Online appendix C – Analysis of necessity and sufficiency, robustness of the results

Description: in this appendix, technical details are provided about the analysis of necessity (section 1) and sufficiency. Concerning the latter, we examine limited diversity and logical remainders both for the outcome URBSPRA (2) and for the negated outcome ~URBSPRA (4). A robustness test for the URBSPRA analysis is also presented (3).

1. NECESSITY ANALYSIS

Presented here is the necessity analysis for both the outcome URBSPRA and ~URBSPRA. The parameters of consistency and coverage are reported. No real necessary condition was found despite some high values of consistency, since logically contradictory cases exist for all the potential necessary conditions.

Table C.1: Necessity analysis for the outcome URBSRPA

Outcome : URBSPRA				
Conditions		Consistency	Coverage	Logically contradictory cases
1.	MUNAUT	0.892	0.703	Solothurn (0.33; 0.88) and Aargau (0.33; 0.69)
	~MUNAUT	0.303	0.478	
2.	INSFRA	0.887	0.698	Uri (0.45; 0.72), Obwalden (0.36; 0.66), Schaffhausen (0.26; 0.62) and Appenzell Ausserrhoden (0.45; 0.55)
	~INSFRA	0.357	0.565	
3.	OVDBZ	0.857	0.902	Schaffhausen (0.48; 0.62) and Uri (0.45; 0.72)
	~OVDBZ	0.527	0.553	
4.	DEMO	0.712	0.576	
	~DEMO	0.497	0.745	
5.	ECOPOW	0.372	0.471	
	~ECOPOW	0.836	0.752	
6.	URBPOP	0.681	0.533	
	~URBPOP	0.475	0.761	

Table C.2: Necessity analysis for the outcome ~URBSRPA

Outcome : ~URBSPRA				
Conditions		Consistency	Coverage	Logically contradictory cases
1.	MUNAUT	0.633	0.450	
	~MUNAUT	0.528	0.829	
2.	INSFRA	0.695	0.494	
	~INSFRA	0.575	0.821	
3.	OVDBZ	0.528	0.502	
	~OVDBZ	0.897	0.849	Appenzell Innerrhoden (0.38; 0.63) and Vaud (0.47; 0.57)
4.	DEMO	0.812	0.593	
	~DEMO	0.419	0.568	
5.	ECOPOW	0.695	0.793	
	~ECOPOW	0.536	0.435	
6.	URBPOP	0.835	0.589	
	~URBPOP	0.338	0.489	

2. SUFFICIENCY ANALYSIS FOR THE OUTCOME URBSPRA

Outcome: URBSPRA

Logical remainders

45 logical remainders resulted from the truth table analysis (presented in the main text). The following logical remainders were included into the logical minimization based on theoretical and substantial knowledge:

MUNAUT*INSFRA*~OVDBZ*~DEMO*~ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*~DEMO*~ECOPOW*~URBPOP
MUNAUT*~INSFRA*OVDBZ*~DEMO*~ECOPOW*~URBPOP
MUNAUT*~INSFRA*OVDBZ*~DEMO*ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*~DEMO*ECOPOW*~URBPOP
~MUNAUT*INSFRA*OVDBZ*DEMO*~ECOPOW*~URBPOP

For every empirically observed sufficient combination that included ~MUNAUT, ~INSFRA, ~OVDBZ and/or URBPOP, similar combinations but with MUNAUT, INSFRA, OVDBZ or ~URBPOP were selected. This is coherent with the formulated hypotheses and with the context knowledge. For example, since high degrees of urban sprawl are observed in a case with MUNAUT*~INSFRA*~OVDBZ*~DEMO*~ECOPOW*URBPOP (Uri-UR), we can safely assume that the same combination but with in addition high degrees of institutional fragmentation (MUNAUT*INSFRA*~OVDBZ*~DEMO*~ECOPOW*URBPOP) will yield high degrees of urban sprawl too. Thus, it can be used as easy counterfactual.

