

[Help](#)

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#include <stdlib.h>
#include "bs2d_std2d.h"
#include "error_msg.h"
#include "enums.h"

static double *Mesh = NULL, *Path = NULL, *Price = NULL, *VectInvMeshDensity = N
static double *Aux_BS_TD_1 = NULL, *Aux_BS_TD_2 = NULL, *InvSigma = NULL;
static double Norm_BS_TD, DetInvSigma;
static double *AuxBS = NULL, *Sigma = NULL, *Aux_Stock = NULL;

static int BrGl_Allocation(long AL_Mesh_Size, int OP_Exercise_Dates, int BS_Dime
{
    if (Mesh == NULL)
        Mesh = malloc(AL_Mesh_Size * OP_Exercise_Dates * BS_Dimension * sizeof(doubl
    if (Mesh == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    if (Price == NULL)
        Price = malloc(AL_Mesh_Size * OP_Exercise_Dates * sizeof(double));
    if (Price == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    if (Path == NULL)
        Path = malloc(OP_Exercise_Dates * BS_Dimension * sizeof(double));

    if (Path == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    if (VectInvMeshDensity == NULL)
        VectInvMeshDensity = malloc(AL_Mesh_Size * sizeof(double));

    if (VectInvMeshDensity == NULL)
        return MEMORY_ALLOCATION_FAILURE;

    if (Aux_BS_TD_1 == NULL)
        Aux_BS_TD_1 = malloc(BS_Dimension * sizeof(double));
    if (Aux_BS_TD_1 == NULL)
        return MEMORY_ALLOCATION_FAILURE;
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if (Aux_BS_TD_2 == NULL)
    Aux_BS_TD_2 = malloc(BS_Dimension * sizeof(double));
if (Aux_BS_TD_2 == NULL)
    return MEMORY_ALLOCATION_FAILURE;

if (InvSigma == NULL)
    InvSigma = malloc(BS_Dimension * BS_Dimension * sizeof(double));
if (InvSigma == NULL)
    return MEMORY_ALLOCATION_FAILURE;

if (Sigma == NULL)
    Sigma = malloc(BS_Dimension * BS_Dimension * sizeof(double));
if (Sigma == NULL)
    return MEMORY_ALLOCATION_FAILURE;

if (AuxBS == NULL)
    AuxBS = malloc(BS_Dimension * sizeof(double));
if (AuxBS == NULL)
    return MEMORY_ALLOCATION_FAILURE;

if (Aux_Stock == NULL)
    Aux_Stock = malloc(BS_Dimension * sizeof(double));
if (Aux_Stock == NULL)
    return MEMORY_ALLOCATION_FAILURE;

return OK;
}

static void Brod_Liberation()
{
    if (Mesh != NULL)
    {
        free(Mesh);
        Mesh = NULL;
    }

    if (Price != NULL)
    {
        free(Price);
        Price = NULL;
    }
}
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if (Path != NULL)
{
    free(Path);
    Path = NULL;
}

if (VectInvMeshDensity != NULL)
{
    free(VectInvMeshDensity);
    VectInvMeshDensity = NULL;
}

