

# Detailed regression models and complete set of boxplots for validation step for the paper: Multiple Imputation on Design of Experiments with Multiple Responses using STATA

I. Following are the final regression models that complement the ones shown in the paper “Multiple Imputation on Design of Experiments with Multiple Responses using STATA”

These models are obtained after: (a) using the predictive mean matching (pmm) impute option under the command **mi impute** in STATA, and (b) adjusting significant linear regression models for each of the 15 response variables in the study using the command **mi estimate**. In this study, the **mi impute pmm** command was invoked to impute  $m=5$  values for each response variable at each experimental condition with missing data. Quadratic models are assumed to describe each response in terms of the 7 factors or independent variables. The initial regression models contained all the possible terms in a second order polynomial model on the factors. Quadratic terms and second order interactions were included except those involving categorical variables. The non-significant factors are iteratively removed until significant regression models are obtained for each response variable.

```
mi estimate : regress newRough_IC Current Torch_height Slowoncurves E_0 G_0
Current
> 2 Pressure2 Cut_speed2 Presscutspeed , noconstant
```

```
Multiple-imputation estimates      Imputations      =      5
Linear regression                  Number of obs    =     89
                                   Average RVI      =    1.5340
                                   Complete DF     =     80
DF adjustment: Small sample       DF: min         =     5.49
                                   avg              =    15.78
                                   max              =    41.59
Model F test: Equal FMI           F( 9, 33.3)     =    97.21
Within VCE type: OLS              Prob > F         =    0.0000
```

newRough_IC	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
Current	.2321414	.0449056	5.17	0.001	.1281956 .3360873
Torch_height	6.236696	3.893651	1.60	0.165	-3.508671 15.98206
Slowoncurves	-.2198405	.1122605	-1.96	0.057	-.446565 .0068839
E_0	-.9734168	.6295891	-1.55	0.171	-2.496726 .5498922
G_0	-.6539388	.4252378	-1.54	0.143	-1.553897 .2460191
Current2	-.0016838	.0004318	-3.90	0.005	-.002686 -.0006815
Pressure2	-.0003931	.0001303	-3.02	0.004	-.0006561 -.0001301
Cut_speed2	-.0004677	.0002474	-1.89	0.103	-.001059 .0001236
Presscutspe~d	.001024	.000324	3.16	0.011	.000293 .001755

```
mi estimate, vartable nocitable
Multiple-imputation estimates      Imputations      =      5
```

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Variance information

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Current	.000777	.001033	.002017	1.59558	.67145	.881609
Torch_height	4.05337	9.25596	15.1605	2.74023	.783796	.864484
Slowoncurves	.010254	.001957	.012602	.229046	.200131	.961514
E_0	.124081	.226918	.396382	2.19454	.74152	.87085
G_0	.1086	.06019	.180827	.665081	.442217	.918743
Current2	7.1e-08	9.6e-08	1.9e-07	1.62803	.676182	.880874

Pressure2		1.4e-08	2.6e-09	1.7e-08	.223891	.19627	.962229
Cut_speed2		2.0e-08	3.4e-08	6.1e-08	2.01843	.724171	.873489
Presscutsp~d		4.6e-08	4.9e-08	1.0e-07	1.29762	.62078	.889556

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newRough\_IC

Variable	Obs	Mean	Std. Dev.	Min	Max
newRough_IC	267	7.310861	2.270436	3	10

**mi estimate : regress newRough\_ec Current Torch\_height E\_0 E\_0 G\_0 Current2 Cut\_spee**

> d2 Curpress Presscutspeed , noconstant

mi estimate : regress newRough\_ec Current Torch\_height E\_0 G\_0 Current2

Cut\_spee

> d2 Curpress Presscutspeed , noconstant

Multiple-imputation estimates	Imputations	=	5
Linear regression	Number of obs	=	89
	Average RVI	=	0.6183
	Complete DF	=	81
DF adjustment: Small sample	DF: min	=	9.84
	avg	=	22.81
	max	=	51.20
Model F test: Equal FMI	F( 8, 50.8)	=	262.72
Within VCE type: OLS	Prob > F	=	0.0000

newRough_ec	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
Current	.2212003	.0285676	7.74	0.000	.1613434 .2810572
Torch_height	10.46248	2.577055	4.06	0.002	4.707737 16.21722
E_0	-.9127137	.3586481	-2.54	0.017	-1.649832 -.1755959
G_0	-.7728354	.3701539	-2.09	0.054	-1.559127 .013456
Current2	-.0012405	.0002532	-4.90	0.000	-.0017704 -.0007106
Cut_speed2	-.0003235	.0001478	-2.19	0.042	-.0006336 -.0000134
Curpress	-.0008281	.0002461	-3.37	0.001	-.0013221 -.0003342
Presscutsp~d	.0008022	.0002095	3.83	0.001	.0003694 .0012351

mi estimate, vartable nocitable

Multiple-imputation estimates	Imputations	=	5
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Variance information

