A path analysis of PTSD among Ukrainian residents of Kiev and Zhitomyr Oblasts after Chornobyl

Robert Alan Yaffee
Silver School of Social Work
New York University

robert.yaffee@nyu.edu

8 August 2012

Contents

1 Acknowledgements

This project has been funded by National Science Foundation HSD grant 08262983, and to them we remain deeply grateful. We are also grateful to the developers of Stata in College Station, Texas, Salford Systems, Inc. in San Diego, California, and AutoMetrics in Oxford, London for the software they have developed and which we are using. We are also grateful to Ben Jann of ETH in Switzerland for his development of the estout.ado program which allows us to format our output so neatly. We are grateful for invaluable data management

2 Introduction

In this analysis we examine some plausible causal etiological paths of anxiety among residents of Zhitomyr and Kiev Oblasts in the years since Chornobyl. We will focus on omnibus measures of fit, as well as statistically significant paths, broken down into direct, indirect, and total effects. We employ path analysis to allow us to find out which variables are mediating ones and which have direct effects. The path analysis permits us to decompose total into direct, indirect, and spurious effects. In the previous section on our path analysis of depression, we introduced the nomenclature we use and the basis for path analysis. In our presentation of the PTSD models we were able to generate both conventional and robust models. Although we graph the conventional model, we rely on robust standard errors wherever possible, so tables for both types of standard error are presented.

3 Path analysis

Hypothesis 3 postulates that radiation dose directly predicts PTSD symptoms Hypothesis 6 postulates that perceived risk of exposure directly predicts Chornobyl PTSD. The meaning of direct in this context refers to a direct effect in a path model. We will examine these two hypotheses with path models for men and women separately. By decomposing the effects into direct, indirect, and total, we will endeavor to ascertain the extent to which direct effects can explain or predict Chornobyl PTSD symptoms.

We use standardized scales were available. In cases involving recollection of past situations, where standardized scales were not available, we use self-reported PTSD symptoms (PTSDw1 and PTSDw2). However, for the recent past (1997 through the time of the interview, we measure Chornobyl PTSD symptoms with the revised civilian version of the Mississippi Chornobyl PTSD scale for wave three (MiPTSD). The Chornobyl PTSD scale is meant to properly apply only to a wave three application, not to self-expressed PTSD symptoms.

We measure reconstructed external radiation dose with the cumulative external dose in milliGrays. These variables are respectively called cumdose1, cumdose2, and cumdose3. We also measure perceived risk of exposure by a factor score of three variables–the percent to which you believe your health has been affected by Chornobyl, the extent to which your believe your family's health has been affected by Chornobyl, and the percent to which you believe that the number of cancer cases in Zhitomir and Kiev Oblasts are due to Chornobyl. With alpha reliabilities extending upwards of 0.726 for wave 1, 0.822 for wave 2, and 0.834 for wave three, we proceed to use these scale scores as measures of perceived risk of exposure. These variables are crhtw1, crhtw2, and crhtw3, predecessors of and identical to crhrw1, crhrw2, and crhrw3, respectively.

Model building with full-information maximum likelihood can be complex with large models. Model building entails testing sundry plausible alternative paths between variables and pruning out paths that appear to be not statistically significant. Because changing one path can change all paths, model fitting is done on the basis of a global fit index. When the model comprising significant paths is not inconsistent with the data, the likelihood ratio χ^2 for the number of degrees of freedom identifying those paths minus the constraints, will no longer be statistically significant. A model may not unique. Depending on the variables in the model, it is possible for several combinations of paths to provide a fit. The one that offers the best fit is usually deemed the optimal model, if the paths correspond to theoretical reality. However, such model building usually proceeds non-optimally from specific-to-general.

4 Assumptions and Model structure

We rely on the same assumptions and model structure explained in our Hypothesis 4 and 5 discussion on path models.

5 Limitations of path models

Structural equation models are not designed to handle many variables, when they are fit with full information maximum likelihood. When one path is changed in the fitting process, most if not all other paths are changed. Path model generally proceeds from the specific to the general until the curse of dimensionality pushes an upper limit and the model may become fragile as collinearity increases. As we enter more variables, such model may rapidly become fragile and intractible.

If variables are not in the model, they are in the error term. If omitted variables are correlated with explanatory variables in the model, specification error can bias the parameters and significance levels of the included variables. The better models control for all relevant variables. When models contain a small fraction of the relevant variables, it is likely to be susceptible to omitted variable bias.

Structural equation models are not necessarily unique models. However, the fact that several different combinations of variables may provide a fit of the data does not mean that this fit is optimal and the best of all possible possible combinations of paths.

Robert Lucas in 1976 complained that econometric models lacked deep structure and were the products of policy decisions that would change the rule of the game by which the models, which did not depend upon deep structure, would no longer be valid [6, 1]. Christopher Sims, in his article, Macroeconomics and Reality (1980), claimed that these models do not allow the data to properly express themselves by testing a large number of dynamic variables likely to interact at once. He suggested a Bayesian vector autoregression would provide a more realistic framework from which to develop models [7].

These models do not permit the optimal general-to-specific modeling strategy advocated by the Hendry and Richard (1982). For these among other reasons, dependent upon the theory of reduction, one should not rely solely on overly simplified models but should proceed from general-to-specific in the modeling procedure [3, 358]. As George Box wrote, "All models are wrong. But some are useful" If that is true, oversimplifcation would be one way to predispose the model to be less likely to be reliable.

6 Dose-Perceived Chornobyl related risk and PTSD variables

Before elaborately explaining this process, it behooves us to review the names of the variables we use in this model. A variable list of those variables is contained in Table one below. In Figure 1 that follows, we present the path diagram for male respondents, and then in Table 2, we present the model output for that analysis. We will turn to the analysis of the female respondents afterward.

Table 1 Variable index for male PTSD model

variable name	type	format	variable label
age	double	%8.0g	* Respondent´s age
crhtw1	float	%9.0g	Chornobyl related health risk: wave 1 alpha = .726
crhtw2	float	%9.0g	Chornobyl related health risk in wave 2 alpha=.822
crhtw3	float	%9.0g	Chornobyl rleated health risk in wave 3 alpha=0.833 1997-now
cumdose1	double	%8.0g	Cumulative external dose in mGy for wave 1: 1986
cumdose2	double	%8.0g	Cumulative external dose in mGy for wave 1987 through 1996
cumdose3	float	%9.0g	cumulative external dose in mGys in wave 3: 1997-time of interview
PTSDw1	byte	%9.0g	Average PTSD level in percent in wave 1
PTSDw2	double	%9.0g	Average PTSD level in percent in wave 2
MiPTSD	byte	%9.0g	Misssissipi post-traumatic stress disorder scale
fdferw1	byte	%8.0g	* Level (in %) of fear of eating radioactively contaminated food in 1986
injselfr	byte	%9.0g	Were u injured because of Chornobyl acc in 1986?
cumdose1	float	%9.0g	cumulative external dose in mGys in wave 1
cumdose2	float	%9.0g	cumulative external dose in mGys in wave 2

In Figure 1, the path diagram illustrates the paths that were found be be statistically significantly interrelated. Table 2 lists the parameter estimates in detail depicted in this path diagram, and Table 3 and 4 respectively present their robust and non-robust direct effects. Table 5 and 6 present the sum of the indirect effects, and Table 7 and 8 list the standardized robust and non-robust total effects. Now we turn to an explanation of the path diagram and then to a development of the discussion of constitutes the relative magnitudes of the direct and indirect and total pathways of Chornobyl related health risk leading to clinical anxiety. Then we examine the total effects with respect to hypotheses 3 and 6, by which these hypotheses are tested.

