Assessing the predictive power of measures of financial conditions for macroeconomic variables[1]

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Introduction

The interrelationships between the financial and real sectors are very complex. In theory, shocks to any financial market or set of financial institutions could have effects on other financial markets and institutions as well as on the real economy.[5] A great deal of research has focused on the ways in which monetary policy shocks can be transmitted to the real economy both through changes in market interest rates and also indirectly, by affecting agents' balance sheets. Such effects may provide a "financial accelerator" for monetary policy.[6] However, in recent years financial market developments not closely related to monetary policy appear to have played an increasing role in macroeconomic performance. These episodes include many instances of banking and foreign exchange crises, often with substantial real effects.[7] In addition, a number of countries have witnessed substantial booms in asset prices, often accompanied by rapid debt growth, that subsequently reversed with adverse macroeconomic consequences.[8]

Thus, when policymakers decide upon the appropriate stance of monetary policy, they must take account of the possible macroeconomic implications of developments in the financial sector. To do so, they must monitor not only risk-free interest rates and equity prices, but also risk spreads on various instruments, the financial health of businesses and households, the financial health of intermediaries, and the operation of financial markets.[9] With this information in hand, they then need to assess the likely implications of the financial developments for output and inflation.

One way to make such an assessment would be to build and estimate a large structural macroeconomic model that captured the effects of such factors. However, doing so would be difficult. Such an approach would require a structural model that included non-trivial financial markets and institutions and accounted for the effects of developments in markets and institutions on the factors influencing the spending behaviour of households and firms. Moreover, estimation of such a model would require data on the health of financial institutions, measures of risk aversion, and so on. In many cases, however, such variables are not observable, but must be judged from the behaviour of a number of possible indicator variables (such as capital ratios, profitability, asset quality, interest rate spreads and measures of debt and interest burdens).

An alternative approach that at first sight seems simpler would be to use a non-structural method, such as a VAR, to evaluate the effects of financial indicators for output and inflation. Such an

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2 Board of Governors of the Federal Reserve System.

3 Bank for International Settlements.

4 International Monetary Fund.

5 See, for example, Tobin (1969).

6 For a recent treatment, see Bernanke et al (1999).

7 Kaminsky and Reinhart (1999) present evidence on the sources of dual banking and currency crises, and Hoggarth and Saporta (2001) examine the costs of such crises.

8 See Borio and Lowe (2002) for a discussion and some evidence on the possible predictability of such crises.

9 See Nelson and Passmore (2001) for one approach to such monitoring.

approach is difficult, however, because of the large number of measures that may affect the operation of financial institutions and markets and the relatively small number of degrees of freedom available. Including several lags of five, 10, or even more financial measures would quickly use up all of the degrees of freedom available. However, adding the variables one at a time to a baseline specification may give deceptive results, depending on the interrelationships among the financial indicators and the variables included in the baseline estimates.

In the light of these difficulties, the approach here follows the diffusion index method pioneered by Stock and Watson (2002).[10] Their method employs principal components to extract information from a large set of potentially informative indicator variables and then bases forecasts of the variables of interest on the principal components. Here we are interested in whether principal components based on a variety of financial variables can help to forecast output, inflation and investment.[11] To test the resulting empirical model, we compare it to an alternative model based on interest rates and spreads that are known to have forecasting power. The implicit assumption in our approach is that the key underlying factors influencing financial markets and institutions (for example, risk aversion or the financial health of intermediaries, non-financial firms and households) are well captured by the principal components, so that the inclusion of the components accounts for the bulk of the information contained in the factors.

We conduct our exercise for three countries (Germany, the United Kingdom and the United States) for which we were able to obtain data on a sufficient number of financial indicators. This cross-country approach allows us to see if the influence of various financial sector variables (as captured by the principal components) differs importantly across countries. One might expect such differences given the variation in the structure of financial markets and institutions in the different economies.

The next section describes our empirical approach and the data that we employ. The empirical results are described in Section II, and Section III provides some interpretation of the role of the factors. The final section concludes.

I. Method and data

Our approach is analogous to the diffusion index methodology proposed by Stock and Watson (2002) (hereafter referred to as SW). The method consists of extracting a set of principal components from a broad number of series that represent different aspects of the health and performance of financial markets and intermediaries, the level of financial activity, and financial market participants' assessment of future economic prospects.[12] All variables have been tested for stationarity using the Augmented Dickey-Fuller test.[13] In most cases, series for which a unit root could not be rejected at the 95% level have either been differenced or measured as percentage deviations from trend (see below for a discussion of the detrending procedure). However, in some cases - for example, some of the inflation rate and interest rate series - we chose to assume that differences were stationary rather than difference the variables a second time. As in SW, in order to avoid the possibility that measurement units and the volatility of individual series could unduly influence the estimation of the latent factors, all of the variables have been standardised (ie had their means subtracted and been divided by their standard deviations).

The SW procedure is based on the assumption that the set of predictor variables X_t and the variable to be forecast y_{t+k} can be expressed as functions of the same small set of underlying unobservable factors F_t as described by the following equations:

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10 Bernanke and Boivin (2003) employ the same technique in developing forecasts for variables of interest to monetary policymakers.

11 We chose to forecast investment spending because it is the component of output that seems most likely to respond to financial developments.

12 A discussion of the motivation relating to the specific variables used can be found in the next subsection. A description of the complete set of series used for each country is listed in Appendix B.

13 We use five lags for the quarterly frequency variables and two lags for variables that are observed annually.

$$X_t = \Lambda F_t + e_t \text{ and } y_{t+k} = \alpha(L) y_t + \beta F_t + \eta_{t+k} \quad (1)$$

where Λ is the factor loading matrix, $\alpha(L)$ captures the autoregressive component of the variable being forecast, and β is a vector of coefficients on the financial factors. The idiosyncratic errors e_t are assumed to be weakly correlated across variables, and the forecast error η_{t+k} is assumed to be uncorrelated with the unobserved factors (ie $E[\eta_{t+k} | F_t] = 0$). SW show that asymptotically, in other words as the number of observations and the number of variables in X tend to infinity, the factors can be estimated consistently by principal components. The system (1) is potentially dynamic in the sense that X_t may contain lagged predictor variables, which will then influence the values of F_t.