if (Aux_BS_TD_1 != NULL)
{
    free(Aux_BS_TD_1);
    Aux_BS_TD_1 = NULL;
}

if (Aux_BS_TD_2 != NULL)
{
    free(Aux_BS_TD_2);
    Aux_BS_TD_2 = NULL;
}

if (InvSigma != NULL)
{
    free(InvSigma);
    InvSigma = NULL;
}

if (Aux_Stock != NULL)
{
    free(Aux_Stock);
    Aux_Stock = NULL;
}

if (AuxBS != NULL)
{
    free(AuxBS);
    AuxBS = NULL;
}
```

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    if (Sigma != NULL)
    {
        free(Sigma);
        Sigma = NULL;
    }
}

static double Discount(double Time, double BS_Interest_Rate)
{
    return exp(-BS_Interest_Rate * Time);
}

static void BS_Transition_Allocation(int BS_Dimension, double Step)
{
    int i;
    PnlMat InvSigma_wrap, Sigma_wrap;

    Sigma_wrap = pnl_mat_wrap_array(Sigma, BS_Dimension, BS_Dimension);
    InvSigma_wrap = pnl_mat_wrap_array(InvSigma, BS_Dimension, BS_Dimension);
    pnl_mat_inverse(&InvSigma_wrap, &Sigma_wrap);

    /* determinant of InvSigma */
    DetInvSigma = 1;
    for (i = 0; i < BS_Dimension; i++)
        DetInvSigma *= InvSigma[i * BS_Dimension + i];

    Norm_BS_TD = exp(-BS_Dimension * 0.5 * log(2.*M_PI * Step));
}

/*Black-Sholes Conditional Density function knowing Z*/
static double BS_TD(double *X, double *Z, int BS_Dimension, double Step)
{
    int i, j;
    double aux1, aux2;

    for (i = 0; i < BS_Dimension; i++)
    {
        Aux_BS_TD_1[i] = log(Z[i] / X[i]) + Step * AuxBS[i];
    }
    aux1 = Z[0];

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for (i = 1; i < BS_Dimension; i++)
{
    aux1 *= Z[i];
}
if (aux1 == 0)
{
    return -1;
}
else
{
    for (i = 0; i < BS_Dimension; i++)
    {
        Aux_BS_TD_2[i] = 0;
        for (j = 0; j <= i; j++)
        {
            Aux_BS_TD_2[i] += InvSigma[i * BS_Dimension + j] * Aux_BS_TD_1[j];
        }
    }
    aux2 = 0;
    for (i = 0; i < BS_Dimension; i++)
    {
        aux2 += Aux_BS_TD_2[i] * Aux_BS_TD_2[i];
    }
    aux2 = exp(-aux2 / (2.*Step));
    return Norm_BS_TD * DetInvSigma * aux2 / aux1;
}
}

static double MeshDensity(int Time, double *Stock, int OP_Exercise_Dates, int AL
{
    long k;
    double aux = 0;

    if (Time > 1)
    {
        for (k = 0; k < AL_Mesh_Size; k++)
            aux += BS_TD(Mesh + k * OP_Exercise_Dates * BS_Dimension + (Time - 1) *
        return aux / (double)AL_Mesh_Size;
    }
    else
    {

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        return BS_TD(BS_Spot, Stock, BS_Dimension, Step);
    }
}

static double Weight(int Time, double *iStock, double *jStock, int j, int BS_Dim,
                    double Step)
{
    if (Time > 0)
    {
        return BS_TD(iStock, jStock, BS_Dimension, Step) * VectInvMeshDensity[j];
    }
    else
    {
        return 1.;
    }
}

static void BS_Forward_Step(int generator, double *Stock, double *Initial_Stock,
{
    int j, k;
    double Aux;

    for (j = 0; j < BS_Dimension; j++)
    {
        Aux_Stock[j] = Sqrt_Step * pnl_rand_normal(generator);
    }
    for (j = 0; j < BS_Dimension; j++)
    {
        Aux = 0.;
        for (k = 0; k <= j; k++)
        {
            Aux += Sigma[j * BS_Dimension + k] * Aux_Stock[k];
        }
        Aux -= Step * AuxBS[j];
        Stock[j] = Initial_Stock[j] * exp(Aux);
    }
}

static void InitMesh(int generator, int AL_Mesh_Size, int BS_Dimension, double *
{

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int j, k, aux;

for (k = 0; k < AL_Mesh_Size; k++)
{
    BS_Forward_Step(generator, Mesh + k * OP_Exercise_Dates * BS_Dimension + B
}
for (j = 2; j < OP_Exercise_Dates; j++)
{
    for (k = 0; k < AL_Mesh_Size; k++)
    {

        aux = (int)(AL_Mesh_Size * pnl_rand_uni(generator));

        BS_Forward_Step(generator, Mesh + k * OP_Exercise_Dates * BS_Dimension
    }
}

static void BrGl(double *AL_Price,
                long AL_MonteCarlo_Iterations,
                NumFunc_2 *p, int AL_Mesh_Size,
                int AL_ShuttingDown,
                int generator,
                int OP_Exercise_Dates,
                double *BS_Spot,
                double BS_Maturity,
                double BS_Interest_Rate,
                double *BS_Dividend_Rate,
                double *BS_Volatility,
                int gj_flag)
{
    double aux, Step, Sqrt_Step, DiscountStep;
    long i, j, k;
    int l;
    double AL_BPrice, AL_FPrice;
    int BS_Dimension = 2;

    AL_BPrice = 0.;
    AL_FPrice = 0.;
    Step = BS_Maturity / (double)(OP_Exercise_Dates - 1);

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Sqrt_Step = sqrt(Step);
DiscountStep = exp(-BS_Interest_Rate * Step);

/*Memory Allocation*/
BrGl_Allocation(AL_Mesh_Size, OP_Exercise_Dates, BS_Dimension);

/*Black-Sholes initialization parameters*/
Sigma[0] = BS_Volatility[0];
Sigma[1] = BS_Volatility[1];
Sigma[2] = BS_Volatility[2];
Sigma[3] = BS_Volatility[3];
AuxBS[0] = 0.5 * (SQR(Sigma[0]) + SQR(Sigma[1])) - BS_Interest_Rate + BS_Divid
AuxBS[1] = 0.5 * (SQR(Sigma[2]) + SQR(Sigma[3])) - BS_Interest_Rate + BS_Divid
BS_Transition_Allocation(BS_Dimension, Step);

/*Initialization of the mesh*/
InitMesh(generator, AL_Mesh_Size, BS_Dimension, BS_Spot, OP_Exercise_Dates, St

for (i = 0; i < AL_Mesh_Size; i++)
    Price[i * OP_Exercise_Dates + OP_Exercise_Dates - 1] = 0.;

/*Dynamical programing: Backward Price */
for (j = OP_Exercise_Dates - 2; j >= 1; j--)
{
    for (i = 0; i < AL_Mesh_Size; i++)
    {
        VectInvMeshDensity[i] = 1. / MeshDensity(j + 1, Mesh + i * OP_Exercise

    }
    for (i = 0; i < AL_Mesh_Size; i++)
    {
        aux = 0;
        for (k = 0; k < AL_Mesh_Size; k++)
        {

            /*Payoff control variate*/
            aux += (Price[k * OP_Exercise_Dates + j + 1] +
                    (p->Compute)(p->Par, *(Mesh + k * OP_Exercise_Dates * BS_D

        }
        aux *= DiscountStep / (double)AL_Mesh_Size;

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        aux -= (p->Compute)(p->Par, *(Mesh + i * OP_Exercise_Dates * BS_Dimens
                                *(Mesh + i * OP_Exercise_Dates * BS_Dimension + j
        Price[i * OP_Exercise_Dates + j] = MAX(0, aux);
    }
}

aux = 0;
for (i = 0; i < AL_Mesh_Size; i++)
{
    aux += Price[i * OP_Exercise_Dates + 1] + (p->Compute)(p->Par, *(Mesh + i

/*Backward Price*/
if (!gj_flag)
    AL_BPrice = MAX((p->Compute)(p->Par, *(BS_Spot), *(BS_Spot + 1)), DiscountSt
else
    AL_BPrice = DiscountStep * aux / (double)AL_Mesh_Size;

/* Forward Price */
AL_FPrice = 0;
for (i = 0; i < AL_MonteCarlo_Iterations; i++)
{

    for (l = 0; l < BS_Dimension; l++)
    {
        Path[l] = BS_Spot[l];
    }

    j = 0;
    do
    {
        aux = 0;
        for (k = 0; k < AL_Mesh_Size; k++)
        {
            aux += (Price[k * OP_Exercise_Dates + j + 1] + (p->Compute)(p->Par
        }
        aux *= DiscountStep / (double)AL_Mesh_Size;
        aux -= (p->Compute)(p->Par, *(Path + j * BS_Dimension), *(Path + j * B

        j++;
        BS_Forward_Step(generator, Path + j * BS_Dimension, Path + (j - 1)*BS_

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    }
    while ((0 < aux) && (j < OP_Exercise_Dates - 1));
    AL_FPrice += Discount((double)(j) * Step, BS_Interest_Rate) * (p->Compute)
  }
  AL_FPrice /= (double)AL_MonteCarlo_Iterations;

  /*Price = Mean of Forward and Backward Price*/
  *AL_Price = 0.5 * (AL_FPrice + AL_BPrice);

  /*Memory Disallocation*/
  if (AL_ShuttingDown)
  {
    Brod_Liberation();
  }
}

