The changing output-inflation trade-off and the role of the financial sector [*]

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Abstract

In many advanced economies the slope of the Phillips curve is estimated to be very small. At the same time, the share of the financial sector in GDP increased dramatically. Moreover, the cyclical dynamics of the banking industry are markedly different from the rest of the economy. This paper takes Switzerland as an example and documents that these observations are closely related. We show that the financial sector appears to be disconnected from the output-inflation trade-off facing the rest of the economy. For that purpose we estimate a Bayesian DSGE model in which the output of the banking sector is determined by an exogenous error-correction model. We show that the endogenous output gap, i.e. the gap *net* of the financial sector, still has considerable explanatory power for aggregate inflation. The output-inflation trade-off reappears and the Phillips curve slope doubles once we control for the expanding financial sector. Thus, this paper offers an alternative explanation for the apparent flatness of the Phillips curve relationship.

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1 Introduction

The trade-off between output and inflation is central to monetary policy. This trade-off is frequently measured by the slope coefficient of a Phillips curve curve relationship. Understanding the size of this coefficient is important since it indicates the inflationary effect of a given change in real economic activity. Put differently, the slope contains information about how large the economic contract must be in order to reduce a given inflation rate. The output-inflation trade-off in Switzerland as well as in many advanced economies has changed over the past decades. Often the estimated slope of the Phillips curve is very small or even insignificantly different from zero.[1] A flat Phillips curve would imply that a large drop in output is needed to fight a given inflation.

What explains the apparent flatness of the Phillips curve? This paper argues that the growing share of the financial sector in aggregate GDP plays an important role in suppressing the output-inflation trade-off.[2] In fact, we argue that controlling for the financial sector, a sizable output-inflation trade-off reappears.

We start the analysis by decomposing the overall output gap into its financial and non-financial components. It turns out that fluctuations in the financial sector output gap are a multiple of fluctuations in the rest of the economy. Moreover, the output gap series in the financial sector behaves markedly different from the output gap of the rest of the economy. As a result, since the mid-1990s roughly 30% of the total output gap in Switzerland are driven by the financial sector, although the weight in the overall GDP level is about 10%. Moreover, the financial sector is uncorrelated with the rest of the domestic economy. The financial sector gap and the output gap for the rest of the economy exhibit a contemporary negative correlation (-0.08) over a sample from 1983 to 2008 and is negatively correlated (-0.05) also with inflation. The series of financial sector GDP is measured in terms of value-added, which in turn is driven by fees and commissions charged by domestic banks. These commissions, i.e. the remuneration of the bank for securities' trading and wealth management are directly proportional to global stock prices. It follows that the cyclical dynamics of the financial sector are primarily driven

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[1] Smets and Wouters (2003) estimate a DSGE model for the Euro area and obtain an estimated slope coefficient of 0.007. Using a DSGE model similar in size to the one estimated in this paper, Boivin and Giannoni (2006) find that the slope of the U.S. Phillips curve fell from 0.011 in the 1970s to 0.008 for a post-1980 sample. A survey of other estimates is provided in Schorfheide (2008).

[2] For an overview of various other characteristics of different financial systems and their impact on business cycles see IMF (2006).

by financial market conditions abroad.

This decomposition of the overall cycle allows us to address the following issues. First, we estimate the output-inflation trade-off in a New Keynesian Phillips curve (NKPC) framework for two alternative output gap series, i.e. the total gap and the gap net of the financial sector. The results show that controlling for the financial sector restores a significant and quantitatively relevant output-inflation trade-off. Cyclical movements in the financial sector, however, appear to have no inflationary consequences. Second, based on the stylized facts mentioned before and encouraged by the NKPC estimates, we estimate a Bayesian DSGE model for the Swiss economy and take account of the exogenous nature of the financial sector. The model combines price stickiness, inflation indexation, monopolistic competition, and habit persistence in consumption with an exogenous vector error-correction model (VECM) for the Swiss financial sector. Apart from the exogenous banking sector, the model is standard. A long-run equilibrium relationship takes account of the fact that banking GDP reflects commissions for securities trading and links financial sector GDP with global stock prices. The deviation from this equilibrium relationship explains the cyclical position of the banking sector almost completely. In other words, global financial conditions drive the cycle of the domestic banking sector. This equilibrium relationship is then combined with a standard DSGE model in order to estimate the slope of the Phillips curve. While the assumption of an exogenous financial sector appears overly simplistic, we believe it to be a fairly accurate description of the situation in small open economies with a large financial sector such as Switzerland. As the main result we find that the estimated Phillips curve slope doubles from 0.025 to 0.044 once we control for a large and growing financial sector. At the same time, all other estimated parameters are invariant to the specification of the driving force of the Phillips curve.

This paper is closely related to various strands of the literature. First, a voluminous literature analyzes the changing behavior of the output-inflation nexus over the last 15 years. Atkinson and Ohanian (2001) deserve the credit to be the first paper documenting the drop in forecasting power of a traditional Phillips curve after the 1980s. [3] In this paper, we also document the weak connection between aggregate output and inflation However, we take a step beyond this finding and offer one potential explanation for this fact in terms of a large financial sector with quite specific cyclical properties. Second, a current debate focuses on the role of globalization for inflation dynamics. Borio and Filardo (2007), among others, argue that increased

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[3] Stock and Watson (2007, 2008) provide recent surveys and document the time-varying performance of Phillips curve regressions as a forecasting tool for inflation.

trade integration makes the output-inflation trade-off flatter. Ihrig et al. (2007), however, are unable to detect this effect in a set of 11 industrial countries. Similarly, Milani (2009) argues that a global output gap, i.e. a weighted output gap of major trading partners, is more important in driving inflation than the domestic output gap. He finds evidence for this conjecture based on a Bayesian estimation of a small-scale DSGE model for the US economy. Instead of real, i.e. trade, integration, this paper posits that the globalization of the banking industry plays a crucial role in determining the Phillips curve slope.[4]

A third strand of the literature uses supply-side information to construct a hypothetical output gap series, see e.g. Basistha and Nelson (2007). The idea is to employ the Phillips curve to generate the gap as that part of output that causes inflation in this model. Unlike these authors, this paper takes a step back and looks at sectoral output dynamics to find the part of GDP that is mostly relevant in explaining inflation.

This paper is organized as follows. Section two presents the data series and characterizes the different cyclical dynamics of financial sector GDP and the output of the rest of the economy. Section three uses the current workhorse model, the New Keynesian Phillips curve, to estimate the link between output and inflation. Section four uses Bayesian methods to estimate a small-scale DSGE model with an exogenous banking sector to derive the main results of the paper. Finally, section five draws some tentative conclusions.