Forecasting exercise

In our case, we use principal components to estimate a small set of unobserved factors that describe the systematic component of the variation in a large number of financial sector variables. We then explore the forecasting ability of the factors for three macro variables by estimating equations of the form:

$$y_{t+k} = \sum_{j=0}^{m} a_j y_{t-j} + \sum_{j=0}^{m} \beta_j \pi_{t-j} + \sum_{l \in [1,\cdots,6]} \sum_{j=0}^{n} \gamma_i F_{l,t-i} + \eta_{t+k} \quad (2a)$$

or

$$\pi_{t+k} = \sum_{j=0}^{m} a_j \pi_{t-j} + \sum_{j=0}^{m} \beta_j y_{t-j} + \sum_{l \in [1,\cdots,6]} \sum_{j=0}^{n} \gamma_i F_{l,t-i} + \eta_{t+k} \quad (2b)$$

where y is GDP or investment, and π is inflation. The choice of factors to be included in the right-hand side (among the six first principal components estimated in the previous step) and the specific lags for the factors and the variable that is being forecast are chosen by minimising the Bayesian Information Criterion (BIC). The value of the criterion declines with the goodness of fit, but it assigns penalties for lack of parsimony in the specification.[14]

To simplify our forecasting exercise, we choose to forecast the macro variables at the one- and two-year horizons (ie k of 4 or 8 with our quarterly data). These horizons seem appropriate for monetary policy decision-making. Moreover, the existing literature has documented that the forecasting ability of the term spread, a financial variable that is often found to have significant predictive ability for economic activity and inflation, is particularly strong at horizons in this range.[15] In order to reduce the effects of high-frequency noise in the variables to be forecast, we use four-quarter averages. For example, in the output regression, we use the average level of the output gap over the coming four quarters, and the average gap over the four quarters starting four quarters ahead.[16]

Horse race against standard variables

An extant body of the literature identifies a number of financial variables that have predictive ability for future macroeconomic developments. For instance, the predictive content of the term structure for future activity has been documented by Estrella and Hardouvelis (1991) and Estrella and Mishkin (1997), while Mishkin (1990a,b and 1991) has found that the term structure contains important information about future inflation. There is also evidence in the literature that stock prices contain information about future economic prospects. In order to guard against the risk that the predictive content of the principal components reflects primarily the inclusion of just a few standard variables,

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14 The exact formula for the criterion is: $BIC = \frac{k \log(T)}{T} + \log\left(\frac{1}{T}\sum_{t=1}^{T} u_t^2\right)$, where k is the number of variables in the regression, T is the sample size and u_t are the regression residuals.

15 See Smets and Tsatsaronis (1997).

16 SW also use averages, but for the eight-quarter-ahead forecasting exercises they use the eight-quarter average. We thought that the four-quarter average starting in four quarters was easier to interpret.

which might dominate our estimated factors, we run a so-called horse race. This test compares the forecasting power of the latent factors against three variables: the level of the short-term rate, the slope of the yield curve and growth in real equity prices.[17]

We perform the comparison in two ways. We first rerun equation (2) substituting the three specific variables for the set of latent factors *F*. As with the principal components, the number of lags is chosen to minimise the BIC criterion. We then compare the goodness-of-fit measures of the two models. If the latent variables do not possess superior information content then the new sets of equations should produce just as good or better fit.

The second step is a direct comparison of the two sets of variables in an "encompassing regression" framework.[18] Specifically, we add lags of the three specific financial variables to our preferred specification of the forecasting equation based on the latent financial factors. As before, the optimal lag structure is determined by using the BIC criterion. If the latent variables have any information content beyond that contained in the specific variables, then they should enter the augmented equation significantly and will improve the overall explanatory power of the model compared to either of the simpler specifications.

Data

The data we include in the derivation of the latent financial factors fall into one of the following categories: interest rates, exchange rates, risk spreads, asset prices, measures of household and business financial strength, credit aggregates, and measures of the health and performance of the banking sector.[19] Appendix B contains a detailed list of the variables used in the analysis for each country. In this subsection we will discuss the general characteristics of the financial variables we have included and their relevance for measuring the prevailing financial conditions.

The variables we have included are intended to capture aspects of the financial determinants of spending by households or businesses. Interest rates are a measure of the cost of capital and play a substantial role in models of consumption and investment spending. They also play a significant role in most empirical macroeconomic models.[20] The real exchange rate influences output through the level of net exports. Risk spreads capture the additional cost of funding for risky borrowers, and they have proved useful in the past in forecasting output.[21] Asset prices may play a number of roles. First, changes in asset prices will be reflected in the value of household wealth, and so will affect consumption spending.[22] Second, equity prices influence firms' cost of capital, and so should affect investment spending.[23] Third, increases in asset prices boost financial wealth and thereby increase the debt capacity of households and firms, facilitating further extensions of financing.[24] Similarly, measures of financial pressures on households and businesses (for example, debt burdens) could well influence credit terms and so propensities to take on additional debt to support spending. Credit aggregates and their components may play two roles, both picking up aspects of credit supply that are not captured by the interest rates and spreads included here and also reflecting demands for credit, which may be useful indicators of the economic outlook.[25] Finally, measures of the financial condition of banks are included to capture the ability and willingness of banks to provide credit to

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[17] Since we include the inflation rate in the regression, we use the nominal short-term rate rather than the real short-term rate. It might be useful to also include a short-term credit spread in our horse race, but we do not have a short-term private rate for Germany over our sample.

[18] See, for example, Fair and Shiller (1990).

[19] Since real interest rates may matter more than nominal rates, we have also included inflation in the list of financial variables.

[20] For example, in the context of a structural model see Reifschneider et al (1999), and in the context of reduced-form models see Sims (1980a, b).

[21] The importance of risk spreads is emphasised in Bernanke (1990) and Friedman and Kuttner (1992).

[22] For a recent assessment of such effects, see Dynan and Maki (2001).

[23] Again, see Reifschneider et al (1999).

[24] This sort of effect is emphasised in the literature on the "financial accelerator". For example, see Bernanke et al (1999).

[25] Kashyap et al (1993) show that quantities can provide a useful signal of credit market effects in a forecasting context.

bank-dependent borrowers. The work on the economic effects of low levels of bank capital or the "bank credit" channel of monetary policy suggests that such effects can be substantial at times.[26]

In the case of asset prices and some of the credit variables, we have included both growth rates of the variables and their percentage deviations from a trend calculated using a Hodrick-Prescott filter. The inclusion of the deviations from trend is based on the view that such deviations will better capture the possible future effects of asset market imbalances on the macroeconomy than will the growth rates.[27] In order to avoid the possibility that future values of these variables could, by affecting the estimated trend, influence earlier measures of the deviation from trend, we calculate the trend value for each period based on data only through that period. This procedure has the added benefit that, leaving aside data revisions, one can think of the deviation from trend as available to policymakers in real time.[28]

We were not able to include the same set of variables for all countries analysed in this paper. In some cases relevant series or proxies were not available, or were only available for too short a time period. In many cases we excluded variables that were available only for a few years. In other cases, we used information available only at an annual frequency (but over a longer period), which we interpolated on the basis of their relationship to a large number of real and financial sector variables observed quarterly. For this interpolation we used an algorithm similar to that suggested by Stock and Watson (2002), but slightly modified as described in Appendix A.

II. Empirical results

This section contains the empirical results of our exercise. It first discusses the outcome of the principal components calculation, and then proceeds to describe the results from the forecasting exercises for output, investment and inflation.

