

[Help](#)

```
#include "wishart2d_std2d.h"
#include "pnl/pnl_random.h"
#include "pnl/pnl_mathtools.h"
#include "pnl/pnl_vector.h"
#include "pnl/pnl_matrix.h"
#include "pnl/pnl_cdf.h"
#include "enums.h"

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2010+2) //The "#els
static int CHK_OPT(MC_WISHART)(void *Opt, void *Mod)
{
    return NONACTIVE;
}
int CALC(MC_WISHART)(void *Opt, void *Mod, PricingMethod *Met)
{
    return AVAILABLE_IN_FULL_PREMIA;
}
#else

static double DiscLawMatch5(int generator)
{
    double u = pnl_rand_uni(generator);
    if (u < 1. / 6.) return -sqrt(3);
    if (u < 1. / 3.) return sqrt(3);
    return 0;
}

static void Mat_inverse_inplace(PnlMat *a, int dim)
{
    //-----Declaration of variables
    int i;
    PnlMat *tmp;
    PnlVect *tmp1;
    PnlVect *tmp2;
    //-----
    tmp = pnl_mat_copy(a);
    tmp1 = pnl_vect_create_from_double(dim, 0.);
    tmp2 = pnl_vect_create_from_double(dim, 0.);
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    pnl_vect_set(tmp2, 0, 1.);
    pnl_mat_syslin(tmp1, tmp, tmp2);
    pnl_mat_set_col(a, tmp1, 0);

    for (i = 1; i < dim; i++)
    {

        pnl_vect_set(tmp2, i - 1, 0.);
        pnl_vect_set(tmp2, i, 1.);
        pnl_mat_syslin(tmp1, tmp, tmp2);
        pnl_mat_set_col(a, tmp1, i);

    }
    //-----desallocation memory
    pnl_mat_free(&tmp);
    pnl_vect_free(&tmp1);
    pnl_vect_free(&tmp2);
}

//-----Premia ne dispose pas d'une fonction faisant le swap entre deux colon
//-----Cette fonction effectue cette operation à partir d'un rang first
static void Swap_cols_Matrix(PnlMat *a, int i, int j, int dim, int first)
{
    double tmp;
    int k;
    for (k = first; k < dim; k++)
    {
        tmp = pnl_mat_get(a, k, i);
        pnl_mat_set(a, k, i, pnl_mat_get(a, k, j));
        pnl_mat_set(a, k, j, tmp);
    }

    return;
}
//-----Premia ne dispose pas d'une fonction faisant le swap entre deux ligne
//-----Cette fonction effectue cette operation à partir d'un rang first
static void Swap_rows_Matrix(PnlMat *a, int i, int j, int dim, int first)

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{

    double tmp;
    int k;
    for (k = first; k < dim; k++)
    {
        tmp = pnl_mat_get(a, i, k);
        pnl_mat_set(a, i, k, pnl_mat_get(a, j, k));
        pnl_mat_set(a, j, k, tmp);
    }

    return;
}

//-----Permutaion des lignes pour la matrice de passage
static void Permutation_Swap_Matrix(PnlMat *a, int i, int j)
{
    pnl_mat_swap_rows(a, i, j);
    return;
}

//-----Factorization de chlosky avec le resultat, page 145, Matrix Comput
//-----Input t la matrice à decomposer
//-----Output G      : la portion de t inferieur,
//-----              permute: la permutation associe,
//-----              retour : dimension de la partie inversible
//-----la matrice peut etre juste positive
static double  Chol_Factorization_MatHigham(PnlMat *t, PnlMat *G, PnlMat *permut
{
    //-----Parametre temporaire
    //PnlMat* res;
    //-----Initialisation les parameteres de la boucle

    //int ttt;
    int r = 0;
    double tmp = 0;
    double tmp1 = 0;
    int rank = 0;
    int i, j, k;

    //-----l'algorithme Outer Product pour la decomposition de Cholesky
    //-----page 145. Matrix computations Golub

```

```
for (k = 0; k < n; k++)
{
    //---recherche de la valeur maximale

    rank = k;
    tmp = 0;

    for (i = k; i < n; i++)
    {
        //scanf("%d",ttt);
        tmp1 = pnl_mat_get(t, i, i);
        if (tmp < tmp1)
        {
            tmp = tmp1;
            rank = i;
        }

    }

    //---le calcul de cholesky apres la permutation
    if (tmp > 0)
    {
        r += 1;
        Swap_rows_Matrix(t, k, rank, n, 0);
        //Mat_afficher(t);
        Swap_cols_Matrix(t, k, rank, n, 0);
        //Mat_afficher(t);
        Permutation_Swap_Matrix(permute, k, rank);
        pnl_mat_set(t, k, k, sqrt(tmp));

        for (j = k + 1; j < n; j++)
        {
            pnl_mat_set(t, j, k, pnl_mat_get(t, j, k) / sqrt(tmp));
        }
        for (j = k + 1; j < n; j++)
        {
            for (i = k + 1; i < n; i++)

                pnl_mat_set(t, i, j, pnl_mat_get(t, i, j) - pnl_mat_get(t, i, k)
        }
    }
}
```

