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Analyzing Macroeconomic Forecastability

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ABSTRACT
This paper estimates, using stochastic simulation and a multi-country macroeconometric model, the fraction of the forecast error variance of output changes and the fraction of the forecast error variance of inflation that are due to unpredictable asset price changes. The results suggest that between about 25% and 37% of the forecast error variance of output growth over eight quarters is due to asset price changes and between about 33% and 60% of the forecast error variance of inflation over eight quarters is due to asset price changes. These estimates provide limits to the accuracy that can be expected from macroeconomic forecasting. Copyright © 2011 John Wiley & Sons, Ltd.

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INTRODUCTION

This paper examines the limits to macroeconomic forecasting. It uses a structural multi-country macroeconometric model, denoted the 'MC' model. The basic idea is that if changes in asset prices affect the macroeconomy and if these changes are unpredictable, then fluctuations in the macroeconomy due to changes in asset prices are unpredictable. Stochastic simulation is used to estimate the fraction of the forecast error variance of output changes and the fraction of the forecast error variance of inflation that are due to unpredictable asset price changes.

In the MC model asset price changes have important effects on the world economy. The model is discussed in the next section, with particular reference to the effects of asset price changes. The stochastic simulation experiments are explained and the results are presented in the third section. The results suggest that between about 25% and 37% of the forecast error variance of output growth over eight quarters is due to asset price changes and between about 33% and 60% of the forecast error variance of inflation over eight quarters is due to asset price changes.

There is a large literature analyzing the ability of models to forecast the probability that a recession will occur in some future quarter, in particular using the yield curve to forecast such probabilities. Two recent papers are Chauvet and Potter (2005) and Rudebusch and Williams (2008). For example, Rudebusch and Williams define a recession as a quarter with negative real growth and examine horizons of zero to four quarters ahead. They find that the yield curve has some predictive power relative to predictions from professional forecasters.

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There is also a large literature, recently surveyed by Stock and Watson (2003), examining whether asset prices are useful predictors of future output growth and inflation. Stock and Watson examine data on many possible predictor variables for seven countries. Using bivariate and trivariate equations, they obtain mixed results. For some countries and some periods some asset prices are useful predictors, but the predictive relations are far from stable.

This paper is not an examination of possible single-equation predictive relationships. Instead, a structural model of the economy, which has already been estimated, is used. This paper also does not single out recessions as special cases. The structure of the economy—the coefficients in the structural equations—are assumed to be stable over the business cycle.

This study is conditional on the estimated structure of the MC model. Using the model allows questions to be considered that cannot be using single-equation relationships. More economic theory is used than in the use of single equations. A disadvantage of this approach is that it requires a particular model. If the model is a poor approximation of the economy, the results will not be trustworthy.

THE MC MODEL

The MC model is presented in Fair (2004), and it has been updated for the purposes of this paper (version dated 30 January 2010). The updated version is on the author's website.[1] The US part of the MC model will be denoted the 'US model' and the rest of the model will be denoted the 'ROW model'. Sometimes the US model is analyzed by itself, but in this paper the entire MC model is used. The MC model is completely estimated (by 2SLS); there is no calibration. The estimation periods begin in 1954 for the US model and 1962 for the ROW model and go through the latest data at the time of estimation.

The MC model is not just a series of ad hoc regressions. In the theory behind the model, households maximize expected utility and firms maximize expected profits. The theory is used to choose left-hand side and right-hand side variables in the equations to be estimated. The estimated equations are taken to be approximations to the decision equations of agents. The theory leads to many exclusion restrictions in the estimated equations, and lack of identification is not an issue. Expectations are assumed to be adaptive, and under this assumption the Lucas critique is not an issue. This methodology of structural macroeconometric modeling goes back at least to Tinbergen (1939). It differs from the currently popular dynamic stochastic general equilibrium (DSGE) methodology in that the latter imposes rational expectations and uses theory in a tighter way. The cost of the DSGE methodology so far is that many important features of the economy are left out. This may change in the future, but at the moment the models capture far fewer features of the world economy than does a model like the MC model—see Fair (2011) for further discussion. The following is a brief outline of the model, with emphasis on the effects of asset prices.

[1] Because of the size of the MC model, the many links among variables, and the simultaneity, it is not feasible to explain the complete model in one paper. There is thus a danger that the model seems like a black box. I have tried to deal with this problem by putting all the documentation on my website. The complete specification of the MC model is presented on the site, and all coefficient estimates are presented along with tests for each estimated equation. Also, the complete model can be used on the site. It can also be downloaded for use on one's own computer, which allows all of the equations to be estimated by the user if desired. All the results in this paper can be duplicated using the downloaded model and the computer software that goes with it.

