The Equity Premium and the Business Cycle: the Role of Demand and Supply Shocks

P.N. Smith, S. Sorensen and M.R. Wickens[1]

February 2009

Abstract

We examine the relation between US stock market returns and the US business cycle for the period 1960 - 2003 using a new methodology that allows us to analyse the different effects of aggregate demand and supply shocks. Previous empirical evidence, which is based on the relation between stock returns and their volatility, is shown to be limited by it's use of the CAPM and not the more general SDF approach to asset pricing. Our main findings are that historically negative supply shocks have been the most important source of increases in the equity risk premium and demand shocks have been much less important. The model is implemented using a multivariate GARCH-in-mean model with an asymmetric time-varying conditional heteroskedasticity and correlation structure.

[1] University of York, Barrie+Hibbert Ltd and University of York and CEPR, respectively.
The authors would like to thank Dick van Dijk, Athanasios Orphanides, Christoph Schleicher and Enrique Sentana for helpful comments.

JEL Classification: G12, C32, C51, E44
Keywords: Equity Returns, Risk Premium, Asymmetry.

1 Introduction

How should we analyse the effect of the business cycle on the stock market in a no-arbitrage framework? The no-arbitrage relation explains the expected excess return on the return on equity over the risk-free rate by its risk premium. The implication is that the differences in the effects of the business cycle on the stock market and the risk-free rate are transmitted through the equity premium.

The stochastic discount factor (SDF) approach to modelling the risk premium in a no-arbitrage framework, of which the general equilibrium model is a special case, captures the risk premium through the conditional covariance of risky returns with the discount factors. As the conditional covariance is in general time-varying, the risk premium will also be time-varying. This suggests that we should analyse the effects of the business cycle on stock returns by treating the business cycle as a discount factor.

In practice, it is usual to study the effects of the business cycle on the stock market either through correlation and regression analysis, or through the volatility of stock returns. Simple correlation analysis by Erb, Harvey and Viskanta (1994) suggests an asymmetric relation as the US stock market appears to more strongly correlated with the business cycle during downturns than upturns.

The theoretical basis for focussing on the volatility of returns is the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) which relates the excess return on the stock market to the conditional volatility of returns:

$$E_t(R_{t+1}^M - R_{t+1}^f) = \alpha + \beta V_t(R_{t+1}^M) \tag{1}$$

where R_{t+1}^M is the real return on the market and R_t^f is the real return on a risk-free asset. See, for example, French, Schwert and Stambaugh (1987), Harvey (1989), Schwert (1989), Baillie and DeGennero (1990) and Glosten, Jagannathan and Runkle (1993). Under the CAPM, $\alpha = 0$ and β is the coefficient of relative risk aversion.

Estimates of β for the US stock market have varied from significantly positive to significantly negative, depending on the measure of market returns, the model of the conditional variance and the method of estimation. See Glosten, Jagannathan and Runkle (1993), Scruggs (1998) and Scruggs and Glabadanis (2003). Explanations for a negative β include the leverage and volatility-feedback hypotheses of Black (1976) and Campbell and Hentschel (1992)[2] and incompleteness of the information set, see Lettau and Ludvigson (2007).

[2] Bekaert and Wu (2000) and Schwert (1989), amogst others, provide evidence against the leverage hypothesis.

In CAPM, in general, β is time-varying. This provides an alternative explanation for the different findings of the sign of β: different time periods may give differently-signed estimates. CAPM is a special case of the SDF approach to asset pricing in which there is a single factor: the excess return on the market. If other factors affect the price of equity, then β can be shown to vary with the ratio of the conditional covariances of the factors with the excess equity return to the conditional volatility of the excess return.

In related work based on models that link stock returns to their volatility, and on the NBER classification of the business cycle, counter-cyclical expected returns have been documented by Harrison and Zhang (1999). Chauvet and Potter (2001) show that expected returns are related to the cycle in a non-linear way where the risk-return relationship is driven by a Markov process. Expected returns rise towards the end of downturns in their models.

These results suggest that we require a more general no-arbitrage model of the equity risk premium than standard CAPM that includes the business cycle as a discount factor. Following Smith and Wickens (2002) and Smith, Sorensen and Wickens (2008) we use a multivariate GARCH-in-mean in which both the conditional volatility of excess returns and the conditional covariances of the factors with the excess return are included in the mean. In addition, we allow for possible asymmetries in the dynamic structure of the second moments. This model can be given a CAPM interpretation in which β is time-varying. This model enables us to analyse possible asymmetries in the transmission of variations in the business cycle to stock returns via their impact on the equtity premium.

By including inflation as an extra factor we are able to identify business cycle shocks as either demand or supply shocks. This allows us to examine the different impacts on the stock market of positive and negative demand and supply shocks within a no-arbitrage framework.

Using monthly data for the US stock market from 1960-2003, we find that demand shocks have a different effect on stock returns and the equity risk premium from supply shocks. In a single factor model, we find that nominal returns are *negatively* related to the conditional covariance between inflation and nominal returns. But in a multi-factor model that also includes output, the conditional covariance between inflation and nominal returns has a *positive* effect on nominal returns. The reason for the switch in sign is that the conditional covariance between inflation and output is predominantly negative. Positive inflation shocks are associated with negative output shocks. Thus, while a positive demand shock tends to increase both inflation and output, a negative supply shock tends to increase inflation, but reduce output. We find that negative aggregate supply shocks are an important source of increases in the risk premium in recessions. In contrast, aggregate demand shocks appear to be much less important in explaining variations in the risk premium.

The paper is set out as follows. In Section 2 we set out our theoretical framework for asset pricing. In this section we explain the relation between CAPM and the SDF model of asset pricing, the specification of the econometric model, how the business cycle can affect both the equity premium and β, and our method of identifying demand and supply shocks. Our estimation results for the basic econometric model with asymmetries are reported in Section 3. In Section 4 we show how demand and supply shocks affect the equity premium. Some conclusions are presented in Section 5.

2 Theoretical framework

2.1 Asset pricing

The key asset-pricing equation for nominal returns is

$$1 = E_t[M_{t+1}(1 + I^M_{t+1})\frac{P^c_t}{P^c_{t+1}}] \tag{2}$$

where I^M_t is the nominal market rate of return, P^c_t is the consumer price index and M_t is a stochastic discount factor. If $i_t = \ln(1 + I^M_t)$, $i^f_t = \ln(1 + I^f_t)$ and $\pi_{t+1} = \ln(P^c_{t+1}/P^c_t)$ where I^f_t is the nominal risk-free rate and π_{t+1} is the inflation rate, and i_t, i^f_t, π_t and $m_t = \ln M_t$ are jointly normally distributed then the SDF model of for pricing nominal assets is

$$E_t(i_{t+1} - i^f_t) + \frac{1}{2}V_t(i_{t+1}) = -Cov_t(m_{t+1}, i_{t+1}) + Cov_t(\pi_{t+1}, i_{t+1}). \tag{3}$$

And if m_t can be represented as a linear function of $n-1$ factors z_{it}, $\{i = 1,...,n-1\}$ so that $m_t = -\sum_{i=1}^{n-1}\alpha_i z_{it}$ then a general representation of (3) is

$$E_t(i_{t+1} - i^f_t) = \alpha_0 V_t(i_{t+1}) + \textstyle\sum_{i=1}^{n}\alpha_i Cov_t(z_{i,t+1}, i_{t+1}) \tag{4}$$

where $z_{nt} = \pi_t$. Most asset pricing models can be shown to be special cases of this model. They differ mainly due to the choice of factors and the restrictions imposed on the coefficients.

Equation (4) can be re-written in the form of CAPM as

$$\begin{aligned} E_t(i_{t+1} - i^f_t) &= \beta_t V_t(i_{t+1}) \\ \beta_t &= [-\frac{1}{2} + \textstyle\sum_{i=1}^{n}\alpha_i\gamma_{i,t}] \\ \gamma_{i,t} &= \frac{Cov_t(z_{i,t+1}, i_{t+1})}{V_t(i_{t+1})} \end{aligned} \tag{5}$$

This shows that the CAPM is a special case of the SDF model in which the coefficient on the conditional variance is constrained to be constant, rather than time-varying and non-linearly dependent on the factors.[3]

We consider three macroeconomic factors: industrial production, inflation and money growth.

2.2 Econometric model

We wish to estimate the joint distribution of the stock market return and the macroeconomic factors subject to the restriction that the conditional mean of the returns equation satisfies the no-arbitrage condition, equation (4). We also want to allow business-cycle shocks to impact asymmetrically.

Our econometric model is a modification of that used by Smith and Wickens (2002) and Smith, Sorensen and Wickens (2008) in which asymmetries are also incorporated. This a version of the multivariate GARCH-in-mean (MGM) model

$$\mathbf{Y}_{t+1} = \mathbf{A} + \sum_{i=1}^{p} \mathbf{B}_i \mathbf{Y}_{t+1-i} + \sum_{j=1}^{N_1} \mathbf{\Phi}_j \mathbf{H}_{[1:N,j],t+1} + \mathbf{\Theta} \Upsilon_{k,t+1} + \boldsymbol{\epsilon}_{t+1}, \quad (6)$$

where $\mathbf{Y}_{t+1}$ is an $N \times 1$ vector of dependent variables in which the first N_1 elements are assumed to be the excess returns, $\mathbf{A}$ is an $N \times 1$ vector, the $\mathbf{B}_i$ and $\mathbf{\Phi}_j$ and $\mathbf{\Psi}$ matrices are $N \times N$, $H_{[1:N,j],t+1}$ is the $N \times 1$ j^{th} column of the conditional variance covariance matrix. The first N_1 equations satisfy the restrictions imposed by no arbitrage. The risk premia are given by the first N_1 columns of $\sum_{j=1}^{N_1} \mathbf{\Phi}_j H_{[1:N,j],t+1}$. Thus, the associated $\mathbf{\Phi}_j$ matrices are unrestricted except for the j^{th} element which is $-\frac{1}{2}$. The corresponding rows of $\mathbf{B}_j$ are restricted to zero. The remaining equations have no "in-mean" effect but otherwise are unrestricted. $\mathbf{\Upsilon}_{k,t+1}$ is an indicator variable taking the value of 1 in specified periods and zero otherwise.