```

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static int MCBroadieGlassermann2D(double s1, double s2, NumFunc_2 *p, double t,
{

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  double p1, p2, p3;
  int simulation_dim = 1, fermeture = 1, init_mc;
  double s_vector[2];
  double s_vector_plus1[2], s_vector_plus2[2];
  double sigma[4];
  double divid[2];

  /* Covariance Matrix */
  /* Coefficients of the matrix A such that A(tA)=Gamma */
  sigma[0] = sigma1;
  sigma[1] = 0.0;
  sigma[2] = rho * sigma2;
  sigma[3] = sigma2 * sqrt(1.0 - SQR(rho));

  /*Initialisation*/
  s_vector[0] = s1;
  s_vector[1] = s2;
  s_vector_plus1[0] = s1 * (1. + inc);
  s_vector_plus1[1] = s2;
  s_vector_plus2[0] = s1;

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```

s_vector_plus2[1] = s2 * (1. + inc);
divid[0] = divid1;
divid[1] = divid2;

/*MC sampling*/
init_mc = pnl_rand_init(generator, simulation_dim, N);

/* Test after initialization for the generator */
if (init_mc == OK)
{

    /*Geske-Johnson Formulae*/
    if (exercise_date_number == 0)
    {
        BrGl(&p3, N, p, mesh_size, fermeture, generator, 4, s_vector, t, r, di
        BrGl(&p2, N, p, mesh_size, fermeture, generator, 3, s_vector, t, r, di
        BrGl(&p1, N, p, mesh_size, fermeture, generator, 2, s_vector, t, r, di
        *ptprice = p3 + 7. / 2.*(p3 - p2) - (p2 - p1) / 2.;
    }
    else
    {
        BrGl(ptprice, N, p, mesh_size, fermeture, generator, exercise_date_num
    }

