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# How do stock prices respond to fundamental shocks?

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**Abstract**

We estimate various structural vector autoregression models for the US in order to assess the importance of fundamental shocks in explaining stock price movements. The results show that models using real activity variables place more weight on fundamental shocks than models using dividends or earnings. However, according to all models fundamental shocks became substantially less important during the period 1982–2002 if compared to 1953–1982.


*Keywords:* Stock prices; Structural vector autoregression; Fundamentals

## 1. Introduction

Structural vector autoregressions (the SVAR approach) have become a popular tool in empirical investigations of stock prices as it allows analysis of the movements of stock prices in relation to fundamental and nonfundamental shocks. These shocks can be identified by imposing specific restrictions on an estimated VAR that includes stock prices and other variables that are supposed to indicate the change in market fundamentals (dividends, earnings, measures of real activity, interest rates, risk premium). Recent contributions in this field are Lee (1995a), Groenewold (2000), Rapach (2001), and Binswanger (2004a), who estimate SVAR models including stock prices and measures of real activity, and Lee (1995a, 1995b, 1998), Chung and Lee (1998), and Allen and Yang (2004), who estimate SVAR models including stock prices and dividends and/or earnings.

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So far the results reported in the existing literature are difficult to compare, as the SVAR models differ in the variables included in the model, in the restrictions imposed on the VAR, and in the frequency of the data and time periods. In this paper we set out to compare the results of various SVAR models for the US by investigating quarterly data over the post World War II period from 1953 to 2002.[1] Making such a comparison allows for checking the robustness of the assumptions made in SVAR models that are employed in the existing literature. Our comparison is based on forecast error variance decompositions over the full sample and two sub-samples that last from 1953 to 1982 and 1983 to 2002. The latter period largely covers the second stock market boom after World War II that lasted from 1982 till 2000, when the US saw an unprecedented rise in stock prices.[2]

The analysis of the sub-samples is motivated by the results presented in Binswanger (2004a), who reports substantial differences for these periods. While real activity shocks explain a large proportion of the variability of real stock prices during the period 1960–1982, this proportion is very small in the SVAR model estimated for the period 1982–1999.[3] These results support the hypothesis that stock prices over the 1980s and 1990s have been governed by nonfundamental factors such as speculative bubbles or irrational exuberance (Binswanger, 1999; Shiller, 2000) and in this paper we will also investigate whether this finding is robust with respect to different specifications of SVAR models.

The paper is organized as follows. Section 2 describes the SVAR methodology that is used to identify fundamental and nonfundamental shocks. Section 3 presents the results of cointegration tests and forecast error variance decompositions. Section 4 concludes.

## 2. The SVAR methodology

In this paper we consider bivariate and trivariate VAR models that consist of the first differenced log of real stock prices, $p$, and the first differenced log of other fundamental variables, which are denoted $x$ and $y$, respectively. All variables are considered to be $I(1)$ and we suppose that there is no cointegrating relationship between the variables included in the VAR, as otherwise a VAR in first differences would be misspecified. These assumptions are supported by unit root and cointegration test results presented in Section 3.

Let $Z_t$ be a bivariate or trivariate vector consisting of $\Delta x_t$ and $\Delta p_t$, or $\Delta x_t$, $\Delta y_t$, and $\Delta p_t$, respectively. We can write

$$Z_t = A(L)Z_{t-1} + e_t, \tag{1}$$

where $A(L) = [A_{ij}(L)]$ are polynomials in the lag operator $L$ (i.e., $L^i x_t \equiv x_{t-i}$), and $e_t$ is a vector of the observed error terms of the reduced-form VAR model, which usually

[1] Starting in 1953 avoids the weak correlation in the early 1950s due to the Korean war (Fama, 1990).

[2] The data on quarterly real stock prices suggests the fourth quarter of 1982 as the starting date of the stock market boom over the 1980s and 1990s (see, e.g., Ibbotson and Sinquefield, 1994, p. 14), when real stock prices started to rise again after having decreased for several years.