This model is suitable analysing a vector of excess returns, though in the present case we have just one risky return i^e_{t+1} (the log excess return of the stock market). We also have three macroeconomic factors: π_{t+1} is the log inflation rate, Δm_{t+1} is the log first difference in narrow money M1 and Δy_{t+1} is the log first difference of industrial production. Hence, $\mathbf{Y}_{t+1} = \left\{ i^e_{t+1} \; \pi_{t+1} \; \Delta m_{t+1} \; \Delta y_{t+1} \right\}$. Consequently, the first row of $\mathbf{\Phi}_1$ appears in the equation for the risky stock return and must satisfy the no-arbitrage condition. The other elements of $\mathbf{\Phi}_1$ appear in the equations for the macro variables and are therefore restricted to equal zero. We

[3] Equation (4) can also be written as the Sharpe ratio $\frac{E_t(i_{t+1} - i^f_t)}{SD_t(i_{t+1})} = -\frac{1}{2} SD_t(i_{t+1}) + \sum_{i=1}^{n} \beta_i SD_t(z_{i,t+1}) Cor_t(z_{i,t+1}, i_{t+1})$ which is the form of model used by Lettau and Ludvigson (2007). In the special case where the conditional correlations are constant the Sharpe ratio becomes a linear function in the conditional standard deviations. The model coefficients then measure the effect on the Sharpe ratio of a unit of volatility in the factors.

use a first-order vector auto-regression ($p = 1$) implying that the model can be written

$$\mathbf{Y}_{t+1} \;=\; \mathbf{A} \;+\; \mathbf{B}\mathbf{Y}_t \;+\; \mathbf{\Phi}\mathbf{H}_{[1:N,1],t+1} \;+\mathbf{\Theta}\Upsilon_{1987:10,\text{t+1}} +\; \boldsymbol{\epsilon}_{t+1} \tag{7}$$

Only the first row of $\mathbf{B}$ is restricted to be zero; the remaining elements of $\mathbf{B}$ are unrestricted.

$\Upsilon_{1987:10,t+1}$ is a dummy variable which is included to take account of the stock market crash of October 1987. The excess return in this month is clearly an outlier and is almost certainly not explicable by our theory of asset pricing, see Schwert (1998). It takes the value of 1 for $t+1$ corresponding to October 1987 and zero otherwise.

In order to examine whether business-cycle shocks impact on stock returns asymmetrically we specify the error term $\boldsymbol{\epsilon}_{t+1}$ as

$$\boldsymbol{\epsilon}_{t+1} \;=\; \mathbf{H}_{t+1}^{\frac{1}{2}}\mathbf{u}_{t+1}, \qquad \mathbf{u}_{t+1} \;\sim\; \mathcal{D}(0, \mathbf{I}_4)$$

where the conditional covariance matrix $\mathbf{H}_{t+1}$ is an asymmetric version of the BEKK model (ABEKK) defined by

$$\mathbf{H}_{t+1} = \mathbf{C}\mathbf{C}' + \mathbf{D}(\mathbf{H}_t - \mathbf{C}\mathbf{C}')\mathbf{D}' + \mathbf{E}(\boldsymbol{\epsilon}_t\boldsymbol{\epsilon}_t' - \mathbf{C}\mathbf{C}')\mathbf{E}' + \mathbf{G}(\boldsymbol{\eta}_t\boldsymbol{\eta}_t' - \overline{\mathbf{C}\mathbf{C}}')\mathbf{G}', \tag{8}$$

and the asymmetry is due to the term in $\eta_t \;=\; \min[\epsilon_t, 0]$. The bar over CC' indicates that the appropriate correction is made since $\text{E}_t(\eta_t\eta_t') \neq CC'$.[4] [5] Equation (7) is estimated using the Quasi-Maximum Likelihood estimator proposed by Bollerslev and Wooldridge (1992).[6]

The equity risk premium is given by the first row of

$$\phi_t = \mathbf{\Phi}\mathbf{H}_{[1:N,1],t+1}$$

This can be decomposed in different ways. One decomposition is into the components associated with each of the factors. Thus we can write the total risk premium as

$$\phi_t \;=\; \phi_{excess\ return,t} \;+\; \phi_{inflation,t} \;+\; \phi_{money,t} \;+\; \phi_{output,t} \tag{9}$$

where $\phi_{jt} \;=\; Cov_t(i^e_{t+1}, j)$. A second decomposition allows us to determine the importance of asymmetries. $\mathbf{H}_{t+1}$, as defined by equation (8), has four components, and hence can be re-written

[4] $\overline{\mathbf{CC}}'$ is obtained by multiplying the diagonal elements of $\mathbf{CC}'$ by $\frac{1}{2}$ and the off-diagonal elements by $\frac{1}{4}$.

[5] The eigenvalues of

$$(\mathbf{D} \otimes \mathbf{D}) + (\mathbf{E} \otimes \mathbf{E}) + (\overline{\mathbf{G} \otimes \mathbf{G}}),$$

must lie inside the unit circle for the BEKK system to be stationary where $\otimes$ is the Kronecker product.

[6] In estimating this model we make an assumption regarding the initial value of the conditional covariance matrix. One possibility is to set the starting value equal to the unconditional covariance matrix of the dependent variables. Another is to perform an unrestricted vector auto-regression and use the estimated covariance matrix of the residuals. A third possibility is to estimate the starting values, noting from equation (8), that $\text{E}(\mathbf{H}_{t+1}) \;=\; \mathbf{CC}'$. All estimations were carried out using each of the starting values, but the final values were virtually identical.

as

$$\mathbf{H}_{t+1} = \mathbf{H}_0 \ + \ \mathbf{H}_{1,t+1} \ + \ \mathbf{H}_{2,t+1} \ + \ \mathbf{H}_{3,t+1}$$

Pre-multiplying by $\mathbf{\Phi}$ gives the decomposition

$$\phi_t = \phi_0 + \phi_{1t} + \phi_{2t} + \phi_{3t} \tag{10}$$

where ϕ_{3t} is the component of the risk premium due to asymmetries. ϕ_{1t} is the component due to autoregressive effects and ϕ_{2t} is the component due to ARCH effects.

2.3 Identifying the macroeconomic shocks

We wish to categorize the macroeconomic shocks into demand and supply shocks and then study their separate influences on stock returns. The identification scheme used is an extension of the modification of the Blanchard and Quah (1989) method due to Robertson and Wickens (1997). This assumes that demand shocks have no permanent effect on output but supply shocks do. Both demand and supply shocks affect output and inflation in the short term.

If we denote the structural shocks by $\mathbf{u}_t$ then these are related to the model disturbances $\boldsymbol{\epsilon}_t$ through

$$\boldsymbol{\epsilon}_t = \mathbf{G}\mathbf{u}_t$$

where the identifying restrictions are given by

$$\begin{bmatrix} \boldsymbol{\epsilon}_{it} \\ \boldsymbol{\epsilon}_{\pi t} \\ \boldsymbol{\epsilon}_{\Delta m,t} \\ \boldsymbol{\epsilon}_{\Delta y,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ g_{21} & g_{22} & g_{23} & g_{24} \\ 0 & 0 & 1 & 0 \\ g_{41} & g_{42} & g_{43} & g_{44} \end{bmatrix} \cdot \begin{bmatrix} u_{er,t} \\ u_{st} \\ u_{\Delta m,t} \\ u_{dt} \end{bmatrix} \tag{11}$$

with

$$g_{44}[1 - b_{22}] + g_{24}b_{42} = 0 \tag{12}$$

where b_{ij} is the ij^{th} element of the estimate of $\mathbf{B}$. The demand and supply shocks u_{dt} and u_{st}, respectively, have a unit variance and are contemporaneously uncorrelated. The other two shocks, the excess return and money growth shocks, $u_{er,t}$ and $u_{\Delta m,t}$, are identical to the corresponding model disturbances.

3 Empirical results

3.1 The no-arbitrage equations

We estimate alternative versions of the no-arbitrage equation for stock returns all of which are based on the first equation in (7). All models have asymmetric effects. The general equation can be written as

$$E_t(i^e_{t+1}) \ + \ \frac{1}{2}V_t(i^e_{t+1}) \ = \ \mathbf{b}^{\intercal} Cov_t(i^e_{t+1}, \mathbf{Y}_{t+1}) + \theta \Upsilon_{1987:10,t+1}$$

Individual models of this type differ in their choice of $\mathbf{Y}_{t+1}$. Model 1 is CAPM for nominal returns and has two factors: the excess return on the market and inflation are the two factors. Thus $\mathbf{Y}_{t+1} \ = \ \{ \ i^e_{t+1} \ \pi_{t+1}\}$ and the model takes the form

$$E_t(i^e_{t+1}) \ + \ \frac{1}{2}V_t(i^e_{t+1}) \ = \ \gamma V_t(i^e_{t+1}) + Cov_t(\pi_{t+1}, i^e_{t+1}) + \theta \Upsilon_{1987:10,t+1} \tag{13}$$

Model 2 is the most general model having four factors of which three are macroeconomic variables: $\mathbf{Y}_{t+1} \ = \ \{ \ i^e_{t+1} \ \pi_{t+1} \ \Delta m_{t+1} \ \Delta y_{t+1}\}$. The significance of any of the additional terms to Model 1 would serve as a rejection of the CAPM. The remaining models are restricted versions of Models 1 and 2. Model 3-6 price only the macroeconomic factors and so restrict the conditional variance of the market return. Model 3 has all three macroeconomic factors. Models 4, 5 and 6 price each of the macroeconomic variables individually. This enables us to evaluate the total contribution of each macroeconomic variable. Model 7 removes the restriction in Model 1 that the conditional covariance with inflation has a unit coefficient and so provides another test of CAPM.