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US model

There are seven estimated demand equations for goods and services in the US model, explaining the demand for service consumption, nondurable consumption, durable consumption, housing investment, plant and equipment investment, inventory investment, and imports. The main way that equity prices and housing prices affect demand is through a household wealth variable in the three consumption equations. Import prices affect the demand for imports through an import price variable in the import equation. Lagged stock variables are important explanatory variables in the demand equations: durable goods stock in the durable consumption equation, housing stock in the housing investment equation, capital stock in the plant and equipment investment equation, and inventory stock in the inventory investment equation.

It will be useful to explore the real wealth effects further. A change in household wealth, say from a change in stock prices or housing prices, leads to changes in the three categories of consumption through the wealth variable in the consumption equations. Spending out of real wealth is about 4% per year of the wealth change. Most of the variation in real wealth is from variation in stock prices and housing prices.

The variable CG in the model is the nominal value of capital gains or losses on the equity holdings of the household sector. It is based on data from the Flow of Funds accounts. There is an equation in the model explaining CG. The left-hand-side variable is $CG/(PX_{-1} \cdot YS_{-1})$, where PX is a price deflator and YS is an estimate of potential output. The two right-hand-side variables are the change in the bond rate and the change in after-tax profits (normalized by $PX_{-1} \cdot YS_{-1}$). This equation explains very little of the variation in CG, and the two explanatory variables have very small effects on CG. R^2 is only 0.05. CG is essentially unpredictable in the model.

Housing prices are treated as follows. The real stock of housing of the household sector in the model, KH, is based on data from the Department of Commerce, Fixed Assets, Table 15. The market value of real estate of the household sector is available from the Flow of Funds accounts, line 3, Table B.100. PKH, the market price of KH, is this market value of real estate divided by KH. The *relative* price of KH is then taken to be PKH/PD, where PD is the price deflator for domestic sales. Let $PSI14 = PKH/PD$ denote this relative price. Then, in the model PKH is determined as $PKH = PSI14 \cdot PD$. In some uses of the model PSI14 is taken to be exogenous, but in this paper an equation has been estimated in which $\log PSI14 - \log PSI14_{-1}$ is on the left-hand side and a constant is on the right-hand side. In other words, $\log PSI14$, the relative price of housing, is taken to be a random walk with drift, where the drift is estimated.

CG and PSI14 affect household wealth as follows. The variable AH in the model is the nominal value of net financial assets of the household sector excluding demand deposits and currency. It is determined by the following identity:

$$AH = AH_{-1} - (MH - MH_{-1}) + SH + CG - DISH$$

where MH is the nominal value of demand deposits and currency held by the household sector, SH is the financial saving of the household sector, and DISH is an exogenous discrepancy term. CG affects wealth through this identity. Regarding PSI14, when it changes, PKH changes, and so nominal housing wealth, $PKH \cdot KH$, changes.

The real wealth variable that appears in the consumption equations, AA, is determined as

$$AA = [(AH + MH) + (PKH \cdot KH)]/PH$$

where PH is a price deflator relevant to household spending. AH + MH is nominal financial wealth, and PKH · KH is nominal housing wealth. Changes in CG and in PSI14 affect consumption through their effects on AA. Most of the variation in AA is due to variation in CG and PSI14.

Continuing with the US model, there are labor force participation equations for prime-age men, prime-age women, and all others, and there is an equation explaining the number of people holding two jobs. There is a demand for employment equation and a demand for hours worked per worker equation. The unemployment rate is determined by an identity: total labor force minus employment divided by total labor force.

The other main estimated equations are a price equation, a nominal wage equation, an interest rate rule of the Federal Reserve, a term structure equation explaining the AAA corporate bond rate, and a term structure equation explaining a mortgage rate. The import price variable is an important explanatory variable in the price equation; it plays the role of a cost shock variable. In the interest rate rule the Fed responds to inflation and unemployment.

There are a total of 28 estimated equations and about 100 identities in the US model. In the identities all flows of funds among the sectors (household, firm, financial, state and local government, federal government, and foreign) are accounted for. The federal government deficit is determined by an identity, as is the federal government debt. There is an estimated equation determining the interest payments of the federal government as a function of interest rates and the government debt.

