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Lost in space? The effect of direct payments on land rental prices

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Abstract

Decoupled direct payments are a major tool of agricultural policy to support farm income. Since these subsidies are tied to land, the question arises as to who benefits from them when farmers are not the landowners. While theoretical models commonly predict that most of the payments transfer to land prices, empirical findings show that this incidence is low instead. Approaching the issue from the perspective of spatial competition, this paper produces results consistent with empirical evidence. Incidence varies with the competitiveness of the market, ranging from perfect subsidy transfer under specific conditions to low or zero incidence for most of the cases considered.

Keywords: agricultural subsidies, land rental markets, spatial competition

JEL classification: L13, Q12, Q18

1. Introduction

The financial support of farms is a principal objective of agricultural policy in the European Union (EU) and the United States (US). A major instrument of farm income support is direct transfers in terms of decoupled direct payments, i.e. subsidies that are independent of the farm's production decisions. Irrespective of the specific implementation of these instruments, a common feature of direct payments (DP) is the direct link to land.[1] Often, however, farmers are not the landowners. In 2007, 38 per cent of the land in US farms was rented (Nickerson *et al.*, 2012). For the EU, this figure ranges from 17

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1 Since the reform of the common agricultural policy of 2003 and the EU eastern enlargement of 2004 and 2007, farms in the EU receive farm-specific payments under the single payment scheme or uniform per-hectare payments under the single area payment scheme (Swinnen, Ciaian and Kancs, 2008). In the US, decoupled payments are farmland-specific subsidies based on historical yields and acreages (Weber and Key, 2012; Kirwan and Roberts, 2016). In either case, farms need to exhibit (own or have rented) eligible (agricultural) land to receive the payment.

per cent (in Romania) up to 90 per cent (in Slovakia) and is higher than 50 per cent in most member states (Ciaian *et al.*, 2012). Therefore, the land rental market is at centre stage to evaluate whether—and if so to what extent—subsidies are actually translated into farmers' income and do not pass onto land rental prices.

In fact, there is an extensive body of literature on this topic. One striking observation, however, is that empirical evidence almost always diverges considerably from theoretical expectations (Kirwan, 2009; Alston, 2010; Ciaian and Kancs, 2012; Hendricks, Janzen and Dhuyvetter, 2012; Kirwan and Roberts, 2016). While theory suggests perfect or high incidence (i.e. subsidies are fully or to a high degree reflected in land rental prices),[2] the vast majority of empirical studies find the subsidy effect to be rather low. Therefore, Sumner, Alston and Glauber (2010) call to 'reconcile recent econometric findings with the predictions from analytical models'. The first objective of the present paper is to contribute in this direction.

In particular, the presence of imperfect competition in land markets needs to be recognised (Ciaian and Swinnen, 2006, 2009; Kirwan, 2009; Breustedt and Habermann, 2011; Herck, Swinnen and Vranken, 2013; Kirwan and Roberts, 2016). While farms are commonly considered to be price takers in input and output markets, the particularities of the land market challenge this perspective. Land is immobile and spatially distributed, and typically a region's land capacity is more or less fixed. For different reasons, the supply of land to agriculture, which is considered in this paper, features some variability but it is still reasonable to assume that this variability is low at the regional and (most important) local level.[3] *Ceteris paribus*—the cultivation of a plot causes higher costs with increasing distance to the farmstead. This reflects the existence of distance costs in general and transport costs in particular. Such costs have two effects: first, a farmer will prefer land in close proximity to his or her location over land at a more distant location (every other characteristic being the same). Therefore, land is a spatially differentiated production factor. Second, agricultural production is land-based and farms themselves are spatially distributed.

In general, spatially distributed demand and supply, and the existence of transport costs facilitate local market power (Hotelling, 1929; Capozza and Van Order, 1978). This seems to be especially relevant if rented land constitutes an important share of the farms' land endowment and landownership

2 According to Alston and James (2002), incidence is the distribution of benefits and costs of a policy among different interest groups (e.g. farmers and landowners). In this paper, incidence refers to the percentage share of the marginal subsidy Euro (or Dollar) that will go to the landowner.

3 Besides factors that cause the loss of land for all possible uses (e.g. desertification or sea level rise), there are also agronomic (e.g. climate change, land improvements in terms of irrigation or drainage, and degradation or restoration of soil quality) and economic impacts (e.g. land use change in terms of reforestation or urbanisation), which can cause changes of the land supply to agriculture. The quality of land, in contrast, can be vastly different and might change over time. Nevertheless, throughout this paper, it is assumed that land is of equal quality and only its location in the region differs.

structure is characterised by numerous small landowners compared with few large farms—a situation typically observed in eastern European countries and East Germany (Swinnen, 2009).[4] But even with less distinct structural differences in farm size and landownership, recent studies attribute to local market power a decisive effect regarding the distribution of policy rents (Kirwan and Roberts, 2016; O'Neill and Hanrahan, 2016).

Farms can exploit local market power by setting land rental prices below the marginal revenue of land and/or using spatial price discrimination. In the present context, this not only might influence the quantitative effects of the subsidy and its rent allocation among the actors but can also reverse qualitative expectations derived from non-spatial models (Capozza and Van Order, 1978; Salop, 1979; Graubner, Balmann and Sexton, 2011). Surprisingly, despite the evident importance of the spatial dimension for agriculture and its effect on market analysis, spatial pricing and competition are barely considered by agricultural economists.[5] Regarding the analysis of land (rental) markets, a number of authors[6] empirically account for spatial characteristics but a formal analysis has not been proposed yet. Therefore, the second objective of this paper is to provide a first systematic approach to land rental markets from a spatial competition perspective and contribute to spatial economics literature in agricultural markets.

The results in this paper highlight the effect of alternative (spatial) pricing strategies and competitive conduct on subsidy incidence. By showing that incidence is perfect (i.e. the subsidy is fully reflected in rental prices) only under specific circumstances, while in most cases there is no or only partial subsidy incidence, this paper theoretically supports the findings of the majority of empirical studies and provides one explanation for these findings from a spatial, imperfect competition perspective.

Following a literature review, we develop a spatial model of the land rental market under non-discriminatory, non-cooperative competition. An alternative pricing option in terms of spatial price discrimination is subsequently introduced before we investigate both pricing strategies with respect to cooperative competition. The overarching objective of this procedure is to evaluate the subsidy effect for the most common and relevant alternative model specifications. Following the formal derivation of equilibrium prices under these scenarios, we summarise and discuss the results in light of the literature and with respect to real-world examples.

4 For instance, the average farm size in East Germany is 229 ha in 2015. While 15 per cent of the farms are larger than 500 ha, 71 per cent of the land in 2013 was rented (data available at www.destatis.de).

5 Noteworthy exceptions include Sexton (1990); Durham, Sexton and Song (1996); Alvarez *et al.* (2000); Zhang and Sexton (2001); Fousekis (2011); Graubner, Balmann and Sexton (2011); Graubner *et al.* (2011). Balmann and Happe (2001) were the first to consider spatial pricing in agricultural land markets.

6 Including Patton and McErlean (2003); Breustedt and Habermann (2011); Karlsson and Nilsson (2014); Storm, Mittenzwei and Heckelei, 2015, and most recently Hennig and Latacz-Lohmann (2017), who investigate the incidence of biogas subsidies on rental prices.

2. Background and relevant literature

Because we approach the subsidy effect on land rental prices from a spatial competition perspective this section reviews two fairly independent streams of research. First, we present theoretical and empirical results regarding the incidence of subsidy payments on land (rental) prices. The goal is to identify important preconditions that affect whether and to what extent DP capitalise into land prices and to show that empirical findings barely comply with theoretical expectations. The second part of this section discusses concepts of spatial pricing and competition that are most relevant in the context of land rental markets.

2.1. Incidence of subsidy payments on land prices

The empirical literature on this topic shows that most of the direct payment remains with the farmer. Landowners also benefit from DP, albeit considerably less so than farmers. In the comprehensive overview by Latruffe and Le Mouël (2009), only four of the 21 reviewed empirical papers find more than 50 per cent subsidy incidence.[7] Additionally, recent studies support the partial or low transfer of DP onto land (rental) prices. In the US, Kirwan (2009) finds that landowners benefit from agricultural subsidy payments but only to an amount of 25 per cent of the payment. In the short run, Hendricks, Janzen and Dhuyvetter (2012) report that incidence is as low as 12 per cent. Most recently, Kirwan and Roberts (2016) estimate incidence levels of 20–28 per cent of the marginal subsidy dollar.

