Mimic Excel

Yuxing Yan[1]

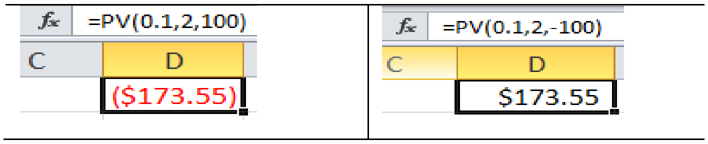
ABSTRACT

Although Excel is an excellent tool to teach finance, some of its properties really confuse my students, such as its sign convention and no clear explanation accompanying an error message. In addition, typing *=fv(0.1,2,0,100)* offers no clue about the formula being used. In this short paper, I will replicate several common Excel functions with and *without* sign convention. The beauty of functions without sign convention is that they come directly from our textbooks. In other words, an exact formula will accompany a result. When typing *=rateExcel(3,10,100)*, we will see the same error message plus a short explanation.

Introduction

When teaching various finance courses, I use Excel intensively. There is no doubt in my mind that Excel is one of the wonderful tools to teach finance. However, it does have some “undesired” properties that I have to spend a huge amount of time discussing with my students, such as its sign convention. There is also no clear and short explanation when an error message pops up. When teaching finance, we introduce many formulae. Nevertheless, no formula is presented when applying an Excel function, such as *=pv(0.1,2,100)*. In this short paper, I offer a simple solution to overcome these three shortcomings. Below, I explain why these issues really bother me and my students.

The first issue is the sign convention: if the future value is positive (negative), then the present value will be negative (positive). For many simple calculations, students are quick to grasp the meaning of such a convention. Here is a simple example. Assume that we want to estimate the present value of an annuity with a discount rate of 10% and an annual payment of $100, where annual cash flows happen at the end of each year for two years. For this example, we apply the Excel *pv()* function, shown below.



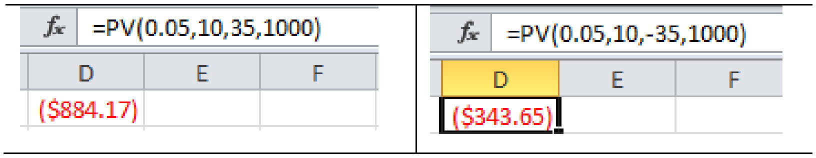
=PV(0.1,2,100)

($173.55)

=PV(0.1,2,-100)

$173.55

When enter a positive (negative) payment, we got a negative (positive) present value, i.e., -173.55 vs. 173.55. For such a simple example, students quickly learn why we have a negative or positive answer. On the other hand, it is a different story for more complex scenarios; Students could be extremely confused with such a sign convention. Let’s look at a little bit more complex example. For a 5-year bond with an annual coupon rate of 7% paid semi-annually, what is the price if the YTM (Yield to Maturity) is 10% compounded semi-annually with a face value of $1,000? The correct answer is $884.17 shown in the left panel below.



=PV(0.05,10,35,1000)

($884.17)

=PV(0.05,10,-35,1000)

($343.65)

During one exam, one of my students gave a value of $343.65, shown on the right panel above. When I asked the whole class the meaning of *=pv(0.05, 10, -35, 1000)*, no student offered a satisfactory explanation. Thus, the Excel sign convention makes such a simple case over complicated.

When applying a formula just once, it is easy to understand the Excel sign convention. To finish my data cases, students usually have to go through several steps; In other words, the further analysis depends on the results of the previous steps. For my first data case in Corporate Finance, students are asked to

[1] Department of Economics and Finance, Canisius College, 2001 Main Street, Buffalo, NY 14208,yany@canisius.edu. I thank Bill Yang, an anonymous referee, Xiaoyu Mo and James Yan for helpful comments and suggestions. All remaining errors are my own.

produce an amortization table based on the estimated monthly payment. Assuming that we borrow $200,000 with a constant monthly payment of $2000 and a 0.25% monthly interest rate, we estimate interest payment for the first month by multiplying the beginning balance with 0.25%, i.e., 500. By deducting the interest payment from the total payment, we have principal reduction (2000-500=1500). Thus, by deducting principal reduction from the balance at the beginning of the period, we end up with an ending balance of 198,500 (200,000-1500). The next period's beginning balance is the same as the ending balance in this period. Repeating the same procedure, we would construct the whole amortization table, shown below.