[3] Results from various tests presented in Binswanger (1999, 2004b) also indicate a structural break in the early 1980s in the relationship between stock prices and GDP and between stock prices and industrial production. However, there is no clear evidence for a structural break in the relationship between stock prices and dividends or earnings.

will be contemporaneously correlated (non-orthonormalized innovations given their non-structural nature).

Provided the fact that the time series under consideration are covariance-stationary and assuming that $A(L)$ is invertible, we can write

$$Z_t = \left[I - A(L)L\right]^{-1} e_t, \tag{2}$$

which is the infinite order moving average representation (MAR) of (1).

Estimating (1) and inverting it, allows to identify structural innovations or shocks, $u_{it}$, by imposing restrictions. As the structural shocks are supposed to be uncorrelated, the variance–covariance matrix of the structural shocks must be diagonal. Furthermore, without loss of generality, the standard deviations of the structural shocks are normalized to 1 leading to an orthonormalized MAR. Generally, making these assumptions yields $n(n+1)/2$ restrictions. However, at least $n^2$ independent restrictions on parameters of the structural form are needed to exactly identify the system. Therefore, in the case of a bivariate VAR, we need one additional restriction, while in the case of a trivariate VAR three additional restrictions are necessary. These restrictions are long-run restrictions as originally proposed by Blanchard and Quah (1989).

The moving average representation of the bivariate SVAR model can be written as

$$\begin{bmatrix} \Delta x_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}, \tag{3}$$

where $C_{ij}(L) = \sum_{k=0}^{\infty} c_{ij}(k) L^k$ for $i, j = 1, 2$, are the infinite polynomials in the lag operator $L$. The long-run cumulative effect of the structural shocks is captured by the long-run impact matrix

$$\begin{bmatrix} C_{11}(1) & C_{12}(1) \\ C_{21}(1) & C_{22}(1) \end{bmatrix},$$

where $C_{ij}(1) = \sum_{k=0}^{\infty} c_{ij}(k)$ for $i, j = 1, 2$, represent the cumulated effects of the shocks $u_{1t}, u_{2t}$ on $\Delta x_t$ and $\Delta p_t$.

Imposing the long-run restriction

$$C_{12}(1) = 0 \tag{4}$$

allows us to identify the shocks $u_{1t}$, $u_{2t}$, which we will label fundamental and nonfundamental shocks, respectively.[4] The restriction implies that the cumulative effect of $u_{2t}$ on $\Delta x_t$ is zero. In other words $u_{2t}$ may have a temporary effect on $x_t$ but it does not have a permanent effect on $x_t$. In the long run, the development of the fundamental variable $x_t$ is solely determined by fundamental shocks.

[4] Suppose that the first differenced fundamental variable $\Delta x_t$ has a univariate moving average representation with the fundamental innovation $u_{1t}$ and that the fundamental component of stock prices is related to the fundamental variable by a present value relationship (i.e., dividend discount model). In this case imposing the restriction $C_{21}(L) = 0$ allows us to identify $u_{1t}$, $u_{2t}$ as fundamental shocks and nonfundamental shocks, respectively (see Lee, 1995a, 1995b for details). Imposing the restriction $C_{21}(1) = 0$ allows for a similar interpretation in terms of the cumulative effects of the shocks.

The trivariate SVAR model is written as

$$\begin{bmatrix} \Delta x_t \\ \Delta y_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) & C_{13}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix}. \tag{5}$$

Analogously to the bivariate SVAR model, we impose the restrictions

$$C_{12}(1) = C_{13}(1) = C_{23}(1) = 0, \tag{6}$$

which allow to identify $u_{1t}$ and $u_{2t}$ as fundamental shocks while $u_{3t}$ is a nonfundamental shock that does not permanently affect $x_t$ and $y_t$ (Lee, 1995a). Additionally, the restriction $C_{12}(1) = 0$ requires $u_{2t}$ to have a zero cumulative effect on $x_t$. An innovation in $y_t$ does not affect $x_t$ permanently (see Lee, 1998; Chung and Lee, 1998).