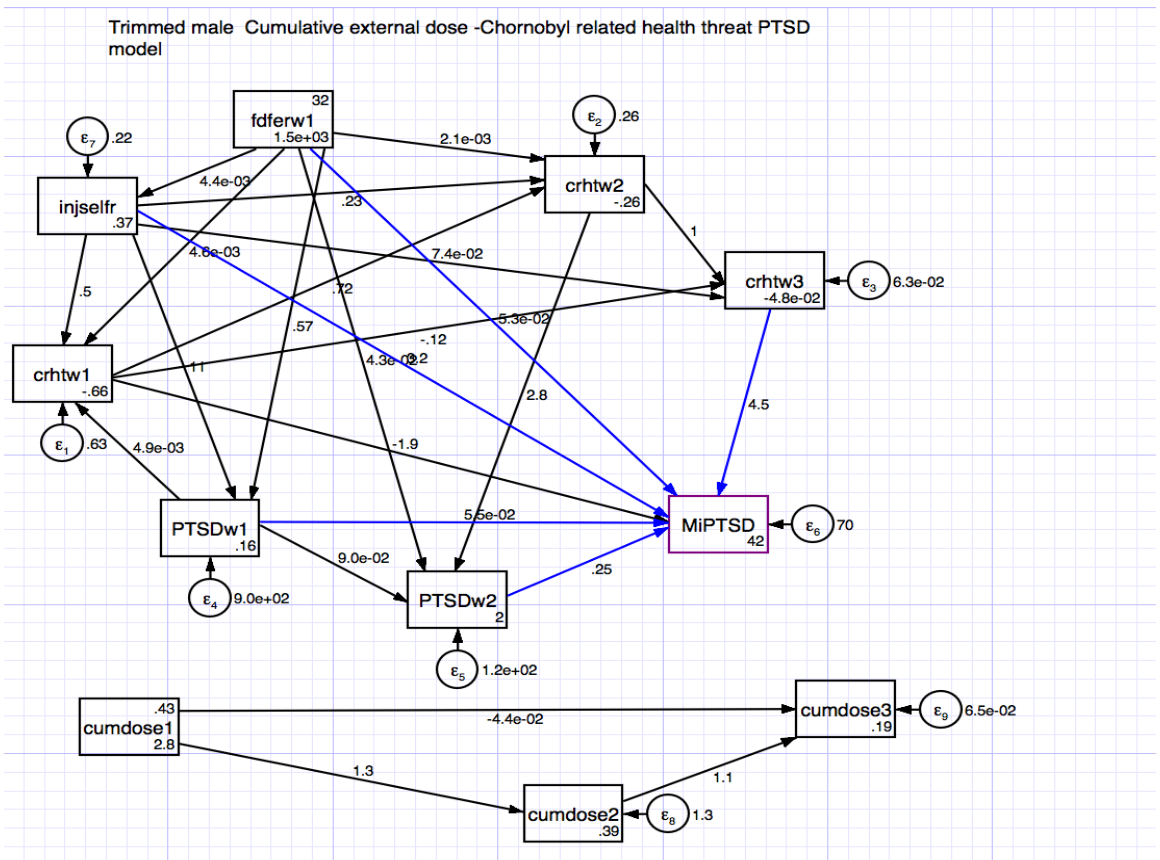

Figure 1: Pathways to PTSD among male respondents

7 Male PTSD path model

We begin by examining hypothesis 3, which postulates that radiation predicts Chornobyl PTSD. The path diagram in Figure 1 illustrates statistically significant paths discovered in Table 2. We do not find a path proceeding from cumulative external dose to injury resulting from Chornobyl. Nor do we observe a path proceeding from cumulative external dose to self-reported PTSD symptoms in 1986. Both of these paths were found to be statistically nonsignificant and therefore were not drawn in the diagram. Nor was there any statistically significant direct path emanating from cumulative external dose in wave 2 or 3 to MiPTSD in wave 3. Both of these paths for males were not found be statistically significant either. However, this model is found in a non-robust form to fit the data (Likelihood ratio χ^2, = 32.10, df = 30, $p > \chi^2$=.3629). There are no feedback loops in the model requiring the listing of the stability index. Nonetheless, all of the moduli are within the unit circle.

Among the direct effects on wave 3 PTSD, measured by the revised civilian version of the Mississippi Chornobyl PTSD scale, colored in blue are from fear of consuming contaminated food, perceived risk of Chornobyl exposure in waves 1 and 3, as well as self-reported PTSD symptoms in waves one and two. By examining the the standardized coefficients presented in Table 3 and 4, we can observe the relative magnitude of the direct effects. Although perceived Chornobyl health risk in waves one and three are significantly related to Chornobyl PTSD in wave three, it helps to examine their relative magnitude to put them into perspective.

In Table 2, we observe that the constant of the MiPTSD equation is significant and large (41.818). Relative to that the perceived Chornobyl related health risk declines during 1986 as most of the respondents reside at a comfortable distance from the exclusion zone. It can be stated with 95% confidence that the average male in our sample resided between 71 and 84 miles from the accident site. In terms of raw impact on the Chornobyl PTSD, it appears that the mean level comes first, and then the recent perceived Chornobyl health risk (crhtw3) comes second, and thirdly having sustained some sort of injury as a result of Chornobyl (injselfr). During the decade following Chornobyl, the self-reported PTSD symptoms comes next down the list of impact on the MiPTSD scale score. If we are referring to absolute impact, the perceived Chornobyl 1986 health risk would come next, although it would be an negative effect indicative of an inverse relationship. Over time, people may have developed a distrust in what they were told about Chornobyl as a result of initial restraint against disclosure of the full nature of the event and countermeasures that might be taken to preclude later biological adverse reactions. It is also possible that people believe that the fallout from the event may have been distributed by meteorological events in ways against which people had no defense and that the fallout may have contaminated the food chain as well.

7.1 Direct effects on male PTSD

When we examine the path diagram we observe direct paths proceeding from several variables to Chornobyl PTSD measured in wave three. Among them are fear of consuming contaminated food, having been injured as a result of the Chornobyl event, self-reported PTSD symptoms in waves one and two, along with perceived exposure to Chornobyl radiation in 1986 and in recent years (since 1997 to the time of the interview). These data are inconsistent with the postulation of hypothesis 3, that our measure of radiation, cumulative external dose, to which these respondents were exposed, predicts and/or explains Chornobyl PTSD. They are not completely inconsistent, however, with hypothesis 6, which postulates a relationship between perceived exposure and Chornobyl PTSD.

The significant relationships between perceived exposure in 1986 and in more recent years consider the difference between immediate short and long-term exposure. This may reflect the difference between perceptions of immediate radiation and the longer term contamination food-chain. Whether by immediate exposure or lifetime indirect exposure, many persons appear to arrive at a greater belief that they have been exposed.

When we combine the self-reported symptoms of PTSD in waves 1 and 3, as well as the perceived exposure, we do get a respectable model, the non-robust version of which fits the data well. There is no statistically significant difference between the overall fit of this model and the data (Likelihood ratio χ^2, df=30, $p > \chi^2$=0.3629.

The largest direct standardized effect on the wave 3 Chornobyl PTSD stems perceived Chornobyl health threat in wave 3 ($stdized\ \beta = 0.351$). The second largest comes from the self-reported PTSD symptoms in wave 2 ($stdized\ \beta = 0.267$) , and the third largest total effect stems from the self-reported PTSD symptoms in wave 1 ($stdized\ \beta = 0.18$). Fourth in the ranking from largest impact to smallest is that of fear of consuming contaminated food ($stdized\ \beta = 0.172$).and fifth is an injury as a result of Chornobyl ($stdized\ \beta = 0.134$). The smallest effect is that of the 1986 perceived Chornobyl health threat ($stdized\ \beta = -0.149$), not counting the lack of a path from perceived Chornobyl exposure to external dose in wave 2.

Approximately 28% of the total direct effect stems from recent perceived Chornobyl health risk, whereas almost 31% derives from the fear of eating contaminated food and an injury from the Chornobyl experience, according to the male respondents. To some extent, the direct effect of recently perceived Chornobyl related health risk can be used to predict an explain male Chornobyl PTSD. The variables that are common to directly predicting self-reported symptoms of PTSD at waves 1 and 2 as well as those predicting Chornobyl PTSD according to the Revised Mississippi civilian scale are fear of consuming contaminated food and having been injured because of Chornobyl. If we are attempting to assess the direct impact of perceived Chornobyl risk, we find no path from this variable in wave 2 to Chornobyl PTSD in wave 3. To obtain a more complete perspective of its impact, we have to consider the indirect and total effects. The extent to which this model provides a basis for explanation/and or prediction will be addressed after we consider the indirect and total effects on Chornobyl PTSD.

7.2 Indirect paths to male PTSD

Important indirect paths may also exist through which effects may be transmitted. The effects presumably can be transmitted through links of paths, only if all path coefficients of those connected links are statistically significant, by taking the product of those linked paths can provide an resulting coefficient the indirect route to the target endogenous variable as well. If a variable has several routes to the target variable, then the sum of the products of those different routes is computed to obtain the standardized coefficients in Tables 5 and 6.

Although these indirect paths are organized according to the original source or point of departure, it is helpful to examine the relative magnitude of their indirect effect on clinical anxiety in wave three. In Table 5 and 6, we examine the sum of indirect effects according to the resulting standardized coefficients to Chornobyl PTSD from their points of origin. All of these effects are statistically significant, and therefore should not be discarded merely because they are not direct.

From the standardized indirect coefficients, we see that the perceived Chornobyl exposure from the decade after 1986 has the largest indirect effect ($stdized\ \beta = 0.420$). Fear of consuming contaminated food comes next ($stdized\ \beta = 0.345$). The perceived Chornobyl health threat from 1986 ranks third in total indirect effect ($stdized\ \beta = 0.263$) . Chornobyl related injury is fourth in ranking ($stdized\ \beta = 0.138$), whereas self-expressed PTSD symptoms in 1986 is last. It is noteworthy that perceived Chornobyl health risk is first among the direct as well as the indirect effects in terms of impact. Although wave 2 perceived Chornobyl risk did not have a statistically significant path to wave 3 Chornobyl PTSD, it apparently has an indirect path to it and that standardized coefficient indicates that it is the one of largest indirect effect as well. For this reason, direct effects alone, are not sufficient by which to assess the effects within a model.

7.3 Total effects on male PTSD

We need to examine the total effects of these variables on male PTSD in Tables 7 and 8. Within the male model, there are seven total effects on male PTSD. Of primary impact of all of these total effects, based on standardized coefficients, is that of fear of eating contaminated food ($stdized\ \ \beta = 0.517$) . The second and third variables with largest total effect are those of perceived Chornobyl health risk in the decade after Chornobyl ($stdized\ \beta = 0.42,$) and in more recent years ($stdized\ \beta = 0.351$) . The smallest total effect was that of 1986 perceived Chornobyl health risk ($stdized\ \beta = 0.114$). Fourth and sixth in descending order of total effects are those of self-reported PTSD symptoms in 1986 and in the decade after, respectively.

