

Dear Editor and Reviewers,

Thank you for your letter and for the reviewers' comments on our manuscript entitled "Spatiotemporal Heterogeneity of Total Factor Productivity of Grain in the Yangtze River Delta, China" (land-2440808). These comments are valuable and helpful for revising and improving our paper. We read the comments and have made point-by-point revisions, which are marked in red in the revised paper. Revision details are listed as follows:

Reviewer #1:

1.Line 8, Line 20: What is "DEA" 、 "GDP", please use full name for first occurrence.

Response: Thanks for your careful review and this comment has been taken. DEA and GDP are the abbreviation of "Data Envelopment Analysis" and "Gross Domestic Product", respectively, both of which are indicated for their first occurrence.

"This study uses the data envelopment analysis (DEA)-Malmquist index method to measure the total factor productivity of grain in each city from 2012 to 2020 based on panel data"

"The driving factors, such as the development level of grain economy, the amount of fertilizer used per unit area and per capita gross domestic product (GDP)"

2. Line172-Line258: Overview (or summarize) rather than piling up literature.

Response: Thanks for your careful review and this comment has been taken. The literature review part has been improved as follow:

"2. Literature Review

Total factor productivity (TFP) refers to the comprehensive productivity of the production unit (mainly the enterprise) as a factor in a system, which is different from factor productivity (such as technical productivity). It is a productivity indicator that measures the total output per unit of total input,

i.e., the ratio of the total output to the sum of all production inputs [5,6]. Basing on the concept of TFP, the TFPG refers to the development and utilization efficiency of various factors, such as labor, capital, and technology, in the process of grain production, which can comprehensively reflect the development level of labor conditions, resource allocation, technological progress, and other factors [7]. And increasing the TFPG is a critical way to ensure grain security and ecological security and to achieve rural revitalization [8]. Lots of literature study the TFPG, including the decomposition, measurement, and its critical role to GDP. For example, Yao, SJ, et al. (2001) used the panel data of China's 30 provincial units from 1987 to 1992 to study the spatial differences in China's grain production efficiency, and they analyzed in detail the impact of the decomposition of TFP on low technical efficiency [9]. Brugnaro, Ricardo, and Bacha, Carlos José Caetano's research focused on agricultural TFP as one of the most important agricultural variables contributing to US GDP [10]. And Chatrath, R. et al. (2007) proposed remedial measures, such as green fertilization and crop residue recovery, balanced fertilization, comprehensive nutrient management, and rice and wheat system diversification, to increase TFP in the context of the declining TFP of high-yield rice and wheat planting systems in the Indo-Ganges Plain [11].

To measure the TFPG, data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are mostly employed. Bayarsaihan, T and Coelli, TJ (2003) used the methods of SFA and DEA to measure the variations of the TFP of grain and potato during 1977-1990 in Mongolia [12]. James Odeck (2007) also used the combination method of parametric SFA and non-parametric DEA to measure the rice production capacity and technical efficiency of 19 professional grain farm producers in eastern Norway based on sample data from 1987 to 1997. Studies have shown that technological efficiency is an important factor in improving grain production capacity [13]. Furthermore, Hossain et al. (2012) used a stochastic frontier production model and DEA to estimate the growth rate of the TFP of rice crops in Bangladesh [14]. These

