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```
#include <stdlib.h>
#include <stdio.h>

#include "pnl/pnl_matrix.h"
#include "pnl/pnl_random.h"
#include "pnl/pnl_basis.h"
#include "local_vol_callable.h"

#define eps 0.0000001

//CODE POUR COUPON CONSTANT
typedef struct
{
    double Pbarre;
    double Nbarre;
    double Cbarre;
    double Sup;
    double Slow;
    double eta;
    double sigma;
    double r;
    double q;
    double gamma0;
    double alpha;
    double R;
    double cbarre;
} param;

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2011+2) //The "#els

#else

//definition du drift local
static double b(double t, double x, double spot, param *P)
{
    return P->r - P->q + P->gamma0 * pow(spot / x, P->alpha);
}

//definition de la vol locale
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static double vol(double t, double x, param *P)
{
    return P->sigma;
}

static double c(double x, double spot, param *P)
{
    return P->cbarre + P->gamma0 * pow(spot / x, P->alpha) * MAX((1.0 - P->eta) *

//definition de la barriere basse
static double low(double x, param *P)
{
    return MAX(x, P->Pbarre);
}

//definition de la barriere haute
static double up(double x, param *P)
{
    return MAX(x, P->Cbarre);
}

//définition du payoff
static double g(double x, param *P)
{
    return MAX(x, P->Nbarre);
}

//definition de mu=r+gamma(S) (elle marche)
static double mu(double spot, double x, param *P)
{
    return P->r + P->gamma0 * pow(spot / x, P->alpha);
}

//simulation par schéma d'euler de la matrice des
//trajectoires. On obtient une matrice de taille (N+1)*M
//(la fonction marche)
static void simul_asset(PnlMat *asset, int M, int N, double spot, double T, para
{
    double h = T / N;
    int i, j;

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PnlMat *G;
double Si_1;
G = pnl_mat_create(0, 0);
pnl_mat_resize(asset, N + 1, M);
pnl_mat_rand_normal(G, N, M, type_generator);
for (j = 0; j < M; j++)
{
    pnl_mat_set(asset, 0, j, spot);
}
for (i = 1; i < N + 1; i++)
{
    for (j = 0; j < M; j++)
    {
        Si_1 = pnl_mat_get(asset, i - 1, j);
        pnl_mat_set(asset, i, j, Si_1 * (1 + b((i - 1)*h, Si_1, spot, P)*h + v
    }
}
pnl_mat_free(&G);
}

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//rend la matrice des H, chaque colonne correspond à une
//trajectoire. H(0,:) est initialisée à 0. Elle est mise à 1
//dès que le sous jacent dépasse Sup, et remise à 0 dès que
//le sous jacent passe sous Slow.

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static void boolean_protection(PnlMatInt *H, PnlMat *asset, int M, int N, param
{
    int i, j;
    double Sij;
    pnl_mat_int_resize(H, N + 1, M);
    for (j = 0; j < M; j++)
    {
        if (pnl_mat_get(asset, 0, j) >= P->Sup) pnl_mat_int_set(H, 0, j, 1);
        else pnl_mat_int_set(H, 0, j, 0);
    }
    for (j = 0; j < M; j++)
    {
        for (i = 1; i < N + 1; i++)
        {
            Sij = pnl_mat_get(asset, i, j);

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        if ((Sij > P->Slow + eps) && (Sij < P->Sup + eps)) pnl_mat_int_set(H,
        else if (Sij >= P->Sup) pnl_mat_int_set(H, i, j, 1);
        else pnl_mat_int_set(H, i, j, 0);
    }
}
}

```

```

//definition du premier instant où on passe au dessus de la
//barriere (elle marche)
static void theta(PnlVectInt *res, PnlMat *asset, int M, int N, param *P)
{
    int j, i;
    pnl_vect_int_resize(res, M);
    for (j = 0; j < M; j++)
    {
        i = 0;
        while ((pnl_mat_get(asset, i, j) < P->Sup - eps) && (i < N)) i++;
        pnl_vect_int_set(res, j, i);
    }
}

```

```

//definition de beta (voir page 10) matrice de taille
//(N+1)*M (elle marche)
static void beta(PnlMat *res, double spot, PnlMat *asset, double T, int N, param
{
    int i, j;
    double h = T / N;
    int M = asset->n;
    pnl_mat_resize(res, N + 1, M);
    for (j = 0; j < M; j++) pnl_mat_set(res, 0, j, 0);
    for (i = 1; i < N + 1; i++)
    {
        for (j = 0; j < M; j++)
        {
            pnl_mat_set(res, i, j, mu(spot, pnl_mat_get(asset, i - 1, j), P));
        }
    }
    pnl_mat_cumsum(res, 'r');
    pnl_mat_mult_double(res, -h);
    pnl_mat_map_inplace(res, exp);
}

