Chapter 1
Introduction and Key Findings

1.1 Problem Setting

The development of the primary sector is important for the global population from the viewpoint of food security and income generation. As is the case in any economic sector, agricultural performance can be tracked by means of multiple indicators reflecting different facets of sustainability. A producer, consumer, or government perspective can be taken. Also, the growth of agricultural production and input use can be taken into consideration. Therefore, this monograph seeks to discuss some of the approaches that have appeared to be the most relevant ones in measuring agricultural performance and development.

The major objective of agricultural activities is an economic one—to produce food at low costs. The OECD/FAO (2020) forecasts that the demand for both crop and livestock products will continue increasing globally throughout 2020–2029. Population growth remains a major driver for such changes. Thus, the agricultural production needs to be adjusted to satisfy the increasing demand and ensure the affordability of food.

The extensive growth mode initially relied on increasing the use of (relatively cheap) agricultural inputs to expand the agricultural production. However, the primary inputs have become scarcer, especially in the developed countries (OECD/FAO 2020). This implies the need for agricultural productivity growth. This topic has been around for decades (Hayami and Ruttan 1971), with technological development seen as the major driver of productivity growth. Fuglie (2018) provided a more recent study on the patterns of agricultural productivity growth across the globe.

The notion of total factor productivity is important in assessing economic performance. Indeed, total factor productivity gains render economic surplus that can be shared among farmers, factor owners, government, and customers (Grifell-Tatjé and Lovell 2015; Veysset et al. 2019). Yet another concept related to total factor productivity is that of efficiency (Latruffe 2010). Basically, efficiency indicates the

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gap between the observed and maximum possible level of productivity. The maximum possible level of productivity can be estimated via a number of approaches. These include parametric and nonparametric methods relying on primal or dual representations of the production technology. The measures of partial factor productivity are also often used to describe the performance of the agricultural sector. Measures of the latter type relate any two indicators (usually output over input) to show the output level per unit of input.

Structural change plays an important role in shaping agricultural production (mode). The structural change mostly manifests itself through changes in farm structure, input structure, and output structure (Chavas 2001). The changes in the farm structure can be related to returns to scale considerations and the question of the optimal farm size. The imperfections in the factor and output markets may create situations where certain groups of farms benefit more than others. In such cases, optimal farm size becomes a blurry concept. Deepening economic integration is likely to accelerate the reallocation of inputs across sectors and regions. For agricultural commodities, economic integration plays an especially important role as the prices of the commodities are established in international markets. The structural changes may also lead to the adoption of different production technologies and adjustment of the output mix. As Chavas (2001) argued, risk aversion appears to be an important factor behind farmers' decisions in regard to the scope of their production.

The increasing scarcity of resources along with the increasing volatility of the climatic conditions has called for a shift towards sustainable agriculture. Sustainable agriculture includes the use of inputs (e.g. agrochemicals, bio-based resources) and farming practices in such a manner that minimum environmental and societal impact is ensured alongside profit maximization (Pretty 2008). It is naturally expected that sustainable agriculture is positively correlated to agricultural resilience. However, this requires the creation of extensive and comparable data sets to guide the decision-making (El Chami et al. 2020). There have also been obstacles related to theoretical and empirical factors (Siebrecht 2020). Therefore, it is important to identify the major concepts underpinning sustainable agriculture and the possibilities for its development in different contexts.

The direct emission from agricultural sector comprises 11% of global greenhouse gas emissions (OECD/FAO 2020). Among other impacts, sustainable agriculture allows greenhouse gas emissions to be mitigated. Sustainable farming practices can also increase carbon sequestration. This leads to mitigation of climate change. In this context, the concept of climate-smart agriculture becomes important as the agricultural sector needs to be both resilient to environmental shocks and operate in a sustainable manner so as to avoid degradation of the ecosystem. A crucial task is to quantify the sustainability level prevailing in farming systems. This requires the development of assessment frameworks at different levels of aggregation.

The issues discussed can be summarized in the structural change–productivity–climate nexus (Fig. 1.1). Agricultural production technology relates the inputs to outputs and defines the production possibilities in the technical sense. Here, productivity impacts the possible output quantities for a given level of inputs.