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        }
    else
    {
        break;
    }
}

//--- traitement de la partie non inversible si il 'existe
//--- le trigger de l'evenement sera la valeur du retour de la fonction
for (k = 0; k < n; k++)
{
    for (i = k + 1; i < n; i++)
    {
        pnl_mat_set(t, k, i, 0.0);
    }
}

if (r < n)
{
    for (k = r; k < n; k++)
    {
        pnl_mat_set(t, k, k, 1.0);
        if (r < n - 1)
        {
            for (i = r - 1; i < k; i++)
            {
                pnl_mat_set(t, k, i, 0.0);
            }
        }
    }
}

//-----Initialisation de la matrice effective G
if (r > 0)
{
    pnl_mat_resize(G, r, r);
}

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        for (k = 0; k < r; k++)
        {
            for (i = 0; i < r; i++)
            {
                if (i > k)
                    pnl_mat_set(G, k, i, 0.0);
                else
                    pnl_mat_set(G, k, i, pnl_mat_get(t, k, i));
            }
        }

    }

    return r;
    //-----Gestion de memoire
}
static void SquarePo(PnlMat *t)
{
    //-----Decalration of variable
    double delta;
    double a, b, d;
    PnlVect *diag;
    PnlMat *Matmp;
    PnlMat *Matmp2;
    PnlMat *Matmp3;
    //-----
    Matmp2 = pnl_mat_create_from_double(2, 2, 0.);
    Matmp3 = pnl_mat_create_from_double(2, 2, 0.);
    diag = pnl_vect_create_from_double(2, 0.);

    if (pnl_mat_get(t, 1, 0) != 0)
    {
        //-----une matrice symetrique non diagonale

        //-----Initialisation des parametres
        a = pnl_mat_get(t, 0, 0);
        d = pnl_mat_get(t, 1, 1);
        b = pnl_mat_get(t, 0, 1);

        //-----redimensionner les objets
        pnl_mat_resize(t, 2, 2);
    }
}

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//-----Calcul des valeurs propres
delta = (a - d) * (a - d) + 4.*b * b;
delta = sqrt(delta);
pnl_vect_set(diag, 0, 0.5 * (a + d + delta));
pnl_vect_set(diag, 1, 0.5 * (a + d - delta));
//-----Calcul des vecteurs propres
delta = b * b + (a - pnl_vect_get(diag, 0)) * (a - pnl_vect_get(diag, 0));
delta = 1. / sqrt(delta);
pnl_mat_set(Matmp2, 0, 0, b * delta);
pnl_mat_set(Matmp2, 1, 1, b * delta);
pnl_mat_set(Matmp2, 0, 1, (a - pnl_vect_get(diag, 0))*delta);
pnl_mat_set(Matmp2, 1, 0, (d - pnl_vect_get(diag, 1))*delta);

}
else
{
    //-----une matrice deja digonale

    pnl_vect_set(diag, 0, pnl_mat_get(t, 0, 0));
    pnl_vect_set(diag, 1, pnl_mat_get(t, 1, 1));
    pnl_mat_set_id(Matmp2);

}

//-----Annuler les valeurs negatives
if (pnl_vect_get(diag, 0) < 0)
    pnl_vect_set(diag, 0, 0.);
else
    pnl_vect_set(diag, 0, sqrt(pnl_vect_get(diag, 0)));

if (pnl_vect_get(diag, 1) < 0)
    pnl_vect_set(diag, 1, 0.);
else
    pnl_vect_set(diag, 1, sqrt(pnl_vect_get(diag, 1)));

//-----Caclul de la nouvelle matrice

Matmp = pnl_mat_create_diag(diag);
pnl_mat_mult_mat_inplace(Matmp3, Matmp2, Matmp);

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pnl_mat_sq_transpose(Matmp2);
pnl_mat_mult_mat_inplace(Matmp, Matmp3, Matmp2);
pnl_mat_clone(t, Matmp);

//-----Desallocation de memoire
pnl_vect_free(&diag);
pnl_mat_free(&Matmp);
pnl_mat_free(&Matmp2);
pnl_mat_free(&Matmp3);

}

//----- Bound computation
//----- computation in one time time all variables that can be used
static void Compute_Tmp_V(double t, double a, PnlVect *diag, int size_d, PnlVect
{
    double u = 0.;
    int i, j;

    pnl_vect_resize_from_double(L_tmp, size_d, 0.0);
    pnl_vect_resize_from_double(phi_tmp, size_d, 0.0);

    pnl_mat_resize(KK_tmp, size_d, size_d);
    pnl_mat_set_double(KK_tmp, 0.);

    for (i = 0; i < size_d; i++)
    {
        if (-pnl_vect_get(diag, i) > 0)
        {

            u = (1. - exp(pnl_vect_get(diag, i) * t)) / (-2.*pnl_vect_get(diag, i)
            pnl_vect_set(L_tmp, i, (1. - exp(2.*pnl_vect_get(diag, i)*t)) / (-2.*p