Similar results are observed for the EU. For instance, Breustedt and Habermann (2011) find 38 per cent subsidy incidence for Germany, while Ciaian and Kancs (2012) estimate 19 per cent for the new EU member states. No subsidy effects on rental prices are found by Guastella *et al.* (2013) for Italy, or by Karlsson and Nilsson (2014) for Sweden (in the case of land sale). The capitalisation rates of DP into land values across the EU 15 member states are reported by Michalek, Ciaian and Kancs (2014), ranging from 4 per cent for Greece to 18 per cent for Portugal and averaging 6–7 per cent. Ciaian, Kancs and Paloma (2015) compare the income effect of different EU subsidy schemes and find that a large portion (approx. 70–80 per cent) of the DP benefit the farmers. In their meta-analysis over empirical findings of 26 articles, Feichtinger and Salhofer (2013) estimate that an average of 25–36 per cent of all agricultural support schemes are capitalised into land sales prices.[8]

7 Most of the papers cited by Latruffe and Le Mouël (2009) investigate farmland (sales) prices. Except for Feichtinger and Salhofer (2013) and Karlsson and Nilsson (2014), empirical results referenced in this paper stem from studies on land rental markets. According to the present value model, sales prices can be derived from the discounted expected value of future net returns of farming or rents (Latruffe and Le Mouël, 2009). Although, rental and sales prices refer to different time horizons (where expectations of future earnings become a major difference), their close relationship causes outcomes derived on rental markets (the focus of this paper) to be relevant for the sales market as well.

8 Kilian *et al.* (2012) report ambiguous results for Germany (Bavaria) of 28–79 per cent incidence depending on the nature of the direct payment and land type. Patton *et al.* (2008) and O'Neill and Hanrahan (2016) are rare instances to find close-to-perfect subsidy transfer. However, both

From a theoretical perspective, the standard framework to account for the subsidy effect on land prices goes back to Floyd (1965). Using a model of two inputs (land and the aggregate of capital and labour) and one farm output, he emphasises the importance of key factors as the elasticity of demand for agricultural products, the elasticity of substitution among the factors, and the elasticities of factor supply. Among others, Alston and James (2002) extend and refine the framework and formally derive the policy effect for different instruments while Latruffe and Le Mouël (2009) illustrate this effect graphically. In any case, the benefits of an *output* subsidy will typically be shared among landowners, farmers and suppliers of non-land inputs as well as consumers. Conversely, if land supply is perfectly price-inelastic and either other inputs are supplied perfectly elastically or there is no possibility of substitution for land with other production factors, only landowners will benefit from an output subsidy (i.e. there is perfect subsidy incidence).

In the case of an *input* subsidy on land, perfectly price-inelastic land supply suffices to guarantee perfect incidence—independent of the other elasticities (Alston, 2010). Despite the fixed capacity of agricultural land in a region, there can be a land supply response to changes in rental prices because of the landowners' arbitrage between agricultural and alternative uses of land. In this case, increasing price elasticity of land would imply decreasing incidence. In general, however, land markets in Europe and the US can be characterised by (perfectly) price-inelastic land supply (Floyd, 1965; Salhofer, 2000; Abler, 2001; OECD, 2008). Using moderate values (within the reasonable range) of elasticity of demand for agricultural products, the elasticity of substitution among inputs, and the elasticity of land supply, Alston (2010) calculates incidence levels of 60–70 cents per dollar input (i.e. land) subsidy.

The theoretical expectation of perfect or high subsidy incidence, however, is barely supported by the aforementioned empirical evidence. On the one hand, empirical work mostly does not account for the long-run effect of subsidies on rental prices. In fact, recent studies show that incidence increases in the long run. Emphasising the importance of inertia due to multi-year contracts or social norms in the US, Hendricks, Janzen and Dhuyvetter (2012) estimate low incidence (12 per cent) in the short-term but the level rises to 32 per cent after an adjustment period of five years and 37 per cent in the long run. Also, Kirwan and Roberts (2016) show that incidence increases with decreasing duration of the rental agreement.[9]

On the other hand, real-world income support policies (i.e. agricultural direct payments) may deviate from the theoretical concepts presented in the literature, including the aforementioned land subsidy. Thus, we can expect entangled effects in empirical results. For instance, due to the 'decoupling' of direct payments from production decisions, such subsidies should not affect

studies investigate the land market in Ireland that is characterised by the 'conacre system' and, therefore, represents a special case.

9 O'Neill and Hanrahan (2016) also report significant effects of inertia but surprisingly with the opposite effect.

input use (Hennessy, 1998; Kirwan and Roberts, 2016).[10] Guyomard, Le Mouël and Gohin (2004) show that a purely decoupled payment has the same income effect as an input subsidy but otherwise no impact on the rental price. If the decoupled payment is tied to land, however, the subsidy increases the farms' willingness to pay, thus yielding perfect incidence as well (Ciaian and Swinnen, 2009). In this case, the subsidy is a lump-sum payment to fixed land units (Roberts, Kirwan and Hopkins, 2003; Sumner, Alston and Glauber, 2010).

Whether EU-direct payments can be regarded (or take effect as) lump-sum transfers *or* land subsidies crucially depends on the number of entitlements and the number of (eligible) hectares (Courleux *et al.*, 2008). If entitlements are in excess relative to the amount of land—which was true for most of the EU member states in 2010 (Ciaian, Kancs and Swinnen, 2014)[11]—DP will be reflected in land prices in the same way as former area payments (Kilian *et al.*, 2012). Therefore, the nature of the supply response to change in the land (rental) price is decisive.[12]

Accordingly, given the surplus of entitlements over eligible land and the inelastic land supply, most, if not all, of the benefits of the subsidy will go to landowners (Alston, 2010; Sumner, Alston and Glauber, 2010; Ciaian and Kancs, 2012; Kirwan and Roberts, 2016). Deviations from this general conclusion must be rooted in the particular characteristics of the land market at hand and/or the violation of underlying conditions of the theoretical models.

For instance, Ciaian, Kancs and Swinnen (2014) point out that the insignificant effect of DP on land rents in Italy, as found by Guastella *et al.* (2013), can be attributed to the deficit of entitlements relative to eligible land.[13] There is also a critical discussion whether decoupled payments indeed have no effect on the farms' production decisions. In the presence of uncertainty, Hennessy (1998) shows that decoupled payments may induce incentives to alter production, which would cause lower incidence levels. However, Bhaskar and Beghin (2009) or Weber and Key (2012) argue that these effects are small or do not transpire if farmers have access to off-farm income opportunities (Chambers and Voica, 2017). Sckokai and Moro (2009) provide empirical

10 O'Neill and Hanrahan (2012) provide empirical support for this by showing that farmers' land market participation in Ireland did not significantly change after the introduction of decoupled payments in 2005.

11 Reasons include that farms not activating entitlements to avoid the assigned environmental requirements (cross compliance) or administrative effort (transaction costs). Additionally, through effects such as urbanisation, agricultural area decreases faster than the reduction of entitlements through retraction by the government (Salhofer, 2009).

12 Regarding the direct payments in the EU, a number of authors theoretically show that other aspects including the implementation of the instrument, the tradability of entitlements, the heterogeneity in productivity and entitlement values, or the access of entrants to entitlements can also affect the degree of subsidy incidence (Courleux *et al.*, 2008; Kilian and Salhofer, 2008; Kilian *et al.*, 2012; Ciaian, Kancs and Swinnen, 2014; Michalek, Ciaian and Kancs, 2014). Whether or not and to what extent these effects actually materialise, however, crucially depends on the entitlement-land ratio and the price elasticity of land supply.

13 Due to presumably surplus entitlements in Sweden (Swinnen, Ciaian and Kancs, 2008), the study by Karlsson and Nilsson (2014) would be a counterexample to this point.

evidence for Italy. While direct payments affect the supply response by farms, these effects are small and the authors conclude that the income transfer can be 'virtually considered decoupled'.

Other reasons that may cause the divergence of empirical findings and analytical expectations include information asymmetries (Ciaian, Kancs and Swinnen, 2014), social norms (Kirwan, 2009; Ciaian and Kancs, 2012; Hendricks, Janzen and Dhuyvetter, 2012; O'Neill and Hanrahan, 2016), and imperfect labour or capital markets (Ciaian and Swinnen, 2006, 2009). Mostly, an analytical account to these issues is not available but Ciaian and Swinnen (2009) theoretically show that the gain of landowners can even exceed the subsidy payment in the presence of credit market imperfections, i.e. incidence is higher than one.