2 The financial sector and the dynamics of the output gap in Switzerland

In most advances countries, the share of the financial sector in aggregate GDP grew steadily over the past three decades. Switzerland experienced a particularly strong expansion with the share of financial sector in aggregate GDP doubling over the last 25 years from about 5% to 10%.

2.1 Decomposing the output gap

We use quarterly value-added GDP data to construct a series of financial sector GDP, denoted by GDP_t^{fin} and a corresponding series of total GDP less

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[4] Kuttner and Robinson (2008) find a flattening of the Phillips curve for Australia and the US and consider a variety of explanations for this finding such as measurement issues, the impact of global trade etc. None of these routes, however, provides an entirely satisfactory explanation.

financial sector GDP, denoted by GDP_t^{nofin}. The sectoral decomposition corresponds to the "financial intermediation" section in Eurostat's "A16 structure" of quarterly national accounts.[5] We use a standard Hodrick-Prescott filter to extract the trend in each series and construct three alternative output gap series, i.e. series of the percentage difference between the respective output series and the corresponding trend output. First, we have the output gap for the total economy. This series will be referred to as y_t^{total}. Second, we have a series of financial sector-output gaps which is denoted by y_t^{fin}. Finally, the non-financial gap, i.e. the gap of the economy net of the financial sector is given by y_t^{nofin}. To summarize, we use the output gap for sector i defined as

$$y_t^i = 100 \times \left(\log GDP_t^i - \log \overline{GDP}_t^i\right)$$

where $i = total, fin, nofin$ and $\overline{GDP}_t^i$ stands for the Hodrick-Prescott trend. These definitions imply

$$y_t^{total} = (1-\omega)\, y_t^{nofin} + \omega y_t^{fin}$$

where ω is the weight of the banking sector in Swiss GDP. Figure (1) plots the decomposition of the overall gap into its financial and non-financial components. While the share of the banking sector in aggregate GDP grew to almost 10% towards the end of the sample period, its contribution to the total output gap is much larger. In the second half of the sample, i.e. after the mid-1990s, the financial sector gap explains roughly 30% over the aggregate gap. Since cyclical fluctuations in financial sector GDP are a multiple of fluctuations in the rest of the economy, even with a share of 10% of the economy the banking sector is the dominant force behinds the overall cycle. Table (1) reports the contemporaneous correlation between the alternative gap series. Crucially, the financial sector is negatively correlated with the rest of the economy.

2.2 Value-added in the financial sector

The output gap dynamics of the financial sector are decoupled from the cycle facing the rest of the economy. In fact, this paper argues that bank output is not only unrelated to aggregate GDP (net of banks), but also orthogonal to current inflation. To understand the cyclical dynamics of financial sector GDP, it is useful to shed some light on the statistics behind the GDP_t^{fin}

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[5] Note that we focus only on financial intermediation and exclude the insurance and the real estate sector from GDP_t^{fin}.

series.[6]

The value-added in the financial sector can be decomposed into two components. First, financial intermediation services driven mainly by the spread between borrowing and lending interest rates. Usually, this component is very stable over time and does not reflect the cycle of the banking industry. Second, commissions and fees charged for transactions on international capital markets. This component explains most of the growth rate of financial sector GDP. In fact, Bindelli (2008) argues that 40% of the variance of Swiss financial sector growth, measures in terms of value-added GDP, is explained by the German stock market index alone. In other words, the cyclical dynamics of the financial sector are primarily driven by financial market conditions abroad. As a result, the financial sector is uncorrelated with the rest of the domestic economy. If the financial sector grows, a larger and larger part of aggregate GDP, therefore, is determined by global financial markets. Taken together, the growing importance of the financial sector has changed the cyclical nature of the output gap.

2.3 Financial sector gaps and aggregate inflation

To the extent the financial sector gap is independent of the cycle in the remaining part of the economy, a growing banking industry also affects the aggregate output-inflation trade-off. We use consumer prices to measure the inflation rate. To account for the effect of high and volatile oil prices, we exclude oil and oil products from the CPI.

Table (1) presents the correlation between the aggregate and the non-financial output gaps and the inflation rate. The numbers show that the financial sector exhibits a negative correlation with inflation while the rest of the economy is positively correlated with inflation.

3 A New Keynesian Phillips curve

This section investigates the output-inflation trade-off within a reduced-form Phillips curve framework. The subsequent section will then broaden the analysis and instead uses a full-blown structural model to investigate the changing trade-off. Consider a standard model of staggered price setting according to Calvo (1983). The linearized supply-side of this model implies the NKPC (see, e.g. Galí and Gertler, 1999)

$$\hat{\pi}_t = \gamma_f E_t \hat{\pi}_{t+1} + \gamma_b \hat{\pi}_{t-1} + \kappa y_t \tag{1}$$

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[6] For more information about the methods of national accounting and a comparative analysis of financial sector sizes across countries see SECO (2006).

Inflation (in deviation from the zero inflation steady state) is determined by expected future inflation and current real activity, where π_t is the quarter-on-quarter inflation rate, γ_f is the reduced-form coefficient on expected future inflation and γ_b the role of past inflation. Note that we impose $\gamma_f + \gamma_b = 1$. The output gap is represented by y_t. The slope coefficient is κ and is inversely related to the degree of price stickiness. This coefficient summarizes the relationship between output and inflation in this model and is the core parameter in this paper. If κ is large, a given change in the output gap has larger consequences for inflation. The reduced form equation (1) is known as the hybrid version of the NKPC since it also contains lagged inflation. Similar equations are estimated in the pioneering studies of Galì and Gertler (1999) and Galì, Gertler and Lopez-Salido (2001).

We replace expected variables with their realizations and employ the GMM estimator. Let G_{t-1} denote a vector of instruments that are observed at time $t-1$. Imposing rational expectations defines the following orthogonality condition, that is the reduced form specification of the GMM estimation

$$E_t \left\{ \left(\hat{\pi}_t - \gamma_f \hat{\pi}_{t+1} - \gamma_b \hat{\pi}_{t-1} - \kappa y_t \right) G_{t-1} \right\} = 0 \tag{2}$$

The vector of instruments includes three lags of the respective output gap and the interest rate spread between government bond yields and the short-term interest rate, and one lag of inflation. From this orthogonality condition we obtain estimates of the reduced form coefficients.