        }
    else
    {
        u = t * 0.5;
        pnl_vect_set(L_tmp, i, t);
    }
}

```



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        pnl_vect_set(phi_tmp, i, u);

    }

    for (i = 0; i < size_d; i++)
    {
        for (j = 0; j < size_d; j++)
        {
            if (a - j >= 1)
                pnl_mat_set(KK_tmp, i, j, 0.);
            else
            {

                u = sqrt(exp(-t * pnl_vect_get(diag, i)) * (1. - (a - (double)j)))
                u = exp(-pnl_vect_get(diag, i) * t) * ((1. - (a - (double)j)) * pn
                pnl_mat_set(KK_tmp, i, j, u);
                u = 0.;
            }

        }

    }

    }
    return;
}

//-----CIR Exact Simulation
/*
 *      Bessel Exact Simultion Glasserman
 *       $dr(t) = (\alpha - kr(t)) dt + 2 * \sqrt{r(t)} * dW_t$ 
 */

//-----CIR discretization New L1
static double CIR_NVA_L1(double t, double x, double a, double k, int generator,
{

    double w = 0;
    double tmp = 0;
    double ksi = 0;

```

```

w = pnl_rand_uni(generator);

if (x >= KK)
{
    //N Victoir discretization paper 2006
    if (w < 1. / 6.)
        w = -1.0;
    else
    {
        if (w < 1. / 3.)
            w = 1.0;
        else
            w = 0.0;
    }

    w = sqrt(3.*t) * w;
    tmp = sqrt((a - 1.) * phii + exp(-k * t * 0.5) * x) + w;
    return tmp * tmp * exp(-k * t * 0.5) + (a - 1.) * phii;
}
else
{
    //Matching moment Aurelien Alfonsi paper 2008
    if (k != 0)
        ksi = x * k / ((exp(k * t) - 1.));
    else
        ksi = x / t;

    tmp = LL * LL * (2 * (a + 2.*ksi)) + (a + ksi) * LL * (a + ksi) * LL;
    ksi = (a + ksi) * LL;
    tmp = 0.5 * (1. - sqrt(1. - ksi * ksi / tmp));
    if (w < tmp)
    {
        return 0.5 * ksi / tmp;
    }
    else
    {
        return 0.5 * ksi / (1. - tmp);
    }
}

```

```

}

//-----CIR Exact Simulation
/*
 *      Bessel Exact Simultion Glasserman
 *       $dr(t) = (\alpha - kr(t)) dt + 2 * \sqrt{r(t)} * dW_t$ 
 */
static double BesselExactRandom(double t, double alpha, double k, double initial
{
    // double sigma =2.0;
    //double pathtime = L*exp(-k*t);
    double d = alpha;
    double c = L;//sigma*sigma*pathtime/(4.0);
    double lambda = (initialValue * exp(-k * t)) / c;
    double z, x;
    double tmp = 0.0;
    if (d > 1.0)
    {
        z = pnl_rand_normal(ge);
        x = 2.*pnl_rand_gamma((d - 1.) * 0.5, 1.0, ge); //ran_chisq(d-1.0,ge);//
        tmp = z + sqrt(lambda);
        tmp = c * (tmp * tmp + x);
        return tmp;
    }
    else
    {
        z = pnl_rand_poisson(lambda * 0.5, ge);
        x = 2.*pnl_rand_gamma((d + 2.*z) * 0.5, 1., ge); //ran_chisq(d + 2.0*z,ge)
        return c * x;
    }
}

//-----Weak order scheme for the operator L witht drift, and a sigma
static void Wishart_Disc(PnlMat *F, int dim, double t, double a, PnlMat *driftEx
{
    //-----Declaration of variable
    PnlMat *K;
    PnlMat *G;
    PnlMat *permute;
    PnlMat *Matmp;

```

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PnlVect *U;
PnlVect *X;
PnlVect *Xtmp;
PnlVect *Vtmp;
double tmp, tmp2;
int i, j, k, h;
int rank;
double D;
int orderoperator;
//-----

//-----Matrix Initialization
Matmp = pnl_mat_create_from_double(dim, dim, 0.);
//-----first step calculus
pnl_mat_mult_mat_inplace(Matmp, F, driftExpT);
pnl_mat_mult_mat_inplace(F, driftExp, Matmp);

//-----Wishart discretization
K = pnl_mat_create_from_double(dim - 1, dim - 1, 0.0);
G = pnl_mat_create_from_double(1, 1, 0.0);
U = pnl_vect_create_from_double(1, 0.0);
X = pnl_vect_create_from_double(dim - 1, 0.0);
Vtmp = pnl_vect_create_from_double(dim - 1, 0.0);
Xtmp = pnl_vect_create_from_double(1, 0.0);
permute = pnl_mat_create_from_double(dim - 1, dim - 1, 0.);
pnl_mat_set_id(permute);

for (h = 0; h < dim; h++)
{
    //-----Matrix Initialization within the loop
    pnl_mat_set_double(K, 0.0);
    pnl_mat_set_double(G, 0.0);
    pnl_vect_set_double(U, 0.);
    pnl_vect_set_double(X, 0.);
    pnl_vect_set_double(Xtmp, 0.);
    pnl_vect_set_double(Vtmp, 0.);
    pnl_mat_set_id(permute);
    D = pnl_vect_get(diagonal, h);

```

