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Spatial agglomeration and product market competition

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Spatial agglomeration and product market competition

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Abstract

This paper tests the hypothesis that product market competition has a negative impact on spatial agglomeration. This hypothesis emerges as an interpretation of the models by Combes and Duranton (2001) and Alsleben (2005) which are about firms' location choice in the presence of knowledge spillovers. Using data for German manufacturing industries, the result is that, while controlling for other agglomeration forces, higher industrial concentration, measured by the Herfindahl index of concentration of sales, implies stronger spatial agglomeration, as measured by Ellison and Glaeser's (1997) index of concentration.

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1 Introduction

In the literature about spatial agglomeration of economic activity knowledge spillovers in the sense of Marshall (1920) are a prominent factor driving firms to cluster in space. Usually this literature presents spillovers as purely unintended and non-pecuniary externalities and treats them as a black-box with no thorough micro-foundation. However, possible channels through which knowledge may leak out of a firm or research institute are labour turnover, local spin-offs, reverse engineering, sub-contracting, co-operation or publication. Subcontracting, co-operation and publication obviously are not involuntary at all and when an employee possesses key knowledge, a firm must offer him an adequate compensation to keep him from joining a competitor or starting his own business. In this case spillovers actually pass through (labour) markets and need to be understood in such a framework. In fact, there is empirical evidence that knowledge spreads with workers changing their job (see Møen (2000) and the references given in Combes and Duranton (2001)). Hence, the transmission of knowledge is not necessarily as unwilling and non-pecuniary as a “black-box” concept of spillovers suggests.

Combes and Duranton (2001, 2003) and Alsleben (2005) present a model of location choice in which “knowledge spillovers” occur through mutual labour poaching and in which the degree of spillovers is determined endogenously in equilibrium. One important insight from these models is that for profit-maximising firms there is not only a benefit of agglomeration. Rather, in equilibrium firms may choose to separate and thus avoid localised spillovers because co-location implies too costly a level of poaching and protective wages. In both models the degree of product market competition determines how strong the competition for “inputs”, i.e. key workers, is and whether co-location becomes worthwhile and hence occurs in equilibrium. A broader interpretation of the condition for co-location is that the degree of competition has a negative impact on the geographic concentration of an industry.

This paper tests this hypothesis in a regression analysis using data on the geographic and industrial concentration of German manufacturing industries and finds support for it. Stronger competition, measured by the Herfindahl concentration index of sales of German manufacturing industries, indeed implies less agglomeration, measured by Ellison and Glaeser’s (1997) index of concentration.

This result is important for several reasons. First, it adds to the literature that has analysed the relationship between innovation and industrial concentration but left out the spatial dimension (Scherer (1967), Smulders and van de Klundert (1995), Gopinath et al.

(2004)). Secondly, this result shows that Porter's (1990, 1998) approach to agglomeration namely his concept of "clusters" and "local rivalry" is not as distinct from the traditional approach focusing on "knowledge spillovers" as is often argued (for example, Beal and Gimeno (2001)). By finding empirical support for a clear hypothesis about the relationship between agglomeration and "competition", this paper helps to reconcile Porter's view and the traditional approach.

2 Model and hypothesis

One important part of the literature on agglomeration focuses on localised knowledge spillovers. The idea which goes back to Arrow (1962) is that firms cannot fully appropriate the knowledge they create by doing research as some fraction spills over to other firms. If this knowledge is tacit, it cannot spread over long distances but requires personal contact and spatial proximity to be transmitted, thus giving rise to localised spillovers. There is much empirical evidence for such spatially bounded spillovers and the agglomeration of firms (Jaffe et al. (1993), Glaeser et al. (1992), Audretsch and Feldman (1996), Henderson (1997), Anselin et al. (1997), Ellison and Glaeser (1997), Rosenthal and Strange (2001) and Alecke et al. (2005); for a comprehensive survey of the literature see Rosenthal and Strange (2004)). However, several of these studies also find that high-technology industries, in which spillovers should be prevalent, are only relatively little agglomerated, if at all.

