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#include <stdlib.h>
#include "bs1d_std.h"
#include "error_msg.h"
#include "enums.h"

static double *FP = NULL, *Traj = NULL;
static PnlMat *M = NULL;
static PnlVect *AuxR = NULL, *VBase = NULL, *Res = NULL;

static double *Pont = NULL;
static double (*basis)(double *stock, int l, NumFunc_1 *p);

static int LongRet_Allocation(long MC_Iterations, int DimApprox, int DimBS)
{
    if (FP == NULL)
        FP = malloc(MC_Iterations * sizeof(double));

    if (FP == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (Traj == NULL)
        Traj = malloc(MC_Iterations * DimBS * sizeof(double));

    if (Traj == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (M == NULL) M = pnl_mat_create(DimApprox, DimApprox);
    if (M == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (Res == NULL) Res = pnl_vect_create(DimApprox);
    if (Res == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (AuxR == NULL) AuxR = pnl_vect_create(DimApprox);
    if (AuxR == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (VBase == NULL) VBase = pnl_vect_create(DimApprox);
    if (VBase == NULL) return MEMORY_ALLOCATION_FAILURE;

    if (Pont == NULL)
        Pont = malloc(MC_Iterations * DimBS * sizeof(double));
    if (Pont == NULL) return MEMORY_ALLOCATION_FAILURE;
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    return OK;
}

static void LongRet_Liberation()
{
    if (FP != NULL)
    {
        free(FP);
        FP = NULL;
    }
    if (Traj != NULL)
    {
        free(Traj);
        Traj = NULL;
    }

    if (Pont != NULL)
    {
        free(Pont);
        Pont = NULL;
    }
    if (M != NULL)
    {
        pnl_mat_free(&M);
    }
    if (Res != NULL)
    {
        pnl_vect_free(&Res);
    }
    if (AuxR != NULL)
    {
        pnl_vect_free(&AuxR);
    }
    if (VBase != NULL)
    {
        pnl_vect_free(&VBase);
    }

    return;
}
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/*Canonical Basis for Regression*/
static double CanonicalD1(double *x, int ind, NumFunc_1 *p)
{
    double aux;
    int i;

    aux = 1.;
    for (i = 0; i < ind; i++)
        aux *= (*x);
    return aux;
}

/*Basis Regression=Payoff + Canonncal*/
static double CanonicalOpD1(double *x, int ind, NumFunc_1 *p)
{
    if (ind == 0) return (p->Compute)(p->Par, *x);
    else return CanonicalD1(x, ind - 1, p);
}

/*Normalized Laguerre Basis*/
static double LaguerreD1(double *x, int ind, NumFunc_1 *p)
{
    switch (ind)
    {
        case 0 :
            return 1;
        case 1 :
            return exp(-(*x) * 0.5);
        case 2 :
            return exp(-(*x) * 0.5) * (1 - (*x));
        case 3 :
            return exp(-(*x) * 0.5) * (1 - 2 * (*x) + 0.5 * (*x) * (*x));
        case 4 :
            return exp(-(*x) * 0.5) * (-0.5 * (*x) * (*x) * (*x) + 4.5 * (*x) * (*x)
                - 9 * (*x) + 3);
        case 5 :
            return exp(-(*x) * 0.5) * (0.5 * (*x) * (*x) * (*x) * (*x) - 8 * (*x) * (*x)
                + 36 * (*x) * (*x) - 48 * (*x) + 12);
        case 6 :
            return exp(-(*x) * 0.5) * (-0.5 * (*x) * (*x) * (*x) * (*x) * (*x)

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+ 12.5 * (*x) * (*x) * (*x) * (*x)
- 100 * (*x) * (*x) * (*x) + 300 * (*x) * (*x)
- 300 * (*x) + 60);

    default :
        return 1;
    }
}

static void name_to_basis(int name_basis)
{

    switch (name_basis)
    {
        case 1 :
            basis = CanonicalD1;
        case 2 :
            basis = LaguerreD1;
        case 3 :
            basis = CanonicalOpD1;

        default :
            basis = CanonicalD1;
    }
}

static void InitBridge(long MC_Iterations, int generator, int dim, double t)
{
    int i;
    long j;
    double squareroott;

    squareroott = sqrt(t);

    for (j = 0; j < MC_Iterations; j++)
        for (i = 0; i < dim; i++)
            Pont[j * dim + i] = squareroott * pnl_rand_normal(generator);
}

static void ComputeBridge(int k, double step, long MC_Iterations, int generator)
{