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Current	.000517	.000249	.000816	.577626	.404741	.925114
Torch_height	3.03018	3.0092	6.64121	1.19169	.598937	.893027
E_0	.091688	.030783	.128628	.402889	.314868	.940757
G_0	.080496	.047098	.137014	.702125	.456825	.916284
Current2	4.1e-08	1.9e-08	6.4e-08	.565844	.399346	.926038
Cut_speed2	1.4e-08	6.7e-09	2.2e-08	.586865	.408912	.9244
Curpress	5.2e-08	7.0e-09	6.1e-08	.161621	.147347	.971374
Presscutsp~d	3.0e-08	1.1e-08	4.4e-08	.450855	.341783	.936017

Note: FMIs are based on Rubin's large-sample degrees of freedom.

summarize newRough\_ec

Variable	Obs	Mean	Std. Dev.	Min	Max
----------	-----	------	-----------	-----	-----

```
newRough_ec |          268    7.880597    1.966174          1          10
```

```
mi estimate : regress newRough_sl Torch_height E_0 Pressure2 Cut_speed2
Presscuts
```

```
> peed
```

```
Multiple-imputation estimates          Imputations =          5
Linear regression                    Number of obs =          89
                                      Average RVI   =         1.7692
                                      Complete DF   =          83
DF adjustment: Small sample          DF: min      =          4.93
                                      avg         =         29.63
                                      max         =         54.85
Model F test: Equal FMI              F( 5, 27.0) =          4.80
Within VCE type: OLS                 Prob > F     =         0.0029
```

newRough_sl	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Torch_height	10.01399	3.782351	2.65	0.046	.2504966	19.77748
E_0	-.4801794	.3353099	-1.43	0.158	-1.152701	.1923418
Pressure2	-.0002524	.0001119	-2.26	0.028	-.0004767	-.0000281
Cut_speed2	-.000347	.0001431	-2.42	0.020	-.0006372	-.0000568
Presscuts~d	.0006549	.0002332	2.81	0.011	.00017	.0011398
_cons	6.768983	1.074328	6.30	0.000	4.273176	9.26479

```
mi estimate, variable nocitable
```

```
Multiple-imputation estimates          Imputations =          5
```

```
Variance information
```

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Torch_height	3.26931	9.19738	14.3062	3.37589	.818493	.859329
E_0	.097226	.012672	.112433	.156404	.143052	.972185
Pressure2	1.1e-08	1.3e-09	1.3e-08	.14661	.134907	.973727
Cut_speed2	1.6e-08	3.7e-09	2.0e-08	.278312	.235622	.954996
Presscuts~d	3.6e-08	1.5e-08	5.4e-08	.514883	.374971	.930238
_cons	.43354	.600534	1.15418	1.66223	.681028	.880122

```
Note: FMIs are based on Rubin's large-sample degrees of freedom.
```

```
. summarize newRough_sl
```

Variable	Obs	Mean	Std. Dev.	Min	Max
newRough_sl	268	8.097015	1.869805	3	10

```
mi impute pmm newFlatness = Current Pressure Cut_speed Torch_height Slowoncurves E_0
E_
```

```
> 1 G_0, noconstant add(5)
```

```
Univariate imputation          Imputations =          5
Predictive mean matching          added =          5
Imputed: m=1 through m=5          updated =          0
```

Variable	Observations per m			total
	complete	incomplete	imputed	
newFlatness	53	36	36	89

```
(complete + incomplete = total; imputed is the minimum across m
```

of the number of filled in observations.)

**mi estimate : regress newFlatness Cut\_speed E\_0**

```

Multiple-imputation estimates      Imputations =          5
Linear regression                  Number of obs =         89
                                   Average RVI   =         0.4335
                                   Complete DF   =          86
DF adjustment: Small sample       DF:      min   =         20.04
                                   avg           =         34.43
                                   max           =         50.17
Model F test:      Equal FMI      F( 2, 22.0) =          4.65
Within VCE type:   OLS            Prob > F    =         0.0207

```

newFlatness	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Cut_speed	-.0000614	.0000325	-1.89	0.067	-.0001275	4.62e-06
E_0	.0060596	.0027282	2.22	0.038	.0003694	.0117498
_cons	.0273574	.0022366	12.23	0.000	.0228654	.0318495

mi estimate, vartable nocitable

```

Multiple-imputation estimates      Imputations =          5

```

Variance information

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Cut_speed	8.0e-10	2.1e-10	1.1e-09	.317904	.262372	.950142
E_0	4.8e-06	2.2e-06	7.4e-06	.549906	.391906	.927316
_cons	4.2e-06	6.4e-07	5.0e-06	.181203	.163194	.968393

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newFlatness

Variable	Obs	Mean	Std. Dev.	Min	Max
newFlatness	268	.0263787	.0097561	.0115	.0725