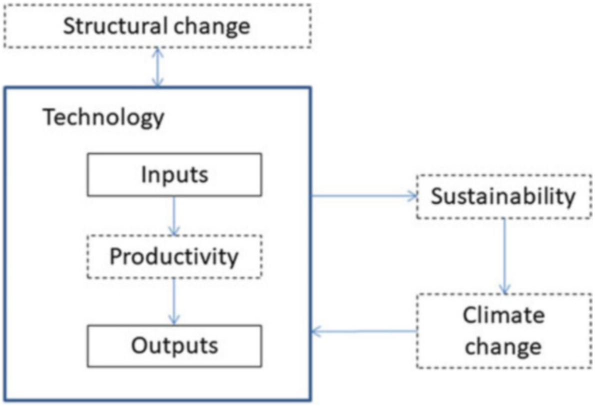

Fig. 1.1 Structural change–productivity–climate nexus in agriculture

As discussed above, technology is developing in line with the external environment and farmers' traits. Structural change itself is influenced by developments in the international markets and the competitive advantages prevailing in certain regions. In addition, agricultural policy can affect the markets of factors and outputs (Swinnen 2018) leading to corresponding structural dynamics. Noteworthy, structural change and structure itself contribute to productivity change (Shen et al. 2018). Thus, structural change may render changes in the input structure, output structure, and productivity. If inputs are used more productively in certain groups of farms, the structural change may result in changes in the average productivity even though farms retain their technologies and the overall input quantity or output volume remains fixed.

The structure (proportions) of inputs and outputs used in the production process depends on the production technology. The scale of production determines the volume thereof. All these circumstances determine the sustainability level of the agricultural production (i.e. the economic, social, and environmental impacts). The environmental impact implies that the ecosystems may be affected by the agricultural production. This gives rise to climate change and adaptation. The concept of climate-smart agriculture becomes important in linking the climate (change) and agricultural production technology. Following this concept, the agricultural technology should be adjusted so as to take into account the risks stemming from climate change.

1.2 The European Union Context

The relationships among structural change, productivity, and climate are determined by a plethora of factors. As previously discussed, trade, public policy, and climate change are among the most important factors of agricultural dynamics (for the sake of brevity, we assume that trade includes intersectoral relations and factor movement as well). The empirical research presented in this monograph focuses on the case of the European Union (EU), which is a major food producer. The Common Agricultural Policy of the EU is the main policy instrument and operates through direct payments, market measures, and rural development measures. The requirements for receiving support payments are adjusted in line with the policy objectives.

The EU has also adopted overarching strategies aimed at increasing the sustainability of the economy. The most recent instance of such strategies is the European Green Deal launched in 2019. In the light of the Green Deal strategy, the CAP is also to be adjusted to meet the objectives of sustainability (European Commission 2020). The strategic planning at the country level is expected to ensure linkages among the objectives of the CAP and the Green Deal via National Energy and Climate Plans and CAP Strategic Plans. Thus, the correspondence with the Governance of the Energy Union is to be maintained. The CAP measures relevant to the Farm to Fork Strategy and Biodiversity Strategy are expected to reduce environmental pressures associated with farming activities (the use of pesticides, nutrient leakages, biodiversity). The promotion of organic farming and eco-schemes is yet another strand of CAP measures that is expected to align with the objectives of the Green Deal. Finally, healthy food consumption and a reduction in food waste should contribute to a more efficient use of resources outside the primary sector.

The European Commission (2020) also stressed that already existing databases (e.g. the Farm Accountancy Data Network) should be extended to take into account environment- and climate-related indicators. This would allow for benchmarking of farms in the sense of the three dimensions of sustainability. Thus, it is important to develop methodologies for farm-level and aggregate benchmarking.

1.3 Major Issues and Findings

The present study is arranged into four chapters dedicated to the issues related to structural change, productivity, and climate. These chapters address the aforementioned issues in the context of the EU, whether at the micro- or macrolevel. The focus is often on Lithuania, an Eastern European country that joined the EU in 2004. We believe the discussion will shed light on the agricultural development of the EU and its member states.

