued)

Figure A.1 (*continued*)

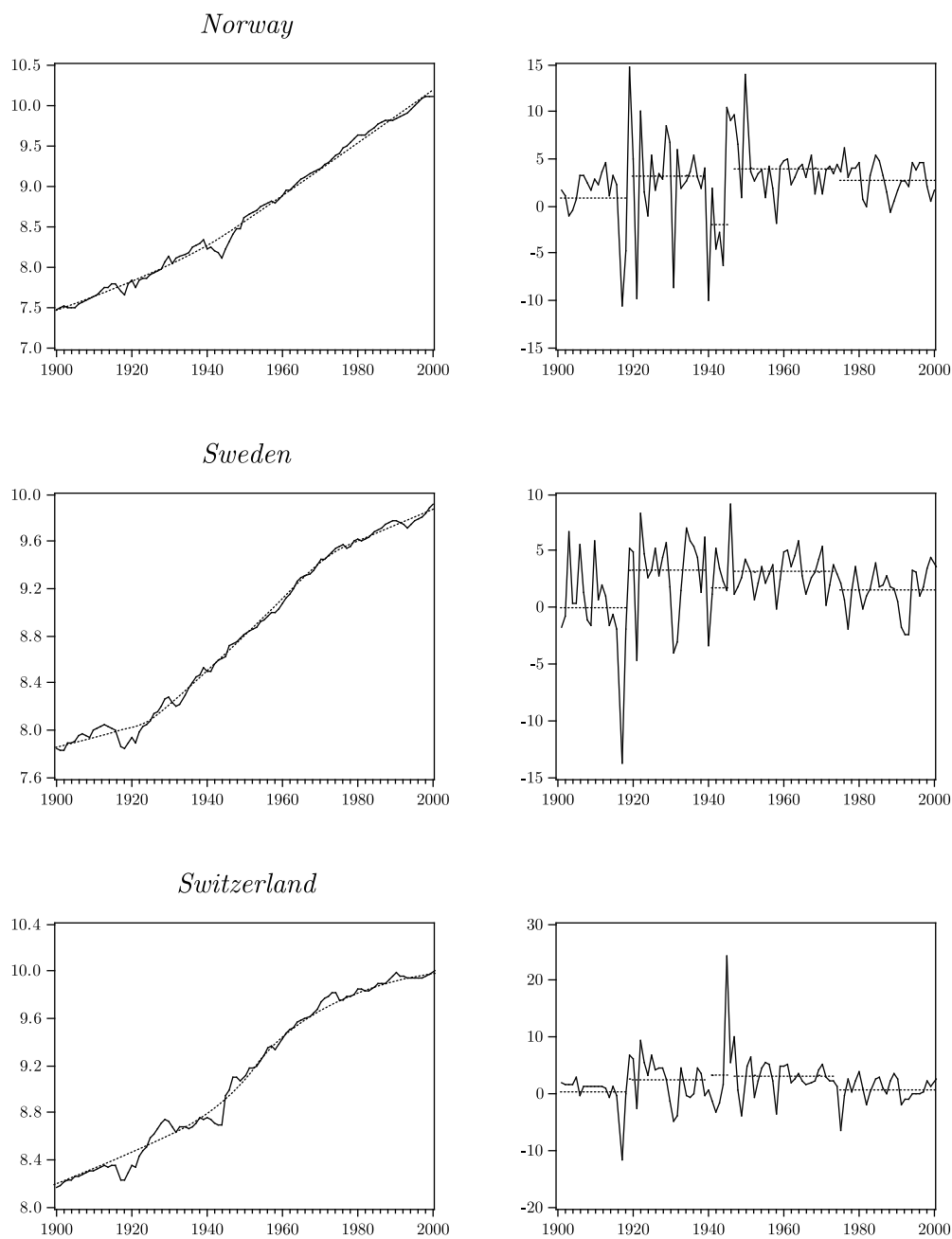


Figure A.1 (continued)

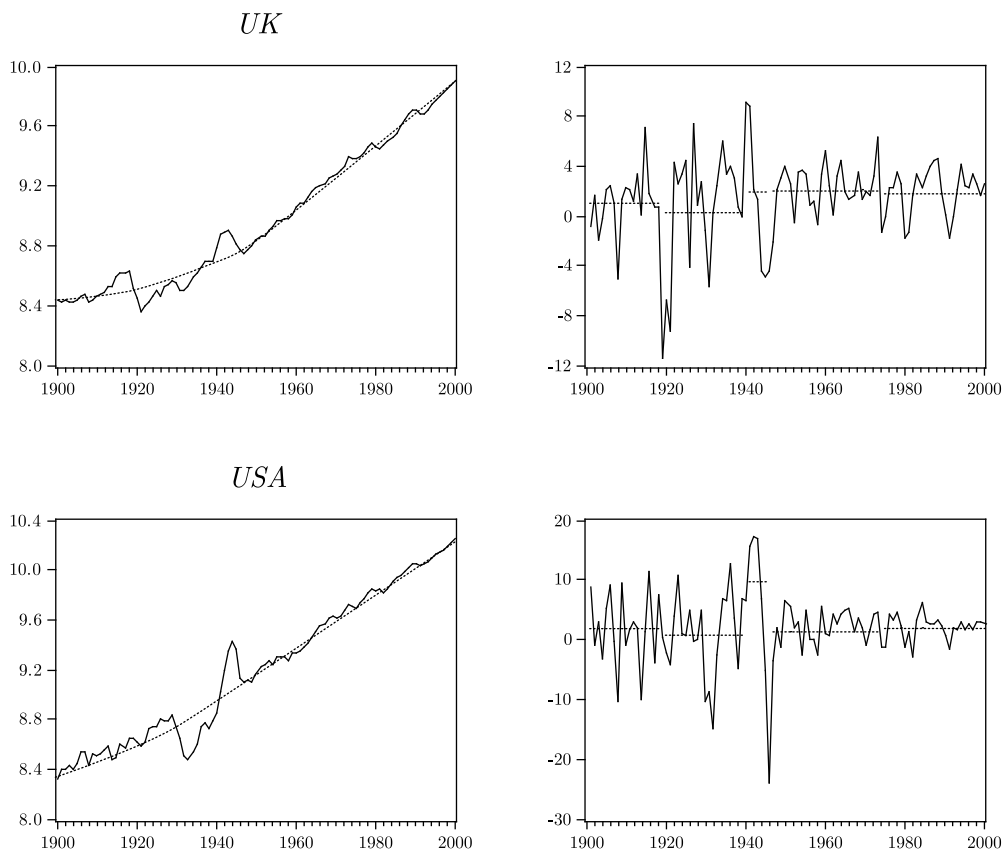


Figure A.1 (*continued*)

A.2 Key Political and Economic Events

The list below provides a chronological overview of key political and economic events in the 20th century:

1901-1918 Liberal Order	
1914-1918	First World War
1919-1939 Roaring Twenties and Dirty Thirties	
1929	Stock market crash (CA, US)
1929-1939	The Great Depression (CA, US)
1940-1945 Second World War	
1940-1945	Second World War
1944	Bretton Woods agreement
1945	Foundation of the United Nations (UN)
1945	Foundation of the International Monetary Fund (IMF)
1946-1973 Golden Age	
1951	Foundation of the later European Union (BE, FR, GE, IT, NL)
1960	Foundation of the Organization of Petroleum Exporting Countries (OPEC)
1971	Collapse of the Bretton Woods system
1973	OPEC oil crisis
1973	Accession of new member states to the EU (DM, UK)
1974-2000 Neoliberal Order	
1975	Anti-inflation act
1979	Foundation of the European Monetary System (EMS)
1989	Free trade agreement between Canada and the USA
1989-1992	Stock market collapse (JP)
1990	Reunion of East and West Germany
1992	Currency crisis, Italy and the UK left the EMS
1995	Accession of new member states to the EU (AT, FI, SE)
1999	Official launch of the Euro (AT, BE, FI, FR, GE, IT, NL)

