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Monetary policy, Farm sector income and Farm Household Well-being --a VECM Analysis

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Abstract

Farm sector seems to be countercyclical to the household well-being and general economy. In recent years the farm sector is experiencing downtrend with net farm income significantly drops from 2013 high. On the other hand, average farm household income keeps booming, even has higher growth rates than average U.S. household income. Considering the whole economy fully recovered, Federal Reserve started to hike interest rate in 2015. This paper aims to address the linkage and equilibrium among farm sector income, farm household well-being and macroeconomic monetary policies empirically.

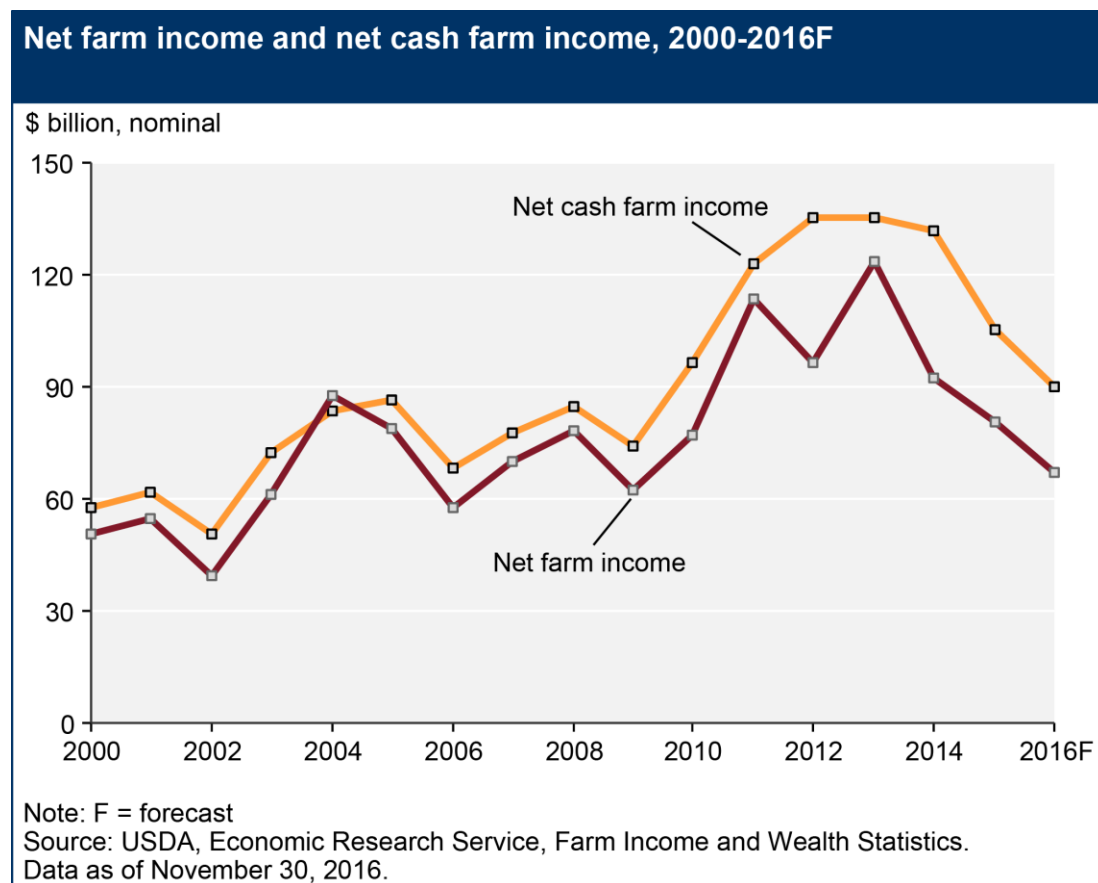
By using Vector Error Correction Model (VECM), we show both the ratio of average farm household income to U.S. household income and the off-farm earnings of farm household are cointegrated with CPI. Farm portion of farm household income, although strongly positive correlated with farm sector net income, is not cointegrated with either CPI or farm sector net income. Towards sector level analysis, farm sector net income, Federal Funds Rate (FFR) and CPI are proved to be all cointegrated. CPI is dominating the decision of FFR and further affecting net farm income. Combining our results from household level and sector level, a jump in FFR can lead to slower pace of CPI and farm sector net income, then dragging down the ratio of average farm household income to U.S. household income and the off-farm earnings.