```

orderoperator = h;

//-----Permutation for the operator L_h
Swap_rows_Matrix(F, 0, h, dim, 0);
Swap_cols_Matrix(F, 0, h, dim, 0);

for (i = 1; i < dim; i++)
    for (j = 1; j < dim; j++)
        pnl_mat_set(K, i - 1, j - 1, pnl_mat_get(F, i, j));
for (i = 1; i < dim; i++)
    pnl_vect_set(X, i - 1, pnl_mat_get(F, 0, i));
//-----Chloesky Factorization modified
rank = Chol_Factorization_MatHigham(K, G, permute, dim - 1);

if (rank != 0)
{
    //-----If the matrix is not null
    pnl_mat_mult_vect_inplace(Vtmp, permute, X);
    pnl_vect_clone(X, Vtmp);
    k = G->m;
    pnl_vect_resize(Xtmp, k);
    pnl_vect_resize(U, k);
    for (i = 0; i < k; i++)
        pnl_vect_set(Xtmp, i, pnl_vect_get(X, i));

    pnl_mat_lower_syslin(U, G, Xtmp);

    //pnl_vect_rand_normal(Xtmp,k,generator);

    for (i = 0; i < k; i++)
    {
        pnl_vect_set(Xtmp, i, DiscLawMatch5(generator));
    }

    pnl_vect_mult_double(Xtmp, sqrt(pnl_vect_get(L_tmp, orderoperator)));

    tmp = pnl_vect_norm_two(U);

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tmp = tmp * tmp;
pnl_vect_mult_double(U, exp(t * D));
pnl_vect_plus_vect(Xtmp, U);

tmp = CIR_NVA_L1(t, pnl_mat_get(F, 0, 0) - tmp, a - (k), -2.*D, genera

tmp2 = pnl_vect_norm_two(Xtmp);
tmp2 = tmp2 * tmp2;
pnl_mat_set(F, 0, 0, tmp + tmp2);

for (i = 0; i < k; i++)
    pnl_vect_set(X, i, pnl_vect_get(Xtmp, i));
for (i = k + 1; i < dim - 1; i++)
    pnl_vect_set(X, i, 0.);

//-----Original vector C computation in t
pnl_mat_mult_vect_inplace(Vtmp, K, X);
pnl_vect_clone(X, Vtmp);

pnl_mat_mult_vect_transpose_inplace(Vtmp, permute, X);
pnl_vect_clone(X, Vtmp);

for (i = 1; i < dim; i++)
{
    tmp = pnl_vect_get(X, i - 1);

    pnl_mat_set(F, 0, i, tmp);
    pnl_mat_set(F, i, 0, tmp);
}
}
else
{
    //-----If the submatrix is null

    tmp = CIR_NVA_L1(t, pnl_mat_get(F, 0, 0), a, -2.*D, generator, pnl_vec

    pnl_mat_set(F, 0, 0, tmp);
}

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        //-----Back to the original matrix
        Swap_rows_Matrix(F, 0, h, dim, 0);
        Swap_cols_Matrix(F, 0, h, dim, 0);
    }
    //-----Last step of discretization
    pnl_mat_mult_mat_inplace(Matmp, F, driftExpT);
    pnl_mat_mult_mat_inplace(F, driftExp, Matmp);

    //-----Memory desallocation
    pnl_mat_free(&K);
    pnl_mat_free(&G);
    pnl_mat_free(&permute);
    pnl_mat_free(&Matmp);

    pnl_vect_free(&Vtmp);
    pnl_vect_free(&U);
    pnl_vect_free(&X);
    pnl_vect_free(&Xtmp);

    return;
}

```

```

static void Wishart_Disc_E(PnlMat *F, int dim, double t, double a, PnlMat *drift
{
    //-----Declaration of variable
    PnlMat *K;
    PnlMat *G;
    PnlMat *permute;
    PnlMat *Matmp;

    PnlVect *U;
    PnlVect *X;
    PnlVect *Xtmp;
    PnlVect *Vtmp;
    double tmp, tmp2;
    int i, j, k, h;
    int rank;
    double D;

```

```

int orderoperator;
//-----

//-----Matrix Initialization
Matmp = pnl_mat_create_from_double(dim, dim, 0.);
//-----first step calculus
pnl_mat_mult_mat_inplace(Matmp, F, driftExpT);
pnl_mat_mult_mat_inplace(F, driftExp, Matmp);