Table 2 Male PTSD model parameter estimates

Endogenous variables

Observed: crhtw1 crhtw2 crhtw3 MiPTSD PTSDw2 PTSDw1 injselfr cumdose2 cumdose3

Exogenous variables

Observed: cumdose1 fdferw1

Fitting target model:

Iteration 0: log likelihood = -7940.4683
Iteration 1: log likelihood = -7940.4683

Structural equation model Number of obs = 339
Estimation method = ml
Log likelihood = -7940.4683

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
crhtw1 <-						
PTSDw1	.0048578	.0014287	3.40	0.001	.0020577	.007658
injselfr	.5014995	.0928059	5.40	0.000	.3196033	.6833957
fdferw1	.0046318	.0014264	3.25	0.001	.0018362	.0074274
_cons	-.6637911	.065033	-10.21	0.000	-.7912534	-.5363288
crhtw2 <-						
crhtw1	.7231965	.0347066	20.84	0.000	.6551729	.7912201
injselfr	.2288853	.0624287	3.67	0.000	.1065272	.3512434
fdferw1	.0020516	.0008037	2.55	0.011	.0004763	.0036268
_cons	-.2634203	.0481185	-5.47	0.000	-.3577309	-.1691097
crhtw3 <-						
crhtw1	-.1230361	.0255087	-4.82	0.000	-.1730323	-.0730399
crhtw2	1.040848	.0263316	39.53	0.000	.9892394	1.092457
injselfr	.074456	.0306789	2.43	0.015	.0143264	.1345856
_cons	-.0480025	.021924	-2.19	0.029	-.0909727	-.0050323
MiPTSD <-						
crhtw1	-1.907961	.7608603	-2.51	0.012	-3.39922	-.4167026
crhtw3	4.544354	.7900611	5.75	0.000	2.995862	6.092845
PTSDw2	.2509758	.0417516	6.01	0.000	.1691442	.3328074
PTSDw1	.0550842	.0160018	3.44	0.001	.0237213	.0864471
injselfr	3.191296	1.055686	3.02	0.003	1.122189	5.260404
fdferw1	.0525907	.0156695	3.36	0.001	.0218791	.0833024
_cons	41.81764	.8310319	50.32	0.000	40.18884	43.44643
PTSDw2 <-						
crhtw2	2.825478	.7231279	3.91	0.000	1.408174	4.242783
PTSDw1	.0904689	.019674	4.60	0.000	.0519085	.1290292
fdferw1	.0431227	.0202467	2.13	0.033	.0034398	.0828056
_cons	2.032031	.8651793	2.35	0.019	.3363108	3.727751

Continued...

Table 2 continued

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
PTSDw1 <-						
injselfr	11.48699	3.472512	3.31	0.001	4.680996	18.29299
fdferw1	.5689734	.0445575	12.77	0.000	.4816422	.6563046
_cons	.1572958	2.472281	0.06	0.949	-4.688287	5.002878
injselfr <-						
fdferw1	.0043575	.0006555	6.65	0.000	.0030728	.0056423
_cons	.3670591	.0331329	11.08	0.000	.3021198	.4319985
cumdose2 <-						
cumdose1	1.339597	.0366997	36.50	0.000	1.267667	1.411527
_cons	.3879549	.0632438	6.13	0.000	.2639992	.5119105
cumdose3 <-						
cumdose2	1.087217	.0123079	88.34	0.000	1.063094	1.11134
cumdose1	-.0439337	.0184663	-2.38	0.017	-.080127	-.0077403
_cons	.1920846	.0151063	12.72	0.000	.1624768	.2216924
Variance						
e.crhtw1	.6254351	.0480394			.5380243	.7270473
e.crhtw2	.2641008	.0202855			.2271901	.3070083
e.crhtw3	.0632691	.0048597			.0544266	.0735482
e.MiPTSD	70.21191	5.392944			60.39909	81.61898
e.PTSDw2	119.9617	9.214201			103.1958	139.4514
e.PTSDw1	903.8907	69.42742			777.5629	1050.743
e.injselfr	.2211203	.0169841			.1902165	.2570449
e.cumdose2	1.271465	.0976606			1.093765	1.478035
e.cumdose3	.0652934	.0050152			.056168	.0759014

LR test of model vs. saturated: chi2(30) = 32.10, Prob > chi2 = 0.3629

Table 3 Nonstandardized and standardized direct path coefficients with robust variances

Direct effects

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	.0048578	.0013114	3.70	0.000	.2036448
injselfr	.5014995	.0949467	5.28	0.000	.2700536
fdferw1	.0046318	.0014057	3.29	0.001	.1943801
crhtw2 <-					
crhtw1	.7231965	.0426289	16.96	0.000	.7294776
PTSDw1	0	(no path)			0
injselfr	.2288853	.0715661	3.20	0.001	.1243234
fdferw1	.0020516	.0008489	2.42	0.016	.086845
crhtw3 <-					
crhtw1	-.1230361	.0383291	-3.21	0.001	-.1242207
crhtw2	1.040848	.0316977	32.84	0.000	1.041821
PTSDw1	0	(no path)			0
injselfr	.074456	.0295742	2.52	0.012	.04048
fdferw1	0	(no path)			0
MiPTSD <-					
crhtw1	-1.907961	.7956899	-2.40	0.016	-.1486941
crhtw2	0	(no path)			0
crhtw3	4.544354	.8420389	5.40	0.000	.3507802
PTSDw2	.2509758	.0681866	3.68	0.000	.2667816
PTSDw1	.0550842	.0205745	2.68	0.007	.1799631
injselfr	3.191296	.9792807	3.26	0.001	.1339278
fdferw1	.0525907	.0190261	2.76	0.006	.1720028
PTSDw2 <-					
crhtw1	0	(no path)			0
crhtw2	2.825478	.6673048	4.23	0.000	.2053697
PTSDw1	.0904689	.0231606	3.91	0.000	.2780555
injselfr	0	(no path)			0
fdferw1	.0431227	.0198095	2.18	0.029	.1326807
PTSDw1 <-					
injselfr	11.48699	3.56193	3.22	0.001	.1475549
fdferw1	.5689734	.0518786	10.97	0.000	.5695893
injselfr <-					
fdferw1	.0043575	.0005858	7.44	0.000	.3395974
cumdose2 <-					
cumdose1	1.339597	.2873117	4.66	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0775735	14.02	0.000	1.019854
cumdose1	-.0439337	.0846185	-0.52	0.604	-.0274676

Table 4 Nonstandardized and standardized direct effects for Male model with non-robust standard errors

Direct effects

	Coef.	OIM Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	.0048578	.0014287	3.40	0.001	.2036448
injselfr	.5014995	.0928059	5.40	0.000	.2700536
fdferw1	.0046318	.0014264	3.25	0.001	.1943801
crhtw2 <-					
crhtw1	.7231965	.0347066	20.84	0.000	.7294776
PTSDw1	0	(no path)			0
injselfr	.2288853	.0624287	3.67	0.000	.1243234
fdferw1	.0020516	.0008037	2.55	0.011	.086845
crhtw3 <-					
crhtw1	-.1230361	.0255087	-4.82	0.000	-.1242207
crhtw2	1.040848	.0263316	39.53	0.000	1.041821
PTSDw1	0	(no path)			0
injselfr	.074456	.0306789	2.43	0.015	.04048
fdferw1	0	(no path)			0
MiPTSD <-					
crhtw1	-1.907961	.7608603	-2.51	0.012	-.1486941
crhtw2	0	(no path)			0
crhtw3	4.544354	.7900611	5.75	0.000	.3507802
PTSDw2	.2509758	.0417516	6.01	0.000	.2667816
PTSDw1	.0550842	.0160018	3.44	0.001	.1799631
injselfr	3.191296	1.055686	3.02	0.003	.1339278
fdferw1	.0525907	.0156695	3.36	0.001	.1720028
PTSDw2 <-					
crhtw1	0	(no path)			0
crhtw2	2.825478	.7231279	3.91	0.000	.2053697
PTSDw1	.0904689	.019674	4.60	0.000	.2780555
injselfr	0	(no path)			0
fdferw1	.0431227	.0202467	2.13	0.033	.1326807
PTSDw1 <-					
injselfr	11.48699	3.472512	3.31	0.001	.1475549
fdferw1	.5689734	.0445575	12.77	0.000	.5695893
injselfr <-					
fdferw1	.0043575	.0006555	6.65	0.000	.3395974
cumdose2 <-					
cumdose1	1.339597	.0366997	36.50	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0123079	88.34	0.000	1.019854
cumdose1	-.0439337	.0184663	-2.38	0.017	-.0274676