Combes and Duranton (2001, 2003) and Alsleben (2005) give an explanation for this observation. They argue that there is not necessarily a mutual benefit for profit-maximising firms if one takes into account the strategic interaction between firms. In the case of knowledge spillovers it is important to point out that the benefit from absorbing external knowledge is only one of actually two aspects in the location decision. Opposed to the benefit is the disadvantage of sharing private knowledge with other (rival) firms so that in addition to the incentive to cluster there is also one to separate. This aspect becomes even more vital if one considers firms that differ with regard to the quality of knowledge they emit. While a "poor" firm certainly benefits from the "good" one, the good one may be concerned with making its rival stronger while not receiving any benefit itself and may thus have no incentive to co-locate. Shaver and Flyer (2000) find empirical evidence for this effect.

In Combes and Duranton (2001, 2003) and Alsleben (2005) knowledge spillovers are modelled in a precise way and a distinction is made between product market competition and competition for inputs. It is assumed that firms operate in a national market and that there is no particular local competition in the goods market. However, when co-locating, firms

“compete” for local inputs, namely valuable knowledge, in the sense that they are subject to labour poaching. Knowledge is incorporated in “key employees” (e.g. engineers, managing directors) and may flow between firms through labour poaching if firms locate close to each other.

There are two firms which have to choose between two locations. If they co-locate (in any of the two regions) they can poach workers from their rival. If they separate, no poaching is possible because labour is immobile across regions. Knowledge is complementary and workers possess key knowledge (e.g. about customers, the organisation, technical layout, production process etc. acquired when they built up the production facilities) which helps each firm to reduce its production costs when it poaches workers from the rival. Knowing this, firms can protect themselves against such poaching by offering their workers higher wages and thus making poaching by the rival more costly.

In sum, “spillovers” are endogenous in this model as firms decide about how much they receive (by poaching workers) and how much they emit (by setting own wages) and they are pecuniary in the sense that they affect wages. The location decision goes together with a decision about the cost function: firms can reduce their variable costs if they “invest” in cost-saving technology (poaching) and incur some fixed costs (with respect to output). In addition they control wages which means they determine the “price” of the rival’s investment.

It turns out that, with an interior solution, firms opt to separate because otherwise they would commit to too high a level of poaching and protective wages. In fact they face a prisoner’s dilemma when deciding about poaching and protective wages. There is a “moderate” level that maximises joint profits but each firm has got an incentive to deviate by poaching more and setting higher wages. It is the strategic interaction that induces them to behave predatorily. The resulting equilibrium is a lot worse than the case with symmetric “moderate” poaching and wages. This result is well-known in industrial economics and has been analysed in different frameworks (see, for example, Brander and Spencer (1983) for a simple R&D set-up and Brander and Lewis (1986) for a financial perspective). Firms anticipate this result and choose to separate in order to avoid these subgames with too costly commitment.

While Combes and Duranton’s (2001, 2003) model is about differentiated products in duopoly, Alsleben (2005) extends the model to an arbitrary Cournot oligopoly with homogenous goods. In both models the degree of product market competition determines whether firms cluster in equilibrium. In the Cournot model the condition for co-location reads

$$\frac{\alpha}{\beta} \frac{n-1}{(n+1)^2} > T$$

where α , β are the parameters of the linear demand function, T the training costs for poached workers and n the number of firms. The expression on the left-hand-side is readily interpretable as the degree of product market competition. Both a smaller market (higher α) and a steeper demand curve (higher β) clearly imply stronger competition. For $n \geq 4$ the expression decreases with the number of firms, n , so that a greater number of firms also implies stronger competition as measured by this expression.

Hence, a broader interpretation of the condition for agglomeration in this model is that, all else equal, industries with stronger product market competition avoid agglomeration while those with weaker competition do cluster. Hereby it is assumed that the training cost, T , are the same across industries. Note that due to standardisation in the model T must be read as a percentage of original production cost. It is reasonable to presume that training costs are roughly the same fraction of production costs. Industries producing a complex product and hence employing workers with very specialised skills should have higher training costs. But a complex product is also likely to be more costly to produce so that the ratio should be fairly the same.

3 Data

The empirical test carried out in this paper is whether competition has a negative impact on observed agglomeration. As has been noted by Cohen and Levin (1989), market concentration, demand structure and technological opportunity and appropriability all together determine the degree of competition. Unfortunately the latter two are difficult to measure and data are hardly available. In this study competition is measured by the Herfindahl index of concentration of 2001 sales of the German manufacturing industries (published by the *Monopolkommission*). A higher Herfindahl index implies stronger industrial concentration and hence weaker competition.

