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*Publication date:*
2011

*Document version*
Publisher's PDF, also known as Version of record

*Citation for published version (APA):*
Henningsen, G., Henningsen, A., & Henning, C. H. C. A. (2011). *Measuring the influence of information networks on transaction costs using a non-parametric regression technique*. Paper presented at Congress of the European Association of Agricultural Economists 2011, Zürich, Switzerland.

# Measuring the Influence of Information Networks on Transaction Costs Using a Non-parametric Regression Technique

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**Paper prepared for presentation at the EAAE 2011 Congress**
Change and Uncertainty
Challenges for Agriculture,
Food and Natural Resources

August 30 to September 2, 2011
ETH Zurich, Zurich, Switzerland

## Abstract

All business transactions as well as achieving innovations take up resources, subsumed under the concept of transaction costs (TAC). One of the major factors in TAC theory is information. Information networks can catalyse the interpersonal information exchange and hence, increase the access to non-public information. Our analysis shows that information networks have an impact on the level of TAC. Many resources that are sacrificed for TAC are inputs that also enter the technical production process. As most production data do not separate between these two usages of inputs, high transaction costs are unveiled by reduced productivity. A cross-validated local linear non-parametric regression shows that good information networks increase the productivity of farms. A bootstrapping procedure confirms that this result is statistically significant.

## 1 Transaction Costs and Social Networks

Traditional neoclassical economics assumes that the exchange of goods is costless so that—in this respect—markets are efficient and always provide goods at the lowest possible price. However, more than 70 years ago, Coase (1937) argued in his essay "The Nature of the Firm" that market transactions often involve higher costs than just the market price. Other costs (e.g. search and information costs, bargaining costs, and policing and enforcement costs) can increase the costs of procuring something from a market. His theory became manifest in the concept of transaction costs, which has become a major field in institutional economics especially during the past 30 years.

Transaction costs can be divided into two main categories: technological transaction costs and institutional transaction costs (Green and Sheshinski, 1975). Both technological and institutional transaction costs refer to the sacrifice of resources. Furthermore, institutional transaction costs include search, negotiation, and control costs, while technological transaction costs can be divided into innovation transaction costs and physical transportation costs.

Institutional transaction costs can occur in three different stages of the transaction: *i)* contact phase, *ii)* contracting phase, and *iii)* control phase (den Butter and Mosch, 2003).

In the *contact* phase of a potential transaction, the actor is looking for information on potential trade partners (buyers or sellers), information on non-observable quality characteristics of his preferred product, and prices of the product (either seller or buyer prices). These searching costs occur because the search for information is not free, nor is information always complete, reliable, or easily accessible. Akerlof (1970) shows in his classical lemons problem that information asymmetry can be so severe and access to reliable information so costly and difficult that a market collapses. Searching costs are reduced if information is more easily accessible. Well functioning information networks can provide their members with information on business opportunities by giving cheap access to the above mentioned informations (Granovetter, 1983; Dekker, 2001; Henning and Zuckerman, 2006). As a further benefit, they increase the reliability of the information. In fact, with more information available in the network, and with easier transfers to all interested members, the probability that the information is of high quality increases, i.e. the information can be trusted to be relevant and true (Casson, 1997; Fafchamps, 2001). Based on the theory of weak ties (Granovetter, 1973), Montgomery (1992) demonstrates that weak ties are positively related to higher wages and higher aggregate employment rates. Actors with many loose ties (gatekeeper) are superior in the access to reliable information on market opportunities and perform better on the market.