ROW model

The ROW model consists of estimated equations for 37 countries. There are up to 13 estimated equations per country and 16 identities. There are a total of 274 estimated equations in the ROW model. The estimated equations explain total imports, consumption, fixed investment, inventory investment, the domestic price level, the demand for money, a short-term interest rate, a long-term interest rate, the spot exchange rate, the forward exchange rate, the export price level, employment, and the labor force. The specifications are similar across countries. The short-term interest rate for each country is explained by an estimated interest rate rule for that country. In some cases the US interest rate is an explanatory variable in the estimated rule, where the Fed is estimated to have an effect on the decisions of other monetary authorities. The exchange rates are relative to the dollar or the euro. The two key explanatory variables in the exchange rate equations are a relative interest rate variable and a relative price level variable. The two key explanatory variables in the domestic price equation are a demand pressure variable and a cost shock variable—the price of imports. In the price of exports equation, the price of exports in local currency is a weighted average of the domestic price level and a variable measuring the world export price level (translated into local currency using the exchange rate). The weights are estimated.

There are 59 countries in the MC model (counting an ‘all other’ category), and the trade share matrix is 59×59. Data permitting, a trade share equation is estimated for each country pair. In a trade share equation, the fraction of country i’s exports imported by country j is a function of the price of country i’s exports in dollars relative to a weighted average of all other countries’ export prices in dollars (excluding oil exporting countries). The weights are trade shares lagged one quarter. A total of 1302 trade share equations are estimated. Trade shares for which there are no estimated equations are still used in the solution of the MC model; they are simply taken as exogenous. The trade share data are from the IFS Direction of Trade data. Quarterly data are available back to 1960. While the trade share equations are all quarterly, the structural equations for some countries are estimated using annual data. Interpolation is used when necessary to convert annual variables to quarterly variables.

There are many links among countries. The use of the trade shares means that the differential effects of one country's total demand for imports on other countries' exports are accounted for. There are interest rate links through the US interest rate affecting some other countries' rates in the estimated interest rate rules. In a few cases the euro (earlier German) interest rate affects other countries' interest rates. Exports are endogenous for each country, since they depend on the imports of other countries, which are endogenous. The price of exports in local currency of each country is endogenous, since it depends, as noted above, on the domestic price level and the world price level. The price of exports in dollars is endogenous because the price of exports in local currency is endogenous and the exchange rate is (for most countries) endogenous. The price of imports in each country is endogenous because it depends on the price of exports of the other countries weighted by the trade shares. Since, as noted above, the price of imports affects the domestic price level in each country's estimated domestic price equation, there are price links among countries. An increase in the price of exports in dollars in one country leads to increases in other countries' import prices, which affects their domestic and thus export prices, which feeds back to the original country, etc.

The main exogenous variables in the MC model are government fiscal policy variables and demographic variables. Monetary policy is endogenous because of the estimated interest rate rules of the monetary authorities.

There are two key sets of asset prices in the ROW model: exchange rates and the price of exports of the oil-exporting countries. Consider oil first. There are 10 oil-exporting countries in the model.[2] Let POIL_i denote the price of exports in dollars of one of these 10 countries i, which is roughly the dollar price of oil. For some uses of the MC model POIL_i is taken to be exogenous, but for this paper 10 equations have been estimated, with $\log \mathrm{POIL}_i - \log \mathrm{POIL}_{i-1}$ on the left-hand side and a constant on the right-hand side. In other words, for each of the 10 countries $\log \mathrm{POIL}_i$ has been modeled as a random walk with drift.

Regarding exchange rates, there are 23 estimated nominal exchange rate equations in the model. As noted above, two explanatory variables in these equations are a relative interest rate variable and a relative price level variable. The equations are in logs and also include the lagged dependent variable. The lagged dependent variable has a coefficient estimate close to one in the equations, and they explain very little of the variance of the change in the log of the exchange rate. The R^2 for the main countries are 0.12 or less. The exchange rate equations are thus not too different from estimated random walks with drift.

Asset price effects

The key asset price variables in the MC model are thus CG, the nominal value of capital gains or losses on the equity holdings of the US household sector, PSI14, the ratio of US housing prices to an aggregate price deflator, oil prices, and exchange rates. Very little of the variation in these variables can be explained, and the variables have important effects on the macroeconomy. CG and PSI14 affect US household wealth and then consumption. Oil prices affect import prices, which affect domestic prices through the estimated domestic price equations. Exchange rates affect the relative prices of imports and exports and have widespread effects.