A.3 Long-run Economic Growth Paths

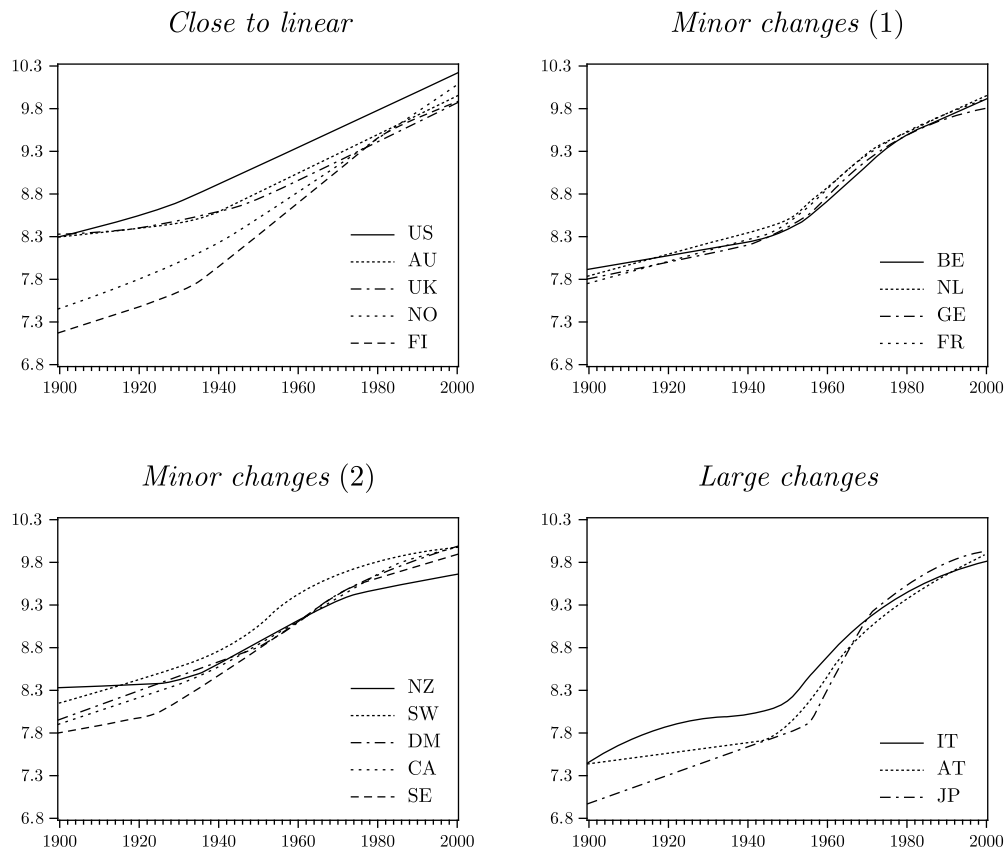


Figure A.2: Visually estimated long-run economic growth paths.

Notes: The growth paths are classified by the number and magnitude of growth adjustments needed. For ease of comparison, the graphs are equally scaled.

A.4 Time-varying Correlations Across Growth Rates

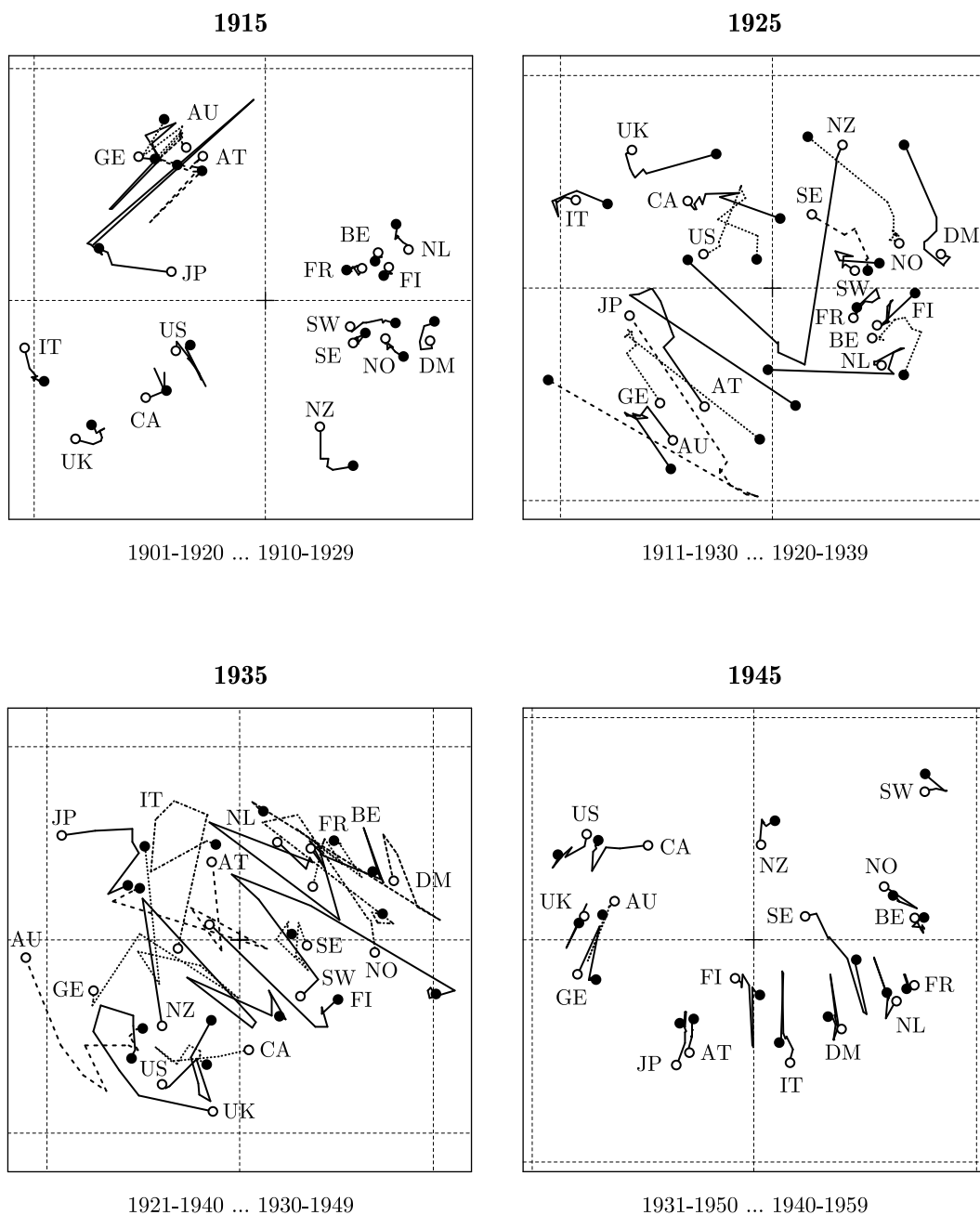


Figure A.3: Frames of the MDS solutions obtained for subperiods of the 20th century.

Notes: The white and black circles represent the first and last positions of countries, respectively, obtained for the subperiods given below each frame. Subsequent positions in between these two points are connected by straight, dashed, or dotted lines. Name labels are shown as close as possible to the first positions. The dashed grid lines represent one unit distances, where the origin is indicated by a cross. At the top of each frame, the midpoint of the window is given.