methods usually assume that all producers follow the same technical constraints when evaluating production efficiency, but, in reality, there are differences in the technical level and resource allocation of different farmers, which cannot fully meet this ideal situation. Song W et al. (2016) used the traditional three-stage Malmquist productivity index (MPI) and bootstrap Malmquist productivity index (Bootstrap MPI) to measure TFP, compensating for the shortcomings of the traditional MPI models that underestimate the technical change index and technical efficiency change index of crop production machinery components in China [15]. Zhang Q et al. (2018) used the three-stage DEA model and the Tobit regression model to analyze the influencing factors of China's grain production efficiency, based on the provincial panel data of the main grain-producing areas from 2006 to 2016 [16]. Linn Maenhout et al. (2019) used descriptive statistics and DEA to analyze the profitability and efficiency of rice production in the Irrawaddy region of Myanmar based on the original data of 130 randomly sampled farmers [17]. Other parts of the literature used the geographically weighted regression model, but the data used in the geographically weighted regression model are cross-sectional. Due to excessive parameters, the model parameters cannot be estimated [34]. The spatiotemporal geographically weighted regression model can solve the above non-estimated problems, through introducing the time dimension into the geographically weighted regression model[35]. Therefore, this study used the DEA-Malmquist index method to measure TFPG and explored the spatiotemporal evolution of TFPG with the geographically and temporally weighted regression model.

The evolution characteristics of the TFPG is important local knowledge to deepen understanding of TFPG at macro scale. Panel dataset at household, county, province, and country level are mostly employed to map TFPG. For example, Yao, SB, and Li, H (2010) collected household data to calculate TFP using the Malmquist index method, and analyzed the evolution characteristics of TFP from 1998 to 2004 [18]. Hou, LK et al. (2012), mainly based on county-level data, used random frontier and mapping analysis

methods to explore the spatial and temporal changes in TFP in China's agricultural production from 1995 to 1999 [19]. Song, W et al. (2016) used the panel data of 31 provincial units in China from 1999 to 2008 to measure the changes in the TFP of crop production in China. Key, N (2019) estimated the TFP of five scale levels of grain production farms in the corn belt region of the United States to determine whether the observed productivity differences are likely to persist [20]. Zhang, DH et al. (2021) explored the evolution characteristics and regional distribution differences of the TFPG in 13 major grain-producing regions of China from 2001 to 2007; they analyzed it from the perspective of the decomposition index and found that its changes mainly depend on changes in technological efficiency [21]. Zheng, ZH et al. (2022) analyzed the changes in the TFP of grain and major grain crops as commodities using provincial and time-series data merged from 1980 to 2018 in China. The research conducted by Zheng, ZH, Cheng, S, and Henneberry, SR (2022), from the perspective of financial support, discussed the evolution characteristics and regional distribution differences of the TFP index of grain production in China's main grain-producing areas, including agricultural loans in the input index. Hence, it can be concluded that evolution characteristics of TFPG is place-specific. Zhang , DH et al. (2021) and Zheng, ZH et al. (2022) are basis of this study, but both of them ignored the importance of urbanized area. This study focused on the China's urbanized area, the Yangtze River Delta, to explore its spatial and temporal heterogeneity.

The influencing factors of TFPG is the basis to propose practical strategies. The TFPG can be affected by numerous factors, including social, economic, natural factors, and technological progress has been widely acknowledged as a key factor. For example, Myyra, S et al. (2009) highlighted the nature of grain cultivation in Finland while also considering the overall trend of TFP and the challenges and influencing factors faced due to annual changes [22]. Li, L et al. (2010) used a DEA to determine the changes in TFP, the sources of growth, and the determinants at the farm level, and found that land terraces

