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ABSTRACT

This report is about the problem of making transition or enrollment rate gains comparable. It is shown that measures based on the proportions themselves, i.e. the difference between proportions, the proportion ratio and the residual gain ratio do not make the gains comparable. Instead a non-linear transformation has to be done. Two such transformations are discussed: probits and logits. As shown in the report they both make the transition gains comparable. However, it is important not to base the conclusions on the transformed values directly, since they are very difficult to interpret. Instead the transformed values should be used to predict transition rates on the assumption of comparable gains. After that the observed gains are compared with the predicted ones. A problem, more important than the choice of transformation, is that of sampling error. Comparing transition rate gains means a comparison between differences and in this case the sampling error is greater than when studying mere differences. Therefore, a statistical test is appropriate when studying transition rate gains, since it provides a measure of the effect of the independent variable at the same time as it provides a statistical test of whether this effect has been changed or not. (Author/LMO)

On comparing transition rate gains

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This report is about the problem of making transition or enrollment rate gains comparable. It is shown that measures based on the proportions themselves, i.e. the difference between proportions, t e proportion ratio and the residual gain ratio do not make the gains comparable. Instead a non-linear transformation has to be done. Two such transformations are discussed: probits and logits. As shown in the report they both make the transition gains comparable. Consequently it does not matter which transformation is used.

However, it is important not to base the conclusions on the transformed values directly since they are very difficult to interpret. Instead the transformed values should be used to predict transition rates on the assumption of comparable gains. After that the observed gains are compared with the predicted ones.

A problem, more important than the choice of transformation, is that of sampling error. Comparing transition rate gains means a comparison between differences and in this case the sampling error is greater than when studying mere differences. Therefore, a statistical test is to be recommended. Earlier no such tests were available, but now by the development of log-linear models they are. This test is shown to be very appropriate when studying transition rate gains since it provides a measure of the effect of the independent variable at the same time as it provides a statistical test of whether this effect has been changed or not.

Introduction

Normally, transition rates between two educational levels are expressed as proportions or percentages. The number of individuals entering the higher educational level is related to the total number of individuals on the lower one. These measures have the advantage of being easy to interpret as long as we are interested in the transition rates themselves or in studying transition rate changes. On the other hand if these changes are used for drawing conclusions about the *effect* of an independent variable the proportions create problems. This is due to the fact that there is no linear relationship between the independent variable, e.g. social background, study assistance and so on and the dependent variable (transition rate) when the latter one is expressed as a proportion. Instead the relationship is described by an S-shaped curve as shown in figure 1.

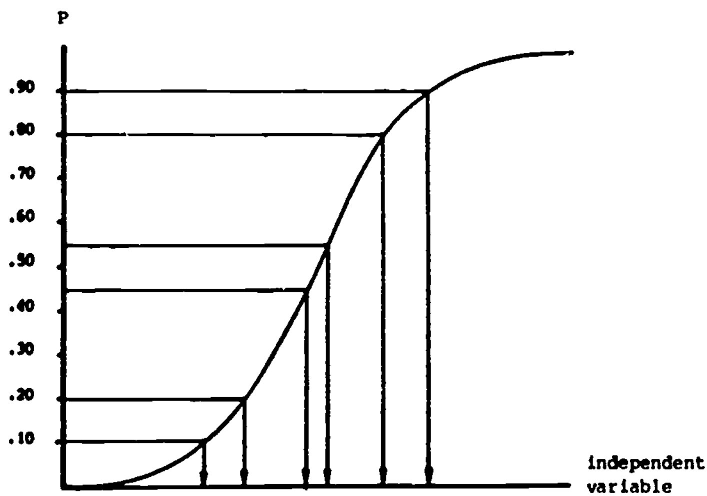

Figure 1. *The relationship between an independent variable and a dependent variable when the latter one is expressed as proportions (P).*

The shape of the curve implies that a fixed change in the independent variable entails a varying change in the depending variable as a function of the initial level. In the middle of the curve (near the proportion 0.50) the dependent variable is more easily changed than in the two extremes. Consequently, the transition rate gains are not comparable. This relationship is shown in figure 1 where the increase from 0.45 to 0.55 requires a smaller change in the independent variable than do the increases from 0.10 to 0.20 or from 0.80 to 0.90.