Most often, however, the presence of imperfect competition on land markets is quoted (Ciaian and Swinnen, 2006; Kirwan, 2009; Breustedt and Habermann, 2011; Kirwan and Roberts, 2016; O'Neill and Hanrahan, 2016). Scrutiny from a theoretical perspective is rarely presented though. Ciaian and Swinnen (2006) model imperfect competition on land markets with a price-setting (large) corporate farm and a group of price-taking individual farmers. While an input subsidy on land only benefits landowners, decoupling of the subsidy will shift the benefits to farmers, provided new entrants cannot claim entitlements. Using a similar framework, Michalek, Ciaian and Kancs (2014) show that heterogeneity in entitlement values yields lower levels of subsidy incidence; perfect incidence can be expected under the EU single area payment scheme or if there is perfect harmonisation of entitlement values after the EU CAP reform of 2013.

While a number of factors influence the degree of capitalisation of DP into land (rental) prices, there is much confusion in the literature as to the extent theory and empirical evidence are consistent. In fact, the available theoretical models are barely suitable to explain the empirically observed low degree of subsidy incidence. As a consequence, alternative explanations are required (Sumner, Alston and Glauber, 2010). Most recently, Kirwan and Roberts (2016) underscore this point: 'the low-incidence findings cannot be attributed to the production effects of decoupled subsidies. Instead, […] the competitive-markets assumption in the theory of factor-specific incidence might not hold.'

2.2. Pricing and competition on spatially differentiated land rental markets

The consideration of the spatial dimension of markets has important roots in agricultural economics. For instance, the pioneering work of von Thünen (1826) highlights the importance of distance (between the site of production and consumption) for land-use decisions. Lösch (1944) extends von Thünen's monocentric model to a multi-market framework and, for example, derives the optimal market area for a brewery. Most spatial models in agricultural economics, however, follow the approach of spatial equilibrium modelling

(Fackler and Goodwin, 2001), where competitive centres of supply and demand are separated by geographical distance. If locations of demand *and* supply are spatially dispersed, as in the case of agricultural land markets, an alternative approach is required, which accounts for imperfect competition (Faminow and Benson, 1990).

With regard to the present paper, the most relevant stream of literature originates in Hotelling's 'Main Street' model (Hotelling, 1929), which paves the way for the microeconomic-oriented approaches in spatial economics, in particular spatial price and competition theory. Once adapted to an input market setting, the model captures features characteristic of land rental markets, including the inelastic local supply of land and its uniform distribution across the region. Unlike Hotelling, however, the farm's location will be treated as given in this paper[14] and the possibility of spatial price discrimination will be considered.

In a spatial monopolistic setting, Hoover (1937) was the first to highlight the effects of spatial price discrimination where distance costs are not fully reflected in price differences between two locations (Phlips, 1983). A prominent example is uniform pricing, where the monopolist absorbs the freight costs and sets a uniform price across the market region. Smithies (1941) shows that this strategy is more profitable for the isolated firm relative to non-discriminatory pricing if the local demand (supply) is inelastic. In this case, uniform pricing is the equilibrium strategy under oligopolistic/oligopsonistic competition (Espinosa, 1992; Graubner, Balmann and Sexton, 2011) because firms can capture all or most of the consumers' (suppliers') surplus (Zhang and Sexton, 2001).

Spatial competition models mostly use either non-discriminatory (Capozza and Van Order, 1978) or uniform pricing (Gronberg and Meyer, 1981) and compare the equilibrium outcome under alternative competition scenarios, including cooperative and non-cooperative competition.[15] Two important conclusions can be derived from this literature: (i) the obtained results are sensitive towards key assumptions, in particular concerning the nature of competition and the price policy. (ii) The market outcome can be quite different and even reversed in a spatial and non-spatial setting. For instance, Salop (1979) considers non-discriminatory pricing and states that a cost increase due to an excise tax results in a consumer price decrease, i.e. the incidence of the tax is negative. A corresponding account for uniform pricing in a context relevant to land rental markets does not exist.[16]

14 This is a reasonable assumption because location decisions by farmers are singular events (if at all) whereas interactions with competitors on land rental markets occur frequently.

15 The focus in this paper is on price competition as opposed to quantity competition. This seems to be rational because land rental markets resemble the features of price competition (cf. Hobbs, 1986) where farmers announce rental prices rather than quantities and the capacity constraint is not binding or implicitly considered within the spatial price strategy (as shown later in the paper).

16 Beckmann (1973) or Zhang and Sexton (2001) investigate uniform pricing but both models consider mobile goods where consumers/suppliers face the same transport costs as producers/buyers, which facilitates spatial arbitrage. Shilony (1981) is the only one who derives the equilibrium strategy in a framework where spatial arbitrage by consumers is not possible because

The interpretation of spatial competition as a special case of horizontal product differentiation helps to relate the spatial framework to discrete choice theory (Anderson, De Palma and Thisse, 1992). For instance, Anderson, De Palma and Kreider (2001) consider oligopolistic price competition and show that incidence for ad valorem and unit excise taxes can be larger than one. In case of an excise tax, Bonnet and Réquillart (2013) find a similar result for the soft-drink market in France. While these models are powerful in dealing with imperfect competition, product differentiation and third degree price discrimination in order to investigate incidence (Weyl and Fabinger, 2013), the theoretical framework presented in this paper is convenient as it explicitly represents the continuous spatial nature of the land market (i.e. localised competition).

Due to data availability issues, there is little or no knowledge regarding the farms' spatial price or competition strategies on land rental markets. Because of this and because the subsidy effect might depend on the price and competition strategy, a comparative approach is required. Commonly, however, only one price (competition) strategy under alternative competition (price) conjectures is considered. This paper presents the results for relevant price and competition strategies together to permit this comparison.

3. A spatial model of non-cooperative competition in the land rental market

To evaluate the effect of DP on land rental prices, we use a duopsony framework derived from Hotelling's 'Main Street' model (Hotelling, 1929). While most of the assumptions are standard for spatial input markets (Löfgren, 1986; Zhang and Sexton, 2001; Fousekis, 2011; Graubner, Balmann and Sexton, 2011), some modifications are required to capture specific features of the land market. Nevertheless, most of the results presented below mirror findings on consumer markets or represent adjusted results for input markets. The discussion in Section 3.2, however, contains new insights regarding the subsidy incidence under spatial price discrimination.

Two farms are located at the endpoints of a line market with length l. In a price-setting game, the farms compete for land plots uniformly distributed along this line. Land is homogenous in quality (except for its location) and size, and one land unit is owned by one landowner.[17] The local land supply $Q(d)$ at location $d = [0, l]$ is perfectly price inelastic $Q(d) = 1$ as long as the rental price $q(d)$ exceeds a given reservation price v[18]:

of prohibitive transport costs. This reflects immobility, the inherent feature of land markets, and has non-trivial effects on the determination of the equilibrium outcome as demonstrated by Shilony (1981). The author, however, normalises marginal costs to zero, which prevents any conclusion regarding potential tax/subsidy effects.

17 A reasonable interpretation of this linear model is the main street in a village (similar to Hotelling's original model) where land is located on both sides of the street and two farms are located at the entrance of the village and its exit. Besides the common use of this representation of a spatial market in the literature, the model is also easily generalisable to oligopsony.

18 The introduction of a reservation price deviates from prior literature on input markets. In this setting, the reservation price corresponds to an alternative usage of agricultural land, e.g. for

$$Q(d) = \begin{cases} 1 & \text{if } q(d) \geq v, \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

Both farmers produce an agricultural good (or aggregate of goods) y with technology $y(x, \mathbf{X}) = \min\{\alpha x, f(\mathbf{X})\}$. α represents a constant rate of conversion between the land input x and the product while $f(\mathbf{X})$ is a vector of other production factors. For the sake of simplicity and with appropriate choice of measurement, we can set $\alpha = 1$.