In the next few years with FFR goes up, we expect farm sector income will keep in relatively low level and farm household may suffer from reduced off-farm earnings. Related farm supporting policies are then discussed conceptually.

Introduction

In 2013 farm sector net income has achieved a record high level at 123.7 billion dollars. Accompanied with declining commodity prices, farm sector income shrinks year by year after 2013. The USDA has predicted the net income of the whole farm sector in 2016 as 66.9 billion dollars, roughly half of that in 2013. This is a reduction of 17.2 percentage compared with farm sector net income of 2015. Notice that in 2015, net farm income is “only” 12.7 percent lower than that of 2014. All these numbers show that farm sector has entered a hard period.¹

Figure 1. Net farm income and net cash farm income



Although there is downtrend for the whole farm sector, the average farm household income keeps rising for years. The mean farm household income in 2014 is 134,164 dollars, which is

¹ USDA ERS-2016 Farm Sector Income Forecast, “Farm Sector Weakness To Continue Into 2016”

1.77 times of the U.S. average household income. This ratio drops to 1.51 in 2015. Although it is lower than 1.77, it still means on average farm household can earn 51 percent more than all US household average level. Not only has the ratio, the farm household income also has grown at faster speed than U.S. average. The whole farm sector may be in bad time now, the household level is not. There is unequal trend in sector level and household level. In this paper we investigate the reasons for these unequal trends and the linkage between them. We then make some policy suggestions after explaining our results.

In the following of this paper, we first list some related findings in existing literatures. Data and detailed model are then described. The long term equilibriums in sector level and household level are explained in results part. Short term deviations and corrections lightened by the model are also discussed. Based on these findings, some policy suggestions are raised at the end.

Literatures

The U.S. farm sector contains vast fields of production activities and contributes significant proportion of U.S. gross domestic product (GDP). In 2014 total value added by agriculture and agriculture-related industries is 985 billion dollars, roughly 5.7 percent of U.S. GDP that year². As farm activities vary across regions and different market structures, it can be hard to measure by detailed or specific economic tools. A highly aggregated indicator will be the first choice to monitor the economic condition and productivity of the whole sector. Two widely used indicators for U.S. agriculture sector are net farm sector income and farm sector debt to asset ratio(Schnepf, 2012). Both indicators are reported by USDA periodically. Since debt to asset ratio of farm sector is relatively steady over time and the linkage between sector level and

² USDA, ERS and Bureau of Economic Analysis

household level is of more research interest in this paper, farm net income is the main variable we use to capture the health and well-being of the farm sector. Potential problem of using this highly aggregated indicator is that any regional or market specific characteristics will be eliminated (Schnepf, 2012).

The record high net farm income of 2013 was explained as joint results of high commodity prices, strong export and relative weak dollars (Schnepf, 2012, USDA-ERS). However, the linkage between agricultural activities and macroeconomic policies was ignored. There is few existing literatures trying to use macroeconomic policies explaining agricultural events. Gardner (1981) has proved that inflation generally caused those severe problems in agriculture in 1980s, but he failed to reveal the linkage between inflation and macroeconomic policies. As the Federal Reserve has adopted a contractionary monetary policy now, federal funds rate (FFR) is expected keep rising in the coming years. A contractionary monetary policy will generally push up the value of dollar and thus hurt export. On the other hand contractionary policy will cool down general demand and make the agricultural commodity prices even lower (Penson, et al., 1986). none of these will favor farm sector.