The results for two alternative sample periods are presented in table (). Two findings stand out. First, in the 1983-2008 sample, the model based on the output gap without the financial sector gives rise to an estimated slope coefficient that is more than two time larger than the model based on the total economy-gap. In the former case, $\kappa = 0.069$, while in the latter case $\kappa = 0.028$. Moreover, this coefficient is insignificantly different from zero. Based on this estimate, the Phillips curve appears to be flat. Controlling for the output gap of the financial sector, however, increases the slope drastically and the output-inflation trade-off reappears. A steeper Phillips curve would imply a lower degree of price rigidity in the economy. Second, the 1995-2008 sample indicates that the coefficient on the overall output gap remains insignificantly different from zero. When estimated on the non-financial output gap, however, the slope increases to 0.11. The cyclical properties that are specific to the sector of financial intermediation, therefore, have subdued the output-inflation trade-off over the past decade. Once we control for the banking sector, a positively sloped Phillips curve is restored.

The change in the NKPC slope is likely to be a gradual process. Therefore, we estimate (1) over time. Put differently, we estimate the model for a sample of 15 years, add one observation to both the start and the end of the sample and estimate the model again. Iterating this procedures gives us a series of estimates of κ together with the resulting standard errors. Figure (2) depicts these series based on our alternative output gap definitions. Apparently, the standard Phillips curve specification gives insignificant slope estimates for most of the sample periods. If inflation is driven by y_t^{nofin}, however, the significantly positive trade-off is restored. Throughout the rolling-windows, the slope coefficient is estimated to be larger than in the standard model based on y_t^{total}. We also clearly see an increase in the slope towards the end of the sample period. The subsequent section shows that a small estimated DSGE model is able to replicate these patterns.

4 A small DSGE Model

The previous sectors established the inflation-disconnect characterizing the financial sector. Estimates of the Phillips curve increases significantly once this disconnect is taken into account. Although suggestive, the single-equation estimates of the New Keynesian Phillips curve can only provide limited insights into the changing output-inflation trade-off. A deeper analysis embeds the Phillips curve into a structural Dynamic General Equilibrium (DSGE) model of the economy. Schorfheide (2008) finds that single-equation estimates of the NKPC parameters are fragile and highly sensitive with respect to the model specification. As a consequence, he advocates the use of structural DSGE models to extract information about the NKPC. This section formulates and estimates a small DSGE model. Apart from the treatment of the financial sector the model is standard. A detailed exposition of the Bayesian estimation techniques is given by An and Schorfheide (2007). Milani (2009) employs a similar approach to assess the relative role of alternative output gap series, i.e. domestic versus foreign, in driving inflation.[7]

4.1 The linearized model

We take a standard DSGE model that includes monopolistic competition, price stickiness generated by a Calvo (1982) mechanism, habit persistence in consumption, and inflation indexation. The model consists of optimizing households and firms, a central bank setting the short-term interest rate,

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[7] The literature on estimated DSGE model for the Swiss economy is very limited. Beltran and Draper (2008) estimate an open-economy DSGE model with Bayesian methods. However, these authors focus on identification issues rather than the changing nature of inflation dynamics.

and an exogenous banking sector. The only difference with respect to the standard model is that we allow for a banking sector that accounts for a fraction ϖ of total GDP. As explained below in some detail, the banking sector GDP is determined exogenously. Since the derivation is standard, we restrict ourselves to the explanation of the linearized equilibrium conditions. All variables are in log-deviations from the steady state, where $\hat{x}_t = \log x_t - \log \bar{x}$.

The aggregate resource constraint, modified to allow for an exogenous banking sector, reads

$$\hat{y}_t = \hat{c}_t + g_t + \varpi \hat{y}_t^{fin} \tag{3}$$

where $\hat{y}_t$ is total GDP, $\hat{c}_t$ is consumption, g_t is exogenous government spending, which can also be interpreted more broadly as a demand shock. Output of the financial sector is given by $\hat{y}_t^{fin}$. Put differently, only $\hat{y}_t - \varpi \hat{y}_t^{fin}$ is determined endogenously. With $\varpi = 0$ the model collapses to the standard New-Keynesian DSGE model. The linearized optimality condition of firms' price setting problem results in a hybrid Phillips curve

$$\hat{\pi}_t = \frac{\chi}{1+\beta\chi}\hat{\pi}_{t-1} + \frac{\beta}{1+\beta\chi}E_t\hat{\pi}_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta(1+\beta\chi)}\left(\widehat{mc}_t + a_t\right) \tag{4}$$

where $\hat{\pi}_t$ inflation, $\widehat{mc}_t$ is marginal cost, and a_t is a mark-up shock. The Calvo frequency of non-adjustment of prices is given by θ, while β denotes the discount factor and χ the degree of inflation indexation. As before, we interpret the changing output-inflation nexus in terms of the slope coefficient $\frac{(1-\theta)(1-\beta\theta)}{\theta(1+\beta\kappa)}$. Note that the slope of the Phillips curve is a composite parameter that depends negatively on the degree of price stickiness in the economy and the degree of indexation. Marginal cost can be expressed as $\widehat{mc}_t = -\hat{\lambda}_t - a_t$, where $\hat{\lambda}_t$ is the marginal utility of consumption which is explained by

$$-\hat{\lambda}_t = \frac{\tau}{1-\beta h}\hat{C}_t - \frac{\beta h}{1-\beta h}E_t\left(\tau\hat{C}_{t+1} + z_{t+1}\right)$$

Here τ is the coefficient of relative risk aversion and h the degree of habit persistence in consumption. The technology shock is represented by z_t. Consumption is given by

$$\hat{c}_t = h\left(\hat{c}_{t-1} - z_t\right) + (1-h)\hat{C}_t \tag{5}$$

The habit stock is denoted by $\hat{C}_t$. With $h = 0$, $\hat{c}_t = \hat{C}_t$. Under habit persistence and inflation indexation, lagged consumption and lagged inflation, respectively, enter the equilibrium conditions and generate additional persistence. The consumption Euler equation relates the marginal utility of income to the real interest rate and the technology shock

$$-\hat{\lambda}_t = -E_t\hat{\lambda}_{t+1} - \left(\hat{R}_t - E_t\widehat{\pi}_{t+1}\right) + E_t z_{t+1} \tag{6}$$

Finally, monetary policy is assumed to follow a standard instrument rule to set the interest rate $\hat{R}_t$ with interest rate smoothing described by ρ_R

$$\hat{R}_t = \rho_R\hat{R}_{t-1} + (1-\rho_R)\left[\phi_1\hat{\pi}_t + \phi_2\left(\hat{y}_t - \hat{g}_t - \varpi\hat{y}_t^{fin}\right)\right] + e_t \tag{7}$$

The central bank responds to inflation and the output gap that matters for inflation dynamics within the Phillips curve. Thus, the central bank responds to $\hat{y}_t - \hat{g}_t - \varpi\hat{y}_t^{fin}$, which equals consumption. As usual, a shock e_t is appended that can be interpreted as an unanticipated deviation from the policy rule or a monetary control error.
The productivity shock a_t, the demand shock z_t, and the government expenditure shock g_t follow AR(1) processes

$$\begin{aligned} z_t &= \rho_z z_{t-1} + \varepsilon_t^z \\ a_t &= \rho_a a_{t-1} + \varepsilon_t^a \\ g_t &= \rho_g g_{t-1} + \varepsilon_t^g \end{aligned} \tag{8}$$

with the variances of the i.i.d. innovations given by σ_z, σ_a, and σ_g. The monetary policy shock e_t is assumed i.i.d. with variance σ_e.

