Using a Macroeconometric Model to Analyze the 2008–2009 Recession and Thoughts on Macroeconomic Forecastability

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Abstract

A macroeconometric model is used to examine possible causes of the 2008-2009 U.S. recession. The results suggest that about 30 percent of the recession so far (through 2008:4) is due to four unexplained shocks to the nondurable and durable consumption equations, 21 percent to the fall in equity wealth, 8 percent to the fall in housing wealth, 19 percent to import price shocks, and 22 percent to the fall in exports. All these except perhaps for part of the fall in exports are essentially unforecastable, and so the results suggest that most of the current recession is caused by unforecastable events.

1 Introduction

This paper is work in progress. It was written using data available at the end of February 2009, and it will be expanded as new data become available. A macroeconometric model of the United States (denoted the "US model") is used

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to analyze various questions about the U.S. recession that began in 2008.[1] The broad issue considered is to what the current recession can be attributed.

One question considered is whether the unexplained shocks (i.e., the estimated residuals) in the demand equations are larger in absolute value in the current recession than in previous ones. There are six estimated demand equations in the US model, explaining service consumption expenditures (CS), nondurable consumption expenditures (CN), durable consumption expenditures (CD), housing investment (IHH), plant and equipment investment (IKF), inventory investment (IVF), and imports (IM). As will be seen, of the 24 estimated residuals for the six equations and the four quarters of 2008, five are larger than two standard errors in absolute value—the IHH residual for 2008:2 and the CN and CD residuals for 2008:3 and 2008:4. The two consumption residuals for 2008:4 are the largest negative residuals in absolute value in the sample period (1954:1–2008:4). Also, there are no other cases in the sample period in which there are two consecutive residuals larger than two standard errors in absolute value. To get a sense of the size of the effect of the four consumption shocks, the model is used to estimate how different the economy would have been in 2008 had these four shocks been zero (with everything else the same).[2]

The three consumption equations have household wealth lagged one quarter as an explanatory variable. This wealth variable includes both financial wealth and

[1]The US model is described in Fair (2004). It has been updated for purposes of this paper. The updated version and documentation are on the website mentioned in the introductory footnote. All the results in this paper can be duplicated using the model on this site. The model can also be downloaded for use on one's own computer.

[2]The size of the effect of the 2008:2 shock to the IHH equation turned out to be fairly modest, and it has not been used here in order to focus on the consumption shocks.

housing wealth. It has a positive and significant coefficient estimate in each of the equations, and overall the size of the wealth effect on demand is fairly large. Since wealth is in the consumption equations, any large residuals in these equations cannot be attributed to wealth effects—these have already been accounted for. Given this, another question considered in this paper is how different the economy would have been in 2008 had there been no fall in equity values and in housing values. The model can be used to estimate this, where both the decrease in equity values and the decrease in housing values can be considered separately.

A property of the US model is that positive price shocks are contractionary. If there is a positive price shock, the domestic price level rises faster than does the nominal wage rate, and so, other things being equal, the real wage (and real income) falls. In addition, real wealth falls, other things being equal. Also, there is an estimated interest rate rule of the Fed in the model, where the Fed is estimated to respond to an increase in inflation, other things being equal, by raising nominal interest rates, which is contractionary.[3] A third question considered is how different the economy would have been in 2008 had there been no price shocks (essentially no oil price shocks). Again, the model can be used to estimate this.

A final question concerns U.S. exports. Exports fell dramatically in 2008:4. In the multicountry (MC) econometric model in which the US model is imbedded, U.S. exports are endogenous since they are imports of other countries, which are endogenous.[4] In the US model alone exports are exogenous. For present purposes

[3]Consumption in the model responds to nominal, not real, interest rates. I have done extensive tests of nominal versus real interest rates in consumption equations, and nominal interest rates dominate—see Fair (2004, Chapter 3).

[4]The MC model is also described in Fair (2004), and it can also be used on the website mentioned in the introductory footnote and downloaded for use on one's own computer.

the MC model has not been used because of data availability. If it were used, one could examine shocks to the demand equations of the other countries to see how much of, say, a fall in import demand is due to unexplained shocks and how much to effects that are captured in the model. Instead, for present purposes an experiment was run using the US model alone in which exports are assumed to grow at a normal rate throughout 2008. The model is used to estimate how different the economy would have been with normal export growth. Again, part of this difference should be attributed to unexplained shocks and part to explained effects, but without the use of the MC model there is no way of separating the two.

