Are Policy Changes Visible in German Farmland Price Time Series?

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Abstract

Farmland prices have shown extraordinary developments over the last decades. Potential price drivers are agricultural policy events. A present value model to connect policy events with farmland purchase price shocks is stated. A data-based outlier detection in German farmland price time series detects years with anomalous price developments. The results indicate that the identified shocks in farmland price time series mostly occur simultaneously to exogenous political events. Within the model it can be assumed that several agricultural policies might have an intertemporal effect on farmland prices.

Keywords

Farmland prices, time series analysis, agricultural policy shocks, outlier identification

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1 Introduction

Farmland prices faced a vivid development over the last decades (Plogmann et al., 2020). Many publications have tried to reach an adequate explanation for farmland price developments by examining possible price determinants. One potential driver of farmland prices are worldwide macroeconomic developments (Just & Miranowski, 1993). Huang et al. (2006) identify within an hedonic pricing approach that farmland prices in Illinois decrease with increasing parcel sizes, ruralness respectively distance to large cities and swine farm density. Soil productivity, population density and personal income, in contrast, lead to higher land prices. In times of increasing urbanization, one major price driver is urban sprawl which is asserted by several studies (Kuethe & Pede, 2011; Lehn & Bahrs, 2018; Zhang & Nickerson, 2015). Furthermore, Lütz and Bastian (2002) find that environmental amenities also have a significant impact on land prices. Major subjects of interest are political determinants. By investigating how bioenergy feed in–tariffs affect prices of arable land, Habermann and Breustedt (2011) and Hennig and Latacz-Lohmann (2017) discuss the relevance policy measures can have for agricultural land prices. Besides the effects resulting from policies targeting at the increased supply of renewable energies, the influence of agricultural subsidies on land prices is of major relevance and poses the predominant aspect of this analysis. Latruffe and Le Mouel (2009) report significant effects of direct payments on agricultural land prices (see also Feichtinger and Salhofer, 2013). This hypothesis is supported by Weersink et al. (1999) who found that farmers tend to value governmental subsidies as a stable source of income. Nonetheless, the effect of policy changes on farmland prices is hard to detect. Furthermore, those analyses are mainly conducted in a static framework, which limits its meaningfulness for policy events over time. To the authors' knowledge, questions remain if general and agricultural policy changes might have an intertemporal effect upon farmland prices. For example, changing agricultural policies of the European Union as well as changing ground transfer policies on a national level could be of interest. Big reforms with a huge effect on agriculture might not spare the farmland market.

Furthermore, farmland price development over time is hardly examined, mainly because adequate time series are hard to find. An investigation over time has been made possible within the deployment of aggregated land price data in Germany over the last decades. Yang et al. (2017) use aggregated land price data in Lower Saxony to make a spatial-temporal approach for quantifying spatial and temporal diffusion of land prices. Their results show that land price developments differ on a regional scale, although a certain measure of price conversion exists. Plogmann et al. (2020) use aggregated land price data for Western German federal states to investigate land rent-price ratios in a temporal framework. They identify similarities of the German farmland market to housing and stock markets and made a first interpretation of developments in the raw univariate price time series. Questions remain, where extraordinary developments in farmland prices occur which are not visible at first sight.

This study concentrates on the following question: Are general and agricultural policy changes visible as shocks in farmland price time series and could they have an intertemporal effect on farmland price development? An answer could help the study come to conclusions about policy events which may have contributed to land price changes and cannot be evaluated in a static framework.

Methodically, an intuitive approach would be the application of tests for structural changes in time series on the raw data, which are able to identify breakpoints (Bai & Perron, 1998; Zeileis et al., 2002). However, those tests are only able to identify huge structural changes in the time series, e.g. the enormous price growth after the financial crisis in 2007, which is even visible in the raw data. Plogmann et al. (2020) made a first attempt to link changing expectations of returns to political events in the raw data without using an explicit model. For the purpose of this study, a method was found, which is able to identify marginal outliers, usable for univariate short time series and not depending on predefined explanatory variables.Several publications present methods to identify small time series outliers (Bell & Hillmer, 1983; Chang et al., 1988; Chen & Liu, 1993; de Jong & Penzer, 1998; Tsay, 1988). This paper aims to apply the Chen and Liu (1993) method on land purchase price time series for a robust detection of small outliers. This method is suitable since it is applicable to short time series and can detect multiple outliers with different shapes simultaneously. The method has already been used by Chan and Liu (2002) to detect outliers in the Southeast Asian stock markets and by Darné and Charles (2011) to identify shocks in the U.S. macroeconomic time series. Both of these studies directly relate those outliers to political events.

The approach of Chen and Liu (1993) was applied to identify farmland price outliers. It was examined whether those outliers in the farmland purchase price time series occur at the same time as policy events, which are assumed to have an intertemporal effect on farmland purchase prices. The study focuses on an available dataset of German farmland prices, since it is strongly balanced and based on reliable sources. Also, German farmland price time series reflect a vivid development. A more detailed investigation is possible due to differentiation between the federal states and their differing production focuses and farm structures. While the general political environment in Western Germany is determined by the Common Agricultural Policy of the European Union, the federal structure of Germany allowing single states to enforce laws triggers the heterogeneity among federal states. Additionally, Germany provides longer time series than other European States. Data from *Statistisches Jahrbuch* (1976-2019) will be used to apply the analysis on two levels: Western Germany completely and each western federal state individually for higher robustness. The detected shocks will be matched with historical and political events, which are assumed to have an influence on land prices. Therefore, policies with a relation to agriculture or land purchases are considered. Additionally, the study uses descriptive data from each federal state to explain potential different results between the federal states.