Beginning balance	Monthly payment	Interest payment	Principal reduction	Ending balance
200,000	2,000	500	1,500	198,500
198,500	2,000			

Obviously, in the above chain of logic, we assume that every number is positive. Whenever a student uses the monthly payment based on the previous step, he/she might be confused with its sign. My solution is to use positive values only, i.e., ignoring the Excel sign convention.

The second issue is that Excel functions offer no clue about the formula being used. When discounting a future cash flow happening at the end of the nth period with a discount rate of R, all finance textbooks introduce the following formula.

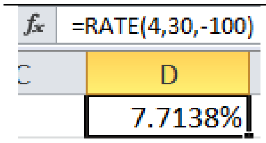
$$PV = \frac{FV}{(1+R)^n} \tag{1}$$

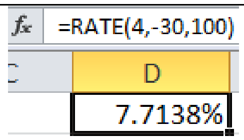
For example, assume that we have the following values: FV=100, R=0.08 and n=5. Based on the above equation, I can show my students that 100/(1+0.08)^5 would lead to a result of 68.06. However, when using Excel's present value function of *=pv()*, I have to explain why we would get -68.06 instead of 68.06. Instead of the previous formula, the formula used by Excel is to add a negative sign in front of Equation (1), as shown below:

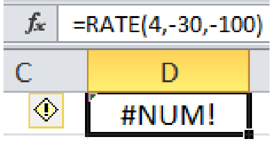
$$PV = -\frac{FV}{(1+R)^n} \tag{2}$$

Unfortunately, no finance textbook would write present value function this way. This is true for other Excel functions, such as the *fv()* function as well.

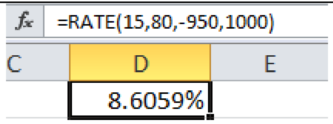
The third issue is that there is no clear and short explanation when an error occurs, such as #NUM! after typing *=rate(3,10,100)*. When applying the Excel *rate()* function, we could estimate yield or IRR, as shown below.

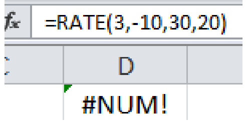

=RATE(4,30,-100)
D
7.7138%

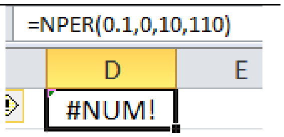

=RATE(4,-30,100)
D
7.7138%


=RATE(4,-30,-100)
C D
#NUM!

Here are other error messages.


=RATE(15,80,-950,1000)
C D E
8.6059%


=RATE(3,-10,30,20)
D
#NUM!


=NPER(0.1,0,10,110)
D E
#NUM!

When clicking the image on the left-side of error cell, we could explore a possible solution. However, few people would expend time on it.

A simple solution to overcome those three shortcomings

My approach is very simple: download and install R first. Then issue just one line of R codes. To install R, we have the following steps.

```
Step 1: Go to http://www.r-project.org
Step 2: Click "CRAN" under "Download, Packages" (left-hand side)
Step 3: Choose a mirror address
Step 4: Choose appropriate software (PC, Mac)
Step 5: Click "base"
```

After launching R, just issue the following one line codes.

```
> source("http://canisius.edu/~yany/mimicExcel")
```

Here, “>” is the R prompt. Since R is case sensitive, we have to type “*mimicExcel*” instead of “*mimicexcel*”. After hitting the Enter-key, the following screen would pop up:

```
  *------------------------------------------------------------*
  *   Mimic Excel                                  3/27/2015   *
  *------------------------------------------------------------*
  *   Functions         Utilities                              *
  *------------------------------------------------------------*
  *   pvExcel           pvExcelNoSignConvention                *
  *   fvExcel           fvExcelNoSignConvention                *
  *   pmtExcel          pmtExcelNoSignConvention               *
  *   nperExcel         nperExcelNoSignConvention              *
  *   rateExcel         rateExcelNoSignConvention              *
  *   npvExcel          npv_f                                  *
  *   effectExcel       effectYan                              *
  *   days360Excel                                             *
  *   priceExcel        shortcut                               *
  *   yieldExcel        severalRcommands                       *
  *------------------------------------------------------------*
  *   >pvExcel          # find out the usage of pvExcel        *
  *   >mimicExcel       # back to this menu                    *
  *------------------------------------------------------------*
```