3.2 The data

The data are monthly for the US over the period 1960:01 to 2003:12. The stock market returns are the log value-weighted return on all NYSE, AMEX and NASDAQ stocks. The risk-free rate is the one-month US Treasury Bill rate.[7] The macroeconomic data are the log first difference of the index of real industrial production, log CPI inflation and the log first difference of M1. These data are obtained from the Federal Reserve Bank of St. Louis.

In Table 1 we report descriptive statistics for these data. The excess stock market return has little autocorrelation but displays negative skewness, excess kurtosis, non-normality and autocorrelation both in the squared returns and in the absolute returns. This indicates that the volatility of returns is partly predictable and there is evidence of asymmetries in the volatility process. It suggests that an ARCH process with asymmetries may be able to represent these data.

Inflation has substantial autocorrelation, has positive skewness, does not show excess kurtosis, but is non-normal. There is autocorrelation in squared inflation and in the absolute value of inflation. Money growth is very like inflation except that its absolute values have less autocorrrelation. Industrial production closely resembles stock-market returns except that it has stronger first-order autocorrelation in its squares and absolute values. This uni-variate evidence supports the use of a multi-variate asymmetric ARCH model.

[7] This is available from the homepage of Kenneth French, http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/.

3.3 The estimates

Estimates of the various no-arbitrage models are reported in Table 2. Model 1 (CAPM) has the lowest explanatory power as measured both by the log-likelihood and by the percentage of the variation in the excess return (adjusted for the Jensen effect and 1987 outlier) explained by variations in the risk premium. The mean residual is significantly different from zero. CAPM constrains the coefficient on the conditional covariance with inflation to be unity; Model 7 shows that this restriction is invalid and suggests that inflation has a stronger impact on returns than CAPM predicts.

In our general model, Model 2, three variables are significantly priced: the market return, and two macroeconomic variables: inflation and industrial production. The variability of the implied risk premium for Model 2 is more than 11 times higher than that of Model 1; moreover, its residuals are considerably closer to zero than those of Model 1. The 1987 dummy is only significant in Model 1. Model 2 is therefore clearly preferred to CAPM.

In Model 3 all three macroeconomic variables are significantly priced. The significance of money growth in Model 3 - but not in Model 2 - reflects the correlation between the explanatory variables, i.e. the conditional covariance terms. The unconditional correlation between the conditional covariance of money growth with the market return and the conditional variance of the market return is 0.65. This suggests that money growth may only be significant due to omitting the market return, which is a more significant variable.

Models 4-6 have only a single macroeconomic factor. Inflation is the most significantly priced, followed by industrial production; money growth on its own is not significantly priced. This is a further indication of the effects of correlation between the conditional covariance terms.

These results support previous findings that the volatility of the US stock return is significant in explaining the return. They also show that CAPM can be rejected in favour of a more general asset-pricing model which includes additional macroeconomic factors that enter the model in a way consistent with the absence of arbitrage.

As money growth does not appear to be significantly priced, in our subsequent analysis we omit it as a factor. We do not, however, eliminated it from the model entirely as it is retained as part of the information set and so still has its own equation. Money is therefore still a conditioning variable and able to help forecast the conditional covariance matrix of the other variables. This is justified by the significance of money in the multivariate GARCH process. Apart from this change, we now concentrate on Model 2.

The full set of estimates of Model 2 are reported in Table 3. There are four equations in the model. The first equation is for the excess return and is restricted to satisfy the condition of no-arbitrage. The other three equations have no "in-mean" effects, but do have VAR effects. These are captured in the matrix **B**. Apart from significant own lags, the lagged excess return is strongly significant in the money equation, and lagged inflation is significant in the output equation.

Turning to the GARCH process, the matrices **D** and **E** are highly significant. Although the diagonal terms are the most significant, there are significant off-diagonal effects too so that each variable seems to significantly explain all of the others.[8] For example, an increase in the variance of output growth in the previous period predicts there will be an increase in the variance of the excess return on the stock market in the following period, and vice-versa. There is, therefore, a strong interaction between the stock market and business cycle volatility. There are similar interactions between the stock market and inflation and, interestingly, between output and inflation. A higher inflation variance predicts higher future output variability.

The matrix **G** shows that there are strong asymmetries, with negative shocks giving larger covariances. The negative sign on the variance of stock returns implies that negative own shocks have a lower impact on the volatility of returns than positive shocks, whereas the positive sign of the output variance implies that negative output shocks have a greater impact on business cycle volatility than positive shocks. We also find that there are strong asymmetries arising from the off-diagonal terms of **G**. These are more difficult to interpret as they involve cross-effects with other elements of **G** and the elements of $\eta_t\eta_t' - \overline{\mathbf{CC}'}$. A likelihood ratio test of the joint significance of the elements of the **G** matrix suggests that they are significant at less than the 0.1% significance level ($103.0 \sim \chi^2(16)$).

3.4 The equity risk premium

In Figure 1 we plot the risk premia for Models 1 and 2, together with the excess stock market return. The shaded areas are recessions as defined by the NBER. The risk premium for Model 2 clearly varies over time much more than for Model 1, which is positive in each period because in CAPM the risk premium is proportional to the conditional variance of the market return. Whilst the risk premium for Model 2 is mainly positive, on occasion it is negative; the risk premia for the one-factor Models 4-6 display many more periods when the risk premium is negative.[9]

The fact that the risk premium for Model 2 is less prone to being negative indicates that the conditional covariances are negatively correlated and offset each other. This demonstrates that the simplifying assumption of a constant correlation over time is not appropriate for modelling the joint distribution of the excess return and the macroeconomic variables.

[8] The restrictions provided by the diagonal BEKK model were tested and rejected in favour of our more general BEKK model.

[9] See Figure A1 in the Appendix available from the authors.

Table 4, which reports the autocorrelation coefficients of the risk premia for the six models, shows that Model 1 has the most persistent risk premium, and Models 4-6 have the least persistent and most volatile premium. The persistence of the risk premia for Models 2 and 3 are similar, and are similar to that for Model 6 for which output is the sole factor. This underlines the importance of the business cycle as a risk factor.

For most of the time, when the risk premium in Model 2 is largest, this tends to be periods of recession. Model 3 is similar in this respect. This is further support for the importance of asymmetries.

In Figure 2 we plot the risk premium for Model 2 together with the conditional variances of the equity return and the three macroeconomic factors. It is clear from Figure 2 that the equity premium is not closely related to its conditional variance as predicted by CAPM with a constant β. The highest co-movement between the equity premium and a conditional variance is that between the risk premium and the volatility of output. This provides further support for the contribution of the business cycle in explaining the equity risk premium.

The asymmetric effects on the risk premium of good and bad news may be judged from Figure 3 where the three time-varying components of the risk premium ϕ_{1t}, ϕ_{2t} and ϕ_{3t} from equation (10) are plotted. It is clear that ϕ_{1t}, the autoregressive component, is the most important, but next most important is ϕ_{3t}, the asymmetric effect. Moreover, asymmetries seem to have their greatest effect on the risk premium in recessions. This is consistent with the notion that risk attaches more to recessions than booms.

4 Assessing the impact of structural macroeconomic shocks on the risk premium

4.1 The influence of macroeconomic factors on the equity risk premium

We have shown that the equity premium varies with the the business cycle. We now explore the connection in more detail. First we consider the relation between stock returns and the business cycle using the recession dates according to the NBER dating committee reported in Table 5.

The top panel of Table 6 provides summary statistics for NBER recession and non-recesssion periods. The lower panel presents the means of the covariances of the variables with the excess return multiplied by the estimated coefficient, i.e. the contribution of each macroeconomic variable to the equity premium. These results show a striking difference between the mean stock returns and output growth rates during recession and non-recession. This evidence confirms the strong effect of the business cycle on stock returns. In contrast, we note that the correlations between returns and the macroeconomic variables are not very different between recessions and non-recessions.

The interest in this result is that we find that the conditional correlation coefficient of returns and output is strongly time varying, suggesting that this is masked using unconditional correlations.

Table 6 also shows that the model generates an equity premium which is higher in recessions than non-recessions and that this is due not only to higher uncertainty associated with increased volatility of returns, but also to greater covariances associated with higher inflation and lower output growth.

A necessary condition for the macroeconomic factors to be priced sources of time-varying risk is that they display time-varying volatility. The conditional volatilities of the macroeconomic factors are shown in Figure 2. They clearly vary through time and they tend to be largest during recessions when the risk premium is also at its greatest. As widely discussed, inflation and output volatility seem to have been lower in the last twenty years than in the more turbulent 1970's whereas, more recently, after a period of tranquility, money growth volatility has returned to the high levels of 1970's.

Another necessary condition for the macroeconomic factors to be priced is that they are correlated with the excess return. In Figure 4 we plot the time-varying correlations between the market excess return and the macroeconomic factors. This shows the strength of the correlations and that they vary over time. The conditional correlation between the excess market return and inflation is predominantly negative, unlike the correlations with output and money growth. These are also cyclical.

Combining this information gives the contribution of each factor to the total risk premium. This is plotted in Figure 5. We find that the contribution of the market return is positive, but that of inflation is nearly always negative, whilst the contribution of output fluctuates in sign, being largely negative in the 1970's and positive in the 1980's, but becoming negative again during the late 1990's recession.

To gain further understanding, in Figure 6 we show the time-varying correlations between certain macroeconomic factors and the correlation with the risk premium. In the 1974/5 recession, for example, a large negative cyclical shock is associated with a substantial rise in the risk premium. Figure 7 also reveals that during this recession, the correlation between inflation and output are strongly negative. A positive correlation between inflation and output suggests a demand shock, and a negative correlation a supply shock. This evidence is therefore consistent with the standard explanation of the 1974/5 recession that it was due to a supply shock - the rise in oil and other commodity prices - and not a demand shock. Another strong negative correlation occurs in 1979 when there was a second oil price shock. During later recessions inflation and output are positively correlated which is consistent with these recessions being due instead to negative demand shocks.