The database we use provides the 1998 plant-level employment across counties for Germany's 116 manufacturing industries (including extractive industries). The employment data are not classified and contain precise figures for each plant regardless of its size. Agglomeration is measured by Ellison and Glaeser's (1997) index of geographic concentration of manufacturing employment. Ellison and Glaeser (1997) (EG) proposed a measure of agglomeration that is derived from an explicit location decision model. The point of departure is the "raw concentration" of an industry defined as $G := \sum_i (s_i - x_i)^2$ where s_i

is the portion of the industry's employment located in region i and x_i is the percentage of total employment in that region. G measures concentration relative to total employment; as long as an industry mimics the pattern of aggregate employment it is not considered as being concentrated. The advantage of defining concentration relative to overall employment (as opposed to, for example, population or land area) is that one can take the overall distribution of employment (i.e. cities) as given and does not have to take into account location-specific characteristics such as commuting pattern, size and age of the population, soil conditions etc. which certainly determine the distribution of employment. Also, one does not need to take an equal distribution of employment as a benchmark which is clearly no reasonable hypothesis. EG assume that firms choose their location as if dartboards were thrown at a map and that there exists an allocation process which yields the observed employment distribution in expectation. They show that under these assumptions $E(G) = (1 - \sum_i x_i^2)(\gamma + (1 - \gamma)H)$ where γ is a combined measure of the strength of natural advantages and spillovers between plants in a broad sense and $H = \sum_r \left(\frac{x_r}{\bar{x}}\right)^2$ is the plant Herfindahl index with x_r being the employment of plant r and \bar{x} total employment of the industry. Rearranging yields γ which is the index of geographic concentration.

Both from theory and other empirical studies such as Rosenthal and Strange (2001) we know (some of) the determinants of agglomeration. New trade theory (Helpman and Krugman (1985)) and the new economic geography (for example Krugman (1991)) predict that industries with lower trade costs are more concentrated.¹ Although we do not want to test any particular new economic geography model and refrain from interpreting the regression coefficients structurally, we still want to control for this effect. Hummels (2001) shows that for the majority of traded goods “explicit costs” such as tariffs and freight costs are the most important components in trade costs. Therefore, average trade cost are measured by the inverse of the industry's average unit value. From trade data containing both the total weight (tons) and value of goods imported and exported the average reciprocal unit value is

$$\text{calculated as } TC = \frac{1}{UV} = \frac{\text{weight}(\text{imports} + \text{exports})}{\text{value}(\text{imports} + \text{exports})} .^2$$

¹ Marshall (1920) argued that higher transportation costs induce firms to locate closer to suppliers and customers. This results in the co-location of trade partners and has to be distinguished from pure localization economies because it can make a *single industry* either agglomerated or dispersed.

² The transportation cost per unit of weight are assumed to be constant across industries so that the portion of total transportation cost in output (the importance of transportation cost), $\frac{c}{t} \frac{\text{weight}}{\text{output}}$, is proportional to the inverse unit value.

Inputs sharing. With fixed costs of production, product specialisation can lead to a cumulative process of concentration. The more customers an industry producing a non-tradable service has, the more it can specialise and exploit increasing returns to scale. This increases productivity and/or the variety of the products which in turn benefits the purchasing industry which is assumed to like variety à la Dixit and Stiglitz (1977). This mechanism may eventually lead to the agglomeration of specialised input producers and specialised purchasing industries (Abdel-Rahman and Fujita (1990)). From the 1998 survey on the cost structure of German manufacturing industries carried out by the German Census Bureau we have for each industry detailed data about the structure of the total costs of production. The portion of *technical and industrial services* in total shipments is taken as an indicator of how specialised the goods produced are and hence how large gains from sharing inputs could be.