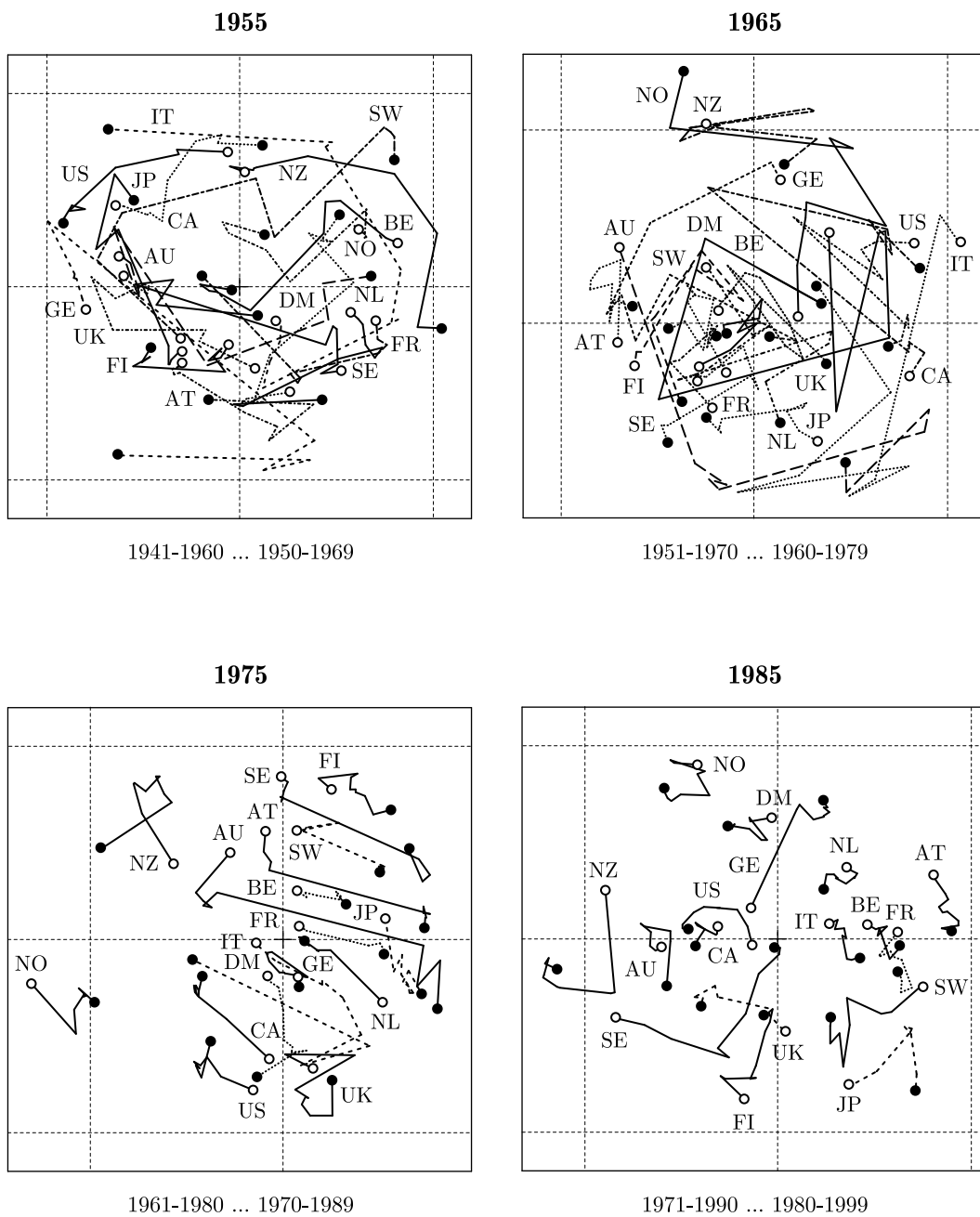


Figure A.4 (continued)

A.5 Results of the Univariate STAAR Model

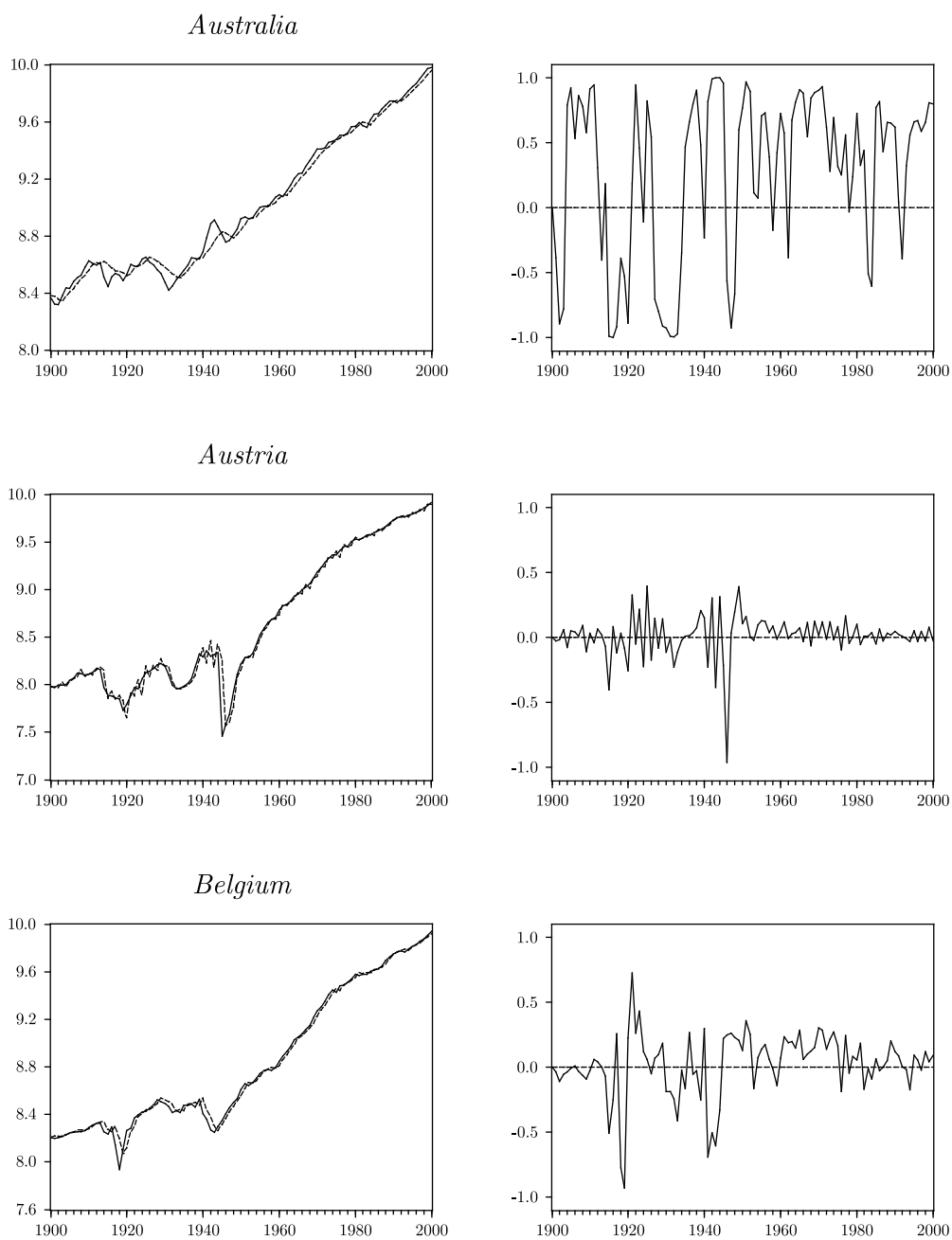


Figure A.4: Estimated trends of the univariate STAAR model.

Notes: In the left panels, the logarithmic real per capita GDP levels (solid lines) and the estimated trends of the univariate STAAR model (dashed lines) are shown, whereas in the right panels, we show the output series of the transition function.