Although this work is not able to verify causal relationships between policy changes and farmland prices but only temporal matches such as Chan and Liu (2002) and Darné and Charles(2011), it contributes valuable knowledge to the existing literature in the following way: First, it focuses on policy events, which are to the author’s knowledge not considered as price drivers in the farmland market itself yet, for example the german reunification in 1990 and the land transfer tax reform in 1983. Second, it proposes a more precise time series modeling approach for farmland price developments. And third, it underlines the results of previous research on the relationship between farmland prices and policy events.

The rest of this paper is structured as follows: In section two, a theoretical framework to underly the hypothesis is built. In section three, the applied methodology of Chen and Liu (1993) is further explained. The fourth part introduces the aggregated land price data and study regions. In section five, the results are explained. Finally, section six concludes.

2 Theoretical Framework

The hypothesis is straight forward: General or agricultural policy changes influence farmland prices, although they are not directly addressed to them. This idea was strengthened within a present value approach. The PV model is used due to its parsimony and prevalence in evaluating land purchase decisions, which is quite helpful for interpreting the results. Hence, the model might reflect realistic price building. Similar present value approaches have been used several times to investigate farmland purchase prices and farmland value determination (Devadoss & Manchu, 2007; Falk, 1991; Tegene & Kuchler, 1993; Weersink et al., 1999).

The PV approach rests on the idea that the value of a good is the sum of its discounted cash flows. In case of agricultural land, those cash flows depend on the produced agricultural goods. Consequently, agricultural policies addressing agricultural goods do also affect the discounted cash flows of agricultural land and hence, the PV of agricultural land.

Farmers are usually the main buyers of agricultural land, not at least due to political restrictions, but as can be seen, it partially prevents the trade of farmland for non-agricultural buyers. If they use instruments as the PV model for their investment decisions, they might also anticipate effects of agricultural policies. The study considers farmland as an investment decision with infinite duration, hence the returns are an infinite rent (Glauner, 2018; Gudehus, 1959). The PV of farmland can be represented as following:

(1)
$$PV = -PP(1+r) + (GM + DP)\frac{1}{z}$$

with

$$GM = agricultural\ yield \cdot product\ price - \ variable\ costs\ of\ production$$

PV is defined as the net present value of a farmland investment or, equivalent to that, the utility a profit maximizing farmer can derive from buying the farmland, PP as the purchase price which is multiplied by the incidental expenses rate r, GM the expected gross margin generated from agricultural production and DP as expected direct payments for farmland from the government. The interest rate is z. The condition for a farmland transaction to happen, which is considered in the dataset, is $PV \geq 0$. Important to notice is that GM, DP, z and r are exogenous values in the model, while the purchase price PP can be considered as an endogenous real-time decision by buyer and seller. Hence, PP might react on changes of the other values to fulfill the transaction condition $PV \geq 0$.

Within the model, GM can be defined as revenues from the investment. In case of farmland, this can mainly be defined as monetary yields from agricultural production. The GM is potentially influenced y agricultural policies: they might have an effect on product prices, yields and variable costs. Within the model, a growth of GM has a direct positive effect on the present value. Hence, buyers of land would accept a higher purchase price $PP$to fulfill the investment condition $PV \geq 0$. Vice versa, a reduction of GM causes a reduction of the PV. The purchase price has to decrease to keep a positive PV. The same assumption is valid for direct payments DP. Additionally, a change of the incidental expenses rate r has a direct effect upon the purchase price PP, which is again influencing the PV. Within the model, the study relies on standard neoclassical market assumptions for simplification. The model assumes full information and rational behavior of sellers and buyers. Although recent publications are questioning those assumptions for farmland markets (Seifert et al., 2020), it is noted here that this might not affect the findings, since the data is aggregated on a very high level and several asymptotically normal distributed microdata variations can be assumed as canceled out.

3 Empirical Method

In the empirical application, there is a particular interest in the potential changes of the purchase price PP. It can be seen that the purchase price can be set in relation not only to the incidental expenses rate r but also to the expected gross margin GM generated from agricultural production and the expected direct payments for farmland DP. Hence, the study looks ahead to identify outliers in PP and then to come to conclusions about potential positive and negative changes in r, GM and DP caused by policies. Since the study wants to detect the visibility of policy events in the data, a time series approach was choosen. This has the big advantage that policy events at several points in time can be considered which in turn allows a lot of European and German policy reforms to be considered.

The Chen and Liu (1993) method for estimating outlier effects in time series has been developed based on the procedures by Chang et al. (1988), Hillmer et al. (1983) and Tsay (1988). The method allows to detect time series outliers and estimate parameters jointly. Since the time series are too short for forecasting, the study will concentrate upon the first goal of Chen and Liu (1993), namely the detection of outlying values. The Chen and Liu (1993) method is best for investigating outliers in aggregated land price time series, since it is appropriate for short, univariate time series and able to detect several types of small outliers within one calculation. The intuition behind it is straight forward: A time series Autoregressive Moving Average (ARMA) process is fitted to smooth the raw data. ARMA processes have the advantage that they are relatively easy to fit upon various univariate time series. Outliers, which are deviant from the fitted model, are detected within a detection term. What is special about this method is that it can indicate minimal outliers, which are unlike structural changes and big variations not captured by the fitted ARMA process.