and access to credit greatly contributed to TFP and technological growth [23]. Kunimitsu, Y, and Kudo, R (2015) evaluated the impact of extreme rainfall incidence on the TFP of rice in Japan by estimating causal functions [24]. Elasmraag, YH, and Alarcon, S (2017) mainly focused on measuring the TFP of major wheat-producing provinces in Egypt from 1990 to 2012, and decomposed it into technological change, efficiency change, and scale change. They found that the contribution of technological change components is more important than that of efficiency change components. Njuki, E et al. (2018) focused on quantifying and investigating the role of changing weather patterns in explaining annual fluctuations in the TFPG [25]. Key, N (2018) concluded that there was a strong positive correlation between farm size and TFP, indicating that the integration of production contributes to the recent total productivity growth of the crop sector [26]. Sheng, Y, and Chancellor, W (2019) used farm-level data from the Australian grain industry from 1989 to 2004 to investigate the relationship between farm size, TFP, and its potential determinants [27]. Zuo, YX (2019) analyzed the impact of agricultural human capital, product market development, factor market development, financial support, non-agricultural employment, total employment, and disaster rate on agricultural TFP. Conradie, B et al. (2021) studied the effect of moist heat stress on the TFP of crop cultivation under experimental farm conditions, and the results showed that the interaction between heat and water stress generally reduces productivity. Fan, QQ et al. (2022) found that technological progress contributes significantly to the overall and regional TFP of China's grain enterprises by examining their convergence. Although these studies were conducted globally, they provide important factor list of TFPG for this study. The influencing factors of the TFPG mainly include the level of disaster caused by grain crops, the development level of grain economy, the amount of fertilizer used per unit area, the total power of agricultural machinery, per capita GDP, per capita operating scale, the proportion of the grain-growing population, and the yield per unit area of grain."

3. Line290-292: sentences were not understandable.

Responses: Thanks for your careful review and this comment has been taken. The revised sentences are as follows:

“This study used the DEAP to calculate the TFPG in 41 cities in the Yangtze River Delta and analyzed the spatiotemporal evolution of the TFP across the Yangtze River Delta. The output indicator is the grain production of the 41 cities, and the input indicators include the number of employees in the primary industry, the sown area of grain, the total power of agricultural machinery, and the use of agricultural fertilizers.”

4. Figure 4 and Figure 6: Please give the labels and the units of the axis coordinates. Furthermore, please improve the resolution of images.

Response: Thanks for your careful review and these comments have been taken. The improved Figure 3 and Figure 5 are inserted into the manuscript, as follow:

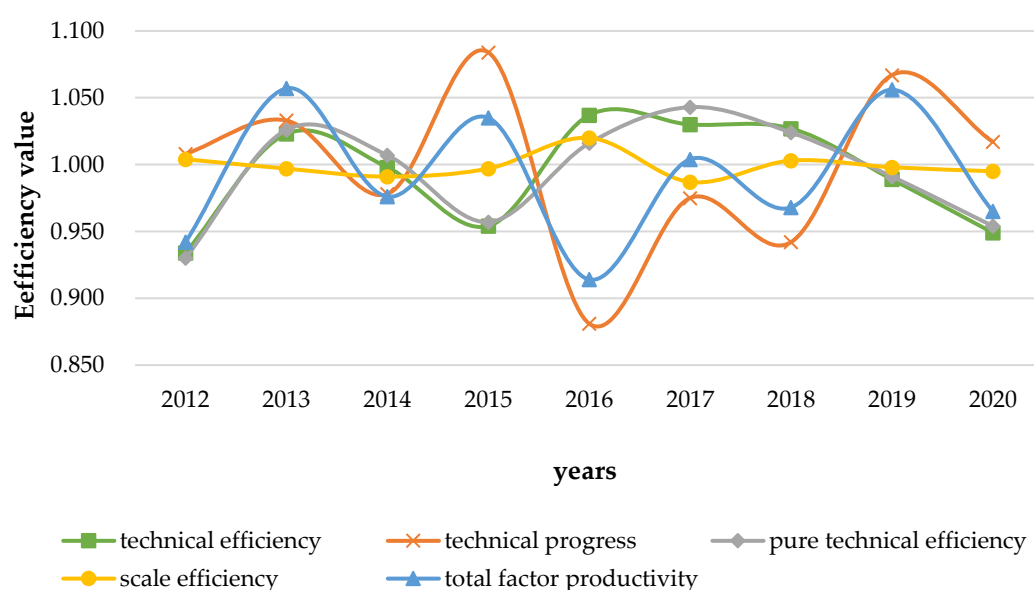


Figure 3. Temporal evolution of total factor productivity of grain (TFPG) in the Yangtze River Delta from 2012 to 2020. Data source: China Statistical Yearbook and China Rural Statistical Yearbook.