Not only the whole farm sector will be affected by contractionary monetary policy, there should also be negative impacts in household level. It is important and of great research interest to focus both on sector level and on household level when investigating farm sector well-beings. Usually, most farm households have income from both on-farm and off-farm activities. Fernandez-Cornejo, et al. (2007) has shown that a farm operator's off-farm income generally has negative correlation with the farm size. According to USDA-ERS, family farms are the main components of all US farm (USDA-ERS, 2016). The share of family farms to total farms is steadily at around 98%. Among all these family farms, great proportion of them have annual gross sales less than

50,000 dollars. In 2015, this ratio is 72.9%. Only 3.8% of family farms have gross sales larger than one million dollars³. All these indicate that the majority in US agricultural sector are small farmers. Studies focusing on farm household well -beings must pay special attention to small farmers (in terms of farm size and gross sales). If Fernandez-Cornejo, et al. (2007)'s conclusion is true, a down turn in farm sector will push more farmers into off-farm labor market. Mishra and Goodwin (1997)'s work offers some support to this idea. By using a sample of Kansas farmers, farmers are proved to be risk averse and when farm income variability tend to be high, off-farm labor supply will increase(Fernandez-Cornejo, et al., 2007). Not only in U.S., have farmers in Mexico and Pakistan also sought great distribution of household income from off-farm activities(Adams Jr, 1994, De Janvry and Sadoulet, 2001). Not surprisingly, education plays an important role in building farmers' access to off-farm employment (Adams Jr, 1994, De Janvry and Sadoulet, 2001, Mishra and Goodwin, 1997).

All these literatures show that there will be higher pressure for small farmers' income stability when the whole farm sector is sliding from peak. Again, no literatures have tried to build a connection between macroeconomic policy, farm sector well-being and household well-being.

Data and Model

The data using in this study includes yearly farm sector net income, average yearly farm household income (both farm portion and non-farm portion are used), average yearly U.S. household income, consumer price index (CPI) and effective Federal Fund Rate (FFR). All income data can be found directly from USDA-ERS website. CPI and FFR data are downloaded

³ USDA, ERS and National Agricultural Statistics Service, 1996-2015 Agricultural Resource Management Survey. Data as of November 30, 2016.

from Federal Reserve economic data (FRED) website. All data are available from 1960 to 2015. For simplicity we set CPI and FFR equal to 100 in 1960.

The vector error correction model (VECM) is the main model used in this study. The advantage of using VECM is that it can capture not only the short-term correlations among variables but also the long-term equilibrium. The long-term equilibrium in VECM, known as “cointegration”, means variables move together at the same pace. It is a stronger relationship than “correlated”. An example is shown in figure 1. The farm sector net income, farm household income and U.S. household income seem to be positive correlated as they tend to move together. Further observation show maybe farm sector net income has the same pace with the movement of farm household income. if this is true, there exist a long-term equilibrium between the two and in any year if there is deviation of their movement from the equilibrium, the deviation will be “corrected” in the next few periods.

Figure 2. Joint movement of income variables



Results

Sector level

A VECM is first adopted in sector level analysis. All variables are tested to be non-stationary. A Johansen test (Johansen, 1991, Johansen, 1988) for cointegration is used to find out the number of cointegrations among farm sector net income, FFR and CPI. Trace test result (table 1) shows that there are maximum of two cointegrations among the three variables.

Table 1. Johansen tests for cointegration among farm sector net income, FFR and CPI

Johansen tests for cointegration					
Trend: rconstant			Number of obs =		54
Sample: 3 - 56			Lags =		2
				5%	
maximum			trace	critical	
rank	parms	LL	eigenvalue	statistic	value
0	9	-1534.3336	.	55.2629	34.91
1	15	-1521.2471	0.38411	29.0899	19.96
2	19	-1510.5159	0.32797	7.6274*	9.42
3	21	-1506.7022	0.13173		

A VECM is then built to capture the cointegration relationship among these variables in sector level. The two long term equilibriums (error correction terms) are,

$$FSI - 1.262359CPI - 9057.446 = e_1 \text{ and } FFR + 0.4271099CPI - 14171.64 = e_2.$$