The estimated factors

We apply the principal components methodology discussed above to the sets of financial variables for each country to estimate the unobserved financial factors. Table 1 gives an idea of the ability of the estimated factors to explain the overall variability of the financial measures. It shows the share of the overall variance of the financial measures used that is explained by the first 10 factors. The factors are labelled conventionally in descending order of their ability to capture the overall variance. The first factor explains the largest proportion of the variance, the second the next largest, and so on. There is surprisingly little cross-country variation in the explanatory power of these factors. There is a fairly general pattern: the first component explains about one eighth to one seventh of the common variance while the collective explanatory power of the first six factors is slightly higher than 50%. The prevalence of this pattern is especially surprising when one bears in mind that these are statistical factors, and so there is no reason why the second factor in order of importance for Germany, for example, should reflect the influence of the same set of underlying forces as in the other two countries.

The set of figures C.1-3 in Appendix C plot the time series of the first six estimated latent financial factors for each country. We will base the assessment of each factor's importance in driving business cycle developments on their ability to forecast a set of macroeconomic variables. Hence, we do not try to identify factors or select particular rotations of the factors that might render them more interpretable. Nevertheless, the movements of some of the estimated factors over time are suggestive of their close connection to developments in the financial sector. For instance, the patterns in the movement of

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[26] Prominent proponents of this view include Peek and Rosengren (1995) and Bernanke and Lown (1991). For a discussion of the credit channel in the monetary transmission mechanism, see Bernanke and Blinder (1992).

[27] For a detailed argument along these lines, see Borio and Lowe (2002).

[28] The other included variables (interest rates, risk spreads and bank health measures) are not revised importantly. However, the bank data often lag substantially.

some factors resemble, at least in the sense of the timing of their peaks and troughs, the general movement of interest rates in the three countries. Other factors, however, appear to be far more volatile and have no clear link to the historical behaviour of any particular variable. Arguably, the normalisation and differencing of the variables undertaken in the construction of the components make these comparisons more difficult than one might first expect.

Table 1

The information content of the latent financial factors

Percentage of total variance explained

	United States	**Germany**	**United Kingdom**
Factor 1	14.1	13.0	13.8
Factor 2	12.0	10.9	10.5
Factor 3	9.4	8.6	8.9
Factor 4	7.1	7.7	8.6
Factor 5	5.4	6.9	6.6
Factor 6	5.3	5.8	5.8
Factor 7	4.6	5.2	5.2
Factor 8	3.9	4.8	4.4
Factor 9	3.5	4.2	4.3
Factor 10	3.1	3.6	4.1
Variance explained by first six components	53.3	53.0	54.2

Forecasting macro variables

The criterion we use for identifying the relevant latent factor structure that summarises the impact of the financial sector on the macroeconomy is based on the predictive ability of these variables for real sector developments at the one- and two-year horizons. We run a set of forecasting regressions of the form (2), where the variable to be forecast is alternatively: the output gap, the investment gap and the change in the inflation rate. Consistent with our definitions of the detrended debt and asset price series discussed earlier, we have defined the two gap variables to be the percentage difference between the actual values of GDP and private investment (less inventories) and their trend values based on a backward-looking Hodrick-Prescott filter. For the forecasting exercise, the left-hand variables are measured as the average quarterly values over the four-quarter period ending either four or eight quarters ahead. We present the results of these forecasting exercises in Tables 2.1-3, which are organised by the three variables being forecast. In each table we include the results of the exercise for the four- and eight-quarter-ahead forecasts for all the countries in our analysis.

There are three general patterns that emerge from a comparison of the results across variables, forecast horizons and countries. The first is that the latent factors do help to predict the macroeconomic variables. In all but three cases, these factors are significant at conventional levels in the forecasting equations. The performance of the financial factors is least impressive in the case of inflation, where the factors enter significantly in only four of the six equations. At least for the two gap variables, the significance of the financial factors appears to be somewhat greater at longer forecasting horizons.

The second noteworthy feature of the regressions is that the performance of the models, at least judged by the adjusted R^2, is quite good. With only two exceptions, these goodness-of-fit measures range between 40% and 85% for the two output measures. Both of the lower values relate to forecasts of investment over the eight-quarter horizon. Not surprisingly, the adjusted R^2s generally decline at the longer forecast horizon. The decline is relatively mild in a number of cases, however, perhaps suggesting that the effects of the financial variables on spending take time to emerge. By contrast, in the case of the inflation equations the performance of the models is less good, and the decline in predictive ability at the longer horizon is more pronounced.

The final regularity is that a fairly small number of the estimated financial factors generally enters the forecasting equations. Moreover, while the procedure for selecting the factors tries the first six in each equation, only the first four (in terms of their overall ability to describe the dynamics of the financial sector variables) are retained in any of the equations by the BIC. Moreover, there is relative stability in the set of selected factors across the two horizons: typically the same components appear in the forecasting models at both horizons, albeit sometimes with a difference in lag. We interpret this result as indicating that the dynamic relation between the financial sector factors and the two real sector variables is quite robust.

Table 2.1

The information content of financial factors for the output gap

	United States		**Germany**		**United Kingdom**	
	k = 4	**k = 8**	**k = 4**	**k = 8**	**k = 4**	**k = 8**
GAP_t	2.9954 [6.62]	0.2810 [0.81]	1.71873 [4.67]	0.0609 [0.20]	2.65 [8.73]	2.4883 [3.89]
GAP_{t-1}	–4.1953 [4.54]	–0.7604 [2.31]	–1.4306 [–3.93]	–0.8598 [2.77]	–2.2930 [8.00]	–2.7237 [4.63]
GAP_{t-2}	1.4292 [2.74]					
$INFL_t$	0.0011 [0.64]	0.0066 [2.98]	0.0036 [1.98]	–0.0076 [2.76]	–0.0019 [1.98]	–0.0037 [2.37]
$INFL_{t-1}$	0.0050 [2.31]	0.0055 [2.00]	8.46E-05 [0.06]	–0.0076 [2.98]	–0.0009 [0.88]	–0.0011 [0.57]
$INFL_{t-2}$	0.0054 [2.28]					
$PC1_t$	0.0003 [0.90]	0.0019 [3.68]	–0.0004 [0.72]		–0.0008 [1.87]	–0.0017 [3.27]
$PC1_{t-1}$	0.0008 [1.77]				–0.0010 [2.16]	
$PC2_t$				0.0036 [4.17]		–0.0010 [2.27]
$PC3_t$				0.0018 [3.56]	0.0009 [2.23]	
$PC3_{t-1}$					0.0003 [1.00]	
$PC4_t$				0.0015 [2.98]		
R^2 adj	57.6	40.3	45.6	45.8	84.9	66.8
RMSE						
Financial factors' significance	0.015	0.0005	0.4721	0.000	0.000	0.000

