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Total factor productivity change of agriculture in five Southern European countries

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Abstract

The aim of this paper is to compute the Total Factor Productivity (TFP) change in the agricultural sector of five Southern European countries (Greece, Spain, Italy, Cyprus and Portugal) during 2007-2018. We measure TFP change using the Färe-Primont index that satisfies a set of basic axioms from index theory (e.g., identity, proportionality, transitivity). By decomposing this index, estimates of technical change and technical efficiency as well as scale and mix efficiency are obtained. The results show that Cyprus is the most productive country and the only one that experiences an increase in TFP due to both technical progress and improvement in scale and mix efficiency. The rest of the countries face TFP declines over time due to declining scale and mix efficiency. Technical progress was not adequate to offset the deterioration in efficiency. Policy implications of these results are that countries should continue to pursue technical progress and to improve scale and mix efficiency by changing at least one input and at least one output.
Key words: Färe-Primont index; total factor productivity; scale-mixed efficiency;

technological change

1. Introduction

The Common Agricultural Policy (CAP) has changed over time with the last fundamental change agreed upon in 2013 for the period 2014-2020. Apart from the official objectives in the Treaty, the Commission has defined a broader and more specific set of objectives[1]:

a. viable food production, with a focus on agricultural income, agricultural productivity and price stability;

b. sustainable management of natural resources and climate action, with a focus on greenhouse gas (GHG) emissions, biodiversity, soil and water;

c. balanced territorial development, with a focus on rural employment, growth and poverty in rural areas.

In addition, the 2013 reform of the CAP established a Common Monitoring and Evaluation Framework (CMEF) with the aim of measuring the performance of the CAP implementation for 2014-2020, demonstrating its achievements and improving its efficiency. The performance of the CAP instruments (the direct payments, market measures, and rural measures) shall be measured in relation to the above-mentioned objectives. Five types of indicators were defined to support the assessment of the performance of the CAP[2]: 45 context indicators, 84 output indicators, 41 result indicators, 24 target indicators and 16 impact indicators. The impact indicators reflect the common main objectives of the CAP and will be determined at the evaluation stage at the end of the end of the programme period. Total Factor Productivity (TFP) in agriculture is one important impact indicator to monitor the progress made in reaching the CAP objective of viable food production. In addition, it is a key measure of the economic performance of agriculture and an important driver of farm incomes[3]. Moreover, innovation is one of the drivers of productivity and sustainability (OECD, 2019). The role of innovation in TFP growth is well established in the theoretical and evidence-based literature, and based on this, the European Commission launched the European Innovation Partnership for Agricultural productivity and sustainability (EIP-AGRI) in 2012. It aims at reversing the recent trend of diminishing TFP gains by 2020[4] and promoting a resource-efficient, economically viable, productive and competitive agriculture and forestry sector through funding innovative projects and networking.

EU agricultural productivity is gaining renewed interest not only for international reasons (its capacity to feed more than 9 billion people worldwide in a context of climate change), but also due to competitiveness issues of the EU agricultural and agri-food sector. It should be noted that the European Commission considers productivity and efficiency to be the most reliable long-term indicators or measures of competitiveness (European Commission, 2008). According to the European Commission (2016), productivity in the EU has increased over time, but at a slower rate in recent years than in the past. Specifically, the annual growth rate of agricultural TFP increased by 0.8% over the 2005-2015 period in the EU-28 compared to the previous decade 1995-2015 (1%).

A general definition of productivity is the ability to turn production inputs into outputs that can be measured at the farm, industry or national level (OECD, 2001). It can be simply measured as a partial productivity indicator, relating output to one input (e.g., crop yield or partial productivity of labour), but this does not account for the possibility of either input substitution or output substitution. By contrast, the more comprehensive measure of TFP is a ratio that relates the aggregation of all outputs to the aggregation of all inputs (Latruffe, 2010). According to Latruffe (2010), productivity improvement can be the result of efficiency increase or exploiting economies of scale or technological progress.