The farmers are price takers in the output market where Φ is the price of the farm product. With constant marginal costs c of other inputs, the marginal revenue (i.e. the price net of other production costs but land) is given by $p = \Phi - c$. All land is eligible to receive the DP and the subsidy s per unit of land is constant, i.e. we model DP in terms of a *land subsidy*. We parameterise $0 \leq v \leq p + s$. Furthermore, if land is cultivated by a farm, there are plot-specific costs that increase linearly with distance according to an exogenously given transport rate $t \geq 0$.

3.1. Non-discriminatory pricing and incidence of a land subsidy

Initially, it is assumed that farms use a price schedule that reflects transport costs via a distance-dependent rental price. Let d_i be the location of farmer $i = \{A, B\}$ with $d_A = 0$ and $d_B = l$. The local price is then

$$q_i(d) = f_i - t\,|d_i - d|, \tag{2}$$

where f_i is the rental price at the location of farm i – which we denote the base price—and td represents the distance costs from farm A to d while $t(l - d)$ corresponds to the distance costs from farm B to d, respectively.[19]

At any location d, the local profit from agricultural production on this plot is given by $\pi_i = p + s - t\,|d_i - d| - q_i(d)$, where $p + s - t\,|d_i - d|$ can be denoted as the local land rent. As long as $\pi_i > 0$, the farm will embrace the possibility to produce at d. Equation (2) yields a constant, distance-independent profit per unit land of $p + s - f_i$. The overall profit of the farm is

$$\Pi_i = (p + s - f_i)D_i, \tag{3}$$

where D_i is the total amount of land used by farm i. To determine D_i, two conditions need to be considered:

(semi-)subsistence or hobby agriculture, gardening or forestation, and is constant and uniform across landowners.

19 In spatial price theory and under non-discriminatory pricing, free-on-board or mill price are typically used in this context. The alternative term *base price* is used in this paper due to the immobility of land.

$$v \leq q(d) = \max\{q_i(d)\}, \quad \forall\, i = \{A, B\}. \tag{4}$$

First, the rental price needs to be higher than the reservation price of the landowner (left hand side of (4)) and, second, farm i has to offer the highest rental price across all farms for land at the desired locations (right-hand side of (4)). In general, a landowner at location D is indifferent between renting to A or B if $f_A - tD = f_B - t(l - D)$ and if $f_i - t\,|d_i - D| \geq v$ is satisfied, which gives the land demand of farm i[20]:

$$D_i = \min\left\{\frac{(f_i - v)}{t}, \frac{(f_i - f_{-i} + \sigma)}{2t}\right\}, \quad \forall\, i = \{A, B\} \text{ and } i \neq -i. \tag{5}$$

Due to the linear nature of the spatial model, D_i also represents the farm size in terms of land endowment.

A central concept in spatial competition models is the *absolute importance of space* denoted by $\sigma \equiv tl$. In relation to the profit potential, it reflects the *competitiveness of the market*, formally denoted as: $\hat{\sigma} \equiv \sigma/(p + s - v)$ (cf. Alvarez *et al.*, 2000; Zhang and Sexton, 2001; Graubner, Balmann and Sexton, 2011). When either the distance between both farms is zero or there are no transport costs (i.e. $\sigma = 0$), the model collapses to perfect or Bertrand price competition. With increasing importance of space, the competitiveness of the market decreases and eventually the two farms act as locally separated monopsonies. In this case, there is no indifferent landowner and the first condition of (5) determines the land demand. Substitution for D_i into (3) and maximisation with respect to f_i yields

$$f^{\text{Mon}} = \frac{p + s + v}{2}, \quad D^{\text{Mon}} = \frac{p + s - v}{2t}. \tag{6}$$

From $2D^{\text{Mon}} \leq l$, we conclude that both farms are monopsonists if $p + s - v \leq \sigma$ or $\hat{\sigma} \geq 1$.

Under competition, however, the farm size is determined by the second term of equation (5) and substitution of D_i in (3) and maximisation with respect to f_i gives the reaction function:

$$f_i(f_{-i}) = \frac{1}{2}(p + s + f_{-i} - \sigma). \tag{7}$$

By solving the corresponding equations for farms A and B, we obtain the equilibrium base price for both farms:

$$f^{\text{SD}} = p + s - \sigma. \tag{8}$$

Note that the rental price received by the indifferent landowner (at $l/2$) would be below the reservation price, $q(D|f^{\text{SD}}) \leq v$ if $\sigma \geq 2(p + s - v)/3$ (see

20 Note that the location of the indifferent landowner, if one exists, is $D = |d_i - D_i|$.

Figure 1b). Hence, the equilibrium price (8) only applies if $0 \leq \sigma < 2(p + s - v)/3$, which is referred to as *strict duopsony* and indicated by the superscript SD.[21]

In the case of moderate importance of space, $2(p + s - v)/3 \leq \sigma < p + s - v$, denoted as *weak duopsony*, multiple equilibria exist (Mérel and Sexton, 2010). For simplicity, we focus on symmetric strategies.[22] To solve for the equilibrium prices, the local price at the location of the indifferent landowner must match the reservation price. Therefore, the condition $(f_i - f_{-i} + \sigma)/2t = (f_i - v)/t$ must be satisfied, which yields

$$f_i\,(f_{-i}) = 2v + \sigma - f_{-i}. \tag{9}$$

Accordingly, the equilibrium price under the weak duopsony is given by

$$f^{\mathrm{WD}} = (\sigma + 2v)/2. \tag{10}$$

Equation (11) summarises the previous results for non-discriminatory spatial competition:

$$f^* = \begin{cases} p + s - \sigma & \text{if } 0 \leq \sigma < 2(p - v + s)/3, \\ (\sigma + 2v)/2 & \text{if } 2(p - v + s)/3 \leq \sigma < p - v + s, \\ (p + v + s)/2 & \text{if } \sigma \geq p - v + s. \end{cases} \tag{11}$$

These three competition scenarios are illustrated in Figure 1. While the market is covered (all land is rented) under strict (a) and weak duopsony (b), there is unrented land in the case of monopsonies (c). Accordingly, the farm size (see the dashed vertical lines in Figure 1) is determined by the second term of equation (5) for the strict duopsony, by the equality of both terms under weak duospony, and by the first term under monopsony.

We now examine the subsidy effect (i.e. whether and if so to what extend the land subsidy s will be transferred to the base price). In particular, the relation $\partial f^*/\partial s$ needs to be evaluated.

Obviously, the land subsidy affects the rental prices under fierce competition $(0 \leq \sigma < 2(p - v + s)/3)$ as well as in the case of monopsony $(\sigma \geq p - v + s)$. While incidence is perfect $(\partial f^*/\partial s = 1)$ in the first case, only half of the subsidy is transferred to the base price in the latter case $(\partial f^*/\partial s = 1/2)$. Interestingly, the land subsidy does not affect the rental price $(\partial f^*/\partial s = 0)$ under the weak duopsony (cf. footnote 22).

21 Following Mérel and Sexton (2010) in their study on consumer markets.

22 The derivation of asymmetric equilibria as in the paper by Mérel and Sexton (2010) is omitted because the effect of the land subsidy (as discussed below) is ambiguous. To illustrate, the equilibrium rental prices are given by $f_i^{\mathrm{WD}} \in [(4v + 3\sigma - p - s)/3, (p + s + 2v)/3]$ if $2/3 < \hat{\sigma} \leq 5/6$ and $f_i^{\mathrm{WD}} \in [(p + s - v)/2, (2v + 2\sigma - p - s)/2]$ if $5/6 < \hat{\sigma} \leq 1$ (for details see Mérel and Sexton, 2010). Therefore, the subsidy effect on the rental price has the same magnitude for both farmers but is positive for one and negative for the other, which causes no effect of the land subsidy under symmetric strategies as derived subsequently.

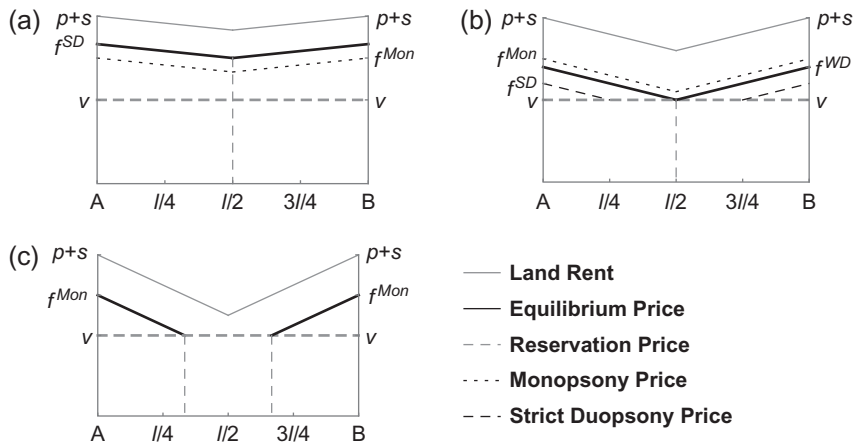

Figure 1. Spatial competition under non-discriminatory base pricing. (a) Strict duopsony, (b) weak duopsony and (c) Monopsony.