In the stochastic simulation experiments, which are discussed next, the amount that the variation in these asset prices affect the overall forecast error variation is estimated.

[2] Saudi Arabia, Venezuela, Nigeria, Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, and United Arab Emirates.

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STOCHASTIC SIMULATION EXPERIMENTS AND RESULTS

There are 1615 estimated equations in the MC model, counting the estimated equation for PSI14 and the 10 estimated equations for $POIL_i$, of which 1302 are trade share equations. The estimation period for the US is 1954:Q1–2009:Q4. The estimation periods for the other countries begin as early as 1962:Q1 and end as late as 2009:Q3. The estimation period for most of the trade share equations is 1966:Q1–2008:Q4. For each estimated equation there are estimated residuals over the estimation period. Let $\hat{u}_t$ denote the 1615-dimension vector of the estimated residuals for quarter t.[3] Most of the estimation periods have the 1972:Q1–2007:Q4 period—144 quarters—in common, and this period is taken to be the 'base' period. These 144 observations on $\hat{u}_t$ are used for the draws in the stochastic simulation procedure discussed below.[4]

Twelve sets of non overlapping eight-quarter periods are analyzed. The first is 1986:Q1–1987:Q4, and the last is 2008:Q1–2009:Q4. Consider the first period. Each trial of the stochastic simulation procedure is as follows. First, 2 years are randomly drawn with replacement between 1972 and 2007. The eight quarterly error vectors for these 2 years are chosen, where the quarterly order for each year is kept. Each vector consists of 1615 errors.[5] Using these errors, the model is solved dynamically for the 1986:Q1–1987:Q4 period. In this solution the actual values of the exogenous variables are used. In addition, before solution the estimated errors (the residuals) are added to each of the 1615 equations and taken to be exogenous. The drawn errors are then added on top of these errors. This means that if the model is solved with no drawn errors used, a perfect tracking solution is obtained. The drawn errors are thus off of the perfect tracking solution. The solution values are recorded, which completes the trial.

If the above procedure is repeated, say, N times, there are N solution values for each endogenous variable, from which forecast error variances can be computed. For the results in this paper 1000 trials were used for each stochastic simulation experiment.

Let g be the growth rate of US real GDP over eight quarters at an annual rate, and let π be the growth rate of the US GDP deflator over eight quarters at an annual rate. The focus in this paper is on the forecast error variances of g and π. Let σ^2 denote the estimated forecast error variance of g or π for one of the 12 eight-quarter periods. The 12 values of σ^2 for g and for π are presented in the first column of Table I.

Forecast error variances like those in Table I are not constant across time because the model is non linear. In Table I the range is from 1.178 to 1.563 for g and from 0.648 to 0.987 for π. (All numbers are in percentage points.) These differences are not due to stochastic simulation error because the same draws were used for each of the 12 periods. In other words, the same 12,920,000 ($= 1615 \times 8 \times 1000$) errors were used for each stochastic simulation experiment.

It is important to be clear on what is being estimated in Table I. Estimated historical errors between 1972 and 2007 are being used for the draws for all equations, including the 35 asset price equations—the CG equation, the PSI14 equation, the 10 oil price equations, and the 23 exchange rate equations.

[3] For equations estimated using annual data, the error is put in the first quarter of the year with zeros in the other three quarters (which are never used). If the initial estimate of an equation suggests that the error term is serially correlated, the equation is re-estimated under the assumption that the error term follows an autoregressive process (usually first order). The structural coefficients in the equation and the autoregressive coefficient or coefficients are jointly estimated (by 2SLS). The $\hat{u}_t$ error terms are after adjustment for any autoregressive properties, and they are taken to be i.i.d. for purposes of the draws. As discussed in the text, the draws are by year—four quarters at a time.

[4] If an estimation period does not include all of the 1972:Q1–2007:Q4 period, zero errors are used for the missing quarters.

[5] Remember that for annual equations the errors for the last three quarters are zero (and never used).