Table 5 Sum of indirect path coefficients to male PTSD

Indirect effects

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	0	(no path)			0
injselfr	.0558017	.0173032	3.22	0.001	.0300488
fdferw1	.0051924	.0008921	5.82	0.000	.2179079
crhtw2 <-					
crhtw1	0	(no path)			0
PTSDw1	.0035132	.0009484	3.70	0.000	.1485543
injselfr	.4030383	.0700976	5.75	0.000	.218918
fdferw1	.0081022	.0010123	8.00	0.000	.3429748
crhtw3 <-					
crhtw1	.7527379	.0443702	16.96	0.000	.7599851
crhtw2	0	(no path)			0
PTSDw1	.003059	.0008258	3.70	0.000	.1294701
injselfr	.5891685	.0937468	6.28	0.000	.3203172
fdferw1	.0096843	.0010894	8.89	0.000	.4103275
MiPTSD <-					
crhtw1	3.374426	.2539494	13.29	0.000	.2629808
crhtw2	5.43911	.2214633	24.56	0.000	.420239
crhtw3	0	(no path)			0
PTSDw2	0	(no path)			0
PTSDw1	.0298293	.0060747	4.91	0.000	.097454
injselfr	3.294119	.5009282	6.58	0.000	.1382429
fdferw1	.1053479	.0156516	6.73	0.000	.3445498
PTSDw2 <-					
crhtw1	2.043376	.1204471	16.96	0.000	.1498126
crhtw2	0	(no path)			0
PTSDw1	.0099263	.0026797	3.70	0.000	.0305086
injselfr	2.824702	.4381856	6.45	0.000	.1115199
fdferw1	.0846922	.0199497	4.25	0.000	.2605826
PTSDw1 <-					
injselfr	0	(no path)			0
fdferw1	.0500551	.01603	3.12	0.002	.0501093
injselfr <-					
fdferw1	0	(no path)			0
cumdose2 <-					
cumdose1	0	(no path)			0
cumdose3 <-					
cumdose2	0	(no path)			0
cumdose1	1.456433	.2682484	5.43	0.000	.9105718

Table 6 Sum of conventional indirect effects without robust standard errors

	Coef.	OIM Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	0	(no path)			0
injselfr	.0558017	.0168688	3.31	0.001	.0300488
fdferw1	.0051924	.000997	5.21	0.000	.2179079
crhtw2 <-					
crhtw1	0	(no path)			0
PTSDw1	.0035132	.0010332	3.40	0.001	.1485543
injselfr	.4030383	.0682166	5.91	0.000	.218918
fdferw1	.0081022	.0009806	8.26	0.000	.3429748
crhtw3 <-					
crhtw1	.7527379	.0361243	20.84	0.000	.7599851
crhtw2	0	(no path)			0
PTSDw1	.003059	.0008996	3.40	0.001	.1294701
injselfr	.5891685	.0880359	6.69	0.000	.3203172
fdferw1	.0096843	.0011272	8.59	0.000	.4103275
MiPTSD <-					
crhtw1	3.374426	.2215238	15.23	0.000	.2629808
crhtw2	5.43911	.2173851	25.02	0.000	.420239
crhtw3	0	(no path)			0
PTSDw2	0	(no path)			0
PTSDw1	.0298293	.0053638	5.56	0.000	.097454
injselfr	3.294119	.4901042	6.72	0.000	.1382429
fdferw1	.1053479	.0131261	8.03	0.000	.3445498
PTSDw2 <-					
crhtw1	2.043376	.0980626	20.84	0.000	.1498126
crhtw2	0	(no path)			0
PTSDw1	.0099263	.0029193	3.40	0.001	.0305086
injselfr	2.824702	.4342978	6.50	0.000	.1115199
fdferw1	.0846922	.014392	5.88	0.000	.2605826
PTSDw1 <-					
injselfr	0	(no path)			0
fdferw1	.0500551	.0169015	2.96	0.003	.0501093
injselfr <-					
fdferw1	0	(no path)			0
cumdose2 <-					
cumdose1	0	(no path)			0
cumdose3 <-					
cumdose2	0	(no path)			0
cumdose1	1.456433	.0431728	33.73	0.000	.9105718

Table 7 Total robust effects on male PTSD

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	.0048578	.0013114	3.70	0.000	.2036448
injselfr	.5573012	.0969274	5.75	0.000	.3001024
fdferw1	.0098242	.0011884	8.27	0.000	.412288
crhtw2 <-					
crhtw1	.7231965	.0426289	16.96	0.000	.7294776
PTSDw1	.0035132	.0009484	3.70	0.000	.1485543
injselfr	.6319236	.0974661	6.48	0.000	.3432414
fdferw1	.0101538	.001118	9.08	0.000	.4298197
crhtw3 <-					
crhtw1	.6297018	.0511086	12.32	0.000	.6357645
crhtw2	1.040848	.0316977	32.84	0.000	1.041821
PTSDw1	.003059	.0008258	3.70	0.000	.1294701
injselfr	.6636245	.0983398	6.75	0.000	.3607972
fdferw1	.0096843	.0010894	8.89	0.000	.4103275
MiPTSD <-					
crhtw1	1.466464	.8310835	1.76	0.078	.1142867
crhtw2	5.43911	.2214633	24.56	0.000	.420239
crhtw3	4.544354	.8420389	5.40	0.000	.3507802
PTSDw2	.2509758	.0681866	3.68	0.000	.2667816
PTSDw1	.0849135	.0221344	3.84	0.000	.2774171
injselfr	6.485415	1.069413	6.06	0.000	.2721708
fdferw1	.1579386	.0161015	9.81	0.000	.5165526
PTSDw2 <-					
crhtw1	2.043376	.1204471	16.96	0.000	.1498126
crhtw2	2.825478	.6673048	4.23	0.000	.2053697
PTSDw1	.1003952	.0232454	4.32	0.000	.3085641
injselfr	2.824702	.4381856	6.45	0.000	.1115199
fdferw1	.1278148	.0244761	5.22	0.000	.3932633
PTSDw1 <-					
injselfr	11.48699	3.56193	3.22	0.001	.1475549
fdferw1	.6190285	.0491758	12.59	0.000	.6196985
injselfr <-					
fdferw1	.0043575	.0005858	7.44	0.000	.3395974
cumdose2 <-					
cumdose1	1.339597	.2873117	4.66	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0775735	14.02	0.000	1.019854
cumdose1	1.412499	.3182587	4.44	0.000	.8831041

7.4 Analysis of total PTSD effects among males

Another way to consider the impact on Chornobyl PTSD is to review the total effects. Among the total effects, the greatest impact on Chornobyl PTSD

Table 8 Total non-robust effects on male Chornobyl PTSD

	Coef.	OIM Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
PTSDw1	.0048578	.0014287	3.40	0.001	.2036448
injselfr	.5573012	.0943265	5.91	0.000	.3001024
fdferw1	.0098242	.0011791	8.33	0.000	.412288
crhtw2 <-					
crhtw1	.7231965	.0347066	20.84	0.000	.7294776
PTSDw1	.0035132	.0010332	3.40	0.001	.1485543
injselfr	.6319236	.0924708	6.83	0.000	.3432414
fdferw1	.0101538	.0011585	8.76	0.000	.4298197
crhtw3 <-					
crhtw1	.6297018	.0442228	14.24	0.000	.6357645
crhtw2	1.040848	.0263316	39.53	0.000	1.041821
PTSDw1	.003059	.0008996	3.40	0.001	.1294701
injselfr	.6636245	.0932283	7.12	0.000	.3607972
fdferw1	.0096843	.0011272	8.59	0.000	.4103275
MiPTSD <-					
crhtw1	1.466464	.7924526	1.85	0.064	.1142867
crhtw2	5.43911	.2173851	25.02	0.000	.420239
crhtw3	4.544354	.7900611	5.75	0.000	.3507802
PTSDw2	.2509758	.0417516	6.01	0.000	.2667816
PTSDw1	.0849135	.0168768	5.03	0.000	.2774171
injselfr	6.485415	1.163905	5.57	0.000	.2721708
fdferw1	.1579386	.0141501	11.16	0.000	.5165526
PTSDw2 <-					
crhtw1	2.043376	.0980626	20.84	0.000	.1498126
crhtw2	2.825478	.7231279	3.91	0.000	.2053697
PTSDw1	.1003952	.0198894	5.05	0.000	.3085641
injselfr	2.824702	.4342978	6.50	0.000	.1115199
fdferw1	.1278148	.0162299	7.88	0.000	.3932633
PTSDw1 <-					
injselfr	11.48699	3.472512	3.31	0.001	.1475549
fdferw1	.6190285	.0425806	14.54	0.000	.6196985
injselfr <-					
fdferw1	.0043575	.0006555	6.65	0.000	.3395974
cumdose2 <-					
cumdose1	1.339597	.0366997	36.50	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0123079	88.34	0.000	1.019854
cumdose1	1.412499	.040758	34.66	0.000	.8831041

is that of whether the individual was injured because of Chornobyl. The total effect of this variable appears to account for about 82% of the total effect. Perceived Chornobyl health risk only accounts for less than 10% of this total effect, if we use the total of the standardized coefficients as a basis for comparison.

7.5 A sequential non-nested alternative perspective

Another approach that may be used to assess the impact of these variables. based on a sequence of non-nested regressions. The problem is that our dependent variable is not the same over all three waves. Nor is our cumulative external dose, because in the later model, the newer variable (e.g., cumdose2 replaces the cumdose1 and later cumdose3 replaces cumdose2). This non-nesting make nested comparisons inappropriate.

Nevertheless, there is heuristic value in observing parameter stability, with respect to significance and with respect to persistence, and with respect to sign and magnitude.