Table 2.2

The information content of financial factors for the investment gap

	United States		Germany		United Kingdom	
	k = 4	**k = 8**	**k = 4**	**k = 8**	**k = 4**	**k = 8**
Inv GAP_t	0.7612 [4.29]	–0.1960 [1.37]	0.258 [1.56]	0.0132 [0.06]	–0.4039 [4.04]	–0.0062 [0.08]
Inv GAP_{t-1}	–0.2281 [0.98]		0.0085 [0.41]	–0.4608 [2.05]		
Inv GAP_{t-2}	0.5337 [2.23]		–0.4787 [2.79]			
$INFL_t$	0.0083 [1.68]	0.0164 [2.65]	0.0014 [0.37]	–0.0151 [2.30]	0.0050 [0.82]	–0.0112 [1.87]
$INFL_{t-1}$	0.0093 [2.02]		–0.0157 [3.15]	–0.0181 [2.57]		
$INFL_{t-2}$	0.0117 [3.26]		–0.0210 [4.47]			
$PC1_t$	–0.0008 [0.75]				–0.0009 [0.56]	–0.0075 [5.86]
$PC1_{t-1}$	–0.0026 [2.93]				–0.0059 [4.55]	–0.0022 [1.67]
$PC2_t$			–0.0029 [1.70]	0.0069 [3.09]		
$PC2_{t-1}$			0.0114 [6.11]			
$PC3_t$				0.0038 [3.20]		
$PC4_t$			0.0057 [6.01]	0.0039 [2.78]		
$PC4_{t-1}$		0.0040 [3.28]	0.0053 [5.55]			
R^2 adj	49.2	19.5	58.9	28.9	58.5	55.4
RMSE						
Financial factors' significance	0.010	0.0015	0.000	0.000	0.000	0.000

Table 2.3

The information content of financial factors for inflation

	United States		Germany		United Kingdom	
	k = 4	k = 8	k = 4	k = 8	k = 4	k = 8
GAP_t	124.43 [4.19]	0.1488 [0.04]	2.0799 [0.41]	–6.5562 [1.31]	120.65 [3.78]	–17.16 [1.77]
GAP_{t-1}	–209.54 [3.94]				–115.37 [4.08]	
GAP_{t-2}	83.91 [2.99]					
$INFL_t$	–0.1955 [2.99]	–0.0220 [0.19]	–0.3251 [3.23]	–0.1989 [1.89]	–0.7057 [4.96]	0.2033 [2.11]
$INFL_{t-1}$	0.0904 [1.14]				0.0819 [0.75]	
$INFL_{t-2}$	0.2060 [3.15]					
$PC1_t$	0.1065 [5.09]		0.0655 [1.32]	–0.0586 [2.97]	–0.0368 [0.93]	
$PC1_{t-1}$			–0.1287 [2.65]			
$PC2_t$	0.0441 [2.88]				–0.0599 [1.48]	
$PC3_t$					–0.0761 [3.16]	0.0556 [1.80]
$PC4_t$		0.0463 [1.59]				
$PC4_{t-1}$		0.0087 [0.44]				
R^2 adj	44.7	1.8	17.6	14.0	45.5	11.5
RMSE						
Financial factors' significance	0.0000	0.2467	0.001	0.0039	0.0049	0.0777

Horse race results

To gauge the extent to which the predictive content of the estimated factors is superior to the information incorporated in more traditional financial variables, we run a set of "horse race" forecasting equations. For each model we include the short-term rate (three-month rate on government securities), the slope of the (nominal) yield curve between three months and 30 years and the growth rate in (real) stock prices as right-hand variables in addition to the estimated latent factors.

Table 3

“Horse race” against select financial variables: predicting the output gap

	United States				Germany				United Kingdom			
	k = 4		k = 8		k = 4		k = 8		k = 4		k = 8	
	Financial variables	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**
$PC1_t$		–0.0000 [0.082]		0.0016 [2.695]		–0.0004 [0.735]				0.0002 [0.348]		–0.0022 [3.662]
$PC1_{t-1}$		0.0008 [2.045]		0.0003 [0.137]						–0.0018 [3.248]		
$PC2_t$								0.0035 [3.843]				–0.0004 [1.122]
$PC3_t$								0.0019 [3.346]		0.0007 [1.160]		0.0013 [3.093]
$PC3_{t-1}$										–0.0003 [0.585]		
$PC4_t$								0.0015 [2.731]				
Int $rate_t$	0.0016 [1.105]	0.00009 [0.672]	0.0003 [0.121]	0.0003 [0.137]	0.0030 [0.758]	0.0020 [0.532]	0.0084 [1.844]	–0.00001 [0.004]	–0.0020 [0.770]	–0.0012 [0.662]	–0.0018 [0.824]	–0.0056 [2.905]
Int $rate_{t-1}$									–0.0014 [0.920]	–0.0012 [0.723]		
Int $rate_{t-2}$									0.0013 [0.583]	–0.0027 [1.576]		
Term $spread_t$	0.00002 [1.607]	0.00000 [0.746]	0.00004 [1.706]	0.00003 [0.120]	0.00006 [2.389]	0.00006 [2.450]	–0.0000 [0.226]	–0.0000 [0.0341]	–0.0000 [0.220]	–0.0000 [0.239]	–0.00002 [0.740]	–0.0003 [1.975]
Term $spread_{t-1}$									–0.0000 [1.342]	–0.0000 [0.205]		
Term $spread_{t-2}$									–0.0000 [0.416]	–0.0000 [0.750]		

Table 3 (cont)

"Horse race" against select financial variables: predicting the output gap

	United States				**Germany**				**United Kingdom**			
	k = 4		**k = 8**		**k = 4**		**k = 8**		**k = 4**		**k = 8**	
	Financial variables	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**	**Financial variables**	**Encompassing regression**
Equity price$_t$	0.0608 [3.397]	0.0497 [3.135]	0.0576 [2.081]	0.0192 [0.834]	0.0119 [1.579]	0.0117 [1.553]	0.0006 [0.041]	–0.0060 [0.449]	0.0365 [2.584]	0.0260 [1.969]	0.0490 [1.992]	0.0409 [3.150]
Equity price$_{t-1}$									0.0379 [3.450]	0.0348 [2.820]		
Equity price$_{t-2}$									0.0273 [2.528]	0.0153 [1.721]		
R^2 adj	57.9	61.1	27.6	41.8	49.3	49.5	17.3	43.8	83.7	90.7	47.6	74.8
Excl PCs		0.121						0.0010		0.0003		0.0001
Excl other		0.035		0.4194	0.0218	0.0106	0.1013	0.9708		0.0000	0.0362	0.0000

The results are tabulated in Table 3. For each country and each maturity, we report the outcome of two regressions: one that substitutes the three financial variables for the latent factors (left column), and one that includes both sets of variables (the encompassing regression, shown in the right column). For space considerations, we report only the coefficients for the financial variables and not those of the lags of the macroeconomic variables.

