

Decision Modeling Challenge

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The Problem

A tax expert has given us this decision table in Excel:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	IF This year's filing	1	2	3	4	5	6	7	8	9	10	11	12
2	Doc Code being processed is 7, 8 or 28	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	Taxable Income < 50,000	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	Interest Income < 400	-	N	N	N	N	-	-	-	-	Y	Y	Y
5	Taxable Pension = 0	-	-	-	-	-	N	N	Y	Y	Y	Y	Y
6	Under 65 Years Old	-	Y	N	N	Y	N	N	N	N	Y	Y	Y
7	AGI < 25,000	-	-	N	Y	-	N	Y	N	Y	-	-	-
8	Doc Code being processed is a 28	-	-	-	-	-	-	-	-	-	Y	N	N
9	Zip Code OK (not SC, APO or LL)	-	-	-	-	-	-	-	-	-	-	Y	-
10	THEN												
11	Next Year send the taxpayer the following forms and schedules: 1040EZ Telefile (MFR 15)										Y	Y	
12	Next Year send the taxpayer the following forms and schedules: 1040EZ (MFR 13)												Y
13	Next Year send the taxpayer the following forms and schedules: 1040A, with Sch 1, 2 (MFR 02)	Y	Y	Y		Y	Y		Y				
14	Next Year send the taxpayer the following forms and schedules: 1040A with Sch R (MFR 14)				Y			Y		Y			

There are 12 rules here, but are they correct?

1. Are there any missing rules? (Incompleteness)
2. Are there any unnecessary rules? (Redundancies)
3. Do any of these rules conflict with each other? (Ambiguities)

The answer is “yes” to each question. The tax expert’s rules are flawed and, unfortunately, very typical.

But the flaws are also quite hard to find just by looking at the Excel spreadsheet. And Excel gives you no help whatsoever in finding these problems.

Try finding the flaws yourself before reading further.

The rest of this document will explore ways to identify and resolve these problems.

My choices for resolution are somewhat arbitrary and other vendors may choose different ways to deal with the problems. But the important thing to compare is the amount of assistance that various tools provide in dealing with such problems in decision tables.

BTW in all my years of working with rules specified by business users (and programmers) I have rarely come across one that didn't suffer from one or more of these three problems. It's just very hard to get it right.

So, rather than try to pick our way through these Excel rules trying to make sense of what they may or may not have intended, let's simply rewrite these rules in a real decision table tool so we can take advantage of some automated checking features.

Here are the rules in Corticon. Note that condition 9 in Excel has been reversed in the decision table (h) to avoid the use of 'not'.

Tax_As_Specified.ers		1	2	3	4	5	6	7	8	9	10	11	12
	Conditions												
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	T	T	T	T	T	T	T	T	T	T	T
c	Tax.interestIncome<400	-	F	F	F	F	-	-	-	-	T	T	T
d	Tax.taxablePension=0	-	-	-	-	-	F	F	T	T	T	T	T
e	Tax.age<65	-	T	F	F	T	F	F	F	F	T	T	T
f	Tax.agi<25000	-	-	F	T	-	F	T	F	T	-	-	-
g	Tax.docCode='28'	-	-	-	-	-	-	-	-	-	T	F	F
h	Tax.zipCode in {'SC', 'APO', 'LL'}	-	-	-	-	-	-	-	-	-	-	F	-
	Actions												
	Post Message(s)												
A	Tax.formToSend='MFR15'										<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
B	Tax.formToSend='MFR13'												<input checked="" type="checkbox"/>
C	Tax.formToSend='MFR02'	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>				
D	Tax.formToSend='MFR14'				<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>			

Completeness

The first question we ask is “does the decision table cover every possible combination of conditions?” The completeness checker can immediately tell us that the following combinations were missing.

*Step 2 Tax Completed.ers		13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	14
	Conditions									
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T	F
b	Tax.taxableIncome<50000	T	T	T	T	T	T	T	T	-
c	Tax.interestIncome<400	T	T	T	T	T	T	T	T	-
d	Tax.taxablePension=0	F	F	F	F	F	F	F	F	-
e	Tax.age<65	T	T	T	T	T	T	T	T	-
f	Tax.agi<25000	T	T	T	T	F	F	F	F	-
g	Tax.docCode='28'	T	T	F	F	T	T	F	F	-
h	Tax.zipCode in {'SC','APO','LL'}	T	F	T	F	T	F	T	F	-
	Actions									
	Post Message(s)									
A	Tax.formToSend='MFR15'									
B	Tax.formToSend='MFR13'									
C	Tax.formToSend='MFR02'									
D	Tax.formToSend='MFR14'									

Obviously the tool cannot know what the correct actions are for these missing rules so we need to talk to our tax expert.