Several aspects of this model remain stable over time, regardless of wave. The constant is positive and significant throughout the three waves of the model. Cumulative external dose remains unrelated to any of the other variables in the model. The fear of consuming contaminated food persists throughout all of the waves. Self- reported PTSD symptoms serve as precursors of the PTSD in the next wave.

The wave three model which could serve as a nowcasting model explains about 49% of the explained variance.

Table 9 PTSD regressions with cluster robust standard errors

	PTSDwave1m b/t/p	PTSDwave2m b/t/p	MiPTSDwave3m b/t/p
cumdose1	0.515		
	(0.82)		
	(0.414)		
injselfr	7.548*	-0.219	3.274**
	(2.20)	(-0.26)	(3.30)
	(0.028)	(0.794)	(0.001)
fdferw1	0.518***	0.044*	0.053**
	(9.42)	(2.16)	(2.73)
	(0.000)	(0.031)	(0.007)
crhtw1	6.755***	-1.162	-1.875
	(3.53)	(-1.34)	(-1.92)
	(0.000)	(0.182)	(0.055)
cumdose2		-0.236	
		(-1.21)	
		(0.227)	
PTSDw1		0.095***	0.055**
		(4.17)	(2.65)
		(0.000)	(0.008)
crhtw2		3.796***	-0.118
		(4.18)	(-0.06)
		(0.000)	(0.954)
cumdose3			-0.126
			(-0.48)
			(0.629)
PTSDw2			0.249***
			(3.61)
			(0.000)
crhtw3			4.650**
			(2.66)
			(0.008)
_cons	4.534*	2.251**	41.931***
	(2.00)	(3.11)	(49.57)
	(0.046)	(0.002)	(0.000)
r2	0.423	0.254	0.505
r2_a	0.417	0.240	0.493
bic	3286.994	2623.496	2455.205
N	339.000	339.000	339.000

A more longitudinal approach is a panel data model that adjusts for the autocorrelation among the waves as well as heteroskedasticity among the panels. According to this approach the fit is much better when the panels are corrected for autocorrelation but heteroskedasticity is accommodated with robust standard errors. To perform this analysis, we would have to assume that we could use the MiPTSD over all three waves, for which it was not designed, and which application would be inappropriate. However, the higher R^2 it would yield would probably justify the use of such an analysis for explanation and prediction.

7.6 Hypothesis tests

With respect to hypothesis 3 that radiation as measured by our reconstructed external cumulative dose, we do not find evidence that this explains Chornobyl PTSD on the part of a representative sample of Ukrainian male residents of Kiev and Zhitomyr Oblasts.

As for hypothesis 6, we find that in terms of the direct effects on PTSD, there is evidence of a statistically significant relationship between the summary score for perceived Chornobyl health risk and Chornobyl PTSD This evidence does not extend through all 3 waves. Rather it extends from the first and third waves only. The proportion of variance explained by the third wave model is the largest (adjusted R^2=.0.493) and for the first wave model is the second largest (adjusted $R^2 = 0.417$) in sequential but not nested regression models. As for the path model, it has been found to be consistent with the data (LR test of model vs. saturated: chi2(30) = 32.10, $Prob > \chi^2 = 0.3629$) insofar as the non- robust version, which is the version that is fitted reveals no significant difference between the model and the data). Although the parameter estimates in the robust version have slightly larger standard errors, they do not require a significant difference between what we have already revealed and our interpretation of the model, other than to say that they also control for the clustered correlation across our waves.

8 Female PTSD path model

In Figure 2, we present the path diagram for the female Chornobyl PTSD model. This diagram shows the statistically significant paths that extend to PTSD among the females in our sample. To facilitate explanation the paths have been color-coded. The purple box on the right is the target endogenous variable. The direct paths extending to it are lavender if they come from self-reported PTSD symptoms before. The red path extends from cumulative external dose in 1986 to self-reported PTSD symptoms. Apart from the lavender paths, the blue paths designate direct effects from other variables on Chornobyl PTSD. Brown paths are direct effects on perceived Chornobyl related health threat over time. Forest green colored arrows indicate direct effects on self-expressed PTSD symptoms in previous waves. The color coding will help readers distinguish one type of path from another.

To help the reader interpret the path coefficients, Table 10 lists the parameter estimates from which the path diagram was developed. The non-robust version of the model is consistent with the data (LR $\chi^2 = 81.91, prob > \chi^2 = 0.1198$).

8.1 Direct effects for females

The female model differs from the male model. Whereas in the male model, we saw no evidence of a statistically significant direct main effect on the part of cumulative external dose and Chornobyl PTSD, on the part of the females, we observe a statistically significant direct effect from cumulative external dose

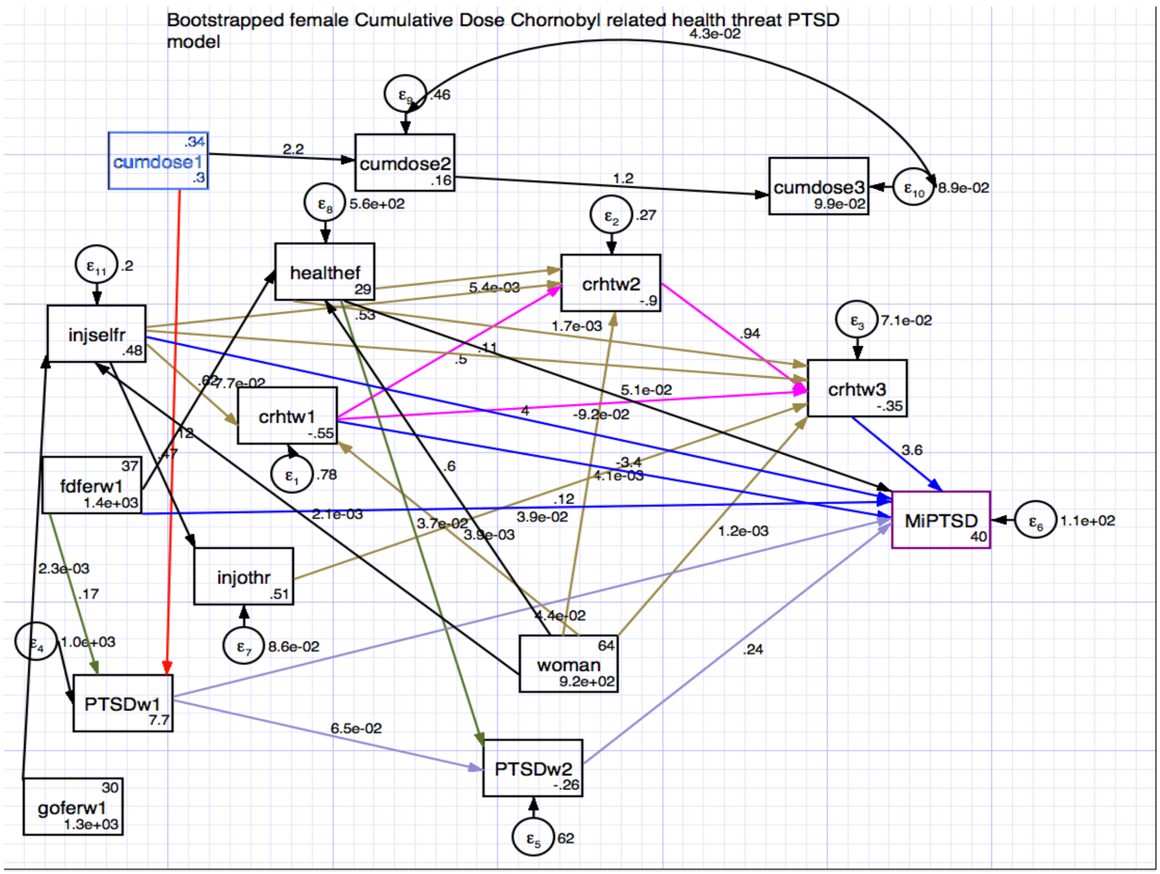

Figure 2: Pathways to PTSD among females residents of Kiev and Zhitomyr Oblasts

in 1986, in Figure 2 ($stdized\ \beta = 0.1974$). This has implications for our test of hypothesis 3, which stipulates that radiation predicts Chornobyl PTSD. We evidence for a PTSD prediction only in 1986, where we have no standardized scale for it. This is a self-report of PTSD symptoms only. So hypothesis three appears to be inconsistent with our data.

Hypothesis 6 posits a relationship between perceived Chornobyl health risk and Chornobyl PTSD. We have some evidence for this relationship. In waves one and three, we found direct effects from perceived Chornobyl health risk to Chornobyl PTSD as measured by the Russian translated revised civilian Mississippi PTSD scale. We provide the parameter estimates for Figure 2 are listed for the female model in Table 10 and in Table 12 we provide the standardized direct effect parameter estimates. We now turn to a consideration of indirect effects.

8.2 Indirect effects for females

To obtain a broader perspective we examine the indirect path coefficients to clinical anxiety in Table 13. We do not have a significant indirect path from cumulative external dose to Chornobyl PTSD, although we have one that is almost statically significant, but this is not horseshoes ($stdized\ \beta = 0.033, p = 0.067$). However, if we could rely only on 1986 self-reported symptoms of PTSD, we find that there is a statistically significant relationship ($stdized\ \beta = 0.197, p = 0.011$). We have no evidence of an indirect path to Chornobyl PTSD from our measure of cumulative external dose.