The *contract* phase starts when two trade partners agree upon making a deal. Transaction costs in this phase are mainly negotiation costs. Both partners have to agree on how to divide potential rents from trade, i.e. negotiation of trading conditions (Braun and Gautschi, 2000). Because of bounded rationality, a perfect contract that accounts for all eventualities is unachievable. First, not all arrangements are verifiable by third parties (verification problem). Second, many eventualities cannot be foreseen (environmental and behavioural uncertainty). The higher the ex ante trust level between trading partners the lower is the necessity to negotiate every detail of the transaction (Portes and Sensenbrenner, 1993; Uzzi, 1996). Hence, costs of negotiation can be reduced considerably(Nee, 1998; Fafchamps, 2001). In fact, Rooks et al. (2000) show in a vignette study that socially well embedded transactions led the purchase manager to put less effort into the management of the transaction. In total less time was invested in the transaction and fewer departments were involved when the ex ante trust level was high because of social embeddedness, which included temporal, network, and institutional embeddedness. The study shows that network embeddedness has a significant influence to lessen resources invested into the transaction.

Finally, if contracts are signed, the *control* phase starts. This consists of monitoring and enforcing the contract. Both actions involve many resources and, thus, induce high transaction costs. The first step is the monitoring of the partner to ensure that she meets the arrangement manifested in the contract. If one of the partners behaves opportunistically by not keeping to the agreements, the next step is enforcement of the contract. In most cases, legal procedures are troublesome, expensive and of long duration. Informal punishment systems, such as the loss of a good reputation or exclusion from future trade possibilities (Kandori, 1992; Greif, 1994; Buskens, 1998), can reduce the costs of contract monitoring and enforcement (Ménard, 2000; Rooks et al., 2000). The better these informal mechanisms work, the lower is the incentive to defect in transaction and, hence, the lower are monitoring and enforcement costs (Buskens, 1999; Richman, 2006).

*Innovation* transaction costs in turn refer to resources sacrificed to gather reliable information on novelties and innovative production methods and processes. Although information on innovations are accessible via public resources as consulting or professional journals, a considerable amount of information is private (e.g. a competitor's experience with a new production method).

However, this does not mean that private information is unavailable at all. Managers might have close business and social contacts that possess this information and are willing to share it. Hence, the quality and quantity of relationships to other professionals and the relevance of these partners may have an important impact on a firm's innovation transaction costs (Castilla et al., 2000). It is quite straightforward that information networks which allow these informations to spread among entrepreneurs can have a significant impact on the productivity of those entities that have a better access to the network, i.e. have a better access to reliable non-public information about innovative production methods and processes (Jenssen and Koenig, 2002).

It has become apparent that a driving force to explain the level of transaction costs an entity faces is information (Greif, 1994; Noorderhaven, 1996; Calvert, 1995; Levi, 2000). Both institutional as well as innovation transaction costs therefore are materially depending on the access to information. As shown above can information networks provide an efficient and opportune way of gathering especially non-publicly available information (Granovetter, 1983; Raub and Weesie, 1990; Moschandreas, 1997; Buskens, 1999; Burt, 2001; den Butter and Mosch, 2003; Wiebusch et al., 2004).

As the structure of personal and interpersonal networks differs, the ability to gather information via information networks may be limited for some entities and may be amplified for others depending on their individual situation in a network (Buskens, 1999). Hence, we conclude that the individual network position should have an effect on an entity's transaction costs.

The question remains which network structures are beneficiary for the reduction of transaction costs. Apart from physical transportation that is only determined by local distance and infrastructure all sources of transaction costs —searching, negotiation, control, and innovation transaction costs— are related to information networks. The difficulty that arises is that on the one hand what might be beneficiary for one kind of transaction costs might be adverse to others, on the other hand, literature is not clear-cut on the effects of network structures on certain problems.

Beginning with searching costs, literature suggests that beneficiary network structures are characterised by weak ties, i.e. from the ego centered point of view a high number of outdegrees with lower density. In the case of negotiation and enforcement costs on the other hand literature states that these costs profit from strong social control as a consequence of tight information networks, i.e. networks with high density. The *closure argument* (Granovetter, 1985; Coleman, 1990) argues that dense networks increase the social control, develop common norms, and provide the possibility of punishment in the case of misbehaviour. Thus, dense networks supply their members with high levels of trust and reliable information. This hypothesis is supported by a simulation study of Buskens (1998) showing that the level of trust increases with both outdegree and density. But in cases where trust on the dyadic level is low, the importance of density exceeds the influence of oudegrees.