Figure 2 illustrates the results with and without a subsidy payment.[23] Obviously, the relationship between the equilibrium base price and the market competitiveness is not monotonic and for moderate importance of space, the base price falls below the monopsony level. These observations are characteristic for non-discriminatory pricing under unit demand/supply but also translate to price-elastic consumer/supplier responses (Zhang and Sexton, 2001; Mérel and Sexton, 2010; Graubner, Balmann and Sexton, 2011). The results further show that a land subsidy directly influences the competitiveness of the market, overall increasing competition, and enabling competition for high importance of space where otherwise (i.e. without the subsidy) local monopsonies would emerge.

There are three major observations from this section of spatial non-cooperative competition under non-discriminatory base pricing: (1) this spatial price competition for land causes low or no transfer of the land subsidy to rental prices if the spatial dimension of the market is sufficiently important. (2) Under fierce competition (i.e. low importance of space), the subsidy is fully reflected in the rental price. (3) The relationship between base price and importance of space changes significantly (e.g. at $\sigma = 2(p - v + s)/3$) (cf. Figure 2). Before we discuss these findings, the alternative strategy of spatial price discrimination is presented.

3.2. Rental prices and incidence under spatial price discrimination

Price discrimination plays an important role in spatial markets (Greenhut, Norman and Hung, 1987; Zhang and Sexton, 2001; Graubner, Balmann and Sexton, 2011). A prominent instance is uniform (delivered) pricing, which we

23 For $s = 0$, the figure mirrors the duopoly result of (Mérel and Sexton, 2010, Figure 1) except that asymmetric equilibrium strategies are not depicted here.

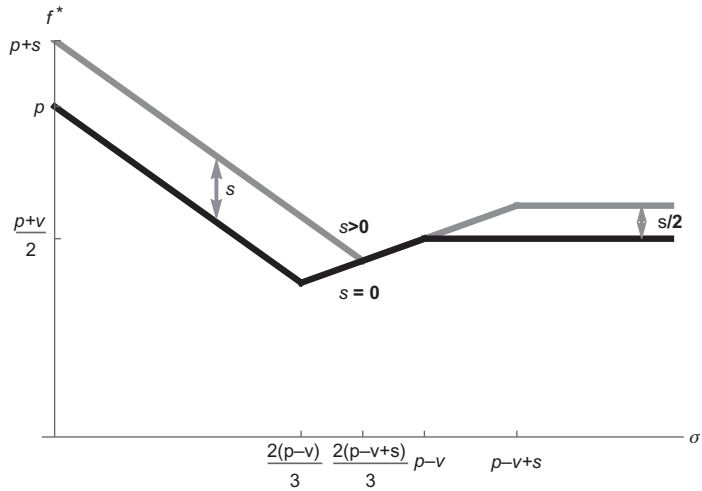

Figure 2. Equilibrium base price f^* dependent on the absolute importance of space σ with and without a subsidy s.

will refer to as uniform rental (UR) pricing.[24] Under UR pricing, the farm absorbs the full distance costs and pays the same rental price r_i to all of its landowners:

$$q_i(d) = r_i. \tag{12}$$

Another difference between UR pricing and the non-discriminatory base price is the determination of the farm's land demand (i.e. its size). Under non-discriminatory pricing, the land demand is determined by the landowners' decision to rent to the farm which offers the highest price. In contrast, under UR pricing, the farm restricts its land demand and only rents land at locations with positive local profits (i.e. where the local land rent is higher or equal to the uniform rental price, $p + s - t\,|d_i - d| \geq r_i$). Let D_i^{UR} be a farmer's land demand under UR pricing. At the marginal location the farmer's profit breaks even and $p + s - tD_i^{\mathrm{UR}} - r_i = 0$, which yields

$$D_i^{\mathrm{UR}} = \frac{p + s - r_i}{t}. \tag{13}$$

Because distance costs are not passed on to the local rental prices, the local profit (per unit of land) decreases with distance. The total profit of the farm under the UR regime can be written as[25]

24 The term uniform delivered (UD) pricing is common in the literature on consumer markets (Beckmann, 1976; Greenhut, Norman and Hung, 1987). Again, due to the immobility of land, the alternative notion of UR pricing is used here.

25 By interpreting D_i^{UR} as distance from the farmstead to the marginal plot, we simplify the notation and present the profit for farms A and B alike, i.e., the lower limit of the integral is always zero and the upper limit is given by (13).

$$\Pi_i^+ = \int_0^{D_i^{\mathrm{UR}}} (p - td + s - r_i)\mathrm{d}d = \frac{(p + s - r_i)^2}{2t}. \tag{14}$$

With respect to r_i, Π^+ is monotonic decreasing in the economic relevant range ($0 \leq r_i \leq p$) and, therefore, the farm will set its price as low as possible, i.e. $r_i = v$.

Both farms, however, can only offer the monopsony price and yield the resulting land demand if $l \geq 2D_i^{\mathrm{UR}}(v)$, which refers to high importance of space $\sigma \geq 2(p - v + s)$ and locally separated markets.[26]

For lower values of σ, both farms compete for land and the farm with the higher UR price will capture all or most of the land supply. If $(p - v + s) \leq \sigma < 2(p - v + s)$, i.e. the importance of space is moderate, one farm cannot rent all land (without making local losses) because $D_i^{\mathrm{UR}} < l$ for any rental price. In this case, there is a residual land supply $l - D_i^{\mathrm{UR}}$, which the other farm can capture with the profit maximising monopsonistic price. For sufficiently high UR prices, a residual supply will also exist if $\sigma \leq p - v + s$, i.e. if the importance of space is low.[27] If there is no residual land supply, it is always profitable for the farm to marginally overbid the competitor. In the presence of residual land supply, the farm can always earn positive non-zero profits, independent of the other farms UR price r_{-i}. If r_{-i} is sufficiently high, this profit can be higher than the potential profit of marginally overbidding the competitor. This discontinuity in the payoff functions of the farms is the reason that a Nash-equilibrium in pure strategies fails to exist in a model of UR pricing. A mixed strategy equilibrium, however, can be represented by a cumulative distribution function (Beckmann, 1973; Shilony, 1981; Zhang and Sexton, 2001).[28]

In general, the farm faces the choice to set a higher or lower UR price than the competitor; matching the other farm's price is always dominated by these two options (Beckmann, 1973). If $r_i > r_{-i}$, i's profit is given by (14). The profit for $r_i < r_{-i}$ is

26 Note that the land demand of the farm in a monopolistic position is higher under UR pricing compared to the non-discriminatory base price discussed in the previous section (cf. equations (6) and (13) if $r_i = v$). Hence, price discrimination facilitates larger farms if the importance of space is high (*ceteris paribus*).

27 The critical price is $\bar{r} = (p + s - \sigma)$. If the UR price is below $\bar{r}$, either farm can earn positive profits at the location of the other farm and the one with the higher price rents all land. Contrary, if a UR price is above $\bar{r}$, it is not profitable to rent all land and there is a residual supply.

