Deliverable 3.3.

Dynamic efficiency impact model

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Sustainable financing for sustainable agriculture (SUFISA) project[6]

1. Meeting the objectives of D3.3.

Four objectives have been formulated for D3.3. In the following it is briefly outlined how they were met.

1. Determine production frontiers in combination with market powers:

We provide a model that allows integrating output and input market rigidities using the production approach. Within a production function setting, we derive an equation that relates the identification of the markup variables. Furthermore, we investigate to what extent these rigidities influence firm efficiency. We also investigate the impact of assumptions relating to market structure and the production function.

Market power is the ability to influence or determine either the price or the quantity. Market power can, however, lead to a market party making a profit in a sustainable way as a result of a price-setting that is based on a monopolistic or oligopolistic pricing. While the counterparty has to deal with too low operating profit to survive. This can result in undesirable market results.

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Because a prevalent indication of market power is lacking, the model construction must be sufficiently flexible to allow for different types of market structures. The issue of market power, its measurement, and its implications will continue to be revisited in the food economics literature.

2. Integrate input prices to determine the allocative efficiency.

We simultaneously estimate market imperfections in input and output markets and explicitly investigate the role of market power on firm efficiency. Only a few studies have simultaneously considered imperfections in the input and the output market. By estimating markups in the input and the output market, this study contributes to bridging the gap between the econometric literature on input and output market imperfections.

In the output market, the markup is a price wedge between the market price and the marginal cost of the product. Likewise, in the input markets, the markups are the price wedges between the input market prices and the shadow value for factor inputs. The focus on markups rather than on conjectural variations is also a methodological choice. The equations for the conjectural variations depend on the estimation of the price elasticities both in the input and the output market. Some studies are based on fixed estimates for the price elasticities. Our model adopts an alternative solution and estimates the ratio of the elasticity and the conjectural variation in one variable as the price markup. We use a production function approach that allows all inputs to be used in variable proportions and allows the derivation of market-specific markups.

3. Combine technical and allocative efficiency in an overall measure of cost or profit efficiency.

If a market is assumed to be characterized by some form of imperfect competition in the output and/or input market, this assumption should also be reflected in the construction of a Total Factor Productivity (i.e., technical efficiency) measure to take into account possible biases. Often, productivity is measured under neoclassical assumptions of perfect competition and constant returns to scale. This implies, amongst others, that there is no market power and production units make zero profits (Vancauteren and de Frahan 2011). Our strategy to measure Total Factor Productivity (TFP) and markups is based on the total scale elasticity and builds on previous work by Amoroso et al. (2015) and Vancauteren and de Frahan (2011). This section extends this method to account for oligopsonic behavior.

TFP is econometrically estimated allowing for imperfect competition in the output and input markets. The markup in this paper yields to an estimated scale elasticity times the output-input ratio that is computed with real data. The main aim is to solve for firm's efficiency under different parameter assumptions of the output markup and the input markup to the model. We measure TFP as the residual of the estimation of the standard Cobb-Douglas production function. A major advantage of using firm-level data is that we can estimate the production function in a panel model. Panel regressions allow us to capture more heterogeneity.

4. Incorporate the inter-temporal nature of producers' decision making:

Due to the challenges of including dynamics within econometric market power models, another method was chosen to incorporate dynamics. Criticism about the Structure-Conduct-Performance (SCP) paradigm within the body of Industrial Organization (IO) illustrates the limitations of econometrics in dealing with endogeneity. The bi-directionality of structure and conduct lead to the development of New Empirical Industrial Organization (NEIO) models. However, these models focus on conduct and do not solve the problem of the SCP paradigm. While the SCP paradigm struggles with the feedback between structure and conduct, systems thinking embraces feedback mechanisms. Moreover, systems thinking supports the understanding of dynamic behavior (Sterman 2000). Therefore, it is suggested to employ systems thinking to understand the dynamics of the market. This approach has been applied to one case study, using causal loop diagrams. For future research steps it is aspired to employ system dynamics, to further analyze the dynamics of the market.

2. Introduction

Deliverable 3.3. is part of Work Package three (WP3), which focuses on impact assessment. Broadly SUFISA investigates conditions that primary producers face. It is acknowledged that market imperfections are an increasing problem for the agrifood sector (Bukeviciute et al. 2009; ECN 2012; Kaditi 2013). Within SUFISA the main emphasize is on market power and asymmetric information. WP3 aims at analyzing the impact of these two market imperfections on primary producers on a case study level.

The model developed for this Deliverable is based on the general New Empirical Industrial Organization (NEIO) model presented in D.3.1. Generally, the NEIO approach simultaneously estimates a supply relation and a demand function so as to identify the "conjectural variation elasticity" or "conduct parameter", which serves as a measure of market power. The NEIO model was based on the idea of measuring conjectural variations. Hence, it is presumed that companies have assumptions about competitors' behavior regarding changes in price or output. The conjectural variation parameter in the NEIO model served as indicator for collusive behavior and thus for market power. This model has been applied to the pork sector whereat market power between pork farmers and slaughterhouses was analyzed. According to this analysis farmers have more market power than slaughterhouses. However, as pointed out in D.3.1. there are shortcomings to the developed model. Hence, one needs to be careful to automatically infer from these results that pork farmers do have market power.