Since the structural shocks in the SVAR models are orthonormalized with $\text{var}(u_t) = I$, we can allocate the variance of each variable $\Delta x_t$, $\Delta y_t$, and $\Delta p_t$ to the shocks $u_{it}$. The percentage of the $t$-step ahead forecast error variance of $Z_i$, which is accounted for by shocks $u_{it}$, is given by

$$\frac{\sum_{k=0}^{t-1} c_{ij}(k)^2}{\sum_{k=0}^{t-1} \sum_{j=1}^{m} c_{ij}(k)^2} * 100,$$

where $m = 2$ in the bivariate models, and $m = 3$ in the trivariate models.

Referring to (3) and (5), we will estimate the following bivariate and trivariate VAR models:

| Bivariate VAR models | Trivariate VAR models |
|---|---|
| Model I: $x$ = real GDP | Model V: $x$ = real GDP, $y$ = real interest rate |
| Model II: $x$ = industrial production | Model VI: $x$ = real earnings, $y$ = real interest rate |
| Model III: $x$ = real dividends | Model VII: $x$ = real earnings, $y$ = real dividends |
| Model IV: $x$ = real earnings | |

Models I to IV are bivariate models that include real stock prices and one fundamental variable that is either an indicator of real activity (GDP or industrial production) or a cash flow variable (real dividends or earnings). The trivariate models V and VI include real interest rates as a further fundamental variable additional to GDP (model V) and earnings (model VI).[5] Model VII is similar to the model used by Chung and Lee (1998) and includes earnings and dividends as fundamental variables. The trivariate models allow for decomposition of shocks to real stock prices into two categories of fundamental shocks, which are termed fundamental shocks I and II, and nonfundamental shocks.

[5] In order to save space, we only present the results for models including real GDP or real earnings as the first fundamental variable but the results are very similar if we use trivariate models including industrial production or real dividends.

## 3. Empirical results

The quarterly data for this study span 1953 January–2002 December. We will concentrate on tests using quarterly observations rather than monthly observations because results in Fama (1990) as well as in Binswanger (1999) suggest that monthly stock returns possess only little explanatory power for growth rates in real activity. Stock prices (S&P composite index), dividends, and earnings are from Robert Shiller's webpage. The other data are from the Federal Reserve Board. The GDP and industrial production series are seasonally adjusted. Nominal stock prices, GDP, dividends, earnings are deflated by the consumer price index in order to obtain real data. The nominal interest rate is the 3-month Treasury bill rate and the real interest rate is the 3-months Treasury bill rate minus the consumer price index growth rate. All growth rates (or returns) are calculated as changes in real log levels of the variables.

According to unit root tests (augmented Dickey–Fuller test and Phillips–Perron test) all variables (including the interest rates) are $I(1)$ and, therefore, non-stationary in levels but stationary in first differences. Table 1 shows the result of the Johansen cointegration test for all 7 models.

Based on the results of the Johansen cointegration test the null hypothesis of no cointegration cannot be rejected at the 5 percent level in any model. Therefore, we are able to estimate SVAR models in fist differences as indicated in Section 2. In order to make the results comparable, we chose the same number of lags in all VAR models. Based on the results of the Akaike information criterion and the Schwarz criterion, we use 4 lags for all estimates, which is sufficient to avoid residual autocorrelation. The result of the stock price forecast error variance decompositions are presented in Table 2.