//-----Wishart discretization
K = pnl_mat_create_from_double(dim - 1, dim - 1, 0.0);
G = pnl_mat_create_from_double(1, 1, 0.0);
U = pnl_vect_create_from_double(1, 0.0);
X = pnl_vect_create_from_double(dim - 1, 0.0);
Vtmp = pnl_vect_create_from_double(dim - 1, 0.0);
Xtmp = pnl_vect_create_from_double(1, 0.0);
permute = pnl_mat_create_from_double(dim - 1, dim - 1, 0.);
pnl_mat_set_id(permute);

for (h = 0; h < dim; h++)
{
    //-----Matrix Initialization within the loop
    pnl_mat_set_double(K, 0.0);
    pnl_mat_set_double(G, 0.0);
    pnl_vect_set_double(U, 0.);
    pnl_vect_set_double(X, 0.);
    pnl_vect_set_double(Xtmp, 0.);
    pnl_vect_set_double(Vtmp, 0.);
    pnl_mat_set_id(permute);
    D = pnl_vect_get(diagonal, h);
    orderoperator = h;

    //-----Permutation for the operator L_h
    Swap_rows_Matrix(F, 0, h, dim, 0);
    Swap_cols_Matrix(F, 0, h, dim, 0);

    for (i = 1; i < dim; i++)
        for (j = 1; j < dim; j++)

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    pnl_mat_set(K, i - 1, j - 1, pnl_mat_get(F, i, j));
for (i = 1; i < dim; i++)
    pnl_vect_set(X, i - 1, pnl_mat_get(F, 0, i));
//-----Chloesky Factorization modified
rank = Chol_Factorization_MatHigham(K, G, permute, dim - 1);

if (rank != 0)
{
    //-----If the matrix is not null
    pnl_mat_mult_vect_inplace(Vtmp, permute, X);
    pnl_vect_clone(X, Vtmp);
    k = G->m;
    pnl_vect_resize(Xtmp, k);
    pnl_vect_resize(U, k);
    for (i = 0; i < k; i++)
        pnl_vect_set(Xtmp, i, pnl_vect_get(X, i));

    pnl_mat_lower_syslin(U, G, Xtmp);

    pnl_vect_rand_normal(Xtmp, k, generator);

    pnl_vect_mult_double(Xtmp, sqrt(pnl_vect_get(L_tmp, orderoperator)));

    tmp = pnl_vect_norm_two(U);

    tmp = tmp * tmp;
    pnl_vect_mult_double(U, exp(t * D));
    pnl_vect_plus_vect(Xtmp, U);

    tmp = BesselExactRandom(t, a - k, -2.*D, pnl_mat_get(F, 0, 0) - tmp, g);
    tmp2 = pnl_vect_norm_two(Xtmp);
    tmp2 = tmp2 * tmp2;
    pnl_mat_set(F, 0, 0, tmp + tmp2);

    for (i = 0; i < k; i++)
        pnl_vect_set(X, i, pnl_vect_get(Xtmp, i));
    for (i = k + 1; i < dim - 1; i++)

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        pnl_vect_set(X, i, 0.);

        //-----Original vector C computation in t
        pnl_mat_mult_vect_inplace(Vtmp, K, X);
        pnl_vect_clone(X, Vtmp);

        pnl_mat_mult_vect_transpose_inplace(Vtmp, permute, X);
        pnl_vect_clone(X, Vtmp);

        for (i = 1; i < dim; i++)
        {
            tmp = pnl_vect_get(X, i - 1);

            pnl_mat_set(F, 0, i, tmp);
            pnl_mat_set(F, i, 0, tmp);
        }
    }
else
    {
        //-----If the submatrix is null
        tmp = BesselExactRandom(t, a, -2.*D, pnl_mat_get(F, 0, 0), generator,
        //CIR_NVA_L1(t,pnl_mat_get(F,0,0), a,-2.*D,generator, pnl_vect_get(phi

        pnl_mat_set(F, 0, 0, tmp);

    }

    //-----Back to the original matrix
    Swap_rows_Matrix(F, 0, h, dim, 0);
    Swap_cols_Matrix(F, 0, h, dim, 0);
}

//-----Last step of discretization
pnl_mat_mult_mat_inplace(Matmp, F, driftExpT);
pnl_mat_mult_mat_inplace(F, driftExp, Matmp);

//-----Memory deallocation
pnl_mat_free(&K);
pnl_mat_free(&G);
pnl_mat_free(&permute);
pnl_mat_free(&Matmp);

```

```

    pnl_vect_free(&Vtmp);
    pnl_vect_free(&U);
    pnl_vect_free(&X);
    pnl_vect_free(&Xtmp);

    return;
}

//-----weak order of the first scheme in model presented by Gouriéroux
static void HW(PnlVect *S, PnlMat *F, PnlMat *Y, int dim, double t, double a, Pn
{

    //-----Declaration of variable
    int i, j;
    PnlMat *tmp1;
    PnlMat *tmp2;
    double tmp;
    //-----

    tmp1 = pnl_mat_copy(F);
    tmp2 = pnl_mat_create_from_double(dim, dim, 0.);
    //-----discretization of the Wishart matrix Xt
    Wishart_Disc(F, dim, t, a, driftExp, driftExpT, diagonal, generator, phi_tmp,
    //-----discretization of the median matrix Yt
    pnl_mat_plus_mat(tmp1, F);
    pnl_mat_mult_double(tmp1, 0.5 * t);
    pnl_mat_plus_mat(Y, tmp1);
    //-----discretization of the stock St
    //pnl_mat_minus_mat(tmp2, Y);
    for (i = 0; i < dim; i++)
    {

        pnl_mat_mult_mat_inplace(tmp2, tmp1, D[i]);
        tmp = 0;
        for (j = 0; j < dim; j++)
        {
            tmp += pnl_mat_get(tmp2, j, j);
        }
    }
}

```