The outlier detection of Chen and Liu (1993) is based on the definition of a general ARMA process

(2) $$Y_t = \frac{\theta(B)}{\alpha(B)\phi(B)}\alpha_t\,, \qquad t = 1, \dots, n$$

where Y_t is the time series of interest, n is the number of observations and B is the backward shift operator with its polynomials $\theta(B)$, $\alpha(B)$ and $\phi(B)$. All roots of $\theta(B)$ and $\phi(B)$ are outside the unit circle and all roots of $\alpha(B)$ are on the unit circle. If the time series is integrated of order *d*, that is the time series that is differenced d times, it is considered as an ARIMA process in the following. This model class is useful, since it can be fitted to univariate time series in a simple way and is also suitable for many types of time series. Chen and Liu (1993) now assume the influence of multiple non-repetitive events on this time series within the following model, with Y_t as subject to m various interventions at time points $t_1, t_2, \dots, t_m$:

(3) $$Y_t^* = \sum_{j=1}^{m} w_j \; L_j(B) I_t(t_1) + \frac{\theta(B)}{\alpha(B)\phi(B)} a_t$$

where $I_t(t_1)$ works as the indicator function for outlier effects, which are 1 if $t = t_1$ and 0 otherwise. The parameter w_j indicates the magnitude of the effect. $L_j(B)$ has the following definitions:

$L_j(B) = 1$ for an Additive Outlier (AO),

$L_j(B) = \frac{1}{(1-B)}$ for a Level Shift (LS) and

$L_j(B) = \frac{1}{(1-\delta B)}$ for a Temporary Change (TC) at $t = t_j$,

where δ is a predetermined parameter for the TC type and given, as recommended from Liu and Chen (1993), with a value of 0.7. The outlier types are referring to the aggregated time series. Additive outliers are one outlying observation in time, level shifts are an intertemporal change of the price level and temporary changes are intertemporal changes which are converging back to the original level. The types of outliers are frequently discussed in literature (Bell & Hillmer, 1983; Tsay, 1988) and visualized in appendix I.

For investigating the outlier effects, the study estimates the time series, which is observed from $t = -J$ to $t = n$ with the parameters from an ARIMA process *p*, *d* and *q*, which are orders of the polynomials $\theta(B)$, $\alpha(B)$ and $\phi(B)$ and *J* is an integer larger than *p*+*d*+*q*. The $\pi(B)$ polynomial has to be defined as

(4)
$$\pi(B) = \frac{\{\phi(B)\alpha(B)\}}{\{\theta(B)\}}.$$

The estimated residuals $\hat{e}_t$ could then be expressed as

(5)
$$\hat{e}_t = \pi(B)Y_t^*$$

which can alternatively be written as

(6) $$\hat{e}_t = \omega x_{it} + a_t, \text{ with } t = t_1, t_1+1, \dots, n \text{ and } i = 1,2,3,4$$

Where n denotes the point in time, $x_{it} = 0$ for all i and $t < t_1$, $x_{it1} = 1$ for all i and $k \geq 1$, $x_{1(t_1+k)} = 0$, $x_{2(t_1+k)} = -\pi_k$, $x_{3(t_1+k)} = 1 - \sum_{j=1}^{k} \pi_j$ and $x_{4(t_1+k)} = \delta^k - \sum_{j=1}^{k-1} \delta^{k-j} \pi_j - \pi_k$.

Now it enables a calculation of the least squares estimates for the effect of a single outlier at $t = t_1$, which can be expressed as

(7) $$\hat{\omega}_{AO}(t_1) = \frac{\sum_{t=t_1}^{n} \hat{e}_t \, x_{2t}}{\sum_{t=t_1}^{n} x_{2t}^2}$$

$$\hat{\omega}_{LS}(t_1) = \frac{\sum_{t=t_1}^{n} \hat{e}_t \, x_{3t}}{\sum_{t=t_1}^{n} x_{3t}^2}$$

$$\hat{\omega}_{TC}(t_1) = \frac{\sum_{t=t_1}^{n} \hat{e}_t \, x_{4t}}{\sum_{t=t_1}^{n} x_{4t}^2}$$

.

For detecting the presence of outliers, the $\hat{\omega}`s$ can be used to calculate the maximum value of the standardized τ – statistics

(8) $$\hat{\tau}_{AO}(t_1) = \left\{\frac{\hat{\omega}_{AO}(t_1)}{\sigma_a}\right\} \left(\sum_{t=t_1}^{n} x_{2t}^2\right)^{\frac{1}{2}}$$

$$\hat{\tau}_{LS}(t_1) = \left\{\frac{\hat{\omega}_{LS}(t_1)}{\sigma_a}\right\} \left(\sum_{t=t_1}^{n} x_{3t}^2\right)^{\frac{1}{2}}$$

$$\hat{\tau}_{TC}(t_1) = \left\{\frac{\hat{\omega}_{TC}(t_1)}{\sigma_a}\right\} \left(\sum_{t=t_1}^{n} x_{4t}^2\right)^{\frac{1}{2}}$$

.

where σ_a is the standard deviation of the residuals, calculated by the median absolute deviation method. The τ – statistics in the following are compared to a predetermined critical value C, where $\eta_t = max\{|\hat{\tau}_{AO}(t)|, |\hat{\tau}_{LS}(t_1)|, |\hat{\tau}_{TC}(t_1)|\}$. If $max_t\{\eta_t\} > C$, where C is a predetermined critical value, then an outlier is assumed. The critical values are set as proposed by Chen and

Liu (1993) for a time series shorter than 100 observations. Additionally, every detected shock must be robust over an interval of C from at least 2.7 to 2.9. Based on this comparison, the existence of an outlier at time point t is assumed or not. It is not possible to detect a shock at the very end of a time series. Further methodological issues, for example the joint estimation of multiple outliers and inner loops in the detection process can be retraced in Chen and Liu (1993). A fourth type, the innovational outlier, is left out for simplification. For calculations, the package *tsoutliers* (López-de-Lacalle, 2019) has been used in R.

4 Study Region and Data

The empirical analysis is conducted in Western Germany. The study inspects both the price developments on the aggregated Western German farmland market as well as in each of the Western German federal states alone. Recent as well as previous price developments on the Western German agricultural land market qualify Western Germany as an appropriate candidate for this analysis.[1] The heterogeneity within the federal states is visible in the price development of agricultural land values but also in the production structures. The data on land sales prices is retrieved from *Statistisches Jahrbuch* (1976-2019) published by *Federal Office of Statistics*. This database provides nominal land sales prices on an annual basis for every federal state and covers both prices of arable and grassland sale transactions. The data is visualized in Figure 1.

