8 Main Results

This section discusses our main quantitative results. First, it presents the estimates for the parameters that determine the process of structural change. Second, it studies the transitional dynamics of the estimated model and proposes a series of counterfactual exercises to study the different sources of structural change. Third, it shows the important effects of structural change for business cycle fluctuations.

Estimated initial conditions and drifts. Table 3 shows the prior and posterior estimates for the parameters related to structural change. We focus the analysis on the sets of parameters that determine the process of structural change and report the full set of estimated parameters in the Appendix B.[27] The process of structural change is determined by two factors: (i) the initial conditions for the levels of the share of non-tradable consumption, $P_{N,0}C_{N,0}/C_0$, the share of employment in the non-tradable sector, $L_{N,0}/L_0$, the initial level of aggregate unemployment, U_0, and (ii) the drifts that determine the relative fall in the disutility of working (controlled by the parameter $\Delta_{\tilde{\xi}}$),[28] the relative rise in the preferences for consumption of non-tradables (Δ_{γ_N}), and the one-off rise in the level (Δ_κ), persistence (ρ_κ) and volatility (from σ_κ to σ'_κ) of commodity prices.

Priors. We assume normal prior distributions for the initial conditions of the non-tradable consumption and non-tradable employment shares and aggregate unemployment centred around the initial values of the respective data series in the sample. We also set normal prior distributions for sectoral drift parameters, Δ_{γ_N} and $\Delta_{\tilde{\xi}}$. We choose the mean and variance of the priors to account for the observed trends in the non-tradable consumption and non-tradable employment shares. The estimation of the system is highly sensitive to the prior distributions for Δ_{γ_N} and $\Delta_{\tilde{\xi}}$ since they interplay with the size of the persistence and variance of business cycle shocks to match the observed trends. Large and persistent business cycle shocks are needed to replicate the observed change in the trends that is not explained by the estimates for Δ_{γ_N} and $\Delta_{\tilde{\xi}}$.

[27] The estimation of the system involves estimates for habit in consumption, vacancy adjustment costs, and the persistence and standard deviation of stochastic processes. We report those estimates in Appendix B (Table 5).

[28] We estimate a single parameter $\Delta_{\tilde{\xi}}$ that captures the change in both tradable and non-tradable employment preferences and determines the speed of the drifts in those preferences. See the Online Appendix for details.

Table 3: Prior and Posterior Distribution of Structural Parameters

	Prior distribution			Posterior distribution			
Parameter	Distribution	Mean	S.d.	Mean	Mode	5%	95%
Initial Conditions							
$\frac{P_{N,0}C_{N,0}}{C_0}$	Normal	0.511	0.002	0.510	0.510	0.507	0.513
$\frac{L_{N,0}}{L_0}$	Normal	0.596	0.003	0.597	0.597	0.593	0.601
U_0	Normal	0.068	0.005	0.057	0.058	0.050	0.064
Structural Transformation							
$\Delta_{\gamma_N} \times 10^3$	Normal	0.7	0.03	0.705	0.714	0.670	0.737
Δ_{ξ}	Normal	1.9	0.03	1.886	1.884	1.852	1.926
Commodity Prices							
Δ_{κ}	Uniform [-0.25,3]	1.375	0.94	0.318	0.298	0.233	0.408
σ_{κ}	Inv. Gamma	0.1	2	0.062	0.062	0.050	0.076
σ'_{κ}	Inv. Gamma	0.1	2	0.092	0.093	0.076	0.113
ρ_{κ}	Beta	0.5	0.2	0.948	0.953	0.930	0.962

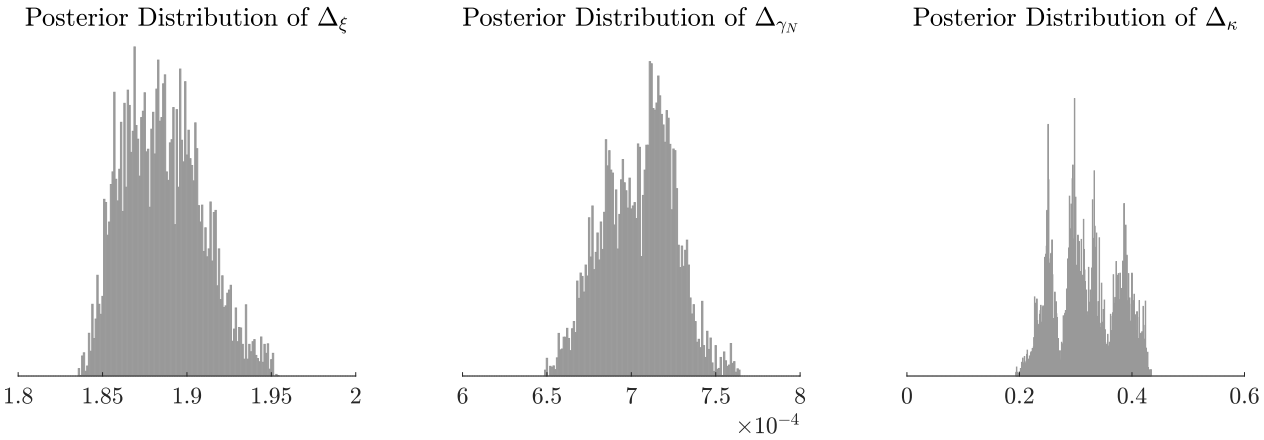
Note: Prior and posterior distribution of estimated structural parameters. We put a prior around $\Delta_{\gamma_N} \times 10^3$, so the values of Δ_{γ_N} reported in the table are multiplies by 10^3.

To remain agnostic about the change in the long-run level of commodity prices, we assume that the prior on Δ_{κ} is a uniform distribution with a wide support, $[-0.25, 3.5]$. The volatilities of commodity prices before and after the break, σ_{κ} and σ'_{κ}, have Inverse Gamma distributions with mean 0.1 and a standard deviation of 2, consistent with the standard priors for the volatility of shocks. Similarly, the persistence parameter of the shock to commodity prices, ρ_{κ}, has a beta distribution with mean 0.5 and standard deviation 0.2, as is standard in related studies. The prior distributions of these parameters allows the model to replicate salient properties of commodity prices in Australia, and are consistent with Kulish and Rees (2017).

Posteriors. The setup of our model makes the posterior estimates informative about the relevance of each source of structural change to the overall process of structural change. When the estimates for Δ_{γ_N} and Δ_{κ} are close to zero and the estimate for Δ_{ξ} is close to 1,

it suggests that that specific source of structural change plays a limited role in explaining overall structural change. Figure 3 shows the posterior distribution for $\Delta_{\tilde{\xi}}$ (left panel), Δ_{γ_N} (middle panel) and Δ_κ (right panel). The posterior mean for $\Delta_{\tilde{\xi}}$ is 1.9 and is bounded away from 1, thus evincing a sizeable shift in preferences towards working in the non-tradable sector and away from working in the tradable sector. The estimated change in the disutility parameters translates into a 13 percentage points increase in the non-tradable employment share and an equivalent 13 percentage points reduction in the share of tradable employment. The posterior distribution for Δ_{γ_N} ranges between 0.670×10^{-3} and 0.737×10^{-3} and is bounded away from zero. The estimate for the posterior mean implies that γ_N increases from 0.447 in the initial period of the sample to 0.534 at the end of the sample.

Figure 3: Posterior Distributions for Structural Change Parameters



Note: Posterior distribution for $\Delta_{\tilde{\xi}}$, Δ_{γ_N}, and Δ_κ.