28 The non-existence of a pure-strategy Nash-equilibrium under uniform pricing is well documented in consumer markets (d'Aspremont, Gabszewicz and Thisse, 1979; Schuler and Hobbs, 1982) while Zhang and Sexton (2001) provide the analysis for factor markets. The procedure to derive the mixed strategy is presented in the mentioned literature. Despite the introduction of a non-normalised marginal revenue p and the landowners reservation price v, our example does not fundamentally diverge from these models. It is, therefore, convenient to present only a condensed derivation of the mixed strategy.

$$\Pi_i^- = \int_0^{l-D_{-i}^{\mathrm{UR}}} (p - td + s - r_i)\mathrm{d}d$$
$$= -\frac{(p + s - r_{-i} - \sigma)[3(p + s) - r_{-i} - \sigma - 2r_i]}{2t}. \tag{15}$$

Both Π_i^+ in (14) and Π_i^- in (15) are monotonic decreasing in r_i but Π_i^- is monotonic increasing in r_{-i}.[29] Hence, the profit of overbidding decreases with increasing prices while the incentive to set a low monopsonistic price to capture the residual land supply increases. This yields an upper (r^+) and lower (r^-) limit to the rental price with $\Pi^+(r^+) = \Pi^-(r^-)$. This case is schematically illustrated in Figure 3, where farm A uses (r^+). Farm B finds it still profitable to marginally overbid A and rent all land up to the break-even point where local profits are zero (i.e. the UR price equates to the local land rent: $r_i = p + s - t\,|d_i - d|$). The resulting profit of doing so, however, will be smaller than the feasible profit by renting what is left by A, i.e. the residual land supply $l - D_A^{\mathrm{UR}}(r_A^+)$, and setting a monopsonistic rental price, which maximises the profit for the given (but limited) farm size. The shaded areas in the figure represent the respective profits $\Pi^+(r^+)$ and $\Pi^-(r^-)$.

We can now determine the upper and lower price limits with the mixed strategy represented by the cumulative distribution function $\psi(r_i)$, which assigns a non-zero probability $P[r_i \geq r_{-i}]$ to each rental price r_i in its support (i.e. to any price between r_i^- and r_i^+). If farm $-i$ plays its mixed strategy $\psi(r_{-i})$, the expected profit of farm i can be written as[30]

$$E[\Pi_i^{\mathrm{UR}}(r_i, r_{-i})] = \Pi_i^+\psi(r_i) + \Pi_i^-[1 - \psi(r_i)]. \tag{16}$$

The first term on the right-hand side represents the profit if i sets the higher UR price (see equation (14)); the second term refers to the profit if the competitor's rental price (r_{-i}) is higher (equation (15)). The optimal strategy for farm i maximises (16), irrespective of the other farm's strategy. If both farms use their optimal strategies $\psi(r_i)$ and $\psi(r_{-i})$, respectively, equation (16) represents the expected profit guaranteed to i, which is the value of the game V. We can rearrange (16) to

$$\psi(r_i) = \frac{V - \Pi_i^-}{\Pi_i^+ - \Pi_i^-}. \tag{17}$$

Since r_i^- is the lowest price in support of the mixed strategy, $\psi(r_i^-) = 0$, i.e. the probability that the competitor offers a lower price is zero. Furthermore, v is the optimal price for a given farm size and neither farm

29 It is $\Pi_i^- > 0$ only if $p + s - \sigma < r_{-i}$, i.e. there is a residual land supply.

30 See Zhang and Sexton (2001), equation 5. Because of $\psi(r_i) = \int_0^{r_i} \mathrm{d}\psi(r_{-i})$, we can express the expected payoff (16) in terms of $\psi(r_i)$ only. According to equation (15), however, Π_i^- depends on the competitor's price r_{-i}.

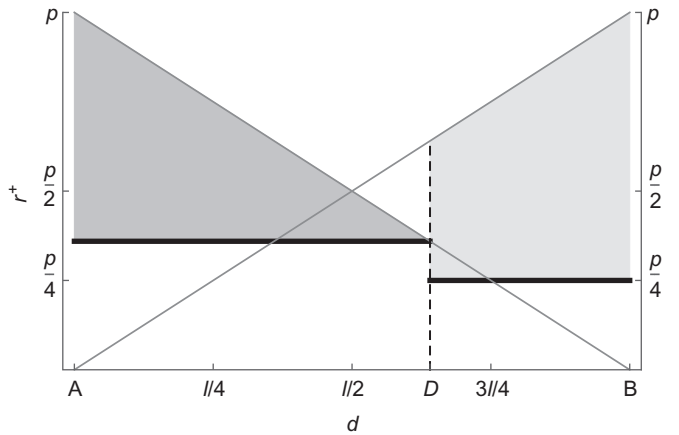

Figure 3. The upper and lower price limit under UR pricing and $p = \sigma$, $v = p/4$.

will set a rental price below this reservation price. Therefore the lower price limit is[31]

$$r_i^- = v. \tag{18}$$

With equation (15), we obtain:

$$V^* = \Pi_i^-(v) = -\frac{(p + s - r_{-i} - \sigma)[3(p + s) - r_{-i} - \sigma - 2v]}{2t}. \tag{19}$$

The highest rental price the farmer will offer is r_i^+ and $\psi(r_i^+) = 1$. From equation (17), we get $V^* = \Pi_i^+$. Considering equations (14) and (19), farm i is indifferent between overbidding the competitor or capturing the residual land supply if $\Pi_i^-(r^-) = \Pi_i^+(r^+)$:

$$-\frac{(p + s - r_{-i} - \sigma)[3(p + s) - r_{-i} - \sigma - 2v]}{2t} = (p + s - r_i^+)^2/2t. \tag{20}$$

This equation can only be true when the opponent sets a price at the upper limit. Because both farms are identical $r_{-i}^+ = r_i^+$ and we can substitute for r_{-i} in (20). Solving for r_i^+ then yields

$$r_i^+ = \left[3(p + s) - \sigma - v - \sqrt{(p + s + \sigma - v)^2 - 2\sigma^2}\right]/2. \tag{21}$$

Instead of proceeding to compute the mixed strategy $\psi(r)$, it is sufficient for the purpose of this paper—the evaluation of the subsidy effect—to investigate the upper and lower price limit. Figure 4 highlights the relationship

31 We get this formally by the substitution of $\psi(r_i) = 0$ into equation (17) and maximising $V = \Pi_i^-$ with respect to r_i. Because $(p + s - \sigma) \leq r_{-i}$ is a precondition for the existence of the residual supply, Π_i^- is monotonic decreasing in r_i and farm i will set its rental price to v.

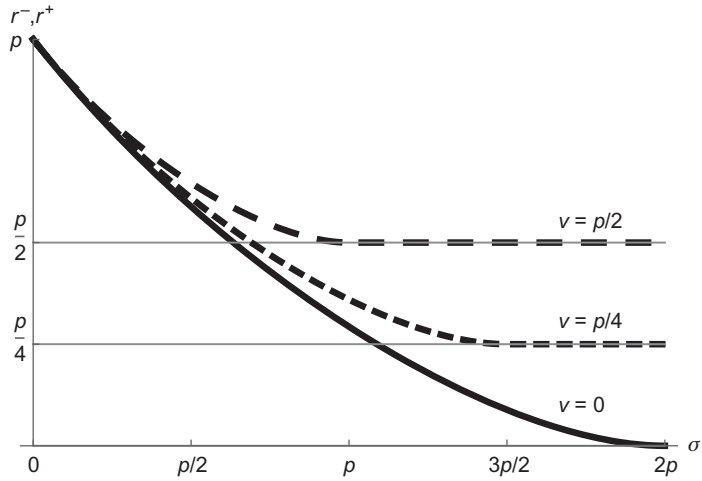

Figure 4. Upper (black) and lower (grey) price limits dependent on the importance of space σ and the landowners' reservation price v.

between both prices, the importance of space, and selected values of the landowners' reservation price.

Now suppose there is a land subsidy $s > 0$. Inspection of (18) and (21) shows that this land subsidy does not change the lower price limit r_i^- but the upper price limit r_i^+ is a function of s. The full subsidy is reflected in this price if $r_i^+(s) - r_i^+(0) = s$ or $\partial r_i^+/\partial s = 1$. Closer evaluation of (21) yields

$$\frac{\partial r_i^+}{\partial s} = \frac{1}{2}\left[3 - \frac{p - v + s + \sigma}{\sqrt{(p - v + s + \sigma)^2 - 2\sigma^2}}\right]. \tag{22}$$

There exists perfect incidence at the upper price limit only when $\sigma = 0$. Otherwise $\partial r_i^+/\partial s < 1$ if $\sigma > 0$. Figure 5 highlights this relationship between incidence and the importance of space at r_i^+. If $\sigma > 2(p - v + s)$, both farms can operate as local monopsonists and set $r_i = v$. Note that the incidence at the lower price limit is zero ($\partial r_i^-/\partial s = 0$). Accordingly, independent of the actual shape of $\psi(r_i)$, the expected incidence is between $\partial r_i^-/\partial s = 0$ and $\partial r_i^+/\partial s \leq 1$ with $\partial r_i/\partial s = 1$ if $\sigma = 0$ and $\partial r_i/\partial s = 0$ if $\sigma > 2(p - v + s)$. As for base pricing, incidence is high under UR pricing if σ is small (i.e. spatial competition is fierce) but here it is perfect only if space does not matter. With increasing importance of space, the transfer of the land subsidy to rental prices decreases.