**mi estimate : regress newAcum\_ic Cut\_speed Torch\_height Pressure2 Cut\_speed2 Slowonc**

**> urves2 Presstorch Cut\_speedtorch**

```

Multiple-imputation estimates      Imputations =          5
Linear regression                  Number of obs =         89
                                   Average RVI   =         0.9367
                                   Complete DF   =          81
DF adjustment: Small sample       DF:      min   =          6.79
                                   avg           =         18.54
                                   max           =         54.78
Model F test:      Equal FMI      F( 7, 40.5) =         12.86
Within VCE type:   OLS            Prob > F    =         0.0000

```

newAcum_ic	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Cut_speed	.1280647	.0345569	3.71	0.005	.0502485	.2058809
Torch_height	-30.20556	15.8748	-1.90	0.071	-63.24187	2.830741
Pressure2	-.0005057	.0003488	-1.45	0.178	-.0012837	.0002723
Cut_speed2	-.0008573	.0003063	-2.80	0.027	-.0015862	-.0001285
Slowoncurv~2	-.0442905	.0325155	-1.36	0.192	-.1132099	.0246288

```

Presstorch | .3150229 .2146767 1.47 0.163 -.1419266 .7719725
Cut_speedt~h | .0960837 .0599204 1.60 0.115 -.0240105 .216178
_cons | 7.450695 2.133743 3.49 0.003 2.91561 11.98578
-----

```

. mi estimate, vartable nocitable

```

Multiple-imputation estimates           Imputations =          5

```

Variance information

```

-----
|           Imputation variance           Relative
|           Within  Between  Total           RVI           FMI           efficiency
-----+-----
Cut_speed | .000523 .000559 .001194 1.28212 .617728 .89004
Torch_height | 166.202 71.5062 252.009 .516285 .375665 .930117
Pressure2 | 5.6e-08 5.5e-08 1.2e-07 1.17873 .596098 .89348
Cut_speed2 | 3.2e-08 5.2e-08 9.4e-08 1.96575 .718527 .874351
Slowoncurv~2 | .000629 .000357 .001057 .682116 .449023 .917596
Presstorch | .026782 .016086 .046086 .720759 .463912 .915095
Cut_speedt~h | .003146 .00037 .00359 .141134 .130305 .974601
_cons | 2.66681 1.57171 4.55286 .707231 .458785 .915955
-----

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newAcum\_ic

```

-----
Variable |      Obs      Mean   Std. Dev.   Min      Max
-----+-----
newAcum_ic |      268   7.253731   2.746974      1      10

```

**mi estimate : regress newAcum\_ec Cut\_speed E\_1 Cut\_speed2**

```

Multiple-imputation estimates           Imputations =          5
Linear regression           Number of obs =          89
                             Average RVI =          0.2647
                             Complete DF =          85
DF adjustment: Small sample           DF: min =          22.02
                             avg =          48.06
                             max =          73.82
Model F test: Equal FMI           F( 3, 49.8) =          45.63
Within VCE type: OLS           Prob > F =          0.0000

```

```

-----
newAcum_ec |      Coef.   Std. Err.   t   P>|t|   [95% Conf. Interval]
-----+-----
Cut_speed | .1820017 .0239893   7.59 0.000   .1327975   .2312058
E_1 | .945579 .3815198   2.48 0.016   .1845045   1.706654
Cut_speed2 | -.0011832 .0002194  -5.39 0.000   -.0016381  -.0007283
_cons | 2.225542 .4644472   4.79 0.000   1.300073   3.15101
-----

```

. mi estimate, vartable nocitable

```

Multiple-imputation estimates           Imputations =          5

```

Variance information

```

-----
|           Imputation variance           Relative
|           Within  Between  Total           RVI           FMI           efficiency
-----+-----
Cut_speed | .000413 .000136 .000575 .393984 .309664 .941679
E_1 | .134548 .009175 .145557 .081826 .07827 .984587

```

```

Cut_speed2 | 3.2e-08 1.3e-08 4.8e-08 .49521 .36509 .931951
_cons | .20358 .010109 .215711 .059589 .057726 .988587
-----

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

```
. summarize newAcum_ec
```

```

Variable | Obs Mean Std. Dev. Min Max
-----+-----
newAcum_ec | 268 7.36194 2.875632 1 10

```

```
. . mi estimate : regress newAcum_sl Cut_speed E_1 Cut_speed2 Curcutspeed
```

```

Multiple-imputation estimates      Imputations = 5
Linear regression                  Number of obs = 89
                                   Average RVI = 0.7078
                                   Complete DF = 84
DF adjustment: Small sample      DF: min = 11.02
                                   avg = 23.65
                                   max = 44.80
Model F test: Equal FMI          F( 4, 31.8) = 18.33
Within VCE type: OLS              Prob > F = 0.0000