Contrary to the closure argument, the *gossip argument* (Coleman, 1990; Burt, 2001) states that high density is not necessary beneficiary to increase the level of trust and can in fact reduce the reliability of the available information. The argument is that networks affected by the gossip effect show a tendency to self-enforcing exaggeration, which leads to very extreme positions about other actors, i.e. actors are characterised either as extreme good or extreme bad. Hence, the information becomes unreliable and the trust level decreases. Both Burt (2001) and Dekker (2001) prove empirical evidence that very dense networks are dominated by the gossip effect and can show lower trust levels than less dense networks.

Finally, in the case of innovation costs —as in the case of searching costs— Granovetter (1983) states that weak ties are the key to innovation diffusion. Loose ties between the egos' clustered core networks increase the diffusion of relevant information on innovation. According to Granovetter (1983) do actors that are enclosed into a tight and locked-in network have no or minimised access to "new" information and stay behind when it comes to innovative production technology while actors with many and loose contacts profit from an increased access to "new" information. Although Granovetter's theory is straightforward, empirical evidence is not definite. In a study among Norwegian entrepreneurs Jenssen and Koenig (2002) find no empirical evidence to support the theory of weak ties. Contrary to what should be expected, Jenssen and Koenig (2002) show in their study that strong ties are important channels to information and influence entrepreneurial success.

As our data leaves no possibility to separate between the different kinds of transaction costs named above, and additionally we find no definite evidence from literature on the effects of information networks on the different sources of transaction costs, we have to limit our empirical analysis to check whether information networks have a noticeable impact on a firm's productivity, and which network structures are most beneficial for obtaining relevant information that transfers into high productivity.

## 2 Microeconomic Foundation

We assume that a firm uses a vector of $n$ input quantities $x = (x_1, \dots, x_n)'$ to produce the output quantity $y$, where the transformation of the inputs into the output can be described by the production function

$$y = f(x, T) \tag{1}$$

and depends on the state of the technology $T$.

### 2.1 Production technology and innovation

We assume that the firm can use resources to improve its production technology $T$, where these resources can be of the same type as the inputs used for the production (e.g. labour, office supplies, IT technology, fuel). We denote these resources by $\bar{x} = (\bar{x}_1, \ldots, \bar{x}_n)'$, where the elements of $\bar{x}$ correspond to the elements of $x$ so that we can calculate the total input quantities that the firm uses for the production and for improving the production technology by $x^* = x + \bar{x}$. Furthermore, the firm can utilise its information networks to improve its production technology by gathering information from peers, which is otherwise difficult or costly to obtain or even unavailable. We assume that these relationships can be described by the function

$$T = k(\bar{x}, z, u), \tag{2}$$

where $z$ is a vector of network parameters characterising the firm's information networks and $u$ is a vector of other factors that might affect the firm's state of technology (e.g. the education of the management). Substituting the function in (2) for $T$ in equation (1), we get

$$y = f(x, k(\bar{x}, z, u)) \equiv f^*(x, \bar{x}, z, u). \tag{3}$$

With respect to resources used for both production and the improvement of the production technology, data sets that are used for estimating production functions generally do not separate between input quantities used for the actual production and input quantities used for improving the production technology. Therefore, the following approximation is necessary for empirical applications:

$$y = f^*(x, \bar{x}, z, u) \approx \hat{f}^*(x + \bar{x}, z, u) = \hat{f}^*(x^*, z, u). \tag{4}$$

## 2.2 Transaction costs in trade

In addition to the resources required for the production $x$ and for improving the production technology $\bar{x}$, the firm needs further resources for trading goods, i.e. purchasing the inputs and selling the output. These resources can be of the same type as the inputs used for the production (e.g. labour, capital, office supplies, IT technology, fuel). We denote the vector of resources used for trading goods by $\tilde{x} = (\tilde{x}_1, \ldots, \tilde{x}_n)'$, where the elements of $\tilde{x}$ correspond to the elements of $x$, $\bar{x}$, and $x^*$. Hence, we can calculate the total input quantities that the firm acquires to produce the output, improve the production technology, and to trade the goods by $x^{**} = x^* + \tilde{x} = x + \bar{x} + \tilde{x}$. We expect that the quantities of the resources required for trading goods depend on the quantities of the traded goods. Furthermore, our considerations in the previous section suggest that good information networks can reduce the input quantities that are sacrificed for trading goods ($\tilde{x}$). We assume that the above mentioned relationships can be described by the (implicit) functions