Prime implicants

MUNAUT*~INSFRA*~DEMO*~ECOPOW*URBPOP; MUNAUT*OVDBZ*~DEMO*~ECOPOW;
MUNAUT*INSFRA*OVDBZ*~ECOPOW

Directional expectations

MUNAUT -> URBSPRA
INSFRA -> URBSPRA
OVDBZ -> URBSPRA
~URBPOP -> URBSPRA

Intermediate solution

MUNAUT*INSFRA*OVDBZ*~ECOPOW + (FR, GL, JU, TG, VS) Consistency: 0.97 Raw coverage: 0.66
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP + (GR, JU) Consistency: 1.00 Raw coverage: 0.26
MUNAUT*~INSFRA*~DEMO*URBPOP + (AR, SH, UR) Consistency: 0.94 Raw coverage: 0.23
INSFRA*OVDBZ*DEMO*~ECOPOW (AG, FR, SO, TG, VS) Consistency: 0.96 Raw coverage: 0.56
solution coverage: 0.77
solution consistency: 0.95

Conservative solution

MUNAUT*INSFRA*OVDBZ*~ECOPOW + (FR, GL, JU, TG, VS) Consistency: 0.97 Raw coverage: 0.66
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP + (GR, JU) Consistency: 1.00 Raw coverage: 0.26
MUNAUT*~INSFRA*~DEMO*~ECOPOW*URBPOP + (AR, UR) Consistency: 1.00 Raw coverage: 0.19
MUNAUT*~INSFRA~OVDBZ*~DEMO*URBPOP + (SH, UR) Consistency: 0.95 Raw coverage: 0.19
INSFRA*OVDBZ*DEMO*~ECOPOW*URBPOP (AG, FR, SO, VS) Consistency: 0.94 Raw coverage: 0.40
solution coverage: 0.76
solution consistency: 0.95

Parsimonious solution

MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP + (GR, JU) Consistency: 1.00 Raw coverage: 0.26
MUNAUT*OVDBZ*~DEMO*~ECOPOW + (AR, GL, JU) Consistency: 0.99 Raw coverage: 0.40
MUNAUT*~INSFRA*~DEMO*URBPOP + (AR, SH, UR) Consistency: 0.94 Raw coverage: 0.23
INSFRA*OVDBZ*DEMO*~ECOPOW (AG, FR, SO, TG, VS) Consistency: 0.96 Raw coverage: 0.56
solution coverage: 0.79
solution consistency: 0.95

3. ROBUSTNESS TEST FOR THE ANALYSIS OF THE OUTCOME URBSPRA

In order to verify the robustness of the results, we performed two types of alternative analysis. First, with run the sufficiency analysis for URBSPRA with two alternative calibrations of the set of the outcome. In section 3.1 we present the analysis with the crossover point of URBSPRA lowered to 10'000 UPU / inhabitant and job, while in section 3.2 we present the analysis with the crossover point raised to 13'000 UPU / inhabitant and job. In section 3.3 we present the second type of alternative analysis: starting from the same truth table as in the paper, the raw consistency cut-off value is raised to 0.96 (URBSPRA is calibrated to 11'000 UPU / inhabitant and job like in the main analysis).

3.1 URBSPRA_10000 (crossover point lowered to 10'000 UPU / inhabitant and job)

Necessity analysis

No necessary conditions were found.

Table C.3: Necessity analysis for the outcome URBSRPA_10000

Outcome : URBSPRA_10000				
Conditions		Consistency	Coverage	Logically contradictory cases
1.	MUNAUT	0.892	0.799	Solothurn (0.33; 0.90) and Aargau (0.33; 0.78)
	~MUNAUT	0.277	0.497	
2.	INSFRA	0.860	0.770	Uri (0.45; 0.80), Obwalden (0.36; 0.76), Schaffhausen (0.26; 0.73), Appenzell Ausserrhoden (0.45; 0.68) and Appenzell Innerrhoden (0.26; 0.54),
	~INSFRA	0.350	0.630	
3.	OVDBZ	0.786	0.941	
	~OVDBZ	0.527	0.629	
4.	DEMO	0.712	0.655	
	~DEMO	0.476	0.812	
5	ECOPOW	0.385	0.553	
	~ECOPOW	0.806	0.825	
6.	URBPOP	0.681	0.606	
	~URBPOP	0.452	0.824	

