

[Help](#)

```
#include <stdlib.h>
#include "cir1d_stdi.h"
#include "error_msg.h"

/*Product*/
static double dt, dr, r_min, r_max;
static double *r_vect;
static double *V, *Vp, *Option_values, *Ps, * *Obst;
static double *beta, *alpha_r, *beta_r, *gamma_r_, *alpha_l, *beta_l, *gamma_l;

/*Memory Allocation*/
static int memory_allocation(int Nt, int Ns)
{
    int i;

    if ((Obst = malloc(sizeof(double *) * (Nt + 1))) == NULL)
    {
        printf("Allocation error");
        exit(1);
    }
    for (i = 0; i <= Nt; i++)
    {
        Obst[i] = malloc(sizeof(double) * (Ns + 1));
    }

    r_vect = malloc((Ns + 1) * sizeof(double));
    if (r_vect == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    V = malloc((Ns + 1) * sizeof(double));
    if (V == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    Vp = malloc((Ns + 1) * sizeof(double));
    if (Vp == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    Option_values = malloc((Ns + 1) * sizeof(double));
    if (Option_values == NULL)
```

```
    return MEMORY_ALLOCATION_FAILURE;

    Ps = malloc((Ns + 1) * sizeof(double));
    if (Ps == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    beta = malloc((Ns + 1) * sizeof(double));
    if (beta == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    alpha_l = malloc((Ns + 1) * sizeof(double));
    if (alpha_l == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    beta_l = malloc((Ns + 1) * sizeof(double));
    if (beta_l == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    gamma_l = malloc((Ns + 1) * sizeof(double));
    if (gamma_l == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    alpha_r = malloc((Ns + 1) * sizeof(double));
    if (alpha_r == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    beta_r = malloc((Ns + 1) * sizeof(double));
    if (beta_r == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    gamma_r_ = malloc((Ns + 1) * sizeof(double));
    if (gamma_r_ == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    return OK;
}

/*Memory Desallocation*/
static void free_memory(int Nt)
{
    int i;
```

```

    for (i = 0; i < Nt + 1; i++)
        free(Obst[i]);
    free(Obst);

    free(beta);
    free(alpha_r);
    free(beta_r);
    free(gamma_r_);
    free(alpha_l);
    free(beta_l);
    free(gamma_l);

    free(r_vect);

    free(V);
    free(Vp);
    free(Ps);
    free(Option_values);

    return;
}

/*Zero Coupon Bond*/
static int zcb_cir(int Nt, int Ns)
{
    int i, TimeIndex;

    /*Maturity conditions for pure discount Bond*/
    for (i = 0; i <= Ns; i++)
    {
        Ps[i] = 1.;
        Obst[Nt][i] = Ps[i];
    }

    /*Finite Difference Cycle*/
    for (TimeIndex = Nt - 1; TimeIndex >= 0; TimeIndex--)
    {
        /*Right factor*/
        V[0] = beta_r[0] * Ps[0] + gamma_r_[0] * Ps[1];
        for (i = 1; i < Ns; i++)

```

```

        V[i] = alpha_r[i] * Ps[i - 1] + beta_r[i] * Ps[i] + gamma_r[i] * Ps[i + 1];

/*Backward Steps*/
Vp[Ns - 1] = V[Ns - 1];
beta[Ns - 1] = beta_l[Ns - 1];
for (i = Ns - 2; i >= 0; i--)
{
    beta[i] = beta_l[i] - gamma_l[i] * alpha_l[i + 1] / beta[i + 1];
    Vp[i] = V[i] - gamma_l[i] * Vp[i + 1] / beta[i + 1];
}

/*Forward Steps*/
Ps[0] = Vp[0] / beta[0];
for (i = 1; i < Ns; i++)
{
    Ps[i] = (Vp[i] - alpha_l[i] * Ps[i - 1]) / beta[i];
    Obst[TimeIndex][i] = Ps[i];
}
}

return 1.;
}

/*Finite Difference for the options prices*/
static int zbo_implicit(int Nt0, int Ns, NumFunc_1 *p, int am)
{
    int i, j, TimeIndex;

    /*Maturity conditions*/
    for (j = 0; j <= Ns; j++)
        Option_values[j] = (p->Compute)(p->Par, Obst[Nt0][j]);

    /*Finite Difference Cycle*/
    for (TimeIndex = Nt0 - 1; TimeIndex >= 0; TimeIndex--)
    {
        /*Right factor*/
        V[0] = beta_r[0] * Option_values[0] + gamma_r[0] * Option_values[1];
        for (i = 1; i < Ns; i++)
            V[i] = alpha_r[i] * Option_values[i - 1] + beta_r[i] * Option_values[i]

        /*Backward Steps*/