Similarly, to the NEIO model introduced in D.3.1. the model presented in section 3 of D.3.3. is based on the idea of conjectural variation as well. However, the D.3.3. model estimates directly whether there is any bargaining power in the input market between farmers and the processor by means of a production function. This bargaining power is the ratio of the elasticity and the conjectural variation in one variable as the markup in the input market. Using a production function, our model is an additional approach next to the NEIO approach used in Deliverable 3.1. and does not require any assumptions on the cost structure of the farmers. Extensions include to impose various scenarios on the interplay between market frictions in the input and output market which may consequently have an impact on productivity. In other words, through which channels of the different natures of competition can efficiency be maximized by processors? This approach only requires data on production volumes and values, factor inputs, and factor costs.

The developed models can only be used for case studies for which the required data is available. Data unavailability can pose restrictions to the applicability of econometric models. Apart from this, market power estimations are problematic in cases where the number of companies is low. A general criticism of econometric models is the assumption of an optimal stage that can be reached (Blaug 2001). Some argue, that perfect competition is unrealistic and that an equilibrium is never reached since market interactions are continuous processes. This criticism can be related to challenges of the Structure-Conduct-Performance (SCP) paradigm within the body of Industrial Organization (IO). It is questioned whether structure only affects conduct and hence performance, or whether the interaction is bi-directional (Lee 2007; Slade 2004). Besides these methodological issues, econometric models are based on a restricted perception of market power. There is increasing awareness that market power is not only expressed in prices exceeding marginal costs (European Parliament, 2016). Therefore, it is suggested to take a more holistic perspective on market power. Such a perspective calls for the employment of other methods to analyze market power. The usage of systems thinking is introduced as a potent tool to analyze market power taking a more comprehensive view. While the SCP paradigm struggles with the feedback between structure and conduct, systems thinking embraces feedback mechanisms. Moreover, systems thinking supports the understanding of dynamic behavior (Sterman 2000). Systems thinking allows the employment of qualitative as well as quantitative data, which allows to take up a more holistic perception of market power. Therefore, systems thinking was taken up as method to study market dynamics.

This deliverable is divided in two main sections. The first section introduces and elaborates on the efficiency impact model developed for the application to a specific case study. In the second section the understanding of market power is discussed and an alternative method to analyze market power is proposed.

3. The efficiency impact model: building blocks

This section deals with the fundamental methodological issue to measure total factor productivity (TFP) for productivity and markups for competition. If a market is assumed to be characterized by some form of imperfect competition in the output and/or input market, this assumption should also be reflected in the construction of a TFP measure to take into account possible biases. Often, productivity is measured under neoclassical assumptions of perfect competition and constant returns to scale. This implies, amongst others, that there is no market power and production units make zero profits (Vancauteren and de Frahan 2011). Our strategy to measure TFP and markups is based on the total scale elasticity and builds on previous work by Amoroso et al. (2015) and Vancauteren and de Frahan (2011). This section extends this method to account for oligopsonic behavior.

3.1. The standard setting

Within a production function setting, we derive an equation that relates the identification of the markup variables. The starting point is a Cobb Douglas production function. In particular, we let each firm $i \in \{1, \dots, N\}$ face the following production function for period t:

$$Y_{it} = A_{it}F_i(X_{it}) \qquad i = 1,2, \dots, N\ ; t = 1,2, \dots, T \tag{1}$$

where Y_{it} measures firm i's gross output, $\boldsymbol{X}_{it} \equiv (X_{i1t}, X_{i2t}, \dots, X_{iJ_it})'$ denotes the vector J_i non-negative factor inputs, $F_i(.)$ is the core of the differentiable production function, and A_{it} is TFP measured as the rate of a Hicks-neutral disembodied technology.

Logarithmic differentiation of production function Eq. (1) yields:

$$\frac{dY_{it}}{Y_{it}} = \frac{dA_{it}}{A_{it}} + \sum_{j=1}^{J_i} \frac{X_{ijt}}{F_i(.)} \frac{\partial F_i(.)}{\partial X_{ijt}} \frac{dX_{ijt}}{X_{ijt}} \tag{2}$$

with $\frac{dY_{it}}{Y_{it}}$ (logarithmic) output growth and $\frac{\partial \log Y_{it}}{\partial t} = \frac{dA_{it}}{A_{it}}$ (logarithmic) TFP growth.

It is assumed that each firm i faces an inverse demand function, $P_{it}(Y_t)$, which represents the market price as a function of aggregate (industry) output $Y_t \equiv \sum_{i=1}^{N} Y_{it}$, i.e., by specifying firm i's (output) price as an arbitrary function of aggregate output we allow for various potential degrees of firm i's market power on its output market.

Firm i's profit optimization problem can be written as follows:

$$\max_{Y_{it}, X_{it}} \{P_{it}(Y_u)Y_{it} - V_{it}X_{it} | Y_{it} = A_{it}F_i(X_{it})\} \tag{3}$$

where $V_{it} \equiv (V_{i1t}, V_{i2t}, \dots, V_{iJ_it})'$ is firm i's vector of J_i input prices.