The general impression is that the estimated latent factors have greater information content than do the short-term yield, the slope of the yield curve and equity price growth. But there are important nuances across countries. In the case of the United States we find that equity prices are very good predictors of the output gap, especially at the one-year horizon. The first factor, however, maintains its significance in the encompassing regression, particularly at the two-year horizon. The results for Germany are more mixed. At the shorter horizon, the term spread is more significant than the estimated components. The opposite is true, however, in the longer-horizon forecasts, where all three components are more significant than the alternative variables. The results for the United Kingdom also point to the greater predictive ability of the latent financial factors. At both horizons, the inclusion of the estimated factors considerably increases the forecasting ability of the model, and in the encompassing framework these variables maintain their significance. However, it must be noted that the interest rate and especially equity price growth remain very significant. As was the case with the other two countries, the results are most favourable for the latent factors at the longer horizon.

Overall, we conclude that the latent financial factors contain strong and independent predictive power for the output gap. Their power is relatively stronger at the two-year horizon, suggesting that the latent factors are capturing relationships between the financial and real sectors of the economy that operate at a relatively lower frequency. This impression is reinforced by the fact that, in the case of the United States and the United Kingdom, the lagged value of the first latent factor is more significant than the contemporaneous value when forecasting at the one-year horizon.

III. Interpreting the factors

Composite factors

One can use the results of the forecasting exercise to calculate composite financial factors for the output gap, for each country. This factor is simply the linear combination of the components chosen based on the BIC. In other words, for a given country:

$$CF_t = \sum_{l \in [1,\cdots,6]}^{6} \sum_{j=0}^{n} \gamma_i F_{l,t-i} \qquad (3)$$

where l sums over up to six included factors, and j sums over up to n lags. This composite factor captures the collective influence of the financial sector variables on the variable being forecast. In other words, if this combination is equal to zero, then one could argue that financial conditions are "neutral" with respect to future activity, while a positive (negative) value of the CF implies favourable (adverse) financial conditions.

Towards the construction of an FCI

This composite factor is relatively close in spirit to the monetary conditions indices or financial conditions indices (FCI) considered in the past. For example, for a time the Bank of Canada monitored a monetary conditions index that was a weighted average of the policy interest rate and the exchange rate, with weights chosen to reflect the relative effects of the two variables on output. More generally, Goldman Sachs has for some time employed a financial conditions index consisting of a weighted average of a real short-term rate, a real long-term rate, the real exchange rate and equity prices to monitor the influence of financial factors on the real economy.[29] The weights employed in the index are

[29] For the Canadian case, see Freedman (1994). For the Goldman Sachs index, see Dudley and Hatzius (1999).

chosen based on the effects of the variables in the Federal Reserve's quarterly model, as reported in Reifschneider et al (1999).

As noted by Macroeconomic Advisors, however, such indices impose the restriction that all of the financial variables included in the index are measured in the same period.[30] Thus, the lag structure of the different financial variables in any subsequent forecasting equation using the index is constrained to be the same. To avoid this problem, Macroeconomic Advisors uses a macroeconomic model to calculate the appropriate weights on the current and lagged values of a small set of financial measures to form an index that does not constrain the lag structure of the effects of the five variables to be the same. Nonetheless, this index only captures the effects of five variables: a real short-term interest rate, a real long-term interest rate, the real exchange rate, real household equity wealth and the price-earnings ratio.

By contrast, the approach taken here can potentially include many more financial variables, as well as a number of lags of those variables. Moreover, since the financial variables may enter the different factors with different weights, and the factors can enter the forecasting equation with different lags, our method imposes less structure on the effective lags employed for different financial variables. To check whether the composite indicator calculated on the basis of the forecasting regression results satisfies the condition that each component variable enters with the same lag structure, we have computed the correlation coefficients of the implied weights on these variables across different lags. These implied weights are calculated by multiplying the weights on the various financial variables in the factors by the coefficients on the factors in the forecasting equation, and then summing the resulting values separately for each lag of the financial variables.

Table 4 contains the results of these calculations for the three countries. The results, perhaps somewhat surprisingly given the discussion in Macroeconomic Advisors (1998), suggest that the lag structure does not differ as much as one might have suspected across the included variables. The correlation coefficients between the implicit weights that the variables are assigned in the composite factor across the different lags range between 66% and 99%. These relatively high correlations suggest that including current and lagged values of a single index of the financial variables at each date may not have a large effect on forecast accuracy. Indeed, we conjecture that if one averaged the individual weights across lags, and then used the average weights to construct an FCI at each date, forecasts based on that FCI would have forecasting power relatively close to that of the more general procedure used here.[31]

Table 4

Correlation coefficients across lags of individual component variable weights

		United States			Germany			United Kingdom		
		t	**t − 1**	**t − 2**	**t**	**t − 1**	**t − 2**	**t**	**t − 1**	**t − 2**
k = 4	T	1			1			1		
	t − 1	0.98	1		0.96	1		0.79	1	
	t − 2	0.88	0.94	1	..	..	..	0.66	0.66	1
k = 8	t	1			1			1		
	t − 1	0.88	1		0.91	1		0.74	1	
	t − 2	..	..	..	..	..	.	..	..	.

Note: Entries correspond to the correlation of the implicit weights on the financial variables at the lag shown in the top row with the implicit weights on the same variables at the lag shown in the first column. The implicit weights are calculated based on the weights on the variables in the estimated latent factors and the coefficients on these factors in the output gap regressions reported in Table 2.

30 See Macroeconomic Advisors (1998).

31 This is left for future investigation.

IV. Conclusions

This paper shows how one can use a method similar to that of Stock and Watson (2002) to incorporate a wide variety of information about financial markets and institutions into macroeconomic forecasts. The results suggest that the method has considerable promise. The financial factors captured with the principal components do a good job of forecasting future levels of output and investment. When compared to a standard set of forecasting variables, the factors generally appear to provide significant independent information. Indeed, the improvement in forecasts of output at longer horizons based on the financial factors is very substantial in some cases, suggesting that the standard variables may exclude important information about financial developments that affect output with a longer lag. By contrast, the financial factors do a much poorer job of forecasting inflation, suggesting that the main effects of financial developments are on the level of activity, with effects on inflation mostly indirect via the level of activity.