Sufficiency analysis

Table C.4: Truth table for the outcome URBSRPA_10000 *Raw consistency cut-off 0.94*

1. MUNAUT	2. INSFRA	3. OVDBZ	4. DEMO	5. ECOPOW	6. URBPOP	Number	Outcome	Raw consist.	PRI consist.	Cantons
1	1	1	0	0	0	1	1	1.00	1.00	JU
1	1	1	1	0	0	1	1	1.00	1.00	TG
1	1	1	0	1	0	1	1	1.00	1.00	GR
1	0	0	0	0	1	1	1	1.00	1.00	UR
1	0	1	0	0	1	1	1	1.00	1.00	AR
1	1	1	0	0	1	1	1	1.00	1.00	GL
1	1	1	1	0	1	2	1	0.98	0.95	FR, VS
1	1	0	0	1	1	1	1	0.98	0.88	BE
1	0	0	0	1	1	1	1	0.98	0.90	SH
1	0	1	1	0	0	2	1	0.97	0.90	AI, OW
1	1	1	1	1	1	2	1	0.96	0.85	TI, VD
1	1	0	1	0	0	1	1	0.94	0.75	LU
0	1	1	1	0	1	2	1	0.94	0.83	AG, SO
0	1	0	1	0	1	1	0	0.90	0.72	SZ
1	1	0	1	1	1	2	0	0.90	0.64	SG, BL
1	0	0	1	1	0	1	0	0.88	0.15	NW
0	1	0	1	1	1	1	0	0.63	0.18	ZH
0	0	0	0	1	1	2	0	0.49	0.05	BS, NE
0	0	0	1	1	1	2	0	0.41	0.01	GE, ZG

Logical remainders

The ESA procedure was applied. The following logical remainders were included into the logical minimization:

MUNAUT*INSFRA*~OVDBZ*~DEMO*~ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*~DEMO*~ECOPOW*~URBPOP
MUNAUT*~INSFRA*OVDBZ*~DEMO*~ECOPOW*~URBPOP
MUNAUT*~INSFRA*OVDBZ*~DEMO*ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*~DEMO*ECOPOW*~URBPOP
MUNAUT*INSFRA*OVDBZ*~DEMO*ECOPOW*URBPOP
MUNAUT*INSFRA*~OVDBZ*~DEMO*ECOPOW*~URBPOP
MUNAUT*INSFRA*OVDBZ*DEMO*ECOPOW*~URBPOP
~MUNAUT*INSFRA*OVDBZ*DEMO*~ECOPOW*~URBPOP

Directional expectations

MUNAUT –> URBSPRA_10000
INSFRA -> URBSPRA_10000
OVDBZ -> URBSPRA _10000
~URBPOP -> URBSPRA_10000

Intermediate solution

MUNAUT*~DEMO*URBPOP + (AR, BE, GL, SH, UR) Consistency: 0.96 Raw coverage: 0.34
MUNAUT*INSFRA*OVDBZ + (FR, GR, GL, JU, TG, TI, VD, VS) Consistency: 0.98 Raw coverage: 0.67
INSFRA*OVDBZ*DEMO*~ECOPOW + (AG, FR, SO, TG, VS) Consistency: 0.97 Raw coverage: 0.50
MUNAUT*INSFRA*DEMO*~ECOPOW*~URBPOP + (LU, TG) Consistency: 0.95 Raw coverage: 0.29
MUNAUT*OVDBZ*DEMO*~ECOPOW*~URBPOP (AI, OW, TG) Consistency: 0.99 Raw coverage: 0.31
solution coverage: 0.85
solution consistency: 0.94

With this alternative calibration, the complexity of the solution increases. This was expected since lowering the crossover point implies considering more cases as positive and thus including more rows into the logical minimization. This is reflected by the higher coverage values. The results remain highly consistent and does not differ importantly from those obtained with the original calibration of the outcome.