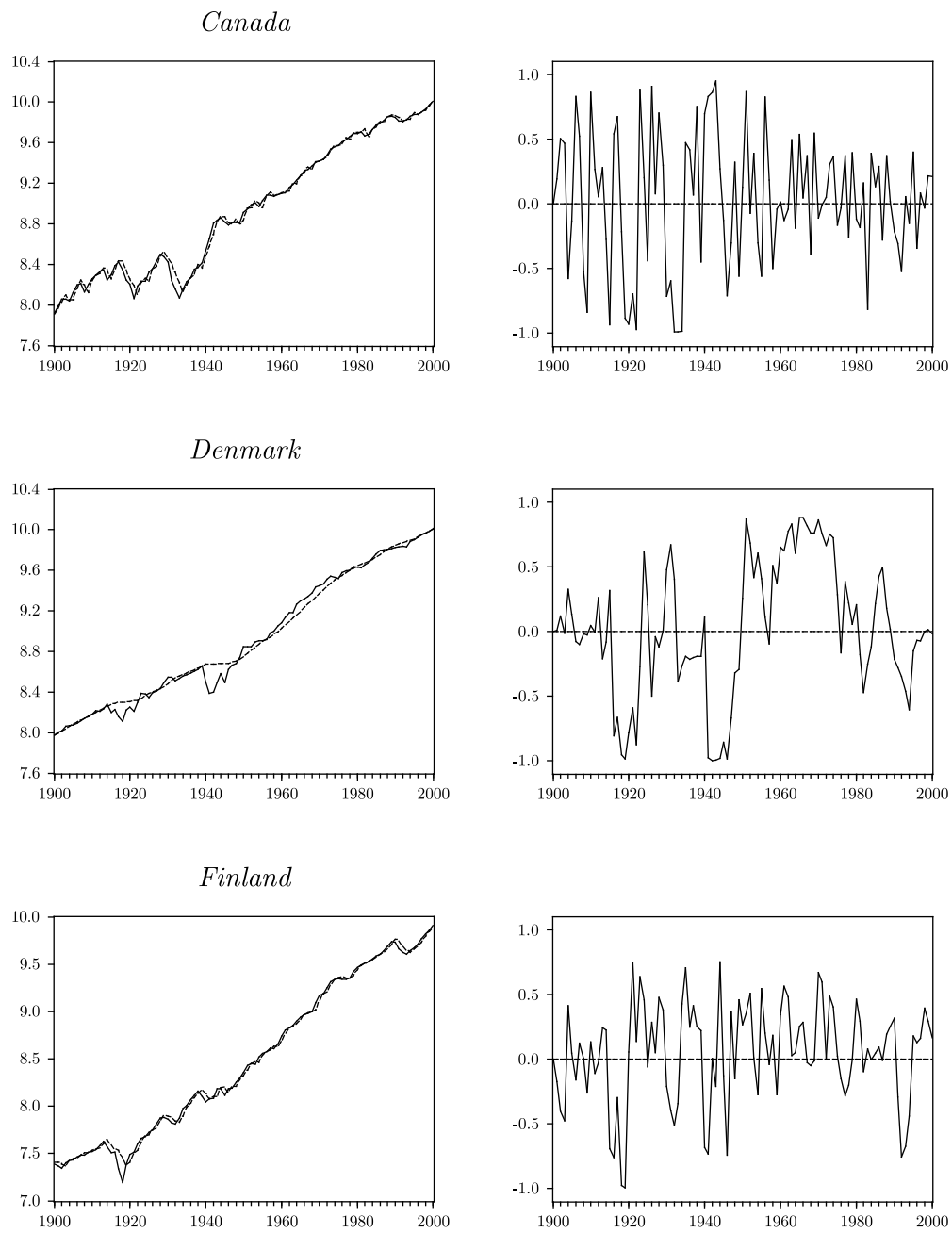


Figure A.5 (continued)

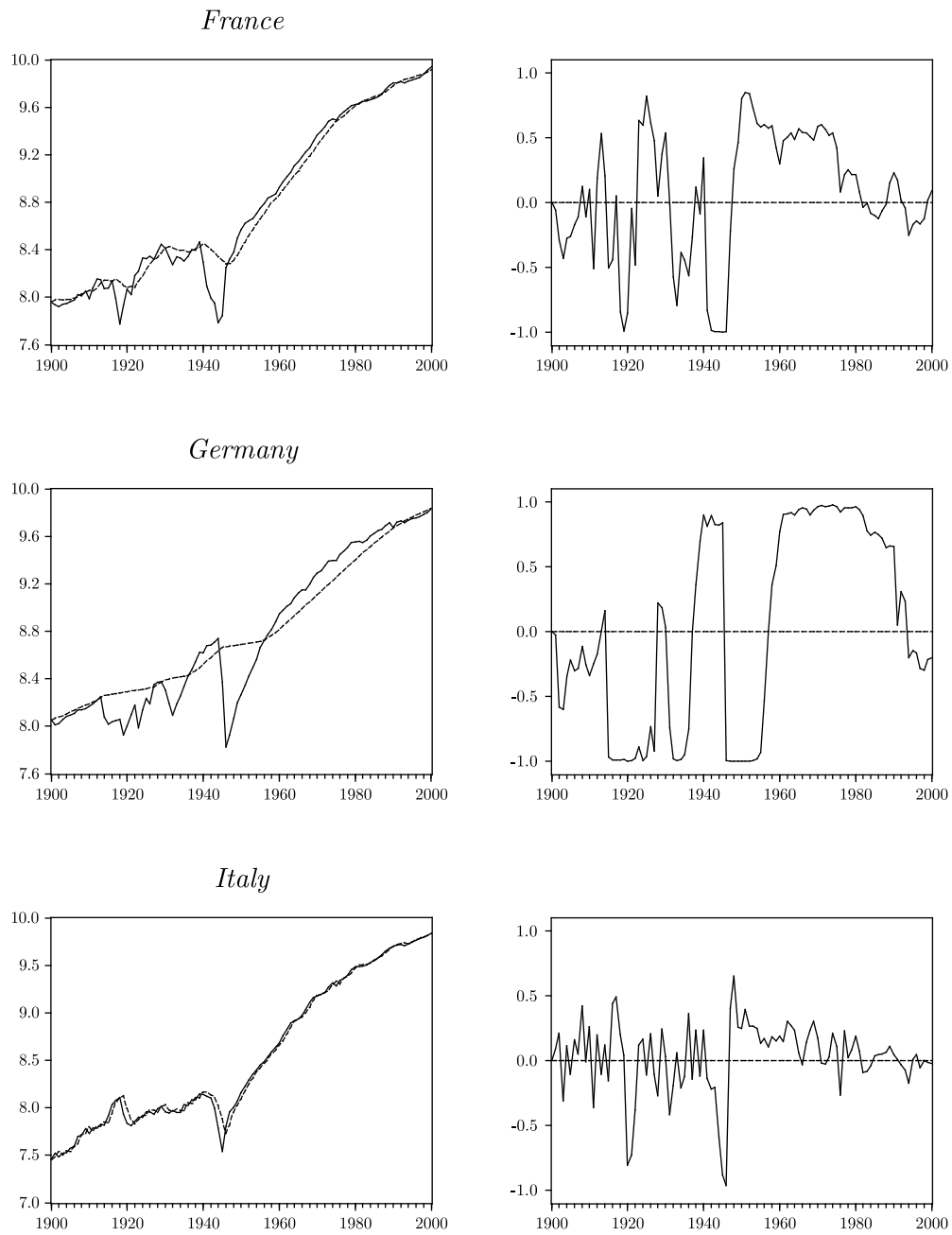


Figure A.5 (continued)

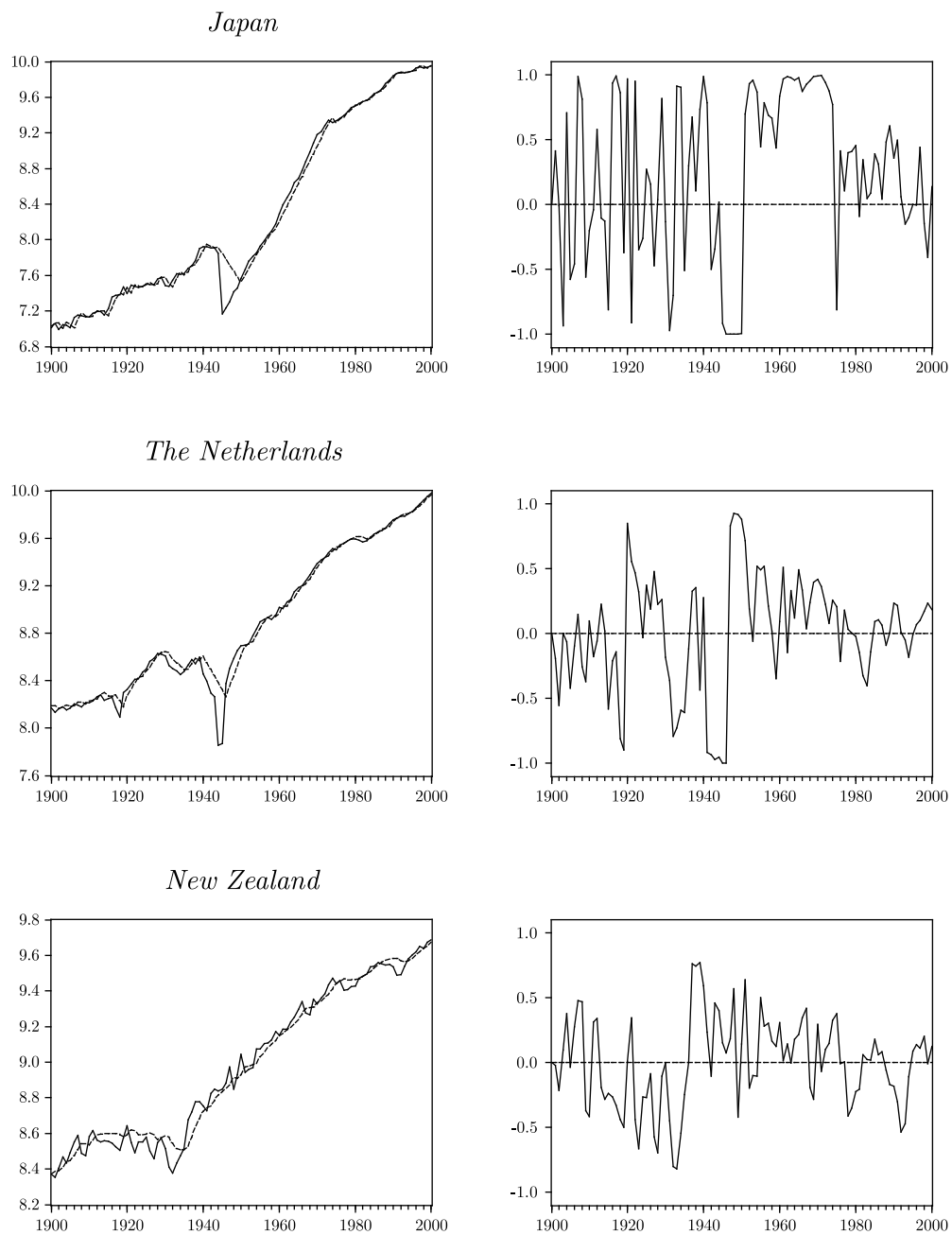


Figure A.5 (continued)