The last two lines are instructions on how to use those functions. For example, after typing *pvExcel* and hit return, we will see its usage, the names and meanings of all the input variables plus a few examples.

```
> pvExcel
function(rate,nper,pmt,fv=0,type=0){
  "Objective: mimic Excel function of =pv(rate,nper,pmt,[fv],[type])
        rate : effective period rate
        nper : number of periods
        pmt  : payment per period
        fv   : future value
        type : 0 payments at the ends (default), 1 at the beginnings

    Example 1: > pvExcel(0.1,1,0,100)
                 since fv>0, then pv <0
                 [1] -90.90909
    Example 2: > pvExcel(0.1,1,0,-100)
                 Since fv<0, then pv>0
                 [1] 90.90909
    Example 3: annuity
               > pvExcel(0.1,3,10)
                 Since pmt>0, then pv <0
                 [1] -24.86852
    Example 4: > pvExcel(0.1,3,0,100,1)
                 Cash flows at the begenings of periods (due).
                 Since fv>0, then pv <0
                 [1] -75.13148
              >  pvExcel(0.1,3,0,100,0)
                 Since fv>0, then pv <0
                 [1] -75.13148
 ";pvExcel_(rate,nper,pmt,fv,type)
}
```

By presenting two functions with and without sign conventions side by side, such as *pvExcel()* and *pvExcelNoSignConvention()*, students could grasp the meaning of each function quite easily, as shown below.

```
> pvExcel(0.1,2,100)
Since pmt>0, then pv <0
[1] -173.5537
> pvExcelNoSignConvention(0.1,2,100)
Since fv=0, formula used is pv = c/r*(1 - 1/(1+r)^n)
[1] 173.5537
```

Also, when we have an error, the program would offer a short explanation.

```
> rateExcel(4,-30,-100)
#NUM!
  Reason: it is not possible with cash outflows only (pmt<0,pv<0,fv=0
> rateExcel(4,30,100)
 #NUM!
  Reason: it is not possible with cash inflows only (pmt>0,pv>0,fv=0)
>
```

To estimate the EAR (Effective Annual Rate), Excel offers an function called *effect()* which takes two values: APR (Annual Percentage Rate)[2] and its compounding frequency.

```
> effectExcel(0.1,2)
[1] 0.1025
```

Nevertheless, there is no general Excel function available to estimate other effective rates. For example, based on the 10% interest rate, compounded semi-annually, what are the effective monthly, daily or weekly rates? For this purpose, I wrote a general and much better function called *effectYan(),* a few examples are given below.

```
> effectYan(0.1,'s2a')
                      Two rates
effective annual rate    0.1025
APR                      0.1025
> effectYan(0.1,'s2q')
                          Two rates
effective quarterly rate 0.02469508
APR                      0.09878031
> effectYan(0.1,'s2c')
                             Two rates
effective continuously rate 0.09758033
APR                         0.09758033
```

The first input variable is APR while the second one is a string indicating how to convert this rate. Letters of "*a*", "*s*", "*q*", "*m*", "*d*", "*c*" are for annual, semi-annual, quarterly, monthly, daily and continuously compounded frequencies, respectively. Thus, '*s2a*' means from a semi-annual rate to an annual rate, while '*q2c*' indicates from a quarterly rate to a continuously compounded rate.

Conclusion

When applying Excel to finance, we have three shortcomings: Excel sign convention, no formula offered and no clear explanation when an error message pops up. In this short paper, I present a simple solution to overcome those three problems. A user needs to do two things: download and install R, then issue the following one-line R codes after launching R.

[2] Excel wrongly names the first input as Nominal Rate instead of Annual Percentage Rate.

```
> source("http://canisius.edu/~yany/mimicExcel")
```

Again, I assume that a potential user has never heard of R, i.e., no prior knowledge about R. For an instructor who intends to use my method to help students to learn Excel, she could simply hand out one one-page instruction to her students at the beginning of each semester, see Appendix A for more details.

APPENDIX A: INSTRUCTION ON HOW TO USE MIMICEXCEL

First, you download and install R with the following 5 steps.

```
Step 1: Go to http://www.r-project.org
Step 2: Click "CRAN" under "Download, Packages" (left-hand side)
Step 3: Choose a mirror address
Step 4: Choose appropriate software (PC, Mac)
Step 5: Click "base"
```

Second, after launching R by clicking R icon on your desktop, just issue the following one-line R codes.

```
> source("http://canisius.edu/~yany/mimicExcel")
```

Note that in the above one-line codes, “>” is the R prompt. Since R is case sensitive, you have to use “*mimicExcel*” instead of “*mimicexcel*”.