Our estimation establishes the breaks in the *level* and *volatility* of commodity prices in 2002:Q2 and 2008:Q1, respectively, suggesting that commodity prices experienced structural changes in both level and volatility.[29] The right panel of Figure 3 plots the posterior distribution of the change in level of commodity prices Δ_κ. The mean estimate for Δ_κ of 0.318 implies an increase in commodity prices of about 32% across the two regimes, and the range of values in the posterior distribution is between 23% and 41%, providing evidence of a statistically relevant permanent increase in commodity prices. This permanent increase in the level is detected alongside a permanent and sizable increase in the volatil-

[29] Our timing for the commodity price boom is consistent with Gruen (2011) who considers the start of the boom to be in the June quarter of 2002.

ity of shocks to commodity prices, with its standard deviation increasing from 0.062 to 0.093.

8.1 Estimated perfect foresight transition paths

To assess the ability of our estimated model in replicating the observed trends, and to study the quantitative implications of the distinct sources of structural change, we compute transitional dynamics for the 'Dutch Disease and Structural Change Facts' of Figure 1 from the posterior estimates. We sample 100 draws from the joint posterior estimates and compute the non-stochastic transition path at each draw: the path the economy would have followed in the absence of cyclical shocks but in the presence of structural change, that is $y_t = C_t + Q_t y_{t-1}$.

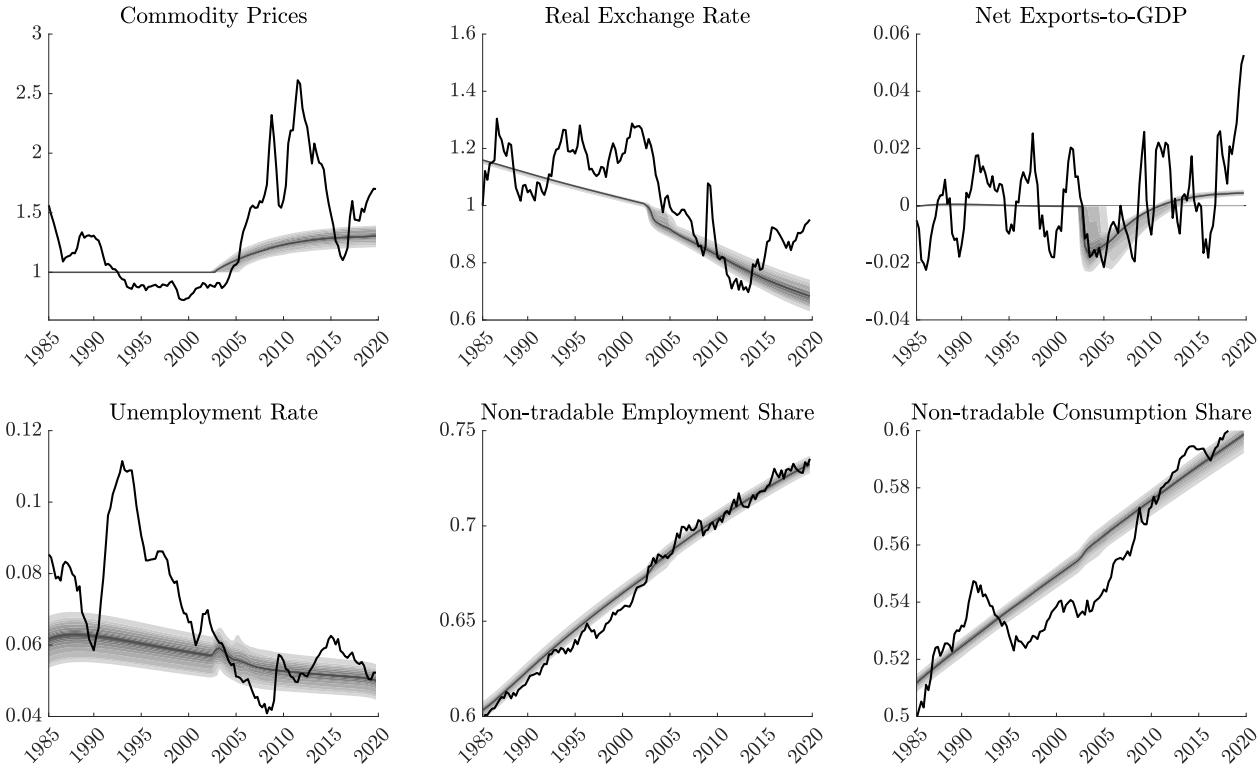
Figure 4 shows the estimated transitional dynamics for commodity prices (top-left panel), the real exchange rate (top-middle panel), net exports-to-GDP (top-right panel), the unemployment rate (bottom-left panel), the non-tradable employment (bottom-middle panel) and non-tradable consumption shares (bottom-right panel). Each entry plots the observed variable (black line) and the non-stochastic transition path (grey line) that encapsulates the joint effect of all the sources of structural change. The shaded area is obtained from the posterior estimates of the model and shows the 95% confidence band for the non-stochastic transition paths.

The figure shows that the different sources of sectoral changes explain the bulk of the trend in the share of non-tradable employment, attributing a limited role to cyclical shocks. Similarly, the estimated mix of structural changes explains a large fraction in the increase of the share of non-tradable consumption, despite requiring large and persistent cyclical shocks to replicate the observed deviation of the series from the trend in the period 1995-2010.

The trend decline in unemployment during the sample period is consistent with the forces of structural change. However, the large increase in the unemployment rate in the decade 1990-2000 results from large and persistent cyclical shocks. Also the permanent increase in the level of commodity prices exerts a mild albeit sudden increase in the trend of the unemployment rate around 2002:Q3, suggesting that movements in commodity prices have a limited effect on unemployment compared to the other sources of structural change. Finally, the permanent increase in the level of commodity prices that began in

2002:Q1, as reflected by the non-stochastic transition path, explains a limited fraction of the increase in commodity prices since mid-2005, while the bulk of price changes is driven by the increase in the volatility of the commodity price shock.