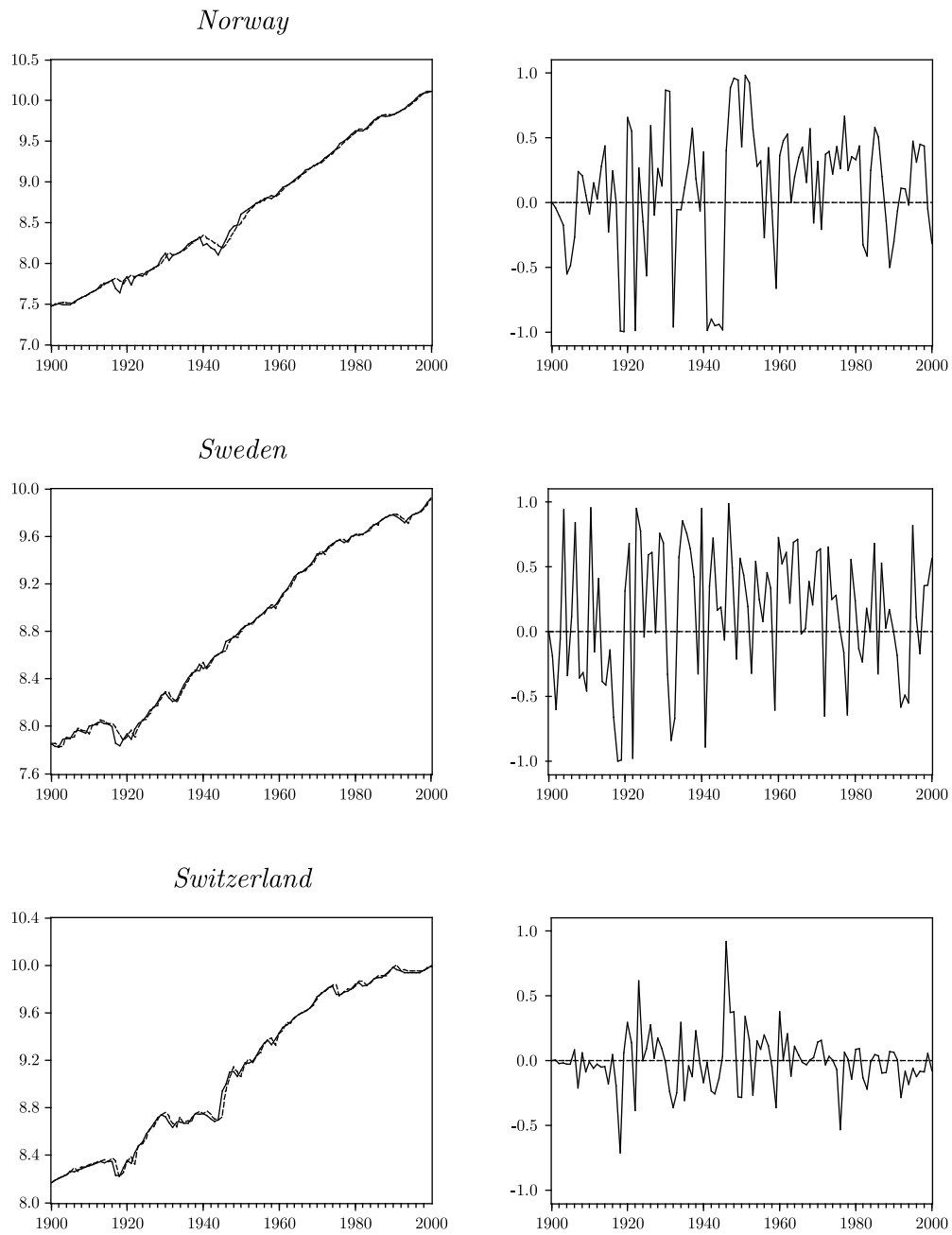
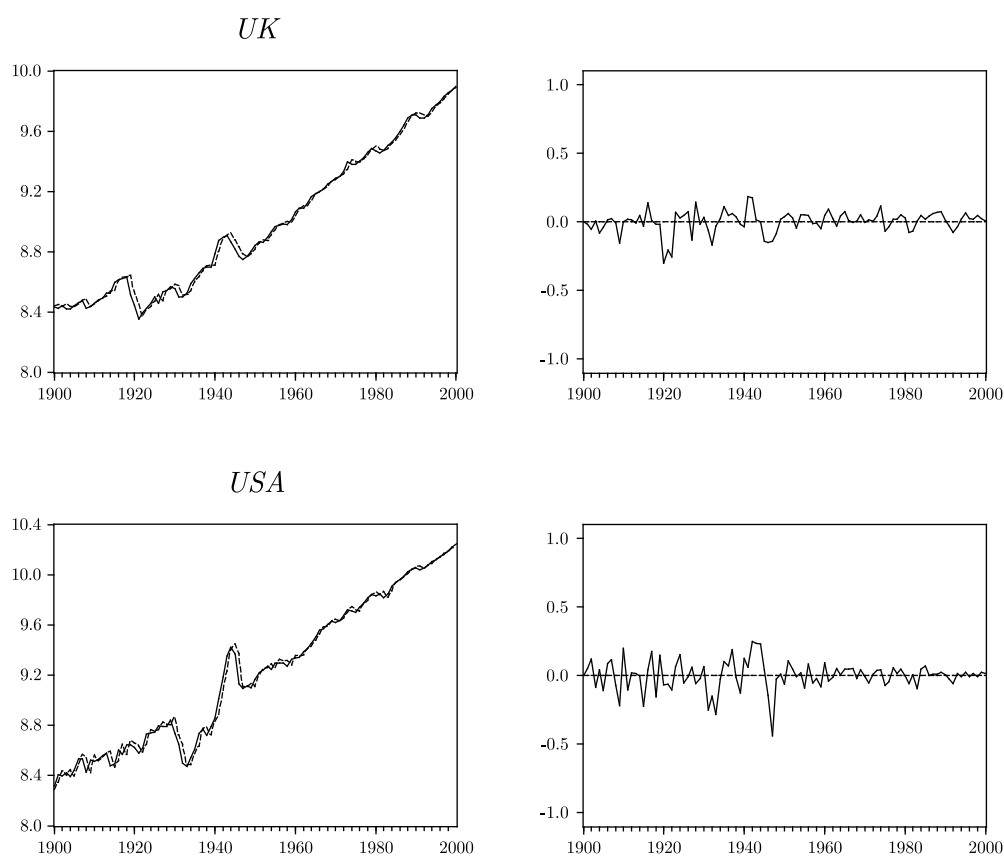


Figure A.5 (continued)

Figure A.5 (*continued*)

A.6 Derivation of the EM Algorithm for Model (5.1)

The complete data likelihood function can be written as:

$$L_c(\Delta \mathbf{y}, \mathbf{s} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2) = \prod_{i=1}^N \prod_{j=1}^J \left(\pi_j \prod_{t=1}^T \phi(\Delta y_{i,t} | \mu_j, \sigma_j^2) \right)^{I[s_i=j]}, \quad (\text{A.1})$$

so that the complete data log-likelihood function is formulated as:

$$\begin{aligned} \ln L_c(\Delta \mathbf{y}, \mathbf{s} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2) &= \sum_{i=1}^N \sum_{j=1}^J I[s_i = j] \ln \pi_j \\ &+ \sum_{i=1}^N \sum_{j=1}^J I[s_i = j] \sum_{t=1}^T \ln \phi(\Delta y_{i,t} | \mu_j, \sigma_j^2). \end{aligned} \quad (\text{A.2})$$

The expectation of this function with respect to $\mathbf{s} | \Delta \mathbf{y}$ is given by:

$$\begin{aligned} \ln \mathcal{L}_c(\Delta \mathbf{y} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2) &\equiv E_{\mathbf{s} | \Delta \mathbf{y}}[\ln L_c(\Delta \mathbf{y}, \mathbf{s} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2)] \\ &= \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \ln \pi_j + \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \sum_{t=1}^T \ln \phi(\Delta y_{i,t} | \mu_j, \sigma_j^2) \\ &= \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \ln \pi_j \\ &\quad - \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \sum_{t=1}^T \left(\ln 2\pi + \ln \sigma_j^2 + \frac{(\Delta y_{i,t} - \mu_j)^2}{\sigma_j^2} \right). \end{aligned} \quad (\text{A.3})$$