For a long time these circumstances have caused problems when comparisons are made of changes in transition rate and several methods have been proposed in order to make the measures comparable. Noonan and Elgqvist-Saltzman (1982) discuss different measures: such that involve nonlinear transformations (logits, probits and tangent transformation) and measures based on the proportions themselves (differences between proportions, proportion ratios and the residual gain ratio).

In this paper I will examine these measures somewhat more thoroughly than Noonan and Elgqvist-Saltzman have done and after that I intend to bring forward a method which is applicable to this kind of comparisons.

Measures based on the proportions themselves

My discussion in connection with figure 1 showed that the *difference between proportions* is an unsatisfactory measure. In order to change the transition rate by a fixed number of units the independent variable has to change more the more extreme the initial transition rate is. Consequently, the difference implies an underestimation of the change when the initial transition rate is either high or low compared to the case where the initial rate is around 0.50. In order to adjust for the varying slope of the curve, the measure of change must attain an increasing value the more extreme the initial transition rate.

By the *proportion ratio* (R) is meant the ratio between the proportion after the change has occurred and the initial proportion. This measure is defined by the following formula:

$$R = \frac{A+B}{A} \quad (1)$$

where A: the initial proportion
B: the change of the proportion

By the *residual gain ration* (RGR) is meant the actual change in transition rate related to the maximum possible change. According to Noonan and Elgqvist-Saltzman the residual gain ratio can be used irrespective of an increase or a decrease in the rate but they do not show how to compute the measure in the last-mentioned case. Therefore, I will confine myself to the case of increasing transition rates.

The residual gain ratio is defined by the following formula:

$$RGR = \frac{B}{1-A} \quad (2)$$

where A and B have the same meaning as in (1)

By rewriting formula (1) the relationship between R and RGR is more obvious.

$$R = 1+\frac{B}{A} \quad (3)$$

Leaving the constant 1 in formula (3) out of account the resemblance becomes even more obvious. The numerators are identical and both the denominators contain "A". The only difference between the two denominators is that the residual gain ratio uses "1-A", i.e. the proportion not entering the higher educational level, while the proportion ratio uses "A", i.e. the proportion entering that level.

Thus, the proportion ratio and the residual gain ratio are of exactly the same nature. However, there is a very important difference between them. If the transition rate gain (B) is constant, an increasing initial rate (A) entails an increasing RGR but a decreasing R. In contrast, a decreasing initial rate entails a decreasing RGR but an increasing R. This is shown in table 1 below.

Table 1. *Changes in R and RGR by initial transition rate when the transition rate gain amounts to 0.05.*

Initial transition rate	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
R	∞	1.50	1.25	1.17	1.13	1.10	1.08	1.07	1.06	1.06	
RGR	0.05	0.06	0.06	0.07	0.08	0.10	0.13	0.17	0.25	0.50	∞

The two measures are not only inversely related. If the R-values are reduced by the constant 1 we will find a complete correspondance between the R-value at the initial transition rate A and the RGR-value at the initial transition rate 1-A. In other words the residual gain ratio is nothing but a reflection of the proportion ratio.

What has been shown here about the proportion ratio and the residual gain ratio is quite remarkable in the light of the conclusions drawn by Noonan and Elgqvist-Saltzman as to the measures based on the proportions. In comparing the difference between proportions and the proportion ratio (they call it the relative comparison) they state:

> Of these two measures, the absolute differences are to be preferred on the grounds that the *base* for the relative comparisons often differs from group to group. Comparison

Table 9. *Comparison between the transition rate gain of social group 1 (0.45-0.50) and varying gains of group 2. The gains of group 2 being determined via probit differences.*