To account for other types of “knowledge spillovers” not captured by our poaching model, we include an industry’s share of R&D personnel. We assume that if any additional spatially bounded knowledge spillovers exist between plants, they render a single plant and consequently the whole industry the more innovative the more concentrated it is. Accordingly, one can expect that plants optimise their location with respect to spillovers to the extent that innovative capacity is crucial for their industry which is basically Arrow’s (1962) argument that knowledge spillovers are relatively more important in research-intensive industries. Note that one important message from the models above is that labour market pooling and knowledge spillovers (through labour mobility) are hard to separate. An industry with a high share of researchers might cluster because it benefits from knowledge spillovers as well as from pooling specialised workers. This is why the share of R&D personnel should be interpreted as capturing both knowledge spillovers and labour market pooling.

In order to control for extractive industries which cluster simply because natural resources are distributed unevenly in space, a dummy is included which is set equal to one for the industries with NACE code 10.1 – 14.5.

4 Results and discussion

The model estimated is

$$\gamma = \alpha + \beta \log(Herf) + \delta^T \mathbf{X} + \varepsilon$$

where γ is EG’s index of geographic concentration, $Herf$ industrial concentration and \mathbf{X} a vector of the above covariates.³ OLS estimation is probably the most intuitive approach to

³ Models about innovation/growth and industrial concentration suggest that there is an inverted U-shape relationship between concentration and innovation (Scherer (1967), Smulders and van de Klundert (1995),

answering the questions we posed but obviously there is the need for a robustness check with the help of an Ordered Probit estimation because γ is an index. Here it is the rare case that the index is continuous so that it needs to be discretised. The results reported below pertain to a discretisation using eleven quantiles. For a further robustness check estimations for the county-level are repeated for the more aggregate planning region-level.

Table 1: OLS regression, county-level

Dependent Variable: GAMMA
Method: Least Squares
Sample(adjusted): 3 116
Included observations: 98

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.021916	0.004921	4.453683	0.0000
TC	-0.001022	0.000366	-2.794245	0.0063
DUMRES	0.042413	0.013000	3.262513	0.0016
INTENS7	-0.041945	0.016444	-2.550803	0.0124
SONSTDL	0.079701	0.038568	2.066488	0.0416
LOG(HHI2001)	0.002986	0.001161	2.570978	0.0117
R-squared	0.252869	Mean dependent var		0.009749
Adjusted R-squared	0.212264	S.D. dependent var		0.012624

Table 2: OLS regression, planning region-level

Dependent Variable: GAMMAROR
Method: Least Squares
Included observations: 98

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.032883	0.008336	3.944667	0.0002
TC	-0.001630	0.000620	-2.629886	0.0100
DUMRES	0.065817	0.022022	2.988656	0.0036
INTENS7	-0.063547	0.027856	-2.281244	0.0248
SONSTDL	0.063700	0.065336	0.974956	0.3321
LOG(HHI2001)	0.003308	0.001967	1.681123	0.0961
R-squared	0.172049	Mean dependent var		0.016613
Adjusted R-squared	0.127052	S.D. dependent var		0.020316

The regression results show that industrial concentration has a significant positive impact on agglomeration, under both estimation methods and at both geographic levels (see Table 1, Table 2 and Table 3, Table 4 in the Appendix). *Transportation costs*, the *extractive industry dummy* and *technical and industrial services* have the anticipated sign and are highly significant except the latter one which turns completely insignificant with Probit estimation. *R&D personnel*, which is our variable for labour market pooling and additional spillovers, significantly reduces agglomeration. This result is in contrast to what common wisdom about inter-firm spillovers—especially in the high-technology field—suggests. It is in line, however,

Munisamy et al. (2004)). When the Herfindahl index and its square are included in the regression the coefficients are significant and imply an inverted U-shape relationship. However, more than 90% of the observations lie on the increasing segment of the parable, indicating that there is presumably a monotonous relationship.

with the prediction of the above models which tell that ultimately labour market pooling and knowledge spillovers are no distinct effects and which argue that there may be a strong force working against co-location. It is also in line with other systematic studies about the agglomeration of (high-tech) industries such as Rosenthal and Strange (2001) for the U.S., Barrios et al. (2003) for Portugal, Belgium and Ireland, Devereux et al. (2004) for the UK and Alecke et al. (2005) for Germany.

