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CHANGES IN THE PRODUCTIVITY OF AGRICULTURE AFTER POLISH ACCESSION TO THE EUROPEAN UNION

Joanna Baran
Warsaw University of Life Sciences – SGGW

Abstract. The article determines changes in agriculture productivity of individual Polish voivodeships in 2005–2012 based on the Malmquist Productivity Index. The model features the following variables: one effect (value of purchased agricultural products) and five inputs (area of agricultural land, number of people employed in agriculture, use of fertilizers, number of tractors, livestock). The study indicated that technological progress had a greater impact on the change in productivity of agriculture in Poland in the period after accession to the EU than changes in technical efficiency. Meanwhile, the highest average index of changes in MPI during the period was achieved by voivodeships: Dolnośląskie, Lubelskie, Pomorskie and Mazoweckie.
Key words: agriculture, voivodeships, efficiency, Malmquist Productivity Index

INTRODUCTION

After the accession of Poland to the European Union, Polish agriculture has been operating under different economic conditions. Participation in the European common market is tantamount to a process of aligning prices and new profit opportunities for agriculture resulting from a higher level of demand, prices and the implementation of economic support under the rules of the Common Agricultural Policy [Poczta 2008]. A number of studies [Jóźwiak 2005, Poczta 2008] indicate that the accession and related changes in economic conditions of farming operations have led to a significant improvement in the income situation of Polish agriculture. After 2004 the significance of European funds for Polish agriculture increased substantially, while the main instruments used for assisting national agriculture consisted of direct payments and the Sectoral Operational Programme [Kowalczyk 2007, Rusielik, Świtłyk 2009]. Direct payments constituted on average of 13.5% of farm income in 2004, while in 2010 this share exceeded 60% [Kruszewski, Sielska 2012].

Corresponding author – Adres do korespondencji: Joanna Baran, Faculty of Economic Sciences, Department of Economics and Enterprise Organization, WULS-SGGW, Nowoursynowska 166, 02-787 Warszawa, Poland, e-mail: joanna_baran@sggw.pl

It should be noted, however, that the impact of integration on the monetary income of agriculture within the country is diverse, due to the fact that agriculture in different regions of the country exhibits higher or lower levels of variation. This stems mainly from the scale of production and the structure of agricultural production, as well as the different levels of marketable agricultural production [Poczta 2008].

One of the objectives of the Common Agricultural Policy is to improve the efficiency of agricultural production. It becomes, therefore, a key issue to perform ongoing monitoring and determine the direction of changes in agricultural efficiency at both the national level and for individual regions. This makes it possible to better assess the opportunities and barriers for the development of Polish agriculture on the one hand and to shape appropriate rules for the allocation of EU funds for the agricultural sector on the other [Rusielik, Świtłyk 2009, Kruszewski, Sielska 2012].

A macroeconomic approach to economic efficiency refers to how well the economy allocates scarce resources to meet the needs and demands of consumers. In turn, a microeconomic approach to efficiency is linked to individual enterprise and defined as the relation between the effects obtained by a particular decision making unit (DMU) and its input. Fried et al. [1993] refer to such a relation between effects and input as productivity, while defining efficiency as the relation between the productivity of a given entity and the maximum productivity achievable in certain technological circumstances.

In Polish literature there are many studies on the efficiency of agriculture based both on sectoral data and data for individual farms. Most of these studies are based on simple, standard efficiency indicators. There also exist efficiency analyses of farming methods based on multi-dimensional methods, inter alia, Rusielik and Świtłyk [1999], Helta and Świtłyk [2007, 2008, 2009], Prochopowicz and Rusielik [2007], Kulawik [2008], Jarzębowski [2010], Bieńkowski et al. [2012], Baran and Żak [2013], Baran [2014]. This paper also used a multi-dimensional method, i.e. the Malmquist Productivity Index, to assess changes in agricultural productivity. Studies in the field of agriculture using MPI were conducted, among others, by: Fulginiti and Perrin [1997], Brümmer et al. [2002], Helta and Świtłyk [2004], Lissitsa and Odening [2005], Rusielik and Świtłyk [2009], Świtłyk [2011].