```

```

-----
newAcum_sl | Coef. Std. Err. t P>|t| [95% Conf. Interval]
-----+-----
Cut_speed | .1318934 .0320432 4.12 0.001 .0629801 .2008067
E_1 | 1.056404 .5231622 2.02 0.065 -.07422 2.187027
Cut_speed2 | -.0009277 .0002681 -3.46 0.005 -.0015175 -.0003378
Curcutspeed | .0002687 .0001826 1.47 0.150 -.0001016 .000639
_cons | 2.86539 .5170255 5.54 0.000 1.823921 3.906859
-----

```

```
. mi estimate, vartable nocitable
```

```
Multiple-imputation estimates      Imputations = 5
```

```
Variance information
```

```

-----
| Imputation variance | Relative
| Within Between Total RVI FMI efficiency
-----+-----
Cut_speed | .000562 .000387 .001027 .827168 .501315 .908874
E_1 | .146072 .106356 .273699 .873726 .516192 .906422
Cut_speed2 | 3.5e-08 3.1e-08 7.2e-08 1.05284 .566379 .89825
Curcutspeed | 2.6e-08 6.1e-09 3.3e-08 .28389 .239485 .954292
_cons | .220805 .038759 .267315 .210641 .186216 .964094
-----

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

```
. summarize newAcum_sl
```

```

Variable | Obs Mean Std. Dev. Min Max
-----+-----
newAcum_sl | 268 7.287313 2.576817 1 10

```

```

mi estimate : regress newGeom_accur_x Cut_speed E_0 Torch_height2 Curslow
Cut_spe
> edtorch Torch_heighslow

```

```

Multiple-imputation estimates      Imputations = 5
Linear regression                  Number of obs = 89
                                   Average RVI = 0.6316

```

```

DF adjustment:    Small sample
Model F test:    Equal FMI
Within VCE type: OLS
Complete DF      = 82
DF: min         = 10.97
      avg        = 21.26
      max        = 63.57
F( 6, 45.8)     = 3.63
Prob > F        = 0.0050

```

```

-----
newGeom_ac~x |      Coef.   Std. Err.    t    P>|t|    [95% Conf. Interval]
-----+-----
      Cut_speed | -0.0005453   .0002664   -2.05  0.065   -0.0011319   .0000413
      E_0       | -0.0176562   .0059819   -2.95  0.004   -0.0296079   -0.0057044
Torch_heig~2  | -0.7538644   .2174191   -3.47  0.005   -1.229646    -0.2780826
      Curslow   | -0.0000782   .0000579   -1.35  0.196   -0.0002012   .0000447
Cut_speedt~h  | .0032381     .0012036    2.69  0.020   .0006162     .00586
Torch_heig~w  | .0256596     .0183792    1.40  0.182   -0.0134168   .0647359
      _cons    | 4.030143     .0115239   349.72 0.000   4.006063     4.054223
-----

```

. mi estimate, vartable nocitable

```
Multiple-imputation estimates      Imputations = 5
```

Variance information

```

-----
          |      Imputation variance
          |      Within  Between  Total    RVI    FMI    Relative
          |-----+-----
Cut_speed | 3.5e-08  3.0e-08  7.1e-08  1.04934  .565494  .898393
      E_0 | .000033  2.7e-06  .000036  .098531  .093333  .981675
Torch_heig~2 | .023775  .01958  .047271  .988289  .549472  .900987
      Curslow | 2.0e-09  1.1e-09  3.4e-09  .697165  .45491  .916605
Cut_speedt~h | 7.5e-07  5.9e-07  1.4e-06  .94337  .536952  .903024
Torch_heig~w | .000197  .000117  .000338  .713534  .461184  .915552
      _cons | .000085  .00004  .000133  .555964  .394753  .926827
-----

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newGeom\_accur\_x

```

-----
Variable |      Obs      Mean      Std. Dev.      Min      Max
-----+-----
newGeom_ac~x |      268    3.993098    .029884    3.87224    4.05728
-----

```

. mi estimate : regress newGeom\_accur\_y Current E\_0 Current2

```

Multiple-imputation estimates      Imputations = 5
Linear regression                 Number of obs = 89
                                   Average RVI     = 0.4683
                                   Complete DF     = 85
DF adjustment: Small sample       DF: min      = 32.46
                                   avg          = 50.56
                                   max          = 57.59
Model F test: Equal FMI           F( 3, 46.9) = 1.73
Within VCE type: OLS              Prob > F     = 0.1734

```

```

-----
newGeom_ac~y |      Coef.   Std. Err.    t    P>|t|    [95% Conf. Interval]
-----+-----
      Current | -0.0122031   .0073695   -1.66  0.103   -0.0269658   .0025596
      E_0     | -0.0381541   .0261215   -1.46  0.154   -0.0913324   .0150242
      Current2 | .0001038     .0000606    1.71  0.092   -0.0000176   .0002252
      _cons   | 6.314087     .2096007   30.12 0.000   5.894232     6.733942
-----