1.3.1 Sustainable Development of the Agricultural Sector and Its Interactions with Other Sectors

The concept of sustainable agriculture stresses the need to integrate the environmental effects of agricultural activities into analysis (besides economic and social facets). This approach is crucial for developing policies and corresponding measures that may effectively improve the resource utilization in the light of the climate–water–land–energy–food nexus. Chapter 2 focuses on the theoretical preliminaries of sustainable agriculture and the case of the EU. Much attention is given to energy use that brings environmental consequences as well.

There is a close relationship between sustainable agriculture and sustainable energy development. More specifically, the use of renewable energy sources in agriculture allows the most important environmental, economic, and social objectives stemming from the concept of sustainable agriculture development to be secured. These include climate change mitigation, resource conservation and reduction, avoiding negative environmental impacts, contributing to the security of the energy supply, cost reduction, diversification of farmers' income, the provision of highly productive jobs, and promotion of the social and economic development of rural communities. Therefore, the future shaping of the CAP should be directly linked to the climate–water–land–energy–food nexus: improving the welfare of the rural countryside, safeguarding food security and safety, environmental protection, natural resource saving, climate change mitigation and adaptation, and preservation of animal health and welfare.

The main EU policy priorities outlined in the Green Deal for the creation of a carbon-neutral society and low-carbon transition by 2050 need to be addressed by the two pillars of the CAP. For this reason, a clear understanding of the need to link climate change mitigation and adaptation with the CAP was shown by the EC; however, it is necessary to point out that the linking of climate issues to CAP goals needs to address the broader climate–water–land–energy–food nexus, and this has not been achieved so far in the recent reform of the CAP aimed at developing climate-smart agriculture (Venghaus et al. 2019).

1.3.2 Agricultural Technology, Production, and Productivity

Chapter 3 of this monograph turns to the theoretical preliminaries and empirical applications of the concepts, measures, and models of productivity. Note that productivity is referred to here in a broad sense rather than merely focusing on total factor productivity growth. Indeed, the core of the empirical analysis is the production function that links the input and output quantities. This setting provides information about output elasticities with respect to the inputs (and time).

The empirical analysis focuses on the case of the selected EU member states. Country-level data from Eurostat are used to describe the inputs and outputs employed in the agricultural production process. The production frontier approach is chosen for the analysis. The estimation of the production frontier is carried out both parametrically and nonparametrically. Also, an estimation with regularity conditions imposed is presented. Thus, the results are verified by using different models.

The findings indicate that the efficiency of the agricultural production in the selected EU countries followed an inverse U-shaped trend over the period

1995–2017 even though technical progress was observed. This indicates that the EU countries still need to ensure the spillover of innovations in order to boost the agricultural productivity. Moreover, the output elasticity with respect to capital tended to decline in general. This further shows that overinvestment may be present in EU agriculture. Thus, the support policies (especially the CAP) need to take into account the differences in the total factor productivity and input-related output elasticities in order to ensure efficient use of the resources (including support funds).

1.3.3 Structural Dynamics in Agriculture

Over the last few centuries, the research on the ongoing evolution of agricultural systems has played an important role. Bah (2011) identified a clear nexus between structural change scenarios and the development level of the country. In this context, the recent structural changes in the EU agricultural system after the main enlargement in 2004 contribute to a challenging academic discussion with significant variations in terms of research objects and applied methodological frameworks. Indeed, the previous research often demonstrates a fragmented picture and focuses on individual member states. Therefore, Chap. 4 investigates the evolution of the EU economy and the corresponding developments of the agricultural systems in member states after the main enlargement of the EU.

The dynamics of structural change indices for employment and gross value added (GVA) imply that structural changes in the EU economic system have evolutionary rather than revolutionary characteristics. However, in some member states, the remarkable acceleration of national transformations could be explained by the new business environment, including policy changes, after countries have joined the EU. According to Eurostat, the share of employment and GVA for agriculture, forestry, and fishing economic activity in the EU economy is diminishing, while the direction of the development of the EU economy is in line with previous studies; i.e., the role of the service sector in economic systems is growing (Pannell and Schmidt 2006; Bah 2011). Indeed, the directions and speed of GVA and labour force reallocation in national economies depend on the member states.