The overall results are roughly as follows. Had 1) the four residuals been zero, 2) stock prices not fallen in 2008, 3) housing values not fallen in 2008, 4) there been no price shocks, and 5) export growth been normal (but everything else the same, including the other shocks), there would have been no recession. For example, the unemployment rate in 2008:4 would have been 5.2 percent instead of the actual value of 6.9 percent. This predicted outcome will be called the "no recession" outcome. Of the 1.7 percentage point difference in the unemployment rate in 2008:4, it will be seen that the four residuals account for about 30 percent of the difference. Exports account for about 22 percent, and price shocks account for about 19 percent. Wealth shocks account for the remaining 29 percent—21 percent from equity and 8 percent from housing.

Since the four residuals in the CN and CD equations account for about 30 percent the difference between the actual and no recession outcomes, which is fairly large, it is interesting to speculate what might have caused them (they are obviously unexplained in the model). One possibility is that consumers were

spooked by negative comments of policy makers in the last half of 2008 and decided to save more. Another possibility is that consumers cut back spending because they could not borrow, being subject to credit rationing. Although it is, of course, hard to test whether it is negative animal spirits, credit rationing, or something else that caused the four large residuals, it is important to keep in mind that over half of the difference between the actual and no recession outcomes is not spooking or credit rationing but simply what appear to be normal (i.e., historically estimated) reactions to wealth and price changes.

2 The Five Experiments

The US Model

The US model is briefly discussed in Appendix A. The model consists of 30 estimated equations and about 100 identities.[5] The estimation period is 1954:1–2008:4, and the simulation period for the present results is 2008:1–2008:4. The estimation method is two stage least squares. There is no calibration; labor market clearing is not imposed; rational expectations are not imposed; and the Lucas critique is not a problem if expectations are not rational.

[5]For the results in this paper the "stock market" equation in the model, which explains capital gains or losses on the equity holdings of the household sector (variable CG), is not used. As will be seen, one of the experiments requires changing CG. This equation explains very little of the variation of CG.

Estimated Residuals

Table 1 lists the quarters in which an estimated residual in one of the six demand equations is greater than two standard errors in absolute value. The ratio of the residual to the standard error is also presented. The sign for the import residuals has been reversed because imports subtract from GDP. Four of the seven equations have no large residuals in 2008; the housing investment equation has one; and two of the consumption equations have two. It is interesting that the investment equations are not affected except for 2008:2 for housing investment, although there are obviously large shocks to two of the three consumption equations in the last half of 2008.

The first experiment consists of setting the four consumption residuals to zero and all the other residuals to their actual (i.e., estimated) values. The model is then solved dynamically for the 2008:1–2008:4 period. The difference between the predicted value of a variable from this simulation and the actual value is the estimated effect of the change.[6]

Table 2 presents results for all the experiments. Results are presented for real GDP, both level and growth rate, for inflation as measured by the percentage change in the private non farm price deflator, for the unemployment rate, and for the number of jobs in the firm sector.[7] For the first experiment, setting the four residuals to zero, the results show that in 2008:4 real GDP is larger by 1.8 percent,

[6]Note that when the model is solved with all the residuals set to their actual values, a perfect tracking solution is obtained. The "base case" that should be used for comparison, with all the residuals set to their actual values, is thus just the set of actual values.

[7]In the model all flow variables are at quarterly rates, but for presentation purposes in Table 2 real GDP is listed at an annual rate. The percentage changes in real GDP and in the price deflator are at annual rates.