```

```
-----
. mi estimate, vartable nocitable
```

```
Multiple-imputation estimates           Imputations   =           5
```

```
Variance information
```

```
-----
```

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Current	.000047	5.8e-06	.000054	.1459	.134312	.97384
E_0	.000516	.000139	.000682	.322753	.265544	.94957
Current2	3.2e-09	3.7e-10	3.7e-09	.137786	.127475	.975139
_cons	.038361	.004643	.043932	.145245	.133763	.973944

```
-----
```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

```
. summarize newGeom accur_y
```

```
-----
```

Variable	Obs	Mean	Std. Dev.	Min	Max
newGeom_ac~y	268	5.970652	.0962789	5.25689	6.04213

```
-----
```

```
. mi estimate : regress newbevel_int_cur Current Torch_height2 Curpress
Curcutspeed
```

```
> Curslow Presstorch Pressslow
```

```
Multiple-imputation estimates           Imputations   =           5
Linear regression                       Number of obs   =          89
                                         Average RVI     =         0.6263
                                         Complete DF    =          81
DF adjustment: Small sample             DF: min        =         11.46
                                         avg            =         20.88
                                         max            =         35.80
Model F test: Equal FMI                 F( 7, 47.9)    =          4.22
Within VCE type: OLS                    Prob > F        =         0.0011
```

```
-----
```

newbevel_i~r	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Current	.606645	.3040021	2.00	0.067	-.0489087	1.262199
Torch_heig~2	-199.9436	135.8393	-1.47	0.154	-480.5801	80.69279
Curpress	-.0075702	.003232	-2.34	0.035	-.014531	-.0006094
Curcutspeed	.0020868	.000483	4.32	0.000	.0010817	.0030918
Curslow	-.0461831	.0353227	-1.31	0.199	-.1178345	.0254682
Presstorch	1.223799	.7612383	1.61	0.126	-.3794851	2.827084
Pressslow	.050433	.0303152	1.66	0.106	-.0113648	.1122308
_cons	-15.01253	9.403097	-1.60	0.138	-35.60816	5.583095

```
-----
```

```
. mi estimate, vartable nocitable
```

```
Multiple-imputation estimates           Imputations   =           5
```

```
Variance information
```

```
-----
```

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
Current	.050172	.035205	.092417	.842018	.506152	.908075
Torch_heig~2	12722.7	4774.69	18452.3	.450347	.341508	.936065
Curpress	5.7e-06	3.9e-06	.00001	.83009	.502274	.908715

```
-----
```



Curcutspeed		1.5e-07	6.6e-08	2.3e-07	.514769	.374915	.930247
Curslow		.000977	.000226	.001248	.277221	.234863	.955135
Presstorch		.35674	.18562	.579484	.624387	.425325	.921604
Pressslow		.000693	.000188	.000919	.325829	.267545	.949209
_cons		44.3615	36.7139	88.4182	.99313	.550783	.900774

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newbevel\_int\_cur

Variable	Obs	Mean	Std. Dev.	Min	Max
newbevel_i~r	267	5.031835	10.47715	-23	26.5

. mi estimate : regress newbevel\_ext\_cur Cut\_speed Torch\_height

```

Multiple-imputation estimates          Imputations =          5
Linear regression                     Number of obs =          89
                                       Average RVI   =         1.8703
                                       Complete DF   =          86
DF adjustment: Small sample           DF:    min    =          6.90
                                       avg         =          8.78
                                       max         =         12.07
Model F test:      Equal FMI          F( 2, 8.1) =          6.45
Within VCE type:  OLS                 Prob > F    =          0.0212

```

newbevel_e~r	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Cut_speed	.1512444	.0490091	3.09	0.018	.035005	.2674838
Torch_height	38.09256	21.37498	1.78	0.116	-11.94611	88.13122
_cons	-11.59085	4.436849	-2.61	0.023	-21.25133	-1.930369

. mi estimate, vartable nocitable

```

Multiple-imputation estimates          Imputations =          5

Variance information
-----
|          Imputation variance          Relative
|          Within  Between  Total          RVI          FMI  efficiency
-----+-----
Cut_speed | .000811  .001326  .002402  1.96328  .718258  .874392
Torch_height | 164.137  243.961  456.89  1.78359  .697137  .877634
_cons | 10.0755  8.00847  19.6856  .953818  .539922  .90254

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newbevel\_ext\_cur

Variable	Obs	Mean	Std. Dev.	Min	Max
newbevel_e~r	268	4.585821	12.19459	-39	23.5

. mi describe

