

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search http://ageconsearch.umn.edu aesearch@umn.edu

Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.

Income stabilisation tool and the pig gross margin index for the Finnish pig sector

Petri Liesivaara^{*)} and Sami Myyrä

Natural Resources Institute Finland, Luke

Contributed Paper prepared for presentation at the 90th Annual Conference of the Agricultural Economics Society, University of Warwick, England

4 - 6 April 2016

Copyright 2016 by Liesivaara and Myyrä. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

*) petri.liesivaara@gmail.com, +358 50 3383674.

Authors acknowledge research funding obtained from Ministry of Agriculture and Forestry.

Abstract

Larger price volatility in agricultural markets and decreasing subsidy levels have increased the market risks in Finnish hog production. One option for the Finnish government to strengthen risk management in the pig sector is to introduce an income stabilisation tool (IST). An IST was included as part of rural development legislation in the reform of the Common Agricultural Policy (CAP) of the EU in 2014. In this paper, we introduce a gross margin index for the Finnish pig sector on which the IST could be based and empirically evaluate the index itself and individual time series composing the index. The results reveal that the volatility of the pig meat price was the most significant factor in the volatility of the pig gross margin. The results also indicate that the pig meat price series is persistent and thus has a long memory. The obtained results have major implications for the design and simulation of an IST scheme in Finland.

Keywords: Income stabilisation tool, random walk hypothesis

JEL code Q14, Q18

1. Introduction

Animal producers in the EU have only limited means to handle risks related to agricultural markets. There are two main reasons for this. First, futures markets for animal products are underdeveloped in the EU. Second, agricultural policy measures aimed at reducing income fluctuations due to price movements are almost totally lacking (Meuwissen et al. 2003, Smith and Glauber 2012). Agricultural subsidies in the EU have been decoupled from production in reforms of the EU Common Agricultural Policy (CAP), which has increased price volatility in the market. In effect, one of the major objectives of the CAP, market stability, has been lost (Matthews 2010).

Increased price volatility in agricultural markets and decreasing subsidy levels increase the market risks in hog production. Increased income risks reduce the incentive and ability of hog producers to invest in future production. Thus, they lower the rate of investment and in effect lower the rate of agricultural growth. In a volatile production environment, it can be difficult for producers to perceive the true price signal, which leads to inefficient allocation of resources. In the whole food chain, price volatility increases the contract risk and makes long-term planning difficult (Matthews 2010).

Finland is at the outskirts of the EU common market. However, price movements in the EU are transmitted to the Finnish market, and Finnish producers compete in the same playing field with other EU producers. Since 1995, when Finland joined the EU, natural constraints due to the farm structure and harsh climate have been compensated with extensive national subsidies. However, since 2009, the level of national subsidies has been declining for the pig sector. The decreasing subsidy levels coupled with the more volatile agricultural market environment have made Finnish producers increasingly vulnerable. The situation has escalated during 2015, as Russia's import bans on EU food products have overcrowded the market. The profitability of hog production is currently sharply decreasing in Finland.

An EU income stabilisation tool (IST) was introduced as part of rural development legislation in the 2014 CAP reform (EU 2013). According to the legislation, member states can devote part of their second pillar expenditure to farmers' mutual funds, providing an income stabilization tool on non-profit basis for farms that are part of the mutual. The subsidy is directed to compensation payments rather than participation/premium payments. Thus, subsidies are paid directly to the mutual. In addition, mutual funds may allocate subsidies for the administrative costs of the system. The IST opens a new way to support agricultural producers. Similar systems are in use in North America. In the US, hog producers can insure their income from hog production through Livestock Gross Margin (LGM) insurance (Small

et al. 2007). In Canada, the AgriStability programme provides protection against declining income at the farm level (AAFC 2014).

The structure of the IST introduced in the CAP legislation is similar to that in use in Canada. It also follows the guidelines of green box government subsidies in WTO regulations (WTO 1994). In the IST introduced by the EU, current farmer incomes are compared to the historical farm income. If a farmer's income (market return and subsidies deductible from input costs) falls below the reference level, the mutual fund will pay compensation. The reference level income is derived from incomes in past years (a three-year average, or five-year average without the highest and lowest value). In the Canadian system, farmer incomes are derived from farm-level data. Thus, the administrative costs related to the scheme are considerable. The purpose of IST is to smooth the fluctuations in farmer incomes. However, as Finger and El Benni (2014) demonstrated, IST will also reduce income inequality.