Let’s suppose we are told that these are the expected responses

Step 2 Tax Completed.ers		13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8
	Conditions								
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	T	T	T	T	T	T	T	T
c	Tax.interestIncome<400	T	T	T	T	T	T	T	T
d	Tax.taxablePension=0	F	F	F	F	F	F	F	F
e	Tax.age<65	T	T	T	T	T	T	T	T
f	Tax.agi<25000	T	T	T	T	F	F	F	F
g	Tax.docCode='28'	T	T	F	F	T	T	F	F
h	Tax.zipCode in {'SC','APO','LL'}	T	F	T	F	T	F	T	F
	Actions								
	Post Message(s)								
A	Tax.formToSend='MFR15'	✓	✓			✓	✓		
B	Tax.formToSend='MFR13'								
C	Tax.formToSend='MFR02'			✓	✓			✓	✓
D	Tax.formToSend='MFR14'								

And that we don’t need to worry about Tax.docCodes other than 7, 8 and 28 since they are handled by a different decision table.

After renumbering the rules this is what we get

Step 3 Tax Renumbered.ers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Conditions																						
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	
b	Tax.taxableIncome<50000	F	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	
c	Tax.interestIncome<400	-	F	F	F	F	-	-	-	T	T	T	T	T	T	T	T	T	T	T	T	
d	Tax.taxablePension=0	-	-	-	-	-	F	F	T	T	T	T	F	F	F	F	F	F	F	F	F	
e	Tax.age<65	-	T	F	F	T	F	F	F	F	T	T	T	T	T	T	T	T	T	T	T	
f	Tax.agi<25000	-	-	F	T	-	F	T	F	T	-	-	-	T	T	T	T	F	F	F	F	
g	Tax.docCode='28'	-	-	-	-	-	-	-	-	-	T	F	F	T	T	F	F	T	T	F	F	
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	-	-	-	-	-	F	-	T	F	T	F	T	F	T	F	
Actions																						
Post Message(s)		✉	✉	✉	✉	✉	✉	✉	✉	✉	✉	✉	✉	✉								
A	Tax.formToSend='MFR15'										✓	✓		✓	✓				✓	✓		
B	Tax.formToSend='MFR13'												✓									
C	Tax.formToSend='MFR02'	✓	✓	✓		✓	✓		✓							✓	✓				✓	✓
D	Tax.formToSend='MFR14'				✓			✓		✓												

And Corticon will confirm that this is a complete set (given that codes other than 7, 8 or 28 are handled elsewhere)



But do we actually need all 20 rules. There are only 4 different outcomes so maybe it's possible to do this with fewer than 20 rules. It's very tedious to figure this out manually.

Redundancies

If we use Corticon as the decision modeling tool we can automatically compress this table:

- 3, 6 and 8 can be merged
- 4, 7 and 9 can be merged
- 5, 10, 13, 14, 17, 18 can be merged
- 8, 15, 16, 19, 20 can be merged

So 8 rules are actually sufficient to represent the 12 original and 8 missing rules defined by the tax expert.

Step 4 Tax Compressed.ers		1	2	3	4	5	6	7	8
Conditions									
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	-	-	T	T	T	T	-
c	Tax.interestIncome<400	-	F	-	-	T	T	T	-
d	Tax.taxablePension=0	-	-	-	-	-	T	T	F
e	Tax.age<65	-	T	F	F	T	T	T	T
f	Tax.agi<25000	-	-	F	T	-	-	-	-
g	Tax.docCode='28'	-	-	-	-	T	-	F	F
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	F	-	-
Actions									
Post Message(s)		✉	✉	✉	✉	✉	✉	✉	✉
A	Tax.formToSend='MFR15'					✓	✓		
B	Tax.formToSend='MFR13'							✓	
C	Tax.formToSend='MFR02'	✓	✓	✓					✓
D	Tax.formToSend='MFR14'				✓				

The next question is “are there any ambiguities in these rules?” That is, can the same input data produce two or more conflicting results?