Table 2. Cointegrating equations

Johansen normalization restrictions imposed						
beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_ce1						
farmsectorincome	1	.	.	.	.	.
ffr100	0	(omitted)				
cpi100	-1.262359	.1088376	-11.60	0.000	-1.475676	-1.049041
_cons	-9057.446	5039.845	-1.80	0.072	-18935.36	820.4678
_ce2						
farmsectorincome	0	(omitted)				
ffr100	1	.	.	.	.	.
cpi100	.4271099	.0667918	6.39	0.000	.2962003	.5580194
_cons	-14171.64	3092.87	-4.58	0.000	-20233.55	-8109.726

These two equations reveal the long term equilibriums among farm sector income, FFR and CPI.

A straightforward explanation ignoring constant is that farm sector net income has the same

movement pace with CPI while has negative pace with FFR. The detailed results of the VECM is as follows,

Table 3. Output of VECM in sector level

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D_farmsectorincome						
_ce1						
L1.	-.6828985	.1474357	-4.63	0.000	-.9718671	-.3939298
_ce2						
L1.	-.4538531	.2541011	-1.79	0.074	-.9518821	.0441759
farmsectorincome						
LD.	.0099676	.1314767	0.08	0.940	-.2477219	.2676572
ffr100						
LD.	.4662859	.2669288	1.75	0.081	-.056885	.9894568
cpi100						
LD.	-1.184732	3.044366	-0.39	0.697	-7.15158	4.782116
D_ffr100						
_ce1						
L1.	-.1650295	.0778297	-2.12	0.034	-.317573	-.012486
_ce2						
L1.	-.3783764	.1341373	-2.82	0.005	-.6412806	-.1154722
farmsectorincome						
LD.	.0410783	.0694051	0.59	0.554	-.0949533	.1771099
ffr100						
LD.	.3905079	.1409089	2.77	0.006	.1143315	.6666843
cpi100						
LD.	2.930897	1.607089	1.82	0.068	-.2189389	6.080733
D_cpi100						
_ce1						
L1.	-.0212132	.0079269	-2.68	0.007	-.0367497	-.0056768
_ce2						
L1.	.0126515	.0136618	0.93	0.354	-.0141251	.0394281
farmsectorincome						
LD.	.0164104	.0070689	2.32	0.020	.0025557	.0302651
ffr100						
LD.	.0472715	.0143515	3.29	0.001	.0191432	.0753999
cpi100						
LD.	.4615891	.1636808	2.82	0.005	.1407807	.7823976

This model can be viewed as three equations. From the equations of farm sector net income, it is safe to conclude that farm net income is dominated by CPI from equilibrium one. A positive movement in CPI will push up farm sector net income in the next period. Notice that the coefficient of its own lag difference is not significant. So farm sector net income is affected more by its lag value than by its lag difference.

Results of FFR equation are also consistent with classical economic theory. The coefficient of equilibrium two has larger absolute value and is more significant, meaning FFR is more affected and corrected by CPI. This is consistent with decision making by policy makers as one of the goals in setting FFR is to control CPI in reasonable range. The coefficients of its own lag difference is also significant at 1% level, meaning the FFR is strongly affected by its previous change. This shows the same idea as currently policy makers want to make the interest rate hiking at steady pace.

As agricultural commodity prices contribute heavily to CPI, it is not surprisingly to see CPI is strongly correlated with farm sector net income through equilibrium one, as farm sector net income is also tied to agricultural commodity prices. For CPI equation, the positive coefficient of lag difference in farm net income proves this relation. In addition, CPI is also closely related to its own lag difference and lag difference of FFR. Again, these offer evidence for traditional macroeconomic theories.

An important usage for this model in this study is to see how CPI and farm sector net income response to a “shock” in FFR. Concerning the Federal Reserve has started the progress of hiking interest rate, the impulse response function for this VECM may offer some prediction for future farm sector well-being given FFR increasing.