Figure 4: Data and Fan Chart of Estimated Transitional Dynamics

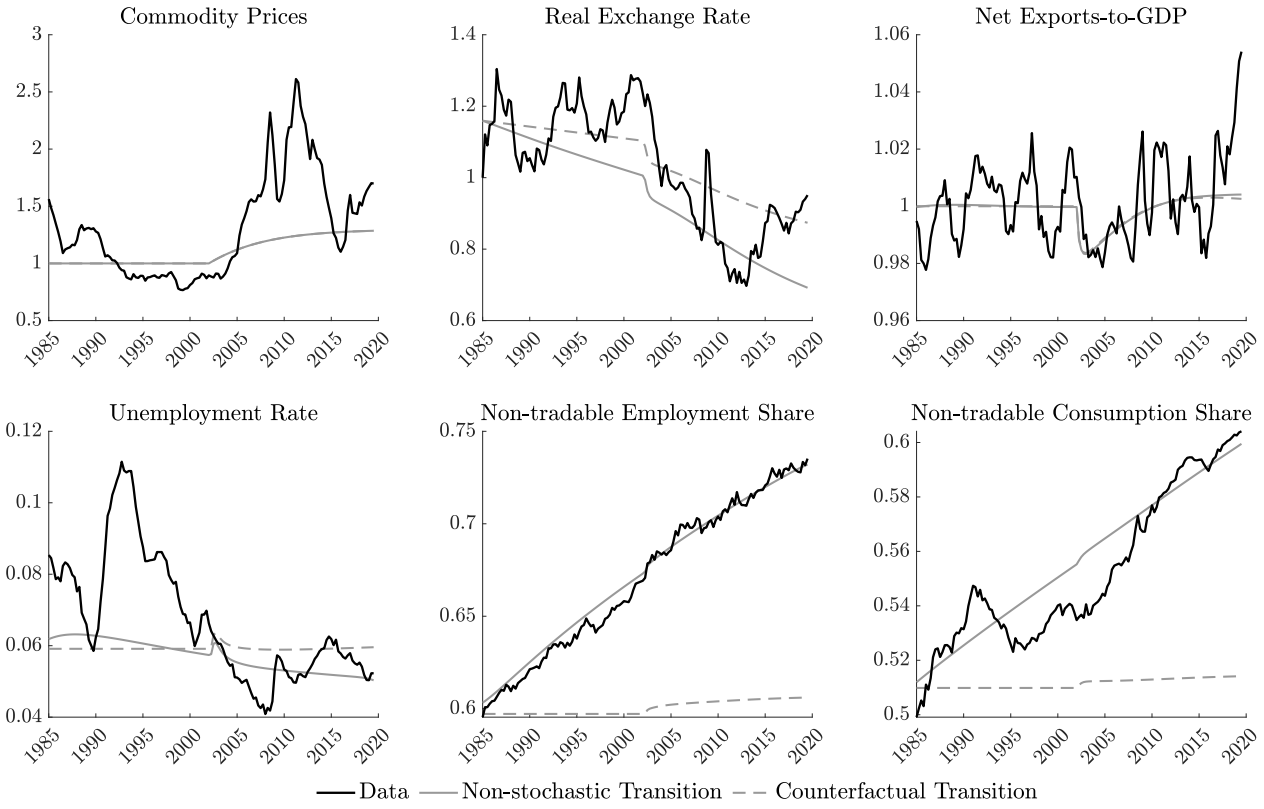


Note: Estimated transitional dynamics for observed variables. Each entry plots the observed variable (black line) and the non-stochastic transition paths (grey lines) determined by the joint effect off all sources of structural change. The shaded area is obtained from the posterior estimates of the model and shows the 95% confidence band for the non-stochastic transition paths.

Decomposing the estimated transitional dynamics. To study the contribution of the distinct sources of structural change to explain the observed trends in the data, we run a series of counterfactual exercises that focus on the effect of each separate source of structural change.

Figure 5 shows the counterfactual scenario (dashed-grey line) that imposes the increase in commodity prices from the estimated posterior distribution as the only source of structural transformation, by fixing $\Delta_\kappa = 0.297$ at the estimated mode, while letting $\Delta_{\xi_N} = \Delta_{\xi_H} = \Delta_{\gamma_N} = \Delta_{\gamma_T} = 0$, against the estimated model with the contemporaneous

Figure 5: Counterfactual Transitional Dynamics with Δ_κ



Note: Counterfactual transitional dynamics for the observed variables. The only source of structural change is the change in the level of commodity prices, by fixing $\Delta_\kappa = 0.297$ at the estimated mode and letting $\Delta_{\xi_N} = \Delta_{\xi_H} = \Delta_{\gamma_N} = \Delta_{\gamma_T} = 0$. The solid-dark line shows the data, the solid-gray line the estimated transitional dynamics, and the dashed-gray line the counterfactual transitional dynamics.

effect of all structural changes (solid-grey line).[30] The figure shows that the estimated one-off increase in commodity prices and the resulting appreciation of the real exchange rate are critical to explain the fall in the net export-to-GDP ratio (top-right panel), as suggested by the almost perfect overlap between the benchmark estimation that accounts for the complete set of forces of structural change and the counterfactual scenario with only the change in commodity prices. At the same time, however, the permanent increase in commodity prices explains little of the sharp rise in commodity prices in the post-2005s. The appreciation of the real exchange rate decreases consumption of domestically-produced tradable goods while raising the consumption of foreign-produced tradable goods that are

[30]Note that the estimated change in the volatility of commodity prices plays no role for the counterfactual exercise since the non-stochastic transition paths rule out the influence of shocks and thus the estimated break in σ_κ, has no impact on those paths.

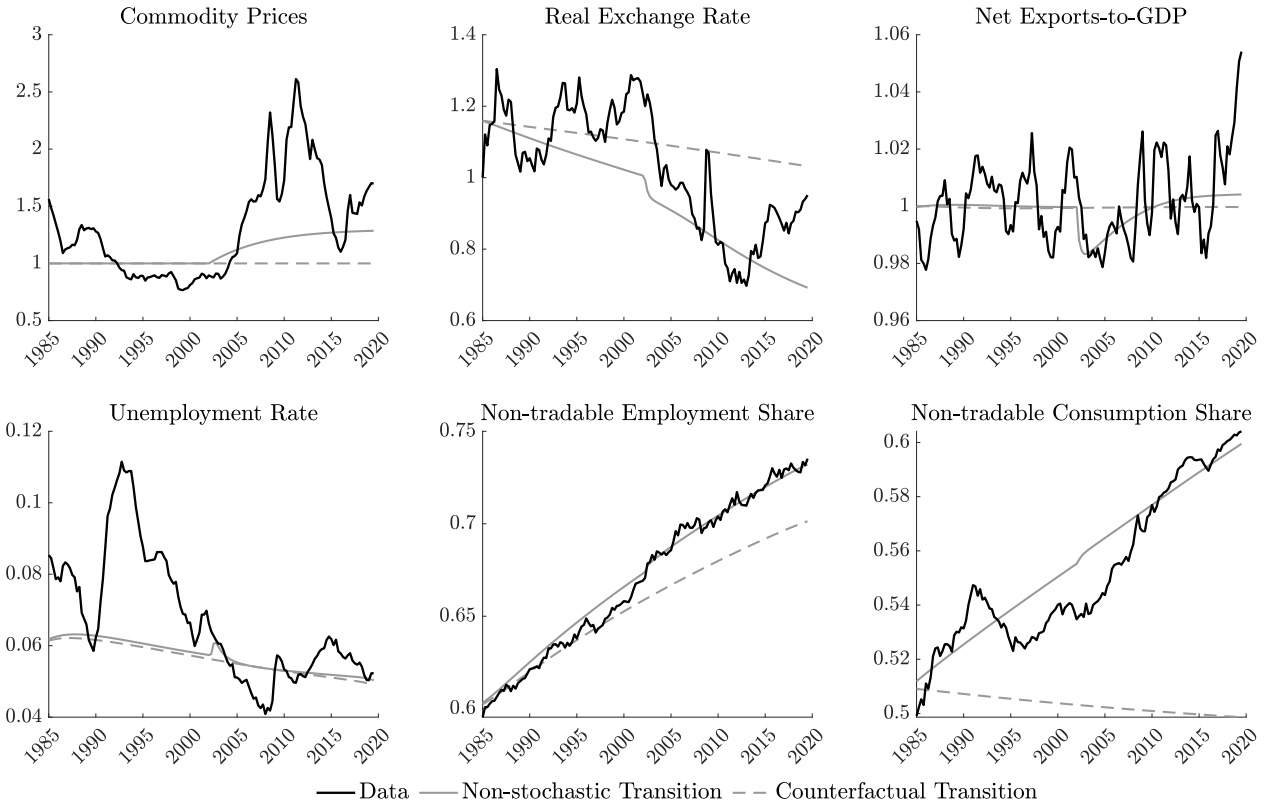
now cheaper to domestic households. Thus, production, hiring and employment decrease for the home-produced tradable goods, leading to a raise in unemployment in the tradable sector that mildly increases the aggregate unemployment rate (bottom-left panel).

The corresponding mild fall in employment in the tradable sector is paralleled by a mild raise in employment in the non-tradable sector, which is insufficient to explain the observed increase in the share of non-tradable employment. Thus, the increase in commodity prices alone is unable to generate the observed increase in non-tradable employment. The increase in commodity prices alone generates a limited rise in the share of non-tradable consumption as revealed by the contained increase in the counterfactual path. The rise in commodity prices and the appreciation of the real exchange rate induce home consumers to substitute domestically-produced with foreign-produced tradable goods that are now cheaper. This substitution between domestically and foreign produced goods contains the increase in non-tradable goods, thus reducing the impact of the real exchange rate on the share of non-tradable consumption. Overall, the increase in commodity prices explains the bulk of fall in the net export-to-GDP ratio, but it is unimportant to explain the observed increase in the shares of non-tradable employment and consumption.