Ambiguity Checking

Again Corticon can tell us there are conflicts (Step 5)

Both rules 6 and 7 will both fire when docCode is not 28 and zipCode is not SC, APO or LL resulting in MFR15 and MFR13 as the result. Again Corticon cannot tell whether this is what was intended.

Perhaps the tax expert really does intend that the taxpayer gets both forms. But as specified rule 7 will overwrite the result of rule 6 since they both set the value of a single variable (formToSend).

*Step 5 Tax Conflicts.ers		1	2	3	4	5	6	7	8
Conditions									
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	-	-	T	T	T	T	-
c	Tax.interestIncome<400	-	F	-	-	T	T	T	-
d	Tax.taxablePension=0	-	-	-	-	-	T	T	F
e	Tax.age<65	-	T	F	F	T	T	T	T
f	Tax.agi<25000	-	-	F	T	-	-	-	-
g	Tax.docCode='28'	-	-	-	-	T	-	F	F
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	F	-	-
Actions									
Post Message(s)									
A	Tax.formToSend='MFR15'					✓	✓		
B	Tax.formToSend='MFR13'							✓	
C	Tax.formToSend='MFR02'	✓	✓	✓					✓
D	Tax.formToSend='MFR14'				✓				

So we need to get our tax expert to clarify what was intended.

Let's assume they tell us that it should be MFR13 for both rule 6 and rule 7.

After making this change we find there is now a conflict between rules 5 and 6.

*Step 5 Tax Conflicts.ers		1	2	3	4	5	6	7	8
Conditions									
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	-	-	T	T	T	T	-
c	Tax.interestIncome<400	-	F	-	-	T	T	T	-
d	Tax.taxablePension=0	-	-	-	-	-	T	T	F
e	Tax.age<65	-	T	F	F	T	T	T	T
f	Tax.agi<25000	-	-	F	T	-	-	-	-
g	Tax.docCode='28'	-	-	-	-	T	-	F	F
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	F	-	-
Actions									
Post Message(s)									
A	Tax.formToSend='MFR15'					✓			
B	Tax.formToSend='MFR13'							✓	✓
C	Tax.formToSend='MFR02'	✓	✓	✓					✓
D	Tax.formToSend='MFR14'				✓				

Perhaps our tax expert now says rules 6 and 7 should both have resulted in form MFR15.

Then we get a decision table that is now ambiguity free and complete.

However, observe that form MFR13 is then never used.

If it is actually required then we need to establish unambiguously the conditions when it applies.

Step 6 Tax Conflict Free.ers		1	2	3	4	5	6	7	8
Conditions									
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	-	-	T	T	T	T	-
c	Tax.interestIncome<400	-	F	-	-	T	T	T	-
d	Tax.taxablePension=0	-	-	-	-	-	T	T	F
e	Tax.age<65	-	T	F	F	T	T	T	T
f	Tax.agi<25000	-	-	F	T	-	-	-	-
g	Tax.docCode='28'	-	-	-	-	T	-	F	F
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	F	-	-
Actions									
Post Message(s)									
A	Tax.formToSend='MFR15'					✓	✓	✓	
B	Tax.formToSend='MFR13'								
C	Tax.formToSend='MFR02'	✓	✓	✓					✓
D	Tax.formToSend='MFR14'				✓				

For now let's assume this form is obsolete and no longer required.

In fact now that we have resolved the conflicts we can apply the compression checker again and find that we only need seven rules since 6 and 7 can be merged given that they have the same outcome.

Now we have a complete and consistent decision table. But there are still improvements that can be made.

