

[Help](#)

```
extern "C" {
#include "
href../../../../mod/fps2d/fps2d_std/fps2d_std_h_src.pdf fps2d_std.h"

#include "
href../../../../common/math/highdim_solver/laspack/highdim_vector_h_src.pdf math/high
#include "
href../../../../common/math/highdim_solver/laspack/qmatrix_h_src.pdf math/highdim_so
#include "
href../../../../common/math/highdim_solver/laspack/highdim_matrix_h_src.pdf math/hig
#include "
href../../../../common/math/highdim_solver/laspack/operats_h_src.pdf math/highdim_so

#include "
href../../../../common/math/highdim_solver/fd_solver_h_src.pdf math/highdim_solver/f
#include "
href../../../../common/math/highdim_solver/fd_operators_h_src.pdf math/highdim_solve
#include "
href../../../../common/math/highdim_solver/fd_operators_easy_h_src.pdf math/highdim_
#include "
href../../../../common/math/highdim_solver/error_h_src.pdf math/highdim_solver/error
}
#include <cmath>
using namespace std;

typedef double (*paramf_t)(double, double);

typedef struct _Model
{
    // Independent model parameters
    paramf_t f;
    double nu_f, nu_s;
    double alpha, delta;
    double rho1, rho2, rho12;
    double r;
    double m_f, m_s;
    double lambda_f, lambda_s;
    double K, T;
    double x0, y0, z0; // Initial coordinates
}
```

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unsigned N1, N2, N3;    // Number of grid points per dimension
double (*boundary)(struct _Model *, double, double);

// Dependent model parameters
// Solution domain definition
double xL, xR;
double yL, yR;
double zL, zR;

// Offset
int offx, offy, offz;

} FPS2DModel;

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2008+2) //The "#els
#else

static void setup(FPS2DModel *m)
{
    m->xL = 1;
    m->xR = 200;
    m->yR = -0.000001;
    m->yL = m->yR + 3.0 * m->y0;
    m->zR = -0.000001;
    m->zL = m->zR + 3.0 * m->z0;

    m->offx = (int)floor((m->x0 - m->xL) * (m->N1 - 1) / (m->xR - m->xL));
    m->offy = (int)ceil((m->y0 - m->yL) * (m->N2 - 1) / (m->yR - m->yL));
    m->offz = (int)ceil((m->z0 - m->zL) * (m->N3 - 1) / (m->zR - m->zL));

    m->xR = (m->N1 - 1) * (m->x0 - m->xL) / m->offx + m->xL;
    m->yL = -1.0 * ((m->N2 - 1) * (m->yR - m->y0) / (m->N2 - m->offy - 1) + m->yR)
    m->zL = -1.0 * ((m->N3 - 1) * (m->zR - m->z0) / (m->N3 - m->offz - 1) + m->zR)
}

// Model to solution space
//
/*static void c_m2s(FPS2DModel *m, double v1, double v2, double v3,
                    double *w1, double *w2, double *w3)
{

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        if(w1) *w1 = (v1-m->xL)/(m->xR-m->xL);
        if(w2) *w2 = (v2-m->yL)/(m->yR-m->yL);
        if(w3) *w3 = (v3-m->zL)/(m->zR-m->zL);
    }*/

static void v_m2s(FPS2DModel *m, double t, double V, double *W)
{
    *W = exp(m->r * (m->T - t)) * V;
}

/*static void m2s(FPS2DModel *m, double t, double v1, double v2, double v3, double
                double *w1, double *w2, double *w3, double *W)
{
    c_m2s(m,v1,v2,v3,w1,w2,w3);
    v_m2s(m,t,V,W);
}*/

// Solution to model space

static void c_s2m(FPS2DModel *m, double w1, double w2, double w3,
                double *v1, double *v2, double *v3)
{
    if (v1) *v1 = (m->xR - m->xL) * w1 + m->xL;
    if (v2) *v2 = (m->yR - m->yL) * w2 + m->yL;
    if (v3) *v3 = (m->zR - m->zL) * w3 + m->zL;
}

static void v_s2m(FPS2DModel *m, double tau, double W, double *V)
{
    *V = exp(-1.0 * m->r * tau) * W;
}