In contrast to a system relying on farm-level bookkeeping data, we here introduce a gross margin index that serves as a basis for IST designed for hog producers. Three benefits of the index type of IST can be recognised. First, with indices, the administrative costs can be reduced, because there is no need for bookkeeping of the reference income or indemnity payment calculations for individual farms. Instead, these can be obtained from public statistics. Second, moral hazard problems related to the income stabilization tool can be avoided (Liesivaara et al. 2012). Three, even if indices are not used in the IST, the insurer (i.e. farmers' mutual fund) needs to make assumptions concerning the future income of farms in order to determine the participation fees (Meuwissen et al. 2003). As futures markets for pig meat are underdeveloped in the EU, price paths need to be evaluated by other means (for example with indexes). This implies the modelling of future price paths¹. Before any sensible modelling of the IST is performed, the independence properties need to be evaluated for individual price time series determining the pig gross margin.

In this paper, we introduce a gross margin index for the Finnish pig sector and empirically evaluate the index itself and individual time series composing the index. The aims of our study were to i) develop an index that could be used as a basis for an income stabilization tool for the pig sector in Finland, ii) decompose the variance of the gross margin index into different components and iii) evaluate whether different components of the index satisfy the random walk hypothesis (RWH). Whether the time series follow random walks has major implications for the insurability of farmers' incomes with the index. The underpinning theory behind the analysis of this paper is the efficient market hypothesis. In efficient markets, prices follow a random walk, or more precisely, a martingale (Samuelson 1965), and price behaviour has no memory. Thus, returns from an efficient market are white noise, which suggests that it is impossible to make long-term profits by predicting price trends. The analysis performed in this study built on past work mainly carried out in North America. The literature on the long-range dependence of agricultural futures contracts is concentrated on the US market (e.g. Helms et al. 1984, Corazza et al. 1997, Jin and Frechette 2004, Barkoulas et al. 1999, Power and Turvey 2010, Elder and Jin 2009). A study by Turvey (2007) also included Canadian future contracts, and Dawson (2011) investigated European wheat futures contracts.

As no relevant futures markets exist for Finnish hog farmers, the IST needed to be based on spot market prices. Future prices need to be modelled, depending on past price series properties.

2. Structure of the pig gross margin index

Because futures markets for agriculture commodities are underdeveloped in the EU, we were forced to use cash market prices in determining the pig gross margin index. The pig gross margin was formed from four different price series: for pig meat, feed, barley and piglets.

The price data for the pig gross margin index were acquired from two sources. The pig meat, barley and piglet prices were obtained from the Natural Resources Institute. Pig meat and barley prices are published monthly, whereas the piglet price is published weekly. The monthly feed price was obtained from Statistics Finland. The monthly pig feed index is published four times a year. The index was transformed into Euros by using an estimate of the pig feed price for the base year (2010) provided by ProAgria, the Finnish expert services for farmers.

Figure 1 presents the price of pig meat, piglets, pig feed and barley in Finland from 2000–2014. Since 2007, feed and barley prices have fluctuated more than before. In addition, according to a visual check of the price series, pig meat and piglet prices have fluctuated considerably since 2007. However, in 2001, the pig meat and piglet prices peaked, after which they rapidly declined. Due to this price regime change after 2007, we evaluated the

¹ Pig meat futures are notified in Eurex in Frankfurt. However, hog futures markets in Eurex are very thin, and the volatility of hog futures price is higher than in Finnish pig meat spot market.





Figure 1. Monthly piglet price (€/piglet), pig meat price (€/kg), pig feed price (€/kg) and barley price (€/kg) from 2000–2014 in Finland (Natural Resources Institute Finland, 2015; Statistics Finland, 2015).

Table 1. Mean, standard deviation and skewness of the price series for the periods 2000–2014, 2000–2006 and 2007–2014.