4.2 An empirical model for the financial sector

The banking-sector output $\hat{y}_t^{fin}$ is exogenous and is driven by global financial conditions. In particular, the bulk of value-added in the banking sector consists of fees and commission for trades on global stock markets. These commissions, in turn, are directly proportional to the value of the stock market. Therefore, we use a simple exogenous financial sector VAR model that relates real financial sector output Y_t^{fin} to real stock prices S_t^{world}. Since both series are found to be I(1) processes, we test for a cointegration relationship. Both the Johansen maximum-likelihood procedure as well as the Engle-Granger two-step approach confirm that financial sector GDP is cointegrated with global stock prices. We set up the following first-order vector error-correction model

$$\begin{aligned} \Delta X_t &= \mu + \alpha\left(\beta' X_{t-1} + \delta_0 + \delta_1 t\right) + \gamma\Delta X_{t-1} + \Sigma_t & (9) \\ &= \mu + \alpha\left(ec_{t-1}\right) + \gamma\Delta X_{t-1} + \Sigma_t & (10) \end{aligned}$$

where $X_t = \left[Y_t^{fin}, S_t^{world}\right]'$ and t is a deterministic trend. To keep the exposition brief, we do not report the full set of tests and results.[8] The estimated

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[8] The full set of results is available upon request.

cointegration relationship (standard errors in parenthesis) is given by

$$ec_t = Y_t^{fin} - \underset{(0.04^{***})}{8.13} - \underset{(0.02^{***})}{0.15}\, S_t^{world} - \underset{(0.00^{***})}{0.007}\, t \tag{11}$$

Importantly, the error-correction term, ec_t, represents temporary deviation of Y_t^{fin} from its long-run equilibrium. Put differently, this error-correction term captures the cyclical position of the banking sector. Therefore, we take this model as a simple explanatory framework and feed a simple AR(1) process for $\widehat{ec}_t$, i.e. the demeaned error-correction term, into our DSGE model

$$\widehat{ec}_t = \rho_{fin}\widehat{ec}_{t-1} + \varepsilon_t \tag{12}$$

where ε_t is an i.i.d. innovation with variance σ_{fin}. Figure (3) plots this error-correction term against HP-filtered Y_t^{fin}. The error-correction term closely matches the cyclical dynamics of the banking sector.

5 Estimation and results

The model is estimated using the Bayesian methodology, i.e. a full information approach to jointly estimate the parameters of a DSGE model.

5.1 Bayesian estimation

The estimation is based on the likelihood function obtained from the solution of the log-linear version of the model. Prior distributions for the parameters of interest are used to incorporate additional information into the estimation. The system of log-linearized equations forms a linear rational expectations system that can be written in canonical form as follows

$$\Gamma_0(\Theta)X_t = \Gamma_1(\Theta)X_{t-1} + \Gamma_2(\Theta)z_t + \Gamma_3(\Theta)\varepsilon_t \tag{13}$$

where the vector X_t contains the various state variables, the monetary policy control variable as well as four exogenous $AR(1)$ processes describing the structural shocks of the model. The vector Z_t contains the white noise innovation to these shock processes while the vector ε_t contains the rational expectation errors. The elements of the matrices Γ_1, Γ_2 and Γ_3 contain functions of the structural parameters collected in vector Θ. The rational expectations solution to (13) can be written as follows

$$X_t = \Omega(\Theta)X_{t-1} + \Omega_z(\Theta)Z_t \tag{14}$$

Let Y_t be the vector of observable variables. This vector is related to the variables in X_t through the system of measurement equations:

$$Y_t = H(\Theta)X_t + m_t \tag{15}$$

Equations (14) and (15) correspond to the state-space form representation of Y_t. If we assume that the white noise innovations are normally distributed, we can compute the conditional likelihood function for the structural parameters, Θ, using the Kalman filter, $L(\Theta \mid Y^T)$, where $Y^T = \{Y_1 \ldots, Y_T\}$. The parameter vector Θ consists of the structural DSGE parameters and the parameters describing the AR(1) process for the error-correction term

$$\Theta = \{\theta, \chi, \tau, h, \phi_\pi, \phi_y, \rho_a, \rho_e, \rho_g, \rho_z, \bar{R}, \bar{\pi}, \bar{y}^{total}, \sigma_a, \sigma_e, \sigma_g, \sigma_z, \rho_{fin}, \sigma_{fin}\}'$$

Let $\mathbf{p}(\Theta)$ denote the prior density of the structural parameters. We can use the data on the observable variables Y^T to update the priors through the likelihood function. The joint posterior density of the parameters is computed using the Bayes theorem

$$\mathbf{p}(\Theta \mid Y^t) = \frac{L(\Theta \mid Y^T)\mathbf{p}(\Theta)}{L(\Theta \mid Y^T)\mathbf{p}(\Theta)d\Theta} \tag{16}$$

The posterior distributions of the parameter estimates are approximated by generating draws from the Metropolis Hastings algorithm.

5.2 Data and measurement equations

The model is estimated using quarterly data from Switzerland for 1983:Q1-2008:Q4 taken from the SNB's time-series database. The data consist of the quarterly growth rates of real gross domestic product, annualized CPI inflation as well as the LIBOR rate. To account for the effect of high and volatile oil prices, we use a measure of the CPI that excludes oil and oil products. Value-added in the banking-sector corresponds to the A16 structure ("financial intermediation") and is taken from the Swiss State Secretariat for Economic Affairs (SECO). The stock price series is the MSCI global stock price index divided by the deflator of financial-sector GDP. All data series used in the estimation process are depicted in figure (4).