Appendices

A. The interpolation method for annual frequency series

Our objective was to base the derivation of the financial latent factors on as many variables as possible and, in particular, to include variables that contain information about the health and level of activity of financial intermediaries. To do so, we had to make use of variables that are available only at an annual frequency. As a result, we had to interpolate those variables to the quarterly frequency that we had chosen for our empirical analysis. This interpolation was done by adapting the methodology suggested by Stock and Watson (2002), which is based on a two-step procedure that is akin to the EM algorithm. In the first step, a number of factors ARE estimated on the basis of a set of series available at a quarterly frequency. These factors are then annualised and the series that are available only annually are projected on them by OLS regression. In the second step, the estimated coefficients of these regressions are used to construct quarterly series on the basis of the quarterly values of the estimated factors. Finally, we distribute the residuals from the fitted annual model to the quarterly interpolated series, so that the appropriate time aggregation of the interpolated series yields the original annual series. We have slightly modified the SW procedure to adapt it to the problem at hand. The following paragraphs detail these modifications. The interested reader is referred to the SW article for further details.

First, unlike the procedure discussed in Stock and Watson, we calculate the principal components and conduct the interpolation only once, rather than iterating on the estimation of factors and the interpolation of the annual variables until the estimated factors converge. We chose this approach because additional iterations changed the interpolated series only slightly, but they increased the volatility of the estimated latent factors considerably. We believe that this volatility may be a result of the smaller cross-section of variables used in our paper, which could lead the procedure to try to adjust the factors to better fit the interpolated series, which are in turn constructed from the factors themselves.

Second, while our main exercise employed only financial variables in the calculation of the principal components, we used both financial and real variables in the construction of the factors used for the interpolation of the annual series. We did so in order to be able to capture all the underlying forces that might influence the dynamics of the series being interpolated. We also included a one-period lag of all the quarterly financial and non-financial variables when calculating the principal components on the thought that the resulting components might better capture the dynamics in the series. The full list of real variables used is included in Appendix B.

Finally, we projected the series to be interpolated on the 20 first principal components (in other words, those that corresponded to the 20 largest eigenvalues of the covariance matrix). We used a stepwise OLS procedure to fit each of the annual frequency series onto a selected subset of the annualised series of the estimated principal components. The selection procedure resulted in the use of one to four components to fit each annual series. The estimated models for each series were then used to create the quarterly interpolated series for these variables on the basis of the quarterly values of the selected components.

B. Data tables

United States			
	Financial variables	**Frequency**	**Transformation**
1	Banks' capital and reserves/banks' total assets, sa	Quarterly	Differenced
2	Banks' credit to non-banks, sa/nominal GDP, saar	Quarterly	Differenced
3	Growth in real banks' credit to non-banks	Quarterly	None
4	Growth in nominal banks' credit to non-banks	Quarterly	None
5	Banks' credit to the private sector, sa/total banks' credit to non-banks, sa	Quarterly	Differenced
6	Banks' holdings of mortgage debt, sa/total banks' credit to non-banks, sa	Quarterly	Differenced
7	Banks' deposits from non-banks, sa/nominal GDP, saar	Quarterly	Differenced
8	Banks' deposits from non-banks, sa/bank loans to non-banks, sa	Quarterly	Differenced
9	Banks' deposits from non-banks, sa/broad money, sa	Quarterly	Differenced
10	Interbank deposits/banks' total assets, sa	Quarterly	Differenced
11	Banks' loans to non-banks, sa/nominal GDP, saar	Quarterly	Differenced
12	Growth in nominal banks' loans to non-banks	Quarterly	None
13	Growth in real banks' loans to non-banks	Quarterly	None
14	Growth in nominal commercial property price index	Quarterly	None
15	Growth in real commercial property price index	Quarterly	None
16	Total liabilities of non-fin corporations/nominal GDP, saar	Quarterly	Differenced
17	Households' total liabilities/nominal GDP, saar	Quarterly	Differenced
18	Flow of funds total debt/nominal GDP, saar	Quarterly	Differenced
19	Growth in nominal equity price index (S&P 500)	Quarterly	None
20	Growth in real equity price index (S&P 500)	Quarterly	None
21	Equity price-earnings ratio	Quarterly	Differenced
22	Growth in nominal residential house price index	Quarterly	None
23	Growth in real residential house price index	Quarterly	None
24	Yearly percentage change in CPI, sa	Quarterly	Differenced
25	Three-month commercial paper rate	Quarterly	Differenced
26	Corporate bond yields	Quarterly	Differenced
27	Ten-year government bond yields	Quarterly	Differenced
28	Three-month money market rate	Quarterly	Differenced
29	Federal funds rate	Quarterly	Differenced
30	Three-month T-bill rate	Quarterly	Differenced
31	Real long-term interest rate	Quarterly	Differenced
32	Real short-term interest rate	Quarterly	Differenced
33	Spread: three-month commercial paper rate – three-month money market rate	Quarterly	Differenced

United States (cont)			
	Financial variables	**Frequency**	**Transformation**
34	Spread: three-month commercial paper rate – three-month T-bill rate	Quarterly	Differenced
35	Spread: corporate bond yields – 10-year government bond yields	Quarterly	None
36	Term spread: 10-year – three-month paper	Quarterly	None
37	Growth in real effective exchange rate	Quarterly	None
38	Total international reserves minus gold, sa/broad money, sa	Quarterly	Differenced
39	Banks' credit to non-banks/GDP gap	Quarterly	None
40	Banks' credit to the private sector/GDP gap	Quarterly	Differenced
41	Real house price index gap	Quarterly	None
42	Real commercial property price index gap	Quarterly	None
43	Real equity price index gap	Quarterly	Differenced
44	Banks' net interest income/banks' total average assets	Annual	Differenced
45	Banks' provisions on loans /banks' loans to non-banks	Annual	Differenced
46	Banks' return on assets	Annual	Differenced
47	Banks' return on equity	Annual	Differenced

United States			
	Real variables	**Frequency**	**Transformation**
1	Real GDP growth, saar	Quarterly	None
2	Real GDP gap	Quarterly	None
3	Nominal private investment, saar/nominal GDP, saar	Quarterly	Differenced
4	Nominal private investment/GDP gap	Quarterly	None
5	Real private investment growth	Quarterly	None
6	Nominal government spending/nominal GDP, saar	Quarterly	Differenced
7	Growth in real government spending	Quarterly	None
8	Nominal private consumption expenditure, saar/nominal GDP, saar	Quarterly	Differenced
9	Growth in real private consumption expenditure, saar	Quarterly	None
10	Nominal total consumption, saar/nominal GDP, saar	Quarterly	Differenced
11	Unemployment rate, sa	Quarterly	Differenced
12	Current account balance, sa/nominal GDP, saar	Quarterly	Differenced