```

Style: mlong
last mi update 16may2012 13:08:13, approximately 24 hours ago

```

```

Obs.: complete      46
incomplete      43 (M = 0 imputations)
-----

```

total 89

Vars.: imputed: 15; newRough\_IC(37) newRough\_ec(36) newRough\_sl(36) newFlatness(36) newAcum\_ic(36) newAcum\_ec(36) newAcum\_sl(36) newGeom\_accur\_x(36) newGeom\_accur\_y(36) newbevel\_int\_cur(37) newbevel\_ext\_cur(36) newbevel\_left\_sl(41) newbevel\_right\_sl(37) newstartp\_inter(36) newstartp\_exter(36)

passive: 0

regular: 0

system: 3; \_mi\_m \_mi\_id \_mi\_miss

(there are 27 unregistered variables)

mi estimate : regress newbevel\_left\_sl Cut\_speed Torch\_height E\_0 Torch\_height2

Multiple-imputation estimates Imputations = 5
Linear regression Number of obs = 89
Average RVI = 0.6231
Complete DF = 84
DF adjustment: Small sample DF: min = 15.94
avg = 35.56
max = 63.00
Model F test: Equal FMI F( 4, 31.9) = 2.10
Within VCE type: OLS Prob > F = 0.1035

Table with 7 columns: Variable, Coef., Std. Err., t, P>|t|, [95% Conf. Interval]. Rows include Cut\_speed, Torch\_height, E\_0, Torch\_heig~2, and \_cons.

. mi estimate, vartable nocitable

Multiple-imputation estimates Imputations = 5

Variance information

Table with 7 columns: Variable, Within, Between, Total, RVI, FMI, Relative efficiency. Rows include Cut\_speed, Torch\_height, E\_0, Torch\_heig~2, and \_cons.

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newbevel\_left\_sl

Table with 6 columns: Variable, Obs, Mean, Std. Dev., Min, Max. Row includes newbevel\_l~1.

. mi estimate : regress newbevel\_right\_sl E\_0 Curcutspeed, noconstant

```

Multiple-imputation estimates      Imputations      =      5
Linear regression                  Number of obs    =     89
                                   Average RVI       =    1.2168
                                   Complete DF       =     87
DF adjustment:  Small sample      DF:      min     =    11.09
                                   avg             =    14.26
                                   max             =    17.42
Model F test:      Equal FMI      F(  2,  10.2)   =    15.43
Within VCE type:  OLS            Prob > F        =    0.0008

```

```

-----
newbevel_r~1 |      Coef.   Std. Err.    t    P>|t|    [95% Conf. Interval]
-----+-----
      E_0 |   9.452198   2.534007    3.73  0.003    3.88066   15.02374
Curcutspeed |   .00085    .0003174    2.68  0.016    .0001815   .0015184
-----

```

```
. mi estimate : regress newbevel_right_sl E_0 , noconstant
```

```

Multiple-imputation estimates      Imputations      =      5
Linear regression                  Number of obs    =     89
                                   Average RVI       =    1.5906
                                   Complete DF       =     88
DF adjustment:  Small sample      DF:      min     =     8.04
                                   avg             =     8.04
                                   max             =     8.04
Model F test:      Equal FMI      F(  1,   8.0)   =    19.40
Within VCE type:  OLS            Prob > F        =    0.0022

```

```

-----
newbevel_r~1 |      Coef.   Std. Err.    t    P>|t|    [95% Conf. Interval]
-----+-----
      E_0 |  12.03333   2.732327    4.40  0.002    5.738298  18.32837
-----

```

```
. mi estimate, vartable nocitable
```

```

Multiple-imputation estimates      Imputations      =      5
Variance information

```

```

-----
              |      Imputation variance      Relative
              |      Within  Between  Total      RVI      FMI      efficiency
-----+-----
      E_0 |   2.88178   3.81986   7.46561   1.59063   .670715   .881723
-----

```

```
Note: FMIs are based on Rubin's large-sample degrees of freedom.
```

```
. summarize newbevel_right_sl
```

```

-----
Variable |      Obs      Mean   Std. Dev.    Min    Max
-----+-----
newbevel_r~1 |      267   6.217228  10.45954    -17   33.5
-----

```

```
. mi estimate : regress newstartp_inter Cut_speed2 Torch_height2 Current Pressure
Pr
> esscutspeed Presstorch
```

```

Multiple-imputation estimates      Imputations      =      5
Linear regression                  Number of obs    =     89
                                   Average RVI       =    0.7515
                                   Complete DF       =     82
DF adjustment:  Small sample      DF:      min     =    13.01

```

```

                                avg      =      32.06
                                max      =      69.38
Model F test:      Equal FMI      F( 6, 42.1) =      3.71
Within VCE type:      OLS      Prob > F      =      0.0047

```

```

-----+-----
newstar~nter |      Coef.   Std. Err.   t   P>|t|   [95% Conf. Interval]
-----+-----
    Cut_speed2 |  -.0002833   .0001382   -2.05  0.049   -0.0005651  -1.50e-06
Torch_heig~2 | -45.69955   23.79239   -1.92  0.070   -95.59127   4.192166
    Current    |  .0232977   .0088919    2.62  0.011   .0055607   .0410348
    Pressure    | -.1085442   .0324741   -3.34  0.004   -.1769636   -.0401247
Presscutsp~d |  .0005529   .0001952    2.83  0.007   .0001603   .0009456
    Presstorch |  .2969818   .1373146    2.16  0.050   .0003452   .5936184
    _cons      |  11.88003   1.665679    7.13  0.000   8.467984   15.29207
-----+-----

```

. mi estimate, vartable nocitable