Table 1
Johansen cointegration tests
Bivariate models

| $H_0$ | Model I | | Model II | | Model III | | Model IV | | Critical values (95%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic |
| $r = 0$ | 8.52 | 8.35 | 4.89 | 3.37 | 10.35 | 7.88 | 10.54 | 8.62 | 15.41 | 14.07 |
| $r \leqslant 1$ | 0.69 | 0.69 | 0.40 | 0.40 | 1.96 | 1.96 | 1.92 | 1.92 | 3.76 | 3.76 |

Trivariate models

| $H_0$ | Model V | | Model VI | | Model IV | | Critical values (95%) | |
|---|---|---|---|---|---|---|---|---|
| | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic | Trace statistic | $\lambda_{max}$ statistic |
| $r = 0$ | 18.72 | 14.73 | 26.16 | 14.38 | 13.20 | 8.58 | 29.68 | 20.97 |
| $r \leqslant 1$ | 3.99 | 3.93 | 11.78 | 10.36 | 10.27 | 7.54 | 15.41 | 14.07 |
| $r \leqslant 2$ | 0.61 | 0.61 | 1.42 | 1.42 | 2.73 | 2.73 | 3.76 | 3.76 |

*Notes*. The test uses log levels of all variables except for the interest rates. The Johansen test assumes a linear deterministic trend in the data. The test statistics shown in the table are the trace statistic and the maximum eigenvalue statistic. The optimal lag length has been determined according to the Akaike information criterion from an unrestricted VAR, which includes the variables of the model expressed in levels.

Table 2
Stock price forecast error variance decompositions
Model I

| Quarters-ahead | 1953–2002 | | 1953–1982 | | 1982–2002 | |
|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | Percent of variance attributable to | | Percent of variance attributable to | |
| | Funda-mental shocks | Nonfunda-mental shocks | Funda-mental shocks | Nonfunda-mental shocks | Funda-mental shocks | Nonfunda-mental shocks |
| 1 | 54.86 | 45.14 | 73.55 | 26.45 | 22.01 | 77.99 |
| | (1.9) | (1.8) | (3.5) | (3.3) | (2.3) | (2.4) |
| 2 | 55.14 | 44.86 | 71.90 | 28.10 | 24.92 | 75.08 |
| | (1.9) | (1.8) | (3.2) | (3.2) | (3.5) | (3.4) |
| 3 | 54.46 | 45.54 | 71.27 | 28.73 | 24.56 | 75.44 |
| | (2.2) | (2.1) | (3.5) | (3.4) | (4.5) | (4.9) |
| 4 | 54.33 | 45.67 | 71.05 | 28.95 | 24.99 | 75.01 |
| | (3.1) | (2.9) | (4.7) | (4.7) | (5.0) | (5.4) |
| 5 | 53.64 | 46.36 | 69.89 | 30.11 | 25.00 | 75.00 |
| | (3.5) | (3.3) | (5.6) | (5.7) | (5.1) | (5.5) |
| 10 | 53.64 | 46.36 | 69.72 | 30.28 | 25.00 | 75.00 |
| | (3.9) | (3.7) | (6.1) | (6.2) | (5.5) | (6.1) |

Model II

| Quarters-ahead | 1953–2002 | | 1953–1982 | | 1982–2002 | |
|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | Percent of variance attributable to | | Percent of variance attributable to | |
| | Funda-mental shocks | Nonfunda-mental shocks | Funda-mental shocks | Nonfunda-mental shocks | Funda-mental shocks | Nonfunda-mental shocks |
| 1 | 61.12 | 38.88 | 70.92 | 29.08 | 50.83 | 49.17 |
| | (0.9) | (0.8) | (1.7) | (1.7) | (3.0) | (1.4) |
| 2 | 56.62 | 43.38 | 64.34 | 35.66 | 49.67 | 50.33 |
| | (1.6) | (4.2) | (2.6) | (2.5) | (3.9) | (1.8) |
| 3 | 56.02 | 43.98 | 63.67 | 36.33 | 49.68 | 50.32 |
| | (2.2) | (5.7) | (3.5) | (3.6) | (4.6) | (2.7) |
| 4 | 55.88 | 44.12 | 63.46 | 36.54 | 49.95 | 50.05 |
| | (2.9) | (6.5) | (4.9) | (4.6) | (5.0) | (3.3) |
| 5 | 54.54 | 45.46 | 61.16 | 38.84 | 50.33 | 49.67 |
| | (3.5) | (6.7) | (5.9) | (5.5) | (5.2) | (3.5) |
| 10 | 54.40 | 45.60 | 60.59 | 39.41 | 50.64 | 49.36 |
| | (3.8) | (6.7) | (6.4) | (6.0) | (5.4) | (3.8) |