	Germany		
	Financial variables	**Frequency**	**Transformation**
1	Banks' credit to non-banks/nominal GDP, sa	Quarterly	Differenced
2	Growth in real banks' credit to non-banks	Quarterly	None
3	Growth in nominal banks' credit to non-banks	Quarterly	None
4	Banks' credit to the private sector/total banks' credit to non-banks	Quarterly	Differenced
5	Banks' deposits from non-banks, sa/nominal GDP, sa	Quarterly	Differenced
6	Banks' deposits from non-banks, sa/bank loans to non-banks, sa	Quarterly	Differenced
7	Banks' loans to non-banks, sa/nominal GDP, sa	Quarterly	Differenced
8	Growth in nominal banks' loans to non-banks	Quarterly	None
9	Growth in real banks' loans to non-banks	Quarterly	None
10	Growth in nominal equity price index (Dax index)	Quarterly	None
11	Growth in real equity price index (Dax index)	Quarterly	None
12	Equity price-earnings ratio	Quarterly	Differenced
13	Yearly percentage change in CPI, sa	Quarterly	Differenced
14	Day-to-day money rate	Quarterly	None
15	Ten-year government bond yields	Quarterly	Differenced
16	Three-month government rate	Quarterly	Differenced
17	Real long-term interest rate	Quarterly	Differenced
18	Term spread: 10-year – three-month paper	Quarterly	Differenced
19	Growth in real effective exchange rate	Quarterly	None
20	Banks' credit to non-banks/GDP gap	Quarterly	None
21	Banks' credit to the private sector/GDP gap	Quarterly	None
22	Real equity price index gap	Quarterly	None
23	Banks' capital and reserves/banks' total assets, sa	Annual	Differenced
24	Banks' net interest income/banks' total average assets	Annual	Differenced
25	Banks' provisions on loans /banks' loans to non-banks	Annual	None
26	Banks' return on assets	Annual	None
27	Banks' return on equity	Annual	None
28	Growth in nominal commercial property price index	Annual	None
29	Growth in real commercial property price index	Annual	None
30	Growth in nominal residential house price index	Annual	None
31	Growth in real residential house price index	Annual	None
32	Real house price index gap	Annual	None
33	Real commercial property price index gap	Annual	None
34	Total liabilities of non-fin corporations/nominal GDP, saar	Annual	Differenced
35	Households' total liabilities/nominal GDP, saar	Annual	Differenced

	Germany		
	Real variables	**Frequency**	**Transformation**
1	Real GDP growth, sa	Quarterly	None
2	Real GDP gap	Quarterly	None
3	Nominal investment, sa/nominal GDP, sa	Quarterly	Differenced
4	Nominal investment/GDP gap	Quarterly	None
5	Real investment growth	Quarterly	None
6	Nominal government spending, sa/nominal GDP, sa	Quarterly	Differenced
7	Growth in real government spending	Quarterly	None
8	Nominal private consumption expenditure, sa/nominal GDP, sa	Quarterly	Differenced
9	Growth in real private consumption expenditure, sa	Quarterly	None
10	Nominal total consumption, sa/nominal GDP, sa	Quarterly	Differenced
11	Unemployment rate, sa	Quarterly	Differenced
12	Current account balance, sa/nominal GDP, sa	Quarterly	Differenced

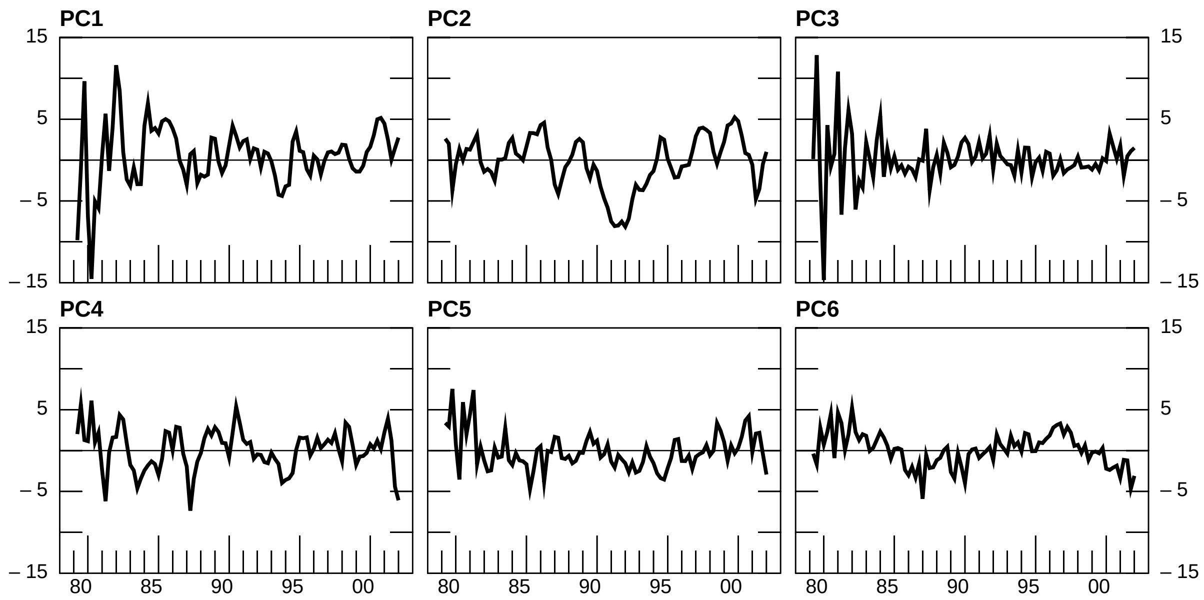
United Kingdom			
	Financial variables	**Frequency**	**Transformation**
1	Banks' credit to non-banks, sa/nominal GDP, sa	Quarterly	Differenced
2	Growth in real banks' credit to non-banks	Quarterly	None
3	Growth in nominal banks' credit to non-banks	Quarterly	None
4	Banks' credit to the private sector/total banks' credit to non-banks, sa	Quarterly	Differenced
5	Banks' deposits from non-banks, sa/nominal GDP, sa	Quarterly	Differenced
6	Banks' deposits from non-banks, sa/broad money, sa	Quarterly	Differenced
7	Interbank deposits/banks' total assets, sa	Quarterly	Differenced
8	Growth in nominal equity price index (FTSE All Share)	Quarterly	None
9	Growth in real equity price index (FTSE All Share)	Quarterly	None
10	Equity price-earnings ratio	Quarterly	Differenced
11	Growth in nominal residential house price index	Quarterly	None
12	Growth in real residential house price index	Quarterly	None
13	Yearly percentage change in CPI, sa	Quarterly	Differenced
14	Policy rate: official band 1 dealing rate	Quarterly	Differenced
15	Overnight sterling interbank deposit rate	Quarterly	Differenced
16	Ten-year government bond yields	Quarterly	Differenced
17	Money market rate: three-month sterling interbank deposit rate	Quarterly	Differenced
18	Three-month government rate	Quarterly	Differenced
19	Real long-term interest rate	Quarterly	Differenced
20	Real short-term interest rate	Quarterly	None
21	Spread: three-month money market rate – policy rate	Quarterly	None
22	Term spread: 10-year – three-month paper	Quarterly	Differenced
23	Growth in real effective exchange rate	Quarterly	None
24	Total international reserves minus gold/broad money, sa	Quarterly	Differenced
25	Real house price index gap	Quarterly	None
26	Real equity price index gap	Quarterly	Differenced
27	Banks' net interest income/banks' total average assets	Annual	Differenced
28	Banks' provision expenses/banks' loans to non-banks	Annual	Differenced
29	Banks' return on assets	Annual	Differenced
30	Banks' return on equity	Annual	Differenced
31	Banks' capital and reserves/banks' total assets, sa	Annual	Differenced
32	Banks' deposits from non-banks, sa/bank loans to non-banks	Annual	Differenced
33	Banks' loans to non-banks/nominal GDP, sa	Annual	Differenced
34	Growth in nominal banks' loans to non-banks	Annual	None
35	Growth in real banks' loans to non-banks	Annual	None
36	Growth in nominal commercial property price index	Annual	None
37	Growth in real commercial property price index	Annual	None