	_	2000–2	2014	2000–2006			2007-2014			
_	Mean	SD	Skewness	Mean	SD	Skewness	Mean	SD	Skewness	
Pig meat (€/kg)	1.44	0.165	0.426	1.34	0.123	0.652	1.534	0.141	0.561	
Feed price										
(€/kg)	0.433	0.068	0.446	0.372	0.013	0.488	0.486	0.050	-0.508	
Barley price										
(€/kg)	0.129	0.034	0.954	0.108	0.008	0.892	0.147	0.036	-0.032	
Piglet (€/piglet)	52.7	6.468	1.123	54.4	8.385	0.588	51.3	3.616	0.586	
י ית	· 1									

Pig gross margin index

The mean values, standard deviations and skewness of individual price series in the periods 2000–2014, 2000–2006 and 2007–2014 are presented in Table 1. All the price series had positive skewness in 2000–2014 and 2000–2006. Thus, the right tail of the price distribution was longer. In 2007–2014, the barley price and feed price displayed negative skewness, which suggests that the left tail was longer. The standard deviation of prices was higher in the period 2007–2014 than in 2000–2006 for pig meat, feed and barley prices. The standard deviation of the piglet price was more volatile in 2000–2006 than in 2007–2014.

In the monthly pig gross margin (GM), the revenue from the sale of one pig was considered. Thus, feed costs and piglet costs are deducted from the revenue from pig meat sales. As subsidies play only minor role in current pig meat production, these were not considered in determining the GM. Formally the monthly GM is formed:

$$GM = 83 * P_{pig\,meat} - 38 * P_{feed} - 214 * P_{barley} - P_{piglet}.$$
(1)

The multipliers for the amount of pig meat, feed and barley needed for growing the pig for slaughter were obtained from Heinola et al. (2012). The gross margin in 2010 was then normalized to 100 (the mean value of 2010 was assigned a value of 100). Thus, other years in the pig gross margin were compared with the base year, 2010. Figure 2 presents the pig gross margin from 2000 to 2014. The volatility of the pig gross margin was considerable. In 2000–2014, the standard deviation of the index was 27.4 and the mean value was 87.9.



Figure 2. Monthly pig gross margin from 2000–2014 (2010 = 100).

3. Research methods

As described in the previous section, the pig sector gross margin was based on four individual price series. The income stabilization tool is planned to be based on this index. Thus, the properties of individual price series and the index are examined here. Although we did not evaluate the design or fair premiums of the scheme in this study, the aim was to ensure an actuarially viable product for the Finnish pig sector. Hence, we evaluated how well the price

series follow a pure random walk and where the risks in the pig gross margin originate. In this section, we describe how this was done.

3.1. Variance decomposition

The variance of gross margin (GM) can be decomposed into different components of pig returns, feed cost, barley cost and piglet cost by using method by Burt ja Finley (1968). With different components of variance and covariance, we can observe which factors increase or reduce the overall variance in the gross margin index. Covariance terms between index components reveal the natural hedge in the pig gross margin.

3.2. Variance ratio tests

Variance ratio (VR) tests were performed in order to examine whether individual price series used to determine the pig sector gross margin follow the random walk hypothesis (RWH). The RWH provides a means to test whether markets are unpredictable (Fama, 1970). VR tests are used to test the hypothesis that a given time series is a collection of i.i.d. observations or that it follows a martingale difference sequence.

Over the years, numerous variance ratio tests have been developed (Charles and Darné, 2009). From these, we performed two individual ratio tests (in which the null hypothesis is tested for an individual period). Next, we provide a brief description of the performed VR tests.