Output growth, inflation, and the nominal interest rate together with the error-correction term capturing the cycle in the financial sector are linked to the variables of the model by a system of measurement equations

$$\begin{bmatrix} \Delta Y^{total}_{obs,t} \\ \Delta CPI_{obs,t} \\ R_{obs,t} \\ \widehat{ec}_{obs,t} \end{bmatrix} = \begin{bmatrix} \bar{y}^{total} \\ \bar{\pi} \\ \bar{R} \\ 0 \end{bmatrix} + \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} \\ 4\hat{\pi}_t \\ 4\hat{R}_t \\ \hat{y}^{fin}_t \end{bmatrix} + \begin{bmatrix} z_t \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{17}$$

where $\bar{y}^{total}$ is the quarterly trend growth rate, $\bar{\pi}$ is the steady-state level of inflation, and $\bar{R}$ is the steady-state nominal interest rate.

In accordance to the literature, the discount factor is calibrated to $\beta = 0.99$. Likewise, we calibrate the weight of the financial sector in overall output gap used in (3). In the full sample, we set $\varpi = 0.2$.

5.3 Results

The Bayesian approach followed in this paper rests on properly defined prior distributions of the model parameters. These priors assumptions are listed in table (3). For the shock variances we choose relatively uninformative priors in order to let the data speak. All other prior distributions are standard. The model is estimated for the whole sample period, i.e. 1983-2008, and the two alternative output gap specifications, i.e. for $\varpi = 0$ and $\varpi = 0.20$. All posterior distributions are based on 200.000 draws of the Metropolis-Hastings algorithm with the first 40000 observations treated as a burn-in sample.

The posterior means and their confidence bands are presented in table (4). The table also reports the implied slope coefficient $(1-\theta)(1-\beta\theta)(\theta(1+\beta\chi))^{-1}$. As the most important result, the estimated parameters θ and χ imply very different slope coefficients. When estimated for $\varpi = 0$, i.e. the standard specification without an explicit role for the financial sector, the slope amounts to 0.015. Once we estimate the model for $\varpi = 0.20$, i.e. the DGSE model is fitted to the output gap net of the financial sector contribution, the slope doubles to 0.044. In other words, by controlling for the large fraction of the output gap due to the banking sector, the output-inflation trade-off becomes much more pronounced. At the same time, most other parameter estimates are surprisingly invariant to the choice of the output gap specification. Take τ and h which are considered deep and structural, thus being insensitive to the macroeconomic environment. We find that, indeed, these coefficients hardly change across specifications. All other parameter estimates, e.g. the policy rule coefficients and the steady state values, are plausible.

To recover the behavior of the estimated slope coefficient over time, we estimate the model over three subperiods. Due to the short overall sample, the three subperiods (1983-1996, 1989-2002, and 1995-2008) overlap. The results of the standard DSGE specification with $\varpi = 0$ are given in table (5). As θ and χ fall over the subperiods, the implied slope coefficient increases. While the slope remains roughly unchanged between the first and the second sample, it increase to 0.068 in the final sample. Let us contrast these results with the extended model that controls for the financial sector. The results are reported in table (6). Across subsample, the share of the financial sector gap is allowed to increase from $\varpi = 0.1.$ to $\varpi = 0.20$ and finally to $\varpi = 0.30$ in the last subsample. Again, the slope of the Phillips curve increases across sample periods. In contrast to the standard specification, however, the increase is much more pronounced. As the financial sector grows, the NKPC slope coefficients diverge. Take the first subsample. Both specifications give rise to a slope of 0.031. In the final sample, the richer model that controls for the expanding banking sector, the slope is 0.103 compared to 0.068 in the standard model. This is consistent with the results of the rolling GMM estimates of the NKPC presented before. Note that these findings are likely to understate the effect of the financial sector since all three subsample overlap. The distribution of the estimated slope coefficients are plotted in figures (5) and (6). Apparently, the probability mass shifts to the right as the financial sector grows.

6 Conclusions

Over the past decade, the financial sector in many advanced economies grew rapidly, thereby following a distinctively different cyclical pattern than the rest of the economy. At the same time, the trade-off between consumer price inflation and the output gap appears to be very weak. This paper argues that both observations are closely related. Estimates of the New Keynesian Phillips curve established the "inflation-disconnect" of the financial sector. Put differently, the financial sector activity in Switzerland is only loosely connected to inflation dynamics. Together with a growing share of the banking sector in aggregate GDP, this property could therefore be one explanation for the apparent flatness of the Phillips curve trade-off in many industrial countries. An estimated DSGE model that controls for the fact that financial sector output is orthogonal to the rest of the economy generates a sizable Phillips curve slope. Thus, the trade-off between real activity and inflation reemerges once we take account of the financial sector. This findings has important implications for monetary policy. [To be completed.]

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Table 1: Correlation of alternative output gaps series and inflation, 1983-2008

	y_t^{total}	y_t^{nofin}	y_t^{fin}	π_t
y_t^{total}	1.00			
y_t^{nofin}	0.92	1.00		
y_t^{fin}	0.31	-0.08	1.00	
π_t	0.38	0.42	-0.05	1.00

Table 2: Results from GMM estimation of the NKPC

sample	output gap	parameters		J-Test
		γ	κ	
1983 - 2008	total economy	0.589 (0.046***)	0.028 (0.020)	0.45
	no financial sector	0.636 (0.051***)	0.069 (0.027**)	0.55
1995 - 2008	total economy	0.513 (0.092***)	-0.055 (0.029)	0.39
	no financial sector	0.806 (0.141***)	0.110 (0.046**)	0.52

Notes: A significance level of 1%, 5%, and 10% is indicated by ***, **, and *. The list of instruments for the GMM estimation includes three lags of the output gap and the interest rate spread and one lag of inflation.