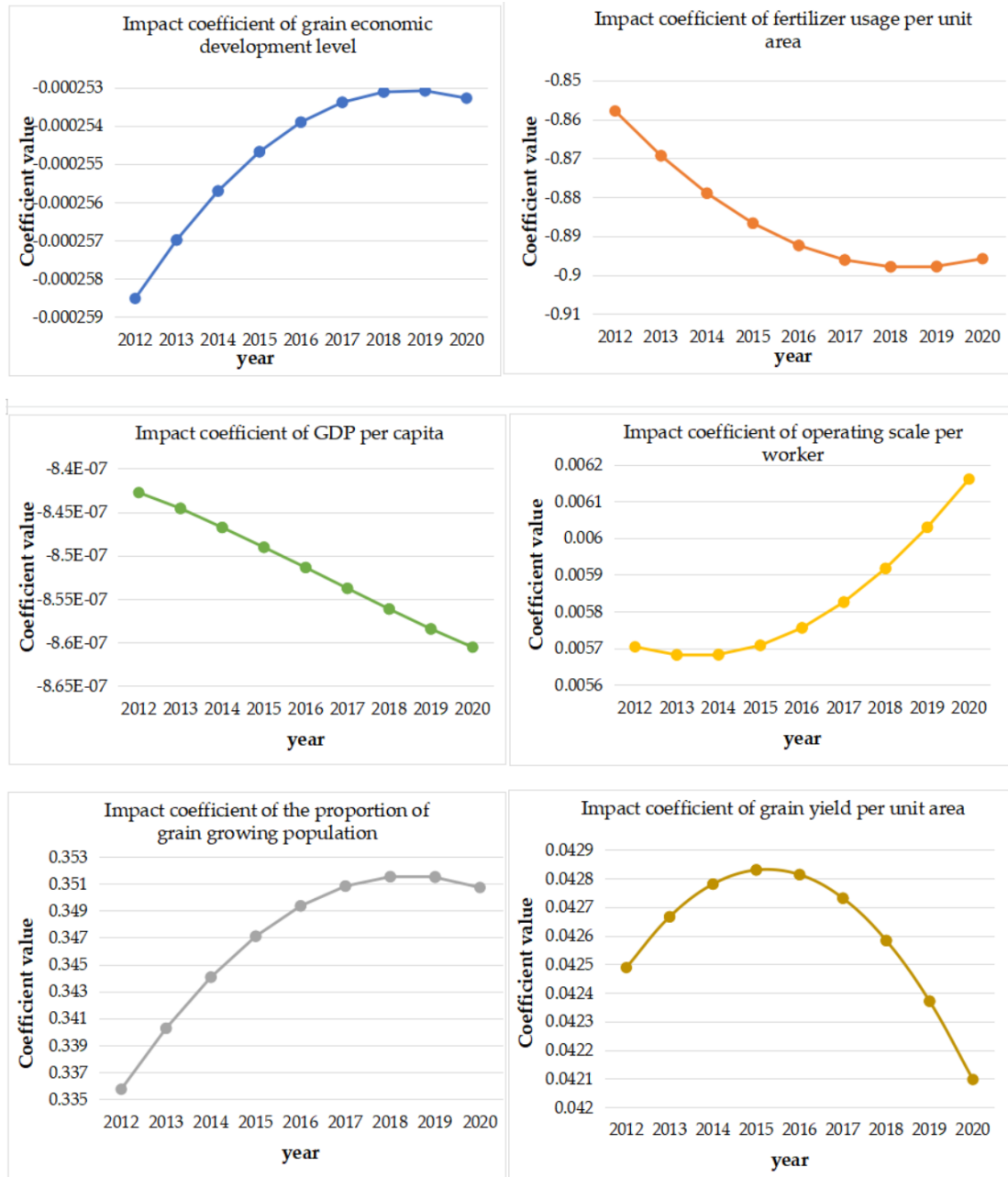


Figure 5. Time heterogeneity of driving factors of total factor productivity of grain (TFPG). Data source: China Statistical Yearbook and China Rural Statistical Yearbook.