Figure 6 shows the counterfactual scenario (dashed-grey line) that imposes the decrease in the disutility of working in the non-tradable sector and the rise in the disutility of working in the tradable sector as the unique source of structural change, by fixing $\Delta_{\xi_N} = -0.0039$ and $\Delta_{\xi_H} = 0.0106$ at the estimated values, while letting $\Delta_\kappa = \Delta_{\gamma_N} = \Delta_{\gamma_T} = 0$, against the estimated model with the contemporaneous effect of all structural changes (solid-grey line). The fall in the disutility of working in the non-tradable sector leads households to expand labor supply in the non-tradable sector, thus decreasing the sectoral wage and consequently leading to an expansion in hiring and employment in the non-tradable sector. Thus, the share of non-tradable employment robustly rises, capturing the observed increase in the data.

Lower wages in the non-tradable sector lead to a fall in prices in the non-tradable sector that increase consumption of non-tradable goods. Since the elasticity of substitution across goods is less than unitary, the fall in prices leads to the counterfactual fall in the share of non-tradable consumption that is opposite to the observed increase in the share of non-tradable consumption. The changes in the disutility of work have a minimal effect on the real exchange rate and thus play a limited role in explaining movements in

Figure 6: Counterfactual Transitional Dynamics with Δ_{ξ_N} and Δ_{ξ_H}

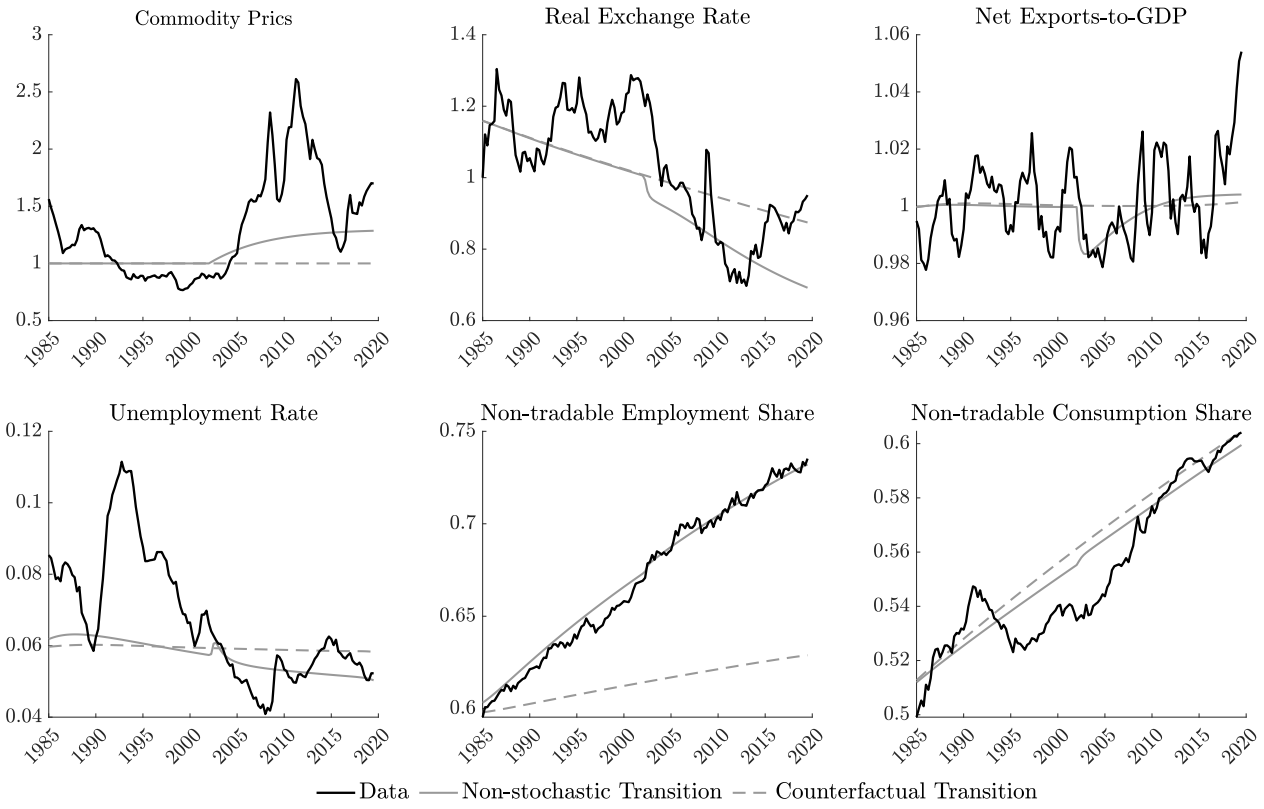


Note: Counterfactual transitional dynamics for the observed variables. The only source of structural change is from the changes in the disutility of working, by fixing $\Delta_{\xi} = 1.884$ at the estimated mode and letting $\Delta_{\gamma_N} = \Delta_{\gamma_H} = \Delta_{\kappa} = 0$. The solid-dark line shows the data, the solid-gray line the estimated transitional dynamics, and the dashed-gray line the counterfactual transitional dynamics.

the net export-share-to-GDP ratio. Overall, the movements in the disutility of working are powerful in explaining the bulk of the increase in the share of non-tradable employment, while they generate a counterfactual fall in the share of non-tradable consumption and have substantially no power in explaining the changes in commodity prices, the real exchange rate, and net exports.

Figure 7 shows the counterfactual scenario (dashed-grey line) that imposes the increase in the preferences for non-tradable consumption in the aggregate consumption basket, by fixing $\Delta_{\gamma_N} = 0.714 \times 10^{-3}$ and $\Delta_{\gamma_T} = -0.714 \times 10^{-3}$ at the estimated mode, while letting $\Delta_{\kappa} = \Delta_{\xi_N} = \Delta_{\xi_H} = 0$, against the estimated model with the contemporaneous effect of all structural changes (solid-grey line). The increase in the preferences for non-tradable consumption goods leads to a rise in the consumption of non-tradable goods and thus

Figure 7: Counterfactual Transitional Dynamics with Δ_{γ_N}



Note: Counterfactual transitional dynamics for the observed variables. The only source of structural transformation is the increase in the preferences for non-tradable consumption, by fixing $\Delta_{\gamma_N} = 0.714 \times 10^{-3}$ at the estimated value and letting $\Delta_{\xi_N} = \Delta_{\xi_H} = \Delta_\kappa = 0$. The solid-dark line shows the data, the solid-gray line the estimated transitional dynamics, and the dashed-gray line the counterfactual transitional dynamics.

production, hiring and employment in the non-tradable sector, which increases the wage and prices in the non-tradable sector. The concomitant increase in the price and the demand of non-tradable goods lead to a raise in the share of non-tradable consumption, while the same wage raise in the non-tradable sector dampens the expansion of employment in the non-tradable sector, as can be seen by the mild increase of the non-tradable employment share that remains greatly lower than the observed increase. Overall, the increase in the preferences for non-tradable consumption is important to explain the bulk of the increase in the share of non-tradable consumption, but it produces a limited increase in the share of non-tradable employment and a mild, counterfactual increase in aggregate unemployment.

Impulse response functions. To study the role of structural change for business cycles shocks, we compare impulse responses at the start and the end of the sample, the two points of the sample for which the structures are most different.

Structural change expands the non-tradable and the commodity sectors while contracting the domestic tradable sector. These changes exert two critical forces for the propagation of shocks: (i) they increase the relevance of shocks in the non-tradable and the commodity sectors for the response of aggregate variables since the size of those sectors increase, while for the same reason they diminish the importance of shocks from the smaller tradable sector, but (ii) they also increase the response of the smaller tradable sector to shocks, since a given shock exerts a larger influence on a small sector, and they reduce the response of the larger non-tradable and commodity sector to the same shock.