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```
}

```

```
//creation du vecteur tau, chaque composante est le premier
//instant avant theta sur une trajectoire où le prix vaut la barrière
//basse, si on dépasse theta, tau vaut N

```

```
static void tau(PnlVectInt *res, int M, int N, PnlMat *V, PnlMat *asset, PnlVectInt *theta)
{
    int i, j;

    pnl_vect_int_resize(res, M);
    for (j = 0; j < M; j++)
    {
        i = 0;
        /* printf("low=%f \ n",low(pnl_mat_get(asset,i,j)));
        * printf("V=%f \ n",pnl_mat_get(V,i,j)); */
        while (((pnl_mat_get(V, i, j) > low(pnl_mat_get(asset, i, j), P) + eps) ||
            if (i >= pnl_vect_int_get(res_theta, j)) pnl_vect_int_set(res, j, N);
            else pnl_vect_int_set(res, j, i);
        }
    }
}

```

```
//creation du vecteur zeta, chaque composante est le premier
//instant sur une trajectoire où le prix vaut soit la barrière
//basse soit la barriere haute (inf(tau,theta))
static void zeta(PnlVectInt *res, PnlVectInt *res_tau, PnlVectInt *res_theta)
{
    int M = res_tau->size;
    int j;
    pnl_vect_int_resize(res, M);
    for (j = 0; j < M; j++)
        pnl_vect_int_set(res, j, MIN(pnl_vect_int_get(res_tau, j), pnl_vect_int_get(res_theta, j)));
}

```

```
static void prix(PnlMat *res, PnlMatInt *H, int M, int N, PnlMat *asset, double theta)
{
    int i, j;
    double Sij, mu_ij, v0;

```

```

PnlVect *Si, *V_iplus1, *alpha, *c_iplus1; //(ligne i de la matrice)
PnlMat MSi;
double h = T / N;
Si = pnl_vect_new();
alpha = pnl_vect_new();
c_iplus1 = pnl_vect_create(M);
V_iplus1 = pnl_vect_new();
pnl_mat_resize(res, N + 1, M);
for (j = 0; j < M; j++) pnl_mat_set(res, N, j, g(pnl_mat_get(asset, N, j), P))
for (i = N - 1; i >= 1; i--)
{
    for (j = 0; j < M; j++) pnl_vect_set(c_iplus1, j, c(pnl_mat_get(asset, i + 1, j), P));
    pnl_mat_get_row(Si, asset, i);
    pnl_vect_mult_double(Si, 1.0 / spot);
    pnl_mat_get_row(V_iplus1, res, i + 1);
    pnl_vect_plus_vect(V_iplus1, c_iplus1);
    MSi = pnl_mat_wrap_vect(Si);
    pnl_basis_fit_ls(basis, alpha, &MSi, V_iplus1);
    for (j = 0; j < M; j++)
    {
        Sij = pnl_mat_get(asset, i, j) / spot;
        mu_ij = mu(spot, spot * Sij, P);
        if (pnl_mat_int_get(H, i, j) == 0)
        {
            pnl_mat_set(res, i, j, MAX(low(spot * Sij, P), exp(-mu_ij * h)*pnl_mat_get(asset, i, j)));
        }
        else pnl_mat_set(res, i, j, MIN(up(spot * Sij, P), MAX(low(spot * Sij, P), exp(-mu_ij * h)*pnl_mat_get(asset, i, j))));
    }
}
pnl_mat_get_row(V_iplus1, res, 1);
for (j = 0; j < M; j++) pnl_vect_set(c_iplus1, j, c(pnl_mat_get(asset, 1, j), P));
pnl_vect_plus_vect(V_iplus1, c_iplus1);
v0 = pnl_vect_sum(V_iplus1) / M;
v0 = MAX(low(spot, P), exp(-mu(spot, spot, P) * h) * v0);
for (j = 0; j < M; j++)
{
    if (pnl_mat_int_get(H, 0, j) == 0) pnl_mat_set(res, 0, j, v0);
    else pnl_mat_set(res, 0, j, MIN(up(spot, P), v0));
}
pnl_vect_free(&Si);
pnl_vect_free(&V_iplus1);

```