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double aux1, aux2, *ad, *admax;

aux1 = (double)k / (double)(k + 1);
aux2 = sqrt(aux1 * step);
ad = Pont;
admax = Pont + MC_Iterations;

for (ad = Pont; ad < admax; ad++)
    *ad = aux1 * (*ad) + aux2 * pnl_rand_normal(generator);

return;
}

static void BackwardPaths(double t, long MC_Iterations, double s, double sigma,
                        double r, double divid)
{
    long n;
    double forward_stock;

    forward_stock = s * exp(((r - divid) - 0.5 * SQR(sigma)) * t);
    for (n = 0; n < MC_Iterations; n++)
        Traj[n] = forward_stock * exp(sigma * Pont[n]);
}

static void Regression(long MC_Iterations, NumFunc_1 *p, int DimApp)
{
    int i, j, k;

    pnl_vect_set_double(AuxR, 0.0);
    pnl_mat_set_double(M, 0.0);

    for (k = 0; k < MC_Iterations; k++)
    {
        if ((p->Compute)(p->Par, *(Traj + k)) > 0)
        {
            for (i = 0; i < DimApp; i++)
            {
                pnl_vect_set(VBase, i, basis(Traj + k, i, p));
            }
        }
    }
}

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        for (i = 0; i < DimApp; i++)
            for (j = 0; j < DimApp; j++)
            {
                double tmp = pnl_mat_get(M, i, j);
                pnl_mat_set(M, i, j, tmp + pnl_vect_get(VBase, i) *
                    pnl_vect_get(VBase, j));
            }

        for (i = 0; i < DimApp; i++)
        {
            double tmp = pnl_vect_get(AuxR, i);
            pnl_vect_set(AuxR, i, FP[k] * pnl_vect_get(VBase, i) + tmp);
        }
    }
    pnl_vect_clone(Res, AuxR);
    /* solve in the least square sense, using a QR decomposition */
    pnl_mat_ls(M, Res);

    return;
}

static void LoScRet(double *PrixDir, long MC_Iterations, NumFunc_1 *p, int name_
{
    long i;
    int k, l;
    double AuxOption, discount1, step, AuxScal;

    /*Initialization of the regression basis*/
    name_to_basis(name_basis);

    /*Memory Allocation*/
    LongRet_Allocation(MC_Iterations, DimApprox, 1);

    step = t / (exercise_date_number - 1.);
    *PrixDir = 0;

    /*Initialization of brownian bridge at maturity*/
    InitBridge(MC_Iterations, generator, 1, t);

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/*Initialization of Black-Sholes Paths at maturity*/
BackwardPaths(t, MC_Iterations, s, sigma, r, divid);

/*Payoff at maturity*/
discount1 = exp(-r * step);
for (i = 0; i < MC_Iterations; i++)
{
    FP[i] = (p->Compute)(p->Par, *(Traj + i));
    if (FP[i] > 0) FP[i] = discount1 * FP[i];
}

/*Backward dynamical programming*/
for (k = exercise_date_number - 2; k >= 1; k--)
{

    /*Backward simulation of the brownian bridge from time k+1 to k*/
    ComputeBridge(k, step, MC_Iterations, generator);

    /*Backward simulation of Black-sholes Paths from time k+1 to k*/
    BackwardPaths(k * step, MC_Iterations, s, sigma, r, divid);

    /*Regression of FP with respect to Black-Sholes Paths at time k*/
    Regression(MC_Iterations, p, DimApprox);

    /*Dynamical programming*/
    for (i = 0; i < MC_Iterations; i++)
    {
        AuxOption = (p->Compute)(p->Par, *(Traj + i));

        /*The regression take into account only at the money paths*/
        if (AuxOption > 0)
        {
            AuxScal = 0.;
            for (l = 0; l < DimApprox; l++)
                AuxScal += basis(Traj + i, l, p) * pnl_vect_get(Res, l);

            if (AuxOption > AuxScal)
                FP[i] = AuxOption;
        }
        FP[i] *= discount1;
    }
}

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    }
}

/*At time 0, regression=mean*/
AuxOption = (p->Compute)(p->Par, s);
if (AuxOption > 0)
{
    double tmp = 0.;
    for (i = 0; i < MC_Iterations; i++) tmp += FP[i];
    tmp /= MC_Iterations;
    if (!gj_flag)
    {
        if (AuxOption > tmp)
            for (i = 0; i < MC_Iterations; i++)
                FP[i] = AuxOption;
    }
}

/*Mean along the optimal stopping time*/
for (i = 0; i < MC_Iterations; i++)
{
    *PrixDir += FP[i];
}

/* Forward Price*/
*PrixDir /= (double)MC_Iterations;