$$\tilde{x}_i = g_i(x^{**}, y, z, v) \; \forall \, i, \tag{5}$$

where $z$ is—again—the vector of network parameters and $v$ is a vector of other factors that might influence the resources required to trade the goods (e.g. heterogeneity of goods, distance to potential sellers and buyers). Now, we rearrange the above system to get a system of implicit functions for $x^*$

$$x_i^{**} - x_i^* = g_i(x^{**}, y, z, v) \; \forall \, i \tag{6}$$

$$x_i^* = x_i^{**} - g_i(x^{**}, \hat{f}^*(x^*, z, u), z, v) \; \forall \, i \tag{7}$$

$$x_i^* \equiv g_i^*(x^{**}, x^*, z, u, v) \; \forall \, i, \tag{8}$$

which we can solve to get a system of explicit functions for $x^*$

$$x_i^* \equiv h_i(x^{**}, z, u, v) \; \forall \, i. \tag{9}$$

Substituting these functions for $x^*$ in the production function that accounts for activities to improve the production technology (4), we get

$$y = \hat{f}^*(h(x^{**}, z, u, v), z, u) \equiv \hat{f}^{**}(x^{**}, z, u, v). \tag{10}$$

As data sets generally do not separate input quantities that are used for the actual production, for improving the production technology, and for trading goods into these three parts, production economists usually do not estimate the *real* production function $f(x)$ but an *augmented* production function $\hat{f}^{**}(x^{**}, z, u, v)$ that includes not only the production process but also the trading of goods and activities to improve the production technology. Hence, transaction costs and innovation costs are usually included in the estimated production technology. According to our assumptions, firms with better information networks need less resources for trading goods and can improve their production technology easier and less costly (see discussion in the previous section). Hence, these firms should be able to produce the same amount of output ($y$) with smaller (total) input quantities ($x^{**}$), i.e. they should appear to be more productive.

## 3 Model and Data

If our considerations about transaction costs and information networks are correct and we use a typical data set, where the input quantities include both resources used for the production $x$, recourses used to improve the production technology $\bar{x}$, and resources used for trading goods $\tilde{x}$, the production function should not only depend on the input quantities but also on the entity's network position. Hence, we can test the hypothesis that information networks influence transaction costs by estimating the *augmented* production function $\hat{f}^{**}(x^{**}, z, u, v)$ defined in (10) and test if the network parameters $z$ have a significant influence.

Given our microeconomic model derived above, the relationship between the total input quantities $x^{**}$, the network parameters $z$, the other factors $u$ and $v$, and the output quantity $y$ is unknown and could be rather complex. To avoid specifying a parametric functional form, we estimate this *augmented* production function by a non-parametric regression technique. We apply the non-parametric local-linear estimation method for both continuous and categorical explanatory variables described in Li and Racine (2004); Racine and Li (2004), where the second-order Epanechnikov kernel is used for continuous regressors, the kernel proposed by Aitchison and Aitken (1976, p. 29) is used for unordered categorical explanatory variables, and the kernel proposed by Wang and van Ryzin (1981) is used for ordered categorical explanatory variables. The bandwidths of the regressors are selected according to the expected Kullback-Leibler cross-validation criterion (Hurvich et al., 1998). The estimation was done within the statistical software environment "R" (R Development Core Team, 2009) using the add-on package "np" (Hayfield and Racine, 2008).