Therefore, the purpose of this article is to determine changes in the productivity of the agricultural sector in individual voivodeships since Poland's accession to the European Union. The study aims to verify the following hypotheses:

- H1: Changes in technical efficiency were the main factor for improvements in the productivity of agriculture in Poland in 2005–2012.
- H2: Voivodeships that received the most support from EU funds per 1 ha of agricultural land observed the greatest improvement in agricultural productivity in 2005–2012.

MATERIAL AND METHODS

The study used GUS data for the period 2005–2012 on agriculture in particular voivodeships published in the Statistical Yearbooks of Agriculture and data from the reports on the activities of the Agency for Restructuring and Modernisation of Agriculture for the year 2012 as source materials.

The Malmquist Productivity Index (MPI) was employed in order to verify the research hypotheses on the basis of data for the agricultural sector in individual voivodeships. Malmquist Productivity Index is the most frequently used approach to quantification of changes in total factor productivity. MPI first introduced by Malmquist [1953] has further been studied and developed by Färe et al. [1992, 1994]. Färe et al. [1992] constructed the DEA-based MPI as the geometric mean of the two Malmquist Productivity Indices of Caves et al. [1982] – one measures the change in technical efficiency and the other measures the shift in the frontier technology. Färe et al. [1994] developed it into the output-based Malmquist productivity change index. The input-oriented Malmquist Productivity Index of a DMU can be expressed as:

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{D^t(y_{t+1}, x_{t+1})}{D^t(y_t, x_t)} x \frac{D^{t+1}(y_{t+1}, x_{t+1})}{D^{t+1}(y_t, x_t)} \right]^{\frac{1}{2}} \quad (1)$$

where: x_t, x_{t+1} – input vectors of dimension l at time t and $t + 1$, respectively;
y_t, y_{t+1} – corresponding k-output vectors;
D^t, D^{t+1} – an input-oriented distance function with respect to production technology at t or $t + 1$, which is defined as:

$$D(x, y) = \max\{\rho : (s / \rho) \in L(y)\} \quad (2)$$

where: $L(y)$ – number of all input vectors with which a certain output vector y can be produced, that is, $L(y) = \{x{:}y \textit{ can be produced with } x\}$;
ρ – reciprocal value of the factor by with the total inputs could be maximally reduced without reducing output.

M measures the productivity change between periods t and $t + 1$, productivity declines, if $M < 1$, remains unchanged, if $M = 1$ and improves, if $M > 1$. The frontier technology determined by the efficient frontier is estimated using DEA for a set of DMUs. However, the frontier technology for a particular DMU under evaluation is only represented by a section of the DEA frontier or a facet. Färe et al. [1994] decomposed the MPI in eq. (1) into two terms, as shown in eq. (3), that makes it possible to measure the change of technical efficiency and the shift of the frontier in terms of a specific DMU. This implies that productivity change includes changes in technical efficiency (EFCH) as well as changes in production technology (technical change TECH):

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \underbrace{\frac{D^t(y_{t+1}, x_{t+1})}{D^t(y_t, x_t)}}_{EFCH^{t+1}} x \left[\underbrace{\frac{D^t(y_{t+1}, x_{t+1})}{D^{t+1}(y_{t+1}, x_{t+1})} x \frac{D^t(y_t, x_t)}{D^{t+1}(y_t, x_t)}}_{TECH^{t+1}} \right]^{\frac{1}{2}} \quad (3)$$

The first term on the left hand side captures the change in technical efficiency (EFCH) between periods t and $t + 1$. EFCH > 1 indicates that technical efficiency change improves while EFCH < 1 indicates efficiency change declines. The second term measures the technology frontier shift (TECH) between periods t and $t + 1$. A value of TECH > 1 indicates progress in the technology, a value of TECH < 1 indicates regress in the technology. TECH = 1 indicates no shift in technology frontier. The technical efficiency change can further be decomposed into scale efficiency change (SECH) and pure technical efficiency change (PTEC) [Färe et al. 1992].