There are two indirect paths to Chornobyl PTSD from perceived Chornobyl health risk. The first path extends from 1986 perceived exposure to Chornobyl PTSD for women ($stdized\ \beta = .105, p = 0.000$). The second path extends from wave 2 perceived exposure to Chornobyl PTSD, ($stdized\ \beta = 0.244, p = 0.000$). We find no indirect path from recent perceived Chornobyl health risk. None of these paths results in a negative cancellation of a direct effect.

8.3 Total effects on Chornobyl PTSD among females

Table 14 lists the total effects on the variables. We observe there no statistically significant total effect from reconstructed cumulative external radiation dose in any of the waves, although that in 1986 is quasi-significant (cumdose1 stdized β = .771, p=.067). We can therefore say that Hypothesis 3 is not consistent with these data at the conventional 0.05 level of significance.

As for hypothesis 6, we find partial support for this hypothesis in these data. In all three waves, there are statistically significant total effects of perceived Chornobyl health risk with Chornobyl PTSD. From wave 1 the parameter estimate of this relationship is shown to be ($stdized\ \beta = -0.165, p = 0.009$). From wave 2, it is ($stdized\ \beta = 0.244, p = 0.000$) and from wave 3 is appears to be ($stdized\ \beta = 0.263, p = 0.000$).

Table 10 PTSD path model for female respondents

Endogenous variables

Observed: crhtw1 crhtw2 crhtw3 MiPTSD PTSDw1 PTSDw2 injothr healthef injselfr cumdose2 cumdose3

Exogenous variables

Observed: fdferw1 goferw1 woman cumdose1

Structural equation model Number of obs = 362
Estimation method = ml
Log likelihood = -13082.789

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
crhtw1 <-						
injselfr	.6200944	.1020416	6.08	0.000	.4200964	.8200923
woman	.00395	.0015604	2.53	0.011	.0008917	.0070083
_cons	-.5463274	.1199652	-4.55	0.000	-.7814549	-.3111999
crhtw2 <-						
crhtw1	.4966621	.0311382	15.95	0.000	.4356323	.5576919
healthef	.0053704	.0011538	4.65	0.000	.0031089	.0076318
injselfr	.5280348	.0634423	8.32	0.000	.4036902	.6523795
woman	.004122	.0011752	3.51	0.000	.0018186	.0064253
_cons	-.8967527	.0812535	-11.04	0.000	-1.056007	-.7374988
crhtw3 <-						
crhtw1	-.0923206	.0207534	-4.45	0.000	-.1329965	-.0516446
crhtw2	.9423043	.0271109	34.76	0.000	.8891678	.9954407
injothr	.1150786	.0484954	2.37	0.018	.0200293	.2101279
healthef	.0017293	.0006062	2.85	0.004	.0005412	.0029173
injselfr	.1124159	.0406178	2.77	0.006	.0328065	.1920254
woman	.0012238	.0006101	2.01	0.045	.0000281	.0024194
_cons	-.350573	.0551292	-6.36	0.000	-.4586243	-.2425218
MiPTSD <-						
crhtw1	-3.433859	.7128543	-4.82	0.000	-4.831028	-2.03669
crhtw3	3.566905	.9486628	3.76	0.000	1.70756	5.42625
PTSDw1	.0439002	.0173977	2.52	0.012	.0098013	.0779992
PTSDw2	.2447084	.0691501	3.54	0.000	.1091766	.3802402
healthef	.0510452	.0206098	2.48	0.013	.0106508	.0914397
injselfr	4.013214	1.412112	2.84	0.004	1.245525	6.780902
fdferw1	.0391754	.0154171	2.54	0.011	.0089584	.0693924
_cons	39.99789	1.859341	21.51	0.000	36.35365	43.64213
PTSDw1 <-						
fdferw1	.168436	.0445324	3.78	0.000	.081154	.2557179
cumdose1	11.94243	3.066746	3.89	0.000	5.931721	17.95314
_cons	7.677188	2.485257	3.09	0.002	2.806174	12.5482
PTSDw2 <-						
PTSDw1	.0645792	.0124924	5.17	0.000	.0400945	.0890639
healthef	.037285	.0136543	2.73	0.006	.0105231	.0640468
_cons	-.2571743	1.047878	-0.25	0.806	-2.310978	1.79663

Continued...

Table 10 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
injothr <-						
injselfr	.4746775	.0332963	14.26	0.000	.4094179	.5399371
_cons	.5132743	.0276148	18.59	0.000	.4591504	.5673983
healt~f <-						
fdferw1	.0772755	.0338094	2.29	0.022	.0110102	.1435408
woman	.599946	.0421943	14.22	0.000	.5172468	.6826453
_cons	28.69494	2.976987	9.64	0.000	22.86015	34.52973
injse~r <-						
goferw1	.0023167	.0006807	3.40	0.001	.0009825	.0036509
woman	.0021098	.0008115	2.60	0.009	.0005192	.0037004
_cons	.4842527	.0552466	8.77	0.000	.3759714	.592534
cumdo~2 <-						
cumdose1	2.188894	.0649526	33.70	0.000	2.061589	2.316199
_cons	.1613576	.0418234	3.86	0.000	.0793853	.2433299
cumdo~3 <-						
cumdose2	1.231235	.0130516	94.34	0.000	1.205654	1.256816
_cons	.0990387	.0195777	5.06	0.000	.0606671	.1374104
Variance						
e.crhtw1	.7800055	.0579774			.6742615	.9023333
e.crhtw2	.2735126	.02033			.236433	.3164074
e.crhtw3	.0712263	.0052942			.0615703	.0823967
e.MiPTSD	106.2418	7.896894			91.83881	122.9037
e.PTSDw1	1008.937	74.99371			872.1573	1167.168
e.PTSDw2	61.88182	4.599639			53.4926	71.5867
e.injothr	.0861711	.006405			.074489	.0996853
e.healthef	560.0518	41.62833			484.1266	647.8844
e.injselfr	.2005192	.0149045			.1733352	.2319665
e.cumdose2	.4605614	.0342333			.3981239	.532791
e.cumdose3	.0890991	.0067161			.076862	.1032845
Covariance						
e.cumdose2						
e.cumdose3	.0427649	.0124315	3.44	0.001	.0183996	.0671303

LR test of model vs. saturated: chi2(68) = 81.91, Prob > chi2 = 0.1198

Table 11 Robust path model for PTSD among female respondents

Endogenous variables

Observed: crhtw1 crhtw2 crhtw3 MiPTSD PTSDw1 PTSDw2 injothr healthef
injselfr cumdose2 cumdose3

Exogenous variables

Observed: fdferw1 goferw1 woman cumdose1

Structural equation model   Number of obs   =   362
Estimation method = ml
Log pseudolikelihood= -13082.789

(Std. Err. adjusted for 362 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
crhtw1 <-						
injselfr	.6200944	.0952207	6.51	0.000	.4334653	.8067235
woman	.00395	.0015425	2.56	0.010	.0009268	.0069732
_cons	-.5463274	.1121438	-4.87	0.000	-.7661253	-.3265296
crhtw2 <-						
crhtw1	.4966621	.0378379	13.13	0.000	.4225011	.5708231
healthef	.0053704	.0011006	4.88	0.000	.0032132	.0075276
injselfr	.5280348	.0714051	7.39	0.000	.3880834	.6679863
woman	.004122	.0011316	3.64	0.000	.001904	.0063399
_cons	-.8967527	.0899003	-9.97	0.000	-1.072954	-.7205513
crhtw3 <-						
crhtw1	-.0923206	.0297358	-3.10	0.002	-.1506017	-.0340394
crhtw2	.9423043	.0352957	26.70	0.000	.873126	1.011483
injothr	.1150786	.0455472	2.53	0.012	.0258078	.2043495
healthef	.0017293	.0006304	2.74	0.006	.0004938	.0029648
injselfr	.1124159	.0451043	2.49	0.013	.0240131	.2008187
woman	.0012238	.0006315	1.94	0.053	-.000014	.0024615
_cons	-.350573	.0627999	-5.58	0.000	-.4736586	-.2274875
MiPTSD <-						
crhtw1	-3.433859	.7949584	-4.32	0.000	-4.991949	-1.875769
crhtw3	3.566905	.8958233	3.98	0.000	1.811123	5.322686
PTSDw1	.0439002	.0197735	2.22	0.026	.0051449	.0826556
PTSDw2	.2447084	.085389	2.87	0.004	.0773491	.4120677
healthef	.0510452	.0171199	2.98	0.003	.0174909	.0845995
injselfr	4.013214	1.304467	3.08	0.002	1.456505	6.569922
fdferw1	.0391754	.0185666	2.11	0.035	.0027855	.0755653
_cons	39.99789	1.399355	28.58	0.000	37.25521	42.74058
PTSDw1 <-						
fdferw1	.168436	.0498099	3.38	0.001	.0708104	.2660615
cumdose1	11.94243	4.684462	2.55	0.011	2.761055	21.12381
_cons	7.677188	2.22312	3.45	0.001	3.319954	12.03442
PTSDw2 <-						
PTSDw1	.0645792	.0152186	4.24	0.000	.0347513	.094407
healthef	.037285	.0117698	3.17	0.002	.0142165	.0603534
_cons	-.2571743	.7522769	-0.34	0.732	-1.73161	1.217261

Continued...