GROUP 2													
Initial rate	.038	.100	.150	.200	.300	.400	.500	.600	.700	.800	.850	.900	.950
Rate after gain	.050	.124	.181	.237	.345	.449	.550	.648	.742	.833	.877	.920	.962
G^2	0.26	0.12	0.05	0.03	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.12	0.26

Table 10. *Comparisons between the transition rate gain of social group 1 (0.45-0.50) and varying gains of group 2. The gains of group 2 being determined via logit differences.*

GROUP 2													
Initial rate	.041	.100	.150	.200	.300	.400	.500	.600	.700	.800	.850	.900	.950
Rate after gain	.050	.119	.177	.234	.344	.449	.550	.647	.740	.830	.874	.917	.959
G^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

> using different bases confounds an already difficult problem, and a ratio of ratios (i.e. the ratio of enrollment or transition rates) confounds it even more. (p. 159)

As to the residual gain ratio they state on the same page:

> The residual gain ratio, by relating the actual gains to the maximum possible gain, can provide useful comparative information. Its advantages are its simplicity and interpretability.

In my opinion, however, their negative judgements as to the proportion ratios are just as valid for the residual gain ratio since, in fact, the two measures have exactly the same characteristics.

Before commenting on the applicability of the residual gain ratio it is advisable to state what requirements a measure has to fulfil in order to be useful in comparing transition rate gains. As mentioned before, a change in enrollment or transition rate becomes successively more difficult when approaching the two extremes 0.00 and 1.00. Consequently, a fixed change in transition rate should be reflected by a gradually increasing measure when starting at the proportion 0.50 and approaching the two extremes.

Are these requirements satisfied by the measures based on proportions directly?

Obviously, the answer to that question is no. The difference between proportions has already been shown to be unsuitable. The proportion ratio and the residual gain ratio cannot be used either. Certainly, a constant change in transition rate is reflected in gradually increasing or decreasing measures but not in such a way as has been stipulated above. As shown by table 1 the proportion ratio results in a gradually decreasing measure going from a low to a high initial transition rate. On the contrary the residual gain ratio results in a gradually increasing measure all over the continuum. Therefore, we can say that these two methods make an adjustment of the measure in a correct direction in either extreme of the curve, but neither of them works in the stipulated way.

We have to conclude that the measures based on the proportions themselves do not make changes in transition rates comparable irrespective of the initial transition rate.

Measures based on nonlinear transformations of proportions

As mentioned before Noonan and Elgqvist-Saltzman discuss three measures based on nonlinear transformations: logits, probits and tangent transformation. I will confine myself to the first two since these are most frequently used.

The formulas for transformations to logits and probits are to be found in Hanushek and Jackson (1977, p. 188 and 189 respectively).

Both logits and probits have the property of transforming a fixed change in transition rate to gradually increasing differences when approaching the two extremes (proportions 0.00 and 1.00). Consequently, they work in accordance with the requirement stated in the preceding section.

However, Noonan and Elgqvist-Saltzman are very critical of these transformations. Their objections are:

1. *there is ambiguity in the choice of transformation*
2. *the results are difficult to interpret*
3. *nonlinear transformations simply do not serve the intended purpose as comparative measures of enrollment and transition increases (p. 148).*

Let me start by examining their first two objections. In doing so I will use the same data as they have used. These data are taken from Anderson (1975) who in his turn has taken them from

Gesser (1971). The data refer to enrollment in Swedish higher education by social group in 1950 and 1970.

Table 2. *Percentage Entering Higher Education in Sweden, by Social Group.*

Year	Social Groups I	II	III
1950	28	5	1
1971	79	20	9

Source: Noonan and Elgqvist-Saltzman, 1982, p. 142

Noonan and Elgqvist-Saltzman's transformations and analyses are shown in tables 3 and 4.