    /*Delta*/
    if (exercise_date_number == 0)
    {
        BrGl(&p1, N, p, mesh_size, fermeture, generator, 2, s_vector_plus1, t,
        BrGl(&p2, N, p, mesh_size, fermeture, generator, 3, s_vector_plus1, t,
        BrGl(&p3, N, p, mesh_size, fermeture, generator, 4, s_vector_plus1, t,
        *ptdelta1 = ((p3 + 7. / 2.*(p3 - p2) - (p2 - p1) / 2.) - *ptprice) / (
        BrGl(&p1, N, p, mesh_size, fermeture, generator, 2, s_vector_plus2, t,
        BrGl(&p2, N, p, mesh_size, fermeture, generator, 3, s_vector_plus2, t,
        BrGl(&p3, N, p, mesh_size, fermeture, generator, 4, s_vector_plus2, t,
        *ptdelta2 = ((p3 + 7. / 2.*(p3 - p2) - (p2 - p1) / 2.) - *ptprice) / (
    }
    else
    {
        BrGl(&p1, N, p, mesh_size, fermeture, generator, exercise_date_number,
        *ptdelta1 = (p1 - *ptprice) / (s1 * inc);
    }
}

```

```

        BrG1(&p2, N, p, mesh_size, fermeture, generator, exercise_date_number,
            *ptdelta2 = (p2 - *ptprice) / (s2 * inc);
    }
}
return init_mc;
}

int CALC(MC_BroadieGlassermann2D)(void *Opt, void *Mod, PricingMethod *Met)
{
    TYPEOPT *ptOpt = (TYPEOPT *)Opt;
    TYPEMOD *ptMod = (TYPEMOD *)Mod;
    double r, divid1, divid2;

    r = log(1. + ptMod->R.Val.V_DOUBLE / 100.);
    divid1 = log(1. + ptMod->Divid1.Val.V_DOUBLE / 100.);
    divid2 = log(1. + ptMod->Divid1.Val.V_DOUBLE / 100.);

    return MCBroadieGlassermann2D(ptMod->S01.Val.V_PDOUBLE,
                                    ptMod->S02.Val.V_PDOUBLE,
                                    ptOpt->PayOff.Val.V_NUMFUNC_2,
                                    ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE,
                                    r,
                                    divid1,
                                    divid2,
                                    ptMod->Sigma1.Val.V_PDOUBLE,
                                    ptMod->Sigma2.Val.V_PDOUBLE,
                                    ptMod->Rho.Val.V_RGDOUBLE,
                                    Met->Par[0].Val.V_LONG,
                                    Met->Par[1].Val.V_ENUM.value,
                                    Met->Par[2].Val.V_PDOUBLE,
                                    Met->Par[3].Val.V_INT,
                                    Met->Par[4].Val.V_INT,
                                    &(Met->Res[0].Val.V_DOUBLE),
                                    &(Met->Res[1].Val.V_DOUBLE), &(Met->Res[2].Val.V_DOUBLE);
}

static int CHK_OPT(MC_BroadieGlassermann2D)(void *Opt, void *Mod)
{
    Option *ptOpt = (Option *)Opt;
    TYPEOPT *opt = (TYPEOPT *) (ptOpt->TypeOpt);

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    if ((opt->EuOrAm).Val.V_BOOL == AMER)
        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_LONG = 10000;
        Met->Par[1].Val.V_ENUM.value = 0;
        Met->Par[1].Val.V_ENUM.members = &PremiaEnumMCRNGs;
        Met->Par[2].Val.V_PDOUBLE = 0.1;
        Met->Par[3].Val.V_INT = 200;
        Met->Par[4].Val.V_INT = 20;

    }

    return OK;
}

```

```

PricingMethod MET(MC_BroadieGlassermann2D) =
{
    "MC_BroadieGlassermann2d",
    { {"N iterations", LONG, {100}, ALLOW},
      {"RandomGenerator", ENUM, {100}, ALLOW},
      {"Delta Increment Rel", PDOUBLE, {100}, ALLOW},
      {"Mesh Size", INT, {100}, ALLOW},
      {"Number of Exercise Dates (0->Geske Johnson Formulae)", INT, {100}, ALLOW},
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CALC(MC_BroadieGlassermann2D),
    { {"Price", DOUBLE, {100}, FORBID},
      {"Delta1", DOUBLE, {100}, FORBID} , {"Delta2", DOUBLE, {100}, FORBID},
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
}

```

```
CHK_OPT(MC_BroadieGlassermann2D),  
CHK_mc,  
MET(Init)  
};
```