Conservative solution

MUNAUT*~INSFRA*~DEMO*~ECOPOW*URBPOP + (AR, UR) Consistency: 1.00 Raw coverage: 0.17
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP + (GR, JU) Consistency: 1.00 Raw coverage: 0.23
MUNAUT*INSFRA*DEMO*~ECOPOW*~URBPOP + (LU, TG) Consistency: 0.95 Raw coverage: 0.29
MUNAUT*OVDBZ*DEMO*~ECOPOW*~URBPOP + (AI, OW, TG) Consistency: 0.99 Raw coverage: 0.31
MUNAUT*OVDBZ*~DEMO*~ECOPOW*URBPOP + (AR, GL) Consistency: 1.00 Raw coverage: 0.25
MUNAUT*~OVDBZ*~DEMO*ECOPOW*URBPOP + (BE, SH) Consistency: 0.98 Raw coverage: 0.18
INSFRA*OVDBZ*DEMO*~ECOPOW*URBPOP + (AG, FR, SO, VS) Consistency: 0.96 Raw coverage: 0.36
MUNAUT*INSFRA*OVDBZ*DEMO*URBPOP (FR, TI, VD, VS) Consistency: 0.96 Raw coverage: 0.38
solution coverage: 0.76
solution consistency: 0.94

Parsimonious solution

MUNAUT*INSFRA*OVDBZ + (FR, GL, GR, JU, TG, TI, VD, VS) Consistency: 0.98 Raw coverage: 0.67
MUNAUT*OVDBZ*~ECOPOW*~URBPOP + (AI, JU, OW, TG) Consistency: 0.99 Raw coverage: 0.38
INSFRA*OVDBZ*DEMO*~ECOPOW + (AG, FR, SO, TG, VS) Consistency: 0.97 Raw coverage: 0.50
MUNAUT*INSFRA*DEMO*~ECOPOW*~URBPOP + (LU, TG) Consistency: 0.95 Raw coverage: 0.29
MUNAUT*~DEMO*URBPOP (AR, BE, GL, SH, UR) Consistency: 0.96 Raw coverage: 0.34
solution coverage: 0.85
solution consistency: 0.94

3.2 URBSPRA_13000 (crossover point raised to 13'000 UPU / inhabitant and job)

In this case, the direct calibration algorithm built in the fs-QCA software returned a 0.5 membership value for Glarus since its raw data value is 13'006 UPU/inhabitant + job. We raised its membership to 0.55 in order to include it in set of the outcome.

Necessity analysis

Two consistent necessary conditions were identified (INSFRA and OVDBZ). It is not rare to encounter necessary conditions when raising the crossover point: since fewer cases now qualify as instances of URBSPRA_13000, it is less likely to encounter cases which logically contradict the necessity relation. The ESA procedure was applied for the sufficiency analysis to avoid assumptions that contradict the statement of necessity.

Table C.5: Necessity analysis for the outcome URBSRPA_13000

Outcome : URBSPRA_13000				
Conditions		Consistency	Coverage	Logically contradictory cases
1.	MUNAUT	0.921	0.537	Solothurn (0.33; 0.72)
	~MUNAUT	0.326	0.381	
2.	**INSFRA**	**0.970**	**0.566**	-
	~INSFRA	0.349	0.409	
3.	**OVDBZ**	**0.947**	**0.738**	-
	~OVDBZ	0.528	0.410	
4.	DEMO	0.746	0.447	
	~DEMO	0.504	0.560	
5.	ECOPOW	0.369	0.346	
	~ECOPOW	0.866	0.577	Graubünden (0.42; 0.96) and Ticino (0.2; 0.66)
6.	URBPOP	0.662	0.384	
	~URBPOP	0.555	0.659	

Sufficiency analysis

Truth table

Table C.6: Truth table for the outcome URBSRPA_13000 *Raw consistency cut-off 0.90*