Let the conjectural variation of firm i in the output market η_{it}, and the sector output price elasticity ε_{it} be defined as:

$$\eta_{it} = \frac{y_{it}}{Y_t} \frac{\partial Y_t}{\partial y_{it}} \tag{4}$$

$$\varepsilon_{it} = \frac{p_{it}}{Y_t} \frac{\partial Y_t}{\partial p_{it}} \tag{5}$$

For the market power dynamics in the input market, a similar derivation is set up. For an individual input factor $k \in J_i$, $X_{kt} = \sum_{i=1}^{N} X_{ikt}$ is the total output k for the entire sector, the conjectural variation ν_{ikt} at the firm-level for each input price ξ_{it} are defined as:

$$\nu_{ikt} = \frac{X_{ikt}}{X_{kt}} \frac{\partial X_{kt}}{\partial X_{ikt}} \tag{6}$$

$$\xi_{it} = \frac{V_{kt}}{X_{kt}} \frac{\partial X_{kt}}{\partial V_{kt}} \tag{7}$$

The first order conditions (FOCs) implied by the solution of Eq. (3) yield the following equations for the Lagrange multiplier and the nominal input prices:

$$P_{it}(Y_t)\frac{\partial Y_{it}}{\partial X_{ikt}}\left[1+\frac{\partial P_{it}(Y_t)}{\partial Y_{it}}\frac{Y_t}{P_{it}(Y_t)}\right]=V_{ikt}\left[1+\frac{X_{ikt}}{V_{ikt}}\frac{\partial V_{ikt}}{\partial X_{ikt}}\right]\quad for\ k\in J_i \tag{8}$$

where the term between square brackets is firm i's markup. Note that in case of perfect competition $\frac{\partial P_{it}(Y_t)}{\partial Y_t}$ goes to zero, implying that prices are set at marginal cost since marginal revenue (MR_{it}) is (always) equal to marginal cost (MC_{it}) (or $MR_{it}=MC_{it}$) and inputs are paid their marginal products (markups in both output and input markets equal to 1).

This equation can be rewritten to show the relation between the conjectural variation in the input and output markets:

$$\left(1+\frac{\eta_{it}}{\varepsilon_{it}}\right)\frac{P_{it}(Y_t)}{V_{ikt}}\frac{\partial Y_{it}}{\partial X_{ikt}}=1+\frac{\nu_{ikt}}{\xi_{it}} \tag{9}$$

Both conjectural variations indicate collusion in their respective markets. Collusion in the output market is measured as the dependence of the total market quantity in the output of firm i. In a perfectly competitive market environment, this indicator equals the market share of the firm i. If the conjectural variation is lower than the market share, it indicates that competitors reduce their output in a reaction to an output increase of firm i, which is a signal of quantity-based collusion in the market. If the conjectural variation is higher than the market share, it indicates that competitors increase their output in a reaction to an output increase of firm i. This signals the existence of a dominating firm in the market, aiming to maintain or increase market share. The interpretation of the conjectural variation in the input market is analogous. If perfect competition is present in the market, and the total number of firms is sufficiently high to make the individual market shares negligible, these parameters equal zero.

3.2. Parameter interpretation

The conjectural variations η_{it} and ν_{ikt} are interpreted as conduct parameters in a quantity-setting game (Bhuyan and Lopez 1998; Gohin and Guyomard 2000). A Cournot conduct is revealed through a conjectural variation equal to the Herfindahl index at the sector level (Sckokai et al. 2013).

This concept is illustrated by rewriting the conjectural variations as markups in output and input markets, respectively μ_{it} and σ_{ikt}. In the output market, the markup is a price wedge between the market price and the marginal cost of the product. Likewise in the input markets, the markups are the price wedges between the input market prices and the shadow value for factor input k in firm i (Morrison Paul 2001). The focus on markups rather than on conjectural variations is also a methodological choice. The former equations for the conjectural variations depend on the estimation of the price elasticities both in the input and the output market. Some studies are based on fixed estimates for the price elasticities (Azzam and Pagoulatos 1990; Mei and Sun 2008; Morrison Paul 2001). This model adopts an alternative solution and estimates the ratio of the elasticity and the conjectural variation in one variable as the price markup.

For firm i, the first order condition with respect to output can be rewritten as:

$$\frac{P_{it}(Y_t) - MC_{it}}{P_{it}(Y_t)} = -\frac{\partial P_{it}(Y_t)}{\partial Y_t}\frac{Y_{it}}{Y_t}\frac{Y_t}{P_{it}(Y_t)} \quad (10)$$

or using Eq. (4) and Eq. (5) the Lerner index L_{it}^0 as a measure of a monopolist's market power is inversely related to the price elasticity of market demand and the conjectural variation[7]:

$$L_{it}^0 = -\frac{\eta_{it}}{\varepsilon_{it}} \quad (11)$$

where $L_{it}^0 \equiv \frac{P_{it}(Y_t)-MC_{it}}{P_{it}(Y_t)}$ is firm i's Lerner index or (relative) price-cost margin. Note that the markup (ratio) μ_{it}, which we define as the ratio of output price over marginal (production) cost, can easily be related to the Lerner index:

$$\mu_{it} \equiv \frac{P_{it}}{MC_{it}} = \frac{1}{1 - L_{it}^0} \geq 1 \quad (12)$$

so that it becomes clear that, if firm i is not perfectly competitive, then the value of its marginal product exceeds its factor cost by some markup μ_{it} in Eq. (8). Combining Eq. (11) and Eq. (12) and comparing it with the definitions of η_{it} and ε_{it} provides:

$$\frac{1}{\mu_{it}} = 1 + \frac{\eta_{it}}{\varepsilon_{it}} \quad (13)$$

The markup on the input price is defined as σ_{ikt} and based on the analogue relation with conjectural variation of firm i in the input market:

$$\frac{1}{\sigma_{ikt}} = 1 + \frac{\nu_{ikt}}{\xi_{it}} \quad (14)$$

The tradition Lerner index in the output market is $L_{it}^0 \equiv \frac{p_{it}-MC_{it}}{p_{it}}$. This definition sets a similar range of possible values for L_{it}^0 from 0 (perfect competition) to $\frac{1}{\varepsilon_{it}}$ (profit optimisation in a monopoly). The equality $\frac{1}{\mu_{it}} = 1 + L_{it}^0$ sets a range for μ_{it} from 1 to $\frac{\varepsilon_{it}}{1+\varepsilon_{it}}$. When defining a Lerner index for input k as L_{ikt}^I, the relations with the markups on the input prices are similar: $\frac{1}{\sigma_{ikt}} = 1 + L_{ikt}^I$, leading to a range of values σ_{ikt} from 1 to $\frac{\xi_{it}}{1+\xi_{it}}$.

This strict view limits the range of the conjectural variations, and the corresponding interpretation of the market structure. However, Kadiyali et al. (2001) showed that a firm's conduct when in competition can lead to conjectural variations that exceed the range previously outlined. First, such conduct is possible when markets contain differentiated products. Secondly, when firms lower prices to gain market share, the related markup may decline, even to less than 1. If a markup of less than 1 is observed in the output market, then products are sold at a loss. This observation indicates strong market power from purchasers or temporary strategic behaviour to increase market share.

[7] The larger the elasticity of demand in absolute terms, the smaller the monopolistic firm's market power.

The interpretation of an extended range of values for σ_{ikt} in the input market i is similar. A value of σ_{ikt} that equals unity indicates perfect competition. A value of σ_{ikt} that falls below unity indicates a firm's effective market power is decreasing its input prices. A value of σ_{ikt} larger than 1 indicates the purchase of input materials at a price higher than the marginal shadow price for the firm. This phenomenon may result from the strong market power of the input sellers, or from firms behaving strategically.

3.3. Returns to scale

To derive at the empirical model using data, we consider the formulas are transformed to include input cost shares. Substituting Eq. (13) and Eq. (14) into Eq. (9) gives:

$$\frac{\partial Y_{it}}{\partial X_{ikt}} = \frac{V_{ikt}}{P_{it}(Y_t)} \frac{\mu_{it}}{\sigma_{ikt}} \tag{15}$$

Multiplying both sides of this result by $\frac{X_{ikt}}{Y_{it}}$ leads to:

$$\theta_{ikt} = \frac{\mu_{it}}{\sigma_{ikt}} s_{ikt} \tag{16}$$

where s_{ikt} denotes the share of the cost of input k in the total production value of firm i, or $s_{ikt} \equiv \frac{V_{ikt}X_{ikt}}{Y_{it}P_{it}(Y_t)}$.

From (10) we obtain that the FOC in Eq. (3) with respect to the vector X_{it} can be rewritten as:

$$V_{it} = P_{it}(Y_t)(1 - L_{it}) \frac{\partial Y_{it}}{\partial X_{it}} \tag{17}$$

The model does not account for market power in each input market k. For any other individual input factor $k' \in J_{i-K}$ we can rewrite this expression as:

$$P_{it}(Y_t)(1 - L_{it}) \frac{\partial \ln Y_{it}}{\partial \ln X_{ik't}} \frac{Y_{it}}{X_{ik't}} = V_{ik't} : k' = 1,2, \dots, J_{i-k} \; ; t = 1,2, \dots, T$$

$$\frac{\partial \ln Y_{it}}{\partial \ln X_{ik't}} = \frac{1}{[1 - L_{it}]} \frac{V_{ik't}X_{ik't}}{Y_{it}P_{it}(Y_t)} = \mu_{it} s_{ik't} \tag{18}$$

where $s_{ik't}$ denotes the share of the cost of input k' in the total production value of firm i, or $s_{ik't} \equiv \frac{V_{ik't}X_{ik't}}{Y_{it}P_{it}(Y_t)}$.