Figure 3. Impulse response of farm sector net income

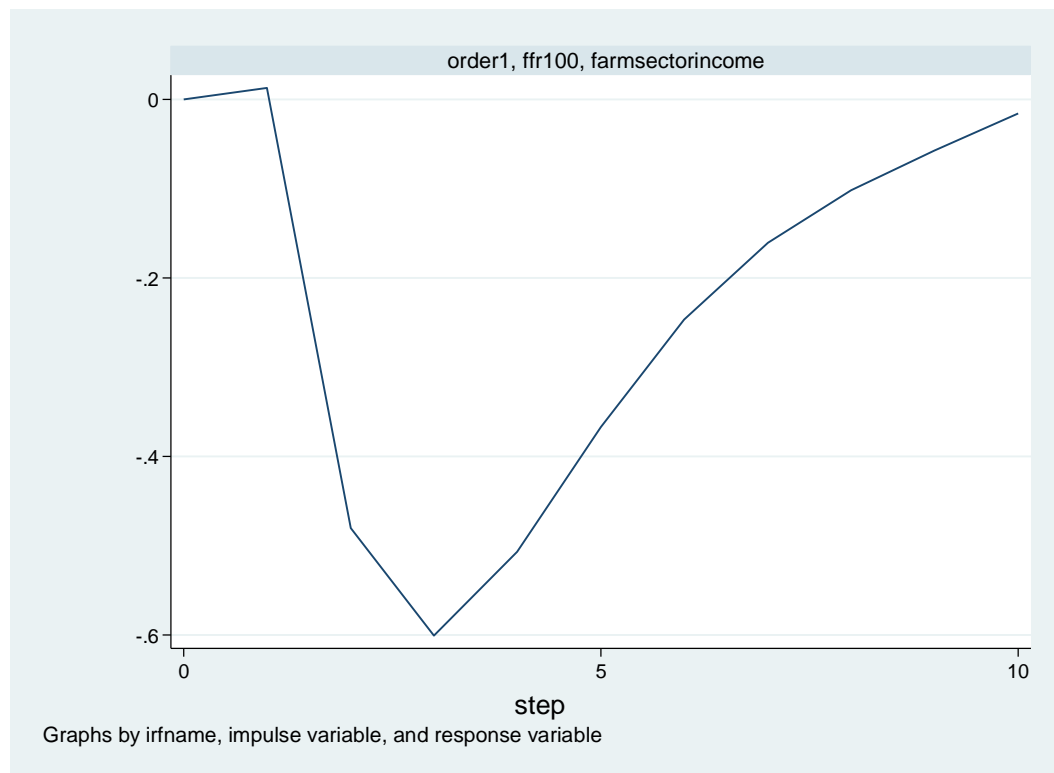
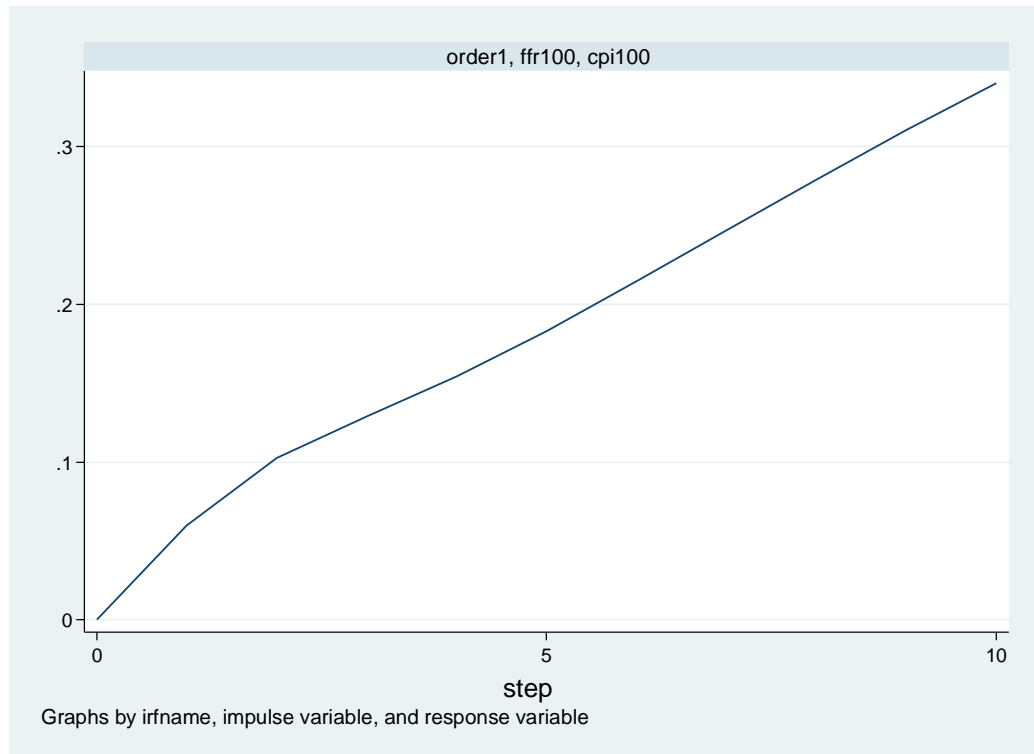