Lo and MacKinlay test

Lo and MacKinlay (1988) introduced a test that uses the variance property of Brownian motion to test for the RWH. The rationale behind the Lo and MacKinlay test is that the variance of any step k (where $1 < k \le T$) must be a linear multiple of the variance of a single step. Formally:

$$\sigma_k^2 = k \sigma_1^2, \tag{5}$$

and

$$VR = \frac{\sigma_k^2}{\sigma_1^2} = 1.$$
 (6)

To accommodate conditional heteroscedasticity in the time series data, Lo and MacKinlay (1988) proposed the heteroskedasticity-robust test statistic:

$$M_2(k) = \frac{VR(x;k) - 1}{\phi(k)^{1/2}},\tag{7}$$

which follows the standard normal distribution asymptotically as described in Lo and MacKinlay (1988). The test statistic is 1 if the time series follows a random walk. The Lo-MacKinlay test is an asymptotic test. Its sampling distribution is approximated based on the limiting distribution. Thus, it is biased and right skewed in finite samples. Therefore, Wright (2000) proposed a nonparametric test as an alternative to conventional asymptotic VR tests, which is introduced next.

Wright test

Wright (2000) suggested a test that uses ranks and signs. When the sample size is small, as in our case with price series components in the pig gross margin, Wright's test has two advantages over the Lo-MacKinlay test. First, rank (R1 and R2) and sign (S1 and S2) tests have an exact sampling distribution. Second, the tests may be more powerful than the conventional VR tests. The tests based on ranks are exact under the i.i.d. assumption. Moreover, the tests based on signs are exact under conditional heteroscedasticity (Charles and Darné 2009). The critical values for R1, R2, S1 and S2 tests can be obtained by simulating their exact sampling distribution².

4. Results

In this section, we evaluate the RWH of the individual price series forming the pig gross margin index and decompose the pig gross margin into different components. We began by performing a variance decomposition of the pig gross margin. Thereafter the variance ratio tests are performed.

² The formal definitions of R1, R2, S1 and S2 statistics are not presented in this paper, but can be obtained from Wright (2000) or from Charles and Darné, (2009).

4.1. Variance decomposition

Table 2 presents the results from a variance decomposition of the pig gross margin for three time periods. From 2000 to 2014, variability in pig meat prices accounted for 65.2% of the total variance in the pig gross margin. The barley price variability and piglet price variability respectively accounted for 17.9% and 14.5% of the total variance. Feed cost variability accounted for only a minor part of the total variance (2.3%). Indirect effects, covariance terms in the variance decomposition, describe the natural hedge that is present in the pig gross margin. For example, the natural hedge between the pig meat price and feed cost reduced the total variance of the gross margin by 18.6%. Thus, as the feed price increases (decreases), the pig meat price also tends to increase (decrease). This reduces the variability in the gross margin. The biggest effect on the gross margin reduction is on the covariance between the pig meat prices reduced the total variance by 43.6%. In addition, the covariance of the pig meat price with the piglet price and feed costs were positive, which reduced the total variance of the gross margin by 29.8% and 18.6%, respectively. Other indirect factors had only minor effects.

In the period 2000–2006, the pig meat price accounted for the highest variance in the gross margin (58.9%). In this period, the piglet price was the second biggest factor, accounting for 39.4% of the total variance, whereas the barley price and feed costs had only minor effects. The positive covariance between the pig meat price and piglet price reduced the variance the most, by 90.2%, in the period from 2000 to 2006.

In the period from 2007–2014, the pig meat price had the biggest effect on the variance of the gross margin (63.7%). In this period, the barley price accounted for as much as 28.5% of the total variance, whereas the piglet price and feed costs had only a minor effect of 6.1% and 1.7%, respectively. Thus, the increased variability in the crop price has had a significant effect on variability in pig sector revenue since 2007.

	2000-2014	2000-2006	2007-2014
Direct effects %			
Pig meat	65.2	58.9	63.7
Feed cost	2.3	0.1	1.7
Barley	17.9	1.6	28.5
Piglet	14.5	39.4	6.1
Indirect effects %			
Pig meat/Feed cost	-18.6	1.2	-16.7
Pig meat/Barley	-43.6	0.1	-49.5
Pig meat/Piglet	-29.8	-90.2	-32.1
Feed cost/Barley	10.6	-0.1	10.7
Feed cost/Piglet	-1.6	-1.6	2.9
Barley/Piglet	0.7	3.9	10.4

Table 2. Results of the variance decomposition.