The measurement of TFP is based on two methodologies: the index number and the production function estimation. According to O'Donnell (2008), there are two approaches to the construction of index numbers: the axiomatic approach and the functional approach. In the first approach, the class of *multiplicatively-complete* TFP indices includes the Laspeyres, Paasche, Fisher, Törnqvist and Hicks-Moorsteen indices which can be written in terms of aggregate input and output quantities. However, a problem with these is that they fail to satisfy a commonsense transitivity axiom from index number theory and therefore are not proper. One index that is not multiplicatively-complete[5] includes the widely used output- and input- oriented Malmquist TFP indices of Caves et al. (1982). Other special cases include the Lowe TFP index and the Färe-Primont index (FPI) defined by O'Donnell (2011a) that satisfy all economically-relevant axioms from index number theory, including the identity and transitivity axioms. The TFP of agriculture in the member states of the EU has been investigated using the Malmquist productivity index (Coelli and Rao, 2005; Domanska et al., 2014; Kijek et al., 2016; Latruffe and Desjeux, 2016; Błażejczyk-Majka and Kala, 2015). However, few studies have applied the FPI approach for both EU and non-EU countries (Rahman and Salim, 2013; Islam et al., 2014; Khan et al., 2014; Baležentis, 2015; Baráth and Fertő, 2017; Dakpo et al., 2018; Dakpo et al., 2019; Kijek et al., 2019). The results of Baráth and Fertő (2017) and of Kijek et al. (2019) can be compared with the result of this study, although these studies use a different data source. Kijek et. al. (2019) investigated the changes in TFP for 25 EU countries between 2004 and 2016 using FPI and data from Eurostat. The results show that Spain has the biggest change (+12%), while Greece and Portugal have (-12%) and (-6%), respectively. No change is observed in Italy. Baráth and Fertő (2017) apply and decompose FPI for 23 EU countries using data from Faostat for the period 2004-2013. The findings imply that agricultural TFP has slightly changed (-0.15%) in the EU; however there are significant differences across member states. Countries like Greece, Italy and Portugal face changes by (-1.18%), (-0.40%) and (-0.36%), respectively, due to decreases in scale and mix efficiency. The increase in TFP that occurs in Spain, by (0.85%) is mainly caused by technical progress.

The aim of the present paper is to investigate relative productivity levels and to decompose agricultural productivity change for Southeast EU countries (Greece, Italy, Portugal, Cyprus and Spain) using FPI, between 2004 and 2016. The rest of the paper is organized as follows. Section 2 discusses and outlines the methodology of Färe-Primont index and associated efficiency decompositions. Section 3 presents the data variables and their sources. Section 4 discusses the results. The paper is concluded in section 5.

2. Methodology

In order to estimate the productivity indexes, we apply the Färe-Primont index (FPI). The FPI is free from restrictive assumptions about the nature of the production technology, a firm's optimizing behavior, the structure of markets, returns to scale and/or price information. Moreover, FPI satisfies all other regulatory conditions of an index, such as multiplicative completeness and the transitivity test (O'Donnell, 2011a). The above is a sufficient condition for decomposing a TFP index into measures of technical change (movements in the production frontier), technical efficiency change (movements of the units toward or away from the production frontier), scale efficiency and mix efficiency change (movements around the production frontier to capture economies of scope and scale) (Laurenceson and O'Donnell, 2014).

Productivity is defined by the OECD (2001) as the relationship between the volume of output and the volume of input used to generate that output. The productivity of a single-output single-input firm is almost always defined as the output-input ratio. Total Factor Productivity (TFP) is defined by O'Donnell (2008) as a concept of multiple-output multiple-input, by formally defining productivity to be the ratio of an aggregate output to an aggregate input.