Generally, the results show that the relation between stock prices and real activity variables is considerably stronger than the relation between stock prices and dividends or earnings no matter whether bivariate or trivariate models are estimated. In the models using GDP or industrial production as fundamental variables (models I, II, V) fundamental shocks explain more than 50 percent of the forecast error variance over the full sample and more than 60 percent of the forecast error variance over the period 1953–1982. This

Table 2 (*Continued*)
Model III

| Quarters-ahead | 1953–2002 | | 1953–1982 | | 1982–2002 | |
|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | Percent of variance attributable to | | Percent of variance attributable to | |
| | Fundamental shocks | Nonfundamental shocks | Fundamental shocks | Nonfundamental shocks | Fundamental shocks | Nonfundamental shocks |
| 1 | 21.58 | 78.42 | 44.06 | 55.94 | 0.70 | 99.30 |
| | (1.8) | (0.7) | (3.4) | (3.2) | (2.0) | (2.2) |
| 2 | 21.97 | 78.03 | 42.70 | 57.30 | 0.74 | 99.26 |
| | (2.1) | (0.7) | (3.3) | (3.2) | (2.9) | (2.0) |
| 3 | 21.73 | 78.27 | 42.02 | 57.98 | 0.89 | 99.11 |
| | (2.3) | (1.5) | (3.7) | (3.7) | (3.5) | (2.7) |
| 4 | 21.87 | 78.13 | 42.03 | 57.97 | 3.79 | 96.21 |
| | (2.3) | (1.7) | (3.9) | (4.0) | (5.1) | (4.8) |
| 5 | 22.64 | 77.36 | 42.27 | 57.73 | 7.48 | 92.52 |
| | (2.8) | (2.3) | (4.1) | (4.2) | (5.9) | (5.5) |
| 10 | 23.44 | 76.36 | 42.46 | 57.54 | 11.59 | 89.41 |
| | (3.7) | (3.3) | (4.7) | (4.8) | (8.4) | (8.8) |

Model IV

| Quarters-ahead | 1953–2002 | | 1953–1982 | | 1982–2002 | |
|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | Percent of variance attributable to | | Percent of variance attributable to | |
| | Fundamental shocks | Nonfundamental shocks | Fundamental shocks | Nonfundamental shocks | Fundamental shocks | Nonfundamental shocks |
| 1 | 28.27 | 71.73 | 65.40 | 34.60 | 17.38 | 82.62 |
| | (1.6) | (1.7) | (2.0) | (2.1) | (3.5) | (3.9) |
| 2 | 24.11 | 75.89 | 61.49 | 38.51 | 16.35 | 83.65 |
| | (1.8) | (1.9) | (2.1) | (1.9) | (4.9) | (4.9) |
| 3 | 24.04 | 75.96 | 61.19 | 38.81 | 16.32 | 83.68 |
| | (2.0) | (2.1) | (2.9) | (3.0) | (5.0) | (5.0) |
| 4 | 24.14 | 75.86 | 61.14 | 38.86 | 16.33 | 83.67 |
| | (2.2) | (2.4) | (3.9) | (4.0) | (5.2) | (5.3) |
| 5 | 24.19 | 75.88 | 60.53 | 39.47 | 17.16 | 82.84 |
| | (2.3) | (2.5) | (4.7) | (4.8) | (5.6) | (5.3) |
| 10 | 26.53 | 73.47 | 60.24 | 39.76 | 23.99 | 76.01 |
| | (3.6) | (3.6) | (5.3) | (5.4) | (8.1) | (7.8) |

percentage is considerably lower in the models using dividends or earnings as fundamental variables where fundamental shocks only account for about a quarter of the forecast error variance over the full sample. Therefore, using earnings and/or dividends potentially underestimates the influence of fundamental shocks on stock prices as part of changes in fundamentals seems to be captured only by real activity variables. Furthermore, model VII shows that if earnings and dividends are included in a trivariate SVAR model, shocks to