A simple example in the case of single input and output technology is illustrated in Figure 1. The change in technical efficiency (EFCH), changes in production technology (TECH) and Malmquist Productivity Index in an input-orientation can be computed as [Cooper et al. 2007]:

$$EFCH(P) = \frac{\frac{BD}{BP_2}}{\frac{AC}{AP_1}} \tag{4}$$

$$TECH = \sqrt{\frac{AC}{AE} \cdot \frac{BF}{BD}} \tag{5}$$

$$MPI = \frac{AP_1}{BP_2}\sqrt{\frac{BF}{AC} \cdot \frac{BD}{AE}} \tag{6}$$

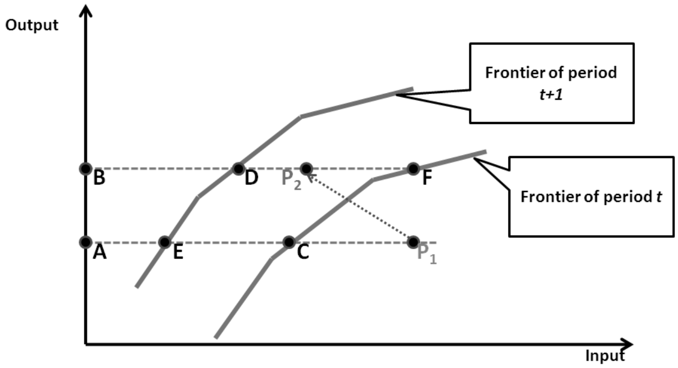

Fig. 1. The Malmquist Productivity Index
Source: Cooper et al. [2007].

RESULTS AND DISCUSSION

In order to determine factors for changes in total productivity of agricultural production in individual voivodeships, the input-oriented Malmquist Productivity Index was used. The model has been oriented to input minimisation, since in the light of current EU legislation on environmental policies and the disseminated principles of sustainable development, it is assumed that currently the only option for the development of Euro-

pean and Polish agriculture is to increase agricultural production through innovation and investment deintensification [Bieńkowski et al. 2012]. The calculated model uses the following variables:
- effect y_1 – value of purchased agricultural goods (million PLN),
- input x_1 – agricultural land area (ha),
- input x_2 – number of people employed in agriculture (people),
- input x_3 – NPK and CaO fertilization (t),
- input x_4 – number of tractors (pcs),
- input x_5 – livestock (thousands).

The average annual growth of the Malmquist Productivity Index for Polish agriculture amounted to 11% (Fig. 2) in the period covered by the study. The most significant increase in agricultural productivity was recorded between 2010 and 2011. The Malmquist Productivity Index for the period was 1.22. The increase of the MPI was influenced primarily by changes in the technology employed. The average growth of the technological change index (TECH) was 8.4% for this period. In turn, the average change of the technical efficiency index (EFCH) was 2.4% for the studied period.

In the period from 2006/2007 to 2009/2010 a visible decline in agricultural productivity in Poland has been observed and only in the period from 2010/2011 to 2011/2012 did the MPI increase to the level of 1.22 and 1.12 accordingly (Fig. 2). It can be concluded that a decrease in agricultural productivity in the first years after Poland's accession to the EU was mainly influenced by adverse changes in technical efficiency. The index for these changes (EFCH) the period from 2005/2006 to 2009/2010 fell from 1.10 to 0.99, indicating a decrease in the technical efficiency of agriculture over this period.

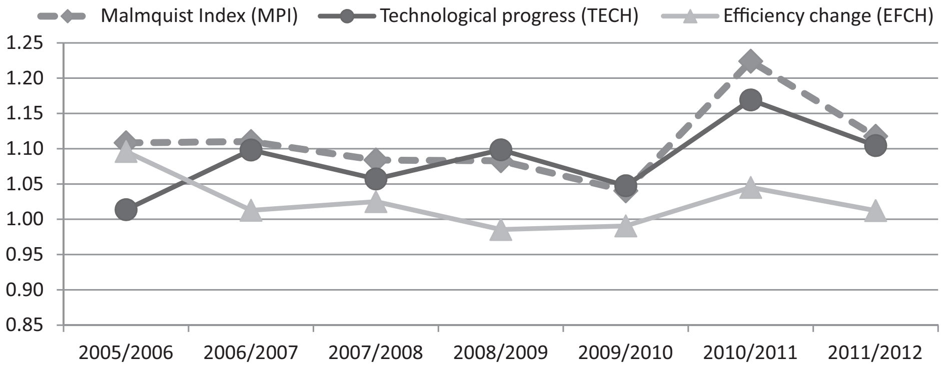

Fig. 2. Malmquist Productivity Index, changes in technical efficiency, changes in production technology calculated for agriculture in Poland

Source: Own calculations.