In our empirical analysis we use a data set on Polish farms. The data were collected within the framework of the "Advanced-Eval" project financed by the European Union within the Sixth Framework Programme (contract number 022708). The data set includes detailed farm accountancy data and information on the farms' ego centered networks. We take the total value of all produced goods as output (in Zloty) and we distinguish between four inputs: labour (in working hours), land (in ha), capital (in Zloty), and intermediate inputs (in Zloty), where the last category consists mainly of seeds, fertilizers, pesticides, purchased feed, fuel, and electricity. We take the logarithm of the output and all the input quantities so that the individual values of these variables are more equally distributed within the range of observed values. Otherwise, there were many observations within the bandwidths for small values (farms) but only very few observations within the bandwidth for large values (farms), which usually causes problems in non-parametric regression.

Since Polish farms usually have a single farm manager, we do not have to model intra-firm networks, which can play an important role in information diffusion. Hence, our data set has the advantage that we can neglected intra-firm networks when modeling information networks. We apply two common information network parameters for ego-centered networks to model the structure of the farms' information networks, namely the number of outdegrees and the density of the network. The first network parameter refers to the total number of contacts $n$ (alteri) an ego—in our case the farm—has. The second network parameter, density, describes the degree of interconnectedness between ego's alteri, $h\big/[m(m-1)/2]$, where $h$ is the actual number of ties between the alteri and $m(m-1)/2$ is the number of possible ties.

The variables that might affect the firm's state of technology ($u$) include management characteristics, namely level of education (ordered categorical variable), working experience (in years) and risk attitudes. The latter is the average response to several questions about risk attitudes, where larger positive values indicate higher risk aversion.

We have only one variable in our data set that might influence the resources required to trade the goods ($v$), namely the region, where the farm is located (unordered categorical variable). Our data include farms from four different municipalities (Gminas). The municipalities Chotcza and Wieliszew are close to urban areas, while Siemiatkowo and Kamieniec are rather remote. While Wieliszew and Kamieniec have a good economic performance, Chotcza and Siemiatkowo have a weak economic performance. Hence, the four municipalities cover all possible combinations of location and economic performance. Of course, this regional variable also accounts for differences in climate and soil and we cannot differentiate between these effects. Although a separation of these effects would be interesting, it is not essential for our study.

## 4 Results

Table 1: Bandwidths

| Variable | Bandwidth | Scale Factor |
|---|---:|---:|
| lLabor | 64083 | 185067 |
| lLand | 103683 | 184643 |
| lCapital | 177112 | 253857 |
| lIntermed | 439205 | 628217 |
| education | 1.000 | 2.202 |
| exper | 15471269 | 2294050 |
| risk | 1421294 | 2882712 |
| municip | 0.591 | 1.300 |
| outdFarm | 4870844 | 4875115 |
| outdHH | 2731927 | 2921081 |
| densFarm | 503279 | 6998705 |
| densHH | 4870860 | 16505559 |

The cross-validated bandwidths obtained by the method of Hurvich et al. (1998) are presented in table 1. The bandwidths of the continuous explanatory variables are very large, indicating that the relationship between these independent variables and the dependent variable is approximately linear. However, in contrast to a parametric linear regression (e.g. OLS), our non-parametric regression with large bandwidths still allows for interaction effects between the regressors, i.e. the effect of one regressor on the dependent variable may depend on the values of all other regressors.

The gradients of the independent variable with respect to the explanatory variables are summarized in table 2. All input quantities (`lLabor`, `lLand`, `lCapital`, `lIntermed`) have a positive effect on the output quantity at all observations. Hence, the monotonicity condition derived from microeconomic production theory is fulfilled in our analysis even though the input quantities include