[1] We refrain from applying the analysis in the Eastern German federal states as well. While we admit that the price development in Eastern German federal states since the German reunification is an interesting study object and contrasting Eastern and Western German federal states would potentially increase the informative value of the envisaged analysis, the time series available for Eastern Germany are simply too short to come to reliable results (see also Plogmann et al., 2020).

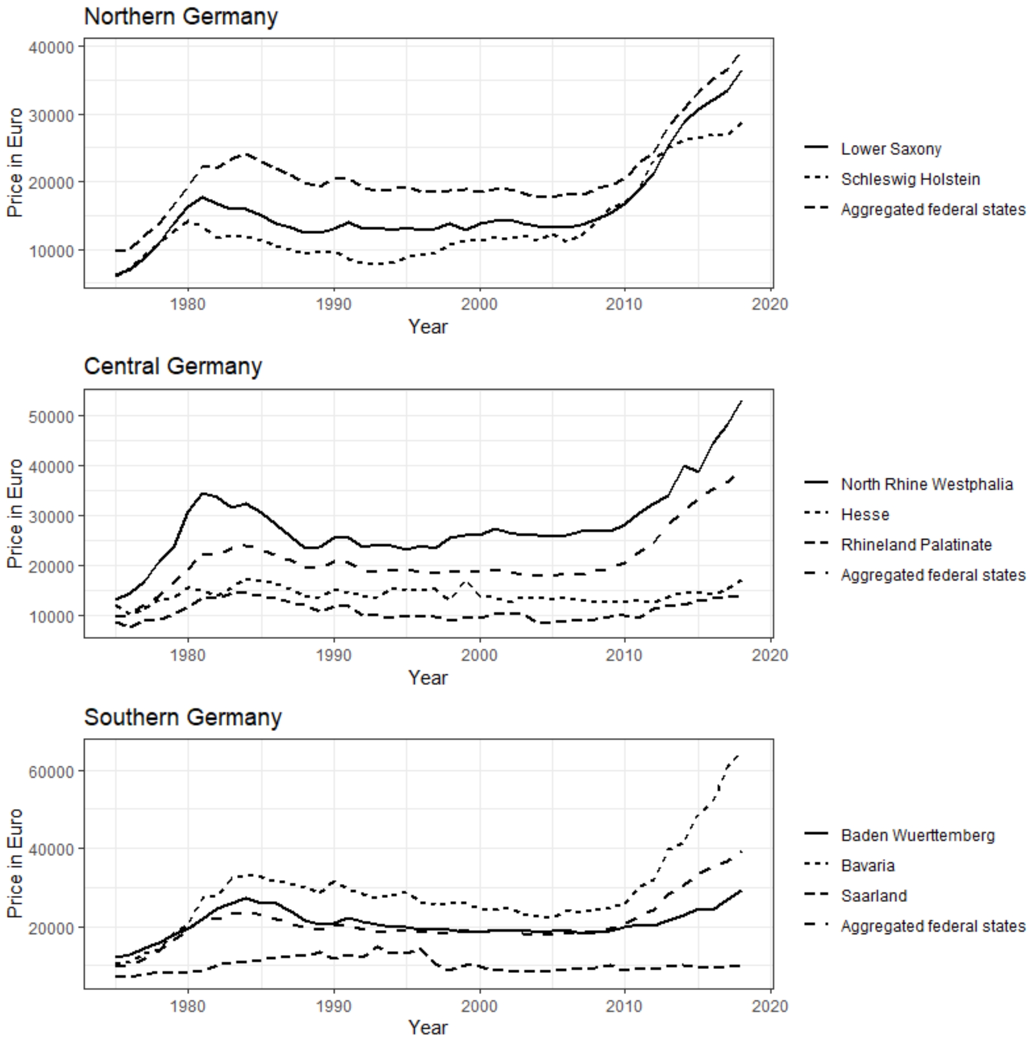

Figure 1: Average yearly nominal farmland purchase price per hectare, retrieved from *Statistisches Jahrbuch* (1976-2019)

To perform the analysis for the aggregate level of Western Germany, the study uses the federal states data and weighs it by means of the agricultural area of every federal state. To investigate both the nominal and the real land price time series, the study converts nominal prices into real land sale prices by applying the Consumer Price Index (CPI) for Germany published by *Federal Office of Statistics*.

Table 1 charaterizes the agricultural structures of each federal state based on the year 2018 so that a detailed overview of the study region can be provided. In total, 241,300 farms are registered in Western Germany and out of these about 11 mio. hectares (ha) of agricultural land are operated. The numbers indicate pronounced heterogeneity in farming structures and production focusses between the federal states.

Table 1. Agricultural characteristics of selected Western German federal states in 2018 a)

Region	**Number of farms (in 1,000)**	**Thereof organic farms (in %)**	**Agricultural area (in 1,000 ha)**	**Thereof organic used area (in %)**	**Arable land (in 1,000 ha)**	**Grassland (in 1,000 ha)**
Baden Wuerttemberg	39.8	8.6	1,413.4	9.3	814.6	547.9
Bavaria	87.0	8.5	3,099.9	8.3	2,022.6	1,063.5
Hesse	15.9	11.2	770.9	11.5	466.1	298.7
Lower Saxony	37.0	3.5	2,601.3	3.2	1,886.7	695.6
North Rhine-Westphalia	31.2	4.5	1,449.4	4.2	1,040.0	395.8
Rhineland Palatinate	16.8	7.4	706.9	8.6	399.6	237
Saarland	1.1	13.8	74.9	15.4	34.3	40.2
Schleswig-Holstein	12.5	3.6	987.4	4.1	663.5	317.7
Aggregated Federal States	241.3	61.3	2,540.1	64.7	2,378.1	2,532.9