Table 1
Residuals Greater than Two Standard Errors
in Absolute Value

Quarter	Resid/SE	Quarter	Resid/SE	Quarter	Resid/SE
CS		IHH		IM	
1960.3	-2.33	1959.1	2.27	1954.2	-3.47
1961.3	-2.13	1964.2	-2.35	1957.1	-2.50
1963.1	-2.18	1967.2	2.08	1965.1	2.98
1974.1	-2.43	1973.2	-2.66	1972.2	2.17
1980.2	-3.28	1974.4	-2.03	1973.3	2.01
1980.4	2.16	1975.2	-2.01	1975.1	3.37
1981.1	-2.41	1976.4	3.03	1975.2	3.66
1985.1	3.17	1977.2	2.47	1980.3	2.74
1985.3	2.51	1978.2	2.09	1984.1	-2.14
1998.4	-2.08	1979.1	-2.06		
2000.1	2.32	1980.3	2.91		
		2008.2	-2.42		
CN		IKF			
1963.4	-2.14	1957.4	-2.09		
1965.4	3.48	1958.1	-2.53		
1972.2	2.41	1960.4	-3.05		
1973.2	-2.58	1965.1	2.27		
1974.1	-3.03	1970.4	-2.15		
1974.4	-2.76	1971.1	3.11		
1984.2	2.29	1971.4	-2.04		
1999.4	2.08	1973.4	2.14		
2003.3	2.04	1981.1	2.77		
2008.3	-2.65	1987.4	2.02		
2008.4	-3.04	1998.1	2.02		
CD		IVF			
1974.4	-2.06	1965.1	2.20		
1980.2	-2.34	1967.1	-2.58		
1986.3	2.48	1975.1	-2.45		
1987.1	-2.68	1981.4	2.52		
2000.2	-3.41	1987.1	-2.02		
2001.4	4.43	1993.1	2.39		
2003.2	2.30	1994.1	-3.68		
2003.3	2.34	1997.4	-2.94		
2005.4	-2.48	1999.2	4.18		
2006.1	2.69	2001.1	-2.69		
2008.3	-2.35				
2008.4	-4.13				

CS = consumption of services
CN = consumption of nondurables
CD = consumption of durables
IHH = housing investment
IKF = plant and equipment investment
IVF = inventory investment
IM = imports (sign reversed)

Table 2
Results of the Experiments for Five Variables

	$GDPR$				$PCGDPR$			
	2008:1	2008:2	2008:3	2008:4	2008:1	2008:2	2008:3	2008:4
actual	11646.0	11727.4	11712.4	11525.0	0.87	2.83	-0.51	-6.25
1) CN, CD	11646.0	11727.4	11785.6	11729.5	0.87	2.83	2.00	-1.89
difference	0.000	0.000	0.006	0.018	0.00	0.00	2.51	4.36
2) CG	11646.0	11741.7	11751.1	11622.7	0.87	3.33	0.32	-4.96
difference	0.000	0.001	0.003	0.007	0.00	0.50	0.83	1.29
3) $PSI14$	11646.0	11732.4	11728.3	11557.2	0.87	3.00	-0.14	-5.71
difference	0.000	0.000	0.001	0.003	0.11	0.17	0.37	0.54
4) PIM	11654.0	11769.7	11800.6	11608.0	1.15	4.03	1.05	-6.37
difference	0.001	0.004	0.008	0.007	0.28	1.20	1.56	-0.12
5) EX	11657.1	11727.5	11726.3	11692.8	1.26	2.44	-0.04	-1.14
difference	0.001	0.000	0.001	0.015	0.39	-0.39	0.47	5.11
Sum	0.002	0.005	0.019	0.050	0.67	1.48	5.74	11.18
All	11665.4	11790.6	11943.4	12090.9	1.55	4.36	5.29	5.03
difference	0.002	0.005	0.020	0.049	0.68	1.53	5.80	11.28
	UR				JF			
	2008:1	2008:2	2008:3	2008:4	2008:1	2008:2	2008:3	2008:4
actual	4.94	5.37	6.05	6,86	131.63	131.54	131.98	129.14
1) CN, CD	4.94	5.37	5.90	6.36	131.63	131.54	131.23	130.02
difference	0.00	0.00	-0.15	-0.50	0.00	0.00	0.25	0.89
2) CG	4.94	5.32	5.89	6.52	131.63	131.59	131.15	129.52
difference	0.00	-0.05	-0.16	-0.34	0.00	0.05	0.17	0.38
3) $PSI14$	4.94	5.35	5.98	6.72	131.63	131.56	131.05	129.29
difference	0.00	-0.02	-0.07	-0.14	0.00	0.02	0.07	0.15
4) PIM	4.93	5.29	5.83	6.55	131.65	131.70	131.40	129.72
difference	-0.01	-0.08	-0.22	-0.31	0.02	0.16	0.42	0.58
5) EX	4.92	5.36	6.01	6.50	131.66	131.56	131.04	129.76
difference	-0.02	-0.01	-0.04	-0.36	0.03	0.02	0.06	0.62
Sum	-0.03	-0.16	-0.64	-1.65	0.05	0.25	0.97	2.62
All	4.91	5.20	5.44	5.24	131.69	131.80	131.95	131.77
difference	-0.03	-0.17	-0.61	-1.62	0.06	0.26	0.97	2.63