Table 11 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
injothr <-						
injselfr	.4746775	.0475909	9.97	0.000	.3814011	.5679538
_cons	.5132743	.0470845	10.90	0.000	.4209903	.6055583
healt~f <-						
fdferw1	.0772755	.0352267	2.19	0.028	.0082325	.1463185
woman	.599946	.049076	12.22	0.000	.5037588	.6961332
_cons	28.69494	3.75406	7.64	0.000	21.33712	36.05276
injse~r <-						
goferw1	.0023167	.0006762	3.43	0.001	.0009915	.003642
woman	.0021098	.0008878	2.38	0.017	.0003697	.0038499
_cons	.4842527	.060146	8.05	0.000	.3663686	.6021368
cumdo~2 <-						
cumdose1	2.188894	.0836046	26.18	0.000	2.025032	2.352756
_cons	.1613576	.0418662	3.85	0.000	.0793013	.2434139
cumdo~3 <-						
cumdose2	1.231235	.0359156	34.28	0.000	1.160842	1.301628
_cons	.0990387	.0305132	3.25	0.001	.039234	.1588434
Variance						
e.crhtw1	.7800055	.0412437			.7032171	.8651788
e.crhtw2	.2735126	.0257737			.2273875	.3289941
e.crhtw3	.0712263	.0103979			.0535032	.0948204
e.MiPTSD	106.2418	11.502			85.92952	131.3556
e.PTSDw1	1008.937	88.86986			848.9616	1199.058
e.PTSDw2	61.88182	25.07611			27.96625	136.9279
e.injothr	.0861711	.0074445			.0727486	.1020701
e.healthef	560.0518	53.47957			464.4582	675.3203
e.injselfr	.2005192	.0094151			.1828895	.2198483
e.cumdose2	.4605614	.2559617			.1549614	1.368836
e.cumdose3	.0890991	.0336145			.0425344	.1866408
Covariance						
e.cumdose2						
e.cumdose3	.0427649	.07504	0.57	0.569	-.1043107	.1898406

Table 12 Standardized direct robust effects impacting female PTSD

Direct effects

(Std. Err. adjusted for 362 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
injselfr	.6200944	.0952207	6.51	0.000	.3045766
goferw1	0	(no path)			0
woman	.00395	.0015425	2.56	0.010	.1268773
crhtw2 <-					
crhtw1	.4966621	.0378379	13.13	0.000	.5383348
healthef	.0053704	.0011006	4.88	0.000	.1875303
injselfr	.5280348	.0714051	7.39	0.000	.2811206
fdferw1	0	(no path)			0
goferw1	0	(no path)			0
woman	.004122	.0011316	3.64	0.000	.1435099
crhtw3 <-					
crhtw1	-.0923206	.0297358	-3.10	0.002	-.0982495
crhtw2	.9423043	.0352957	26.70	0.000	.9251918
injothr	.1150786	.0455472	2.53	0.012	.0476187
healthef	.0017293	.0006304	2.74	0.006	.059289
injselfr	.1124159	.0451043	2.49	0.013	.0587623
fdferw1	0	(no path)			0
goferw1	0	(no path)			0
woman	.0012238	.0006315	1.94	0.053	.0418327
MiPTSD <-					
crhtw1	-3.433859	.7949584	-4.32	0.000	-.2699539
crhtw2	0	(no path)			0
crhtw3	3.566905	.8958233	3.98	0.000	.2634914
PTSDw1	.0439002	.0197735	2.22	0.026	.1215267
PTSDw2	.2447084	.085389	2.87	0.004	.168225
injothr	0	(no path)			0
healthef	.0510452	.0171199	2.98	0.003	.1292821
injselfr	4.013214	1.304467	3.08	0.002	.1549666
fdferw1	.0391754	.0185666	2.11	0.035	.1234591
goferw1	0	(no path)			0
woman	0	(no path)			0
cumdose1	0	(no path)			0
PTSDw1 <-					
fdferw1	.168436	.0498099	3.38	0.001	.1917519
cumdose1	11.94243	4.684462	2.55	0.011	.1974223
PTSDw2 <-					
PTSDw1	.0645792	.0152186	4.24	0.000	.2600494
healthef	.037285	.0117698	3.17	0.002	.1373648
fdferw1	0	(no path)			0
woman	0	(no path)			0
cumdose1	0	(no path)			

Continued...

Table 12 continued:

injothr <-					
injselfr	.4746775	.0475909	9.97	0.000	.5996347
goferw1	0	(no path)			0
woman	0	(no path)			0
healt~f <-					
fdferw1	.0772755	.0352267	2.19	0.028	.0961542
woman	.599946	.049076	12.22	0.000	.5981679
injse~r <-					
goferw1	.0023167	.0006762	3.43	0.001	.1806199
woman	.0021098	.0008878	2.38	0.017	.1379739
cumdo~2 <-					
cumdose1	2.188894	.0836046	26.18	0.000	.8708002
cumdo~3 <-					
cumdose2	1.231235	.0359156	34.28	0.000	.9679574
cumdose1	0	(no path)			0

Table 13 Indirect effects on Chornobyl PTSD among females

(Std. Err. adjusted for 362 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
injselfr	0	(no path)			0
goferw1	.0014366	.0004874	2.95	0.003	.0550126
woman	.0013083	.0005764	2.27	0.023	.0420236
crhtw2 <-					
crhtw1	0	(no path)			0
healthef	0	(no path)			0
injselfr	.3079774	.0472925	6.51	0.000	.1639642
fdferw1	.000415	.0002228	1.86	0.062	.0180318
goferw1	.0019368	.0006232	3.11	0.002	.0803912
woman	.0069476	.0011961	5.81	0.000	.2418872
crhtw3 <-					
crhtw1	.4680068	.0356548	13.13	0.000	.498063
crhtw2	0	(no path)			0
injothr	0	(no path)			0
healthef	.0050605	.0010371	4.88	0.000	.1735015
injselfr	.7851556	.0777521	10.10	0.000	.4104181
fdferw1	.0005247	.0002762	1.90	0.057	.0223838
goferw1	.0020794	.0006671	3.12	0.002	.0847433
woman	.0113353	.0013707	8.27	0.000	.3874839
MiPTSD <-					
crhtw1	1.340037	.143101	9.36	0.000	.1053474
crhtw2	3.36111	.1258964	26.70	0.000	.2437801
crhtw3	0	(no path)			0
PTSDw1	.0158031	.0037241	4.24	0.000	.0437468
PTSDw2	0	(no path)			0
injothr	.4104745	.1624625	2.53	0.012	.0125471
healthef	.0333425	.0053224	6.26	0.000	.0844465
injselfr	1.072236	.3710251	2.89	0.004	.0414034
fdferw1	.0165773	.0052721	3.14	0.002	.0522424
goferw1	.0117816	.0041754	2.82	0.005	.0354683
woman	.0713063	.0132384	5.39	0.000	.1800621
cumdose1	.7130027	.3896804	1.83	0.067	.0326287
PTSDw1 <-					
fdferw1	0	(no path)			0
cumdose1	0	(no path)			0
PTSDw2 <-					
PTSDw1	0	(no path)			0
healthef	0	(no path)			0
fdferw1	.0137587	.0045143	3.05	0.002	.0630732
woman	.022369	.0072657	3.08	0.002	.0821672
cumdose1	.7712326	.3614408	2.13	0.033	.0513396

Continued...

Table 13 continued:

injothr <-					
injselfr	0	(no path)			0
goferw1	.0010997	.0003532	3.11	0.002	.1083059
woman	.0010015	.0004303	2.33	0.020	.0827339
healt~f <-					
fdferw1	0	(no path)			0
woman	0	(no path)			0
injse~r <-					
goferw1	0	(no path)			0
woman	0	(no path)			0
cumdo~2 <-					
cumdose1	0	(no path)			0
cumdo~3 <-					
cumdose2	0	(no path)			0
cumdose1	2.695043	.1392837	19.35	0.000	.8428975