Source: Statistische Ämter des Bundes und der Länder (2020) b)

Region	Live cattle (in 1,000)	Thereof dairy cows (in 1,000)	Hogs (in 1,000)	Biogas plants (in 1,000)	Workers (in 1,000)	Thereof family workers (in 1,000)
Baden Wuerttemberg	949	328	1,610	1,215	148.4	72.7
Bavaria	3,013	1,128	3,056	2,964	223.1	161.9
Hesse	420	131	510	327	50.7	27.2
Lower Saxony	2,450	832	8,275	2,917	130.3	59.2
North Rhine-Westphalia	1,337	401	6,840	1,375	117.0	52.7
Rhineland Palatinate	329	106	153	278	80.3	26.7
Saarland	43	13	3	21	3.4	2.1
Schleswig-Holstein	1,015	377	1,406	837	39.8	19.3
Aggregated Federal States	1,741	2,188	666	1,463	793.0	421.8

Source: Statistische Ämter des Bundes und der Länder (2020)

In Lower Saxony, for example, around 37,000 farms operate on 2.6 mio ha, which shows rather large farm structures compared to other federal states, such as Bavaria where more than twice the number of farms operate with only about 20 % more agricultural area. Moreover, Lower Saxony is the largest live cattle producer in Western Germany, both in absolute terms as well as per farm and beside North Rhine Westphalia it is the federal state with the largest number of hogs in Western Germany. Schleswig Holstein has even larger farm structures than Lower Saxony, with an average farm size of about 78 ha. While it is also a large producer of cattle, Schleswig Holstein stands out for being the federal state with the highest number of biogas plants per farm and per agricultural area. Bavaria, being the largest German federal state, has, in absolute terms, the highest number of farms and biogas plants. However here, as well as in Baden Wuerttemberg, the average farm sizes are rather small. Also, the number of biogas plants per farm is rather small compared to Schleswig-Holstein. Further, Bavaria has the largest share of family workers among agricultural workers in total. Rhineland Palatinate, by contrast has a very small share of family workers and is furthermore the federal state with the highest labor input per farm. With 11.3 workers per 100 ha, farms in Rhineland Palatinate have the highest labor rate. One potential reason is the predominance of labor-intensive wine production in Rhineland-Palatinate. Saarland and Hesse stand out due to their high share of organic producing farms. Lower Saxony and Schleswig-Holstein, by contrast, have the lowest share of organic farms with only about 4 %.

5 Results

For detecting exceptional price developments in the aggregated data several time series have been used: the nominal land prices, the real land prices and the first differences of both for each federal state. In a first step, an ARIMA process is fitted for each univariate time series. A reliable model fit is the most important condition for outlier detection. The Augmented-Dickey-Fuller (ADF)-Test indicates stationary residuals for each investigated process with a significance level of 5% but at least on a significance level of 10%. One exception is the Bavarian time series. The Box-Pierce-Test has been used for each time series to guarantee non-auto-correlated residuals.[2] The results of the model fit are shown in Table 2.[3]

Table 2. Model fit for each farmland price time series

Region	RP	p-value	NP	p-value	DRP	p-value	DNP	p-value
Western Germany	1,2,0	0.03	1,2,0	0.06	1,1,0	0.01	1,1,0	0.03
Baden Wuerttemberg	1,2,0	0.04	1,2,0	0.07	1,1,0	0.02	1,1,0	0.05
Bavaria	1,2,0	0.20	1,2,0	0.22	1,1,0	0.06	1,1,0	0.12
Hesse	0,1,0	0.01	0,1,0	0.09	1,0,0	0.01	1,1,0	0.01
Lower Saxony	1,1,0	0.01	1,1,0	0.01	1,0,0	0.01	1,0,0	0.01
North Rhine-Westphalia	1,2,0	0.01	1,2,0	0.02	1,1,0	0.02	1,1,0	0.05
Rhineland Palatinate	1,2,0	0.03	1,2,0	0.04	1,1,0	0.01	1,1,0	0.02
Saarland	2,2,0	0.01	2,2,0	0.01	2,1,0	0.01	2,1,0	0.01
Schleswig-Holstein	1,1,0	0.01	1,1,0	0.06	1,0,0	0.01	1,0,0	0.04

RP: real prices, NP: nominal prices, DRP: differences real prices, DNP: differences nominal prices, p: p-value from the ADF-Test for Unit Roots, processes: ARIMA-processes, order *p,d,q*, based on Data from Statistisches Jahrbuch (1975-2019).

In a second step, the outliers of each process have been detected with the procedure described in section three, for Western Germany as a whole as well as for each federal state of Western Germany. The results of this outlier detection are shown in Table 3.

[2] In our case, the Box-Pierce-Test assumes non-auto-correlated residuals for each model at a significance level of 5%.

[3] For each model, robustness has been checked within the application of several specifications (not presented here). The specification, which fulfils the conditions above and has robust results has been chosen for final application.