Let $x_{it} = (x_{1it}, x_{2it}, \ldots x_{mit})$ and $q_{it} = (q_{1it}, q_{2it}, \ldots q_{mit})$ where q_{it} and $x_{it} \in R^+$ are the vectors of inputs and outputs quantities (m) for firm *i* in period *t*. TFP is defined as (O'Donnell, 2008):

$$TFP_{it} = Q_{it}/X_{it} \tag{1}$$

where $Q_{it}= Q(q_{it})$ and $X_{it} = (x_{it})$ are the aggregate output and aggregate input, respectively. The aggregator functions are non-negative, non-decreasing and linearly homogeneous.

O' Donnell (2008) measures the overall productive efficiency of a firm as the ratio of observed TFP to the maximum TFP possible, using the available technology. He defines TFP efficiency (TFPE) as:

$$TFPE_{it} = {TFP_{it}}/{TFP^*_{it}}$$

(2)

Like Coelli and Rao (2005), this paper allows for technical progress and regress. Technical progress can be thought of as expansion in the production possibilities set coming, for example, from a scientific discovery. Conversely, technical regress can be narrowly conceptualized as contraction in the production possibilities set. O'Donnell (2010) states that technological regress is narrowly conceptualized as "we forget the things we know".

In this paper, technological change could also be defined as a measure of any changes in the external environment in which production takes place. Agriculture is strongly influenced by environmental factors such as climate and weather. These are exogenous variables that are physically involved in the production process but are beyond the control of the farm.

O'Donnell (2012) shows that equation (2) can be decomposed in several ways using various efficiency measures, such as:

$$TFPE_{it} = OTE_{it} \times OME_{it} \times ROSE_{it}$$

(3)

where OTE_{it}, OME_{it} and $ROSE_{it}$ denote measurements of output-oriented pure technical efficiency, mix efficiency and residual scale efficiency. Specifically:

- OTE, defined by Farell (1957), is the difference between the observed TFP and the maximum TFP possible using the existing technology, while holding the output mix, the input mix and the input level fixed.
- OME defines the pure mix efficiency, which is the difference between TFP at a technically efficient point using existing technology and the maximum TFP that is possible holding the input level fixed but allowing the output level and mix to vary.
- ROSE measures the difference between TFP at a technical and mix efficient point and the maximum TFP that is possible through altering both input and output with existing technology (unrestricted production frontier).

The decomposition of equation (3) focuses on the part of firm efficiency, coming from a misallocation in the mix of outputs and scale efficiency appear then as a residual.

An alternative decomposition is also possible, as:

$$TFPE_{it} = OTE_{it} \times OSE_{it} \times RME_{it}$$

(4)

where OSE_{it}, RME_{it} denote measures of output-oriented scale efficiency and residual mix efficiency. Particularly:

- OSE defines the pure scale efficiency as the difference between TFP at a technically efficient point and the maximum TFP based on existing technology, while holding the input and output mixes fixed but allowing levels to vary.
- RME measures the difference between TFP at a technical and scale-efficient point and the maximum TFP possible through altering input and output mixes with existing technology (unrestricted production frontier).

The decomposition of equation (4) focuses on the part of firm efficiency, coming from a misallocation in the scale of outputs and mix efficiency appear then as a residual.

The last two terms of the previous two decompositions give the same value, which we denote by OSME for output-oriented mix and scale efficiency, i.e.:

$$OSME_{it} = OME_{it} \times ROSE_{it} = OSE_{it} \times RME_{it}$$
(5)

The output-oriented scale mix efficiency (OSME) measures the increase in TFP due to the movements from the technically efficient point to the point of maximum productivity.

These decompositions will allow us to identify the main source of productivity change in the Greek agricultural sector.

3. Data and variables

The dataset used in this empirical exercise is taken from the EUROSTAT database and the economic account for agriculture (values at current prices). The two outputs are the value of crop output and the value of livestock output at producer prices. There are five inputs: Land is the total utilized agricultural area in 1000 hectares. Labour is represented by the total labour measured in Annual Working Units (AWU). Capital is defined as the fixed capital consumption, and intermediate inputs are represented by the total intermediate consumption. The selection of outputs and inputs variables are based on Baráth and Fertő (2017). The livestock capital is taken from the USDA database of Fuglie et al., (2012) defined in "cattle equivalents" based on relative size and feeding requirements. Outputs as well as inputs (except labour and land) are deflated by country price indexes on each individual output and input (2005=100). Descriptive statistics for all variables are presented in Table 1.

