

[Help](#)

```
#include <stdlib.h>
#include "bs1d_std.h"
#include "error_msg.h"
#define PRECISION 1.0e-7 /*Precision for the localization of FD methods*/

static void restriction(int l, double *d, double *u, double *f, double alpha, double beta, double gamma)
{
    int nl1, nl, i;
    double *Aux;

    nl = pow(2, l + 1) - 1;
    nl1 = pow(2, l) - 1;

    Aux = malloc((nl + 2) * sizeof(double));

    for (i = 1; i <= nl; i++)
        Aux[i] = alpha * u[i - 1] + beta * u[i] + gamma * u[i + 1] - f[i];

    for (i = 1; i <= nl1; i++)
        d[i] = Aux[2 * i] / 2.0 + (Aux[2 * i - 1] + Aux[2 * i + 1]) / 4.0;

    free(Aux);

    return;
}

static void subtract_prolongation(int l, double *u, double *v)
{
    int nl1, i;

    nl1 = pow(2, l) - 1;

    for (i = 0; i <= nl1; i++)
    {
        u[2 * i] = u[2 * i] - v[i];
        u[2 * i + 1] = u[2 * i + 1] - (v[i] + v[i + 1]) / 2.0;
    }
}
```

```

    }
    return;
}

```

```

static int MGM(int l, double *u, double *f, double t, double r, double divid, do
{
    int nl, nl1, i, j;
    double *v, *d;
    double h, k, vv, limit, alpha, beta, gamma, z, upwind_alphacoeff;

    nl = pow(2, l + 1) - 1;
    nl1 = pow(2, l) - 1;

    /*Memory Allocation*/
    v = malloc((nl1 + 2) * sizeof(double));
    if (v == NULL)
        return MEMORY_ALLOCATION_FAILURE;
    d = malloc((nl1 + 2) * sizeof(double));
    if (d == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    /*Time Step*/
    k = t / (double)M;

    /*Space Localisation*/
    z = (r - divid) - SQR(sigma) / 2.0;
    limit = sigma * sqrt(t) * sqrt(log(1.0 / PRECISION)) + fabs(z) * t;

    /*Space Step*/
    h = 2.*limit / (double)(nl + 1);

    /*Peclet Condition-Coefficient of diffusion augmented */
    vv = 0.5 * SQR(sigma);
    if ((h * fabs(z)) <= vv)
        upwind_alphacoeff = 0.5;
    else
    {
        if (z > 0.) upwind_alphacoeff = 0.0;
        else upwind_alphacoeff = 1.0;
    }
}

```

```

    }
    vv -= z * h * (upwind_alphacoef - 0.5);

    /*factor of theta-schema*/
    alpha = theta * k * (-vv / (h * h) + z / (2.0 * h));
    beta = 1.0 + k * theta * (r + 2.*vv / (h * h));
    gamma = k * theta * (-vv / (h * h) - z / (2.0 * h));

    if (l == 0)
    {
        u[1] = f[1] / (1 + k * theta * (vv / h / h + r));
    }
    else
    {
        /* 2 iterations of Gauss-Seidel*/
        for (i = 1; i < 3; i++)
        {
            for (j = 1; j <= nl; j++)
                u[j] = (-u[j - 1] * alpha - u[j + 1] * gamma + f[j]) / beta;
        }

        restriction(l, d, u, f, alpha, beta, gamma);

        for (i = 0; i < nl1 + 2; i++)
            v[i] = 0.0;

        MGM(l - 1, v, d, t, r, divid, sigma, N, M, theta);

        subtract_prolongation(l, u, v);

        /* 2 iterations of Gauss-Seidel*/
        for (i = 1; i < 3; i++)
        {
            for (j = 1; j <= nl; j++)
                u[j] = (-u[j - 1] * alpha - u[j + 1] * gamma + f[j]) / beta;
        }
    }
}