Notice that condition **a** is true for all rules and condition **h** is no longer needed (now that MFR13 is obsolete). We can move condition **a** to the filter section and we can remove **h**. We can also remove **B**. This gives us:

Step 7 Tax Compressed.ers		1	2	3	4	5	6	7
Conditions								
a	Tax.docCode in {'7','8','28'}	T	T	T	T	T	T	T
b	Tax.taxableIncome<50000	F	-	-	T	T	T	-
c	Tax.interestIncome<400	-	F	-	-	T	T	-
d	Tax.taxablePension=0	-	-	-	-	-	T	F
e	Tax.age<65	-	T	F	F	T	T	T
f	Tax.agi<25000	-	-	F	T	-	-	-
g	Tax.docCode='28'	-	-	-	-	T	-	F
h	Tax.zipCode in {'SC','APO','LL'}	-	-	-	-	-	-	-
Actions								
Post Message(s)								
A	Tax.formToSend='MFR15'					✓	✓	
B	Tax.formToSend='MFR13'							
C	Tax.formToSend='MFR02'	✓	✓	✓				✓
D	Tax.formToSend='MFR14'				✓			

Step 8 Tax Improved.ers		1	2	3	4	5	6	7
Scope								
Tax								
Filters								
age								
agi								
docCode								
formToSend								
interestIncome								
taxableIncome								
taxablePension								
Filters								
1	Tax.docCode in {'7','8','28'}							
Conditions								
a	Tax.taxableIncome<50000	F	-	-	T	T	T	-
b	Tax.interestIncome<400	-	F	-	-	T	T	-
c	Tax.taxablePension=0	-	-	-	-	-	T	F
d	Tax.age<65	-	T	F	F	T	T	T
e	Tax.agi<25000	-	-	F	T	-	-	-
f	Tax.docCode='28'	-	-	-	-	T	-	F
g								
Actions								
Post Message(s)								
A	Tax.formToSend='MFR15'					✓	✓	
B	Tax.formToSend='MFR02'	✓	✓	✓				✓
C	Tax.formToSend='MFR14'				✓			
D								

Even after doing all of these checks we still have to ask the question: "Does the decision table produce the results that the business (the IRS) wants in every case?" Unfortunately what they want and what they specified may be different!

This is something that cannot be done automatically by any tool¹. We need someone, preferably other than the tax expert who specified the rules, to give us sample scenarios and indicate the expected result in each case. Then we can run the rules and verify that they do indeed produce the desired response.

It doesn't help to use the rule actions as the expected results since obviously the rules are going to produce those results for the various combinations of conditions. The expected results need to be provided independently in order to be considered a valid test.

One important step we might do is to set up the natural language version of the decision table so that the tax expert can modify the rules:

Conditions	1	2	3	4	5	6	7
Is taxable income less than \$5000?	F	-	-	T	T	T	-
Is interest income less than \$400?	-	F	-	-	T	T	-
Is taxable pension zero?	-	-	-	-	-	T	F
Is age less than 65?	-	T	F	F	T	T	T
Is adjusted Gross Income less than \$2500?	-	-	F	T	-	-	-
Is document code '28'?	-	-	-	-	T	-	F

Actions	1	2	3	4	5	6	7
Post Message(s)	✉	✉	✉	✉	✉	✉	✉
Send MFR15					✓	✓	
Send MFR02	✓	✓	✓				✓
Send MFR14				✓			

A final step might be to add rule statements that explain the outcome of the rules in a way that is suitable for sending to the taxpayer in a letter.

Ref	Text
1	You must use form MFR02 because your taxable income is \$50,000 or more
2	You must use form MFR02 because your interest income is \$400 or more
3	You must use form MFR02 because your age is less than 65 and your agi is \$25,000 or more
4	You must use form MFR14 because your age is 65 or more and your agi is less than \$25,000
5	You must use form MFR15 because your taxable income is under \$50,000, your interest income is under \$400, your age is under 65, and your doc code is 28
6	You must use form MFR15 because your taxable income is under \$50,000, your interest income is under \$400, your age is under 65 and your taxable pension is zero
7	You must use form MFR02 because your taxable pension is greater than zero, your age is under 65 and your doc code is not 28

Though if our tax expert was doing this the recommended way they would have started with these statements at the very beginning and would have developed the decision table from them rather than the reverse.

¹ Corticon can be set up to automatically generate every possible combination of input data values, but someone still needs to determine what the expected result should be in each case. In this example there are 7 boolean conditions (assuming doc code is restricted to 7, 8 or 28) which means 128 distinct input test cases.

Conclusion

It seems our tax expert is not such a good expert after all!

Perhaps he should not have tried to use Excel to create the rules but instead have used a decision modeling tool like Corticon that would check his work as he writes the rules.

Then again perhaps we should not be too quick to improve the ability of the IRS to collect our taxes!!!!