Table 3. *Comparison of Enrollment Increases Using the Probit Difference Method.*

	Social Groups I	II	III
Probit 1950	-0.58	-1.64	-2.33
Probit 1970	0.81	-0.84	-1.34
Probit Difference	1.39	0.80	0.99
Standardized Probit Difference	1.00	0.58	0.71

Source: Noonan and Elgqvist-Saltzman, 1982, p. 146

Table 4. *Comparison of Enrollment Increases Using the Logit Difference Method.*

	Social Groups		
	I	II	III
Logit 1950	-0.944	-2.944	-4.595
Logit 1970	1.325	-1.386	-2.314
Logit Difference	2.269	1.558	2.281
Standardized Logit Difference	0.99	0.68	1.00

Source: Noonan and Elgqvist-Saltzman, 1982, p. 145

The standardized differences are computed by comparing each difference with the largest one. According to the standardized differences in table 3 social groups II and III have lagged behind group I. In contrast, the standardized differences in table 4 show that the increase made by group III equals that of group I. Still group II has lagged behind group I.

So far their first two objections seem to be valid. The conclusions differ depending on the transformation used and the measures are very difficult to interpret.

However, in my opinion both these shortcomings are quite easily avoided if the transformations are handled in a different way. The course of action that I will suggest implies that the results are not presented in the form of logit or probit differences but as proportions. In order to achieve that we have to use the transformations for predicting enrollment rates on the assumption that all groups studied have made comparable enrollment rate changes.

In table 5 (next page), this method using probits is shown. There I have started from the probit difference of social group I which amounts to 1.39. On the assumption of an equal probit difference for the other two groups their 1950-probits are predicted. The actual probits are taken from table 3.

Table 5. *Prediction of Probits for Social Groups II and III on the Assumption that All Groups Have Equal Probit Differences.*

	Social Groups		
	I	II	III
Probit 1950 (actual/*predicted*)	-0.58	*-2.23*	*-2.73*
Probit 1970 (actual)	0.81	-0.84	-1.34
Probit Difference (actual/*predicted*)	1.39	*1.39*	*1.39*

Note: Probits in italics imply predicted probits.

Now, the probits in table 5 can be transformed to percentages as shown in table 6. The percentages on line 2 show the predicted transition rates of groups II and III on the assumption that the transition rate gains of these groups are comparable to that of group I. On line 4 the actual transition rate gain of each group is found and on line 5 I show the predicted differences of group II and III. By comparing the actual differences (line 4) with the predicted ones (line 5) we can find out whether groups II and III have lagged behind group I or not. If the predicted difference exeeds the actual one the group has lagged behind but if the predicted difference falls below the actual difference the group has made a larger gain.

Table 6. *Enrollment Rate Gain by Social Group: Actual and Predicted via Probits.*

	Social Groups		
	I	II	III
(1) Enrollment Rate 1950 (actual)	28	5	1
(2) Enrollment Rate 1950 (*predicted*)	-	*1.3*	*0.3*
(3) Enrollment Rate 1970 (actual)	79	20	9
(4) Difference 1970-1950 (actual):(3)-(1)	51	15	8
(5) Difference 1970-1950 (*predicted*) (3)-(2)	-	*18.7*	*8.7*

The figures on line 5 show that the transition rate gain of group I (51 units of percentage) is comparable to the gain of 18.7 and 8.7 units of percentage for group II and III respectively. These last-mentioned gains are to be compared to the actual ones which are 15 and 8 units of percentage respectively. Consequently, the conclusion is that group II has lagged behind group I but group III has made a gain almost comparable to that of group I.

Now, the same procedure is repeated but the transition rate gains will be predicted via logits.

Table 7. *Prediction of Logits for Social Group II and III on the Assumption that All Groups Have Equal Logit Differences.*

	Social Groups		
	I	II	III
Logit 1950 (actual/*predicted*)	-0.944	*-3.655*	*-4.583*
Logit 1970 (actual)	1.325	-1.386	-2.314
Logit Difference (actual/*predicted*)	2.269	*2.269*	*2.269*

Table 8. *Enrollment Rate Gain by Social Group: Actual and Predicted via Logits.*