Table 3. Identified outliers in farmland purchase price time series

Area	Time series	Type	Year	Coefficient
Western Germany	RP	no detected outliers		
	NP	LS	1990	2,350
	DRP	LS	1977	2,948
		AO	1982	-4,515
		LS	1985	-2,495
		AO	1990	3,445
	DNP	LS	1982	-2,608
		LS	1985	-1,901
		AO	1990	2,406
		TC	2013	1,735
Baden Wuerttemberg	RP	TC	1985	-2,096
		AO	1991	2,179
	NP	TC	1991	1,992
		TC	2016	-2,123
	DRP	LS	1985	-2,864
		AO	1988	-3,441
		TC	1992	-3,494
	DNP	LS	1985	-2,287
		TC	1990	2,694
		AO	2016	-2,321
Bavaria	RP	no detected outliers		
	NP	TC	1990	3,733
	DRP	LS	1985	-5,221
		AO	1990	6,337
	DNP	LS	1985	-3,734
		AO	1990	4,155
Hesse	RP	TC	1976	-5,323
		AO	1999	4,492
	NP	AO	1999	3,738
	DRP	no detected outliers		
	DNP	AO	1999	5,165
Lower Saxony	RP	LS	1982	-2,770
		AO	1999	-1,315
	NP	AO	1999	-1,143
	DRP	TC	1982	-4,058
		AO	1992	-2,169
		AO	1999	-2,206
	DNP	TC	1982	-2,250
		AO	1992	-1,403
		AO	1999	-1,934
		TC	2013	2,123
		AO	2018	1,729
North Rhine-Westphalia	RP	no detected outliers		
	NP	LS	1980	5,308
	DRP	AO	1978	4,015
		AO	1980	7,901
		LS	1982	-8,160
		AO	1984	4,337

		LS	1989	3,198
		AO	1990	2,865
		AO	1992	-3,295
		AO	1998	2,204
		AO	2014	5,323
		AO	2015	-5,327
	DNP	AO	1980	3,235
		LS	1982	-5,264
		AO	1990	3,593
		LS	2014	3,754
		AO	2015	-6,022
Rhineland-Palatinate	RP	AO	1981	2,080
		AO	1989	-1,706
		LS	1992	-2,564
		LS	2004	-2,153
	NP	AO	1981	1,217
		LS	1992	-2,081
		LS	2004	-1,868
		AO	2011	-1,054
	DRP	LS	1977	4,248
		AO	1982	-3,162
		AO	1990	2,372
		AO	1992	-2,531
	DNP	LS	1981	4,248
		LS	1982	-1,604
		AO	1990	1,600
		AO	1992	-1,460
		AO	2004	-1,863
		TC	2012	1,402
Saarland	RP	LS	1990	-3,813
		AO	1992	-2,473
		LS	1997	-3,393
	NP	TC	1990	-2,464
		LS	1997	-3,375
	DRP	AO	1990	-3,736
		AO	1997	-4,231
	DNP	AO	1990	-2,578
		AO	1997	-3,507
Schleswig-Holstein	RP	AO	1982	-1,966
		AO	2005	1,565
	NP	AO	1982	-1,098
		AO	2005	1,476
		LS	2012	2,417
		AO	2017	-1,051
	DRP	TC	1981	-4,331
		AO	1982	-3,132
	DNP	AO	2012	2,693

AO - additive outlier; LS - level shift; TC - temporary change, RP - real prices, NP - nominal prices, DRP - differences real prices, DNP - differences nominal prices

The type describes the type of outlier, respectively: AO denotes an additive outlier, LS is a level shift and TC a temporary change. The coefficient gives information about the size of the outlier and its direction. A negative coefficient indicates a price fall, a positive outlier indicates a spontaneous price growth. The coefficient also indicates the outlier's size. For example, an additive outlier with the coefficient 3,445 means that the price in the respective year has been 3,445 Euros higher than expected in relation to the time series. An example of a graphical representation of such outliers is given in Appendix II.

Within the theoretical framework, the study assumes that general and agricultural policy events have an effect on farmland purchase prices. At least some of those outliers are potentially caused by a change in politics. Policy events on a European level and on a county level are considered, which are connected to agriculture and land purchases. Selected ones are described in Appendix III. In the following, the identified price outliers in relation to them are set.

Three years especially stand out in the results as they occur in most federal states time series: A negative outlier in 1982, a positive one in 1990 and a negative shock in 1992. Other shocks are only visible in certain federal states. The study will concentrate on those dominant outliers first. In 1982, a negative additive outlier appears in several federal states as well as in the Western German time series. A reason for this might be a German ground transfer tax reform from January 1983, which led to a reduction in land transfer taxes. Within our theoretical framework, this tax reform reduces the incidental expenses rate *r*, which reduces the farmland purchase price. In expectation of this tax reform and the related purchase price reduction, potential land buyers might have hesitated to acquire land the previous year. Due to reduced demand, prices fell. This assumption is supported by German ground transfer tax data from 1982 and 1983, which is indicating a notable difference in tax incomes between these two years (Bundesfinanzministerium, 2020). The shock is appearing in the Western German aggregated series and additionally in the series of Schleswig Holstein, Lower Saxony and North Rhine Westphalia. All three federal states have a comparably large amount of farmland with a relatively small total number of farms as seen in Table 1. This indicates probably a high amount of economically reasonable land transactions and hence the potential visibility of the land transfer tax reform in the respective time series.

In 1990, a positive outlier occurs in the Western German time series as well as in several federal states. This year was particularly meaningful for Germany due to the German reunification. As a consequence, Germany faced economic uncertainty (Czada, 1998; Fuchs-Schündeln, 2008). Additionally, a post-reunification inflation shock happened because of the incorporation of the eastern federal states (Goldfayn-Frank & Wohlfart, 2020). This might have been an incentive for investors to search for safe investment possibilities. Land is traditionally one of those possibilities. Besides gold and real estate it shows a counter-cyclical price development (Case et al., 1999; Nickerson et al., 2012). This context can explain the sudden price increase in 1990. Within the theoretical model, this fact might be visible in the interest rate. However, a large economic crisis did not occur. Hence, the outlier remains a small additive outlier.