4. Incidence under cooperative competition

Whereas the previous analysis assumes non-cooperative competition, this section investigates whether cooperation among the farms affects the subsidy

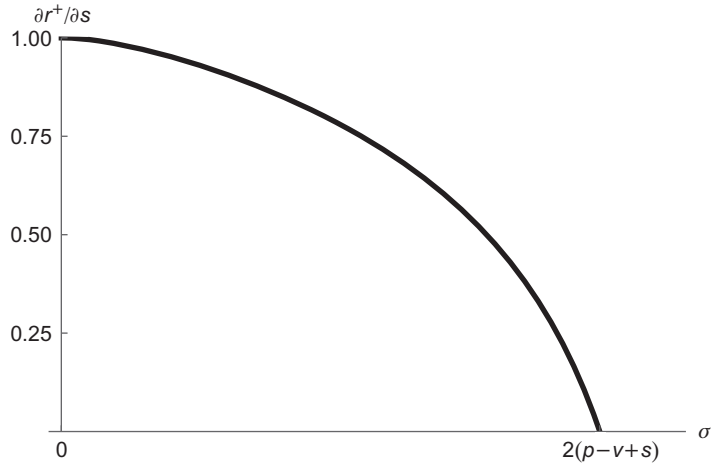

Figure 5. Incidence at the upper price limit.

incidence. Under spatial competition, the farmer has not only to decide on the rental price but also where to rent. Due to distance costs, only a few farms can compete for certain plots in a region, which might incentivise cooperation or even tacit collusion to depress land rental prices and increase farm profits.

Three scenarios that differ by price strategy and the degree of cooperation are most relevant in this context: (a) cooperative rental price differentiation (non-discriminatory pricing), (b) UR pricing with a regional land sharing agreement and (c) UR pricing without a sharing rule. Under spatial rental price differentiation, the farms might agree on a common base price and both will yield the (distance) cost minimising land allocation because of the landowners' decision regarding the higher price at that location. On the contrary, a common UR price does not have this steering function to yield the distance cost-minimizing allocation. Instead, landowners are indifferent about the farms if the prices are identical. Therefore, the farmers might agree on the common UR price *and* on the locations where each farm rents its land (b), or cooperate to a lesser extent and set only the same UR price (c).

4.1. Non-discriminatory pricing

For the following discussion, we assume that both farms can compete for plots at least at one location and thus they do not act as spatially separated monopsonies. If the farms agree on a common base price f^{a} (or simply match the neighbour's price), the optimal farm size (land demand) is $D^{\mathrm{a}} = l/2$ (cf. equation (5) for $f_i = f_{-i}$). Inserting into the farms profit function (3) shows that the profit $\Pi^{\mathrm{a}} = (p - f^{\mathrm{a}})l/2$ is monotonic decreasing with f^{a}. The farm will, therefore, set the base price as low as possible given its

market demand (i.e. considering equation (5), $(f^{\mathrm{a}} - v)/t = l/2$ must be satisfied), which leads us to

$$f^{\mathrm{a}} = (\sigma + 2v)/2. \tag{23}$$

Obviously, this is the same result as under the non-cooperative weak duopsony (equation (10)). Therefore, the common base price features no subsidy incidence ($\partial f^{\mathrm{a}}/\partial s = 0$) but the typical adverse effects of spatial cooperative competition under non-discriminatory pricing (Capozza and Van Order, 1978; Mérel and Sexton, 2010), where the base price increases with decreasing competition (increasing importance of space).

4.2. Discriminatory pricing

In the case of price discrimination, matching the other farm's price under the UR regime leads to a random allocation of land in areas where both farms are willing to rent, unless the farmers are able to agree on a cost-minimizing land allocation (b). Given our assumption that both farms are identical, each farm rents land only at locations where the distance to the farmer's own farmstead is less than the distance to the other farm's location.[32] The respective land demand is again $D^{\mathrm{b}} = l/2$ and substitution of D_i^{UR} in (14) yields a monotonic decreasing profit in r_i

$$\Pi^{\mathrm{b}} = \int_0^{\frac{l}{2}} (p - \mathrm{td} + s - r_i)\mathrm{d}d = \frac{l}{8}[4(p + s - r_i) - \sigma]. \tag{24}$$

Therefore,

$$r^{\mathrm{b}} = v. \tag{25}$$

As in the previous case, the cooperative UR price with a regional sharing agreement is independent of the land subsidy. We obtain the same result if the farms are unable to agree on a rule to share the region. However, two cases regarding the importance of space need to be distinguished. First, both farms might be willing to rent land at any location if $v \leq p + s - \sigma$ (i.e. $D_i^{\mathrm{UR}} \geq l$). Because local prices of both farms are identical, landowners decide randomly. For simplicity, we assume that each farm earns half of the profit at any location. As we saw under cooperation with a regional sharing rule, the (potential) market demand is fixed but now at l (instead of $l/2$). The effect on the profit function, however, is the same; Π^{c_1} is monotonic decreasing in r_i

32 This seems to require a high degree of coordination among both farmers, making this a strong assumption. However, in Germany, it is not uncommon for farms to trade rented land to round off the farmer's own land endowment and thus reduce distance costs and unbeneficial field shapes (Puls, 2007).

$$\Pi^{c_1} = \frac{1}{2}\int_0^l (p - td + s - r_i)\mathrm{d}d = \frac{l}{4}[2(p + s - r_i) - \sigma], \tag{26}$$

which permits the farmers to price at v. The second case features locations where only one farm can rent land (in the neighbourhood of its farmstead) *and* locations where both farms can be active. In this case, space is important and the intensity of competition is low (i.e. $v > p + s - \sigma$). The corresponding profit is

$$\begin{aligned}\Pi^{c_2} &= \int_0^{l-D^{\mathrm{UR}}} (p - td + s - r_i)\mathrm{d}d + \frac{1}{2}\int_{l-D^{\mathrm{UR}}}^{D^{\mathrm{UR}}} (p - td + s - r_i)\mathrm{d}d \\ &= l(p + s - r) - \frac{(p + s - r)^2}{2t} - \frac{\sigma^2}{4t}.\end{aligned} \tag{27}$$

It is easy to evaluate that $\partial\Pi^{c_2}/\partial r < 0$ if $r > p + s - \sigma$. Recalling that this profit function is only valid if $v > p + s - \sigma$, the farms' profit maximising choice is to price at the landowners' reservation price, and as in all instances of cooperative competition, the land subsidy does not affect the rental price decision of farms and there is no subsidy incidence.

5. Summary of the findings

The major objective of the previous sections was to investigate the subsidy effect in a spatial framework under alternative price and competition strategies. The results, with respect to the transfer of the subsidy to the land rental prices, are summarised in Table 1.

The table highlights that incidence decreases from top down and from left to right. The land subsidy is fully transferred to rental prices under non-discriminatory pricing and non-cooperative competition if the importance of space is low or under discriminatory pricing and non-cooperative competition if space does not matter (i.e. farmers occupy the same location or there are no distance costs). For all other cases, the land subsidy is not or only partially reflected in rental prices. Monopsonistic positions of farmers under base pricing or discriminatory UR pricing in the case of competition reduces incidence. While in the first case, 50 per cent of the subsidy is transferred to rental prices, incidence decreases with decreasing competition (increasing importance of space) under UR pricing. Cooperation (independent of the pricing strategy) or no competition among farmers under UR pricing prevents landowners from benefitting from the land subsidy at all.

Comparing the alternative price strategies, it is noteworthy that the farmer is better off under price discrimination (in terms of UR pricing) compared with non-discriminatory base pricing. UR pricing allows for higher land demand, but more importantly, even if land demand is given, UR pricing enables the farmer to capture all or most of the landowner's surplus up to the marginal plot of land.

Table 1. Incidence dependent on the importance of the spatial dimension under different price and competition scenarios

Competition	Pricing	Importance of space		
		Low	Moderate	High
Non-cooperative	Non-discriminatory	1	0	1/2
	Uniform rental (UR)	1 …	0	0
Cooperative	Non-discriminatory		0	
	Uniform rental (UR)		0	

Note that '1' represents perfect incidence (i.e. the subsidy is fully transferred to land rental prices).