	Social Groups		
	I	II	III
(1) Enrollment Rate 1950 (actual)	28	5	1
(2) Enrollment Rate 1950 (*predicted*)	-	*2.6*	*1.0*
(3) Enrollment Rate 1970 (actual)	79	20	9
(4) Difference 1970-1950 (actual) (3)-(1)	51	15	8
(5) Difference 1970-1950 (*predicted*) (3)-(2)	-	*17.4*	*8.0*

As shown by line 5 in table 8, the predicted difference of social group II exeeds the actual one. Consequently, for this group the transformation via logits leads to the same conclusion as the transformation via probits: group II has lagged behind group I. As to group III the logit transformation results in a perfect agreement between the predicted and the actual differences. Therefore, in this case we conclude that the transition rate gain is comparable to that of group I.

On the whole, the probit and the logit transformations imply the same conclusions when handled in this way. Nevertheless, there is a small difference between the two transformations. The differences predicted via probits are somewhat larger than those predicted via logits. The reason why the predicted differences differ in this way is the fact that the probit curve has a somewhat steeper slope than has the logit curve (Hanushek and Jackson, 1977, p. 188).

Consequently, Noonan and Elgqvist-Saltzman are right in stating that there is ambiguity in the choice of transformation. However, this ambiguity is particularly pronounced when the results are presented in the form of standardized differences as these authors do. The reason for this is the fact that the probits and the logits are very sensitive to changes in the two extremes of the proportion scale. This problem is illustrated by the following example: In table 3 the probit 1950 and the probit 1970 for social group III are -2.33 and -1.34 respectively. The probit difference amounts to 0.99. This difference corresponds to a standardized probit difference of 0.71 which means that the probit difference of social group III amounts to 71 per cent of that of social group I. In table 5 the predicted probit 1950 for social group III is -2.73 and now the probit difference of this group equals that of social group I. Consequently, the standardized probit difference of social group III amounts to 1.00.

Changing the probit value from -2.33 to -2.73 implies a decrease in transition rate from 1.0 per cent to 0.3 per cent.

Consequently, a decrease in initial transition rate by 0.7 units of percentage implies that the transition rate gain made by social group III is changed from 71 to 100 per cent of the gain made by group I when the comparison is shown as standardized probit differences. If the initial transition rate of social group III would have been 0.2 per cent its standardized probit difference would change from 100 per cent to 111 per cent. Now, it should be remembered that group I made a transition rate gain of 51 units of percentage - from 28 to 79 per cent.

From this comparison it seems reasonable to conclude that Noonan and Elgqvist-Saltzman's criticism of nonlinear transformations being arbitrary in choice of transformation and being difficult to interpret is caused mainly by their way of handling the data and presenting the results. Probit and logit differences are very difficult to interprete and they become even more so when transformed into standardized differences. On the other hand, if data are handled in the way shown in tables 6 and 8 they are not very difficult to interprete. Furthermore, by this way of presenting the results the ambiguity in choice of transformation is, to a large extent, reduced.

There is another problem, not discussed by Noonan and Elgqvist-Saltzman, but which in my opinion deserves attention. Normally, investigations of transition rate changes use data from samples but not from populations. Therefore, we have a sampling error which should be taken into consideration. When making comparisons between different groups as to changes in transition rates, we are not interested primarily in the changer themselves but in the differences between the changes. This means that we are studying differences between differences or in other words interactions. I think that this fact must be kept in mind since in this case uncertainly due to the sampling error is larger than in the case where a mere difference between two transition rates is studied.

Earlier there have been no statistical methods for testing this kind of interactions but by the development of log-linear models we have now a very suitable tool.

Log-linear models and the problem of measuring transition rate gains

Comparing two or more groups as to transition rates does not involve any problems. In this case only two dimensions are involved and therefore the Chi^2-method is applicable. However, comparing two or more groups as to transition rate *gains* means that one more dimension is included and analyses including more than two dimensions cannot be performed by Chi^2.

One of the major advantages obtained from log-linear models (LLM) is that this method provides a systematic approach to this kind of analyses. Another great advantage is that LLM provides estimates of the magnitude of the effects of each independent variable as well as estimates of the magnitude of the interaction effects.