When analysing the average level of the Malmquist Productivity Index (MPI) in individual voivodeships one should consider that agriculture improved overall productivity over the studied period in each voivodeship. The highest average annual increase in productivity was recorded in the following voivodeships: Dolnośląskie (17%), Lubelskie (17%), Pomorskie (17%) and Mazowieckie (15%), with the lowest in Wielkopolskie (3%) and Lubuskie (2%) – Figure 3.

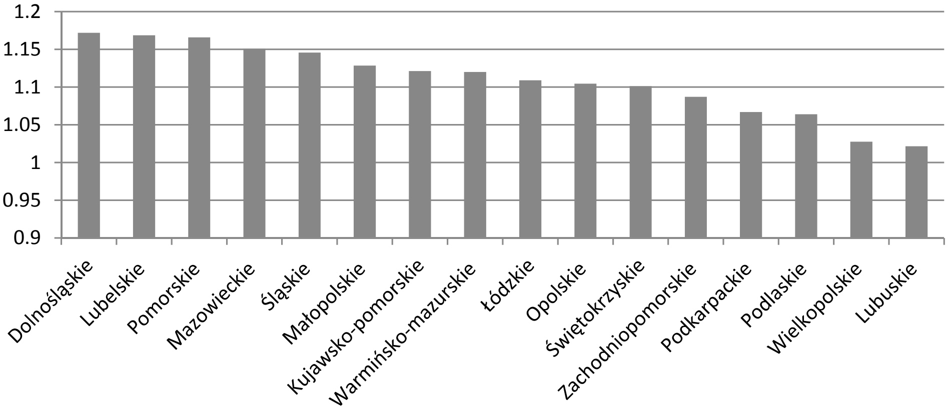

Fig. 3. Average annual Malmquist Productivity Index (MPI) calculated for voivodeships
Source: Own calculations.

Given the index of changes in technical efficiency (EFCH) for agriculture, it has been observed that only Mazowieckie Voivodeship saw an improvement in technical efficiency of agriculture throughout the entire studied period, while the other voivodeships displayed variations in this field. The highest average indices of changes in technical efficiency were recorded in the Śląskie (1.10) and Świętokrzyskie (1.10) voivodeships. In turn, the lowest (less than 1) annual average indices of changes in efficiency were observed in the Lubuskie, Łódzkie and Podlaskie voivodeships (Fig. 4).

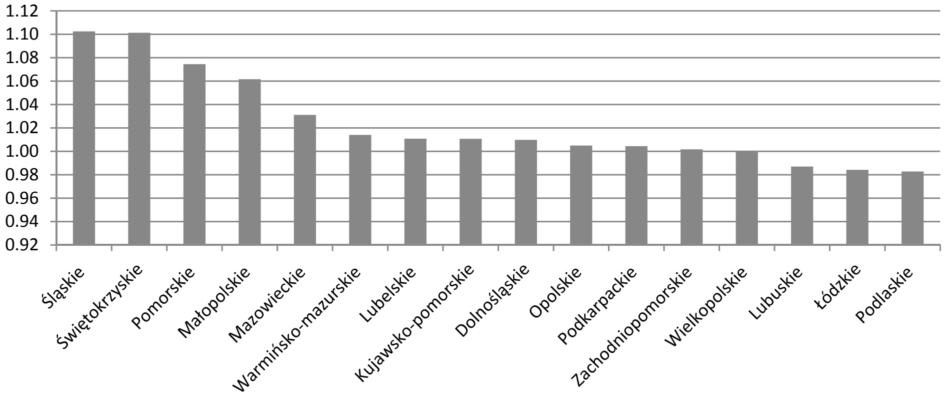

Fig. 4. Changes in technical efficiency (EFCH) for voivodeships
Source: Own calculations.

The largest average annual increases in the index of technological change (TECH) were recorded in Dolnośląskie (16%), Lubelskie (15%) and Łódzkie (13%) voivodeships. One might also assume the least significant level of technological progress was made in the Świętokrzyskie Voivodeship (Fig. 5).