4.2. Variance ratio tests

In this section, we present the results from tests of whether individual price series in the pig gross margin follow Brownian motion. Four variance ratio tests presented in the methods section were performed³. The results of Lo and MacKinlay's and Wright's variance ratio tests are presented in Table 3. A test value of 1 indicates that the price series follows Brownian motion, whereas deviation from 1 indicates fractional Brownian motion. The confidence limits for test statistics were obtained from a simulation method described by Wright (2000) for Wright's rank and sign tests, and bootstrap p-values for different holding periods k for Lo and MacKinlay's variance ratio test were used (Kim 2006). In tests for pig meat, feed and barley prices, monthly observations were considered, while weekly data were used for the piglet price.

Variance ratio tests for pig meat price are mostly significantly different from 1. However, in the period 2007–2014, when the k ratio was 24, the Lo and MacKinlay test statistics were not significantly different from 1. In addition, for the pig meat price, Wright's sign test statistic was statistically different from 1 in the period 2000–2006 when the k ratio was 24. By these resulta, we can conclude that the pig meat price does not follow Brownian motion and a fractional Brownian model should be considered.

Evidence from variance ratio tests for the feed price suggests that it follows ordinal Brownian motion. Only Wright's sign test statistics for k ratios 6, 12 and 24 were statistically

³ Results were obtained with R package "vrtest" (Kim, 2004).

different from 1. Most of test statistics were statistically different from 1 for the barley price in the period 2000–2014. In addition, in the period from 2007–2014, different variance ratio test statistics were different from 1. However, Wright's rank test statistics for the period 2000–2006 were not statistically different from 1, suggesting that the barley price followed ordinal Brownian motion in this period, whereas after 2007 the barley prices followed fractional Brownian motion.

Table 3.Results of Lo and MacKinlay's (M2(k)) and Wright's (R1, R2 and S1) variance ratio tests for
the periods 2000–2014, 2000–2006 and 2007–2014.

VR test	k	Pig meat			Feed price			Barley price			Piglet price		
		00- 14	00- 06	07- 14	00- 14	00- 06	07- 14	00-14	00-06	07-14	00-14	00-06	07-14
M ₂ (k)	2	5.00*	3.72*	3.78*	-0.01	0.72	-0.67	3.48*	2.29*	3.22*	0.91	3.77*	-0.52
	6	7.89*	5.87*	5.69*	1.26	0.07	1.17	3.71*	-0.68	3.74*	2.59*	6.95*	-0.44
	12	8.56*	6.46*	5.66*	1.42	-1.10	1.22	3.90*	-2.11*	3.51*	3.44*	8.20*	-0.43
	24	4.33*	3.36*	1.63	-0.06	-1.39	-0.57	1.50	-1.63*	0.87	1.71*	4.74*	-0.96
R1	2	6.02*	4.36*	4.01*	-0.39	0.24	-0.58	6.12*	3.31*	4.99*	3.24*	4.92*	0.18
	6	9.35*	7.01*	5.77*	1.61	0.53	1.45	5.57*	0.91	5.36*	6.12*	8.40*	0.92
	12	9.95*	7.40*	6.02*	0.77	-0.56	1.06	4.06*	-1.39	4.29*	6.55*	9.10*	0.67
	24	4.68*	3.41*	2.41*	-0.79	-0.95	-0.85	1.66*	-1.27	1.36*	3.62*	5.05*	-0.39
R2	2	6.04*	4.33*	3.81*	-0.22	0.42	-0.42	6.32*	3.01*	5.15*	2.63*	5.03*	-0.37
	6	9.13*	6.56*	5.75*	1.71	0.53	1.49	5.86*	0.60	5.41*	5.44*	8.64*	0.43
	12	9.66*	6.86*	5.97*	1.10	-0.62	1.22	4.64*	-1.43	4.36*	6.09*	9.56*	0.35
	24	4.77*	3.30*	2.06*	-0.50	-1.07	-0.71	1.99*	-1.26	1.38*	3.36*	5.46*	-0.52
S1	2	3.81*	2.09*	3.39*	-0.82	0.55	-1.54	4.86*	3.18*	3.39*	2.62*	3.18*	0.72
	6	5.84*	3.60*	4.50*	4.63*	3.95*	2.59*	2.87*	1.20	2.37*	4.28*	5.28*	0.79
	12	6.17*	4.34*	4.24*	7.14*	5.65*	4.13*	1.38	-0.67	1.55	4.03*	5.64*	0.12
	24	3.53*	1.67	2.68*	9.62*	7.79*	4.54*	0.03	-1.04	-0.01	1.63	2.75*	-0.57

*Significant at the 5% level.