It is not possible to give any details about LLM here. Introductory descriptions are given by Everitt (1977) and Baker (1981) and for a more detailed presentation the reader is referred to Bishop, Fienberg and Holland (1975). Suffice it to say that LLM differs from the Chi^2-method by converting the multiplicative analyses performed by Chi^2 to a linear model. This is accomplished by transforming the frequencies to natural logarithms. Then the logarithms are treated in a manner similar to that of ANOVA.

The LLM-analysis is based on the principle of testing whether a specified model provides an adequate fit of the expected frequencies to the observed ones. Let me give an example:

> Suppose that we have a sample of individuals distributed according to three dichotomous variables which are:
>
> A: year of transition to a higher educational level
> B: social group
> C: educational choice

The sample is distributed according to the three variables as shown in the following tableaun:

Variable				
A	B	C	F	P
1	1	1 entering	900	.45
		2 not entering	1100	
	2	1	0	.00
		2	2000	
2	1	1	1000	.50
		2	1000	
	2	1	100	.05
		2	1900	

N = 8000

It is possible to exactl_ reconstract the frequencies (F) in the tableaun above by the following model.

$$F = GM + A + B + C + A*B + A*C + B*C + A*B*C \qquad (4)$$

where GM: refers to the total number of individuals (N=8000)

A: refers to the distribution according to year of transition

B: refers to the distribution according to social group

C: refers to the distribution according to educational choice

A*B: refer o the first order interaction between year of transition and social group

A*C: refers to the first order interaction between year of transition and educational choice

B*C: refers to the first order interaction between social group and educational choice

A*B*C: refers to the second order interaction.

Since the model (4) contains all the parameters it is called the saturated model.

Now, suppose that we are interested in comparing the transition rate gains made by the t'n social groups from year 1 to year 2. This comparison is done by means of the second order interaction

A*B*C. If the two gains are comparable there is no or only a weak second order interaction but if they differ A*B*C is strong.

As mentioned before the saturated model implies that the observed frequencies are perfectly reconstructed. Now the question is: how much will the reconstructed (expected) frequencies differ from the observed ones when A*B*C is omitted from model (4)? If this omission leads to no or only small differences between observed and expected frequencies the second order interaction is weak. On the other hand, if the differences are large A*B*C is strong and consequently the gains of the two social groups are not comparable. In the first case A*B*C remains omitted from the model and we can go on testing each of the first order interactions in a similar way. In the second case A*B*C cannot be omitted and we have to retain the saturated model.

The difference between the expected and the observed frequencies is expressed as a G^2-value. These values follow the distribution of Chi^2. Consequently, when A*B*C is excluded, a high G^2-value indicates that the second order interaction is considerable.

In our example above the G^2-value amounts to 109.8 and this value is to be compared with the critical value for 5 per cent significance level, which amounts to 3.84 or the critical value for 1 per cent significance level: 6.64. Therefore, we can conclude that the second order interaction A*B*C in the example chosen is highly significant. How is this interaction to be interpreted?

This question can be answered by consulting the parameter estimates which are provided by LLM. In the following tableaun the estimate concerning the second order interaction is presented.

Parameter	Estimate	S.E.	t
A(2) B(2) C(2)	-5.15	1.42	-3.63*

The subgroup which is pointed out is the one having the index "2" in each of the three variables, i.e. those individuals belonging to social group 2 who did not enter the higher educational level at time 2. The estimate of this group is negative, which means that the number of individuals in this group is too low. Consequently, the transition rate of the group is too high. This finding means that the transition rate gain of social group 2 is higher than that of group 1 and this is the cause of the significant second order interaction.