Further evidence of the asymmetric effects of demand and supply shocks on the equity premium may be obtained by including the conditional covariance of inflation and output in the basic model, Model 2:

$$E_t(i^M_{t+1} - i^f_t) = \phi_0 V_t(i^M_{t+1}) + \sum_2^3 \phi_i Cov_t(z_{i,t+1}, i^M_{t+1}) + \sum_4^5 \phi_i Cov_t(z_{it+1}, \pi_{t+1}) \tag{14}$$

Two estimates of this equation are presented as Models 8 and 9 in Table 7. Model 8 shows that the conditional covariance between inflation and output growth is highly significant and has a large positive coefficient, whilst that between inflation, and the equity return, which was previously significant in Model 2, is now insignificant. Model 9 shows that the conditional covariance between money growth and inflation is insignificant. The average value of the conditional covariance between inflation and output is negative as is it's impact on the risk premium. But in recessions the covariance becomes more negative, which suggests that supply shocks are the dominant cause of recessions over the whole sample period. From the contribution to the risk premium of the inflation-output growth covariance, we find that there is a difference in the risk premium between recessions and non-recessions of, on average, 3.5% at an annualised rate. The impact of the return-output growth covariance is negative in Model 8 as it is in Model 2. In recessions, this positive covariance becomes smaller thus increasing the size of the risk premium.

These findings reveal several other things. For example, periods with high risk premia are associated with periods of very low correlation between money and output, suggesting that a negative correlation between money and output shocks coincide with more risky stock market returns. At the end of the recessions, and shortly after, the risk premium tends to decline, implying more favourable economic conditions that make the stock market less risky. The recessions of 1974/5 and 1980 had a negative correlation between inflation and output, and so were heavily affected by a supply shock, but were followed by a strong positive correlation between inflation and output, suggesting a demand stimulus was given to the economy to counteract the recession.

4.2 The influence of demand and supply shocks on the equity risk premium

So far our analysis of the effects of macroeconomic factors on the equity premium has focused on their covariance structure. We now consider the effects of demand and supply shocks using the identification scheme described earlier.

First we relate these demand and supply shocks to the NBER recession periods listed in Table 5. In NBER recession periods the aggregate supply shock has a mean value of -8.45% on an annualised basis. In the non-recession periods the mean supply shock is 4.26%. The demand shock has a mean of 0.71% in recession periods and 2.49% in non-recession periods. The two shocks are plotted in Figure 7 for the NBER recession periods. Negative supply shocks appear to be more closely related to the NBER recession periods than negative demand shocks, especially prior to the mid 1980's. Figure 8 also reveals that demand shocks are mostly smaller than supply shocks.

The consequences of business cycle shocks for the equity premium, and therefore expected excess returns, can be examined in more detail through the impulse response functions for the supply and demand shocks. These are depicted in Figures 8 - 11. We show the responses to negative and positive 1% supply and demand shocks along with 95% confidence intervals computed from 10,000 bootstrap simulations. Comparison of these figures shows that the supply shocks have a greater impact on output than on inflation, whilst demand shocks have a greater impact on inflation than output. These findings echo those in the business cycle literature.

The difference between the impacts of negative and positive supply shocks on the equity premium is striking. Figures 8 and 9 show that a 1% negative supply shock raises the risk premium by more than 1% in the second month of the shock.[10] This effect is significantly positive and persistent. By contrast, a positive supply shock has a small impact, with a negative peak on the equity premium and low significance. In comparison with supply shocks, Figures 10 and 11 show that demand shocks, whether positive or negative, cause the risk premium to fall, although not significantly. In all simulations, the responses of money growth to both aggregate supply or demand shocks are insignificant. The point estimates of the negative (positive) response of money growth to positive supply (demand) shocks are consistent with more developed multivariate structural VAR models such as those in Keating (2000).

In summary, asymmetries in the covariance function have been found to be a major contributory factor in producing these contrasting results. Equally, the importance of demand and supply shocks seem to differ when viewed from the perspective of the equity risk premium.

We began this study by observing that the most previous studies of equity returns and the equity risk premium have based their analysis on the relation between stock returns and their volatility as captured by CAPM. Our results have shown that CAPM is not general enough and that a more model model based on the SDF model is strongly supported. We noted that we can interpret the SDF model as a more general version of the CAPM in which the coefficient on the conditional volatility of returns is time varying. In Figure 12 we plot this coefficient, unsmoothed and smoothed. It is very striking how volatile the coefficient is, thereby revealing the inadequacies of the standard CAPM for explaining the relation between returns and volatility. We note that although the coefficient is positive most of the time, for a period in the 1970's it is

[10] In each case we show the deviation of the risk premium from it's steady-state value.

highly negative. This shows once again the problem that standard asset pricing models have in explaining the behaviour of stock returns during that period.

5 Conclusions

In this paper we have shown that macroeconomic shocks are significantly priced in equity markets and that identified demand and supply shocks have very different effects on the equity premium. In contrast to the pioneering work of Schwert and later purely empirically-based approaches, including simple correlation analysis, our analysis was conducted within an explicit no-arbitrage framework of the relation between returns and their volatility based on several models of asset pricing involving stochastic discount factors. This enabled us to derive a formal relation between returns and the business cycle via the equity risk premium. This model is capable of encompassing a number of different asset-pricing theories, including the CAPM. An advantage of this model is that we can then relate the equity risk premium to the business cycle. We are also able to investigate the potential effects of other macroeconomic variables such as inflation and money growth. Our results support the use of two priced macroeconomic factors: output and inflation.

Another feature of our analysis is that we model the joint distribution of stock returns and observable macroeconomic variables using an asymmetric multivariate GARCH model with conditional covariance "in-mean" effects to represent the risk premium. This is a more general approach than that used hitherto in the literature as it neither excludes conditional covariance effects in the mean, nor does it restrict the conditional correlation structure to be constant over time. Further, the conditional covariances are not restricted to be linear functions of the factors as in the Vasicek model. These generalisations strongly influence our new findings. In addition to the three priced factors, we find that money growth should also be included in the joint distribution.

In our model, there are two channels through which the business cycle may affect stock returns. There is a mean effect coming via the equity risk premium, and there is a volatility effect coming through the conditional covariance matrix. All three macroeconomic variables operate significantly through the volatility of returns, but only output and inflation have a significant effect on the mean return.

As a result of allowing for time-varying correlation we discovered a difference in the effects on stock returns between a recession caused by negative supply shocks and one caused by negative demand shocks. We found that the correlation between output and inflation was negative during the recessions caused by the two oil price shocks of the 1970's. Formal identification of the shocks confirms that they were caused by negative supply shocks. In contrast, the earlier and later recessions were associated with a positive correlation between output and inflation, suggesting that these recessions were caused by negative demand shocks.

References

Baillie, R. and R.P. Degennaro. 1990. Stock Returns and Volatility. *Journal of Financial and Quantitative Analysis*, Vol. 25, No. 2, June.

Blanchard, O. and D. Quah. 1989. The Dynamic Effect of Demand and Supply Disturbances. *American Economics Review.* Vol. 79, p 655-673.

Black, F. 1976. Studies of Stock Price Volatility Changes. *Proceedings of the 1976 Meetings of the Business and Economic Statistics Section, American Statistical Association,* 177-181.

Bollerslev, T. and J.M. Wooldridge. 1992. Quasi-Maximum Likelihood Estimation and Inference in Dynamic Models with Time-Varying Covariances. *Econometric Reviews.* Vol. 11, No. 2, p. 143-172.

Chauvet, M. and S. Potter. 2001. Nonlinear Risk. *Macroeconomics Dynamics.* 5, pp 621-646.

Erb, C., C. Harvey and T. Viskanta. 1994. Forecasting international equity correlations. *Financial Analysts Journal.* Nov., 32-45.

French, K.R., Schwert, G.W. and R.F. Stambaugh, 1987. Expected Stock Return and Volatility. *Journal of Financial Economics.* Vol. 19, p. 3-30.

Glosten, L.R., Jagannathan R. and D.E. Runkle. 1993. On the Relation Between the Expected Value and the Volatility of the Nominal Excess Returns on Stocks. *Journal of Finance,* Vol. 48, p. 1779-1801.

Harrison, P. and H. Zhang. 1999. An Investigation of the Risk and Return Relation at Long Horizons. *Review of Economics and Statistics.* 81(3), p399-408.

Harvey, C. 1989. Time Varying Conditional Covariances in Tests of Asset Pricing Models. *Journal of Financial Economics.* 24. 289-317.

Keating, J.. 2000. Macroeconomic Modeling with Asymmetric Vector Autoregressions. *Journal of Macroeconomics.* 22, 1, 1-28.

Lettau, M. and S.C. Ludvigson. 2007. Measuring and Modeling Variation in The Risk-Return Tradeoff. in *Handbook of Financial Econometrics*, Y. Ait-Sahalia and L.P. Hansen (eds).

Lintner, J. 1965. The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *Review of Economics and Statistics.* Vol. 47, p. 13-37.

Robertson, D. and M.R.Wickens. 1997. Measuring Real and Nominal Shocks and their Transmission Mechanism under Different Monetary Systems. *Oxford Bulletin of Economics and Statistics*, 59, p. 5-28.

Schwert, G. W. 1989. Why Does Stock Market Volatility Change Over Time ? *Journal of Finance.* Vol. 44, No. 5, p. 1115-1153, December.

Schwert, G. W. 1998. Stock Market Volatility: Ten Years after the Crash. *for Brooking-Wharton Conference on Financial Institutions, Available from http://schwert.ssb.rochester.edu/gws.htm.*

Scruggs, J.T. 1998. Resolving the Puzzling Intertemporal Relation between the Market Riskpremium and Conditional Market Variance: A Two-Factor Approach. *Journal of Finance.* Vol. 53, No. 2, p. 575-603, April.