Figure 4. impulse response of CPI



Given a shock in FFR, figure 3 shows that the positive change in FFR will generally have negative effects on the change of farm sector net income. A one percent increase in the change of FFR will lead to a tiny increase in the change of farm sector income for the first period or two, then drag down the movement of it by as large as 0.6 percent. On the other hand, the contractionary monetary policy can slow down the booming of CPI as expected (Figure 4.). Due to the model construction of VECM, the long-term equilibrium will cause the effect of the “shock” to be permanent, which makes the impulse response not returning to zero.

Household level

A similar analysis is used in household level. The main variables using here include, farm household income, U.S. household income, on-farm portion of farm household income, off-farm portion of farm household income and the ratio of farm household income to U.S. farm household income. All variables are proved to be non-stationary. Cointegration was then tested

among each possible group of these variables. The farm portion of farm household income is strongly correlated with farm sector net income, with correlation coefficient of 0.7809, but not cointegrated. The off-farm income of farm household was proved to be cointegrated with CPI. The error correction term is $CPI - 0.0066887offfarm - 15.75603 = e$.

Coefficients can be referred to the following table.

Table 4. Cointegrating equation

Johansen normalization restriction imposed						
beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cel						
cpi1960100	1	.	.	.	.	.
nonfarmport~n	-.0066887	.0007386	-9.06	0.000	-.0081363	-.0052411
_cons	-15.75603	36.63507	-0.43	0.667	-87.55945	56.04739

Table 5. Output of VECM for CPI and Off-Farm Income

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D_cpi1960100 _cel L1.	.0273856	.0115876	2.36	0.018	.0046744	.0500968
cpi1960100 LD.	.5913383	.1301416	4.54	0.000	.3362654	.8464112
nonfarmport~n LD.	.0002987	.0002398	1.25	0.213	-.0001712	.0007686
D_nonfarmpo~n _cel L1.	21.56052	6.419494	3.36	0.001	8.978542	34.1425
cpi1960100 LD.	-80.15131	72.09837	-1.11	0.266	-221.4615	61.15889
nonfarmport~n LD.	-.2780675	.1328229	-2.09	0.036	-.5383955	-.0177395

Since the coefficient of error correction term for off-farm income is much larger, it is reasonable to say long term equilibrium will pull up off-farm income to the pace of CPI growth. This is part of the reason that we see the median farm household has negative income from farming but higher total household income than U.S. household average. Farmers, especially small farmers rely heavily on off-farm income and this portion of off-farm income is strongly correlated with general price level. Again, as Federal Reserve is adopting contractionary monetary policy right now, we expect CPI will cool down with rising FFR and thus, off-farm income will shrink.