Variance ratio tests for the piglet price show the opposite results compared to barley prices. In the periods 2000–2014 and 2000–2006, variance ratio test statistics were different from 1. It appears that the piglet price formation has changed after 2006, as the variance ratio test statistics were not different from 1, which suggest that the price series follows ordinal Brownian motion.

4. Discussion and conclusions

In this study, we introduced a pig gross margin for Finnish hog producers and tested the random walk hypothesis of the individual price series that form the index. The results of the variance decomposition indicate that the volatility of the pig meat price was the most significant factor affecting the volatility of the pig gross margin. In addition, the negative covariance between the pig meat price and costs in the pig gross margin was high. Thus, a natural hedge, i.e. positive correlation, between the price series reduced the volatility in the pig gross margin.

Variance ratio tests suggested that three out of the four individual price series did not follow ordinal Brownian motion in the period 2000–2014. However, for the period 2007–2014, piglet prices did follow ordinal Brownian motion, whereas for the barley price this was found in the period 2000–2006. Results indicate that pig meat price serie is persistent and thus has a long memory. This may cause problems in designing the future IST scheme, by giving insurer possibilities to make long-term profits by predicting price trends. However, this is taken into a count in CAP reform by allowing only farmers mutual funds to start the index insurance markets in EU. Mutual funds working on non-profit basis could recycle these expected profits to the benefits of farmers and taxpayers.

According to our variance decomposition of the pig gross margin from 2000 to 2014, the pig meat price had the largest effect on the volatility of the pig gross margin constructed in this study, and thus the modelling of pig meat prices had the biggest effect on the fair prices and the risk exposure of the IST.

According to our analysis, the pig meat price has a long memory. Thus, in a situation where prices are foreseen to decline, insurers, i.e. farmers' mutual funds, may have little incentive to underwrite IST contracts. Whether the pig gross margin is used as basis for the IST in the pig sector or not, pig, piglet and feed costs need to be modelled in premium calculations for the IST. Our results support the EU approach for the usage of the reference level for income to be derived from incomes in past years (a three-year average, or five-year average without the highest and lowest value) to cut the long term trends in the price series.

As variance decomposition proved, there is a natural hedge between the pig meat price and other prices in the pig gross margin. Thus, declining pig meat prices will most likely result in declining costs, and vice versa, which reduces the income effect. This result does not support the EU policy approach to use market sales as a sole indicator for income drop at the farm.

One of the deficiencies of the IST is moral hazard from the slaughterhouse side. If farmers are insured from large income drops, slaughterhouses may have an incentive to reduce producer prices to levels lower than without the IST. Therefore, if our proposed pig gross margin is approved as a basis for the IST scheme, i.e. CAP legislation allows the use of indices in the future, future market prices could also be considered as basis for the index. There have been no studies on the price relationship between animal product spot prices in Finland and European futures market prices. If the correlation between Finnish and European markets is high, the effect of moral hazard can be avoided by using well-defined multipliers that reflect the market price in Finland.

References

- AAFC. Growing forward 2 AgriStability Program Handbook. Agriculture and Agri-Food Canada. 2014. Available at: http://www.agr.gc.ca/eng/?id=1362577209732#s1 (last accessed: 25.8.2015).
- Barkoulas, J.T., Labys, W.C. and Onochie, J.I. 'Long memory in futures prices', *The Financial Review*, Vol. 34, (1999) pp. 91–100.
- Charles, A. and Darné, O. 'Variance-ratio tests of random walk: An overview'. *Journal of Economic Surveys*, Vol. 23, (2009) pp. 503–527.
- Corazza, M., Malliaris, A.G. and Nardelli, C. 'Searching for fractal structure in agricultural futures markets'. *The Journal of Futures Markets* Vol. 14, (1997) pp. 433–473.
- Dawson, P.J. Do wheat futures returns exhibit long-range dependence? *Agricultural Economics* Vol. 42, (2011) pp. 111–120.
- Elder, J. and Jin, H.J. 2009. Fractional integration in commodity futures returns, *The Finance Review* Vol. 44, (2009) pp. 583–602.
- EU, 2013. Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005.
- Fama, E. 'Efficient capital markets: a review of theory and empirical work', *Journal of Finance* Vol. 25, (1970) PP. 383–417.
- Finger, R. and El Benni, N. 'A note on the effects of the income stabilization toll on income inequality in agriculture', *Journal of Agricultural Economics* Vol. 65 (2014) pp. 739–745.