Scruggs, J.T. and P. Glabadanidis. 2003. *R*isk Premia and the Dynamic Covariance Between Stock and Bond Returns. *Journal of Financial and Quantitative Analysis,* 38, 295-316.

Sharpe, W. 1964. Capital Asset Prices: A theory of Market Equilibrium under Conditions of Risk. *Journal of Finance.* Vol. 19, No. 3, September, 425-442.

Smith, P.N. and M.R. Wickens. 2002. Asset Pricing with Observable Stochastic Discount Factors. *Journal of Economic Surveys.* Vol. 16, 397-446.

Smith, P.N., Sorensen, S. and M.R. Wickens. 2008. General Equilibrium Theories of the Equity Risk Premium: Estimates and Tests. *Quantitative and Qualitative Analysis in Social Sciences*, Vol 3, Issue 3.

Table1 : Descriptive Statistics

	$i^e_{s,t+1}$	π_{t+1}	Δm_{t+1}	Δy_{t+1}
Mean	4.46	4.27	5.02	3.04
Std. Dev	53.46	3.62	6.02	9.00
Skewness	-0.71	1.03	0.12	-0.59
Kurtosis	5.79	4.70	4.08	5.92
Normality	59.91**	90.10**	21.52**	72.36**
$\rho(x_t, x_{t-1})$	0.07	0.66	0.52	0.37
$\rho(x_t, x_{t-2})$	-0.05	0.60	0.33	0.29
$\rho(x_t, x_{t-3})$	-0.01	0.56	0.33	0.26
$\rho(x_t, x_{t-4})$	-0.01	0.54	0.31	0.21
$\rho(x_t, x_{t-5})$	0.07	0.54	0.33	0.08
$\rho(x_t, x_{t-6})$	-0.03	0.54	0.34	0.10
$\rho(x_t^2, x_{t-1}^2)$	0.05	0.66	0.53	0.27
$\rho(x_t^2, x_{t-2}^2)$	0.12	0.62	0.34	0.14
$\rho(x_t^2, x_{t-3}^2)$	0.15	0.59	0.31	0.14
$\rho(x_t^2, x_{t-4}^2)$	0.08	0.56	0.23	0.05
$\rho(x_t^2, x_{t-5}^2)$	0.10	0.57	0.22	-0.04
$\rho(x_t^2, x_{t-6}^2)$	0.09	0.58	0.26	0.07
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-1})$	0.05	0.63	0.44	0.31
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-2})$	0.06	0.61	0.26	0.13
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-3})$	0.07	0.54	0.22	0.10
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-4})$	0.03	0.52	0.23	0.05
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-5})$	0.02	0.55	0.20	-0.04
$\rho(\lvert x\rvert_t, \lvert x\rvert_{t-6})$	0.02	0.52	0.21	0.04
$\rho(.)$ is the correlation and x_t is the relevant column variable				

Note: Two stars as superscipt indicates that normality is rejected using 0.99 CV. x refers to variable in first row of table.

Table 2. Estimates of Models 1 to 7

	M1	M2	M3	M4	M5	M6	M7
$V_t(i^e_{t+1})$	3.57 (3.75)	11.14 (2.53)					10.49 (3.15)
$Cov_t(i^e_{t+1}, \pi_{t+1})$	1	780.28 (2.98)	533.99 (2.10)	−663.67 (4.10)	1	1	1093.17 (3.95)
$Cov_t(i^e_{t+1}, \Delta m_{t+1})$		−18.49 (0.16)	496.42 (2.51)		1342.50 (2.82)		
$Cov_t(i^e_{t+1}, \Delta y_{t+1})$		−312.09 (3.71)	−341.34 (3.38)			−353.60 (4.33)	
$\Upsilon_{1987:10,t+1}$	−0.27 (2.39)	−0.27 (0.82)	−0.2791 (0.84)	−0.29 (1.13)	−0.29 (1.90)	−0.26 (1.28)	−0.28 (1.00)
ν	10.83 (4.83)	9.90 (5.36)	10.05 (5.38)	9.61 (5.27)	9.47 (5.24)	9.84 (5.36)	8.92 (5.57)
Log Likelihood	−2130.5	−2109.2	−2112.0	−2120.5	−2124.2	−2117.5	−2118.8
LR Risk Premium	8.60	7.54	6.79	9.02	7.58	5.69	8.79
Average Residual	−2.27	−1.34	−0.60	−2.74	−1.41	0.46	−2.60
Risk Share (%)	0.59	11.90	12.11	8.70	11.60	11.80	11.20

Note: Share of risk = $100 \cdot Var(\phi_t)/Var(i^e_{t+1} + \frac{1}{2}V_t(i^e_{t+1}) - \widehat{\theta}\Upsilon_{1987:10,t+1})$

ν = degrees of freedom. LR: Long Run or average. Absolute t-statistics in parenthesis.

Table 3. Estimates of Model 2

$$\mathbf{Y}_{t+1} = \mathbf{A} + \mathbf{B}\mathbf{Y}_t + \mathbf{\Phi}\mathbf{H}_{[1:N,1],t+1} + \mathbf{\Theta}\Upsilon_{1987:10,t+1} + \boldsymbol{\epsilon}_{t+1}$$

$$\boldsymbol{\epsilon}_{t+1} = \mathbf{H}_{t+1}^{\frac{1}{2}}\mathbf{u}_{t+1}, \qquad \mathbf{u}_{t+1} \sim \mathcal{D}(0, \mathbf{I}_4)$$

$$\mathbf{H}_{t+1} = \mathbf{C}\mathbf{C}^\intercal + \mathbf{D}(\mathbf{H}_t - \mathbf{C}\mathbf{C}^\intercal)\mathbf{D}^\intercal + \mathbf{E}(\boldsymbol{\epsilon}_t\boldsymbol{\epsilon}_t^\intercal - \mathbf{C}\mathbf{C}^\intercal)\mathbf{E}^\intercal + \mathbf{G}(\boldsymbol{\eta}_t\boldsymbol{\eta}_t^\intercal - \overline{\mathbf{C}\mathbf{C}}^\intercal)\mathbf{G}^\intercal$$

$$\widehat{A} = \begin{bmatrix} 0 \\ \underset{(5.85)}{0.0967} \\ \underset{(4.42)}{0.1306} \\ \underset{(5.80)}{0.2792} \end{bmatrix}, \quad \widehat{\Phi} = \begin{bmatrix} \underset{(2.53)}{11.14} & \underset{(3.02)}{780.28} & \underset{(0.16)}{-18.49} & \underset{(3.71)}{-312.09} \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\widehat{B} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ \underset{(0.70)}{0.0016} & \underset{(20.44)}{0.6621} & \underset{(1.19)}{0.0193} & \underset{(0.87)}{-0.0107} \\ \underset{(4.22)}{0.0142} & \underset{(0.86)}{0.0535} & \underset{(15.78)}{0.6007} & \underset{(0.26)}{-0.0062} \\ \underset{(0.16)}{0.0009} & \underset{(2.24)}{-0.2150} & \underset{(0.92)}{0.0475} & \underset{(6.83)}{0.2793} \end{bmatrix}$$

$$\widehat{D} = \begin{bmatrix} \underset{(4.46)}{0.5589} & \underset{(1.67)}{2.4030} & \underset{(3.29)}{3.5705} & \underset{(3.87)}{2.7721} \\ \underset{(3.12)}{0.0233} & \underset{(8.58)}{0.7501} & \underset{(2.08)}{-0.1550} & \underset{(2.50)}{-0.1349} \\ \underset{(1.88)}{0.0362} & \underset{(0.32)}{-0.1029} & \underset{(6.07)}{-0.5781} & \underset{(1.95)}{0.1246} \\ \underset{(4.26)}{0.1483} & \underset{(2.57)}{-1.1940} & \underset{(1.68)}{0.2977} & \underset{(3.07)}{-0.3907} \end{bmatrix}$$

$$\widehat{E} = \begin{bmatrix} \underset{(0.24)}{-0.0085} & \underset{(1.13)}{-0.4953} & \underset{(1.49)}{-0.7441} & \underset{(0.15)}{0.0315} \\ \underset{(1.09)}{-0.0029} & \underset{(6.55)}{0.3002} & \underset{(0.30)}{-0.0100} & \underset{(1.85)}{-0.0290} \\ \underset{(0.72)}{-0.0035} & \underset{(0.53)}{-0.0568} & \underset{(7.27)}{0.5315} & \underset{(2.65)}{-0.1017} \\ \underset{(2.12)}{-0.0170} & \underset{(0.33)}{-0.0489} & \underset{(2.46)}{-0.2386} & \underset{(0.20)}{0.0131} \end{bmatrix}$$

$$\widehat{G} = \begin{bmatrix} \underset{(1.91)}{-0.0661} & \underset{(1.66)}{-1.5521} & \underset{(3.24)}{-1.3589} & \underset{(0.34)}{0.0762} \\ \underset{(3.76)}{-0.0119} & \underset{(0.80)}{0.0736} & \underset{(0.80)}{-0.0202} & \underset{(2.27)}{0.0575} \\ \underset{(0.19)}{-0.0021} & \underset{(0.97)}{-0.2081} & \underset{(0.04)}{0.0060} & \underset{(0.55)}{-0.0347} \\ \underset{(0.92)}{-0.0117} & \underset{(0.74)}{0.2254} & \underset{(0.96)}{-0.1171} & \underset{(6.66)}{0.5432} \end{bmatrix}$$

$$100 \cdot \widehat{C} = \begin{bmatrix} \underset{(6.74)}{4.8236} & 0 & 0 & 0 \\ \underset{(0.07)}{0.0017} & \underset{(8.30)}{0.2369} & 0 & 0 \\ \underset{(1.08)}{0.0435} & \underset{(1.15)}{0.0469} & \underset{(6.88)}{0.4657} & 0 \\ \underset{(1.57)}{0.1404} & \underset{(0.58)}{0.0458} & \underset{(0.64)}{-0.0382} & \underset{(6.99)}{0.7290} \end{bmatrix}$$

$$1200^2 \cdot \widehat{C}\widehat{C}' = \begin{bmatrix} 3350.40 & 1.18 & 30.24 & 97.50 \\ 1.18 & 8.08 & 1.61 & 1.58 \\ 30.24 & 1.61 & 31.82 & -1.38 \\ 97.50 & 1.58 & -1.38 & 79.87 \end{bmatrix}$$

Note: Absolute t-statistics in parenthesis.