The returns to scale parameter θ_{it} measures the responsiveness of output to an increase in all firm i's inputs by a scalar factor λ at period t. Under the homogeneity assumption of production function Eq. (1) we have that $F(\lambda \boldsymbol{X}_{it}) = \lambda^{\theta_{it}} F(\boldsymbol{X}_{it})$ with $0 < \theta_{it} < \infty$, where $\theta_{it} = 1$ denotes constant returns to scale, $\theta_{it} > 1$ increasing returns to scale, and $\theta_{it} < 1$ decreasing returns to scale. The time-varying, input-dependent returns to scale parameter, expressed as an elasticity of scale, θ_{it}, is defined as follows (see, e.g., Chambers 1988):

$$\theta_{it} \equiv \frac{\partial \ln F(\lambda \boldsymbol{X}_{it})}{\partial \ln \lambda} \Big|_{\lambda=1} = \frac{\partial F(\lambda \boldsymbol{X}_{it})}{\partial \lambda} \frac{\lambda}{F(\lambda \boldsymbol{X}_{it})} \Big|_{\lambda=1} \tag{19}$$

Hence, under constant returns to scale, $\frac{\partial F(\lambda \boldsymbol{X}_{it})}{\partial \lambda} = F(\boldsymbol{X}_{it})$ and $\frac{\lambda}{F(\lambda \boldsymbol{X}_{it})} = \frac{1}{F(\lambda \boldsymbol{X}_{it})}$, or Eq. (19) implies $\theta_{it} = 1$. By analogous reasoning, we find variable returns to scale implying $\theta_{it} \neq 1$. Since the elasticity of scale θ_{it} is equal to the sum of all output elasticities with respect to inputs given by the sum of Eq. (18) over all inputs (Johnson 1913), we can directly express this time-varying, input-dependent elasticity of scale θ_{it} in Eq. (19) as the sum over all partial elasticities of scale θ_{ikt}:

$$\theta_{it} \equiv \frac{\partial \ln F(\lambda \boldsymbol{X}_{it})}{\partial \ln \lambda} \Big| \quad _{\lambda=1} = \sum_{k=1}^{J_i} \frac{\partial Y_{it}}{\partial X_{ikt}} \frac{X_{ikt}}{Y_{it}} = \sum_{k=1}^{J_i} \theta_{ikt} \tag{20}$$

Using the first term of the last equality of Eq. (18) and taking into account $s_{ikt} \equiv \frac{V_{ikt} X_{ikt}}{Y_{it} P_{it}(Y_t)}$ and Eq. (20), the time-varying markup in Eq. (12) can be rewritten as the ratio between the time-varying, input-dependent elasticity of scale and the total (observable with data) input share:

$$\mu_{it} = \frac{Y_{it} P_{it}(Y_t)}{V_{it} X_{it}} \theta_{it} \tag{21}$$

In Eq. (21), only the output-input ratio is observable while the scale elasticity cannot be directly observed.

3.4. Deriving the empirical model for the slaughter input-output market using production function approach

As previously mentioned, the model does not account for market power in each input market. In a similar setting, Dobbelaere and Mairesse (2013), Dobbelaere and Vancauteren (2015), and Amoroso et al. (2015) investigated the interaction between market powers in the labor input market and in the output market. Dobbelaere and Mairesse (2013) based the analysis on the assumption that firms act as price takers in other input markets. In the case of the slaughter market, market power is assumed to exist only in the animal input market and not in the capital or labor markets. Slaughterhouses attract capital and labor from the regional capital and labor markets that are not restricted to their own sector. Given that the slaughterhouse sector in itself is rather small, slaughterhouses are unable to influence capital and labor prices at this regional level. The share of the purchase cost of live pigs (i.e., basic raw material for slaughterhouses) in the total cost structure is greatest in slaughterhouses. In slaughterhouses, this is 85% of the total costs (FOD Economie 2010). The share of labor costs and depreciation (i.e., capital costs) is rather small in slaughterhouses. For example, wages in slaughterhouses account for 4.7% of the total costs and depreciation accounts for 1.3% of the total costs. This information is compiled on the basis of annual accounts data and statistical information from the '*structuurenquête*' (FOD Economie 2010).

We consider a single slaughterhouse production unit $i \in N$. We select the Cobb-Douglas production function where the gross output quantity Q_{it} is related to three quantity input factors as follows:

$$Q_{it} = A_{it} K_{it}^{\theta_{iKt}} L_{it}^{\theta_{iLt}} M_{it}^{\theta_{iMt}} \tag{22}$$

where K_{it} denotes capital, L_{it} labour, and M_{it} denotes intermediate goods under form of live animals. A_{it} represents the Hicksian neutral efficiency level, and is defined as Total Factor

Productivity (TFP)[8]. θ_{iKt}, θ_{iLt}, and θ_{iMt} are the firms' elasticities of output with respect to capital, labour, and intermediate goods, respectively. Taking natural logs of Eq. (22) results in a linear function,

$$q_{it} = \theta_0 + \theta_{iKt}k_{it} + \theta_{iLt}l_{it} + \theta_{iMt}m_{it} + a_{it} \tag{23}$$

where lower-case letters refer to natural logarithms. The logarithm of A_{it} is defined as $\log(A_{it}) \equiv \theta_0 + a_{it}$, where θ_0 measures the mean productivity level across firms and over time, while a_{it} is the productivity shock which is observable by the firm (for example, managerial ability, quality of research), but unobservable to the econometrician and likely to be correlated with the input factor variables, hence a source of potential endogeneity.