```

    pnl_vect_free(&c_iplus1);
    pnl_vect_free(&alpha);
}

```

```

static void prix_en_0_ls(double *res_prix, PnlMat *asset, int M, int N, double s
{
    PnlMat *V, *res_beta;
    PnlMatInt *H;
    PnlVectInt *res_zeta, *res_tau, *res_theta;
    PnlVect *tmp_prix;
    int j, i, zeta_j, tau_j, theta_j;
    double sprix, s;
    double h = T / N;
    //initialisation
    V = pnl_mat_new();
    res_beta = pnl_mat_new();
    res_zeta = pnl_vect_int_new();
    res_theta = pnl_vect_int_new();
    res_tau = pnl_vect_int_new();
    tmp_prix = pnl_vect_create(M);
    H = pnl_mat_int_new();

    //calcul de la matrice H
    boolean_protection(H, asset, M, N, P);
    //calcul du vecteur theta
    theta(res_theta, asset, M, N, P);

    //calcul du prix standard protection
    prix(V, H, M, N, asset, spot, T, P, basis);
    //calcul de tau, zeta et beta
    tau(res_tau, M, N, V, asset, res_theta, P);
    zeta(res_zeta, res_tau, res_theta);
    beta(res_beta, spot, asset, T, N, P);
    //calcul de la somme Monte Carlo
    for (j = 0; j < M; j++)
    {
        s = 0;
        tau_j = pnl_vect_int_get(res_tau, j);
        theta_j = pnl_vect_int_get(res_theta, j);
    }
}

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    zeta_j = pnl_vect_int_get(res_zeta, j);
    if (tau_j < theta_j)
    {
        pnl_vect_set(tmp_prix, j, pnl_mat_get(res_beta, zeta_j, j)*low(pnl_mat
    }
    else
    {
        pnl_vect_set(tmp_prix, j, pnl_mat_get(res_beta, zeta_j, j)*pnl_mat_get

    for (i = 1; i <= zeta_j; i++) s = s + h * pnl_mat_get(res_beta, i, j) * c(
    pnl_vect_set(tmp_prix, j, pnl_vect_get(tmp_prix, j) + s);
}
sprix = pnl_vect_sum(tmp_prix);

pnl_mat_free(&V);
pnl_mat_free(&res_beta);
pnl_vect_int_free(&res_zeta);
pnl_vect_int_free(&res_tau);
pnl_vect_int_free(&res_theta);
pnl_mat_int_free(&H);
pnl_vect_free(&tmp_prix);
*res_prix = sprix / M;
}

static double prix_intermittent_protection(int M, int N, double spot, double T,
{
    PnlMat *asset;
    PnlBasis *basis;
    double sol;
    basis = pnl_basis_create(bindex, m, 1);
    asset = pnl_mat_new();

    simul_asset(asset, M, N, spot, T, P, gen);
    prix_en_0_ls(&sol, asset, M, N, spot, T, P, basis);
    pnl_basis_free(&basis);
    pnl_mat_free(&asset);
    return sol;
}

/**

```



```

* @param prix (output) contains the price on exit
* @param Mod (input) a pointer to the model type
* @param Opt (input) a pointer to the option type
* @param gen (input) the random number generator index
* @param bindex (input) the basis index
* @param m (input) the number of basis functions
* @param M (input) the number of Monte Carlo samples
* @param steps (input) the number of discretisation steps per day, It must be
* an integer
*/
int callable_intermittent_protection(double *prix, TYPEMOD *Mod, TYPEOPT *Opt, i
{
    param *P;
    double T = (double) Opt->Maturity.Val.V_INT / 365.;
    int N = steps * Opt->Maturity.Val.V_INT; //nb dates discrétisation
    double spot = Mod->S0.Val.V_PDOUBLE;
    P = malloc(sizeof(param));
    P->r = log(1. + Mod->Interest.Val.V_DOUBLE / 100.);
    P->q = log(1. + Mod->Divid.Val.V_DOUBLE / 100.);
    P->cbarre = Opt->Coupon.Val.V_PDOUBLE;
    P->Pbarre = Opt->PutStrike.Val.V_PDOUBLE; //intervient dans low
    P->Nbarre = Opt->Strike.Val.V_PDOUBLE; //intervient dans le payoff g
    P->Cbarre = Opt->CallStrike.Val.V_PDOUBLE; //intervient dans up
    P->sigma = Mod->Sigma.Val.V_PDOUBLE;
    P->alpha = 1.2;
    P->gamma0 = 0.02;
    P->eta = Mod->Eta.Val.V_PDOUBLE;
    P->R = Opt->Recovery.Val.V_PDOUBLE;
    P->Sup = Opt->UpperBarrier.Val.V_PDOUBLE;
    P->Slow = Opt->LowerBarrier.Val.V_PDOUBLE;
    /* init */
    pnl_rand_init(gen, M, N);

    *prix = prix_intermittent_protection(M, N, spot, T, gen, bindex, m, P);

    free(P);
    return OK;;
}

#endif

```