Tab. 1. *Descriptive statistics*

GREECE				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Crop output	7144	549	6415	8265
Livestock output	2731	182	2476	3027
AWU	463	40	428	463
UAA	5162	428	3969	5532
Capital	1375	159	1139	1612
Intermediate inputs	5277	189	4987	5640
Livestock capital	2393	61	2318	2393
SPAIN				

Variable	Mean	Std. Dev.	Min.	Max.
Crop output	27099	2218	24197	30430
Livestock output	16474	1216	14665	18647
AWU	892	70	800	1012
UAA	23984	475	23463	25003
Capital	5096	122	4848	5221
Intermediate inputs	20580	1124	18431	22564
Livestock capital	14362	506	13563	14865
		ITALY		
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Crop output	30210	1334	28833	32654
Livestock output	16185	683	15121	17112
AWU	1133	39	1077	1212
UAA	12933	529	12426	14457
Capital	12311	474	11524	12888
Intermediate inputs	23843	738	22890	25141
Livestock capital	9699	112	9536	9923
		CYPRUS		
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Crop output	311	38	250	369
Livestock output	359	37	315	429
AWU	24	3	18	26
UAA	121	12	107	150
Capital	14	2	12	17
Intermediate inputs	386	12	364	406
Livestock capital	226	11	217	249

PORTUGAL				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Crop output	3903	237	3566	4298
Livestock output	2817	95	2673	3044
AWU	289	40	238	351
UAA	3666	43	3591	3726
Capital	767	29	719	816
Intermediate inputs	4283	190	3942	4555
Livestock capital	2210	79	2087	2318

4. Empirical results

Table 2 presents the Färe-Primont estimates (levels) of TFP, maximum TFP and TFP efficiency and their relative change between 2007 and 2018. It is assumed that the production technology exhibits variable returns to scale (VRS) and allows both technical progress and technical regress. All TFP and efficiency measures reported in this section were computed using DPIN 3.0 software provided by the Center for Efficiency and Productivity Analysis (CEPA) at the University of Queensland in Australia (O'Donnell, 2011b). In 2007, Greece was the most productive country and Portugal the least productive. In 2018, Cyprus became the most productive and Portugal remained the least productive. During the sample period, only Cyprus improved its TFP by 21%, while the TFP in the remaining countries deteriorated. Specifically, Greece experienced the biggest decrease, by 10%, followed by Portugal (7%), Italy (4%) and Spain (1%). This outcome is due to the fall in the overall TFPE. It is worth mentioning that in 2007 Greece was fully productive (TFPE=1.00) and Cyprus became fully productive in 2018. The estimates of technical change TFP* are obtained under the assumption that in any given period all countries experience the same set of production possibilities; therefore, they have the same estimates. Each country faces 11% technical progress. However, this can't offset the high decreases in TFPE. Thus, the fall in TFP is due to the deterioration in the overall efficiency.

Tab. 2. *TFP change, technical change and efficiency change: 2007-2018*

	TFP			TFP*			TFPE		
	2007	2018	Δ	2007	2018	Δ	2007	2018	Δ

Greece	0.94	0.85	0.90	0.94	1.04	1.11	1.00	0.82	0.82
Spain	0.93	0.92	0.99	0.94	1.04	1.11	0.99	0.89	0.90
Italy	0.94	0.90	0.96	0.94	1.04	1.11	0.99	0.87	0.88
Cyprus	0.86	1.04	1.21	0.94	1.04	1.11	0.92	1.00	1.09
Portugal	0.84	0.78	0.93	0.94	1.04	1.11	0.89	0.76	0.85