The time-varying, input-dependent elasticity of scale θ_{it} is defined as the sum of all output elasticities with respect to the three non-negative factor input, X_{ikt}:

$$\theta_{it} \equiv \sum_{k\in\{K,L,M\}} \frac{\partial Q_{it}}{\partial X_{ikt}} \frac{X_{ikt}}{Q_{it}} \equiv \sum_{k\in\{K,L,M\}} \theta_{ikt} \tag{24}$$

According to Eq. (16) and Eq. (20), firm i's elasticities of output with respect to capital, θ_{iKt}, labour, θ_{iLt}, and live animals, θ_{iMt}, at period t can then be expressed as:

$$\theta_{iMt} = \frac{\mu_{it}}{\sigma_{ikt}} s_{iMt} \tag{25}$$

$$\theta_{iKt} = \mu_{it}s_{iKt} \tag{26}$$

$$\theta_{iLt} = \mu_{it}s_{iLt} \tag{27}$$

Substituting the output elasticities Eq. (25)-(27) into Eq. (23) delivers:

$$y_{it} = \theta_0 + \mu_{it}s_{iKt}k_{it} + \mu_{it}s_{iLt}l_{it} + \frac{\mu_{it}}{\sigma_{ikt}} s_{iMt}m_{it} + a_{it} \tag{28}$$

$$y_{it} = \theta_0 + \mu_{it}(s_{iKt}k_{it} + s_{iLt}l_{it}) + \frac{\mu_{it}}{\sigma_{ikt}} s_{iMt}m_{it} + a_{it} \tag{29}$$

Eq. (29) provides the basis for the economic specification. The main aim is to solve for $TFP = a_{it}$ under different parameter assumptions of μ_{it} and σ_{ikt} to the model. A major advantage of using firm-level data is that we can estimate Eq. (29) in a panel model. Panel regressions allow us to capture more heterogeneity. In this deliverable, we propose a measure of TFP derived from estimating a production function which accounts for imperfect competition in both output and input markets as derived in Eq. (28).

4. A holistic approach to analyze market power

In Milestone 7 it was pointed out that the analysis of sustainability requires a holistic approach. Within the SUFISA project we aim at understanding how certain conditions affect farmers. The

[8] MFP (multi-factor productivity) is sometimes used interchangeably with TFP, even if there is a slight difference between what they may include. Indeed, taking into account all the factors influencing output levels can be unrealistic, therefore MFP may be a more appropriate term to use. However, the term TFP continues to be used more widely Sara Amoroso et al., 'Productivity, Price- and Wage-Markups: An Empirical Analysis of the Dutch Manufacturing Industry', (CESifo Working Paper No. 5273, CESifo Group Munich, 2015).

goal is to increase or maintain the sustainability of primary production, from the farm perspective. Market imperfections make up such conditions and WP3 is dedicated to investigate them in more detail. While market imperfections, such as market power can have adverse effects on economic welfare due to the creation of a dead weight loss, their impact may not be limited to this. Market power may have other effects as well. Some effects may possibly not be approximated by measurements of markups. Therefore, in the following an extension of the market power concept and a potential analysis tool are discussed.

4.1. Market power extended

On the first sight market power is easily explained, on the second it becomes clear that it is a much more complex issue. This becomes evident by a report of the European Parliament (2016) 'On unfair trading practices in the food supply chain.' Within this report it is outlined that the definition of market power, being the basis for antitrust legislations, is too narrow. In consequence, certain practices that have a negative effect on trading partners cannot be prosecuted. Thus, the European Parliament suggests enacting a legislation that covers unfair trading practices, which are the result of power imbalances. The list of unfair trading practices, provided in the report, transcend pricing and payment issues. Hence, it suggests itself, that market power is more than the ability to charge a markup. The article of Blaug (2001) indicates that the problem lies even much deeper; in the understanding of competition. He points out that the general orthodox economics assumes that there is some sort of equilibrium that is reached, a state of optimum, a state of perfect competition, a state in which all forces are abrogated. Though Blaug (2001) challenges the existence of such an optimum, or final stage, suggesting that competition is nothing that cumulates in a final stage but is an ongoing dynamic force. From this suggestion, he concludes that quantitative assessments do not suffice and qualitative assessments are needed.

In orthodox economics market power is defined as '[…] the ability to set prices above cost, specifically above incremental or marginal costs, that is, the cost of producing an extra unit' (Cabral 2000: 6; compare with: Pindyck and Rubinfeld 2015: 366). The necessity of an extended understanding and definition of market power is stated by several researchers. Bardhan (1991: 265) for example states: 'Economics is, of course, not confined to the exercise of economic power and is often concerned with the consequences of other forms of power, particularly political and ideological.' White (1993), as well, points out the complex manifestation of power within the market system, which is not merely related to a measurable markup or market share. '[Power] is a protean phenomenon and power resources in the markets are many and various' (White 1993: 5). Moreover, also the European Parliament recently issued a report emphasizing that the orthodox definition of market power is too narrow, reducing the actual number of cases that are subject to antitrust legislations. Therefore, they introduced a broader concept of unfair trading practices (European Parliament 2016).