The shift-share analysis sheds some light on regional development differences in GVA and employment and allows benchmarking of the actual change with alternative development patterns. For GVA, outcomes depend on the level of inflation; however, several countries demonstrate a performance of agriculture, forestry, and fishing economic activity at a higher rate than the growth rate of the EU economy. In the case of employment, the growth rates of agriculture, forestry, and fishing economic activity are lower than the growth rate of the entire EU economic system. However, the components of local competitiveness for agriculture, forestry, and fishing economic activity in member states demonstrate the diversity in development patterns and confirm the individuality of member states.

Structural changes in the EU agriculture are investigated by employing average measures of utilized agricultural area, standard output, and directly employed labour force on farms. During the period from 2005 to 2016, important shifts in farming types both at the EU level and in member states took place. At the EU level, the increase in the average farm size in terms of the utilized agricultural area and standard output is accompanied by an almost stable situation of the average directly employed labour force on farms.

The remarkable growth in the average farm size is confirmed for specialist field crops and specialist grazing livestock farms. For these farming types, the decomposition of the structural change measures into structural and pure change components shows that the structural changes at the EU level play an important role. At the same time, the largest decline in the average farm size measures is reported for mixed livestock farms. The decomposed results for member states demonstrate significant country-specific variations in peak periods, change rates, and development directions of agricultural systems. The aforementioned results are explained by the individual combination of multiple factors that determine structural changes in member states. Previous studies on the driving forces of structural changes in agricultural systems allow the following critical factors to be identified: historical legacy, technology, agricultural policy, crises and natural disasters, demographic transition, and dynamics in human capital.

1.3.4 Agri-Environmental Footprint as a Measure of Agricultural Sustainability

Agriculture is a sector of special importance in the economy due to its direct connection to the natural environment (cf. Chap. 2). On the one hand, the production processes depend on natural resources of land and water, and on the other hand, agricultural activity often causes pollution and environmental degradation (e.g. resulting in arable land degradation, eutrophication of water, a decrease in biological diversity, and an increase in greenhouse gas emissions). Additionally, energy use efficiency is seen as an important issue in terms of the sector's sustainability with the potential to decrease the use of fossil fuels along with a reduction in environmental impacts. At the same time, the agricultural sector can play a significant role in generating renewable energy, thereby contributing to the transition of the country to a low-carbon economy.

As already mentioned in Sect. 1.2, the measurement of agricultural sustainability at the farm level is important not only from a purely scientific viewpoint but also as a basis for benchmarking that can be used for guiding support policies in practice. Chapter 5 focuses on the construction of the agri-environmental footprint indicator based on farm-level data from the Farm Accountancy Data Network. The case of Lithuanian family farms is considered.

The lowest values for the whole sample were obtained for indicators related to farms' accessibility, environment-friendly farming, wooded areas, and meadow and pasture areas. In order to foster the environmental sustainability of farms, the policy intervention measures need to focus on the enhancement of farmers' entrepreneurship (e.g. rural tourism and conservation of agricultural heritage activities), increasing the areas under climate-friendly farming methods, and enhancing the carbon sink capacity (e.g. by increasing the wooded areas along with meadow and pasture areas).

1.4 Concluding Remarks

The results indicate that there have been serious structural changes in the structure of farms across the EU (Chap. 4). Different chapters of this monograph (Chaps. 2, 3, and 5) explore the causes and outcomes of structural dynamics in agriculture from theoretical and empirical viewpoints. The results suggest that technological change has pushed the production possibility frontier for EU countries and enabled resource conservation along with production growth. However, not every country has been able to exploit these possibilities to the same extent.

The methods discussed in this monograph may be used for benchmarking the progress towards sustainable agriculture at the micro- and macrolevels. The benchmarking may provide important information for decision-makers when devising support measures. It is also important to explore and ensure the congruence among the objectives of sectoral and general strategies (e.g. the CAP and the Green Deal of the EU). Such research needs to adopt both theoretical and empirical approaches.

In order to further develop evidence-based research, standardized and open databases are needed. The variables used in this research can be used for large-scale comparisons in the EU. The data-driven approach can be used to stimulate the creation of a more sustainable agricultural system in the EU through evidence-based support policies.

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