United Kingdom

	Real variables	Frequency	Transformation
1	Real GDP growth, sa	Quarterly	None
2	Real GDP gap	Quarterly	None
3	Nominal investment, sa/nominal GDP, sa	Quarterly	Differenced
4	Nominal investment/GDP gap	Quarterly	None
5	Real investment growth	Quarterly	None
6	Nominal government spending, sa/nominal GDP, sa	Quarterly	Differenced
7	Growth in real government spending	Quarterly	None
8	Nominal private consumption expenditure, sa/nominal GDP, sa	Quarterly	Differenced
9	Growth in real private consumption expenditure	Quarterly	None
10	Nominal total consumption, sa/nominal GDP, sa	Quarterly	Differenced
11	Unemployment rate, sa	Quarterly	Differenced
12	Current account balance, sa/nominal GDP, sa	Quarterly	Differenced

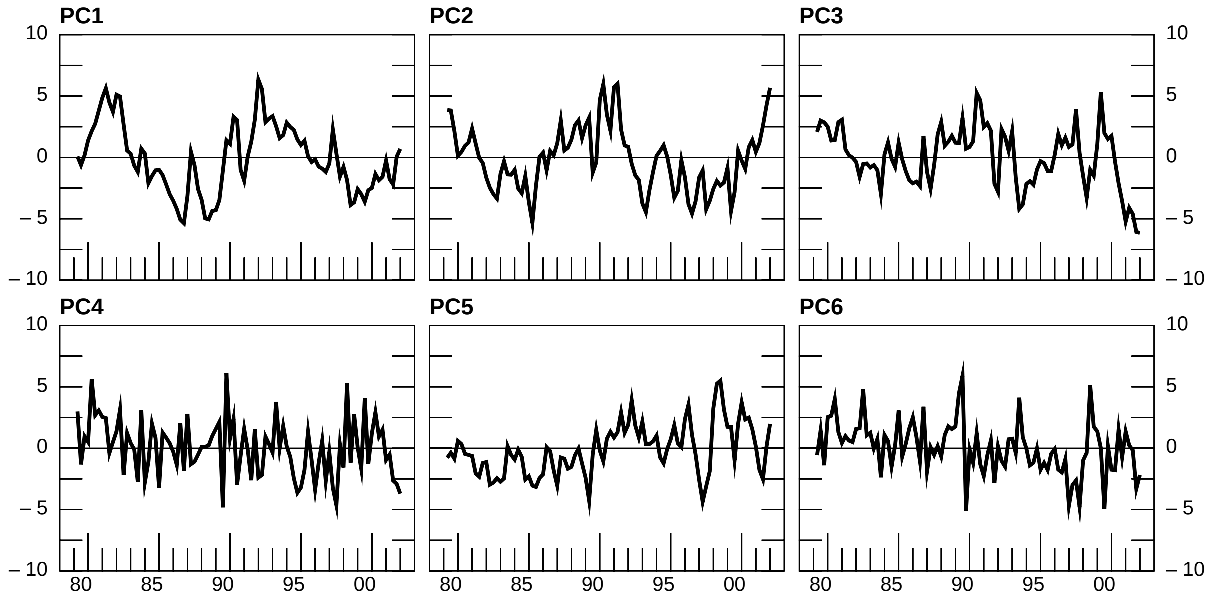
C. The estimated latent financial factors

Estimated financial factors: United States



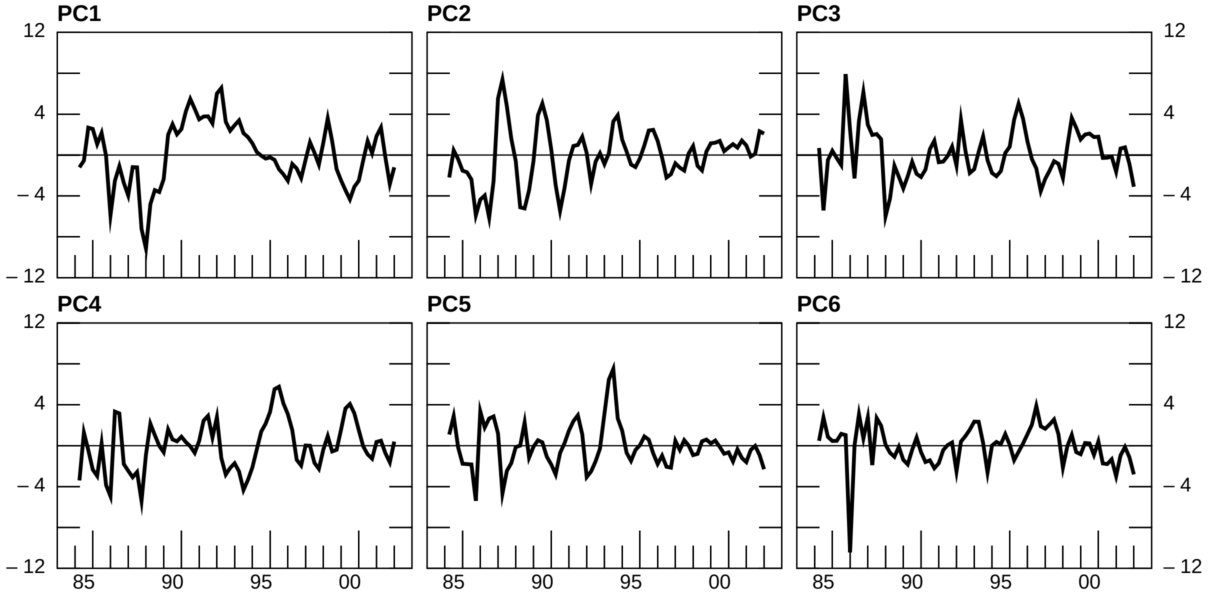
Source: BIS calculations.

Estimated financial factors: Germany



Source: BIS calculations.

Estimated financial factors: United Kingdom



Source: BIS calculations.

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