Looking at transaction cost theory the importance of market power is reduced to the question of efficiency. Williamson (1995) understands market power as a vague concept that is used to explain instances ex post for which other explanations are lacking. Efficiency, rather than power is understood as the main driver for organizational change (Brown 2002; Slade 2004; Williamson 1985). Hence within economics, there are two different point of views on market power; one that attributes it as negative because it reduces welfare and one that attributes it as positive if it helps increasing efficiency. While this may appear like a fundamental disagreement within the same discipline, it is rather the symptom of the cognitive amalgamation of (market) power and the legitimate use of (market) power. On the one hand, in orthodox economic theory market power is evaluated as negative because of its negative impact on welfare (because it is a deviation from optimality). On the other hand, in transaction cost theory market power (or rather market concentration) is seen as positive due to its positive effect on cost reduction. Hence in the latter case the superordinate goal legitimizes market concentration, if and only if this market concentration serves the superordinate goal (Williamson 1995).

Perfect competition has not always been the prevalent way of organizing economic activity (Blaug 2001). Schröter (1996) recalls the history of cartelization and decartelization between 1780 and 1995, outlining that until the end of the Second World War cartelization was commonly supported. According to his analysis the main reason for a change of perspectives after the Second World War was based on the acknowledgment of potential adverse effects of economic power coupled with political power that supported the strengthening of Nazi Germany. The defeat of the Nazis gave way for the 'American Way,' which was in support of competition (compare with: Read 2010). Already Pigou (1932) identified the problematic interrelation between economics and politics: 'These things lie outside the economic sphere, but the risk of them may easily be affected by economic policy. It is true, no doubt, that between economic strength and capacity for war there is a certain rough agreement' (Pigou 1932: :19). Hence, the main problem is the illegitimate use of (market) power, rather than (market) power *per se*. Moreover, the principal reason of demonizing market power is a political. Consequently, market power should not be reduced to the market sphere. Ergo, a much broader definition of market power is needed.

This brief outline of market power considerations within economic theory illustrates the ambiguity and complexity of (market) power. From a normative perspective, there seems to be a legitimate exertion of power, which is based on an overarching normative goal (Lukes 1974). Thus, (market) power per se is not negative, but rather the purpose for which it is employed. Accordingly, market power analysis needs to be holistic to understand the broader context and its effects.

4.2. Systems thinking as tool to analyze market power

The advantage of a restricted definition of market power, is that the mathematical description is easier to implement. However, as pointed out above there is no common understanding of market power within economics. Apart from the *is it efficiency or is it market power debate*, there are also for example discussions about the relevance of market structure versus market share.

According to the theory of Industrial Organization (IO) market power is determined by the structure of the market. From a particular structure, market agents' conduct and performance can be inferred. This relationship is called the Structure-Conduct-Performance (SCP) paradigm. The SCP paradigm within the body Industrial Organization (IO) was until the 1970ies the leading concept to analyze market power issues. A causal relationship between market concentration and market power is postulated by the SCP paradigm (Cabral 2000). Critiques of the SCP paradigm pointed out the endogeneity problem of structure and conduct (Lee 2007; Slade 2004). Due to the criticism other methods have been developed to assess market power (Slade 2004). One for example is the NEIO framework, which focuses on conduct, rather than structure (Cabral 2000; Lopez et al. 2017). However, some may point out that conduct still depends on structure (Brown 2002) and that although structure may suffer from the problem of endogeneity, structure often cannot be changed in the short term and can thus be taken as a stable factor (Martin 2012). While there has been criticism about the validity of the SCP paradigm, there is also evidence for the correctness of the assumptions underlying the SCP paradigm (Martin 2012). Additionally, other theoretical frameworks, such as NEIO, are neither free of shortcomings (Perloff and Shen 2012). In any case, no theoretical framework is perfect, thus, the best of them should be taken from them and possibly combined with others. Brown (2002: 105) states that the SCP paradigm should not be understood as "a straightjacket, but rather a tool for organizing the scientific study of particular problems". Accordingly Borenstein (2016) calls, not for a deepening, but for a broadening of methods.

While the SCP paradigm struggles with the feedback between structure and conduct, systems thinking embraces feedback mechanisms. Moreover, systems thinking supports the understanding of dynamic behavior (Sterman 2000). Brown (2002), emphasizes that NEIO models are based on the assumption of the existence of a state of optimality and results are benchmarked against this optimal state. This fact is also pointed out by Blaug (2001), who expands on the problem of the idea of a final optimal state that is aspired by competition. Blaug (2001) elaborates that there is no perfect competition and hence no optimal final stage of market interaction. From this he concludes that "[…] we must engage instead in qualitative judgements about piecemeal improvements, embracing a dynamic process-conception of competition […]" (Blaug 2001: 40). Apart from this NEIO, models often face the problem of lacking data (Cabral 2000: 160).