1. MUNAUT	2. INSFRA	3. OVDBZ	4. DEMO	5. ECOPOW	6. URBPOP	Number	Outcome	Raw consist.	PRI consist.	Cantons
1	1	1	0	0	0	1	1	0.97	0.92	**JU**
1	1	1	0	1	0	1	1	0.95	0.84	**GR**
1	1	1	1	0	0	1	1	0.91	0.79	**TG**
1	1	1	0	0	1	1	0	0.87	0.39	**GL**
1	0	0	0	0	1	1	0	0.87	0	UR
1	0	1	0	0	1	1	0	0.86	0.17	AR
1	1	1	1	0	1	2	0	0.85	0.65	**VS, FR**
1	0	0	0	1	1	1	0	0.79	0	SH
0	1	1	1	0	1	2	0	0.78	0.39	AG, **SO**
0	1	0	1	0	1	1	0	0.75	0.28	SZ
1	1	0	1	0	0	1	0	0.74	0.28	LU
1	1	1	1	1	1	2	0	0.74	0.28	**TI**, VD
1	1	0	0	1	1	1	0	0.73	0	BE
1	0	0	1	1	0	1	0	0.72	0.10	NW
1	0	1	1	0	0	2	0	0.72	0.22	AI, OW
1	1	0	1	1	1	2	0	0.59	0.02	BL, SG
0	1	0	1	1	1	1	0	0.50	0	ZH
0	0	0	0	1	1	2	0	0.42	0	BS, NE
0	0	0	1	1	1	2	0	0.36	0	GE, ZG

Logical remainders

The following logical remainders were included into the logical minimization:

MUNAUT*INSFRA*OVDBZ*DEMO*ECOPOW*~URBPOP
MUNAUT*INSFRA*OVDBZ*~DEMO*ECOPOW*URBPOP

Directional expectations

MUNAUT –> URBSPRA_13000
INSFRA -> URBSPRA_13000
OVDBZ -> URBSPRA_13000
~URBPOP -> URBSPRA_13000

Intermediate solution

MUNAUT*INSFRA*OVDBZ*~ECOPOW*~URBPOP + (JU, TG) Consistency: 0.93 Raw coverage: 0.49
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP (GR, JU) Consistency: 0.95 Raw coverage: 0.33
solution coverage: 0.50
solution consistency: 0.92

Here we observe the opposite trend compared to the analysis for URBSPRA_10000. Raising the crossover point means that fewer cantons qualify as positive cases, thus fewer rows are included in the minimization and the solution is less complex. Once again the results are highly consistent. The first combination is similar to Solution 1a from the analysis presented in the paper, while the second is identical to Solution 1b. Raising the crossover point means that only the strongest instances of URBSPRA are included in the minimization. Hence, this robustness test confirms the importance of Solutions 1a and 1b, and of the role played by the association of MUNAUT, INSFRA and OVDBZ. This further corroborates our hypotheses.

Conservative solution

The conservative solution is identical to the intermediate solution.

Parsimonious solution

MUNAUT*INSFRA*OVDBZ*~URBPOP (GR, JU, TG) Consistency: 0.92 Raw coverage: 0.52
solution coverage: 0.52
solution consistency: 0.92

3.3 Alternative analysis for URBSPRA: raw consistency cut-off raised to 0.96

Outcome: URBSPRA Raw consistency cut-off 0.96
The truth table is provided in the main text.

Logical remainders
The following logical remainders were included into the logical minimization:

MUNAUT*INSFRA*~OVDBZ*~DEMO*~ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*~DEMO*~ECOPOW*~URBPOP
MUNAUT*~INSFRA*OVDBZ*~DEMO*~ECOPOW*~URBPOP

Prime implicants
MUNAUT*~INSFRA*~DEMO*~ECOPOW

Directional expectations
MUNAUT -> URBSPRA
INSFRA -> URBSPRA
OVDBZ -> URBSPRA
~URBPOP -> URBSPRA

Intermediate solution
MUNAUT*INSFRA*OVDBZ*~ECOPOW* + (FR, GL, JU, TG, VS) Consistency: 0.97 Raw coverage: 0.66
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP + (GR, JU) Consistency: 1.00 Raw coverage: 0.26

MUNAUT*~INSFRA*~DEMO*~ECOPOW (AR, UR) Consistency: 1.00 Raw coverage: 0.24
solution coverage: 0.70
solution consistency: 0.97

Conservative solution

MUNAUT*INSFRA*OVDBZ*~ECOPOW* (FR, GL, JU, TG, VS) Consistency: 0.97 Raw coverage: 0.66
MUNAUT*INSFRA*OVDBZ*~DEMO*~URBPOP (GR, JU) Consistency: 1.00 Raw coverage: 0.26
MUNAUT*~INSFRA*~DEMO*~ECOPOW*URBPOP (AR, UR) Consistency: 1.00 Raw coverage: 0.19
solution coverage: 0.69
solution consistency: 0.98

Parsimonious solution

The parsimonious solution is identical to the intermediate solution.