Tab. 3. *Output-Oriented Components of Efficiency Change*

	TFPE=OTE*OSME			OTE			OSME		
	2007	2018	Δ	2007	2018	Δ	2007	2018	Δ
Greece	1.00	0.82	0.82	1.00	1.00	1.00	1.00	0.82	0.82
Spain	0.99	0.89	0.90	1.00	1.00	1.00	0.99	0.89	0.90
Italy	0.99	0.87	0.88	1.00	1.00	1.00	0.99	0.87	0.88
Cyprus	0.92	1.00	1.09	1.00	1.00	1.00	0.92	1.00	1.09
Portugal	0.89	0.76	0.85	1.00	0.93	0.93	0.89	0.80	0.90

The overall output-oriented efficiency decomposition is reported in Table 3, which indicates that all countries were technically efficient in 2007 and 2018, except for Portugal where its technical efficiency dropped by 7% in 2018. It is known from methodology (eq. 4 & eq. 5) that TFPE can be decomposed in OTE and OSME. For the first four countries, changes in TFPE are mainly due to changes in scale and mix efficiency (OSME). It is observed that OSME has decreased by 22% in Italy, 10% in Portugal, 10% in Spain and 8% in Greece. To the contrary, Cyprus has increased OSME by 9%, becoming fully productive and efficient in 2018.

Table 4 reports the estimated average annual rates of growth in the productivity, technological change and efficiency of agriculture in two sub-periods: 2007–2014 and 2014–2018. Not surprisingly, the average annual rates of the whole period reflect the results of Table 1. In the sub-period 2007-2014, all countries except Cyprus face negative productivity growth due to the deterioration in the overall efficiency. In Cyprus, the growth in TFPE was the driver for the growth in TFP. During this sub-period, Spain experiences the highest negative average rate of growth (-1.73%) per annum in TFP, which was mainly the result of the negative growth in overall efficiency. This sub-period is characterized by technical regress which has affected the negative growth rate in TFP in the case of Italy (-0.63%) and in the case of Portugal (-1,18%). In the second sub-period, the technical progress is the main factor for the growth in TFP for all countries.

Tab. 4. *Average annual rates of growth* in TFP and efficiency (%)*

	2007-2014			2014-2018			2007-2018		
	TFP	TFP*	TFPE	TFP	TFP*	TFPE	TFP	TFP*	TFPE
Greece	-1.54	-0.71	-0.83	0.28	3.67	-3.39	-0.88	0.88	-1.76
Spain	-1.73	-0.71	-1.02	2.67	3.67	-1.00	-0.13	0.88	-1.01
Italy	-0.63	-0.71	0.08	0.13	3.67	-3.54	-0.35	0.88	-1.23
Cyprus	0.54	-0.71	1.25	3.67	3.67	0	1.68	0.88	0.80
Portugal	-1.18	-0.71	-0.46	0.42	3.67	-3.25	-0.60	0.88	-1.48

*$\ln(TFP_{2018}/TFP_{2007})/(2018-2007)$

Cyprus exhibits the highest average rate of growth in TFP in the second sub-period, which was mainly due to the high technical progress. For the whole period it is indicated that the decline in TFP growth for Greece, Spain, Italy and Portugal is due to the decline in TFPE during the period 2014-2018. While in the case of Cyprus the increase in TFP growth is due to the high increase in TFPE during the period 2007-2014. Finally, during the whole period, the negative growth in TFP, for all countries except Cyprus, is the result of the negative growth in overall efficiency. The high negative annual rates of TFPE in 2014-2018 resulted in the deterioration of TFPE in the whole period and in the negative growth of TFP.

Figure 1 presents the Färe-Primont estimates of the TFP of agriculture for the five southern European countries. All measures of TFP and efficiency components for each country are presented in Appendix A at the end of the paper. It is observed that Greece and Spain follow the same trend until 2014 whereas, after that, Spain follows a higher upward trend than Greece. After 2011, for Italy and Portugal, TFP follows a stable trend. The TFP trend for Spain and Cyprus goes up after 2015, while for Greece, it goes down.