Table 3: Prior distributions

Parameter	Range	Distribution	Mean	Std. dev.
θ	$[0,1)$	Beta	0.75	0.15
χ	$[0,1)$	Beta	0.50	0.15
τ	RR^+	Gamma	2.00	0.20
h	$[0,1)$	Beta	0.50	0.10
ϕ_π	RR^+	Gamma	1.50	0.10
ϕ_y	RR^+	Gamma	0.25	0.10
ρ_a	$[0,1)$	Beta	0.50	0.20
ρ_e	$[0,1)$	Beta	0.50	0.20
ρ_g	$[0,1)$	Beta	0.50	0.20
ρ_z	$[0,1)$	Beta	0.50	0.20
$\bar{R}$	RR^+	Gamma	1.00	0.10
$\bar{\pi}$	RR^+	Gamma	1.25	0.10
$\bar{y}^{total}$	RR^+	Gamma	0.40	0.10
σ_a	RR^+	Inv. Gamma	0.50	4.00
σ_e	RR^+	Inv. Gamma	0.50	4.00
σ_g	RR^+	Inv. Gamma	0.50	4.00
σ_z	RR^+	Inv. Gamma	0.50	4.00
ρ_{fin}	$[0,1)$	Beta	0.50	0.25
σ_{fin}	RR^+	Inv. Gamma	0.50	4.00

Table 4: Posterior distributions for the full sample

Parameter	$\varpi = 0.00$		$\varpi = 0.20$	
	Mean	Confidence Band	Mean	Confidence Band
θ	0.88	[0.84, 0.93]	0.80	[0.74, 0.87]
χ	0.17	[0.09, 0.27]	0.18	[0.07, 0.27]
τ	2.05	[1.84, 2.39]	1.95	[1.75, 2.26]
h	0.65	[0.56, 0.74]	0.63	[0.57, 0.71]
ϕ_π	1.50	[1.36, 1.66]	1.64	[1.50, 1.76]
ϕ_y	0.20	[0.07, 0.29]	0.21	[0.13, 0.33]
ρ_a	0.93	[0.87, 0.96]	0.93	[0.89, 0.96]
ρ_R	0.85	[0.79, 0.88]	0.82	[0.77, 0.87]
ρ_g	0.72	[0.58, 0.94]	0.67	[0.44, 0.87]
ρ_z	0.76	[0.52, 0.93]	0.88	[0.85, 0.92]
$\bar{R}$	1.13	[0.98, 1.27]	1.09	[0.94, 1.28]
$\bar{\pi}$	1.12	[1.03, 1.25]	1.06	[0.88, 1.19]
$\bar{y}^{total}$	0.34	[0.23, 0.50]	0.41	[0.30, 0.54]
σ_a	1.82	[0.67, 3.50]	0.73	[0.36, 1.22]
σ_e	0.17	[0.16, 0.19]	0.17	[0.15, 0.19]
σ_g	0.34	[0.25, 0.39]	0.48	[0.39, 0.55]
σ_z	0.39	[0.21, 0.67]	0.25	[0.17, 0.33]
ρ_{fin}			0.88	[0.84, 0.94]
σ_{fin}			2.40	[2.22, 2.58]
Slope	0.015		0.044	

Table 5: Posterior distributions across subsamples

Parameter	1983-1996, $\varpi = 0.00$		1989-2002, $\varpi = 0.00$		1995-2008, $\varpi = 0.00$	
	Mean	Confidence Band	Mean	Confidence Band	Mean	Confidence Band
θ	0.82	[0.71, 0.91]	0.82	[0.74, 0.90]	0.75	[0.63, 0.87]
χ	0.35	[0.14, 0.57]	0.26	[0.10, 0.42]	0.27	[0.09, 0.44]
τ	2.11	[1.79, 2.43]	2.11	[1.78, 2.44]	2.03	[1.71, 2.36]
h	0.63	[0.51, 0.76]	0.57	[0.45, 0.69]	0.50	[0.37, 0.64]
ϕ_π	1.58	[1.40, 1.75]	1.55	[1.38, 1.70]	1.52	[1.36, 1.68]
ϕ_y	0.16	[0.05, 0.27]	0.17	[0.06, 0.27]	0.19	[0.07, 0.31]
ρ_a	0.89	[0.83, 0.97]	0.90	[0.85, 0.96]	0.65	[0.43, 0.86]
ρ_R	0.78	[0.69, 0.88]	0.82	[0.76, 0.88]	0.75	[0.65, 0.85]
ρ_g	0.67	[0.41, 0.94]	0.73	[0.51, 0.95]	0.72	[0.49, 0.96]
ρ_z	0.60	[0.37, 0.84]	0.36	[0.14, 0.57]	0.36	[0.13, 0.58]
$\bar{R}$	1.07	[0.89, 1.25]	1.06	[0.88, 1.24]	1.11	[0.93, 1.29]
$\bar{\pi}$	1.18	[1.02, 1.34]	1.18	[1.02, 1.34]	1.15	[1.01, 1.30]
$\bar{y}^{total}$	0.39	[0.25, 0.53]	0.32	[0.21, 0.42]	0.44	[0.32, 0.56]
σ_a	2.16	[0.97, 3.35]	1.62	[0.80, 2.46]	1.41	[0.44, 2.58]
σ_e	0.25	[0.20, 0.29]	0.20	[0.16, 0.23]	0.19	[0.15, 0.22]
σ_g	0.34	[0.25, 0.43]	0.32	[0.24, 0.41]	0.32	[0.23, 0.40]
σ_z	0.54	[0.30, 0.80]	0.57	[0.36, 0.76]	0.50	[0.32, 0.67]
Slope	0.031		0.033		0.068	

Table 6: Posterior distributions across subsamples

Parameter	1983-1996, $\varpi = 0.10$		1989-2002, $\varpi = 0.20$		1995-2008, $\varpi = 0.30$	
	Mean	Confidence Band	Mean	Confidence Band	Mean	Confidence Band
θ	0.82	[0.74, 0.90]	0.79	[0.70, 0.90]	0.70	[0.58, 0.81]
χ	0.35	[0.15, 0.55]	0.27	[0.09, 0.45]	0.28	[0.09, 0.48]
τ	2.12	[1.76, 2.46]	2.09	[1.76, 2.42]	2.02	[1.70, 2.35]
h	0.60	[0.47, 0.73]	0.55	[0.43, 0.67]	0.49	[0.34, 0.64]
ϕ_π	1.55	[1.37, 1.72]	1.52	[1.35, 1.68]	1.52	[1.36, 1.68]
ϕ_y	0.17	[0.06, 0.28]	0.19	[0.08, 0.30]	0.23	[0.08, 0.37]
ρ_a	0.90	[0.83, 0.97]	0.91	[0.86, 0.97]	0.71	[0.52, 0.89]
ρ_R	0.79	[0.71, 0.88]	0.82	[0.76, 0.89]	0.73	[0.62, 0.83]
ρ_g	0.68	[0.44, 0.93]	0.69	[0.46, 0.95]	0.59	[0.30, 0.91]
ρ_z	0.63	[0.41, 0.84]	0.46	[0.25, 0.68]	0.53	[0.34, 0.73]
$\bar{R}$	1.09	[0.90, 1.27]	1.08	[0.89, 1.26]	1.12	[0.94, 1.29]
$\bar{\pi}$	1.18	[1.01, 1.34]	1.19	[1.04, 1.34]	1.13	[0.99, 1.29]
$\bar{y}^{total}$	0.39	[0.23, 0.53]	0.35	[0.22, 0.47]	0.43	[0.29, 0.57]
σ_a	2.00	[0.86, 3.26]	1.30	[0.55, 2.10]	0.65	[0.29, 1.10]
σ_e	0.25	[0.20, 0.29]	0.20	[0.17, 0.24]	0.19	[0.15, 0.23]
σ_g	0.32	[0.24, 0.41]	0.34	[0.23, 0.44]	0.38	[0.27, 0.48]
σ_z	0.57	[0.33, 0.80]	0.72	[0.46, 0.98]	0.51	[0.32, 0.69]
ρ_{fin}	0.88	[0.79, 0.97]	0.90	[0.83, 0.98]	0.90	[0.82, 0.97]
σ_{fin}	2.44	[2.03, 2.83]	2.77	[2.34, 3.18]	2.18	[1.82, 2.54]
Slope	0.031		0.046		0.103	