Table 4. Autocorrelation coefficients for risk premia

	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_{12}
$\phi_t^{Model\ 1}$	0.98	0.96	0.93	0.91	0.88	0.85	0.65
$\phi_t^{Model\ 2}$	0.43	0.59	0.31	0.30	0.09	0.09	−0.10
$\phi_t^{Model\ 3}$	0.33	0.58	0.26	0.27	0.11	0.07	−0.12
$\phi_t^{Model\ 4}$	0.73	0.61	0.42	0.23	0.09	−0.03	−0.23
$\phi_t^{Model\ 5}$	0.57	0.58	0.41	0.32	0.20	0.17	−0.13
$\phi_t^{Model\ 6}$	0.26	0.60	0.18	0.35	0.05	0.20	−0.07
$\phi_t^{Model\ 7}$	0.64	0.70	0.50	0.47	0.28	0.26	−0.09

Table 5: Recession dates and number of observations

60:03-61:05	69:11-70:10	73:11-75:03	80:01-80:07	81:07-82:11	90:07-91:03	01:03-01:11
15	12	17	7	17	9	9

Total no. obs. = 86

Table 6. Summary statistics comparing periods of recession with other periods

Model 2	log return	inflation	money	ind. prod.	risk premium
Mean in recessions	−6.5147	5.9593	5.0598	−7.3957	10.88
Mean elsewhere	6.4664	3.8649	5.0537	4.9132	7.038
Correlation with log returns in recessions	1	−0.1417	0.0920	0.0190	
Correlation with log returns elsewhere	1	−0.1394	0.0723	0.0480	
Mean conditional SD during recessions	54.9312	3.4322	5.7111	10.6250	
Mean conditional SD deviation elsewhere	48.9321	2.4689	4.9801	7.4919	
Mean contributions to risk prem. in recessions	28.6471	−16.7822	−0.2983	−0.6827	1
Mean contributions to risk prem. elsewhere	22.7963	−9.2757	−0.1772	−6.3054	1

Table 7. Alternative risk premium representations

	Model 2	Model 8	Model 9
$\mathrm{V}_t(i^e_{t+1})$	11.15 (2.53)	5.58 (2.11)	11.45 (2.38)
$\mathrm{Cov}_t(i^e_{t+1}, \pi_{t+1})$	780.28 (2.98)	13.46 (0.12)	876.0 (2.78)
$\mathrm{Cov}_t(i^e_{t+1}, \Delta m_{t+1})$	−18.49 (0.16)	177.15 (2.30)	0.332 (0.00)
$\mathrm{Cov}_t(i^e_{t+1}, \Delta y_{t+1})$	−312.09 (3.71)	−136.45 (2.51)	−337.06 (3.61)
$\mathrm{Cov}_t(\pi_{t+1}, \Delta m_{t+1})$			960.96 (0.70)
$\mathrm{Cov}_t(\pi_{t+1}, \Delta y_{t+1})$		4534.8 (3.96)	
$\Upsilon_{1987:10,t+1}$	−0.27 (0.82)	−0.278 (0.48)	−0.27 (0.67)
ν	9.90 (5.36)	9.58 (5.64)	9.80 (5.38)
Log Likelihood	−2109.2	−2105.0	−2109.0
LR Risk Premium	7.54	6.61	7.54
Average residual	−1.3402	−0.3737	−1.3501
Risk Share (%)	11.90	12.9	12.0

Note: Share of risk = $100 \cdot Var(\phi_t)/Var(i^e_{t+1} + \frac{1}{2}V_t(i^e_{t+1}) - \widehat{\theta}\Upsilon_{1987:10,t+1})$

ν = degrees of freedom. LR: Long Run or average. Absolute t-statistics in parenthesis.

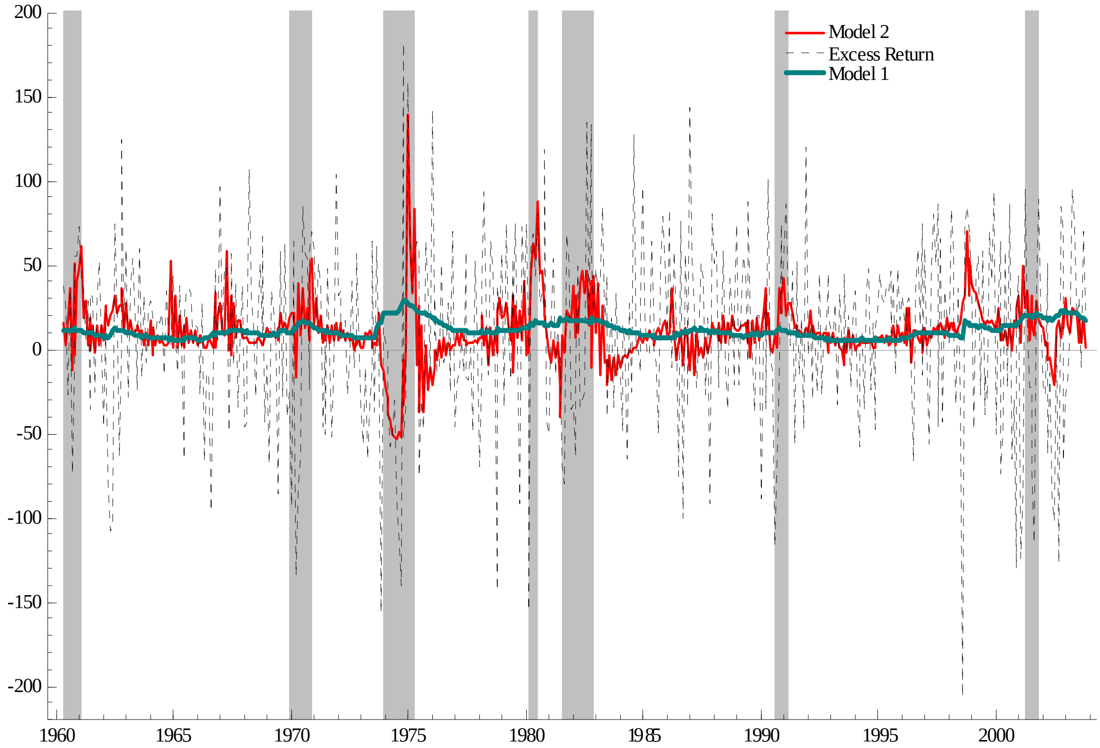

Figure 1: Risk premia for Models 1-2 and excess return

Notes: The excess return is net of the Jensen effect and the October 1987 dummy. The data are measured in annualised percentages. Shaded areas are recessions as defined by the NBER.

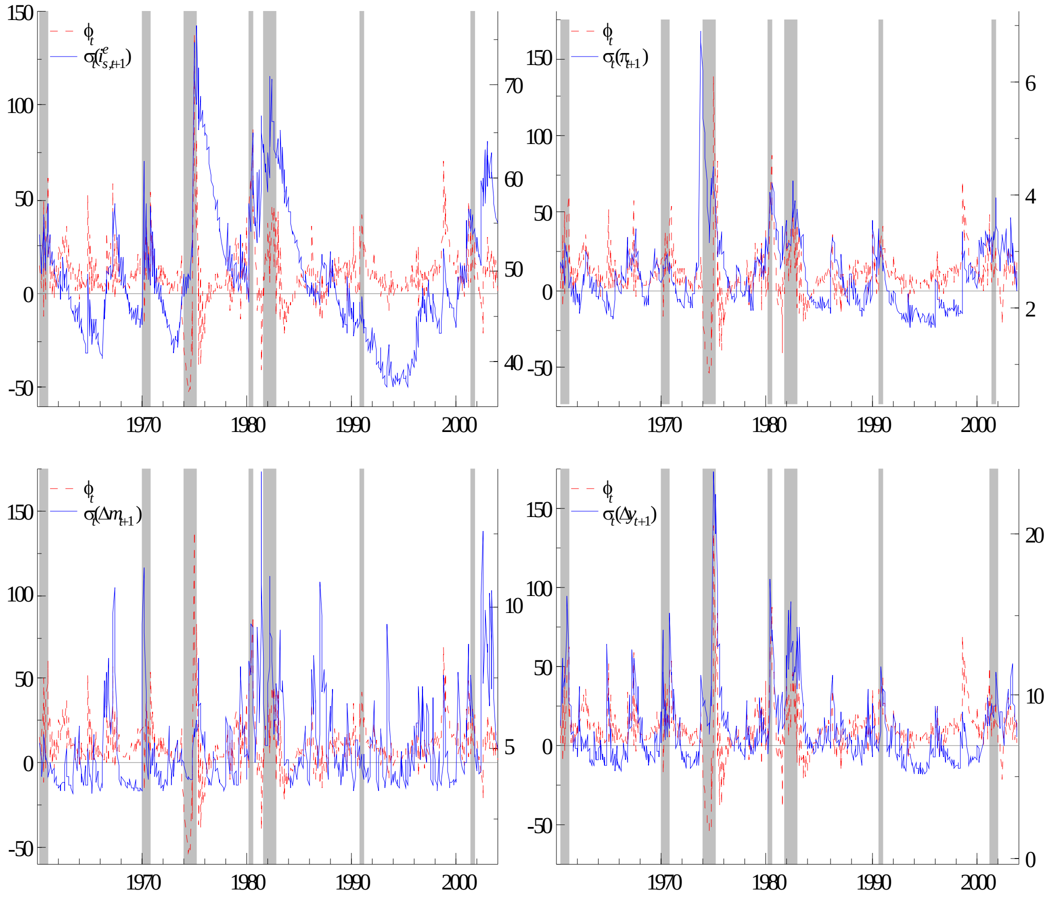

Figure 2: The risk premium and the conditional variances of the factors

Notes: the scale for the risk premium is on the left axis and that for the conditional variances is on the right. All are measured in annualised percentages. Shaded are recessions as defined by the NBER.