The third frequent outlier, a negative shock in 1992, coincides with one of the most famous reforms in the history of the Common Agricultural Policy of the European Union: The MacSharry-reform. Since this reform was actually addressed towards agricultural production (Sinabell & Schmid, 2017), it could be assumed to have an effect on the gross margin *GM* in the theoretical framework. This can probably also be led back to the adoption of the set-aside obligation, which was as a part of the MacSharry-reform that was meant to reduce agricultural overproduction (EUR-Lex, 2020). Since the outlier occurs as a level shift in some time series as well as an additive outlier in others, it could be assumed that the reform had varying consequences for the farmland prices in different federal states. For example, the livestock cluster in the very west of Germany might react different to those policies than crop intensive regions. Nonetheless, the scope of this study does not allow to confirm this assumption.

Other outliers only occur in single time series. Hence, it is often harder to interpret them. Several outliers can be referred to German renewable energy law reforms. This concerns especially the federal state of Schleswig Holstein, which shows additive outliers and level shifts in 2005 and 2012. This is not surprising given the relevance of renewable energies in Schleswig-Holstein shown in Table 1. The importance of the German renewable energy law reforms in the farmland market is strengthened by Forstner et al. (2011), who find that the bonuses paid within this law, which can be considered as direct payments in the theoretical framework, are an important reason for investors to buy land.

A policy change which seems to have had an effect on the southern German federal states was the establishment of the milk quota in 1984. Here, a negative shock appears as a level shift and a temporary change in 1985 in Bavaria as well as in Baden Wuerttemberg. Both states have a high share of milk production, combined with a small-scaled farm structure and a high share of family work, according to Table 1. The establishment of the quota could have forced many milk producing farms to reduce production. Small farms had a lower incentive to remain in the market and many of them might have given up. Hence, land prices fell due to increased supply. The fact that those shocks persisted as longer lasting changes in the price level may confirm this observation. Additionally, a negative outlier occurs in 1988 for Baden Wuerttemberg. In 1988, the EU decided to limit agricultural expenditures. This additional potential loss of subsidies could have influenced farmer's incentives to buy land as well. Again, the reason for this shock only to appear in Baden Wurttemberg could be due to the small-scaled structure described in Table 1, which makes farms more dependent on agricultural subsidies (Bojnec & Latruffe, 2013).

6 Conclusion

This study wants to contribute to the question, if outliers in farmland purchase price time series, which are detected by the Chen and Liu (1993) method match policy events in time and thus might be affected by them. First, a theoretical framework is built, where the present value of land, which is the assumed farmland investment criterion, is set in relation to the purchase price of land, gains from agricultural production, direct payments, an interest rate and an incidental expenses rate. The endogenous purchase price is reacting to changes of the other components. This allows the study to interpret a time series outliers in farmland purchase prices which are caused by policy events. Within a time series approach outliers in Western German farmland purchase price time series were detected, which indicate unusual price changes and relate themto policy events.

The results indicate that many detected outliers can be set into an intertemporal relation to policy events. Especially remarkable are agricultural policy changes from the European Union, but also a German land transfer tax reform might be visible. Hence, the assumption from recent literature stating that agricultural policies do have an impact on farmland prices can be strengthened. Furthermore, the study successfully managed to detect an approximate size of the influence within the estimated coefficients and a temporal development of the shock within the outlier type in Table 3.

The appearance of temporary changes and level shifts, are of special interest in this study as they indicate an influence which is exclusively detectable by time series methods. The most intuitive example here is the shock assigned to the land transfer tax reform in 1983 and its expectation in 1982, which is plausibly appearing as a level shift in most cases. Also, the shock assigned to the milk quota appeared as a level shift. Beside this, it is also remarkable that other policies seem to have only a short-term effect on farmland prices. The shock corresponding to the MacSharry reform shows differing types over the federal states, nonetheless it is mostly detected as an additive outlier. Hence, it can be assumed that some policies have an effect on farmland prices which is irrelevant one year later or absorbed by other factors influencing farmland prices.

At least, some outliers' occurrence is hard to explain. Identifying these explanations is non-trivial, since many unobservable factors can influence the development of land prices, which is subject to future research with methods addressing causal relationships. Additionally, the consideration of explanatory variables within multivariate models could be of interest, when it comes to investigating single political events more in detail.

Possible implications for future policies are on the one hand that policy makers could consider laws, which are primarily meant for agricultural production control, additionally as a price driver on the land purchase market. Those changes are potentially influencing land purchase rentability and thus have a feedback effect on agricultural production. However, this requires further scrutiny. On the other hand, policy makers should consider their impact on the expectations of land buyers and sellers. Especially the announcement of land transfer tax reforms, like the one from the year 1983, seem to have a remarkable effect on land purchase prices. For future research it may be interesting to apply this method additionally to other states. This may provide further evidence for the policy effects assumed in this study. To allow for a direct policy analysis, another possible approach would be a structural time series model with explanatory variables or a state-space interpretation with policies as a state variable, but in this case one has to make pre-assumptions about the explanatory factors which makes an estimation more accurate but also limited. For future research, the presence of outliers should be considered when modeling farmland price time series.