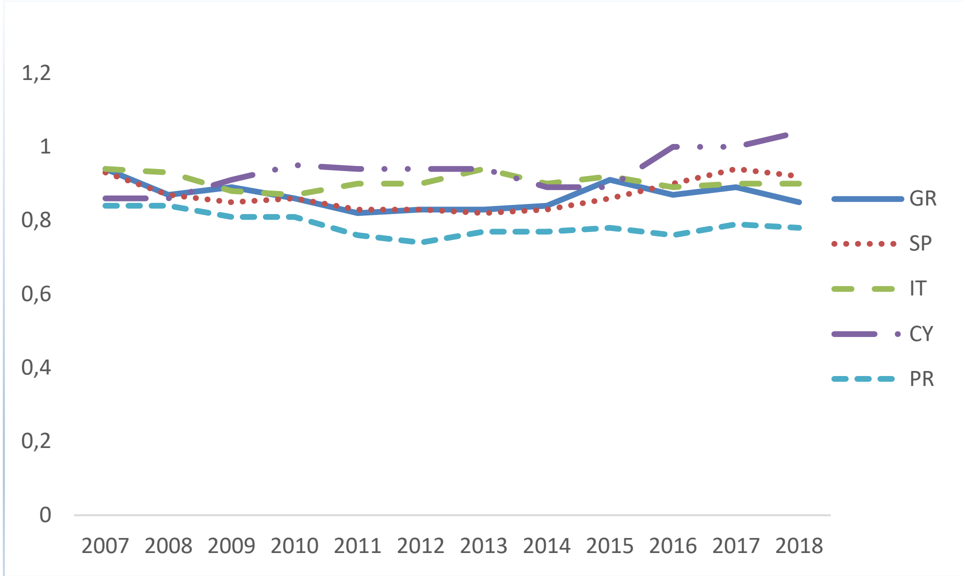

Fig. 1. *Färe-Primont estimates of the TFP*

It is observed that, on average, all countries are technically efficient (OTE=1), meaning that they operate on the frontier. An OSE value equal to 1 indicates that the optimal size is achieved for all countries except Portugal (OSE=0.90). Additionally, for OME=1, the result reveals that economies of scope are achieved by changing optimal the output mixes (Appendix A).

Cyprus is the most productive (93%) and most efficient (99%) country in all years except 2007, 2008 and 2015. Cyprus is fully efficient, reaching the highest productivity in 2018. Italy comes second in terms of the average value of TFP (0.91), being 95% scale and mix efficient. Spain and Greece exhibit the same TFP, but Greece is 1% less efficient than Spain. Finally, Portugal is the least productive (79%), reaching the highest value in 2007 and 2008. The average inefficiency in the examined period is high in Portugal (17%) while smaller in Greece (9%), Spain (8%) and Italy (5%).

5. Conclusions

The main aim of this paper is to provide estimates of agricultural productivity growth for five Southern European countries (Greece, Cyprus, Spain, Italy and Portugal) using more recent methodology. We calculate the Färe-Primont index to obtain indicators of TFP covering an 11-year period (2007 to 2018). The TFP indices are decomposed into a measure of technical change and measures of efficiency change including pure technical efficiency, mix efficiency change and scale efficiency change.

The empirical results reveal that, during the study period, TFP declined for all countries except Cyprus, where TFP increased by 21% (0.80% p.a.). This increase is due to both technical progress and the improvement in scale and mix efficiency. The smallest decrease in TFP, by 1% (1.01% p.a.), is recorded in Spain and the biggest is in Greece, by 10% (1.76% p.a.). Consequently, Portugal follows with a 7% (1.48% p.a.) decrease and Italy with 4% (1.23% p.a.). These decreases in TFP are due to the decreases in the scale and mix efficiency. However, the technical progress could not offset the deterioration in overall efficiency. Technical efficiency is satisfied, and economies of scope are achieved by changing optimal output mixes. In order for managers to increase TFP in those four countries, they will need to change at least one output and at least one input. Comparable information with our results regarding the TFP of Greek agriculture can be found in Barath and Fertő, (2017) and in Kijek et al., (2019). Barath and Fertő's findings show that TFP for Greece decreased significantly by 11%, for Italy by (-4%), for Portugal by (-3%),but increased for Spain by 8%, for the period 2004-2013 using Färe-Primont indexes. Kijek et al.'s (2019) results for 25 EU countries in 2004-2016 using Färe-Primont indexes indicate a significant decrease of 14% for Greece, (-3%) for Italy and (+17%) for Spain. Hence, we can conclude that our results concerning TFP for Greece, Italy and Portugal are consistent with the relevant findings of Barath and Ferto (2017) and Kijek (2019), while they record contradictory results with ours for Spain. Additionally, Barath and Ferto (2017) agree with our result that the deterioration in scale and mix efficiency is the main driver of the decrease in TFP.