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Table I. Estimated variances

Period	(1) σ^2	(2) σ_a^2	(3) $\sigma^2 - \sigma_a^2$	(4) $\frac{\sigma^2-\sigma_a^2}{\sigma^2}$
Output growth over eight quarters, annual rate				
1986:Q1–1987:Q4	1.519	0.961	0.558	0.367
1988:Q1–1989:Q4	1.489	0.944	0.545	0.366
1990:Q1–1991:Q4	1.563	0.983	0.580	0.371
1992:Q1–1993:Q4	1.438	0.931	0.507	0.353
1994:Q1–1995:Q4	1.353	0.930	0.423	0.313
1996:Q1–1997:Q4	1.273	0.906	0.367	0.288
1998:Q1–1988:Q4	1.178	0.877	0.301	0.256
2000:Q1–2001:Q4	1.242	0.877	0.361	0.294
2002:Q1–2003:Q4	1.316	0.933	0.383	0.291
2004:Q1–2005:Q4	1.269	0.923	0.346	0.273
2006:Q1–2007:Q4	1.327	0.961	0.366	0.276
2008:Q1–2009:Q4	1.525	0.996	0.529	0.347
Inflation over eight quarters, annual rate				
1986:Q1–1987:Q4	0.936	0.606	0.330	0.353
1988:Q1–1989:Q4	0.987	0.598	0.389	0.394
1990:Q1–1991:Q4	0.947	0.554	0.393	0.415
1992:Q1–1993:Q4	0.816	0.518	0.482	0.591
1994:Q1–1995:Q4	0.734	0.495	0.239	0.326
1996:Q1–1997:Q4	0.696	0.441	0.255	0.366
1998:Q1–1988:Q4	0.648	0.410	0.238	0.367
2000:Q1–2001:Q4	0.683	0.380	0.303	0.444
2002:Q1–2003:Q4	0.702	0.393	0.309	0.440
2004:Q1–2005:Q4	0.818	0.389	0.429	0.524
2006:Q1–2007:Q4	0.879	0.379	0.500	0.569
2008:Q1–2009:Q4	0.955	0.381	0.574	0.601

Note: σ^2 = total forecast error variance; σ_a^2 = forecast error variance, asset-price errors not used; 1000 trials each experiment; same draws for each experiment; 1615 equations, of which 35 are asset price equations; historical errors between 1972:Q1 and 2007:Q4 drawn; values are in percentage points.

The variation in asset prices that is being used, for example, is the variation implicit in the historical errors of the asset price equations. Similarly, the variation in all the other equations that is being used is that implicit in the historical errors of the equations. The historic correlation of the error terms is accounted for since the actual, historic errors are used. Also, the procedure is not based on any assumptions about error distributions. Drawing is from the estimated errors, not from some distribution.

It is also important to realize that the estimated variances in Table I do not depend on the actual values of the endogenous variables. For example, the estimated variance for g is computed from the 1000 solution values of g; the actual value of g is never used. Also, it would not make much difference if the historical errors were not added to the equations before solution. If the errors were not added, the draws would not be off the perfect tracking solution, but instead off the predicted path using zero errors. This would give different solution values of g and a different mean, but the variance computed from the 1000 solution values would be similar.

In the second column of Table I estimated variances, denoted σ_a^2, are presented in which no errors are used for the 35 asset price equations. This means for the PSI14 equation and the 10 oil price

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Table II. Variance components

Period	σ^2	$\sigma^2 - \sigma_a^2$	$\sigma^2 - \sigma_1^2$	$\sigma^2 - \sigma_2^2$	$\sigma^2 - \sigma_3^2$	$\sigma^2 - \sigma_4^2$	Sum
Output growth over eight quarters, annual rate							
2006:Q1–2007:Q4	1.327	0.366	0.148	0.102	0.174	–0.018	0.406
2008:Q1–2009:Q4	1.525	0.529	0.281	0.116	0.189	–0.007	0.579
Inflation over eight quarters, annual rate							
2006:Q1–2007:Q4	0.879	0.500	0.003	–0.010	0.449	0.150	0.592
2008:Q1–2009:Q4	0.955	0.574	0.009	–0.012	0.529	0.147	0.673

Note: σ_1^2 = forecast error variance, CG errors not used; σ_2^2 = forecast error variance, PSI14 errors not used; σ_3^2 = forecast error variance, oil price errors not used; σ_4^2 = forecast error variance, exchange rate errors not used; see also note to Table I.

equations, which are just estimated random walk equations with drift, the solution values are the same across all trials—there is no variation in the variables. For the other equations there is some variation because there are right-hand-side endogenous variables, but most of the variation has been eliminated by not using errors. Again, there is no stochastic simulation error comparing across estimated variances because the same draws are used for all the experiments.[6] The third column presents the difference in the two variances for each period, and the fourth column presents the percentage difference.