/*Memory Disallocation*/
if (Fermeture)
{
    LongRet_Liberation();
}

return;
}

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static int MCLongstaffSchwartz(double s, NumFunc_1 *p, double t, double r, double
{

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double s_plus, p1, p2, p3;
int simulation_dim = 1, fermeture = 1, init_mc;

/*Initialisation*/
s_plus = s * (1. + inc);

/*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)
    {
        LoScRet(&p1, N, p, basis, dimapprox, fermeture, generator, 2, s, t, r,
        LoScRet(&p2, N, p, basis, dimapprox, fermeture, generator, 3, s, t, r,
        LoScRet(&p3, N, p, basis, dimapprox, fermeture, generator, 4, s, t, r,
        *ptprice = p3 + 7. / 2.*(p3 - p2) - (p2 - p1) / 2.;
    }
    else
    {
        LoScRet(ptprice, N, p, basis, dimapprox, fermeture, generator, exercise_date_number, s, t, r,
    }

    /*Delta*/
    /* init_mc= pnl_rand_init(generator,simulation_dim,N);
    */
    if (exercise_date_number == 0)
    {
        LoScRet(&p1, N, p, basis, dimapprox, fermeture, generator, 2, s_plus,
        LoScRet(&p2, N, p, basis, dimapprox, fermeture, generator, 3, s_plus,
        LoScRet(&p3, N, p, basis, dimapprox, fermeture, generator, 4, s_plus,
        *ptdelta = ((p3 + 7. / 2.*(p3 - p2) - (p2 - p1) / 2.) - *ptprice) / (s - s_plus);
    }
    else
    {
        LoScRet(&p1, N, p, basis, dimapprox, fermeture, generator, exercise_date_number, s_plus,
        *ptdelta = (p1 - *ptprice) / (s * inc);
    }
}

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    }
}

return init_mc;
}

int CALC(MC_LongstaffSchwartz)(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 MCLongstaffSchwartz(ptMod->S0.Val.V_PDOUBLE,
                               ptOpt->PayOff.Val.V_NUMFUNC_1,
                               ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE,
                               r,
                               divid,
                               ptMod->Sigma.Val.V_PDOUBLE,
                               Met->Par[0].Val.V_LONG,
                               Met->Par[1].Val.V_ENUM.value,
                               Met->Par[2].Val.V_PDOUBLE,
                               Met->Par[3].Val.V_ENUM.value,
                               Met->Par[4].Val.V_INT,
                               Met->Par[5].Val.V_INT,
                               &(Met->Res[0].Val.V_DOUBLE),
                               &(Met->Res[1].Val.V_DOUBLE));
}

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

    if ((opt->EuOrAm).Val.V_BOOL == AMER)
        return OK;
    else
        return WRONG;
}

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PremiaEnumMember Basis1dMembers[] =
{
    { "CanonicalD1",    1 },
    { "LaguerreD1",     2 },
    { "CanonicalOpD1",  3 },
    { NULL, NULLINT }
};

static DEFINE_ENUM(Basis1d, Basis1dMembers);

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

        Met->Par[0].Val.V_LONG = 50000;
        Met->Par[1].Val.V_ENUM.value = 0;
        Met->Par[1].Val.V_ENUM.members = &PremiaEnumMCRNGs;
        Met->Par[2].Val.V_PDOUBLE = 0.01;
        Met->Par[3].Val.V_ENUM.value = 3;
        Met->Par[3].Val.V_ENUM.members = &Basis1d;
        Met->Par[4].Val.V_INT = 4;
        Met->Par[5].Val.V_INT = 20;

    }

    return OK;
}

PricingMethod MET(MC_LongstaffSchwartz) =
{
    "MC_LongstaffSchwartz",
    { {"N iterations", LONG, {100}, ALLOW},
      {"RandomGenerator", ENUM, {100}, ALLOW},
      {"Delta Increment Rel", PDOUBLE, {100}, ALLOW},
      {"Basis", ENUM, {100}, ALLOW},
      {"Dimension Approximation", INT, {100}, ALLOW},
      {"Number of Exercise Dates (0->Geske Johnson Formulae", INT, {100}, ALLOW},
    }
}

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    {" ", PREMIA_NULLTYPE, {0}, FORBID}
},
CALC(MC_LongstaffSchwartz),
{ {"Price", DOUBLE, {100}, FORBID},
  {"Delta", DOUBLE, {100}, FORBID} ,
  {" ", PREMIA_NULLTYPE, {0}, FORBID}
},
CHK_OPT(MC_LongstaffSchwartz),
CHK_mc,
MET(Init)
};
```