Although this study is limited to only the estimation of TFP and its various components, farm- specific factors (such as farm size, education and infrastructure) and government institutions (such as extension services and research development) are also significant in determining agricultural productivity. Therefore, the effects of these variables on TFP will need to be investigated in future studies.

NOTES:

[1] Article 110(2) of Regulation (EU) No 1306/2013.
[2]Commission Implementing Regulation (EU) No 834/2014.
[3]European Commission (2017 updated) CAP CONTEXT INDICATORS 2014-2020 "27. Total factor productivity".
[4]COM (2012) 79 final.
[5]There are two special cases in which the Malmquist productivity index is a multiplicatively complete and recognized measure of TFP change. The first case is when the technology is input-homothetic and exhibits constant returns to scale, and the second case is when the technology exhibits constant returns to scale and there is no technical change (O'Donnell, 2010).

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APPENDIX A

Tab. A1 *Measures of TFP and efficiency components in Greece*

Year	TFP	TFP*	TFPE	OTE	OSME	OSE	OME	RME	ROSE
2007	0.94	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	0.87	0.93	0.93	1.00	0.93	1.00	1.00	0.93	0.93

2009	0.89	0.91	0.98	1.00	0.98	1.00	1.00	0.98	0.98
2010	0.86	0.95	0.90	1.00	0.90	1.00	1.00	0.90	0.90
2011	0.82	0.94	0.87	1.00	0.87	1.00	1.00	0.87	0.87
2012	0.83	0.94	0.89	1.00	0.89	1.00	1.00	0.89	0.89
2013	0.83	0.94	0.88	1.00	0.88	1.00	1.00	0.88	0.88
2014	0.84	0.90	0.94	1.00	0.94	1.00	1.00	0.94	0.94
2015	0.91	0.92	0.98	1.00	0.98	1.00	1.00	0.98	0.98
2016	0.87	1.00	0.87	1.00	0.87	1.00	1.00	0.87	0.87
2017	0.89	1.00	0.89	1.00	0.89	1.00	1.00	0.89	0.89
2018	0.85	1.04	0.82	1.00	0.82	1.00	1.00	0.82	0.82
G-mean	*0.87*	*0.95*	*0.91*	*1.00*	*0.91*	*1.00*	*1.00*	*0.91*	*0.91*

Tab. A2 *Measures of TFP and efficiency components in Spain*

Year	TFP	TFP^{*}	TFPE	OTE	OSME	OSE	OME	RME	ROSE
2007	0.93	0.94	0.99	1.00	0.99	1.00	1.00	0.99	0.99
2008	0.87	0.93	0.93	1.00	0.93	1.00	1.00	0.93	0.93
2009	0.85	0.91	0.93	1.00	0.93	1.00	1.00	0.93	0.93
2010	0.86	0.95	0.90	1.00	0.90	1.00	1.00	0.90	0.90
2011	0.83	0.94	0.89	1.00	0.89	1.00	1.00	0.89	0.89
2012	0.83	0.94	0.88	1.00	0.88	1.00	1.00	0.88	0.88
2013	0.82	0.94	0.88	1.00	0.88	1.00	1.00	0.88	0.88
2014	0.83	0.90	0.92	1.00	0.92	1.00	1.00	0.92	0.92
2015	0.86	0.92	0.93	1.00	0.93	1.00	1.00	0.93	0.93