To see these opposing forces more clearly in the context of the model, consider the log-linearized version of the aggregate employment equation (24):

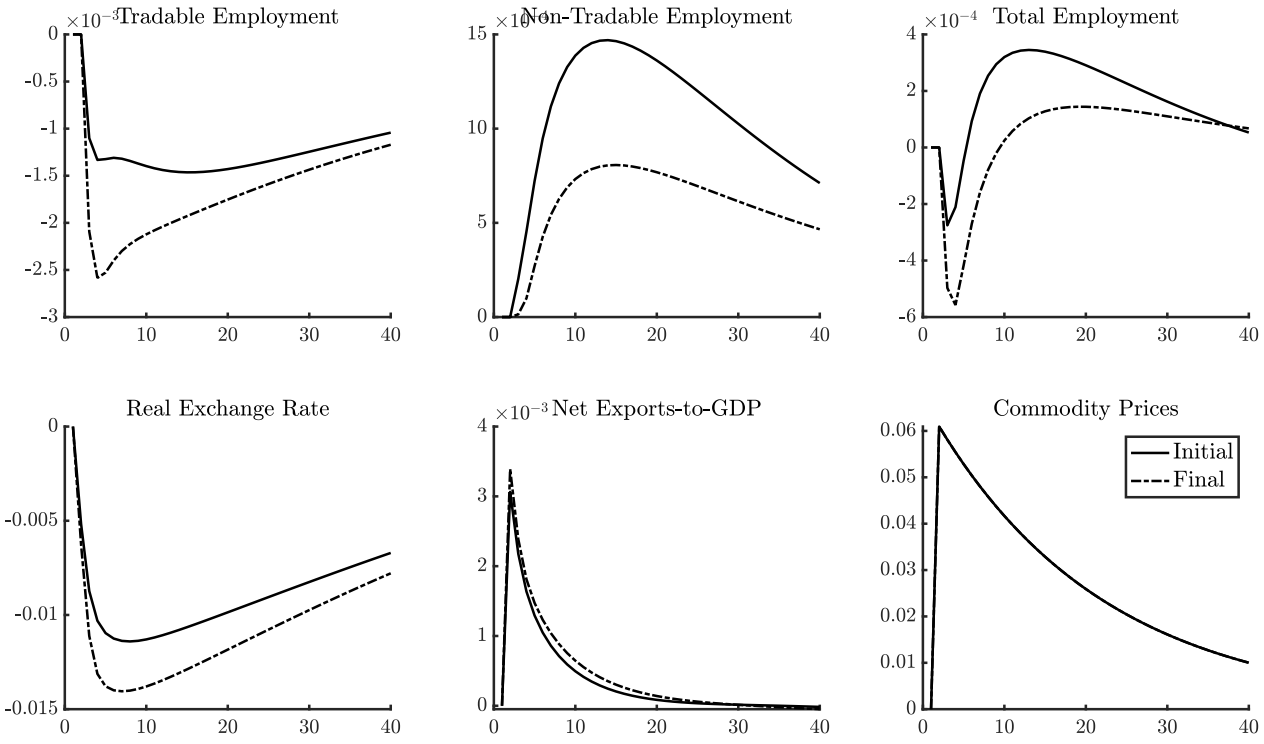
$$\hat{\tilde{L}}_t = \frac{L_H}{L}\hat{L}_{H,t} + \frac{L_N}{L}\hat{L}_{N,t} + \frac{L_X}{L}\hat{L}_{X,t}, \tag{66}$$

where the ratios L_H/L, L_N/L, and L_X/L are the steady state shares of employment in the tradable, non-tradable and commodity sectors, respectively, and the variables with a caret express the percentage deviation of the variable from the steady state. The sectoral change increases the share of employment in the non-tradable and commodity sector from 60.4% and 1.1% to 72.9% and 1.3%, respectively, while it decreases the share of employment in the tradable sector from 38.5% to 25.8%. In addition, the sectoral change also alters the percentage response of the economy from the steady state, increasing the reaction of the variables whose steady state has diminished (i.e., the tradable sector).[31] Our numerical simulations show that the large fall in employment in the contracted tradable sector outweighs the rise in employment in the expanded non-tradable sector, leading to the sharp fall in employment in the tradable sector that determines the decrease in *aggregate* employment to shocks at the end of the period of structural change, despite the significant reduction in the size of the tradable sector and the increase of the non-tradable sector.

Figure 8 shows the impulse response functions for selected sectoral and aggregate variables to a positive shock to commodity prices for the model at the start and at the end of the sample (solid and dashed lines, respectively). The figure shows that the increase in

[31] A similar channel operates in search and matching models with labor market institutions, as shown in Thomas and Zanetti (2009) and Zanetti (2011b).

Figure 8: Impulse Response Functions for a Shock to Commodity Prices



Note: Impulse response function to a commodity price shock. The solid (dashed) line shows the responses from the estimated model at the start (end) of the process of structural change.

commodity prices exerts a larger negative effect on aggregate employment at the end of the sample than at the start. This is driven by a stronger response of the employment in the tradable sector. At the end of the sample, the commodity sector is larger given the higher level of commodity prices, so a commodity price shock has a larger effect on the real exchange rate (lower left panel) which in turn leads to a more pronounced shift towards imported goods and larger contraction of the tradable sector.

Variance decompositions. To study the changes in the role of the cyclical shocks over the process of structural change, we compare variance decompositions at the beginning and at the end of the sample period. Table 4 shows traditional variance decompositions for the estimated model at the beginning and the end of the sample (top and bottom panels, respectively), assuming the parameters at the beginning and at the end were to stay constant. The process of structural change expands the non-tradable sector and contracts the tradable sector, changing the share of fluctuations explained by the shocks across two critical dimensions. First, the structural change that reduces the disutility of working in

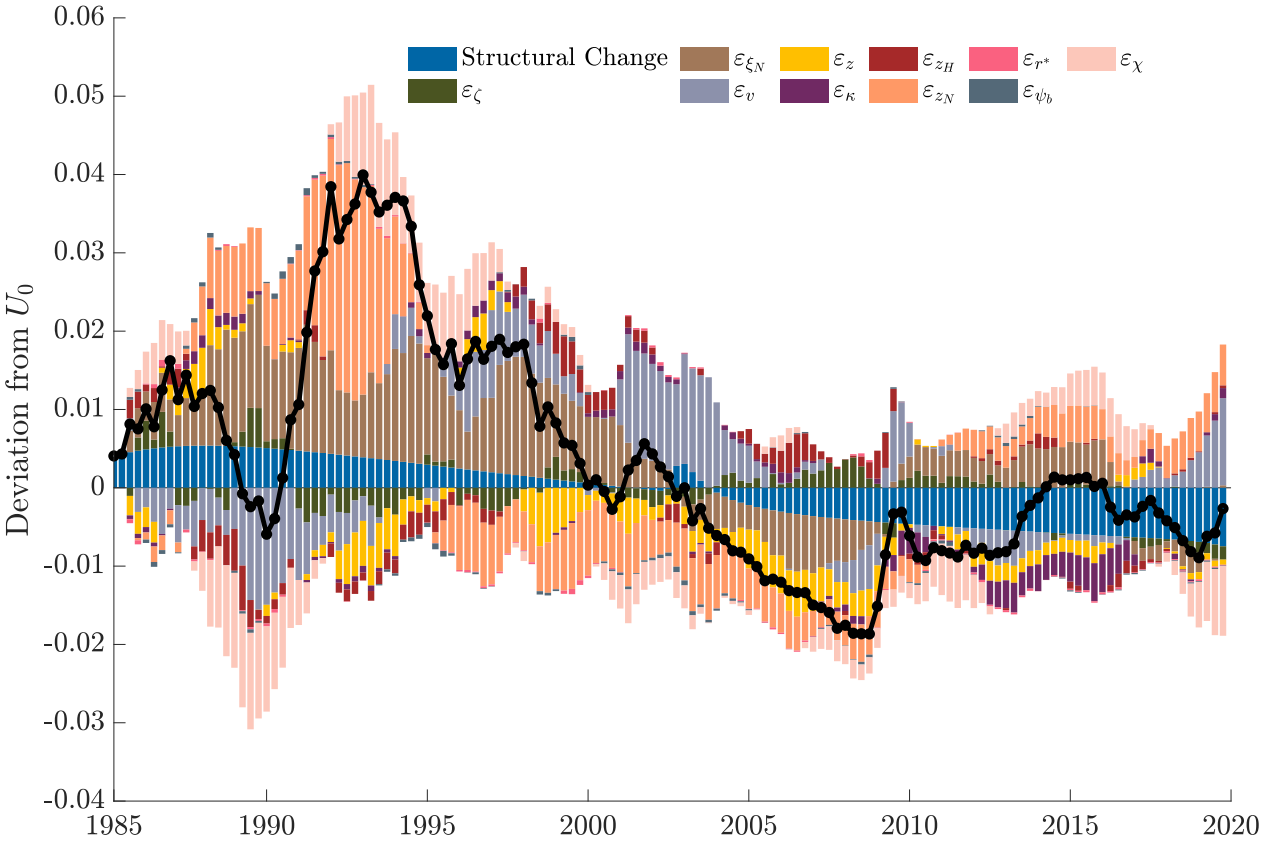
Table 4: Variance Decompositions at the Beginning and End of the Sample