7 Literature

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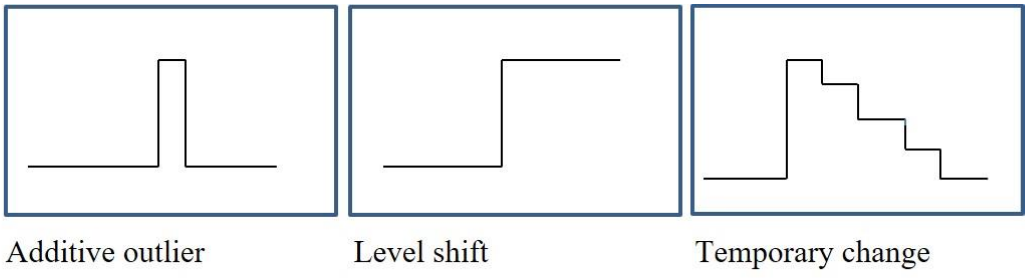
Appendix I

Outlier types



Appendix II

Graphic examples of outlier detection, x-axis: years, y-axis: prices in Euro/hectare

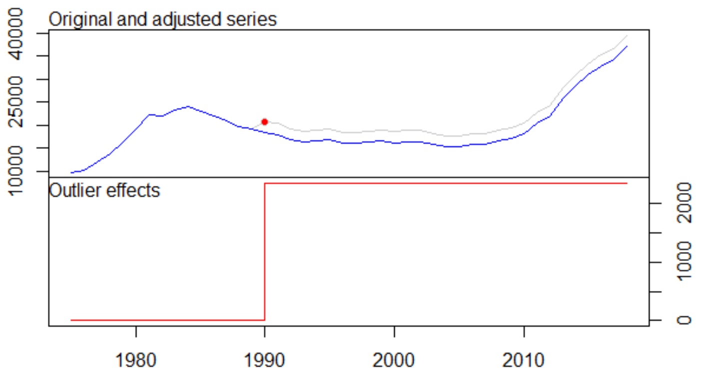


Figure A.1: Outliers in nominal farmland price time series, Aggregated federal states of Western Germany 1975 -2018

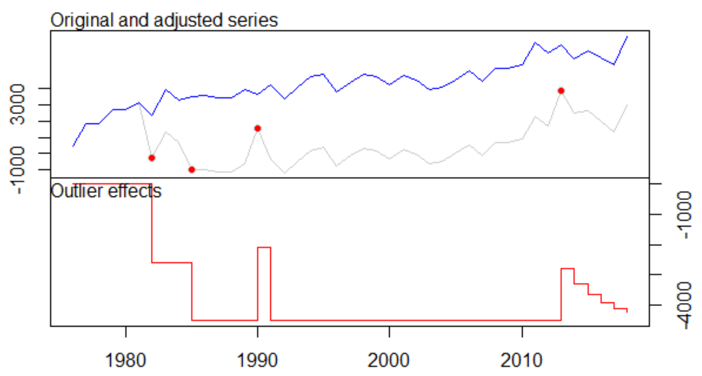


Figure A.2: Outliers in differenced nominal farmland price time series, Aggregated federal states of Western Germany 1975 -2018

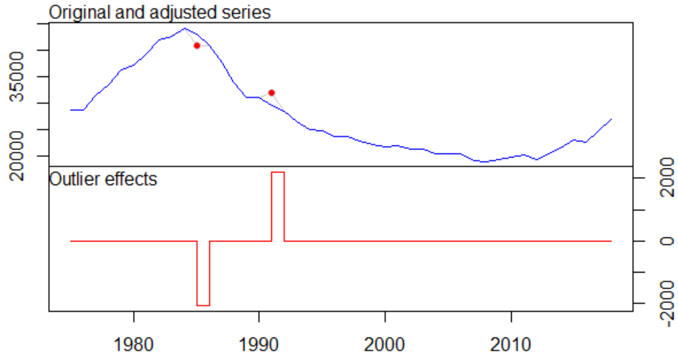


Figure A.3: Outliers in differenced real farmland price time series, Aggregated federal states of Western Germany 1975 -2018

Appendix III

Description of selected political events

EEG reform 2012 (Germany)

The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz; EEG) 2012 amended the previous EEG 2009 and thus established the goals of expanding the electricity sector. The share of renewable energies in electricity consumption should be at least 35% in 2020 and grow to at least 80% by 2050. In addition, the overall system should be optimized by improving the interaction between renewable and conventional energies as well as storage and consumption. Furthermore, the remuneration system for bioenergy has changed. Storage facilities were exempted from the EEG surcharge and a flexibility premium to promote the construction of gas storage facilities at biogas plants was decided (Bundesministerium für Wirtschaft und Energie, 2021).

EEG reform 2004 (Germany)

The Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*; EEG) 2004 represented the first amendment of the EEG 2000 and formulated a concrete objective for the expansion of renewable energies. The share of renewable energies should be 12.5% by 2010 and at least 20% by 2020. The EEG also contains changes and additions to the structure of the law. Network operators were enabled to pass costs and quantities on to the end user (Bundesministerium für Wirtschaft und Energie, 2021).

MacSharry reform 1992/1993 (EU)

Agriculture that was increasingly intensified and specialized in the 1970/80s led to considerable overproduction and negative ecological effects. In 1992, the then Agriculture Commissioner MacSharry implemented a reform of agricultural policy. This was particularly characterized by the fact that the former income-oriented price policy increasingly developed into a market-oriented agricultural policy. Measures included the reduction of intervention prices, the establishment of farmland-based price compensation payments and a mandatory set-aside. In addition, the financial support of environmentally friendly production processes has been established in the GAP (Thuenen Institut, 2021).

CAP reform 1988 (EU)

The agricultural spending of the Common Agricultural Policy (CAP) has increased due to government guaranteed purchases and the resulting overproduction. In 1988, a decision was made in Brussels to expand the budget, which was to be provided by the member states and additional deposits. Moreover, the growth in the cost of agricultural policy has been limited by setting measures against agricultural surpluses. These measures related, for example, to the setting of maximum quantities, surplus levies, the financial support of non-production and subsidies for an early exit from agricultural production (Stiftung Marktwirtschaft, 1988).

Milk quota 1984 (EU)

In the context of agricultural overproduction, so-called milk lakes and butter mountains arose at the beginning of the 1980s, as the European Economic Community bought unsold quantities at the guaranteed price. In 1984 this led to the introduction of the milk quota, which assigned each member state a fixed production quota for milk. All amounts above the limited amount were sanctioned (Bundesgesetzblatt, 1984)