In the next stage of studies it has been decided that the following question should be answered – whether the voivodeships where the greatest productivity was observed were

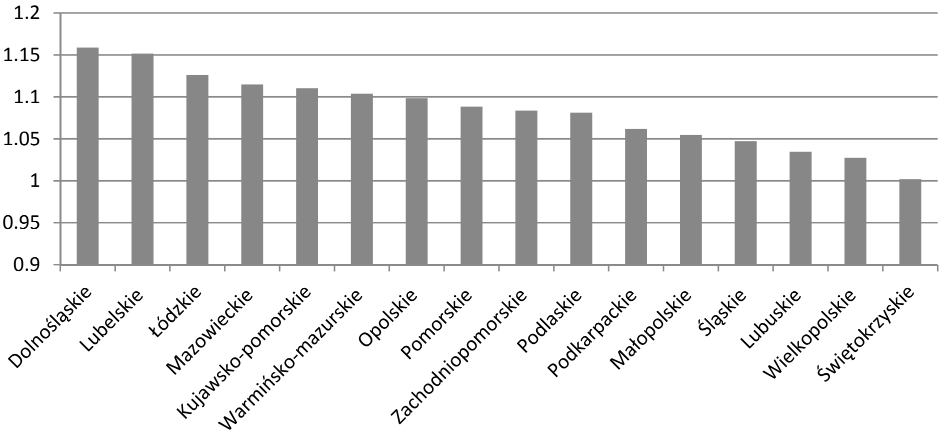

Fig. 5. Changes in production technology (TECH) for voivodeships
Source: Own calculations.

also the ones to benefit from EU funds to the furthest extent? The following EU programs were included in the flow of funds to the agricultural sector:

- Special Pre-Accession Programme for Agriculture and Rural Development (SAPARD 2004–2006),
- Sectoral Operational Programme "Restructuring and Modernisation of the Food Sector and Rural Development 2004–2006" (SOP 2004–2006),
- Rural Development Plan (RDP 2004–2006),
- Rural Development Programme (RDP 2007–2013),
- "Fruit and Vegetable Common Market Organisation" programme (FVCMO 2008),
- "Common Fisheries Policy" programme,
- direct support schemes.

The value of funds was assigned to individual voivodeships. However, given that absolute amounts should not constitute the basis for comparisons between voivodeships, the inflow of funds from the EU was calculated per 1 ha of agricultural land in individual voivodeships. The following voivodeships received EU funding per 1 ha in the period 2004–2012 in excess of the national average: Kujawsko-pomorskie, Wielkopolskie, Podlaskie, Pomorskie, Mazowieckie, Lubelskie and Łódzkie.

It can be noted that only four of the eight voivodeships, where agriculture in 2005–2012 improved its annual average productivity at a level above the national average, were also characterised in the considered period with the highest funding per 1 ha of agricultural land (Fig. 6). The other four voivodeships, despite a level of support lower than the country average per 1 ha of agricultural land, achieved in the period in question a productivity of agriculture higher than the average for the country. Meanwhile, changes in agricultural productivity in the Wielkopolskie and Podlaskie voivodeships were at a level much below the national average, despite the fact that these regions received the highest level of support from EU funds per 1 ha of agricultural land. This makes it possible to conclude that larger funds from the European Union do not translate into a higher level of agriculture productivity improvement in Polish voivodeships.