```

        tmp += pnl_vect_get(mu, i) * t;
        tmp = pnl_vect_get(S, i) * exp(tmp);
        pnl_vect_set(S, i, (tmp));
    }

    //-----Desallocation memory
    pnl_mat_free(&tmp1);
    pnl_mat_free(&tmp2);
    return ;
}

//Exact Scheme Wishart
static void HW_E(PnlVect *S, PnlMat *F, PnlMat *Y, int dim, double t, double a,
{

    //-----Declaration of variable
    int i, j;
    PnlMat *tmp1;
    PnlMat *tmp2;
    double tmp;
    //-----

    tmp1 = pnl_mat_copy(F);
    tmp2 = pnl_mat_create_from_double(dim, dim, 0.);
    //-----discretization of the Wishart matrix Xt
    Wishart_Disc_E(F, dim, t, a, driftExp, driftExpT, diagonal, generator, phi_tmp

    //-----discretization of the median matrix Yt
    pnl_mat_plus_mat(tmp1, F);
    pnl_mat_mult_double(tmp1, 0.5 * t);
    pnl_mat_plus_mat(Y, tmp1);
    //-----discretization of the stock St
    //pnl_mat_minus_mat(tmp2, Y);
    for (i = 0; i < dim; i++)
    {

        pnl_mat_mult_mat_inplace(tmp2, tmp1, D[i]);
        tmp = 0;
    }
}

```

```

        for (j = 0; j < dim; j++)
        {
            tmp += pnl_mat_get(tmp2, j, j);

        }
        tmp += pnl_vect_get(mu, i) * t;
        tmp = pnl_vect_get(S, i) * exp(tmp);
        pnl_vect_set(S, i, (tmp));
    }

    //-----Desallocation memory
    pnl_mat_free(&tmp1);
    pnl_mat_free(&tmp2);
    return ;
}

static void HZZ(PnlVect *S, PnlMat *F, PnlMat *Y, PnlMat *aT, int dim, double t,
{
    //-----Declaration of variable
    PnlMat *tmp1;
    PnlVect *tmp2;
    PnlVect *tmp3;
    double tmp;
    int i;
    //-----
    tmp1 = pnl_mat_copy(F);
    tmp2 = pnl_vect_create_from_double(dim, 0.);
    tmp3 = pnl_vect_create_from_double(dim, 0.);
    tmp = 0.;

    SquarePo(tmp1);
    pnl_vect_rand_normal(tmp2, dim, generator);
    tmp = sqrt(t);
    pnl_vect_mult_double(tmp2, tmp);
    pnl_mat_mult_vect_inplace(tmp3, tmp1, tmp2);
    pnl_mat_mult_vect_inplace(tmp2, aT, tmp3);

    for (i = 0; i < dim; i++)

```

```

    {
        tmp = pnl_vect_get(S, i) * exp(pnl_vect_get(tmp2, i));
        pnl_vect_set(S, i, (tmp));
    }

//-----Desallocation of memory
pnl_mat_free(&tmp1);
pnl_vect_free(&tmp2);
pnl_vect_free(&tmp3);
return;
}

//-----the scheme for the stock in christian Gourieroux paper derivat
//-----volatility Christian gourieroux and Razvan Sufana
//-----dlog(St) = mu.dt + trace(D1 x Ft).dt + aT x sqrt(Ft) x dWt ; w
//-----dFt = a.dt + (b1 x Ft + Ft x b1T).dt + sqrt(Ft) x dZt + dZtT x
//-----Zt and Wt are independent B.Ms
static int mc_wishart2d(PnlVect *S0, NumFunc_2 *p, double t, double r, PnlVect *
{
    int dim = 2;
    double alphaa, z_alpha;
    double price_sample, mean_price, var_price;
    double S_T1, S_T2;
    //-----Declaration of variable
    double DT;
    int i, j;
    int init_mc;
    PnlVect *phi_tmp;
    PnlVect *L_tmp;
    PnlVect *diagonal;
    PnlVect *Stmp;
    PnlVect *mu;

    PnlMat *Ftmp;
    PnlMat *Ytmp;
    PnlMat *KK_tmp;
    PnlMat *btmp;
    PnlMat *atmp;
    PnlMat *tmp1;
    PnlMat *F0, *Q, *b;

```

```

PnlMat **MatDrift;

//-----Initialisation of variable

F0 = pnl_mat_create_from_double(dim, dim, 0.0);
Q = pnl_mat_create_from_double(dim, dim, 0.0);
b = pnl_mat_create_from_double(dim, dim, 0.0);
mu = pnl_vect_create_from_double(dim, 0.);
pnl_vect_set(mu, 0, r + pnl_vect_get(divid, 0));
pnl_vect_set(mu, 1, r + pnl_vect_get(divid, 1));