5. Figure 5 and Figure 7: please improve the resolution of images.

Response: Thanks for your careful review and these comments have been taken. The improved Figure 4 and Figure 6 are inserted into the manuscript, as follow:

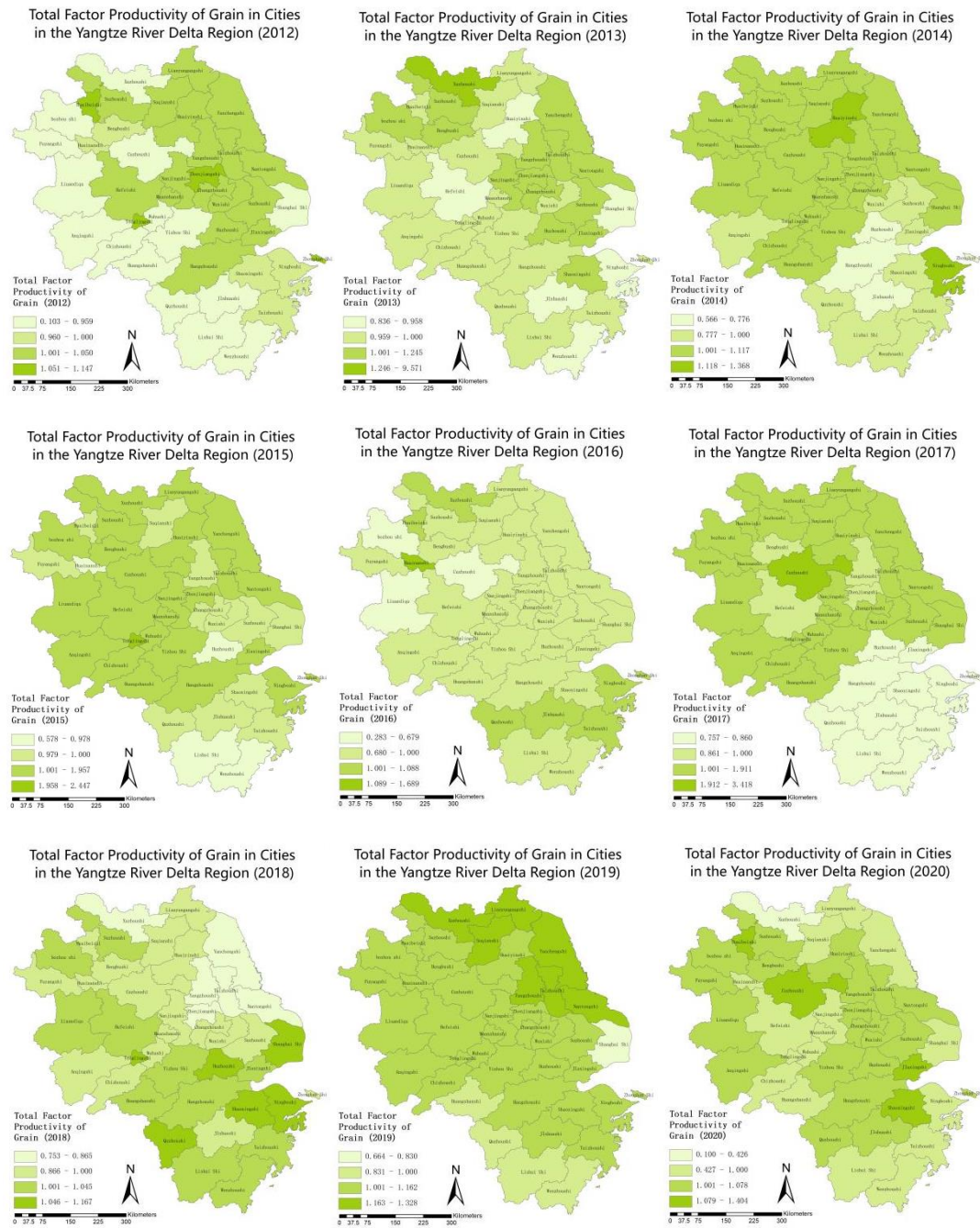


Figure 5. Spatial evolution of total factor productivity of grain in the Yangtze River Delta from 2012 to 2020. Data source: China Statistical Yearbook and China Rural Statistical Yearbook.