Systems thinking can use both quantitative and qualitative data. Qualitative data helps identifying structures, important variables and the boundary of the system. Quantitative data allows to calibrate the model. Though, the fit of the model can finally only be checked by logic considerations based on human sense and information gathered to build the causal loop diagram and the stock and flow model. While we do not intend to downplay the valuable contribution by IO or NEIO models, we suggest that systems thinking can be a potent tool to examine market power and solve the problems of SCP and NEIO models. Therefore, it is suggested to employ systems thinking to study the interrelationships between value chain structure and market power using a sugar beet case study in Belgium.

The analysis of the market situation for the sugar beet sector in Belgium has been performed using systems thinking. As pointed out, even if system dynamics is employed the analysis needs to start with the development of a causal loop diagram. Such a diagram necessitates a thorough thought process about the relationships between variables within the system as well as the boundaries of this system. The logic thought process is the basis to validate the results from system dynamics even after the model has been calibrated with existing quantitative data. Hence, the analysis of the market situation for the Belgian sugar sector started with a causal loop diagram.

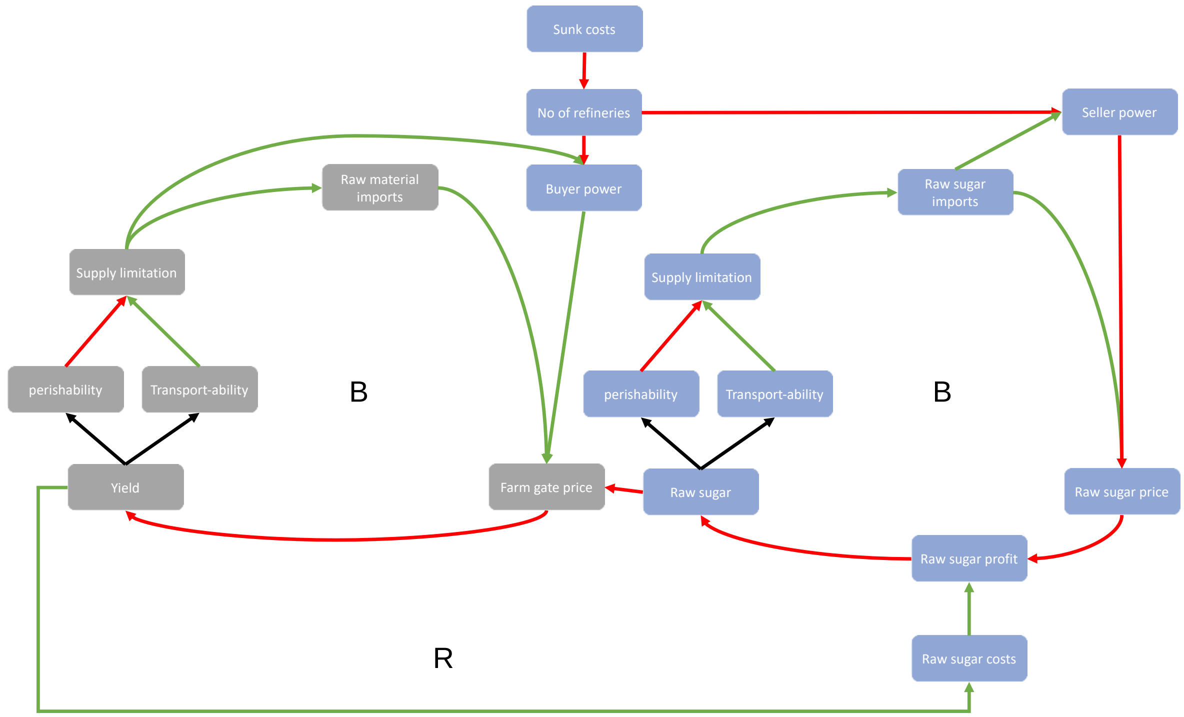

Figure 1: Causal loop diagram, 1st segment of sugar beet supply chain

Figure 1 is the result of the above-mentioned thought process. The causal loop diagram depicts the market situation of sugar beet farmers and refineries. Thus, the figure focuses on the supply chain segment between primary producer and processor. The core of the causal loop diagram are two balancing feedback loops (B) working in conjunction. A third feedback loop is a reinforcing loop (R). The balancing loop describes the relation between output and price. Colors were used instead of the common annotation of "+," and "-". A green connector indicates that the end point moves in the opposite direction compared to the starting point (usually -). The red connectors illustrate that the end point moves in the same direction as the starting point (usually +)[9].

From this exercise it was inferred that the behavior of farmers and refineries, which was observed via qualitative research, can be explained by specific variables. Not only the number and size of market agents are relevant, but also the characteristic of the good (transportability, perishability), which affect the number of market agents as it determines the geographic scale of the market. Further, fixed costs and the possibility to reduce unit costs were identified as relevant factors. Finally, high investment costs form an entrance barrier that builds an obstacle to increase

[9] Colors instead of mathematical operators were chosen due to communication purposes with stakeholders.

the number of refineries. This exercise provides a better understanding of the current situation of the Belgian sugar beet market. It indicates that due to the low number of refineries and the characteristics of the good, refineries may have buyer power but no seller power.

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