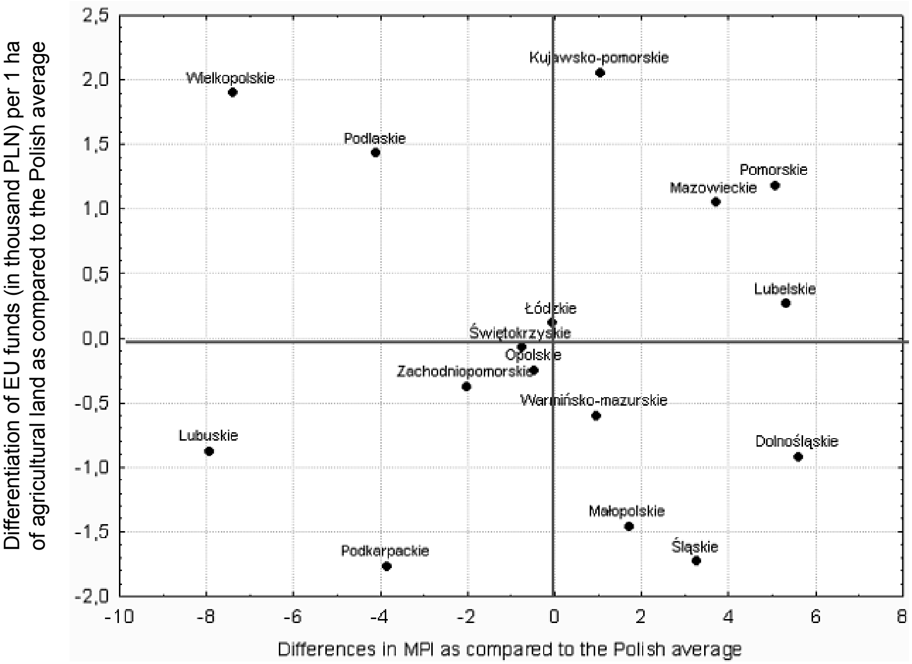

Fig. 6. Differentiation of average annual MPI and EU funds per 1 ha of agricultural land in voivodeships compared to national averages
Source: Own calculations.

It has been decided to verify the above statement by examining the correlation between the inflow of funds from the European Union per 1 ha of agricultural land and the average Malmquist Productivity Index for the individual voivodeships. The correlation coefficient was –0.07, which confirmed the previous observation that larger EU subsidies do not translate into a higher level of agricultural productivity improvement in Polish voivodeships.

CONCLUSIONS

In the article an analysis of the changes in the productivity of Polish agriculture in the 2005–2012 period was performed using the Malmquist Productivity Index. The results of the study have made it possible to indicate the general trend in the change of productivity in agriculture at the national level, as well as for individual voivodeships. The results of the analysis indicate that in 2005–2012 there was a relative increase in agricultural productivity (annual average by 11%). In all voivodeships the average MPI for 2005––2012 period was higher than 1, which indicates an increase in agricultural productivity. However, between individual periods both increases and decreases in productivity were observed. The Kujawsko-pomorskie, Lubelskie, Mazowieckie and Pomorskie voivodeships, where the MPI has not dropped below 0 throughout the analysis period, constitute an exception. The highest annual average MPIs were seen in following voivodeships: Dolnośląskie, Lubelskie, Pomorskie and Mazowieckie.

A decomposition of calculated MPIs has made it possible to identify what factors determined the change in agricultural productivity in Poland. It was found that technological progress was the main factor influencing the change in productivity of Polish agriculture in 2005–2012. In light of the obtained results, it can be said that the current period of integration of Polish agriculture with EU structures was beneficial, because an improvement in agricultural productivity in all voivodeships occurred, but it was conditioned to a greater extent by technological progress than technical efficiency improvement – the conducted studies have therefore made it possible to reject hypothesis H1.

In addition, it was found that productivity of agriculture in voivodeships with a higher inflow of EU funds per 1 ha of agricultural land in 2005–2012 than the national average did not improve to a greater extent than regions with far less support, which allows hypothesis H2 to be rejected.

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ZMIANY PRODUKTYWNOŚCI ROLNICTWA PO AKCESJI POLSKI DO UNII EUROPEJSKIEJ

Streszczenie. W artykule bazując na indeksie produktywności Malmquista, określono zmiany produktywności rolnictwa w poszczególnych polskich województwach w latach 2005––2012. Do modelu przyjęto jako zmienne jeden efekt (wartość skupu produktów rolnych) oraz pięć nakładów (powierzchnia UR, liczba pracujących w rolnictwie, zużycie nawozów, liczba ciągników, inwentarz żywy). W ramach badań wskazano, że większy wpływ na zmianę produktywności rolnictwa w Polsce w okresie po akcesji do UE miał postęp technologiczny niż zmiana efektywności technicznej. Z kolei najwyższy średnioroczny indeks zmian MPI w badanym okresie osiągnęły województwa dolnośląskie, lubelskie, pomorskie i mazowieckie.

Słowa kluczowe: rolnictwo, województwa, efektywność, indeks produktywności Malmquista

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