To maximize this expectation with respect to $\boldsymbol{\pi}$, $\boldsymbol{\mu}$ and $\boldsymbol{\sigma}^2$, different parts can be considered separately:

$$\max_{\pi_j} \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \ln \pi_j \quad \text{for } j = 1, \dots, J, \quad (\text{A.4})$$

$$\max_{\mu_j, \sigma_j^2} \sum_{i=1}^N \sum_{j=1}^J p_{i,j} \sum_{t=1}^T \ln \phi(\Delta y_{i,t} | \mu_j, \sigma_j^2) \quad \text{for } j = 1, \dots, J. \quad (\text{A.5})$$

The solutions to (A.4) are given by (4.21). Also for the maximization problem in (A.5) it is possible to derive closed-form expressions. The first order conditions of this problem are given by:

$$\frac{\partial \ln \mathcal{L}_c(\Delta \mathbf{y} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2)}{\partial \mu_j} = \sum_{i=1}^N p_{i,j} \sum_{t=1}^T \left(\frac{\Delta y_{i,t} - \mu_j}{\sigma_j^2} \right) = 0 \quad \text{for } j = 1, \dots, J, \quad (\text{A.6})$$

$$\begin{aligned} \frac{\partial \ln \mathcal{L}_c(\Delta \mathbf{y} | \boldsymbol{\pi}, \boldsymbol{\mu}, \boldsymbol{\sigma}^2)}{\partial \sigma_j^2} &= \sum_{i=1}^N p_{i,j} \sum_{t=1}^T \left(\frac{1}{\sigma_j^2} - \left(\frac{\Delta y_{i,t} - \mu_j}{\sigma_j^2} \right)^2 \right) = 0 \\ &\text{for } j = 1, \dots, J. \end{aligned} \quad (\text{A.7})$$

It is now easy to verify that the solutions are given by:

$$\mu_j = \frac{\sum_{i=1}^N (p_{i,j} \sum_{t=1}^T \Delta y_{i,t})}{T \sum_{i=1}^N p_{i,j}} \quad \text{for } j = 1, \dots, J, \quad (\text{A.8})$$

$$\sigma_j^2 = \frac{\sum_{i=1}^N (p_{i,j} \sum_{t=1}^T (\Delta y_{i,t} - \mu_j)^2)}{T \sum_{i=1}^N p_{i,j}} \quad \text{for } j = 1, \dots, J, \quad (\text{A.9})$$

which completes the derivation.

A.7 Results of the Latent Class STAAR Model

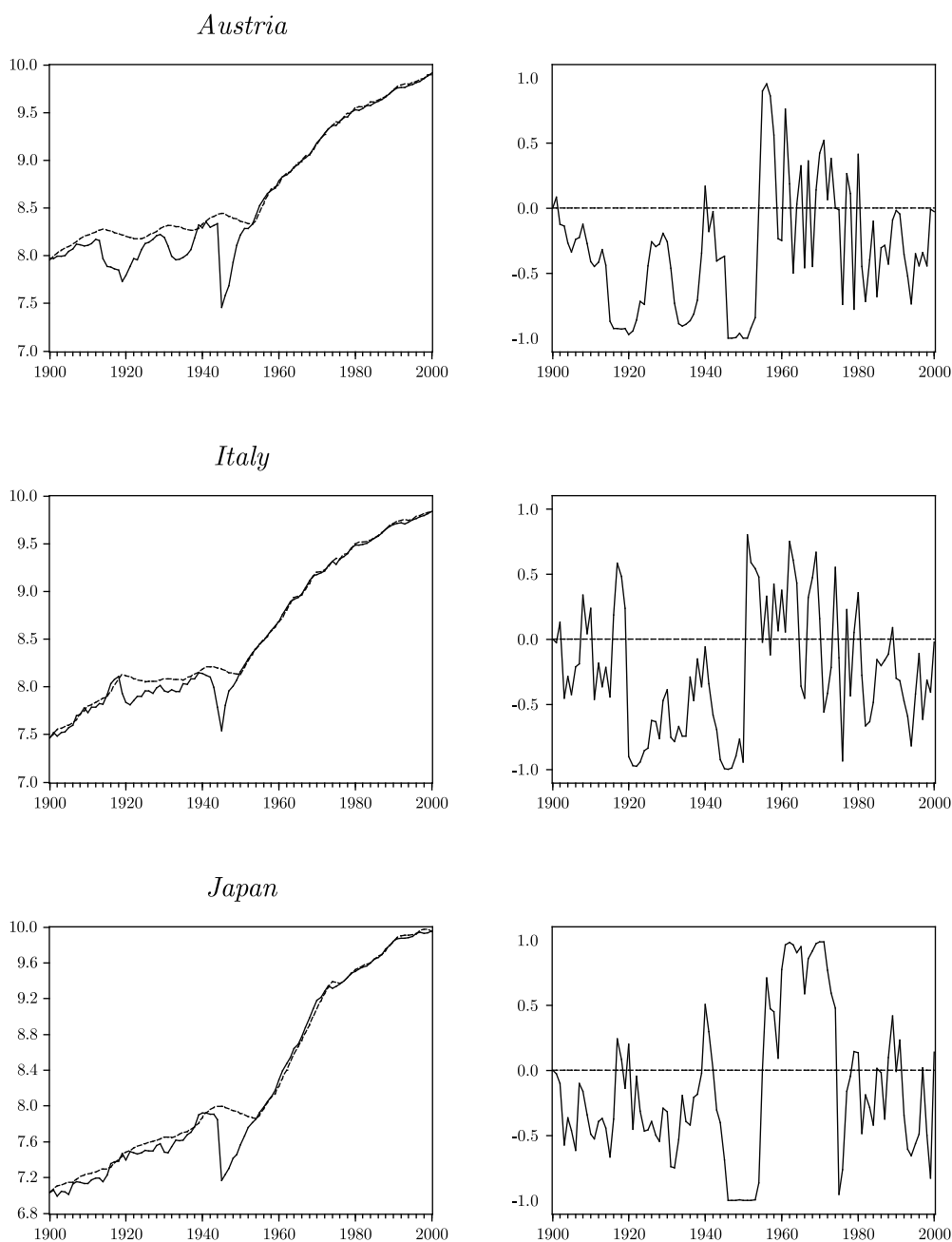


Figure A.5: Estimated trends of the latent class STAAR model for cluster 1.

Notes: In the left panels, the logarithmic real per capita GDP levels (solid lines) and the estimated trends of the latent class STAAR model (dashed lines) are shown, whereas in the right panels, we show the output series of the transition function. To construct the graphs, for each particular country, the cluster specific parameter estimates are used that correspond to the cluster with the highest *ex post* probability of this country.