```

```

Vp[Ns - 1] = V[Ns - 1];
beta[Ns - 1] = beta_1[Ns - 1];
for (i = Ns - 2; i >= 0; i--)
{
    beta[i] = beta_1[i] - gamma_1[i] * alpha_1[i + 1] / beta[i + 1];
    Vp[i] = V[i] - gamma_1[i] * Vp[i + 1] / beta[i + 1];
}

/*Forward Steps*/
Option_values[0] = Vp[0] / beta[0];
for (i = 1; i < Ns; i++)
{
    Option_values[i] = (Vp[i] - alpha_1[i] * Option_values[i - 1]) / beta[i];
    /*American Case*/
    if (am)
    {
        Option_values[i] = MAX(Option_values[i], (p->Compute)(p->Par, Obst));
    }
}

return 1.;
}

/*Option Computation*/
static int zbo_cir1d(double r0, double k, double t0, double sigma, double theta,
{
    int i, j, Nt0;
    double val, val1, sigma2;

    /*Space Localisation*/
    memory_allocation(Nt, Ns);
    sigma2 = SQR(sigma);
    dt = (T - t0) / (double)Nt;
    r_min = 0.;
    r_max = 2.;
    dr = (r_max - r_min) / (double)Ns;
    r_vect[0] = r_min;
    for (i = 0; i <= Ns; i++)
        r_vect[i] = r_min + (double)i * dr;
}

```

```

/*Boundary*/
/*Computation of Rhs coefficients*/
alpha_r[0] = 0.;
beta_r[0] = (1. - cn_theta) * (1 - k * theta * (dt / dr));
gamma_r[0] = (1. - cn_theta) * (k * theta * (dt / dr));

/*Computation of Lhs coefficients*/
alpha_l[0] = 0.;
beta_l[0] = cn_theta * (1 + k * theta * (dt / dr));
gamma_l[0] = cn_theta * (-k * theta * (dt / dr));

/*Computation of the Matrix*/
for (i = 1; i < Ns; i++)
{
    /*Computation of Rhs coefficients*/
    alpha_r[i] = (1. - cn_theta) * (0.5 * sigma2 * r_vect[i] * (dt / SQR(dr))
    beta_r[i] = 1. - (1. - cn_theta) * (sigma2 * r_vect[i] * (dt / SQR(dr)) +
    gamma_r[i] = (1. - cn_theta) * (0.5 * sigma2 * r_vect[i] * (dt / SQR(dr))

    /*Computation of Lhs coefficients*/
    alpha_l[i] = cn_theta * (-0.5 * sigma2 * r_vect[i] * (dt / SQR(dr)) + 0.5
    beta_l[i] = 1. + cn_theta * (sigma2 * r_vect[i] * (dt / SQR(dr)) + r_vect[i]
    gamma_l[i] = cn_theta * (-0.5 * sigma2 * r_vect[i] * (dt / SQR(dr)) - 0.5
}

/*Compute Zero Coupon Prices*/
zcb_cir(Nt, Ns);

/*Number of Step for the Option*/
Nt0 = (int)ceil((t - t0) / dt);

/*Compute Option Prices*/
zbo_implicit(Nt0, Ns, p, am);

/*Linear Interpolation*/
j = 0;
while (r_vect[j] < r0)
    j++;
val = Option_values[j];
val1 = Option_values[j - 1];

```

```

/*Price*/
*price = val + (val - val1) * (r0 - r_vect[j]) / (r_vect[j] - r_vect[j - 1]);

/*Delta*/
/**delta=0.;*/

/*Memory Disallocation*/
free_memory(Nt);

return OK;
}

int CALC(FD_GaussZBO)(void *Opt, void *Mod, PricingMethod *Met)
{
    TYPEOPT *ptOpt = (TYPEOPT *)Opt;
    TYPEMOD *ptMod = (TYPEMOD *)Mod;

    return zbo_cir1d(ptMod->r0.Val.V_PDOUBLE, ptMod->k.Val.V_DOUBLE, ptMod->T.Val.V_
}

static int CHK_OPT(FD_GaussZBO)(void *Opt, void *Mod)
{
    if ((strcmp(((Option *)Opt)->Name, "ZeroCouponCallBondEuro") == 0) || (strcmp(
        return OK;
    else
        return WRONG;
}

static int MET(Init)(PricingMethod *Met, Option *Opt)
{
    if (Met->init == 0)
    {
        Met->init = 1;

        Met->Par[0].Val.V_INT2 = 300;
        Met->Par[1].Val.V_INT2 = 300;
        Met->Par[2].Val.V_RGDOUBLE = 0.5;
    }
}

```

```
    }  
    return OK;  
}  
  
PricingMethod MET(FD_GaussZBO) =  
{  
    "FD_Gauss_Cir1d_ZBO",  
    { {"SpaceStepNumber", INT2, {100}, ALLOW }, {"TimeStepNumber", INT2, {100}, A  
      {" ", PREMIA_NULLTYPE, {0}, FORBID}  
    },  
    CALC(FD_GaussZBO),  
    { {"Price", DOUBLE, {100}, FORBID}/*,{"Delta",DOUBLE,{100},FORBID} */ , {" ", PR  
    CHK_OPT(FD_GaussZBO),  
    CHK_ok,  
    MET(Init)  
} ;
```