Another interesting result here is that the ratio of farm household income to U.S. average household income is also cointegrated with CPI, which means the ratio keeps increasing most of the time. Farm households were considered financially disadvantaged compared with U.S. average household income long time ago(Mishra and Sandretto, 2002). This situation has

changed in early 1990s(Ahearn, 1986, Ahearn, et al., 1993). In terms of average total household income including both off-farm and off-farm portion, this is true. The ratio of average farm household income to U.S. average household income is more than 1.77 in 2014 and drops to 1.51 in 2015. This ratio may be further weakened indicated by the model. The error correction term of CPI and the ratio that is talked about above is, $CPI - 1128.913Ratio + 1233.767 = e$.

Table 6. Cointegrating equation of CPI and Ratio of Household Income

Johansen normalization restriction imposed						
beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cel						
cpi1960100	1	.	.	.	.	.
ratiooffarm~o	-1128.913	334.1079	-3.38	0.001	-1783.753	-474.0739
_cons	1233.767	343.3956	3.59	0.000	560.7237	1906.81

Table 7. Output of VECM for CPI and Ratio of Household Income

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D_cpi1960100 _cel L1.	.0056693	.0032466	1.75	0.081	-.0006938	.0120325
cpi1960100 LD.	.7564044	.1025218	7.38	0.000	.5554654	.9573435
ratiooffarm~o LD.	8.014885	6.752764	1.19	0.235	-5.220289	21.25006
D_ratiooffa~o _cel L1.	.0002176	.0000635	3.42	0.001	.0000931	.0003422
cpi1960100 LD.	-.0054954	.0020067	-2.74	0.006	-.0094284	-.0015624
ratiooffarm~o LD.	-.0020632	.1321735	-0.02	0.988	-.2611184	.256992

Results show that the ratio is strongly affected by error correction term, as long as the lag difference of CPI. On the other hand, CPI is strongly affected by its own lag difference but less likely affected by the ratio and error correction term. This conclusion favors the results from the cointegration of CPI and off-farm income. If CPI fluctuates heavily, off-farm income will be unstable. A further reduction in off-farm activity will hurt small farmers, who has their most income from non-farm employment and thus, the ratio should also fluctuate.

Policy implications

Mishra and Sandretto (2002) has indicated that the non-farm income is the key component to help reducing variability of farm household income and stabilizing farm household well-being in U.S. This study has shown, with interest rate hiking, the farm sector will stay at slow pace in the short future. Although not coingegrated, farm household's farm income is strongly related to

farm sector net income and thus will suffer from the down turn in farm sector. What's worse is the off-farm income is cointegrated with CPI. As we expect the hiking of interest rate will slow down the growth of CPI, the off-farm income will also freeze or shrink. If both on-farm and off-farm income stand on the edge, small farmers will suffer from great income variability.

Fluctuation in agricultural commodity prices, economic business cycle and climate are major reasons for farm income variability(Cochrane, 1979, Schultz, et al., 1947). Ahearn, et al. (1993), Mishra and Sandretto (2002) have shown that even with government assistant and support programs, farm households are experiencing low-level of income if only farm portion of income is considered. It may be a good time for policy maker to consider putting more attention on the support of off-farm activities for farm households. As off-farm activities are negatively related with farm size(Fernandez-Cornejo, et al., 2007), more attention should be paid on small farm operators. As education is proved to be key factor in accessing off-farm labor market employment(De Janvry and Sadoulet, 2001) and farm level efficiency is inversely correlated with off-farm work(Fernandez-Cornejo, et al., 2007), government supported training program may be well considered. On one hand it may push forward agricultural innovation in farm level, increasing technical efficiency. On the other hand higher technical efficiency will save time for farm operators for off-farm activities. Training program could also strengthen education for farm operators and thus increase their chance for off-farm employment.

Another consideration may be financial support from financial institutions. As shown from USDA-ERS report⁴, average financial indicators of farm household are far from perfect. We expect this situation will continue due to low agricultural commodity prices, high interest rates

⁴ USDA-ERS," 1996-2015 agricultural resource management survey"

and expenses and low land value. Financial institutions may consider different underwriting standards in boom and bust credit cycles. More consideration may be put on capability to repay or lending purposes, instead of looking only at indicators.

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