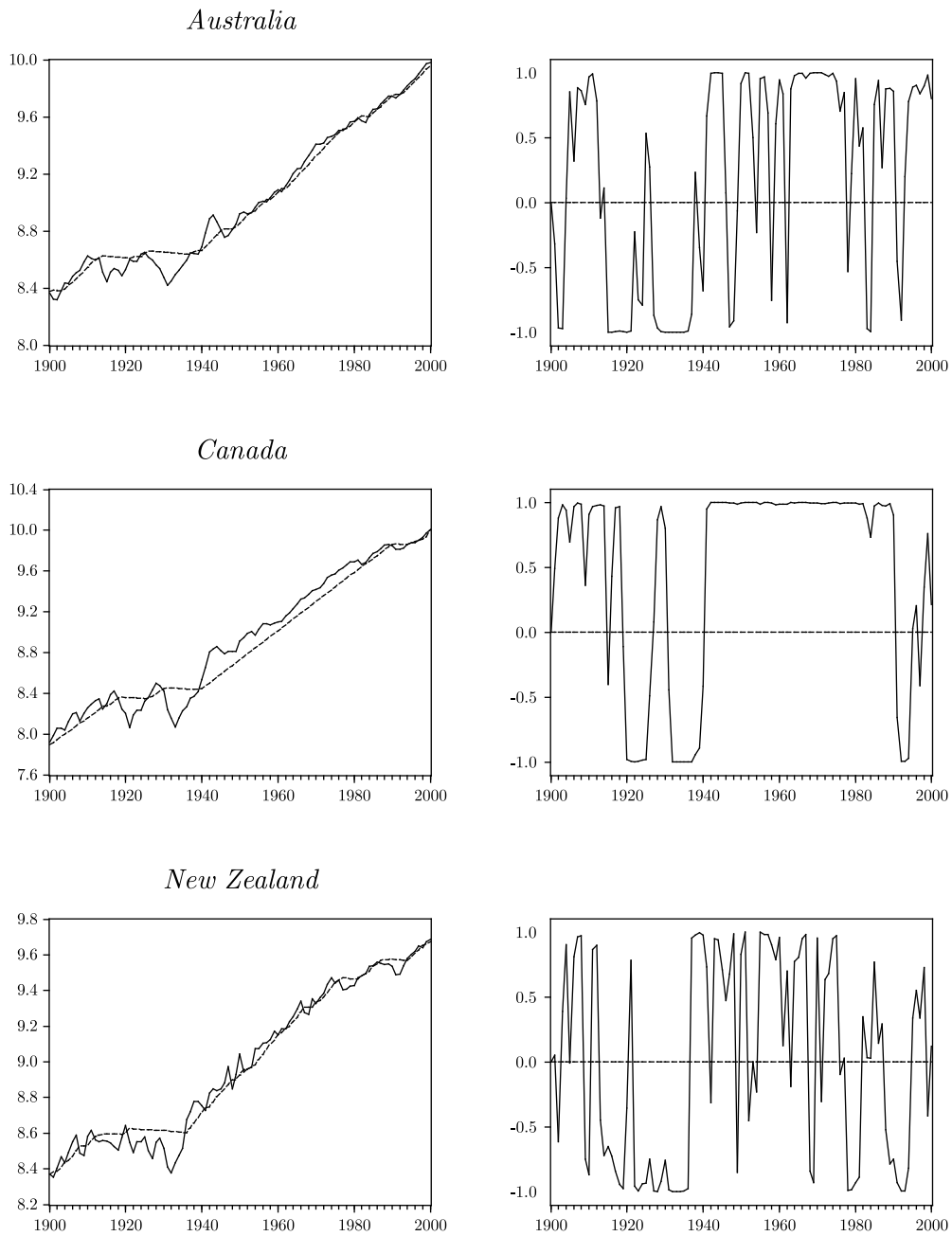


Figure A.6: Estimated trends of the latent class STAAR model for cluster 2.

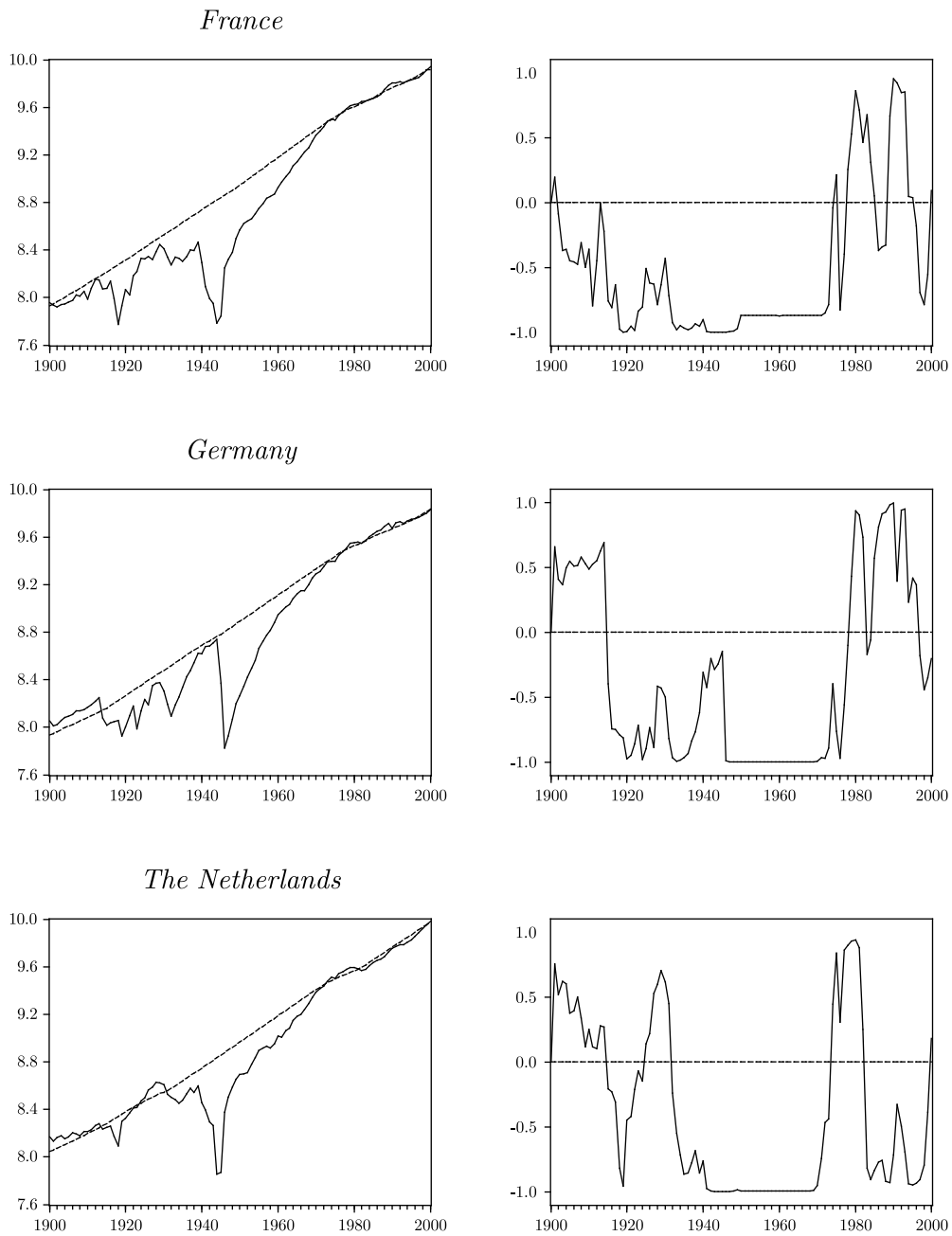


Figure A.7: Estimated trends of the latent class STAAR model for cluster 3.

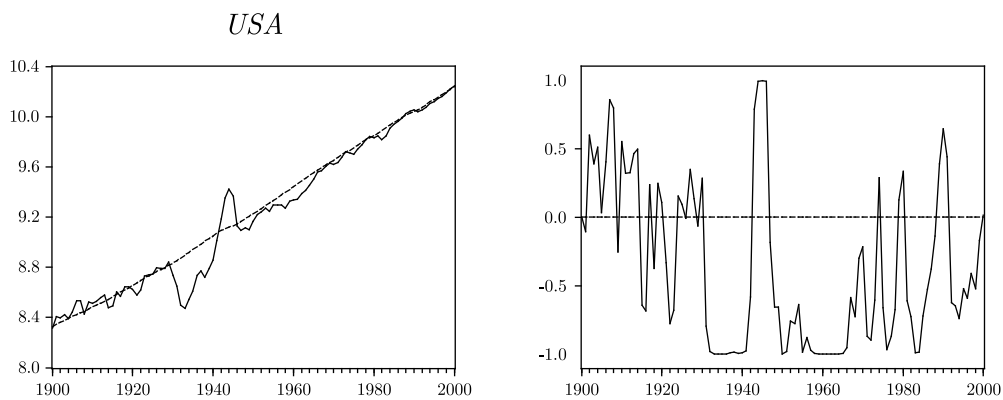


Figure A.7 (continued)