	Shock									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Variable	ε_{ζ}	ε_{ξ_N}	ε_{v}	ε_{z}	ε_{κ}	ε_{z_H}	ε_{z_N}	ε_{r^*}	ε_{ψ_b}	ε_{χ}
Beginning of the Sample										
Consumption growth	50.0	0.2	6.0	30.1	0.3	9.4	3.7	0.1	0.1	0.1
Investment growth	10.2	2.5	45.3	12.2	1.7	5.7	21.3	0.3	0.4	0.2
Net exports-to-Output	4.6	2.1	39.5	8.5	12.0	8.4	21.8	1.3	1.8	0.1
Non-Tradable consumption share	0.7	7.4	16.0	4.2	1.0	18.2	51.8	0.2	0.3	0.1
Real interest rate	0.1	0.2	2.1	0.8	3.9	0.1	2.9	42.1	47.9	0.0
Real exchange rate	2.8	2.1	12.9	8.2	1.1	41.6	30.4	0.3	0.3	0.3
Non-Tradable employment share	0.5	96.1	0.4	0.4	0.8	1.1	0.5	0.1	0.1	0.1
Unemployment rate	0.5	87.0	2.6	2.2	0.2	0.2	4.6	0.0	0.0	2.7
End of the Sample										
Consumption growth	48.5	0.2	7.5	30.5	0.5	6.3	6.3	0.1	0.1	0.1
Investment growth	10.8	0.4	42.0	12.9	4.2	5.0	23.9	0.3	0.4	0.1
Net exports-to-Output	3.2	0.3	32.8	6.8	27.5	5.3	21.8	1.0	1.4	0.1
Non-Tradable consumption share	1.0	2.3	12.4	4.7	2.4	16.6	60.0	0.2	0.3	0.1
Real interest rate	0.1	0.1	1.9	0.8	9.6	0.1	2.8	39.6	45.1	0.0
Real exchange rate	3.0	0.2	11.8	9.1	3.2	29.1	42.8	0.3	0.3	0.2
Non-Tradable employment share	1.0	86.4	2.2	2.8	3.3	2.7	1.3	0.1	0.2	0.1
Unemployment rate	0.6	75.2	5.2	2.7	1.3	1.0	5.5	0.0	0.0	8.4

Note: The variance shares are reported in per cent.

the non-tradable sector also reduces the importance of the shocks to disutility of working in that sector. This can be seen by the reduction in the share of fluctuations accounted by the labour supply shock (ε_{ξ_N}) in column (3). Second, the relative larger size of the non-tradable sector makes shocks to this sector more important than those to the tradable sector to explain the movements in the variables. For instance, consider the effect of sectoral shocks to technology in the tradable and non-tradable sectors, in columns (7) and (8), respectively. The share of fluctuations explained by the technology shocks to the tradable sector (ε_{z_H}) decreases for most variables from the beginning of the sample (top panel) to the end of the sample (bottom panel). Similarly, the share of fluctuations explained by the technology shocks to the non-tradable sector (ε_{z_N}) increases across most variables from the beginning of the sample (top panel) to the end of the sample (bottom panel).

Figure 9: Historical Variance Decomposition: The Unemployment Rate



Note: Historical variance decomposition of the unemployment rate 1985-2020. 'Structural Change': joint forces of structural change; ε_{ξ_N}: shocks to preferences to non-tradable goods; ε_z: shocks to aggregate productivity; ε_{z_H}: shocks to productivity in the home sector; ε_{r^*}: shocks to foreign real interest rate; ε_χ: shocks to matching efficiency in the labor market; ε_ζ: shocks to preferences; ε_v: shocks to marginal efficiency of investment; ε_κ: shocks to commodity prices; ε_{z_N}: shocks to productivity in the non-tradable sector; ε_{ψ_b}: shocks to risk premium.

Historical variance decomposition of unemployment. Figure 9 shows the historical contribution of each shock (different colors) and the three combined sources of structural change (blue color) to the unemployment rate over the period 1985-2020.

The cyclical shocks explain the bulk of the historical movements in the unemployment rate over period 1985-2004, while structural change entails a gradual reduction in the unemployment rate over time. The negative contribution of structural change to the unemployment rate towards the end of the sample period is driven by the reduction of unemployment for the large expansion of the non-tradable sector. The positive contribution of the structural change to the unemployment rate around 2004 is driven by the estimated permanent increase in the level of commodity prices. Also the relevance of commodity

price shocks (purple color) is larger towards the end of the sample, resulting from the increased estimated volatility in commodity prices.

9 Conclusion

We considered the effect of a boom in commodity prices on unemployment in a model of the business cycle that accounts for structural change manifested in the expansion of the non-tradable sector and the contraction of the tradable sector. Our analysis employed a novel Bayesian approach to estimate and separate the contribution of the distinct structural and cyclical forces to the observed movements in the data.

Our application considered Australia, a prototypical open economy rich in natural resources. We find that while permanent changes in the level and volatility of commodity prices generated a reallocation of resources from the tradable to the non-tradable sector and the sharp fall in net exports corresponding to Dutch disease, the long-run decline in unemployment is primarily driven by the gradual reduction in the disutility of working in the non-tradable sector. Similarly, the secular increase in the share of consumption for non-tradable goods is driven by gradual changes in preferences towards these goods instead of being the direct result of the real exchange rate appreciation related to Dutch disease. We conclude that ongoing structural change must be considered to study the response of an open economy to commodity prices and the dynamics of Dutch disease.

To the best of our knowledge, we are the first study to develop a quantitative open economy model that sheds light on the interaction between structural change and business cycle dynamics. The expansion of the non-tradable sector increases the relevance of the sector for the propagation of the cyclical shocks, and it increases the response of the reduced tradable sector to cyclical shocks.

There are several fruitful avenues for future research. First, a direct link between structural change with the distinct trends in the preference for working in the different sectors is indicative of important secular shifts in the value of work and leisure of workers, consistent with the recent studies on structural changes in the labor supply and value of home work in Buera et al. (2019), and Ngai et al. (2022). A careful study of the microfoundation for these changes would certainly be an important avenue for future research. Second, the source of structural change in our analysis is exogenous, and we jointly estimate structural changes with business cycle shocks to achieve the best match of the data. However,

an alternative approach would be to assume that structural change arises endogenously from the growth of income with non-homothetic preferences and productivity differentials. One could consider adapting our methods to estimate models of structural transformation, building on the recent studies by Buera et al. (2020) and Rubini and Moro (2019).