Turning back to the transition rates we will find that group 1 has made a gain from 45 to 50 per cent while the gain of group 2 goes from 0 per cent to 5. Measured as units of percentages the two groups have made an equal gain but since the gain of group 2 is made in the extreme of the proportion scale it indicates a greater change in the effect of the independent variable, social background. Now, we can conclude that LLM makes a proper adjustment of the transition rate gains in the lowest extreme of the proportion scale. In order to test whether LLM makes a proper adjustment all over the continuum we keep the gain of group 2 in the previous example constant (0.05 units of percentage) but we change the initial transition rate systematically. The transition rates of group 1 remain the same as before. The G^2-values now found for the second order interaction A*B*C are shown in the following tableaun:

Initial transition rate of group 2	.00	.10	.15	.20	.30	.40	.50
G^2	109.8	46.7	1.97	0.77	0.08	0 00	0.00
Initial transition rate of group 2	.60	.70	.80	.85	.90	.95	
G^2	0.02	0.28	1.97	5.11	15.29	109.8	

In the centre of the continuum the G^2-values are changing very slowly but when approaching the two extremes they become gradually larger. Furthermore, the G^2-value for the intial rate 0.00 and the one for 0.95 are exactly the same. This is due to the fact that these gains occur at either side of that made by group 1 and at an equal distance from it. For the same reason the G^2-values of initial rate 0.15 and that of 0.80 correspond perfectly.

These two characteristics of the G^2-values are due to the fact that LLM by transforming the frequencies to logarithms changes the S-shaped relationship shown in figure 1 to a linear one.

I should now like to return to Noonan and Elgqvist-Saltzman's criticism that nonlinear transformations do not serve the intended purpose as comparative measures.

Let me first compare the transition rate gain made by social group 1 in the earlier example (from 0.45 to 0.55) with varying gains made by group 2. However, now the gains of group 2 are predicted in the way shown in the preceding section, i.e. the gains of group 2 are determined in such a way that their probit and logit differences correspond to that of group 1. After having determined the gains of group 2 the second order interactions are tested by LLM. If Noonan and Elgqvist-Saltzman's criticism is valid the G^2-values will be considerable. On the other hand, if the nonlinear transformations result in comparative measures, the G^2-values will be 0.00.

The G^2-values in tables 9 and 10 (page 18) are 0 or nearly 0, which means that all the gains of group 2, predicted via probits as well as via logits on the assumption of no second order interaction, are comparable to the gain of group 1. Consequently they are also mutually comparable.

Quite contrary to Noonan and Elgqvist-Saltzman, I therefore state that the nonlinear transformations via probits and logits serve the intended purpose as comparative measures of enrollment and transition rate increases. The transition rates in tables 9 and 10 also give further evidence to what has been said before. It does not matter whether the transition rates are transformed via probits or logits. The small differences at the extremes caused by the different slopes of the two curves can be ignored.

Consequently, the most important problem of comparing transition rate gains is not ambiguity in the choice of transformation. The probit and logit transformations imply very similar results. Instead the main problem is that of testing whether the difference in transition rate gains reflects a real change in the *effect* of the independ variable or whether it is due to sampling errors. This last-mentioned problem is easily solved by the application of LLM.

It should also be said that LLM is not restricted to be used in those analyses where only three variables are involved. As shown by Reuterberg (1984) LLM can be used also in more complicated analyses.

Conclusions

Making transition or enrollment rate gains comparable requires nonlinear transformations. Other measures, for instance proportion differences, proportion ratios or residual gain ratio do not serve the intended purpose. Whether the nonlinear transformations are done via probits or logits does not matter. However, it is important not to base the conclusions on the transformed values directly since they are very difficult to interpret and they easily cause a wrong conclusion. Instead these values should be used to predict transition rates on the assumption of comparable gains of the groups studied. After that the observed gains are compared with the predicted ones.

Another important problem is that of sampling error. Studying transistion or enrollment gains means a comparison between two or more differences and in such a comparison the sampling error is normally greater than when studying mere differences. Therefore, a statistical test is to be recommended. Earlier no such statistical tests were available, but now by the development of log-linear models they are. This test is shown to be very appropriate when studying transition rate changes for different groups since it provides a measure of the *effect* of the independent variable at the same time as it provides a statistical test of this effect.

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