Figure 1: Decomposition of HP-filtered Swiss GDP

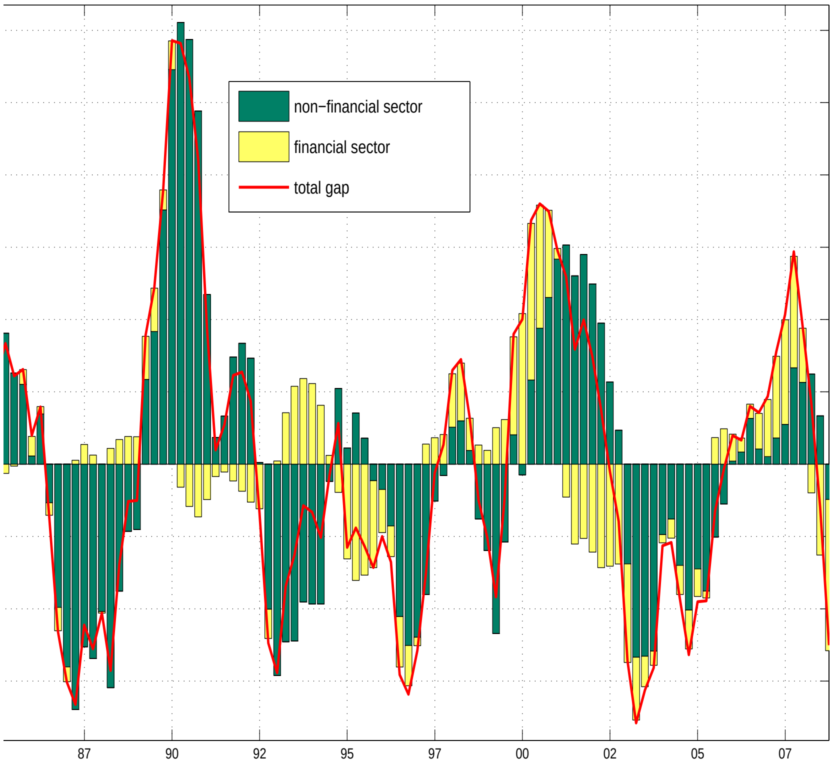
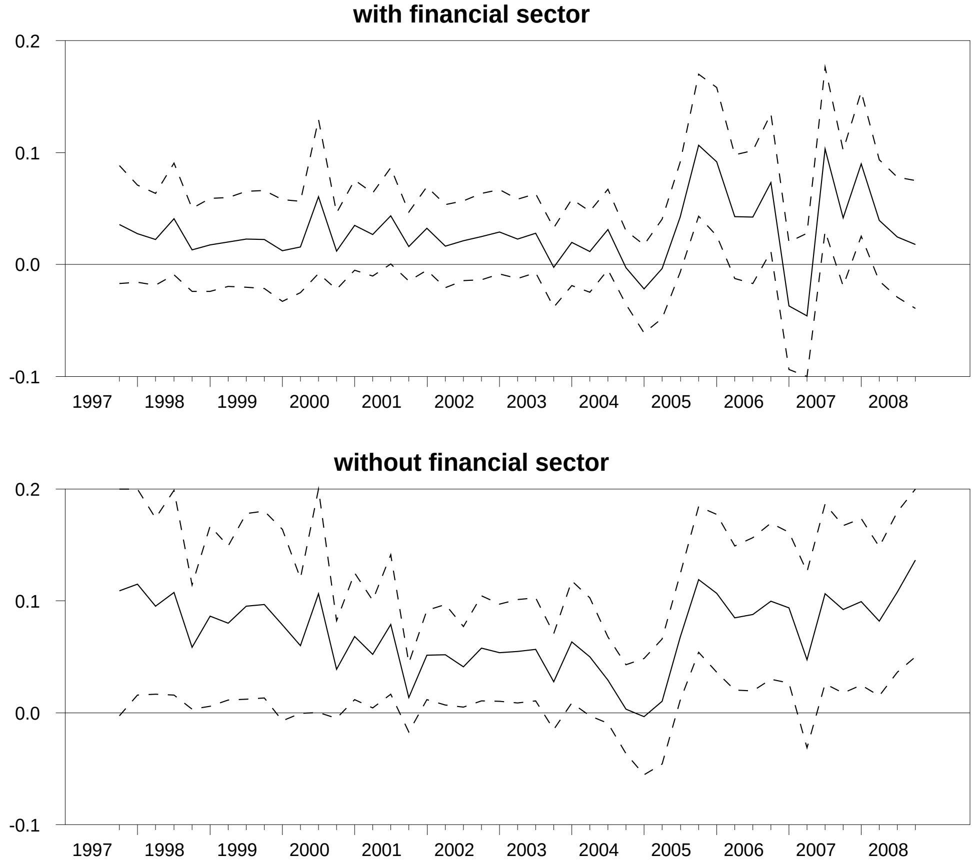