This paper considers the location decision and hence the degree of local competition (for inputs) as endogenous and as determined by the exogenous degree of national (product market) competition. There is a different approach to agglomeration due to Porter (1990, 1998). Porter takes a cluster, i.e. the agglomeration of “related” firms, as given and argues that the primary benefits of agglomeration arise from *local rivalry* itself, rather than from pure knowledge spillovers. According to him the benefits depend on the inter-firm interaction such as increased motivation and a “desire to look good” due to peer pressure and effective mutual control in a “cluster”. In sum, clusters both facilitate innovation and co-operation and intensify rivalry.

A few remarks about how our results relate to Porter’s concept are in order. First, as argued above, possible channels for “knowledge spillovers” are labour turnover, local spin-offs, reverse engineering, sub-contracting, co-operation etc., with the first one perhaps being the most important one. However, any of them constitutes an example for “inter-firm interaction” in the sense of Porter (1998). Thus, his focus on “inter-firm interaction” can be reconciled with the concept of knowledge spillovers if one goes beyond a black-box concept and conceives of a precise way of how exactly knowledge flows between firms.

Secondly, it is a contribution of CD’s and Alsleben’s model to make agglomeration endogenous and to show that it is the very local “inter-firm interaction” which may make firms avoid a “cluster”. This means that taking a broader perspective than Porter, by explicitly considering firms’ location decision and by taking labour poaching as an element of “inter-firm interaction”, challenges the common reasoning: it may not be that agglomeration is “beneficial” because of intensified local rivalry (e.g. for inputs), as Porter argues, but rather conversely that some industries agglomerate *despite* the negative effect of intensified local rivalry.

Finally, Porter’s work on clusters has been criticised for being vague and only descriptive (see the surveys in Martin and Sunley (2003) and Morgan (2004)). In particular, it is not clear which role competition plays in a cluster: “Clusters promote both competition and cooperation. [...] Yet there is also cooperation, much of it vertical, involving companies in

related industries and local institutions. Competition can coexist with cooperation because they occur on different dimensions and among different players.” (Porter 1998, p. 79). Cooperation between firms that are no direct rivals, for example because they belong to different industries, is conceivable. However, co-operation between direct rivals will be rare and usually confined to non-core activities such as joint purchase. First of all, there must be surplus from collaboration. Secondly, the partners must find an agreement on how to share this surplus. Incomplete contracts, the strategic interaction leading to prisoner dilemma-like situations or simply competition regulations may make such agreements very difficult or impossible.

The models considered above are very clear about what types of competition are at work. A distinction is made between product market competition which is assumed to take place at the national level, hence with no spatial dimension, and input market competition, which becomes effective only under co-location. In sum, the degree of product market competition, which can be seen as an exogenous industry characteristic, determines how strong competition for inputs (knowledge) is and hence whether firms agglomerate in equilibrium or not. The results from the regression analysis suggest that there is indeed a negative relationship between the degree of competition and agglomeration.

There is an empirical study by Shaver and Flyer (2000) that analyses under which conditions firms agglomerate and that gives an explanation for why spillovers may not necessarily spur agglomeration. They argue that heterogeneity among firms can lead to asymmetric contributions to and benefits from agglomeration externalities and that firms’ location choice becomes strategic then. They give empirical evidence that firms with superior technologies, human capital or suppliers have the incentive to locate distant from other firms, especially from firms within their industry, i.e. from direct rivals. Alsleben (2005) incorporates such asymmetry in the “quality” of firms in his location-decision model and shows that for sufficiently different firms the equilibrium depends on the (exogenous) order in which decisions are made. The “low-quality” firm would like to co-locate with the “high-quality” firm but not vice versa.

Another empirical study explores the effect of “competition” in a cluster on firm behaviour. Beal and Gimeno (2001) contrast several hypotheses grounded in the “knowledge spillovers” approach and Porter’s approach, respectively, and test them with the help of panel data analysis for the pre-packaged software industry in the U.S. One important hypothesis of the “pure spillovers” perspective is that agglomeration is negatively associated with firm commitment to innovation due to the temptation for firms to free-ride on the innovative

efforts of rivals. The authors find support for the spillovers perspective but no evidence for Porter's one. In particular, localised "knowledge spillovers" seem to increase firm innovative output but decrease firm-level commitment to R&D. Accordingly, Porter's hypothesis that agglomeration should be positively associated with firm commitment to innovation is declined.