Table 2 (continued)

	$PCPF$			
	2008:1	2008:2	2008:3	2008:4
actual	2.98	1.30	5.08	0.83
1) CN, CD	2.98	1.30	5.18	1.18
difference	0.00	0.00	0.10	0.35
2) CG	2.98	1.33	5.19	1.06
difference	0.00	0.03	0.11	0.23
3) $PSI14$	2.98	1.30	5.13	0.93
difference	0.00	0.00	0.05	0.10
4) PIM	2.52	-0.20	3.45	1.96
difference	-0.46	-1.50	-1.63	1.13
5) EX	2.99	1.30	5.10	1.08
difference	0.01	0.00	0.02	0.25
Sum	-0.45	-1.47	-1.35	2.06
All	2.53	-0.13	3.73	2.87
difference	-0.45	-1.43	-1.35	2.04

Notes:
- "difference"is the difference between the predicted value and the actual value.
- For $GDPR$ the difference is the percentage difference.
- "Sum" is the sum of the differences.
- "All" is all five experiments combined.
- $GDPR$ = real GDP, billions of 2000 dollars at an annual rate.
- $PCGDPR$ = percentage change real GDP, percentage points, annual rate.
- UR = unemployment rate, percentage points.
- JF = number of jobs in the firm sector, millions of workers.
- $PCPF$ = percentage change in the non farm price deflator, percentage points, annual rate.

the inflation rate is larger by 0.35 percentage points, the unemployment rate is lower by 0.50 percentage points, and the number of jobs is larger by 890,000 workers.

Equity Values

The variable CG in the model is the 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. Table 3 shows values of CG for 2007 and 2008. In the first three quarters of 2008 the total value of capital losses was $4.8 trillion. For the second experiment this loss was taken away. CG was instead taken to be $351 billion in each quarter of 2008. This figure was obtained as follows. The average value of the ratio of CG to nominal GDP in the estimation period is .10, and the $351 billion number is .10 times $3,510 billion, which is the value of nominal GDP at a quarterly rate in 2007:4. This experiment is thus assuming that CG takes on historically normal values in 2008. Although this change was made for all four quarters, the value for 2008:4 does not matter because wealth enters with a lag of one quarter in the consumption equations. No other changes were made for this experiment, and all the residuals were set to their actual values.[8]

The results are presented in Table 2. They show that in 2008:4 real GDP is larger by 0.7 percent, the inflation rate is larger by 0.23 percentage points, the unemployment rate is lower by 0.34 percentage points, and the number of jobs is larger by 380,000 workers.

Housing Values

In the model variable KH is the real stock of housing of the household sector. It 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. Let PKH be this market value of real estate divided by KH. PKH can be considered to be the market price of KH. The

[8] Appendix B gives the exact definition of the wealth variable, and it discusses results of a test of financial versus housing wealth in explaining aggregate consumption.

Table 3
Assumptions Used for the Experiments

	2007:1	2007:2	2007:3	2007:4	2008:1	2008:2	2008:3	2008:4
Experiment 2								
CG actual	993.1	1306.1	267.0	-836.7	-2022.3	-532.6	-2259.9	-3500.0
CG used					351.0	351.0	351.0	351.0
Difference					2373.3	883.6	2610.9	3851.0
Experiment 3								
$PSI14$ actual	2.154	2.113	2.058	1.975	1.894	1.853	1.777	1.713
$PSI14$ used					1.975	1.975	1.975	1.975
Difference[a]					966.4	1455.6	2362.3	3125.9
Experiment 4								
PIM actual	1.155	1.191	1.212	1.249	1.287	1.371	1.402	1.249
PIM used					1.258	1.268	1.277	1.287
Difference					-.029	-.103	-.125	.038
Experiment 5								
EX actual	340.8	348.1	366.6	370.5	375.2	386.2	389.0	363.7
EX used					377.7	385.0	392.5	400.1
Difference					2.5	-1.2	3.5	36.4