Figure 2: Rolling-window GMM estimates of the NKPC slope


with financial sector

without financial sector

Figure 3: The long-run equilibrium between stock prices and financial-sector GDP

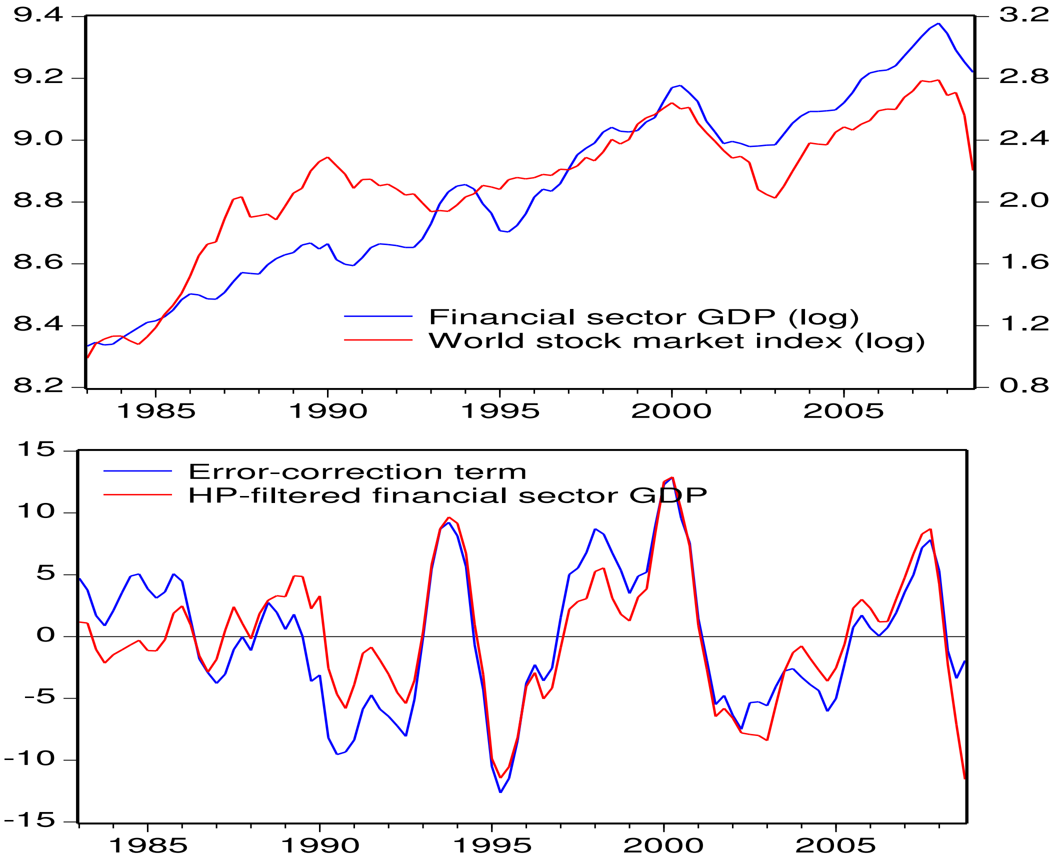


Figure 4: Data series

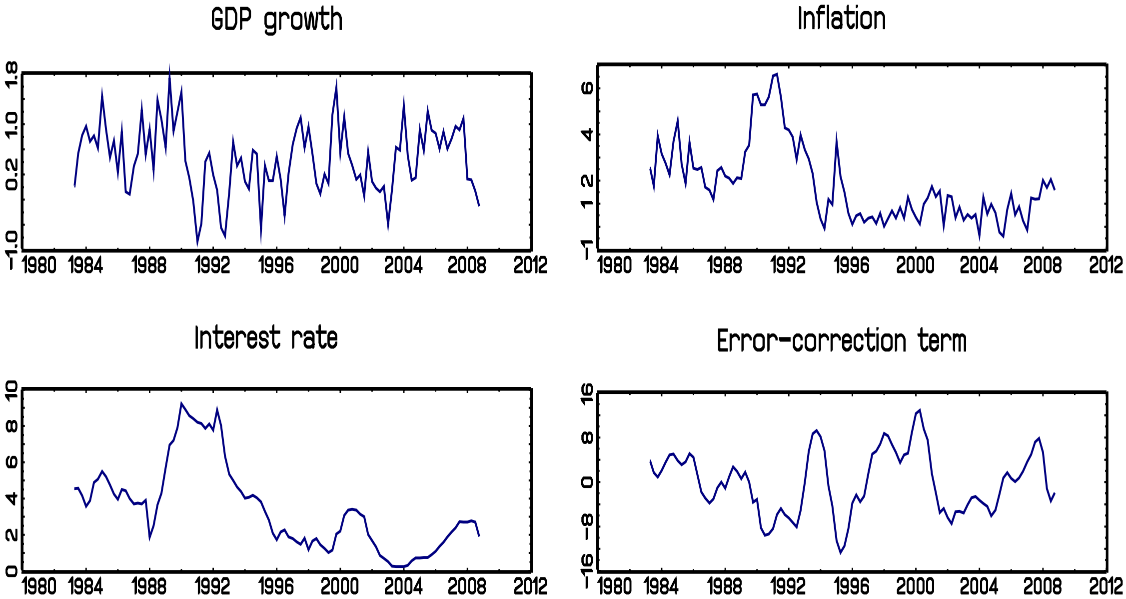


Figure 5: Posterior densities of Phillips curve slope based on total output gap over alternative subsamples

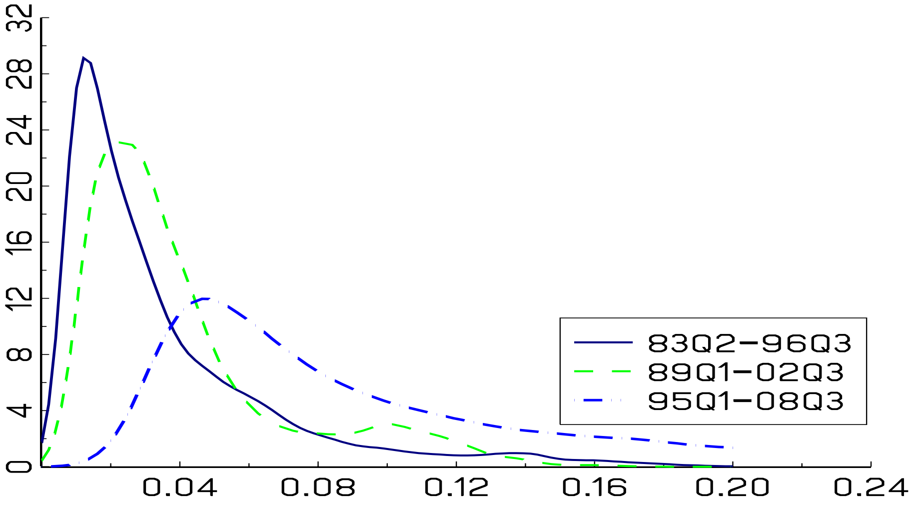


Figure 6: Posterior densities of Phillips curve slope based on non-financial output gap over alternative subsamples