Table 14 Total effects

(Std. Err. adjusted for 362 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
crhtw1 <-					
injselfr	.6200944	.0952207	6.51	0.000	.3045766
goferw1	.0014366	.0004874	2.95	0.003	.0550126
woman	.0052583	.0015796	3.33	0.001	.1689009
crhtw2 <-					
crhtw1	.4966621	.0378379	13.13	0.000	.5383348
healthef	.0053704	.0011006	4.88	0.000	.1875303
injselfr	.8360122	.0860376	9.72	0.000	.4450848
fdferw1	.000415	.0002228	1.86	0.062	.0180318
goferw1	.0019368	.0006232	3.11	0.002	.0803912
woman	.0110695	.0014819	7.47	0.000	.385397
crhtw3 <-					
crhtw1	.3756863	.0401191	9.36	0.000	.3998134
crhtw2	.9423043	.0352957	26.70	0.000	.9251918
injothr	.1150786	.0455472	2.53	0.012	.0476187
healthef	.0067898	.0012626	5.38	0.000	.2327905
injselfr	.8975716	.09487	9.46	0.000	.4691804
fdferw1	.0005247	.0002762	1.90	0.057	.0223838
goferw1	.0020794	.0006671	3.12	0.002	.0847433
woman	.0125591	.0014658	8.57	0.000	.4293165
MiPTSD <-					
crhtw1	-2.093822	.802422	-2.61	0.009	-.1646064
crhtw2	3.36111	.1258964	26.70	0.000	.2437801
crhtw3	3.566905	.8958233	3.98	0.000	.2634914
PTSDw1	.0597033	.019749	3.02	0.003	.1652735
PTSDw2	.2447084	.085389	2.87	0.004	.168225
injothr	.4104745	.1624625	2.53	0.012	.0125471
healthef	.0843878	.0178629	4.72	0.000	.2137286
injselfr	5.085449	1.357681	3.75	0.000	.19637
fdferw1	.0557527	.017631	3.16	0.002	.1757015
goferw1	.0117816	.0041754	2.82	0.005	.0354683
woman	.0713063	.0132384	5.39	0.000	.1800621
cumdose1	.7130027	.3896804	1.83	0.067	.0326287
PTSDw1 <-					
fdferw1	.168436	.0498099	3.38	0.001	.1917519
cumdose1	11.94243	4.684462	2.55	0.011	.1974223
PTSDw2 <-					
PTSDw1	.0645792	.0152186	4.24	0.000	.2600494
healthef	.037285	.0117698	3.17	0.002	.1373648
fdferw1	.0137587	.0045143	3.05	0.002	.0630732
woman	.022369	.0072657	3.08	0.002	.0821672
cumdose1	.7712326	.3614408	2.13	0.033	.0513396
injothr <-					
injselfr	.4746775	.0475909	9.97	0.000	.5996347
goferw1	.0010997	.0003532	3.11	0.002	.1083059
woman	.0010015	.0004303	2.33	0.020	.0827339

healt~f <-					
fdferw1	.0772755	.0352267	2.19	0.028	.0961542
woman	.599946	.049076	12.22	0.000	.5981679
injse~r <-					
goferw1	.0023167	.0006762	3.43	0.001	.1806199
woman	.0021098	.0008878	2.38	0.017	.1379739
cumdo~2 <-					
cumdose1	2.188894	.0836046	26.18	0.000	.8708002
cumdo~3 <-					
cumdose2	1.231235	.0359156	34.28	0.000	.9679574
cumdose1	2.695043	.1392837	19.35	0.000	.8428975

8.4 Total effects for females

When we examine the total effects of the paths on the female Chornobyl PTSD and list these results in Table 14, we observe that among the 12 total effects considered in this model, the one that had the largest total effect, when the coefficients are standardized, is recent Chornobyl perceived health risk ($crhtw3std.\ \beta = 0.263$), which accounts for about 17.2% of the sum of the total effects(but not the sum of the absolute values of each of the total effects). The second largest total effect, in standardized coefficients, is the perceived health risk in the decade after Chornobyl ($crhtw3\ std.\ \beta = 0.244$), which accounts for 16% of the sum of the total effects or 27% of the sum of each of the absolute values of the total effects. Together these two variables account for approximately 33 % of the sum of the (not absolute values of the) total effects. Where the 1986 perceived Chornobyl health risk ranks depends on whether we allow the mean value of the variable, which is negative, allow itself to rank this variable last in the list. If we do not allow that, then its absolute value puts it fourth from the smallest total effect. If we allow it, then its non-absolute negative effect places it last in our list of total effects. In terms of amount of variance explained by these models, we may rely on our non-nested sequential regression analysis in Table 16 for an alternative perspective.

8.5 Non-nested sequential regression alternative perspective

In the male model, we find little in the female PTSD models to assure us of parameter stability. None of the variables remains significant over all three waves. Only fear of consuming contaminated food and health effects are statistically significant for two waves. The R^2 are too minuscule a basis

Table 15 Female PTSD regression analysis with cluster robust standard errors

	PTSDwave1f b/se/t/p	PTSDwave2f b/se/t/p	MiPTSDwave3f b/se/t/p
cumdose1	12.455*		
	(4.950)		
	(2.52)		
	(0.012)		
injselfr	6.650	-0.451	4.037*
	(4.493)	(1.409)	(1.563)
	(1.48)	(-0.32)	(2.58)
	(0.140)	(0.749)	(0.010)
fdferw1	0.250***	0.033	0.065*
	(0.073)	(0.036)	(0.028)
	(3.43)	(0.92)	(2.37)
	(0.001)	(0.356)	(0.019)
goferw1	-0.132#	-0.027	-0.023
	(0.077)	(0.039)	(0.031)
	(-1.72)	(-0.68)	(-0.76)
	(0.087)	(0.495)	(0.449)
injothr	-3.806	2.264*	1.353
	(5.161)	(1.094)	(1.904)
	(-0.74)	(2.07)	(0.71)
	(0.461)	(0.039)	(0.478)
healthef	0.042	0.029**	0.077***
	(0.069)	(0.010)	(0.023)
	(0.61)	(2.95)	(3.41)
	(0.542)	(0.003)	(0.001)
woman	-0.023	0.012	-0.025
	(0.079)	(0.018)	(0.027)
	(-0.30)	(0.68)	(-0.94)
	(0.766)	(0.498)	(0.347)
crhtw1	-0.591	0.433	-4.012****
	(1.912)	(0.553)	(0.968)
	(-0.31)	(0.78)	(-4.14)
	(0.758)	(0.435)	(0.000)
cumdose2		0.420*	
		(0.192)	
		(2.19)	
		(0.029)	
crhtw2		-0.147	3.552
		(0.620)	(2.319)
		(-0.24)	(1.53)
		(0.812)	(0.126)

Continued on the next page...

Table 15 continued

cumdose3			0.272
			(0.522)
			(0.52)
			(0.603)
crhtw3			0.691
			(2.069)
			(0.33)
			(0.739)
_cons	5.616	-1.752	39.641****
	(5.040)	(1.312)	(2.104)
	(1.11)	(-1.33)	(18.84)
	(0.266)	(0.183)	(0.000)
r2	0.100	0.053	0.228
r2_a	0.080	0.029	0.206
bic	3578.455	2594.925	2799.284
N	362.000	362.000	362.000

# p<0.10, * p<0.05, ** p<0.01, *** p<0.001, **** p<0.0001

to believe that any of these regressions provides a comprehensive explanation or prediction of the endogenous variable.

8.6 Hypothesis recapitulation

In the female model we observe no evidence to support hypothesis 3 that radiation directly predicts Chornobyl PTSD as measured by the revised civilian Mississippi PTSD scale. However, there is some evidence that it may have been related to self-reported PTSD symptoms in 1986 among females. It is also the case for males.

There is some evidence to support hypothesis 6 among females. Both perceived Chornobyl health risk in 1986 and recently exhibit statistically significant direct paths to PTSD as measured by our standardized scale for females. For males we found significant paths at all three waves to Chornobyl PTSD. For both males and females we found total effects at all three waves from perceived Chornobyl health threat to Chornobyl PTSD (tables 7 and 8 for males and tables 14 for females).

Although our structural equation model may fit the data, the question as to whether this provides an adequate basis for explanation and prediction depends on whether the later model explains most of the target endogenous variable's variance. If we are to rely on the *adjusted* R^2 provided for each of the equations listed above, our conclusion would be that we need a more variance encompassing model to be confident of that. This model does not even explain a quarter of the variance of the target endogenous variable. Without a more encompassing result, we would not be able to say that perceived risk can explain Chornobyl PTSD.

The strength of the male models is stronger than that for the female models, but not by a lot. We would have to be cautious about claiming that the model for males is sufficiently powerful to provide a reliable basis for explanation and prediction than it currently does and would hesitate to make this claim with as low a proportion of variance explained by the model that we found.

References

[1] Cohen, J. and Cohen, P. 1983 Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences Hillsdale, NJ: Lawrence Earlbaum Associates, 359-360.

[2] Doornik, J.A. and Hendry, Sir D.F. 2009 Empirical Econometric Modeling with PcGive, Vol.I. London, U.K.: Timberlake Consultants, Ltd., 142.

[3] Hendry, Sir David. F. and Richard, J-F. On the Formulation of Empirical Models in Dynamic Econometrics in Hendry, D.F, ed., Econometrics alchemy or science?, chapter 16. Oxford, U.K.: Blackwell, 358-415.

[4] Joreskog, K. and Sorbom, D. 1989 LISREL 8 Users manual Chicago, Ill: Scientific Software International, Inc., 9, 136-137.

[5] Nagel, E. 1961 *The Structure of Science* New York: Harcourt, Brace, and World, 56-78.

[6] Rudebusch, G.D. 2002 *Assessing the Lucas Critique in Monetary Policy Models* Federal Reserve Bank of San Francisco, working paper 2002-02 https://docs.google.com/a/nyu.edu/viewer?url=http://www.frbsf.org/publications /economics/papers/2002/wp02-02bk.pdf, accessed 11 Aug 2012

[7] Sims, Chris *Macroeconomics and Reality* Econometrica, Vol 48, Number 1, 1980, 1-48.

[8] StataCorp Release 12 Structural Equation Modeling 2011 College Station, TX:Stata Press, Inc., 209-219.