- Helms, B.P., Kaen, F.R. and Rosenman, R.E. 1984. Memory in commodity futures contracts. *Journal of Futures Markets* Vol 4, (1984) pp. 559–567.
- Heinola, K., Niemi, J.K. and Myyrä, S. *Indeksivakuutukset sikatalouden tulotason vakuuttamisessa*, Raportti No.71 (MTT Taloustutkimus: Helsinki, 2012).
- Hurst, H.E. 'Long term storage capacity of reservoirs', *Transactions of the American Society of Civil Engineers*, Vol. 116, (1951) pp. 770–799.
- Jin, H.J. and Frechette, D.L. 'Fractional integration in agricultural futures price volatilities', *American Journal of Agricultural Economics*, Vol 862, (2004) pp. 432–443.
- Kim, J.H. vrtest: Variance Ratio tests and other tests for Martingale Difference Hypothesis. R package version 0.97. http://CRAN.R-project.org/package=vrtest (2004).

Kim, J.H. 'Wild bootstrapping variance ratio tests', *Economic Letters*, Vol. 92 (2006) pp. 38–43.

- Liesivaara, P., Myyrä, S. and Jaakkola, A. *Feasibility of the income stabilisation tool in Finland*. Paper prepared for the 123rd EAAE Seminar. Dublin, February 23–24, (2012).
- Lo, A.W. and MacKinlay, A.C. 'Stock market prices do not follow random walks: Evidence from a simple specification test', *The Review of Financial Studies*, Vol 1, (1988) pp. 41– 66.
- Matthews, A. 2010. *Perspectives on addressing market instability and income risk for farmers*', Discussion Paper No. 324, (Institute for International Integration Studies, Trinity College, Dublin, Ireland, 2010).
- Meuwissen, M.P.M., Huirne, R.B.M. and Skees, J.R. 'Income insurance in European agriculture', *EuroChoices*, Vol 2, (2003) pp. 12–17.
- Natural Resources Institute Finland. Statistics service. Helsinki.
- Power, G.J. and Turvey, C.G. 2010. 'Long-range dependence in the volatility of commodity futures prices: Wavelet-based evidence', *Physica A*, Vol 389, (2010) pp. 79–90.
- Samuelson, P.A. 'Proof that properly anticipated prices fluctuate randomly', *Industrial Management Review* Vol. 6, (1965) pp. 41–49.
- Small, R.M., Waterbury, J.A. and Mark, D.R. Livestock gross margin insurance for swine. University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources. (2007) Available at: http://ianrpubs.unl.edu/live/g1744/build/g1744.pdf

Smith, V.H. & Glauber, J.W. 'Agricultural insurance in developed countries: Where have we been and where are we going?', *Applied Economic Perspectives and Policy*, Vol. 34. (2012) pp. 363–390.

Statistics Finland. Index of purchase prices of the means of agricultural production. Helsinki.

- Turvey, C.G. Random walks and fractal structures in agricultural commodity futures prices.
 Working paper 02/02. (Department of Agricultural Economics and Business, University of Guelph, 2002).
- Turvey, C.G. 'A note on scaled variance ratio estimation of the Hurst exponent with application to agricultural commodity prices', *Physic, A* Vol. 377 (2007) pp. 155–165.
- Wright, J.H. 'Alternative variance-ratio tests using ranks and signs', *Journal of Business and Economic Statistics*, Vol. 18 (2002) pp. 1–9.
- WTO. Agreement on agriculture, GATT, Marrakesh Agreement, World Trade Organization, Geneva (1994).