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A Data Sources

This section describes the data used to estimate the model.

Population: Quarterly gross domestic product in chain volume measure (ABS Catalogue 5206.001) divided by quarterly gross domestic product per capita also in chain volume measure (ABS Catalogue 5206.001).

Consumption per capita: Quarterly private consumption in chain volume measure (ABS Catalogue 5206.002) divided by population. The series enters in first difference in estimation with its sample mean adjusted to match that of real output growth.

Investment per Capita: Quarterly gross fixed capital formation in chain volume measure (ABS Catalogue 5206.002) divided by population. The series enters in first difference in the estimation.

Net exports-to-GDP ratio: Net exports-to-GDP is computed as exports-to-GDP less imports-to-GDP. Exports-to-GDP is quarterly exports in current price measure divided by quarterly gross domestic product in current prices. Imports to-GDP is quarterly imports in current prices divided by quarterly gross domestic product in current prices (ABS Catalogue 5206.003). The sample mean of this series is removed prior to the estimation.

Domestic real interest rate: 90-day bank bill rate (RBA Bulletin Table F1). The nominal interest rate is converted to a real rate using the trimmed mean inflation series (RBA Bulletin Table G1). The monthly series is converted into quarterly frequency by arithmetic averaging.

Real exchange rate: Australian Real Trade-Weighted Index (RBA Bulletin Table F15). The series enters in first difference in the estimation.

Unemployment rate: Monthly Australian unemployment rate (ABS Catalogue 6202.001). The monthly series are converted into quarterly frequency by arithmetic averaging.

Non-tradable consumption share: Non-tradable consumption share is computed as the ratio of nominal non-tradable consumption to aggregate nominal consumption. Non-tradable consumption includes the consumption categories: Rent, Electricity, Gas & Water, Operation of Vehicles, Transport Services, Education, Hotels, Cafes & Restaurants, Insurance & Financial Services as well as Healthcare and Other Households Services (ABS Catalogue 5206.008). The series enters in first difference in the estimation.

Non-tradable employment share: Non-tradable employment share is computed as the ratio of non-tradable employment to aggregate employment. Non-tradable employment is defined as the sum of Utilities, Construction, Retail Trade, Media & Telecommunications, Hiring & Real Estate Services, Financial & Insurance Services, Scientific & Technical Services, Administrative Services, Educational, Health care & Social Assistance, and Arts & Recreation employment. (ABS Catalogue 6291.004).

Commodity prices: Quarterly Commodity Price Index (RBA Bulletin Table I2).

Foreign real interest rate: Foreign interest rate is computed as the average policy rate in the Euro area, the United States, and Japan (RBA Bulletin Table F13). The monthly series are converted into quarterly frequency by arithmetic averaging. German interest rate is used before the introduction of the Euro (FRED Database series INTDSRDEM193N).

B Estimates of the stochastic component of the shocks

In this Appendix we report the estimates for the stochastic component of the shocks. The prior on habit formation coefficient, h, is set as a beta distribution with mean of 0.71 and standard deviation of 0.16. We set a normal prior with a mean of 3 and a standard deviation of 0.5 for the investment adjustment cost, Y''. Our choices of priors on the structural shock parameters follow the literature. The parameter that determines the persistence of shocks is drawn from a Beta distribution with mean 0.5 and standard deviation 0.2, while the standard deviation of the shocks is drawn from an Inverse Gamma distribution.

Table 5: Prior and Posterior Distributions for Shock Processes

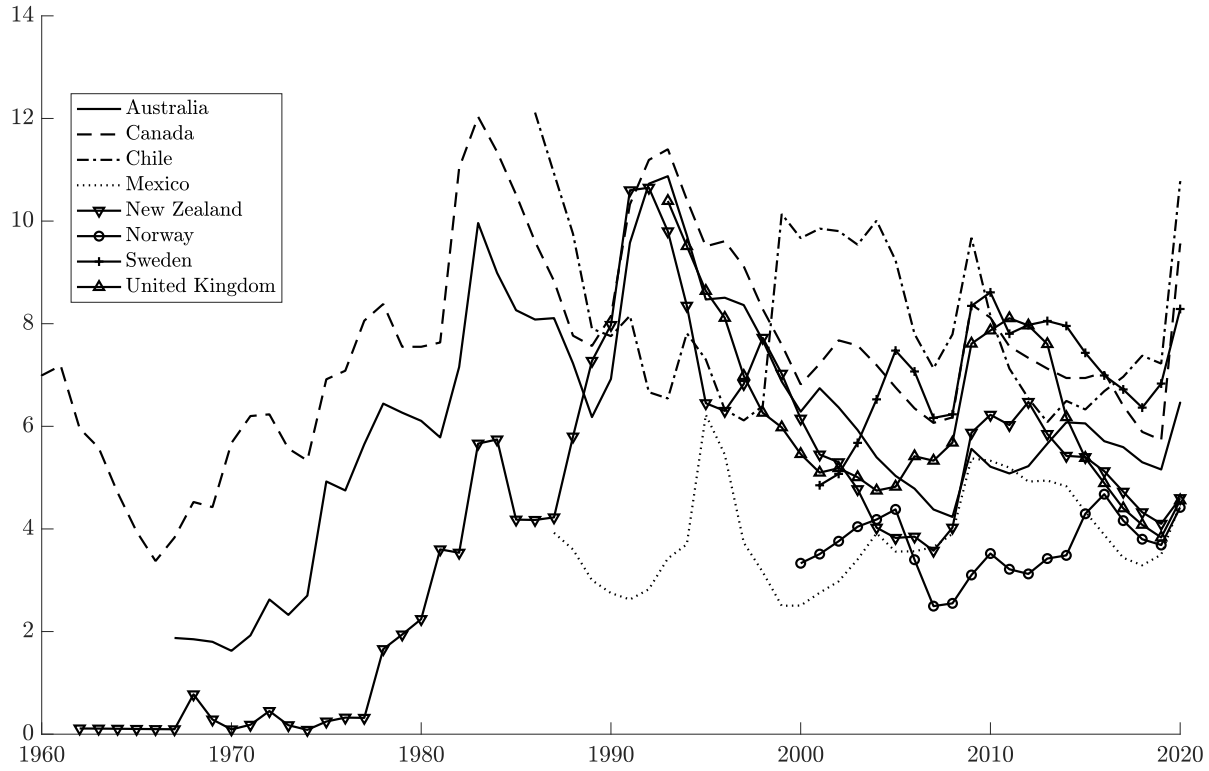
	Prior distribution			Posterior distribution			
Parameter	Distribution	Mean	S.d.	Mean	Mode	5%	95%
Consumption habit and vancancy adjustment costs							
h	Beta	0.71	0.16	0.813	0.818	0.764	0.848
Υ''	Normal	3	0.5	3.431	3.461	3.318	3.521
Standard Deviations							
σ_ζ	Inv. Gamma	0.10	2	0.045	0.047	0.038	0.053
σ_{ξ_N}	Inv. Gamma	0.01	2	0.097	0.095	0.079	0.123
σ_v	Inv. Gamma	0.10	2	0.095	0.099	0.080	0.112
σ_z	Inv. Gamma	0.10	2	0.010	0.011	0.008	0.013
σ_{zH}	Inv. Gamma	0.10	2	0.042	0.043	0.037	0.047
σ_{zN}	Inv. Gamma	0.10	2	0.021	0.021	0.018	0.023
σ_{r^*}	Inv. Gamma	0.01	2	0.003	0.003	0.002	0.003
σ_{ψ_b}	Inv. Gamma	0.01	2	0.003	0.003	0.002	0.003
σ_χ	Inv. Gamma	0.10	2	0.064	0.062	0.051	0.081
AR Coefficients							
ρ_ζ	Beta	0.5	0.2	0.67	0.70	0.54	0.78
ρ_{ξ_N}	Beta	0.5	0.2	0.95	0.97	0.89	0.98
ρ_v	Beta	0.5	0.2	0.57	0.58	0.44	0.69
ρ_z	Beta	0.5	0.2	0.54	0.55	0.36	0.70
ρ_{zH}	Beta	0.5	0.2	0.88	0.90	0.81	0.95
ρ_{zN}	Beta	0.5	0.2	0.96	0.96	0.93	0.99
ρ_{r^*}	Beta	0.5	0.2	0.74	0.74	0.65	0.82
ρ_{ψ_b}	Beta	0.5	0.2	0.76	0.76	0.68	0.82
ρ_χ	Beta	0.5	0.2	0.89	0.89	0.81	0.96