Notes:
- [a]Approximate equivalent nominal wealth difference. See text.
- CG = capital gains or losses on equity held by the household sector.
- $PSI14$ = ratio of the market price of KH to the price deflator for domestic goods.
- PIM = U.S. price of imports.
- PIM grows at a 3 percent annual rate from its 2007:4 value.
- EX = U.S. real exports.
- EX grows at an 8 percent annual rate from its 2007:4 value.

relative price of KH in the model is taken to be PKH/PD, where PD is the price deflator for domestic goods. Define $PSI14$ to be PKH/PD. Then in the model PKH is determined as $PKH = PSI14 \cdot PD$, where $PSI14$ is taken to be exogenous. This simply means that PKH, the market price of KH, is not explained in the model except as it changes with the overall price of domestic goods.

Values of $PSI14$ are presented in Table 3 for 2007 and 2008. $PSI14$ fell sharply in 2008, which means that PKH fell sharply relative to PD. For the third experiment $PSI14$ was taken to be unchanged in 2008 from its 2007:4 value. As with CG, the value in 2008:4 does not matter because wealth enters the consumption equations with a lag of one quarter. Also presented in Table 3 are the increases in housing wealth that approximately correspond to the $PSI14$ increases. These wealth increases are directly comparable to the CG increases in Table 3 in terms of how they change the wealth variable that enters the consumption equations.[9]

The results in Table 2 show that in 2008:4 real GDP is larger by 0.3 percent, the inflation rate is larger by 0.10 percentage points, the unemployment rate is lower by 0.14 percentage points, and the number of jobs is larger by 150,000 workers. These effects are smaller than they are for the second experiment. This is partly due to the fact that the sum of the housing wealth increases for the first three quarters of 2008 is somewhat smaller than the sum of the CG increases and partly due to the fact that the first-quarter CG increase is considerably larger than the first-quarter housing wealth increase (and thus has more overall effect because of lagged effects).

Price Shocks

Variable PIM in the US model is the U.S. import price deflator. It is exogenous in the US model alone but endogenous in the MC model because it depends on

[9]The wealth increases for $PSI14$ in Table 3 were computed as follows. Nominal housing wealth is $PKH \cdot KH$, or $PSI14 \cdot PD \cdot KH$. The value of $PD \cdot KH$ in 2007:4 is \$11,931 billion. This number was multiplied by the difference between the experimental value of $PSI14$ (1.975) and the actual value for each quarter of 2008 to compute the wealth increases.

the export prices of the other countries and on exchange rates, both of which are endogenous except for the export prices of oil exporting countries. For present purposes PIM is taken to be exogenous. Its values in 2007 and 2008 are presented in Table 3. PIM rose substantially in the first three quarters of 2008, which is in large part due to oil price increases. The fourth experiment assumes that these large oil price increases did not take place. PIM was instead taken to grow at an annual rate of 3 percent in 2008 from its 2007:4 value.

The results in Table 2 show that in 2008:4 real GDP is larger by 0.7 percent, the unemployment rate is lower by 0.31 percentage points, and the number of jobs is larger by 580,000 workers. The inflation rate is lower in the first three quarters and higher in the fourth quarter. Although not shown directly in the table, the level of the price deflator is lower in 2008:4 compared to the actual level.

Exports

Variable EX in the US model is the real value of U.S. exports. It is exogenous in the US model and endogenous in the MC model. For present purposes it has been taken to be exogenous. Its values in 2007 and 2008 are presented in Table 3. EX fell sharply in 2008:4. As noted in Section 1, this fall in import demand from other countries could be from negative random shocks to the other countries' demand equations or to responses captured within the MC model. Whatever the case, for the fifth experiment EX has been assumed to grow at an annual rate of 8 percent in 2008 from its 2007:4 value. This experiment is just assuming normal export growth in 2008.