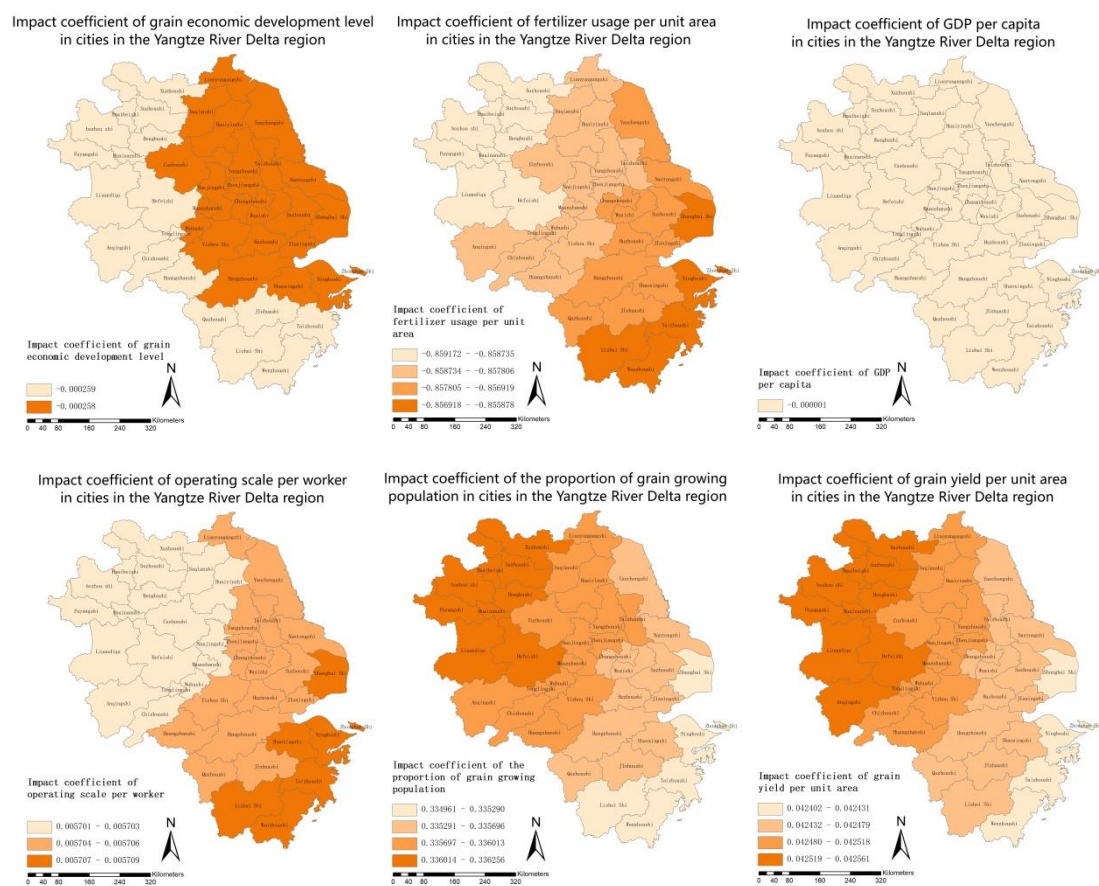


Figure 6. Spatial heterogeneity of driving factors of total factor productivity of grain. Data source: China Statistical Yearbook and China Rural Statistical Yearbook.