Table 2: Gradients: minimum, mean, median, and maximum

| Variable | Min | Mean | Median | Max | Sig |
|---|---|---|---|---|---|
| lLabor | 0.11 | 0.15 | 0.15 | 0.18 | * |
| lLand | 0.26 | 0.37 | 0.37 | 0.45 | *** |
| lCapital | 0.13 | 0.20 | 0.22 | 0.25 | ** |
| lIntermed | 0.31 | 0.41 | 0.40 | 0.50 | *** |
| sum: all inputs | 1.09 | 1.14 | 1.15 | 1.17 | |
| education: 1 $\rightarrow$ 2 | -0.27 | -0.00 | -0.01 | 0.31 | |
| education: 2 $\rightarrow$ 3 | -0.14 | 0.02 | 0.01 | 0.23 | |
| education: 3 $\rightarrow$ 4 | -0.09 | -0.01 | -0.01 | 0.06 | |
| exper | -0.01 | -0.01 | -0.01 | 0.00 | |
| risk | -0.08 | 0.02 | 0.01 | 0.10 | |
| municip: chot $\rightarrow$ kami | -0.06 | 0.09 | 0.08 | 0.28 | * |
| municip: chot $\rightarrow$ siem | -0.19 | -0.01 | -0.01 | 0.14 | * |
| municip: chot $\rightarrow$ wiel | -0.18 | 0.14 | 0.15 | 0.41 | * |
| outdFarm | 0.05 | 0.08 | 0.08 | 0.11 | . |
| outdHH | 0.02 | 0.06 | 0.05 | 0.09 | |
| densFarm | -0.16 | 0.41 | 0.45 | 0.88 | |
| densHH | 0.24 | 0.37 | 0.31 | 0.54 | ** |

transaction costs. As all input and output quantities are logarithmised, the gradients can be interpreted as partial production elasticities of the inputs. However, in contrast to their usual definition, they not only account for the actual production process but also for activities for improving technology and trading goods. While intermediate inputs and land have a relatively large marginal effect on output, the use of labour has only a small marginal effect—probably owing to the abundant use of labour on most Polish farms (Henningsen, 2009). The elasticities of scale, which are equal to the sums over the four partial production elasticities, range from 1.09 to 1.17, indicating that all farms operate under increasing returns to scale.

The gradients with respect to the farm manager's education (`education`) describe the effect of increasing education by one level, i.e. from level 1 to 2, from 2 to 3, and from 3 to 4. The estimated gradients in table 2 show that the effect of the farm manager's education on the output is ambiguous and on average higher education neither increases nor decreases the output. The effect of the farm manager's experience (`exper`) on the output is negative for most farms, where each year of experience can reduce the output by a maximum of 1%. The farm manager's risk aversion (`risk`) has an ambiguous effect, which is positive for some farms and negative for others. The gradients with respect to the municipality where the farm is located (`municip`) describe the expected differences in output that are due to farms lying in different municipalities. We take the municipality Chotcza (`chot`) as the base for our comparison. Farms that are located in the municipality Siemiatkowo (`siem`) need on average roughly as many resources for improving technology, trading goods, and producing the same output as farms in the municipality Chotcza. In contrast, farms that are located in the municipalities Kamieniec (`kami`) and Wieliszew (`wiel`) can produce on average 9% and 14% more outputs, respectively, with the same amount of inputs. Given our model and data, we cannot distinguish if the above-mentioned effects of the management characteristics and the farms' location are due to differences in the production process, differences in the resources used to improve the production technology, or differences in the resources required for trade but we only analyse the combined effect.

The number of outdegrees of the farm network (`outdFarm`) has a positive and rather large effect for all farms; an additional contact increases the farm output on average by 8%. The number of outdegrees of the household network (`outdHH`) also has a positive effect for all farms but this effect is generally smaller than the effect of the contacts in the farm network. In this respect our results support theoretical and empirical conclusions derived from literature.

The density of the farm network (`densFarm`) increases the output for most farms but decreases the output for some farms. Increasing the density of the farm network from zero (a totally loose network without any connection between the alteri) to one (a totally dense network with all alteri connected) would increase the output by approximately 41%. The density of the household network (`densHH`) clearly increases the output of all farms. Increasing this density from zero to one would increase the output by approximately 37%.