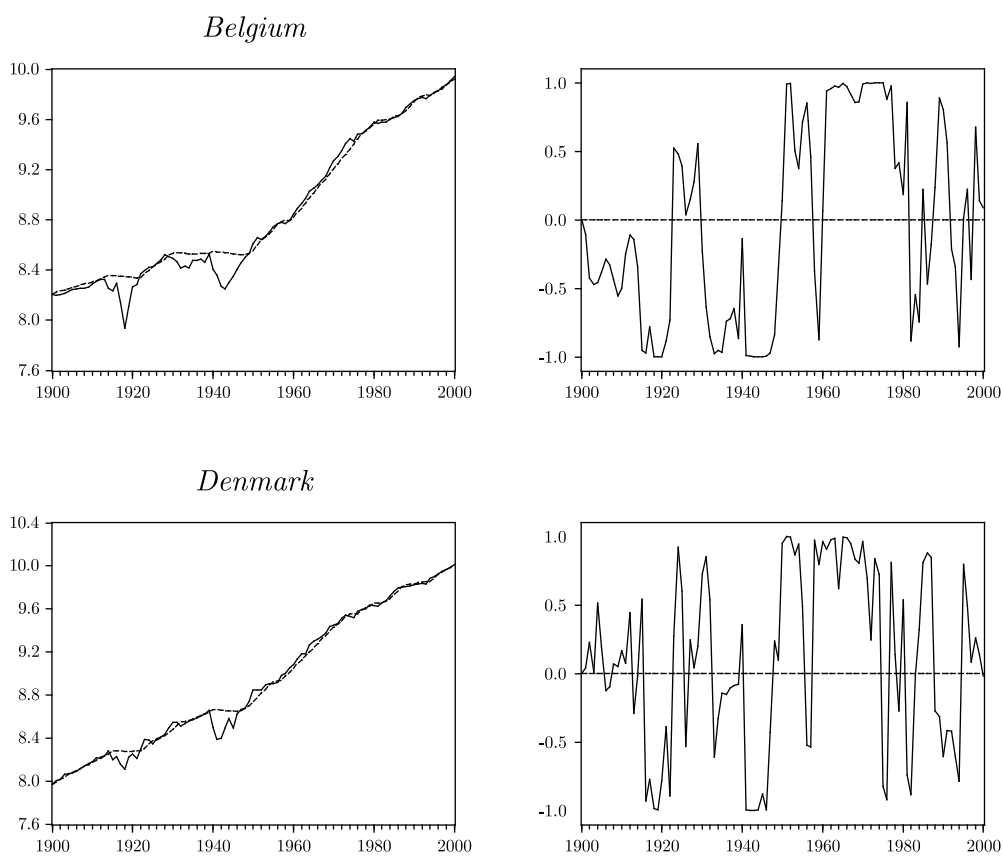


Figure A.8: Estimated trends of the latent class STAAR model for cluster 4.

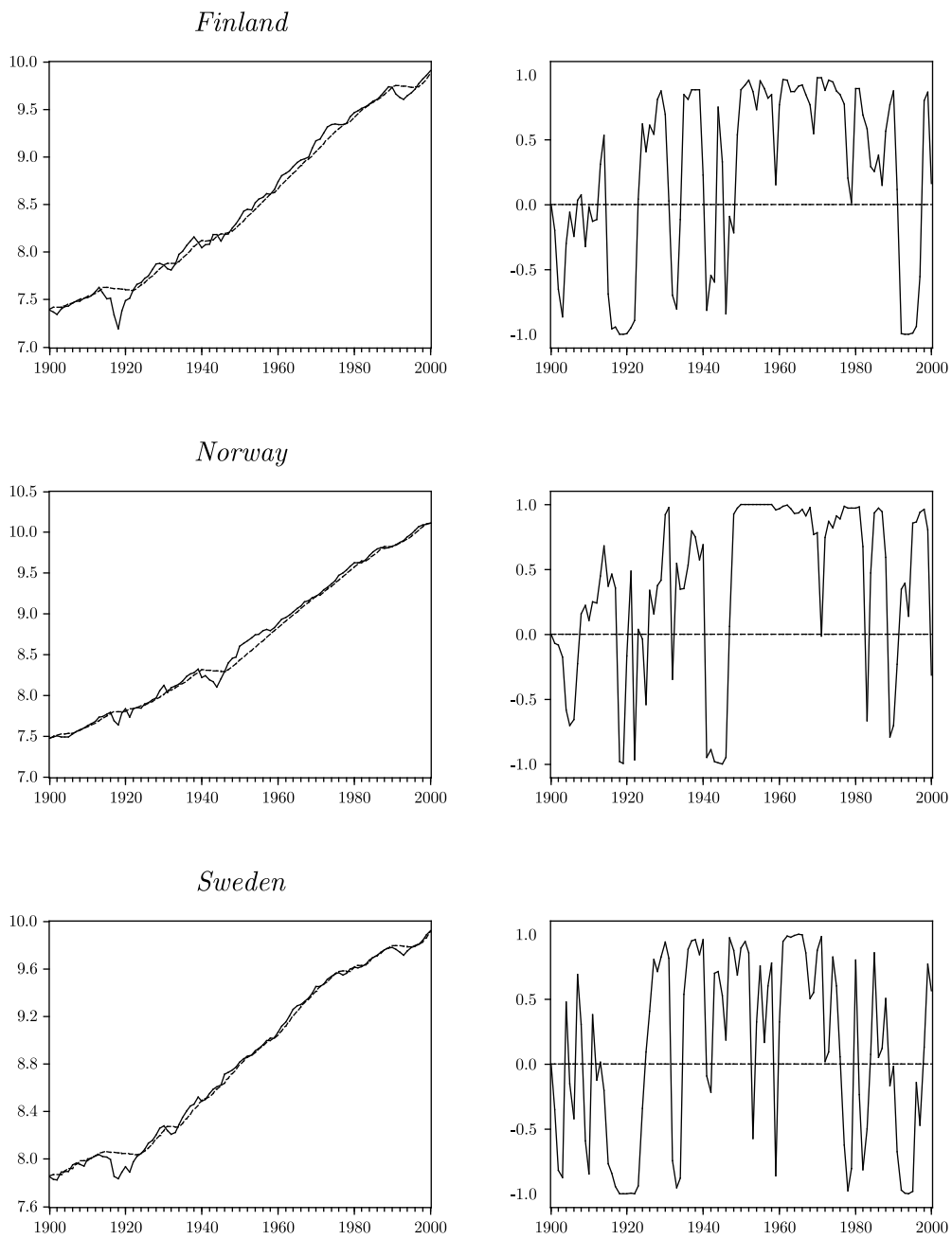
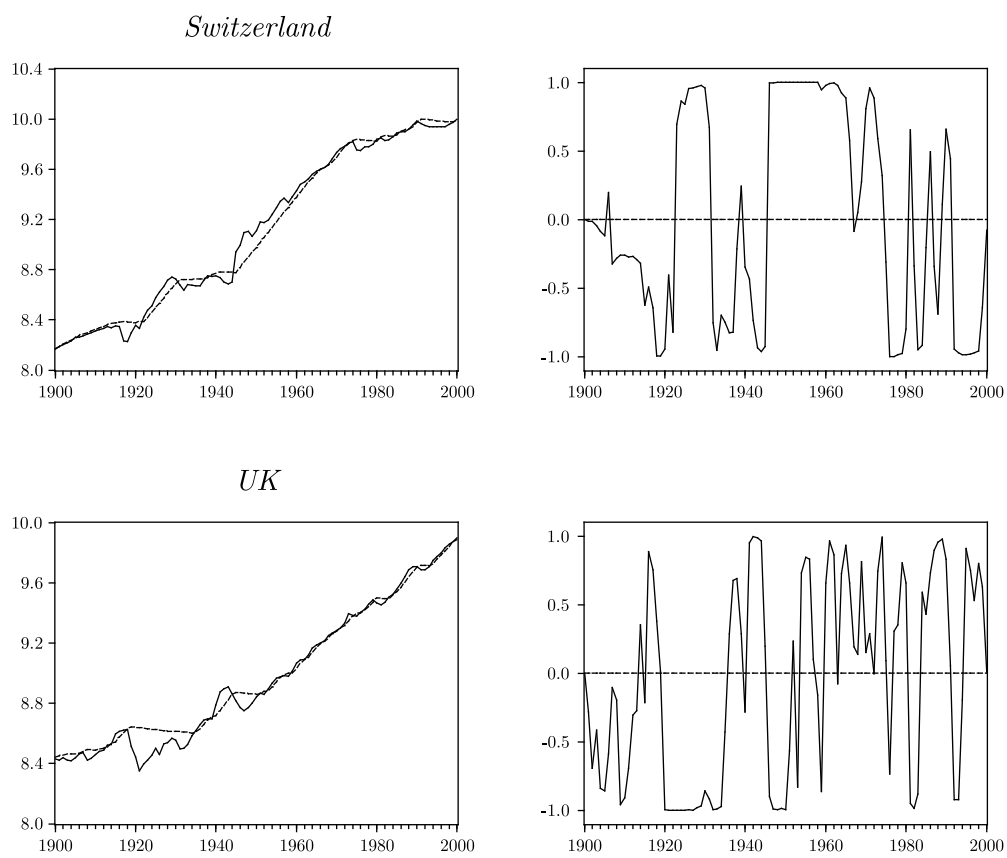


Figure A.7 (continued)

Figure A.7 (*continued*)

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