The results in Table 2 show that in 2008:4 real GDP is larger by 1.5 percent, the inflation rate is larger by 0.25 percentage points, the unemployment rate is lower by 0.36 percentage points, and the number of jobs is larger by 580,000 workers. The only noticeable effects for this experiment are in the fourth quarter since this is the only quarter in which the experimental value of exports is much different from the actual value.

All Together

The effects of the above five experiments are not exactly additive because the model is nonlinear. They are, however, almost additive. Table 2 shows the results of making all five changes at once compared to adding the five separate effects. The results are very close, and so there is no problem with separating out the effects.

The results of combining all five experiments show that in 2008:4 real GDP is larger by 4.9 percent, the unemployment rate is lower by 1.62 percentage points, and the number of jobs is larger by 2.63 million workers. As was the case for the fourth experiment, the inflation rate is lower in the first three quarters and higher in the fourth quarter. Again, although not shown directly in the table, the level of the price deflator is lower in 2008:4 compared to the actual level. The pattern of the inflation results of the combined experiment is thus dominated by the PIM changes for the fourth experiment.

The value of the unemployment rate in 2008:4 is 5.24 for the combined experiment versus the 6.86 actual value. The recession has thus effectively been eliminated. The growth rate of real GDP in 2008:1 is only 1.55 percent, but in the

next three quarters it is 4.36, 5.29, and 5.03 percent, respectively, which are clearly not recession values.

The contribution of each experiment to the total has been summarized at the end of Section 1. Consider the unemployment rate in 2008:4. The sum of the decreases is 1.65 percentage points, with the individual contributions being: .50 for the consumption residuals, .34 for equity wealth, .14 for housing wealth, .19 for price shocks, and .36 for exports.

Conclusion

At the time of this writing (mid March 2009) both stock prices and housing values have fallen since the end of 2008. This, combined with the fact that CG was negative in 2008:4 and $PSI14$ fell, implies, according to the US model, negative wealth effects on consumption in 2009. Whether there will also be further negative consumption shocks is unknown. When data for 2009:1 become available, it will be possible to update the above results. Because of the large further wealth decreases, it could be that case in 2009:1 that there are large decreases in consumption without any negative consumption shocks.

3 Thoughts on Macroeconomic Forecastability

All five of the above experiments concern variables that are hard, if not impossible, to forecast. First, random shocks are by definition unforecastable. Second, stock prices are or are close to being a random walk and are not really forecastable. There is an equation in the US model explaining CG as a function of the change in interest

rates and the change in after tax cash flow, but this equation explains very little of the variation in CG and is essentially useless, As noted in footnote 5, it has not been used for the results in this paper. Third, the market price of housing is close to being unforecastable aside from its ties to the overall price index. This means that variable $PSI14$ in the model is essentially unforecastable. Fourth, the price of imports, variable PIM in the model, depends in large part on oil prices, food prices, and exchange rates. There are equations in the MC model for exchange rates, but only a small fraction of the variance of the change in exchange rates is explained. Oil prices and food prices are essentially unforecastable, and so PIM is close to being unforecastable. Fifth, U.S. exports (EX) depend on the import demands of other countries, and so part of EX is forecastable to the extent that the import demands are forecastable, but the part due to random shocks is, of course, not.

These results thus indicate that the current recession so far is essentially all due to unforecastable events: random consumption shocks, stock prices, housing prices, import prices, and at least part of exports. There are other examples of unforecastable events driving the economy. The results in Fair (2004, Chapter 4) suggest that the rapid growth in the U.S. economy in the last half of the 1990s (the "new economy") was primarily due to the stock market boom. The results in Fair (2005) suggest that the sluggish performance of the U.S. economy in the 2000:4–2004:3 period in spite of expansive monetary and fiscal policies was due in large part to the stock market decline (and in part to exports). The Great Depression also appears to have been unforecastable. Dominguez, Fair, and Shapiro (1988) show that forecasters did not see it coming and that a VAR model using historical data

now available also does not forecast it. A structural model was not tried in this paper, but the results in the present paper suggest that a structural model would not likely forecast the Great Depression either.