```
Multiple-imputation estimates      Imputations      =      5
```

Variance information

```

-----+-----
|      Imputation variance      Relative
|      Within  Between  Total      RVI      FMI  efficiency
-----+-----
    Cut_speed2 |  1.4e-08  4.0e-09  1.9e-08  .333858  .272725  .948276
Torch_heig~2 |  356.517  174.634  566.078  .587801  .409332  .924329
    Current    |  .000074  4.3e-06  .000079  .069518  .066968  .986783
    Pressure    |  .000647  .00034  .001055  .630593  .427961  .921156
Presscutsp~d |  3.2e-08  5.0e-09  3.8e-08  .188814  .169238  .967261
    Presstorch |  .010123  .007277  .018855  .862695  .512742  .906999
    _cons      |  2.0185  .629986  2.77449  .374527  .298059  .943742
-----+-----

```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

. summarize newstartp\_inter

```

-----+-----
Variable |      Obs      Mean      Std. Dev.      Min      Max
-----+-----
newstar~nter |      268      8.36194      1.62136      4      10
. mi estimate : regress newstartp_exter E_0 G_0 Pressure2 Cut_speed2
Presscutspeed P
> resstorch

```

```

Multiple-imputation estimates      Imputations      =      5
Linear regression      Number of obs      =      89
                                Average RVI      =      0.6327
                                Complete DF      =      82
DF adjustment:      Small sample      DF:      min      =      8.95
                                avg      =      31.20
                                max      =      67.47
Model F test:      Equal FMI      F( 6, 50.6) =      6.29
Within VCE type:      OLS      Prob > F      =      0.0001

```

```

-----+-----
newstar~xter |      Coef.   Std. Err.   t   P>|t|   [95% Conf. Interval]
-----+-----
    E_0      |  -.6893232   .3968738   -1.74  0.093   -1.50038   .1217335
    G_0      | -1.026018   .3695054   -2.78  0.009   -1.780748  -.2712885
    Pressure2 | -.0004163   .0001203   -3.46  0.001   -.0006565   -.0001762
    Cut_speed2 | -.0004047   .0001526   -2.65  0.011   -.0007126   -.0000968
Presscutsp~d |  .0008233   .0002438    3.38  0.002   .0003227   .0013239
-----+-----

```

```

Presstorch | .0853614 .0399849 2.13 0.062 -.00516 .1758829
_cons | 8.062731 .8499204 9.49 0.000 6.239003 9.88646
-----

```

```
. mi estimate, vartable nocitable
```

```
Multiple-imputation estimates          Imputations      =          5
```

```
Variance information
```

```
-----
```

	Imputation variance			RVI	FMI	Relative efficiency
	Within	Between	Total			
E_0	.116476	.034194	.157509	.352285	.284388	.946183
G_0	.101339	.029329	.136534	.347296	.281261	.946744
Pressure2	1.3e-08	8.8e-10	1.4e-08	.079124	.075803	.985066
Cut_speed2	1.9e-08	3.6e-09	2.3e-08	.226239	.198033	.961902
Presscutsp~d	4.3e-08	1.4e-08	5.9e-08	.396464	.31112	.941421
Presstorch	.000681	.000765	.001599	1.34717	.630226	.888064
_cons	.401555	.267342	.722365	.79892	.491867	.910437

```
-----
```

Note: FMIs are based on Rubin's large-sample degrees of freedom.

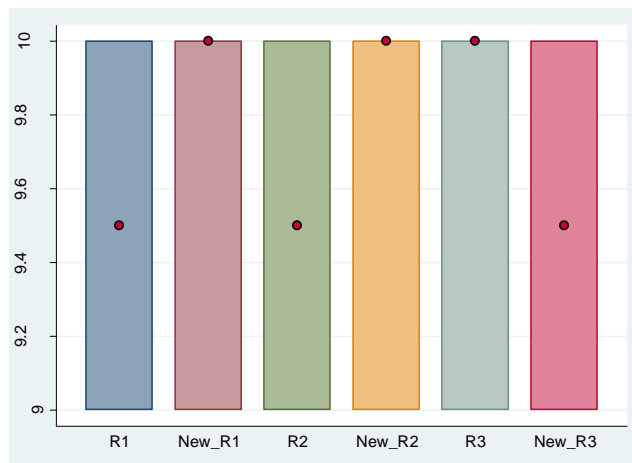
```
. summarize newstartp_exter
```