5 Conclusion

Combes and Duranton (2001, 2003) and Alsleben (2005) present location decision models that specify "spillovers" as knowledge flowing between firms through labour poaching. Both models show that there is a downside associated with such spillovers which stems from the fact that sharing knowledge makes the rival more competitive. Depending on the degree of product market competition, profit-maximising firms may find it too costly to co-locate (and protect themselves against poaching with the help of high wages) so that they choose not to cluster. This paper has tested a somewhat broader interpretation of these models, namely that weaker competition—measured by higher industrial concentration—has a positive impact on spatial agglomeration, in a regression analysis for German manufacturing industries. We find indeed evidence for this effect and it seems to be robust with respect to the estimation method and the geographic level of aggregation used. Thus, industries which exhibit low industrial concentration and hence strong competition tend to be less agglomerated. In the framework of the models presented, an explanation is that (local) competition for inputs, such as strategic knowledge incorporated in key employees, intensifies with product market competition and may make firms avoid co-location. This result is important as it adds to a literature that has analysed the relationship between innovation and industrial concentration but left out the spatial dimension.

In the literature there are two important approaches to the phenomenon of agglomeration of firms. The first concentrates on knowledge spillovers as an externality making firms cluster in space. The second is due to Porter (1990, 1998) and focuses on inter-firm interaction such as intensified rivalry and co-operation. I have argued that these two perceptions are not as distinct as it may seem. In particular, I have criticised that in many models "knowledge spillovers" are treated as a black-box while possible channels through which knowledge may leak out of a firm or research institute are in fact labour turnover, local spin-offs, reverse engineering, sub-contracting, co-operation etc., all of which constitute examples for inter-firm interaction in the sense of Porter. Labour poaching is perhaps the most important channel of knowledge transmission. The theoretical models and the empirical

analysis carried out in this paper both help to clarify Porter's approach and to reconcile it with the concept of pure "knowledge spillovers". While Porter takes agglomeration as given and postulates that there are advantages (such as "intensified rivalry"), the more complete approach pursued here makes the location decision endogenous. Doing this, the line of argument may become reversed: some industries agglomerate *despite* the negative effect of intensified local rivalry, such as the strategic interaction in labour poaching.

A theoretical study of the interplay of *all* potential benefits and disadvantages from clustering including congestion costs, labour poaching, input sharing and transportation costs appears to be a complex task, however, and is left for future work.

Appendix

Table 3: Ordered probit estimation, county-level

Dependent Variable: GAMMA_11Q

Method: ML - Ordered Probit

Included observations: 98

	Coefficient	Std. Error	z-Statistic	Prob.
DUMRES	2.129202	1.272111	1.673754	0.0942
INTENS7	-2.868842	1.509512	-1.900510	0.0574
SONSTDL	2.368295	3.480797	0.680389	0.4963
TC	-0.055852	0.034388	-1.624171	0.1043
LOG(HHI2001)	0.205134	0.106323	1.929351	0.0537
Akaike info criterion	4.905665	Schwarz criterion		5.301324
Log likelihood	-225.3776	Hannan-Quinn criter.		5.065701
Restr. log likelihood	-230.6853	Avg. log likelihood		-2.299771
LR statistic (5 df)	10.61545	LR index (Pseudo-R2)		0.023009
Probability(LR stat)	0.059561			

Table 4: Ordered probit estimation, planning region-level

Dependent Variable: GAMMAROR_11Q

Method: ML - Ordered Probit

Included observations: 98

	Coefficient	Std. Error	z-Statistic	Prob.
DUMRES	2.098201	1.274897	1.645781	0.0998
INTENS7	-2.792971	1.511240	-1.848132	0.0646
SONSTDL	2.217624	3.480271	0.637199	0.5240
TC	-0.054048	0.034446	-1.569044	0.1166
LOG(HHI2001)	0.266775	0.107357	2.484930	0.0130
Akaike info criterion	4.880972	Schwarz criterion		5.276630
Log likelihood	-224.1676	Hannan-Quinn criter.		5.041007
Restr. log likelihood	-230.5852	Avg. log likelihood		-2.287425
LR statistic (5 df)	12.83510	LR index (Pseudo-R2)		0.027832
Probability(LR stat)	0.024974			

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