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In this project I have to find the implicit dividend for a particular maturity T. Therefore the first thing to do is to find an assets that pays dividend, so I decided to analyze PepsiCo, Inc. (PEP).

PepsiCo, Inc. is an American multinational food, snack, and beverage corporation headquartered in Harrison, New York, in the hamlet of Purchase. PepsiCo's business encompasses all aspects of the food and beverage market. It oversees the manufacturing, distribution, and marketing of its products. PepsiCo was formed in 1965 with the merger of the Pepsi-Cola Company and Frito-Lay. PepsiCo has operations all around the world and its products were distributed across more than 200 countries, resulting in annual net revenues of over $70 billion. Based on net revenue, profit, and market capitalization, PepsiCo is the second-largest food and beverage business in the world, behind Nestlé.

The Market Cap is equal to 231.528B while the Enterprise Value is equal to 267.44B. If we search in *yahoo.finance* site we can check the list of ex-dividend date. In particular, in the last year, are : Mar, 2022 ;Dec, 2021 ;Sep, 2021; Jun, 2021. So we can deduce that dividends are paid regularly on a quarterly basis (every three months). At each time the values of the dividend correspond to 1.075 and moreover, if we go in the statistic page, we can see that the Forward Annual Dividend Rate is equal to 4.3 (Data provided by Morningstar, Inc.). Currently (28/03/2022 10:30) the underlying price,S, is 165.24$, while at the open was 164.43$ and at the previous close was 164.47$.

Now, the first thing to do, is to calculate the discount factor D_0 for different maturity T. To do so I used the fact that the price of a Box Spread is a multiple of the discount factor (at maturity T) so I used the Box-Spread formula:

$$C_{K1}(T) - C_{K2}(T) + P_{K2}(T) - P_{K1}(T) = (K_2 - K_1) * D_0(T)$$

where: K_1, K_2 are two different strikes with $K_1 << K_2$; while C_{K1}, C_{K2}, P_{K2}, P_{K1} are respectively the call and put Mid prices for the respectively strikes for a certain maturity *T*.

If we invert the formula we can get the discount factor at maturity *T*. For my calculation I used always K_1 = 145 and K_2 = 185, unless for the case of *T* = 7 months, where I used K_2 = 170, because was the only one available for the put option. In the tables below are reported the Discount factor for different maturity with the relative variables.

T	14/04/2022
K_1	145
K_2	185
C_{K1}	20.35
C_{K2}	0.085
P_{K1}	0.245
P_{K2}	19.08
D_0	0.9775

(a) D_0 for a maturity of 1 month

T	17/06/2022
K_1	145
K_2	185
C_{K1}	21.475
C_{K2}	0.43
P_{K1}	1.395
P_{K2}	21.1
D_0	1.0187

(b) D_0 for a maturity of 3 months

T	21/10/2022
K_1	145
K_2	170
C_{K1}	23.15
C_{K2}	6.825
P_{K1}	3.775
P_{K2}	12.6
D_0	1.0060

(c) D_0 for a maturity of 7 months

T	20/01/2023
K_1	145
K_2	185
C_{K1}	24.6
C_{K2}	3.85
P_{K1}	5.15
P_{K2}	24.525
D_0	1.0031

(d) D_0 for a maturity of 10 months

Figure 1: Discount factor for a fixed maturity T

Now that I have found the discount factor for different maturities, I can calculate the implied dividend for that particular maturity. First I need to fix my analysis to a particular strike *at the money*, so I chose a value for *K* equal to 170. The next thing to do, in order to deduce the dividend, is to exploit the absence of arbitrage opportunity and the Put-Call equality. By the combination of these two properties we obtain the following formulas:

$$price^{call}(K,T) \text{ - } price^{put}(K,T) = D_0(T) * (F_0(T) \text{ - } K)$$

$$F_0(T) = \mathrm{S} * (1 + rT) \text{ - } div$$

where r is the Libor interest rate (linear convention for the interest rate) and *div* are the dividends. I decided to use the Libor interest rate because if I use $1/D_0(T)$ as capitalisation factor I obtain negative dividends. This is due to the fact the D_0(T) values, that I have previously found, are most of the time greater than one and this imply a negative dividend, since the price of the underlying in this case is very high (S = 165.24). If we combine these formulas we obtain:

$$div = \{price^{put}(K,T) \text{ - } price^{call}(K,T) \text{ - } D_0(T)K + D_0(T)\mathrm{S}(1 + \mathrm{rT})\} \Big/ D_0(T)$$

Now I can just replace the values inside the formula to get the corresponding dividends (recall that S = 165.24).

For a maturity of three month I found a dividend of 1.2411 while in *yahoo.finance* site is equal to 1.075. The Forward Annual Dividend Rate is equal of 4.3 while I obtain a value of 3.8233, this is of course related to the fact that I chose a maturity of 10 months instead of 1 Year (the closest available date near one year). From *yahoo.finance* we know that the target dividend (for three months) should be 1.075 while for 1 Year should be 4.3, that is nothing more than the dividend of three months multiply by 4. This suggest that the dividend should be cumulative, so after I know the one of the three months I also know the one of 6 months, 1 Year *etc.*, but this may due to the fact that, in this case, the dividends are constant in the past Ex-Dividend Date. Unfortunately this behavior is not entirely clear from the results I have obtained (Fig. 2).

T	14/04/2022
C	1.68
P	6.7
D_0	0.9755
r	0.0098
div	0.5118

(a) Dividend for a maturity of 1 month

T	17/06/2022
C	3.25
P	8.95
D_0	1.01870
r	0.0098
div	1.2411

(b) Dividend for a maturity of 3 months

T	21/10/2022
C	6.825
P	12.6
D_0	1.006
r	0.0145
div	2.3792

(c) Dividend for a maturity of 7 months

T	20/01/2023
C	9
P	14.725
D_0	1.0031
r	0.0208
div	3.8233

(d) Dividend for a maturity of 10 months

Figure 2: Dividends for a fixed maturity T