As a complement to the gradients shown in table 2, we present the estimation results in figure 1 graphically. While the gradients shown in table 2 are calculated at all data points that are in the sample, the estimated relationships displayed in figure 1 are calculated by holding the other explanatory variables constant at their medians (numeric variables) or their modal values (categorical variables). Furthermore, the figure shows the 95% variability bounds obtained by bootstrapping (see Hayfield and Racine, 2008, p. 17). Most findings derived from the gradients shown in table 2 are confirmed in figure 1, e.g. the output monotonically increases in all inputs and all four network parameters have a positive effect on the output. However, in contrast to the gradients in table 2, figure 1 suggests that the farm manager's experience (`exper`) has virtually no effect and the farm manager's risk aversion (`risk`) even decreases the output. These contradicting results and the variation bounds, which are relatively large compared to the small effects of these two variables, indicate that these variables do not have a clear and significant effect.

Table 3: Statistical significance of regressors

| Variable | P value | |
|---|---|---|
| lLabor | 0.02757 | * |
| lLand | 0.00000 | *** |
| lCapital | 0.00752 | ** |
| lIntermed | 0.00000 | *** |
| education | 0.22306 | |
| exper | 0.14787 | |
| risk | 0.69173 | |
| municip | 0.04261 | * |
| outdFarm | 0.07268 | . |
| outdHH | 0.19048 | |
| densFarm | 0.48120 | |
| densHH | 0.00251 | ** |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

We use the bootstrapping method suggested by Racine (1997) and Racine et al. (2006) to test the statistical significance of all explanatory variables (see Hayfield and Racine, 2008, p. 9). The results are presented in table 3. All four inputs (labour, land, capital, intermediate inputs) as well as the location (municipality) of the farm but none of the three management variables (education, experience, risk attitudes) have a statistically significant effect on the output. While the (positive) effects of the outdegrees of the farm network (`outdFarm`) and the density of the household network (`densHH`) are statistically significant at the 10% and 1% level, respectively, the (positive) effects of the outdegrees of the household network (`outdHH`) and the density of the farm network (`densFarm`)