Table 2 (*Continued*)
Model V

| Quarters-ahead | 1953–2002 | | | 1953–1982 | | | 1982–2002 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | | Percent of variance attributable to | | | Percent of variance attributable to | | |
| | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks |
| 1 | 48.11 | 7.64 | 44.25 | 63.71 | 11.22 | 25.07 | 17.60 | 0.97 | 81.43 |
| | (2.1) | (0.7) | (2.7) | (3.8) | (2.2) | (4.3) | (2.9) | (4.9) | (5.7) |
| 2 | 48.47 | 6.81 | 44.72 | 62.59 | 9.02 | 28.39 | 20.16 | 1.01 | 78.83 |
| | (2.0) | (2.3) | (3.0) | (3.3) | (5.6) | (6.2) | (3.4) | (5.4) | (6.3) |
| 3 | 47.50 | 7.14 | 45.36 | 61.60 | 9.36 | 29.04 | 19.69 | 1.97 | 78.34 |
| | (2.3) | (2.9) | (3.6) | (3.7) | (6.6) | (7.1) | (4.9) | (6.2) | (7.5) |
| 4 | 46.95 | 7.66 | 45.39 | 59.88 | 11.14 | 28.98 | 20.13 | 2.17 | 77.70 |
| | (3.1) | (2.8) | (4.1) | (5.1) | (6.3) | (7.3) | (5.8) | (7.1) | (8.4) |
| 5 | 46.31 | 7.57 | 46.12 | 58.68 | 11.25 | 30.07 | 20.11 | 2.37 | 77.52 |
| | (3.5) | (2.8) | (4.4) | (5.6) | (6.0) | (7.3) | (5.7) | (7.4) | (8.4) |
| 10 | 46.36 | 7.54 | 46.10 | 58.57 | 11.10 | 30.33 | 20.13 | 2.42 | 77.45 |
| | (3.8) | (3.0) | (4.7) | (5.9) | (6.3) | (7.6) | (6.1) | (8.3) | (9.6) |

Model VI

| Quarters-ahead | 1953–2002 | | | 1953–1982 | | | 1982–2002 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | | Percent of variance attributable to | | | Percent of variance attributable to | | |
| | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks |
| 1 | 23.80 | 1.85 | 74.35 | 56.97 | 9.10 | 33.93 | 10.97 | 0.35 | 88.68 |
| | (1.8) | (0.7) | (1.9) | (1.5) | (2.1) | (2.6) | (3.8) | (2.1) | (4.3) |
| 2 | 20.16 | 1.56 | 78.28 | 54.26 | 7.17 | 38.58 | 11.22 | 0.35 | 88.43 |
| | (1.8) | (2.1) | (2.7) | (2.6) | (5.6) | (5.9) | (4.6) | (2.8) | (5.2) |
| 3 | 20.09 | 1.73 | 78.18 | 53.74 | 7.38 | 38.88 | 11.24 | 0.41 | 88.35 |
| | (2.0) | (2.9) | (3.5) | (3.4) | (6.6) | (7.1) | (4.7) | (3.2) | (5.5) |
| 4 | 20.10 | 1.98 | 77.92 | 52.34 | 9.29 | 38.38 | 11.26 | 0.50 | 88.24 |
| | (2.1) | (2.9) | (3.6) | (4.3) | (6.5) | (7.3) | (4.7) | (4.3) | (6.1) |
| 5 | 20.09 | 2.03 | 77.88 | 51.72 | 9.57 | 38.71 | 12.11 | 0.50 | 87.39 |
| | (2.2) | (3.0) | (3.6) | (5.0) | (6.3) | (7.5) | (5.0) | (4.5) | (6.4) |
| 10 | 22.58 | 1.98 | 75.44 | 51.43 | 9.52 | 39.05 | 18.88 | 1.09 | 80.03 |
| | (3.4) | (3.1) | (4.2) | (5.5) | (7.0) | (8.0) | (8.2) | (6.1) | (9.8) |

dividends only capture a very small fraction of forecast error variance, which is similar to the results of Chung and Lee (1998) for Japan and Korea.