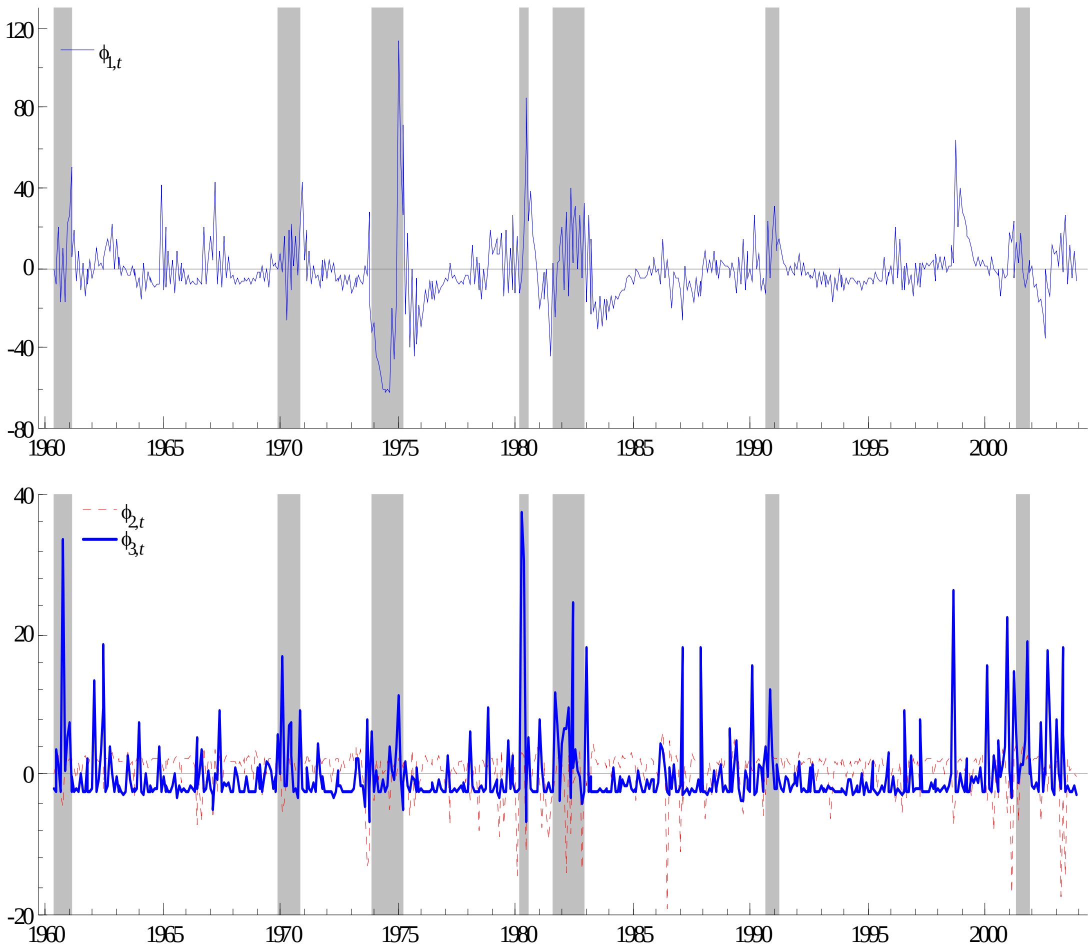

Figure 3: The contribution to risk of asymmetries

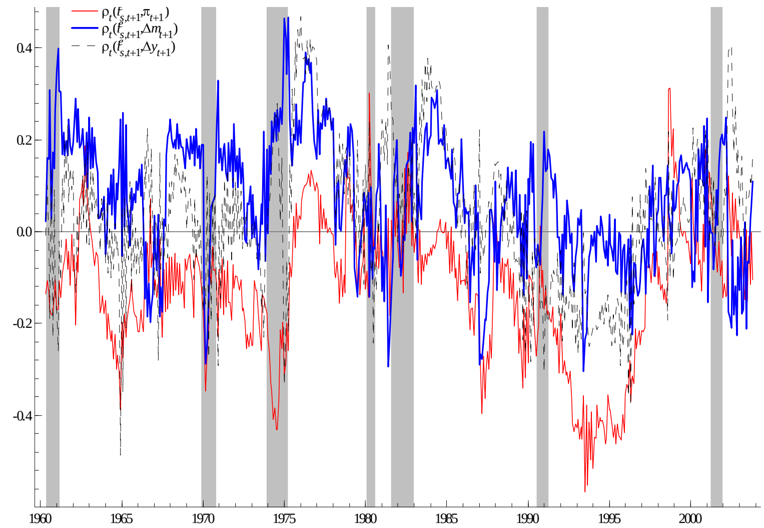

Figure 4: Time-varying correlations between the excess return and the factors

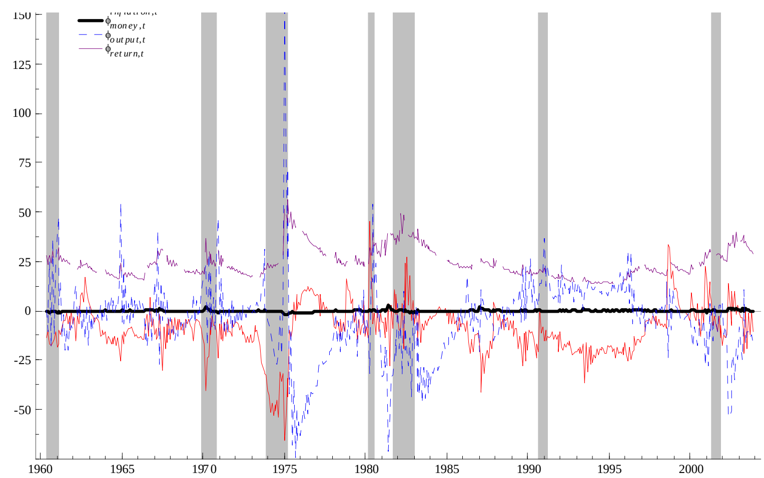

Figure 5: The contribution to risk of the macroeconomic factors

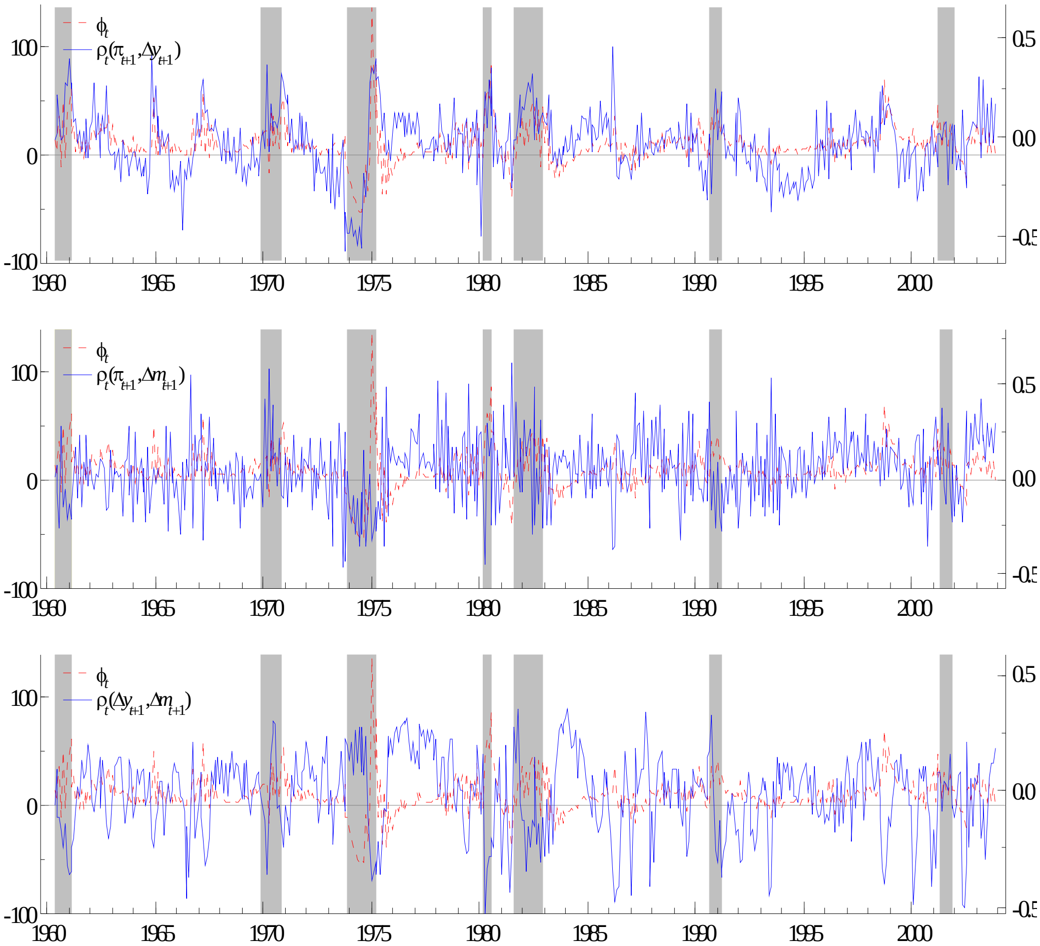

Figure 6: The risk premium and time-varying correlation between the factors

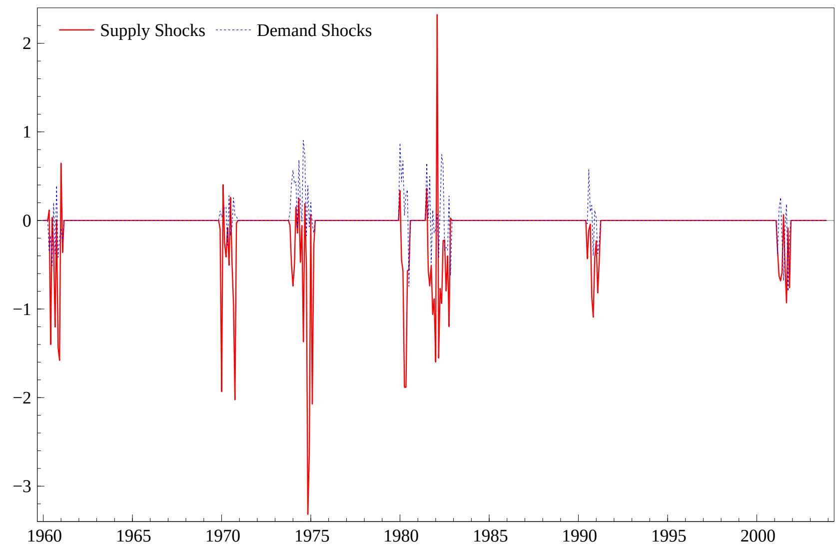