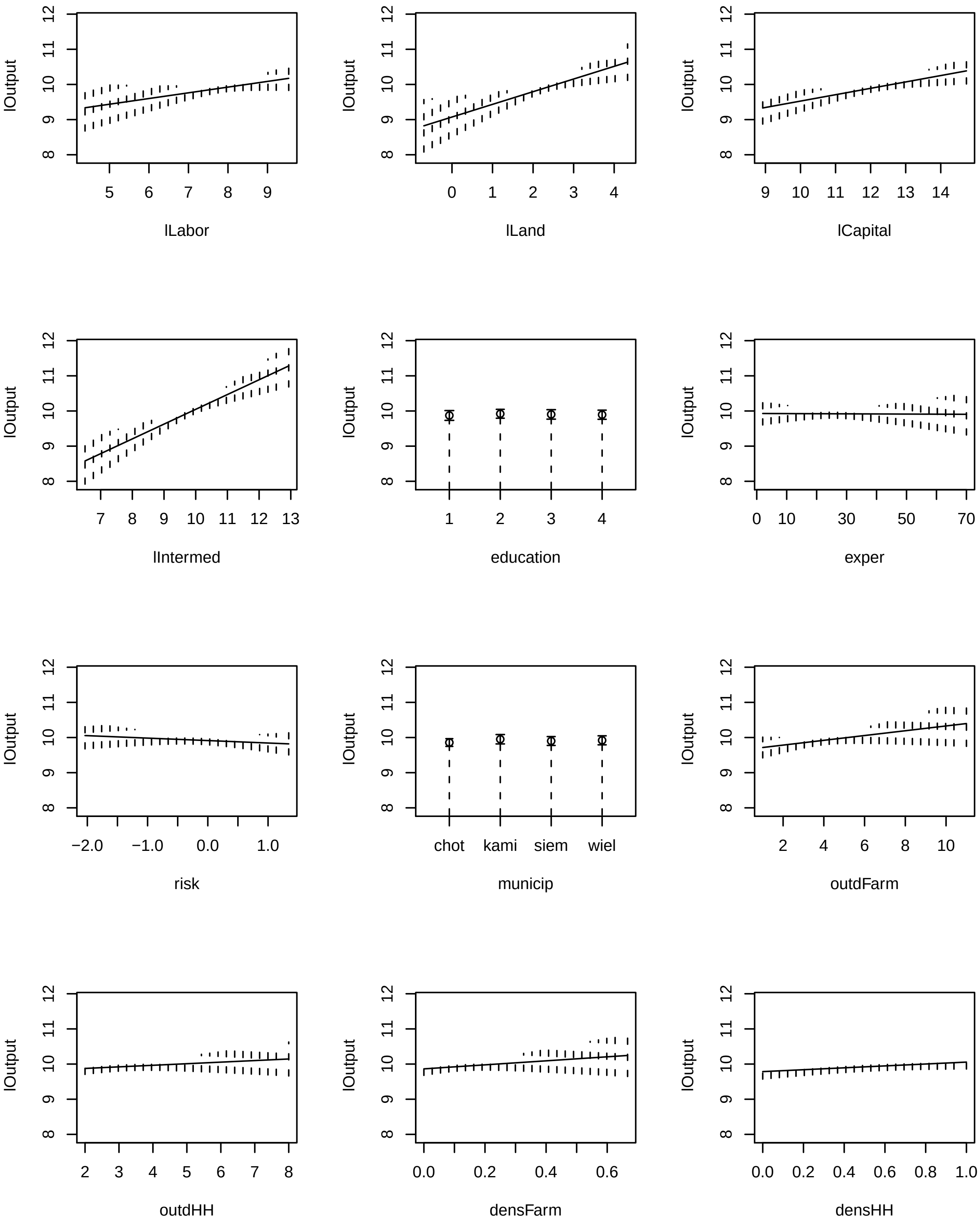


Figure 1: Estimation results

are not statistically significant.

Our results confirm the findings in the literature that the number of outdegrees should decrease transaction costs and increase productivity. As the literature provides partly contradicting results regarding the effect of the density of the firm's network, it is difficult to hypothesis the effect of density on total transaction costs. Since our results indicate a positive influence of dense networks on productivity, our empirical study supports the *closure argument* (Granovetter, 1985; Coleman, 1990). The linear relationship between output and density indicates that our data do not support the *gossip argument* (Coleman, 1990; Burt, 2001) to the extend that a very high density has no negative effect on productivity. We cannot make any valid statement about the *weak ties* hypothesis (Granovetter, 1973; Montgomery, 1992) as we cannot separate the effect of density on technical and institutional transaction costs and we cannot exclude the possibility that the effect of weak ties is overlaid by the closure effect.

## 5 Conclusion

As most data sets do not allow to separate between inputs used for production and resources dedicated to gather information and to trade goods, the variables that are typically used for estimating production functions generally include technical and institutional transaction costs. We showed that this results in estimating an "augmented" production function that includes also the trading of goods and activities to improve the production technology. A vast literature shows that information networks can have a promoting factor in gathering reliable information in an economical way. Our empirical study generally supports these results. Dense farm household networks and large farm business networks have a positive impact on a farm's productivity. Our results regarding the size of the network (outdegrees) support the conclusions derived from literature. On the other hand, the literature shows a very diffuse picture regarding the density of a network. Our results show that increasing density is beneficiary for the firm's productivity and we find no evidence for negative effects of the gossip effect in our data.

Still, further research should be done on this field, especially further empirical studies are needed to get more reliable information about the coherency between information networks and the specific types of transaction costs. Since the farming sector has some very special characteristics (e.g. close connection between household and farm, mainly located in rural areas which includes special norms and a special culture due to small and closed communities), the representativeness of our results is generally limited. In this context it would be interesting to study also other sectors to see whether the effects of information networks differ between sectors. Furthermore, future research should include more advanced network parameters and other types of networks than ego centered networks. Finally, future work should focus on the separation of technical and the different forms of institutional transaction costs. However, the last two suggestions require data that are difficult and costly to collect.

## Acknowledgements

The authors are grateful to Jeff Racine for giving them valuable suggestions regarding the non-parametric regression. Arne Henningsen is grateful to the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) for financially supporting this research. Of course, all errors are the sole responsibility of the authors.

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