MLET(F0, 0, 0) = GET(Sigma0V, 0);
MLET(F0, 0, 1) = GET(Sigma0V, 1);
MLET(F0, 1, 0) = GET(Sigma0V, 2);
MLET(F0, 1, 1) = GET(Sigma0V, 3);

MLET(Q, 0, 0) = GET(QP, 0);
MLET(Q, 0, 1) = GET(QP, 1);
MLET(Q, 1, 0) = GET(QP, 2);
MLET(Q, 1, 1) = GET(QP, 3);

MLET(b, 0, 0) = GET(bP, 0);
MLET(b, 0, 1) = GET(bP, 1);
MLET(b, 1, 0) = GET(bP, 2);
MLET(b, 1, 1) = GET(bP, 3);

/* Value to construct the confidence interval */
alphaa = (1. - confidence) / 2.;
z_alpha = pnl_inv_cdfnor(1. - alphaa);

mean_price = 0.;
var_price = 0.;
price_sample = 0.;

diagonal = pnl_vect_create_from_double(dim, 0.);
Ftmp      = pnl_mat_copy(F0);
Ytmp      = pnl_mat_create_from_double(dim, dim, 0.);
KK_tmp    = pnl_mat_create_from_double(dim, dim, 0.);
Stmp      = pnl_vect_copy(S0);

```

```

L_tmp      = pnl_vect_create_from_double(dim, 0.);
phi_tmp    = pnl_vect_create_from_double(dim, 0.);
MatDrift   = (PnlMat **) malloc(dim * sizeof(PnlMat *));
DT          = (double)(t / ((double)(M)));
Compute_Tmp_V(DT, alpha, diagonal, dim , phi_tmp, L_tmp, KK_tmp);
btmp       = pnl_mat_create_from_double(dim, dim, 0.);
init_mc    = 1;
atmp = pnl_mat_copy(Q);
pnl_mat_sq_transpose(atmp);

//Exact Scheme for Wishart and Weak for the stock
if (flag_scheme == 1)
{
    for (i = 0; i < dim; i++)
    {
        MatDrift[i] = pnl_mat_create_from_double(dim, dim, 0.);
        pnl_mat_set(MatDrift[i], i, i, -0.5);
        pnl_mat_mult_mat_inplace(btmp, MatDrift[i], atmp);
        pnl_mat_mult_mat_inplace(MatDrift[i], Q, btmp);
    }

    pnl_mat_clone(btmp, b);
    tmp1 = pnl_mat_copy(atmp);
    Mat_inverse_inplace(tmp1, dim);
    pnl_mat_mult_mat_inplace(atmp, tmp1, btmp);
    pnl_mat_clone(tmp1, Q);
    pnl_mat_sq_transpose(tmp1);
    pnl_mat_mult_mat_inplace(btmp, atmp, tmp1);

    pnl_mat_mult_double(btmp, 0.5 * DT);
    pnl_mat_exp(atmp, btmp);
    pnl_mat_clone(btmp, atmp);
    pnl_mat_sq_transpose(atmp);

    init_mc = pnl_rand_init(generator, 1, (long) M * N * dim * (dim + 1));

    for (i = 1; i <= N; i++)
    {
        pnl_mat_clone(Ftmp, F0);

```



```

    pnl_vect_clone(Stmp, S0);
    pnl_mat_set_double(Ytmp, 0.);

    for (j = 1; j <= M; j++)
    {

        //-----Scheme discretization

        HZZ(Stmp, Ftmp, Ytmp, tmp1, dim, DT * 0.5, generator);

        HW_E(Stmp, Ftmp, Ytmp, dim, DT, alpha, btmp, atmp, diagonal, gener

        HZZ(Stmp, Ftmp, Ytmp, tmp1, dim, DT * 0.5, generator);

    }
    //-----Payoff calculus
    S_T1 = pnl_vect_get(Stmp, 0);
    S_T2 = pnl_vect_get(Stmp, 1);
    price_sample = (p->Compute)(p->Par, S_T1, S_T2);

    /* Sum */
    mean_price += price_sample;
    /* Sum of squares */
    var_price += price_sample * price_sample;

}

}
//Weak Schemes for Wishart and stock
if (flag_scheme == 2)
{

    for (i = 0; i < dim; i++)
    {
        MatDrift[i] = pnl_mat_create_from_double(dim, dim, 0.);
        pnl_mat_set(MatDrift[i], i, i, -0.5);
        pnl_mat_mult_mat_inplace(btmp, MatDrift[i], atmp);
        pnl_mat_mult_mat_inplace(MatDrift[i], Q, btmp);