2016	0.90	1.00	0.91	1.00	0.91	1.00	1.00	0.91	0.91
2017	0.94	1.00	0.94	1.00	0.94	1.00	1.00	0.94	0.94
2018	0.92	1.04	0.89	1.00	0.89	1.00	1.00	0.89	0.89
G-mean	*0.87*	*0.95*	*0.92*	*1.00*	*0.92*	*1.00*	*1.00*	*0.92*	*0.92*

Tab. A3 *Measures of TFP and efficiency components in Italy*

Year	TFP	TFP*	TFPE	OTE	OSME	OSE	OME	RME	ROSE
2007	0.94	0.94	0.99	1.00	0.99	1.00	1.00	0.99	0.99
2008	0.93	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2009	0.88	0.91	0.96	1.00	0.96	1.00	1.00	0.96	0.96
2010	0.87	0.95	0.91	1.00	0.91	1.00	1.00	0.91	0.91
2011	0.90	0.94	0.96	1.00	0.96	1.00	1.00	0.96	0.96
2012	0.90	0.94	0.97	1.00	0.97	1.00	1.00	0.97	0.97
2013	0.94	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2014	0.90	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.92	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2016	0.89	1.00	0.89	1.00	0.89	1.00	1.00	0.89	0.89
2017	0.90	1.00	0.91	1.00	0.91	1.00	1.00	0.91	0.91
2018	0.90	1.04	0.87	1.00	0.87	1.00	1.00	0.87	0.87
G-mean	*0.91*	*0.95*	*0.95*	*1.00*	*0.95*	*1.00*	*1.00*	*0.95*	*0.95*

Tab. A4 *Measures of TFP and efficiency components in Cyprus*

Year	TFP	TFP*	TFPE	OTE	OSME	OSE	OME	RME	ROSE
2007	0.86	0.94	0.92	1.00	0.92	1.00	1.00	0.92	0.92

2008	0.86	0.93	0.92	1.00	0.92	1.00	1.00	0.92	0.92
2009	0.91	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.94	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	0.94	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	0.94	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2014	0.89	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.89	0.92	0.97	1.00	0.97	1.00	1.00	0.97	0.97
2016	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2017	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018	1.04	1.04	1.04	1.00	1.00	1.00	1.00	1.00	1.00
G-mean	*0.93*	*0.95*	*0.99*	*1.00*	*0.98*	*1.00*	*1.00*	*0.98*	*0.98*

Tab. A5 *Measures of TFP and efficiency components in Portugal*

Year	TFP	TFP*	TFPE	OTE	OSME	OSE	OME	RME	ROSE
2007	0.84	0.94	0.89	1.00	0.89	1.00	1.00	0.89	0.89
2008	0.84	0.93	0.90	1.00	0.90	1.00	1.00	0.90	0.90
2009	0.81	0.91	0.89	1.00	0.89	0.90	1.00	0.99	0.89
2010	0.81	0.95	0.85	1.00	0.85	0.89	1.00	0.96	0.85
2011	0.76	0.94	0.82	1.00	0.82	0.85	1.00	0.97	0.82
2012	0.74	0.94	0.79	1.00	0.79	0.81	1.00	0.98	0.80
2013	0.77	0.94	0.82	1.00	0.82	0.88	1.00	0.93	0.82
2014	0.77	0.90	0.86	1.00	0.86	0.90	1.00	0.95	0.86

2015	0.78	0.92	0.85	1.00	0.85	0.88	1.00	0.97	0.85
2016	0.76	1.00	0.76	1.00	0.79	0.90	0.97	0.88	0.81
2017	0.79	1.00	0.79	1.00	0.83	0.92	0.99	0.89	0.83
2018	0.78	1.04	0.76	1.00	0.80	0.93	0.99	0.86	0.80
G-mean	*0.79*	*0.95*	*0.83*	*1.00*	*0.84*	*0.90*	*1.00*	*0.93*	*0.84*

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