```

```

    free(v);
    free(d);

    return OK;
}

```

```

static int mult_euro1(double s, NumFunc_1 *p, double t, double r, double divid,
{
    double k, z, limit, h, x, alpha1, beta1, gamma1, vv, upwind_alphacoef;
    double *P, *Rhs;
    int Index, i, j, N;

    N = pow(2, l + 1) - 1 + 1;
    /*Memory Allocation*/
    P = malloc((N + 1) * sizeof(double));
    if (P == NULL)
        return MEMORY_ALLOCATION_FAILURE;
    Rhs = malloc((N + 1) * sizeof(double));
    if (Rhs == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    /*Time Step*/
    k = t / (double)M;

    /*Space Localisation*/
    z = (r - divid) - SQR(sigma) / 2.0;
    limit = sigma * sqrt(t) * sqrt(log(1.0 / PRECISION)) + fabs(z) * t;

    /*Space Step*/
    h = 2 * limit / (double)N;

    /*Peclet Condition-Coefficient of diffusion augmented */
    vv = 0.5 * SQR(sigma);
    if ((h * fabs(z)) <= vv)
        upwind_alphacoef = 0.5;
    else
    {
        if (z > 0.) upwind_alphacoef = 0.0;
        else upwind_alphacoef = 1.0;
    }
}

```

```

vv -= z * h * (upwind_alphacoef - 0.5);

/*Rhs factor of theta-schema*/
alpha1 = k * (1.0 - theta) * (vv / (h * h) - z / (2.0 * h));
beta1 = 1.0 - k * (1.0 - theta) * (r + 2.*vv / (h * h));
gamma1 = k * (1.0 - theta) * (vv / (h * h) + z / (2.0 * h));

/*Terminal Values*/
x = log(s);

for (i = 0; i < N + 1; i++)
    P[i] = (p->Compute)(p->Par, exp(x - limit + (double)i * h));

/*Finite Difference Cycle*/
for (i = 1; i <= M; i++)
{
    /*Init Rhs*/
    for (j = 1; j < N; j++)
        Rhs[j] = alpha1 * P[j - 1] + beta1 * P[j] + gamma1 * P[j + 1];

    /*Multi-grid method*/
    MGM(1, P, Rhs, t, r, divid, sigma, N, M, theta);
}
/*End Finite Difference Cycle*/

Index = (int) floor((double)N / 2.0);

/*Price*/
*ptprice = P[Index];

/*Delta*/
*ptdelta = (P[Index + 1] - P[Index - 1]) / (2.0 * s * h);

/*Memory Desallocation*/
free(P);
free(Rhs);

return OK;
}

```

```

int CALC(FD_Multigrid_Euro)(void *Opt, void *Mod, PricingMethod *Met)
{
    TYPEOPT *ptOpt = (TYPEOPT *)Opt;
    TYPEMOD *ptMod = (TYPEMOD *)Mod;
    double r, divid;

    r = log(1. + ptMod->R.Val.V_DOUBLE / 100.);
    divid = log(1. + ptMod->Divid.Val.V_DOUBLE / 100.);

    return mult_euro1(ptMod->S0.Val.V_PDOUBLE, ptOpt->PayOff.Val.V_NUMFUNC_1,
                     ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE, r, divid,
                     Met->Par[0].Val.V_INT, Met->Par[1].Val.V_INT, Met->Par[2].Val.V_INT,
                     &(Met->Res[0].Val.V_DOUBLE), &(Met->Res[1].Val.V_DOUBLE));
}

```

```

static int CHK_OPT(FD_Multigrid_Euro)(void *Opt, void *Mod)
{
    Option *ptOpt = (Option *)Opt;
    TYPEOPT *opt = (TYPEOPT *) (ptOpt->TypeOpt);

    if ((opt->EuOrAm). Val.V_BOOL == EURO)
        return OK;

    return WRONG;
}

```

```

static int MET(Init)(PricingMethod *Met, Option *Opt)
{
    if (Met->init == 0)
    {
        Met->init = 1;
        Met->HelpFilenameHint = "FD_Multigrid_Euro_bs";
        Met->Par[0].Val.V_INT2 = 6;
        Met->Par[1].Val.V_INT2 = 128;
        Met->Par[2].Val.V_RGDOUBLE = 0.5;
    }
}

```

```
    }

    return OK;
}

PricingMethod MET(FD_Multigrid_Euro) =
{
    "FD_Multigrid_Euro",
    {"Number of Grids", INT2, {100}, ALLOW    }, {"TimeStepNumber", INT2, {100},
    CALC(FD_Multigrid_Euro),
    {"Price", DOUBLE, {100}, FORBID}, {"Delta", DOUBLE, {100}, FORBID} , {" ", PR
    CHK_OPT(FD_Multigrid_Euro),
    CHK_fdiff,
    MET(Init)
};
```