Figure 7: Structural Supply and Demand Shocks in NBER Recession Periods

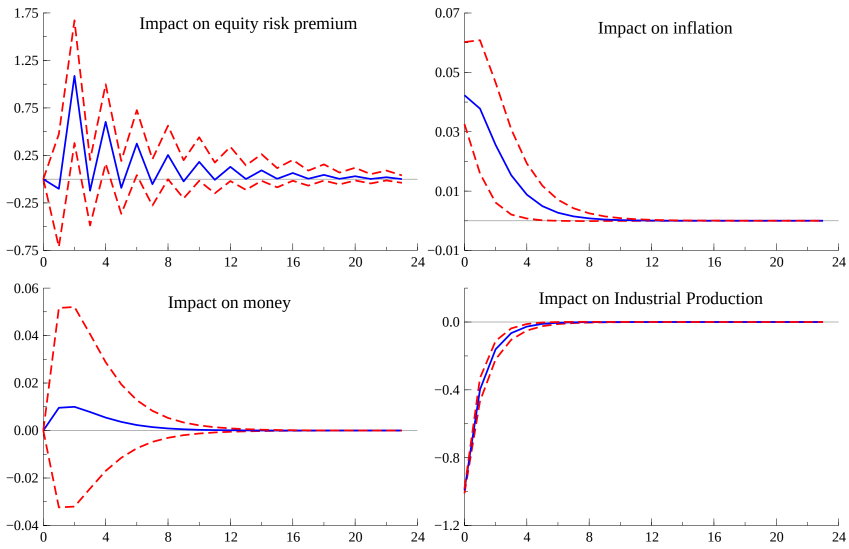

Figure 8: Negative Aggregate Supply Shock (-1 %)

Impact on inflation

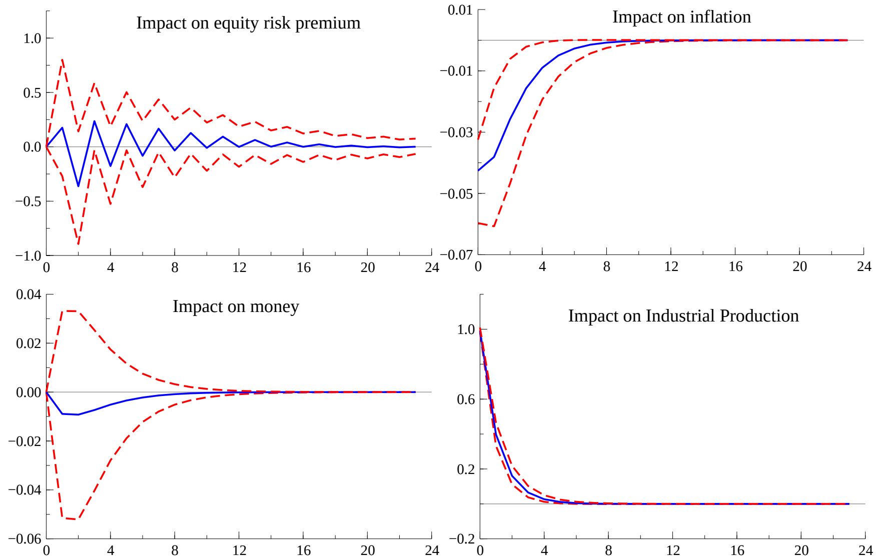

Figure 9: Positive Aggregate Supply Shock (+1 %)

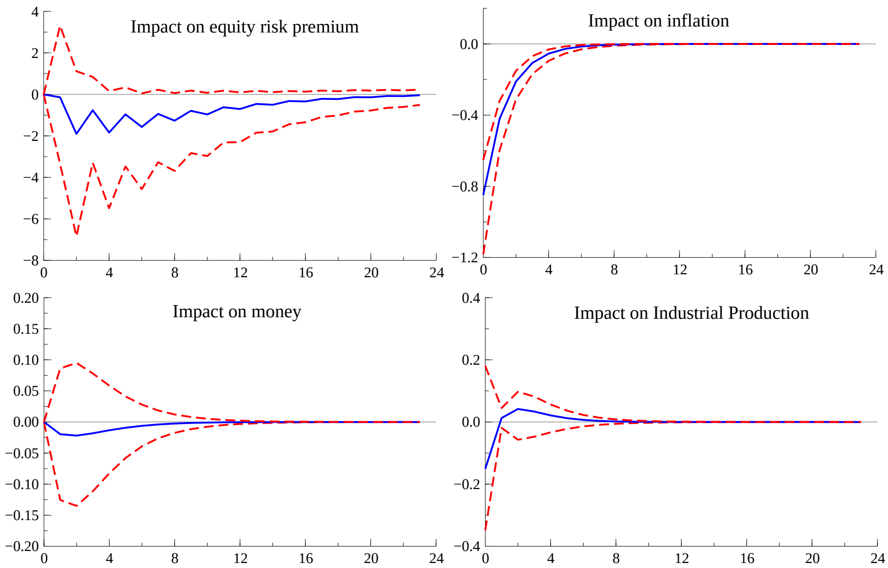

Figure 10: Negative Aggregate Demand Shock (-1 %)

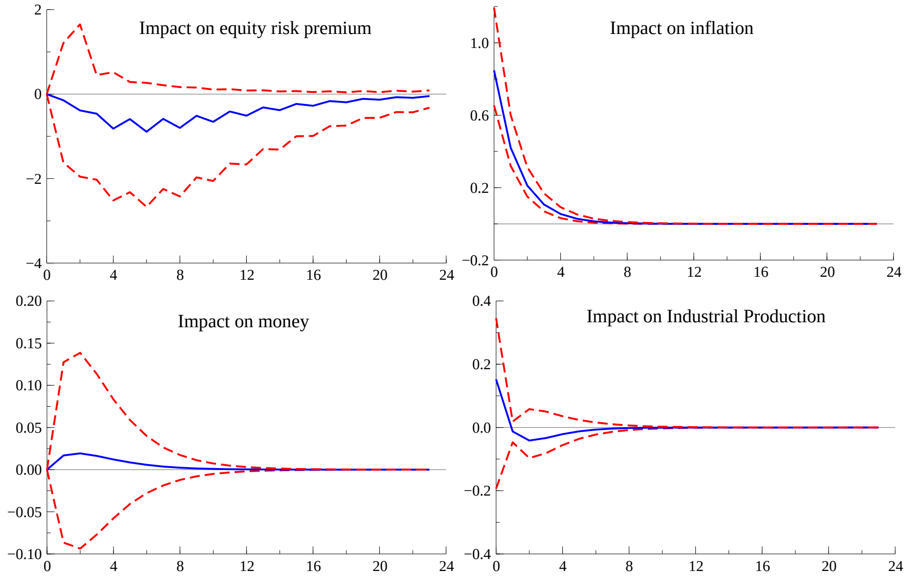

Figure 11: Positive Aggregate Demand Shock (+1 %)

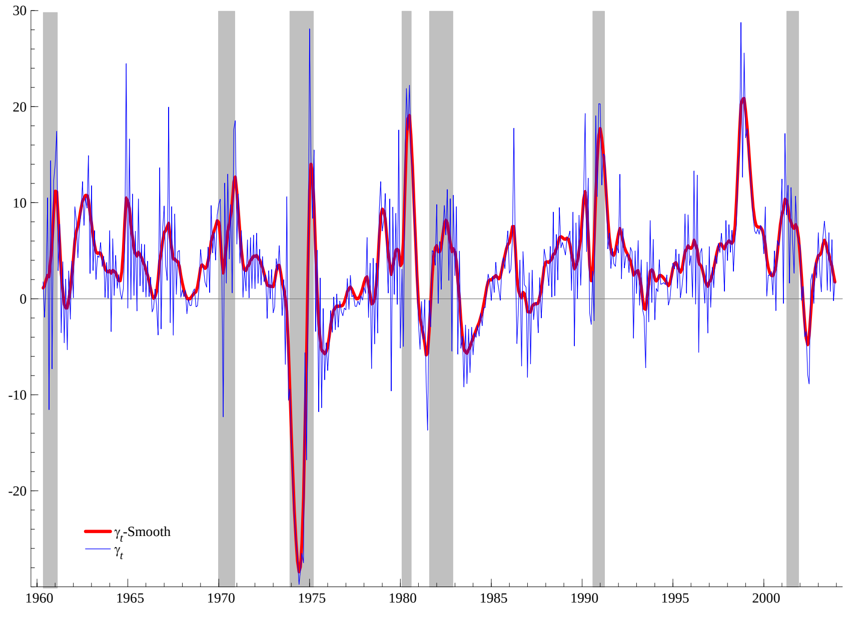

Figure 12: The risk premium per unit of variance