4. SUFFICIENCY ANALYSIS FOR THE OUTCOME ~URBSPRA

~URBSPRA

Truth table

C.7: Truth table for the outcome ~URBSPRA *Raw consistency cut-off 0.91*

1. MUNAUT	2. INSFRA	3. OVDBZ	4. DEMO	5. ECOPOW	6. URBPOP	*Number*	Outcome	Raw consist.	PRI consist.	Cantons
0	0	0	0	1	1	2	1	1.00	1.00	**BS, NE**
0	0	0	1	1	1	2	1	1.00	1.00	**GE, ZG**
1	0	0	1	1	0	1	1	0.97	0.88	**NW**
0	1	0	1	1	1	1	1	0.93	0.86	**ZH**
1	1	0	0	1	1	1	1	0.92	0.52	**BE**
1	1	0	1	1	1	2	1	0.91	0.71	**BL, SG**
1	0	0	0	1	1	1	0	0.88	0.39	SH
1	1	0	1	0	0	1	0	0.87	0.51	**LU**
1	0	0	0	0	1	1	0	0.84	0	UR
1	0	1	1	0	0	2	0	0.84	0.38	**AI**, OW
1	1	1	1	1	1	2	0	0.83	0.35	TI, **VD**
0	1	0	1	0	1	1	0	0.79	0.35	**SZ**
1	0	1	0	0	1	1	0	0.79	0	AR
1	1	1	0	0	1	1	0	0.74	0	GL
0	1	1	1	0	1	2	0	0.72	0.22	AG, SO
1	1	1	0	1	0	1	0	0.67	0	GR
1	1	1	1	0	1	2	0	0.64	0.10	FR, VS
1	1	1	1	0	0	1	0	0.61	0.02	TG
1	1	1	0	0	0	1	0	0.59	0	JU

19 combinations of conditions were empirically observed. The positive cases are in bold.

Logical remainders

45 logical remainders resulted from the truth table. The following were included into the logical minimization:

~MUNAUT*~INSFRA*~OVDBZ*DEMO*ECOPOW*~URBPOP
~MUNAUT*INSFRA*~OVDBZ*~DEMO*ECOPOW*URBPOP
MUNAUT*~INSFRA*~OVDBZ*DEMO*ECOPOW*URBPOP

Prime implicants

~MUNAUT*~OVDBZ*DEMO*ECOPOW*URBPOP

Directional expectations

~MUNAUT –> ~URBSPRA
~INSFRA -> ~URBSPRA
~OVDBZ -> ~URBSPRA
URBPOP -> ~URBSPRA

Intermediate solution

~INSFRA*~OVDBZ*DEMO*ECOPOW* + (GE, NW, ZG) Consistency: 0.99 Raw coverage: 0.31
~MUNAUT*~OVDBZ*ECOPOW*URBPOP + (BS, GE, NE, ZG, ZH) Consistency: 0.96 Raw coverage: 0.46
INSFRA*~OVDBZ*ECOPOW*URBPOP + (BE, BL, SG, ZH) Consistency: 0.91 Raw coverage: 0.40
solution coverage: 0.63
solution consistency: 0.93

Conservative solution

~MUNAUT*~INSFRA*~OVDBZ*ECOPOW*URBPOP + (BS, GE, NE, ZG) Consistency: 1.00 Raw coverage: 0.32

MUNAUT*INSFRA*~OVDBZ*ECOPOW*URBPOP (BE, BL, SG) Consistency: 0.88 Raw coverage: 0.30
MUNAUT*~INSFRA*~OVDBZ*DEMO*ECOPOW*~URBPOP + (NW) Consistency: 0.97 Raw coverage: 0.11
~MUNAUT*~OVDBZ*DEMO*ECOPOW*URBPOP + (GE, ZG, ZH) Consistency: 0.95 Raw coverage: 0.38
solution coverage: 0.63
solution consistency: 0.93

Parsimonious solution

The parsimonious solution is identical to the intermediate solution.