This is not to say, of course, that all macroeconomic events are unforecastable. A model like the US or MC model may be good at forecasting the implications of fiscal policy changes like the current stimulus bill. Once a fiscal-policy bill is passed, models may have something to say.[10] Also, once, say, a decline in equity prices or housing prices is known, models can be used to forecast the future economic consequences of the decline.

Appendix A: The US and MC Models

I have argued elsewhere that a model like the US model is a better approximation of the economy than are currently popular dynamic stochastic general equilibrium (DSGE) models. The most extensive discussion is in Fair (2007, Section 2). Table A.1 is a slightly modified version of Table 2 in this paper; it summarizes some of the main points.

The reference in the last point in Table A.1 presents a comparison in terms of outside sample root mean squared errors of the US model and three models in the DSGE tradition. This comparison is based on results in Ireland (2004), Del Negro, Schorfheide, Smets, and Wouters (2006), and Fair (2004). The results show that the US model is much more accurate, especially regarding real output. This is

[10]The MC model has been used to analyze the effects of the U.S. stimulus bill. The results are available on the website mentioned in the introductory footnote.

Table A.1
DSGE Models versus the US Model

Property	DSGE Models	US Model
Intertemporal optimization?	Yes.	Yes.
Rational expectations?	Yes.	No.
Imperfect competition?	Yes.	Yes.
Costly price adjustment?	Yes.	No.
Estimation.	Parameters of the theoretical model are calibrated or estimated.	The theoretical model is used to guide the specification of the econometric model, which is then estimated. No calibration for econometric model.
Demand disaggregation.	One aggregate demand equation.	Three consumption equations: services, nondurables, durables; three investment equations: nonresidential fixed, residential, inventory; import demand equation.
Government sector?	Usually not.	Yes.
Foreign sector?	Usually not.	Yes.
Stock effects?	No.	Yes, on durable consumption, residential investment, nonresidential fixed investment, inventory investment.
Wealth effects?	No.	Yes, on the three categories of consumption.
Wage equation?	Usually not.	Yes, separately estimated wage and price equations.
Real versus nominal interest rate effects.	Real effects imposed.	Tested, where nominal interest rates generally dominate.
Effects of a positive price shock with the nominal interest rate held constant.	Explosive or indeterminate.	Contractionary.
Lucas critique a problem?	No.	Not under the assumptions about expectations.
Long run tradeoff between inflation and output?	No.	Lack of tradeoff not tested because of limited data. Relationship likely to be nonlinear.
Accuracy.	See Table 1, Fair (2007).	See Table 1, Fair (2007).

perhaps not surprising since DSGE models leave out many first order effects and are based on assumptions like labor market clearing and rational expectations that do not seem realistic. As listed in Table A.1, first order effects that are usually left out of DSGE models include 1) no disaggregation of demand into consumption and investment components, 2) usually no government and foreign sectors, 3) no stock effects and wealth effects, and 4) usually no wage equation. The US model disaggregates demand into three categories of consumption, three categories of investment, and imports. Exports are endogenous in the MC model. Both federal and state and local governments are in the US model. Lagged stock effects play a major role: durable goods stock, housing stock, capital stock, inventory stock. Wealth effects are very important, as has been seen in this paper.

Most DSGE models have the feature that a positive price shock with the nominal interest rate held constant is explosive or indeterminate. This property has important implications for monetary policy. In the US model, on the other hand, a positive price shock is contractionary, as discussed in Section 1 of this paper. This feature seems strongly supported by the data in the tests that I have done. If true, then DSGE models that have the opposite feature are likely to be misleading for most monetary policy analyses.

The US and MC models are completely estimated and have been extensively tested—see Fair (2004, Chapter 2). Not all tests yield positive results, but overall the models seem to be reasonable approximations. In particular the models do fairly well on coefficient stability tests. If the Lucas critique were a problem, it seems likely that more stability hypotheses would be rejected. Also, the Lucas critique is not a problem if expectations are not rational, and tests that I have

performed of the rational expectations hypothesis—again see Fair (2004, Chapter 2)—are not generally supportive of the hypothesis.

The US model has the feature that all flows of funds among the sectors are accounted for, and the MC model has the feature that all bilateral trade flows are accounted for, with most bilateral trade share coefficients explained. Interest rate rules are estimated for many countries. Interest rate, exchange rate, and price links as well as trade links are accounted for across countries.