```
-----
```

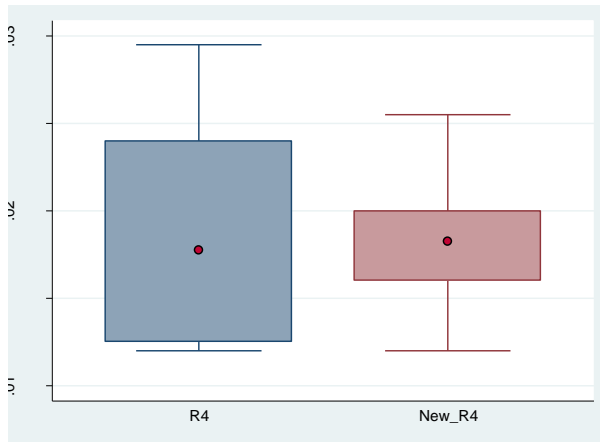
Variable	Obs	Mean	Std. Dev.	Min	Max
newstar~xter	268	7.764925	1.904253	3	10

```
-----
```

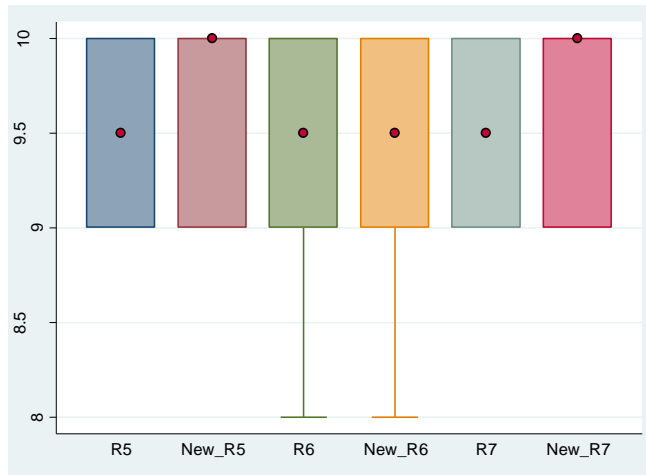
II. The next pages present the whole set of box plots to validate if there are any significant differences for any of the responses if comparing between the best settings found by Risk Solver Platform (RSP) for the experiment with imputed missing values and the best settings found by MINITAB for the experiment with missing values. These box plots complement the ones presented in the paper “Multiple Imputation on Design of Experiments with Multiple Responses using STATA”.



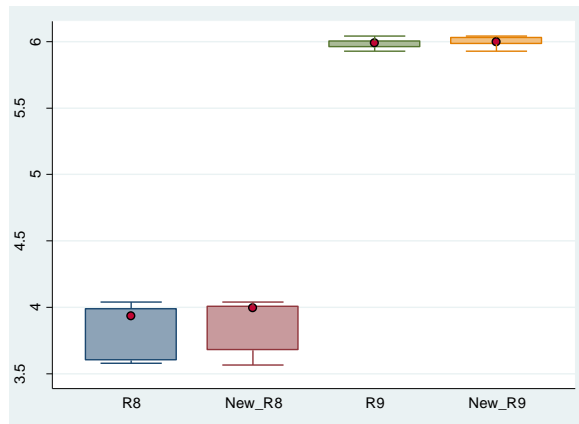
**Figure 1** Values for responses 1-3 using best settings from experiment with missing values (R1-R3) vs. using best settings from experiment with imputed missing values (New\_R1-New\_R3)



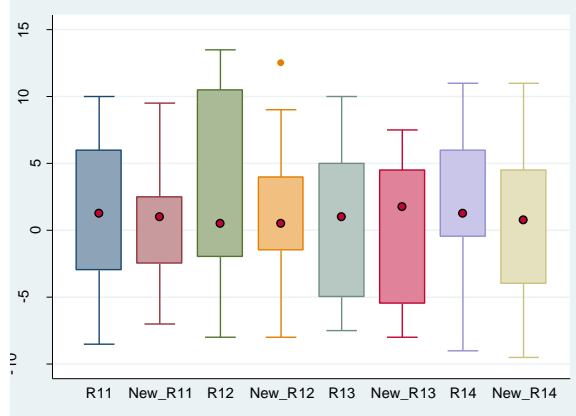
**Figure 2** Values for response 4 using best settings from experiment with missing values (R4) vs. using best settings from experiment with imputed missing values (New\_R4)



**Figure 3** Values for responses 5-7 using best settings from experiment with missing values (R5-R7) vs. using best settings from experiment with imputed missing values (New\_R5-New\_R7)



**Figure 4** Values for response 8-9 using best settings from experiment with missing values (R8-R9) vs. using best settings from experiment with imputed missing values (New\_R8-New\_R9)



**Figure 5** Values for response 11-14 using best settings from experiment with missing values (R11-R14) vs. using best settings from experiment with imputed missing values (New\_R11-New\_R14)



**Figure 6** Values for response 15-16 using best settings from experiment with missing values (R15-R16) vs. using best settings from experiment with imputed missing values (New\_R15-New\_R16)