6. Discussion of the results and some critical remarks

The aforementioned results can provide one explanation for partial and low incidence observed by the majority of empirical studies including Kirwan (2009); Breustedt and Habermann (2011); Ciaian and Kancs (2012); Kirwan and Roberts (2016). Interpreting empirical evidence in light of the spatial competition framework presented here, one can argue that partial incidence reflects moderate to high importance of space (moderate to low competiveness of land markets) under non-cooperative competition. Conversely, if the share of subsidy captured by landowners is high (Patton *et al.*, 2008; Kilian *et al.*, 2012), farms may face fierce competition on land markets and/or employ non-discriminatory pricing. Finally, the observation of very low incidence (Guastella *et al.*, 2013; Karlsson and Nilsson, 2014) may suggest that farms either face moderate competition under non-discriminatory pricing or behave cooperatively (or even collusively) in setting rental prices with or without a local sharing rule.

While it is reasonable to argue that spatial competition for land contributes to partial incidence, the conclusion of cooperative or collusive behaviour seems to be questionable. In Germany, however, farms commonly trade land with neighbours (under rental contracts) to optimise the internal farm structure by managing plots closer to their own farmstead (Puls, 2007). If there is a strong perception for this possibility in a region, it could effectively be considered as one form of a regional sharing rule. In terms of cooperative price setting, actual price arrangements are not necessary. For instance, farms can use the average rental prices of their neighbours for their rental price calculation, which is sufficient to cause the same effect (price matching) as concrete price arrangements (Graubner *et al.*, 2011).

We can also generalise the results by interpreting the land subsidy s in terms of any change of/shock to the marginal revenue product of land. In this respect, the model can help to justify the potentially low price transmission between the agricultural product and land rental prices.[33] It is noteworthy

33 See, e.g. McCorriston (2002) for a general discussion on price transmission under imperfect competition in agricultural markets.

that s affects the intensity of competition, i.e. it alters the relation between the importance of space and the profit potential. The dimension of this change depends on the price and competition strategy by farms. While the effects of such changes on rental prices can be reversed under non-cooperative, non-discriminatory pricing, there is no effect under cooperative competition.

As in any theoretical model, the presented results are to some extent driven by the assumptions that have been made. For instance, the perfectly price-inelastic local land supply and the fixed-proportion (Leontief) production function could be critical. The first allows the farmer to capture all the landowners' surplus under monopsonistic pricing at the landowners' reservation price. As long as the local land supply is sufficiently inelastic (a tenable assumption for agricultural land in the EU and the US), the qualitative results of the model do not change significantly. In this respect, it is also important to note that the farm, because of the presence of distance costs, faces a convex (price-elastic) regional land supply–independent of the shape of the individual (local) land supply by the landowners (Greenhut, Hwang and Ohta, 1975).

The utilised Leontief technology implies that a unit of land will yield a constant level of the aggregated agricultural output as long as the other production factors are not limiting. This is a strong assumption in an agricultural context where, e.g. the yield effect of fertiliser can be considerable. A possible justification, however, can be provided if the elasticity of substitution among land and non-land inputs is sufficiently small. While empirical results on this issue show some variation depending on the type of input related to land (Salhofer, 2000), a low elasticity of substitution among land and the aggregate of all other inputs is a reasonable assumption (Alston, 2010). For example, in case of the US and Canada, the hypothesis that agricultural production functions are indeed Leontief could not be rejected (Abler, 2001). In the framework of our spatial model, the fixed vector of other production factors represents the optimal mix of these inputs at all locations.[34]

It is interesting to note that the consequence of the chosen assumptions, especially the perfectly price-inelastic (local) land supply, stands in sharp contrast to prior work. In the spatial model presented here, we yield low or even no incidence of the land subsidy, while standard models (e.g. due to Floyd, 1965) predict perfect incidence given this assumption. This provides two limiting cases. Accordingly, if we relax the restriction towards a price-elastic land supply function, we yield lower incidence in standard models but higher incidence of the land subsidy in the spatial framework.

The introduction of the landowners' reservation price helps to illustrate the effect of alternative land-use options by setting the lower limit for rental prices above zero. However, it does not change the qualitative results of the model.

34 Note that there is one unit of land at any location and the quality of land was assumed to be homogenous. Hence, the vector of other inputs is the same for each land unit. The underlying production technology does not exclude substitution among the non-land inputs by keeping the optimal output level (e.g. yield per ha) constant.

Because the reservation price is independent of the subsidy payment, farmers have no incentive to transfer the subsidy to land rental prices. This can be restrictive if landowners adjust their reservation price by incorporating government payments in their expectations regarding future earnings. The latter might affect subsidy incidence, in particular, the long-run adjustment of rental prices, as emphasised by Hendricks, Janzen and Dhuyvetter (2012) and Kirwan and Roberts (2016) or by Hüttel *et al.* (2016), who investigate the price effect of the rental contract duration. Because the presented model is static in nature, such adjustment processes, however, are outside the scope of this paper.

Independent of the price and competition strategy, a crucial variable in spatial competition models is the (relative) importance of space σ ($\hat{\sigma}$) (i.e. the intrinsic competitiveness of the market). Throughout the paper, the net marginal revenue p of the farm and the physical distance among farms l was assumed to be constant. While this makes it possible to measure the market's competitiveness by the transport rate t as the single variable of interest, it obscures the fact that farms may receive different prices on the output markets, feature individual cost/production functions, and might have access to distinct infrastructure. Taken together, the competitive situation in terms of the importance of space might vary vastly among individual farms, neighbourhoods or regions.[35]

As mentioned above, if empirical studies find differences in the transfer of the subsidy to land (rental) prices and the authors controlled for (all) other important price determinants, the residual variation of subsidy incidence in different regions can be attributed to differences in the spatial competitive environment of farms. In particular, diverging results could be linked to differences in the intensity of spatial competition, price strategies and/or competitive conduct of the farms. This may also provide a starting point for further empirical research connecting individual pricing behaviour of farms and the intensity of spatial competition.

7. Conclusions

Land is the most crucial input for agricultural production; it features specific characteristics and is an important target of the EU Common Agricultural Policy. Most notably, a farm needs to exhibit eligible land to receive direct payments that are intended to increase farm income. However, this income effect is often challenged by theoretical models predicting perfect or high subsidy incidence, i.e. most if not all of the payment is transferred to land (rental) prices. If land rental represents an important share of the agricultural area, which includes most countries in the EU, former transition economies, and the US, the efficiency of these subsidies seems questionable because the transfer would primarily benefit landowners. Surprisingly, empirical findings

35 For instance, transport costs of maize silage are considerably higher compared with grain production (Steinmann and Holm-Müller, 2010). If respective revenue of silage is lower (or equal) compared with wheat, farms in fodder production areas face less spatial competition for land (*ceteris paribus*).

do not support the theoretical expectation, but instead show low incidence, which causes a considerable contradiction between both perspectives.

Although, the reasons for this discrepancy can be numerous, imperfect competition is often stated as a factor to depress the subsidy effect on land rental prices. However, theoretical support for this hypothesis is rarely provided. This paper fills this gap, and within the limits of the underlying assumptions, it highlights market power as a source to diminish or prevent the transfer of direct payments to land rental prices. Due to the explicit consideration of spatial competition in the paper, these results stand in sharp contrast to prior theoretical investigations.

Because land is immobile and spatially distributed, and there are costs associated with the distance between the field location and the farmstead, the subsidy effect is analysed within a spatial competition framework. Therefore, this paper provides the first systematic approach to land rental markets from a spatial competition perspective. The spatial framework not only accounts for a number of specific features of land but it also enables the investigation of alternative price and competition strategies by the farms.

Because farmers are typically able to differentiate landowners according to the location of their land, spatial price discrimination is possible. The results of the paper support empirical findings of partial or low subsidy incidence, which can be expected under imperfect competition caused by the spatial nature of the market and the possibility of price discrimination. This framework also produces consistent results for high or perfect incidence by relating this observation to fierce spatial competition and/or non-discriminatory pricing. If farms are able to cooperate on land rental markets, there is no subsidy effect on rental prices, which leads to the conclusion that less competition might in fact increase the efficiency of the investigated income support measures. For the farmer, we can conclude that in the majority of the model specifications considered, little or none of the subsidy is lost in space.

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