    }
}

```

```

pnl_mat_clone(bttmp, b);
tmp1 = pnl_mat_copy(atmp);
Mat_inverse_inplace(tmp1, dim);
pnl_mat_mult_mat_inplace(atmp, tmp1, bttmp);
pnl_mat_clone(tmp1, Q);
pnl_mat_sq_transpose(tmp1);
pnl_mat_mult_mat_inplace(bttmp, atmp, tmp1);

pnl_mat_mult_double(bttmp, 0.5 * DT);
pnl_mat_exp(atmp, bttmp);
pnl_mat_clone(bttmp, atmp);
pnl_mat_sq_transpose(atmp);

init_mc = pnl_rand_init(generator, 1, (long) M * N * dim * (dim + 1));

for (i = 1; i <= N; i++)
{
    pnl_mat_clone(Ftmp, F0);
    pnl_vect_clone(Stmp, S0);
    pnl_mat_set_double(Ytmp, 0.);

    for (j = 1; j <= M; j++)
    {

        //-----Scheme discretization

        HZZ(Stmp, Ftmp, Ytmp, tmp1, dim, DT * 0.5, generator);

        HW(Stmp, Ftmp, Ytmp, dim, DT, alpha, bttmp, atmp, diagonal, generat

        HZZ(Stmp, Ftmp, Ytmp, tmp1, dim, DT * 0.5, generator);

    }
    //-----Payoff calculus
    S_T1 = pnl_vect_get(Stmp, 0);
    S_T2 = pnl_vect_get(Stmp, 1);
    price_sample = (p->Compute)(p->Par, S_T1, S_T2);

    /* Sum */
    mean_price += price_sample;
    /* Sum of squares */

```

```

        var_price += price_sample * price_sample;

    }

}

//-----final Value

/*----Price Estimator-----*/
*ptprice = (mean_price / (double)N);
*pterror_price = sqrt(var_price / (double)N - (*ptprice) * (*ptprice)) / sqrt(
/* Price Confidence Interval */
*inf_price = *ptprice - z_alpha * (*pterror_price);
*sup_price = *ptprice + z_alpha * (*pterror_price);

///-----Desallocation memory
pnl_mat_free(&KK_tmp);
pnl_mat_free(&btmp);
pnl_mat_free(&atmp);
pnl_mat_free(&tmp1);
pnl_mat_free(&Ytmp);
pnl_mat_free(&Ftmp);
pnl_mat_free(&Q);
pnl_mat_free(&F0);
pnl_mat_free(&b);

pnl_vect_free(&Stmp);
pnl_vect_free(&phi_tmp);
pnl_vect_free(&L_tmp);
pnl_vect_free(&diagonal);
pnl_vect_free(&mu);
for (i = 0; i < dim; i++)
{
    pnl_mat_free(&MatDrift[i]);

}
free(MatDrift);
return init_mc;
}

```

```

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

    double r;

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

    return mc_wishart2d(ptMod->S0.Val.V_PNLVECT,
                        ptOpt->PayOff.Val.V_NUMFUNC_2,
                        ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE,
                        r,
                        ptMod->Divid.Val.V_PNLVECT, ptMod->alpha.Val.V_PDOUBLE,
                        ptMod->b.Val.V_PNLVECT,
                        ptMod->Sigma0.Val.V_PNLVECT,
                        ptMod->Q.Val.V_PNLVECT,
                        Met->Par[0].Val.V_LONG,
                        Met->Par[1].Val.V_INT,
                        Met->Par[2].Val.V_ENUM.value,
                        Met->Par[3].Val.V_ENUM.value,
                        Met->Par[4].Val.V_PDOUBLE,
                        &(Met->Res[0].Val.V_DOUBLE),
                        &(Met->Res[1].Val.V_DOUBLE),
                        &(Met->Res[2].Val.V_DOUBLE),
                        &(Met->Res[3].Val.V_DOUBLE)
                        );
}

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

#endif //PremiaCurrentVersion

static int MET(Init)(PricingMethod *Met, Option *Opt)
{

```

```

//int type_generator;
if (Met->init == 0)
{
    Met->init = 1;

    Met->Par[0].Val.V_LONG = 15000;
    Met->Par[1].Val.V_INT = 10;
    Met->Par[2].Val.V_ENUM.value = 2;
    Met->Par[2].Val.V_ENUM.members = &PremiaEnumDiscretizationScheme;
    Met->Par[3].Val.V_ENUM.value = 0;
    Met->Par[3].Val.V_ENUM.members = &PremiaEnumMCRNGs;
    Met->Par[4].Val.V_DOUBLE = 0.95;

}

return OK;
}

PricingMethod MET(MC_WISHART) =
{
    "MC_Wishart2D",
    { {"N iterations", LONG, {100}, ALLOW},
      {"TimeStepNumber", LONG, {100}, ALLOW},
      {"Discretization Scheme", ENUM, {100}, ALLOW},
      {"RandomGenerator", ENUM, {100}, ALLOW},
      {"Confidence Value", DOUBLE, {100}, ALLOW},
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CALC(MC_WISHART),
    { {"Price", DOUBLE, {100}, FORBID},
      {"Error Price", DOUBLE, {100}, FORBID},
      {"Inf Price", DOUBLE, {100}, FORBID},
      {"Sup Price", DOUBLE, {100}, FORBID} ,
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CHK_OPT(MC_WISHART),
    CHK_mc,
    MET(Init)
};

```