The results also indicate that it does not make a big difference whether bivariate or trivariate SVAR models are estimated. Adding real interest rates as a further fundamental

Table 2 (*Continued*)
Model VII

| Quarters-ahead | 1953–2002 | | | 1953–1982 | | | 1982–2002 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percent of variance attributable to | | | Percent of variance attributable to | | | Percent of variance attributable to | | |
| | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks | Fundamental shocks I | Fundamental shocks II | Non-fundamental shocks |
| 1 | 29.16 | 3.72 | 67.12 | 68.99 | 1.70 | 29.31 | 11.43 | 4.11 | 84.46 |
| | (1.6) | (1.5) | (2.2) | (1.9) | (4.2) | (4.6) | (3.5) | (1.9) | (3.9) |
| 2 | 25.42 | 6.19 | 68.39 | 64.48 | 3.03 | 32.49 | 12.06 | 4.83 | 83.11 |
| | (1.9) | (1.9) | (2.6) | (2.3) | (5.1) | (5.5) | (5.7) | (2.5) | (6.1) |
| 3 | 25.14 | 6.37 | 68.49 | 64.01 | 3.04 | 32.95 | 12.03 | 4.97 | 83.00 |
| | (1.9) | (2.1) | (2.8) | (3.2) | (5.2) | (5.9) | (5.4) | (3.0) | (6.2) |
| 4 | 25.08 | 6.58 | 68.34 | 63.75 | 3.51 | 32.73 | 12.10 | 6.77 | 81.13 |
| | (2.0) | (2.2) | (3.3) | (4.0) | (5.1) | (6.2) | (5.5) | (4.4) | (6.7) |
| 5 | 24.82 | 7.52 | 67.66 | 62.42 | 5.19 | 32.39 | 11.93 | 8.93 | 79.14 |
| | (2.2) | (2.6) | (3.3) | (4.7) | (5.3) | (6.7) | (5.4) | (5.0) | (6.8) |
| 10 | 25.53 | 7.87 | 66.61 | 61.66 | 5.93 | 32.41 | 13.28 | 12.17 | 74.55 |
| | (2.8) | (3.3) | (4.2) | (5.6) | (5.6) | (7.7) | (5.9) | (7.3) | (8.7) |

*Note*. Numbers in parentheses are standard errors computed by 1000 simulations.

variable (models V and VI) does not significantly increase the fraction of forecast error variance in stock prices explained by fundamentals, which confirms the results of Lee (1995b, 1998). And using a model that includes earnings as well as dividends as fundamental variables (model VII) only slightly increases the proportion of the forecast error variance due to fundamental shocks if compared to a bivariate model that only includes earnings (model IV).

Finally, the results presented in Table 2 show that there are large differences between the results for the 1953–1982 period and the 1982–2002 period. With the exception of model III, fundamental shocks explain more than 60 percent of stock price movements over the period 1953–1982, but this proportion drops significantly over the period 1982–2002 no matter how the model is specified. This finding is robust with respect to the fundamental variables included in the SVAR model and confirms the finding reported in Binswanger (2004a).

## 4. Conclusion

The results presented in this paper show that it matters which fundamental variables are included in bivariate or trivariate SVAR models. In the models using GDP or industrial production as fundamental variables (real activity variables) the percentage of the forecast error variance due to fundamental shocks is considerably larger than in the models using dividends or earnings. However, estimating trivariate models instead of bivariate models that include interest rate variables, or earnings as well as dividends, only marginally increases the fraction of the forecast error variance that is explained by fundamentals when compared to bivariate models.

All models confirm the result of Binswanger (2004a) that fundamental shocks became substantially less important during the period 1982–2002 if compared to the period 1953–1982. The existence of speculative bubbles over the 1980s and 1990s is a possible explanation of this finding.

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