For output growth, g, between 25.6% and 37.1% of the total forecast error variance is reduced when errors for the asset price equations are not used. For inflation, π, between 32.6% and 60.1% is reduced. The range for inflation is fairly large. The size of the reduction for inflation is thus sensitive to the non linearity of the model. The results in Table I thus show that asset price variation has important effects on overall forecast error variation in the MC model.

Table II presents for the last two periods results for four categories of asset prices. These results are based on four extra stochastic simulation experiments per period. For the first all errors are used except those for the CG equation; for the second all errors are used except those for the PSI14 equation; for the third all errors are used except those for the 10 oil price equations; and for the fourth all errors are used except those for the 23 exchange rate equations. Let σ_1^2, σ_2^2, σ_3^2, and σ_4^2 denote the respective estimated variances. The difference between σ^2 and σ_1^2 is the estimate of how much σ^2 is changed when errors are not used for the CG equation, and similarly for the other three. These four differences are presented in Table II.

The last column in Table II is the sum of the four differences. Because of the correlation of the error terms, this sum is not the same as $\sigma^2 - \sigma_a^2$, where σ_a^2 is based on not using errors for all the asset price equations at once. Table II shows that for g the sum is 0.406 versus 0.366 for $\sigma^2 - \sigma_a^2$ for the first period and 0.579 versus 0.529 for the second. These differences are fairly close, and so the correlation of the error terms does not appear to be an important issue in interpreting the results. For π the differences are somewhat larger: 0.592 versus 0.500 and 0.673 versus 0.574.

For g the contribution from the exchange rates is trivial (very small and negative). For the first period the other three (CG, PSI14, and oil prices) are 0.148, 0.102, and 0.174, and for the second period they are 0.281, 0.116, and 0.189. Oil prices thus contribute most for the first period, and stock prices most for the second period. The main point, however, is that all three contribute. For π neither stock prices nor housing prices contribute. Oil prices are most important: 0.449 for the first period and 0.529 for the second. For exchange rates the respective values are 0.150 and 0.147. Cost shocks (oil

[6] The draws for the asset price equations are, of course, just discarded.

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prices and exchange rates) thus drive the results for inflation. For output both demand shocks (stock prices and housing prices) and cost shocks (oil prices) contribute.

CONCLUSION

Results like those in Tables I and II require (1) a model that estimates the effects of asset price changes on the economy, (2) estimates of the variation of asset price changes, and (3) estimates of the variation of other errors. In the MC model stock prices and housing prices affect US household wealth, which affects US consumption. Oil prices affect import prices of all the oil-importing countries, which affect domestic prices through domestic price equations. Exchange rates affect relative prices of imports and exports, which have many effects across countries. Variation is estimated by drawing from vectors of historical errors for the 1972:Q1–2007:Q4 period. The historical errors for the asset price changes are—or are close to being—errors in a random walk equation with drift. The use of these errors reflects the assumption that asset price changes are not predictable except for a possible drift.

The results suggest that between about 25% and 37% of the forecast error variance of output growth over eight quarters is due to asset price changes and between about 33% and 60% of the forecast error variance of inflation over eight quarters is due to asset price changes. The inflation results are due to cost shocks from oil prices and exchange rates. The output results are due to stock prices, housing prices, and oil prices. The results thus suggest that the degree of uncertainty of any particular forecast of the macroeconomy *that one can never eliminate* is large. Any forecast is based implicitly or explicitly on assumptions about asset price changes, which one has no ability to forecast.

The forecast error variances that are estimated in this paper are based on historically estimated errors in the structural equations of the MC model. One can think about these errors as being either random shocks that can never be eliminated or errors that can be eliminated by better specifications. If one could develop a model with very small structural errors, then σ_a^2 in Table I would be close to zero. Almost all the forecast error variation would be from asset price changes. The percentages in column 4 of Table I thus depend on the accuracy of the structural equations of the MC model. A more accurate model, other things being equal, would lead to higher percentages, although column 3 would not be affected. The values in column 3 are simply the forecast error variances from asset price changes.

Since the stochastic simulation estimates reflect historically average behavior, they do not say anything about any one particular eight-quarter period. If in a specific period asset prices change very little, macroeconomic forecasts may be quite good, and conversely if asset prices change a lot. After the fact one could take a model like the MC model and examine how well the model predicted a specific period knowing and then not knowing the asset price changes. The difference in forecasting accuracy between knowing and not knowing the asset price changes would obviously vary across periods, in many cases by a large amount. The estimates in this paper are less tied to specific periods. They weight equally the historical variation between 1972 and 2007. On the other hand, the results do vary somewhat across time because of the non linearity of the model.

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