

## Appendix D: specification checks

The two most important criteria for model appropriateness are (i) validity of the exclusion restrictions and (ii) predictive power of the equation for product innovation advertising.

The first criterion has already been partly validated by my finding of significant effects of the exclusion restrictions in the equations to which they are associated and my finding of insignificant effects of the exclusion restrictions for product innovation advertising in the product innovation equation. What is still missing is a test for insignificance of the exclusion restriction of the product innovation equation in the product innovation advertising equation. The problem here is that product innovation advertising is conditional on product innovation so that “direct” test as described above do not apply. In order to still get an impression on how closely product innovation advertising is related to the exclusion restrictions of the product innovation equation, I use two “informal” test. First, I run a simple binary probit model for non-advertising as in Table ?? and ignore that it is conditional on product innovation. The exclusion restrictions are both jointly and separately insignificantly different from zero at the usual significance levels (the  $p$ -value for the joint test is 0.3148). Second, I regress the generalized residuals from the advertising part of the Heckman-type probit model (using the results from Table ??) on the exclusion restrictions.<sup>1</sup> The results from that auxiliary regression do not provide evidence in favor of non-orthogonality: the specification is jointly insignificant ( $p$ -value 0.2844) with an adjusted  $R^2$  of 0.0004. None of the coefficients is separately significantly different from zero. Even though both procedures are not true test for orthogonality of the exclusion restrictions of the product innovation equation in the product innovation advertising equation, they both strongly suggest that they are indeed orthogonal.

The second criterion for model validity is that the predicted values from the product innovation advertising equation are reasonably well fitted so that they indeed carry information about latent product innovation advertising that is used in the structural form product innovation equation. First of all, the specification for product innovation advertising is jointly highly significant.<sup>2</sup> Second, 62 percent of the binary outcomes of the non-advertising outcomes are correctly predicted.

Additional specification checks involved discarding all firms with more than 250 employees, thus restricting attention to Small and Medium Sized (SMEs) firms only. The results regarding substitutability between product innovation and

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<sup>1</sup>Residuals from an estimation equation cannot be as easily backed out from the fitted values of the dependent variable as in linear regression models so that “generalized” residuals need to be used. See Chesher and Irish (1987) for details.

<sup>2</sup>There is no equivalent to the usual pseudo  $R^2$  since there is no constants-only specification. Note, however, that the pseudo  $R^2$  is just a transformation of a test for joint parameter significance.

product innovation advertising remain the same: there is an even higher correlation between the unobserved components of the two equations ( $\rho=0.907$ ,  $p$ -value 0.0135) while the magnitude and significance of latent product innovation advertising has remained about the same. Probably due to the reduction in firm heterogeneity, the specification fit (correctly predicted outcomes and tests for joint significance) improves if the large firms are discarded.

I have also re-estimated my model leaving out one or more of the main sectors that serve as controls variables in the estimations. Even though the sector dummy variables are both jointly and separately insignificantly different from zero, the effects of each of the variables might differ depending on the sector of consideration. The estimation results from these sector-level estimations also show substitutability between product innovation and product innovation advertising. Both the correlation coefficient and the coefficient on latent product innovation advertising tend to be, however, estimated quite imprecisely. My explanation for the insignificance is that the identification of my model partly stems from sector-level information. The variation in the sector-level variables is reduced if one or more sectors are left out so that less precision in the parameter estimates is a natural outcome.

## Reference

- Chesher, A. and M. Irish, 1987, Residual analysis in the grouped and censored normal linear model, *Journal of Econometrics*, 34, 33-61.