C Additional Figures

Figure 10: Employment Shares for Different Countries

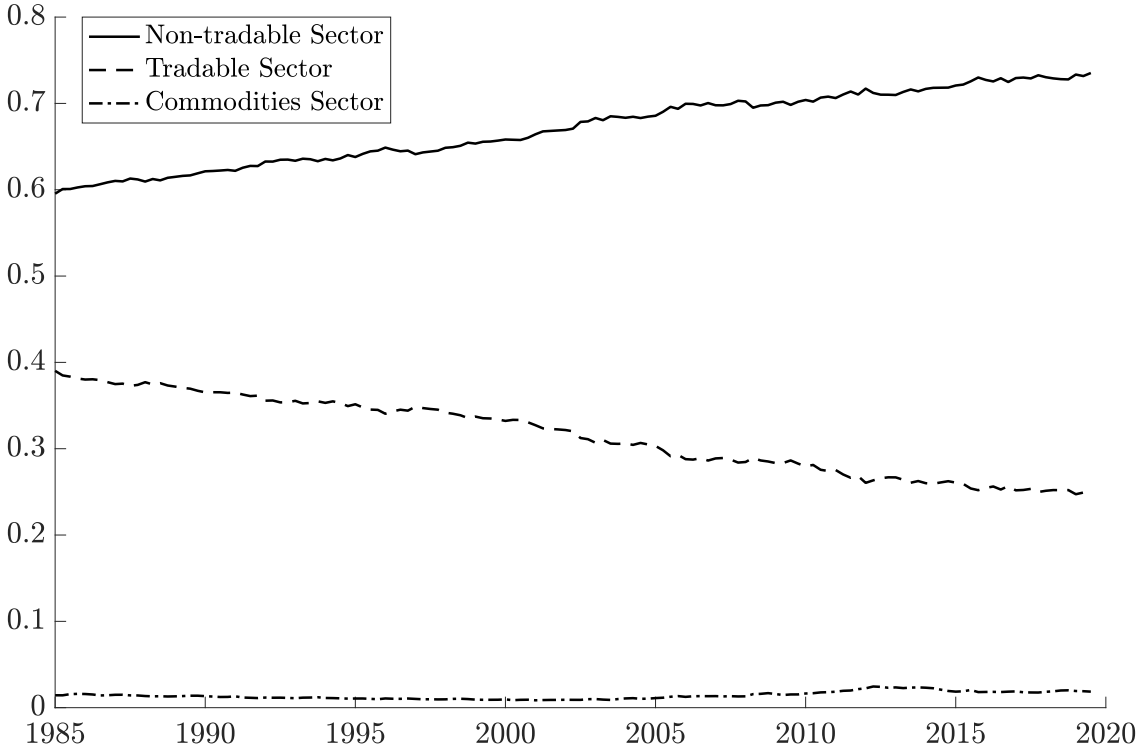
Source: Authors' calculations; OECD Database.

Figure 11: Unemployment Rates for Different Countries



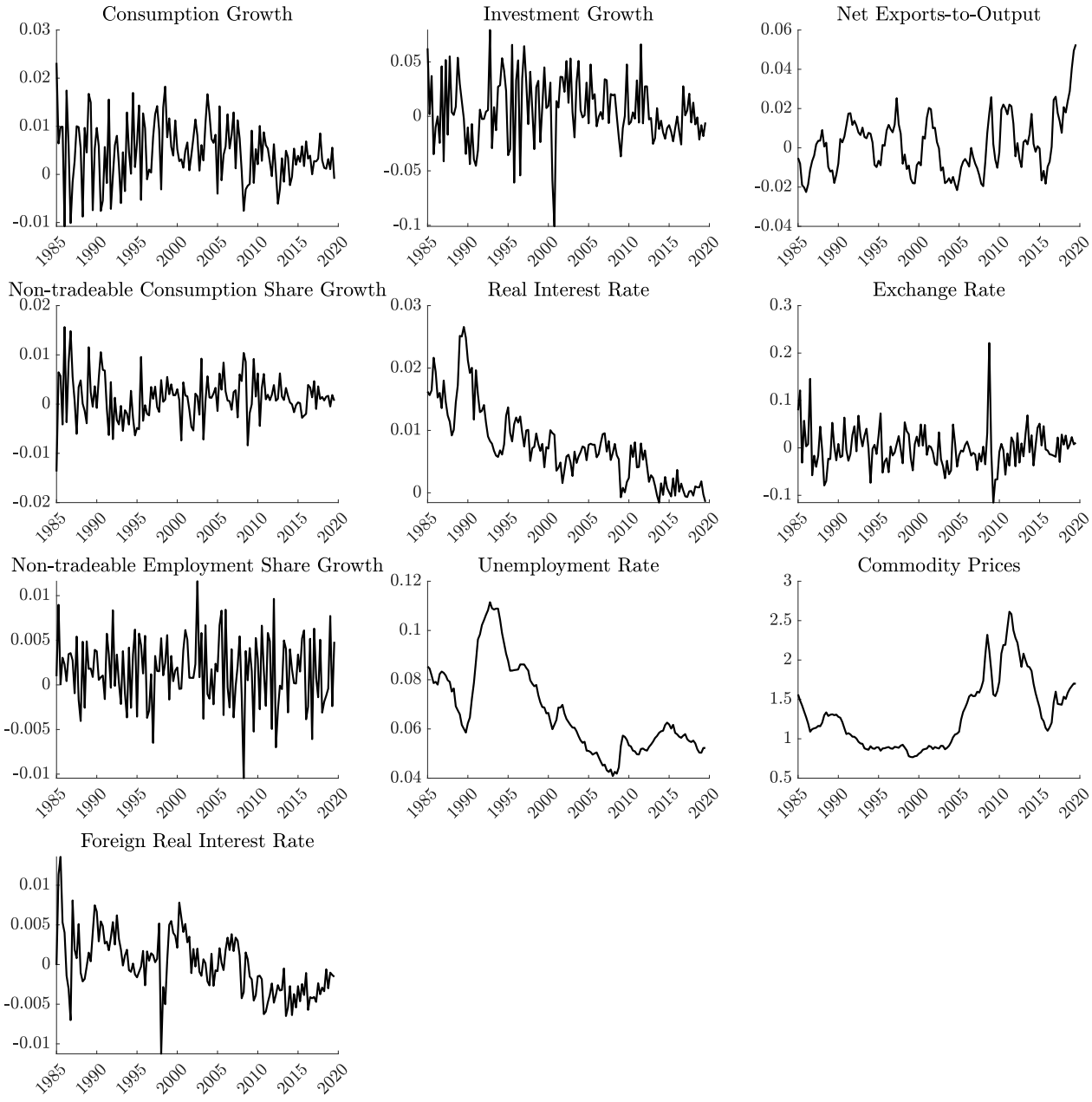
Source: Authors' calculations; OECD Database.

Figure 12: Employment Shares by Sector



Source: Authors' calculations; ABS.

Figure 13: Observed Data Used in Estimation



Source: Authors' calculations; ABS; FRED; RBA.