Micro theory is behind the specification of household and firm behavior. The estimated equations are meant to be approximations to decision equations that result from optimization problems. Theory is used to decide what is on the left hand and right hand sides of the estimated equations. People using the DSGE methodology don't like this way of using theory because it is not as tight as that used in DSGE work. It is considered ad hoc. But my view is that this is exactly the way theory should be used. Any more restrictive or rigorous use of theory is likely to push beyond what the data can tell us. Macroeconomic data are highly aggregated, and there is a limit to what one can expect to learn from the data.

Finally, the current recession puts some of recent academic macroeconomic research in perspective. For one, the great moderation literature has probably run its course. Second, the recession shows the limitations of DSGE research to date. Analyses of the effects of the stimulus bill and analyses like in this paper are out of the range of typical DSGE models. For example, the assumptions of labor market clearing and rational expectations do not seem to fit well the current economic situation in the world. Also, the lack of a government sector in most models is problematic, as well as no stock and wealth effects.

Appendix B: Financial Wealth versus Housing Wealth in Explaining Aggregate Consumption

The wealth variable that appears in the consumption equations in the US model is:

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

where AH is the nominal value of net financial assets of the household sector excluding demand deposits and currency, MH is the nominal value of demand deposits and currency held by the household sector, KH is the real stock of housing, PKH is the market price of KH, and PH is a price deflator relevant to household spending. $AH + MH$ is thus nominal financial wealth, and $PKH \cdot KH$ is nominal housing wealth.

The CS and CN equations are in log per capita terms, and the wealth variable enters as $\log(AA/POP)_{-1}$. The CD equation is in per capita terms (not logged), and the wealth variable enters as $(AA/POP)_{-1}$. This use of AA restricts financial wealth and housing wealth to have the same effects on consumption. This restriction can be tested as follows. Define

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

where λ is a parameter to be estimated. Also define

$$AA1 = (AH + MH)/PH$$

$$AA2 = (PKH \cdot KH)/PH$$

In the CD equation the restriction can be tested by just adding $(AA1/POP)_{-1}$ and $(AA2/POP)_{-1}$ separately and testing that their coefficients are the

same. In the CS and CN equations the restriction can be tested by using $\log(AAA/POP)_{-1}$, where λ is a coefficient to be estimated, and testing whether λ is equal to 1.0. The equations are estimated by two stage least squares (2SLS), and so estimating λ is a non linear 2SLS estimation problem, which is straightforward to do.

The results for the 1954:1–2008:4 estimation period are:

CS **equation**: $\alpha \log(AAA/POP)_{-1}$: $\hat{\alpha} = .0295$, t-statistic = 4.57, $\hat{\lambda} = 1.365$, t-statistic = 2.68, t-statistic for hypothesis that $\lambda = 1$ is 0.72.

CN **equation**: $\alpha \log(AAA/POP)_{-1}$: $\hat{\alpha} = .0593$, t-statistic = 5.96, $\hat{\lambda} = 0.926$, t-statistic = 2.65, t-statistic for hypothesis that $\lambda = 1$ is -0.21.

CD **equation**: $\alpha_1(AA1/POP)_{-1}$ and $\alpha_2(AA2/POP)_{-1}$: $\hat{\alpha}_1 = .00063$, t-statistic = 3.97, $\hat{\alpha}_2 = .00275$, t-statistic = 5.84, t-statistic for hypothesis that $\alpha_1 = \alpha_2$ is 4.79.

The hypothesis that the two wealth variables have the same effects is not rejected for the CS and CN equations. The estimate of λ is slightly greater than one in the first equation and slightly less than one in the second. The hypothesis is rejected for the CD equation, with housing wealth having the larger coefficient. There is thus some evidence that housing wealth has a greater effect, but the evidence is not strong. For purposes of this paper the effects have been assumed to be the same.[11]

[11] Case, Quigley, and Shiller (2005) using annual panel data for countries for 1975–1996 and quarterly panel data for U.S. states for 1982–1999 generally find stronger effects for housing wealth than for financial wealth. For most of their results financial wealth is in fact not significant. Their stronger housing wealth results are consistent with the CD results in this paper, although, contrary to their results, financial wealth is highly significant in the present results.

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