/*static void s2m(FPS2DModel *m, double tau, double w1, double w2, double w3, double
                double *v1, double *v2, double *v3, double *V)
{
    c_s2m(m,w1,w2,w3,v1,v2,v3);
    v_s2m(m,tau,W,V);
}*/

FPS2DModel M;

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static double call_boundary(FPS2DModel *m, double t, double S)
{
    double v = S - m->K * exp(-m->r * (m->T - t));

    return v > 0 ? v : 0;
}

static double put_boundary(FPS2DModel *m, double t, double S)
{
    double v = m->K * exp(-m->r * (m->T - t)) - S;

    return v > 0 ? v : 0;
}

static double payoff(FPS2DModel *m, double S)
{
    return m->boundary(m, m->T, S);
}

////////////////////////////////////////
// Initial & boundary conditions
//
static int ic_f_next_elem(struct _FDSolver *s, FDSolverVectorFiller *f,
                        unsigned *c, double *v)
{
    double S;

    c_s2m(&M, (double)c[0] / (s->size[0] - 1), 0, 0, &S, NULL, NULL);
    v_m2s(&M, M.T - s->t, payoff(&M, S), v);

    return 0;
}

static int b_f_next_elem(struct _FDSolver *s, FDSolverVectorFiller *f,
                        unsigned *c, double *v)
{
    double S;

    c_s2m(&M, (double)c[0] / (s->size[0] - 1), 0, 0, &S, NULL, NULL);
    v_m2s(&M, M.T - s->t, M.boundary(&M, M.T - s->t, S), v);
}

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    return 0;
}

////////////////////////////////////////
// Equation definition
//

static void eq_first_def(FDOperatorJam *j)
{
    unsigned k;

    for (k = 0; k < j->dim; k++)
        FIRST_SPATIAL_DERIVATIVE_CENTERED_MASK(j, k);
}

static int eq_first_apply(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d,
                        double factor)
{
    double x, y, z;
    double wx, wy, wz;

    wx = M.xR - M.xL;
    wy = M.yR - M.yL;
    wz = M.zR - M.zL;

    c_s2m(&M, (double)c[0] / (s->size[0] - 1), (double)c[1] / (s->size[1] - 1),
          (double)c[2] / (s->size[2] - 1), &x, &y, &z);

    FIRST_SPATIAL_DERIVATIVE_CENTERED_SET(j, 0, factor * x * M.r / wx * (M.N1 - 1))
    FIRST_SPATIAL_DERIVATIVE_CENTERED_SET(j, 1, factor * M.alpha * (M.m_f - y) / w)
    FIRST_SPATIAL_DERIVATIVE_CENTERED_SET(j, 2, factor * M.delta * (M.m_s - z) / w)

    return 0;
}

static void eq_second_def(FDOperatorJam *j)
{
    unsigned k, h;

    for (k = 0; k < j->dim; k++)

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    UNIFORM_SECOND_SPATIAL_DERIVATIVE_CENTERED_MASK(j, k);

    for (h = 1; h < j->dim; h++)
        for (k = 0; k < h; k++)
            MIXED_SECOND_SPATIAL_DERIVATIVE_CENTERED_BOUCHUT_MASK(j, h, k);
}

static int eq_second_apply(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d,
                           double factor)
{
    double x, y, z;
    double fv, dv, bv;
    double wx, wy, wz;

    wx = M.xR - M.xL;
    wy = M.yR - M.yL;
    wz = M.zR - M.zL;

    c_s2m(&M, (double)c[0] / (s->size[0] - 1), (double)c[1] / (s->size[1] - 1),
          (double)c[2] / (s->size[2] - 1), &x, &y, &z);

    fv = M.f(y, z) * x;
    bv = M.nu_f * M.rho1 * sqrt(2 * M.alpha);
    dv = M.nu_s * M.rho2 * sqrt(2 * M.delta);

    UNIFORM_SECOND_SPATIAL_DERIVATIVE_CENTERED_SET(j, 0,
        factor * 0.5 * pow(fv / wx * (M.N1 - 1), 2)*s->deltaT);

    UNIFORM_SECOND_SPATIAL_DERIVATIVE_CENTERED_SET(j, 1,
        factor * M.alpha * pow(M.nu_f / wy * (M.N2 - 1), 2)*s->deltaT);

    UNIFORM_SECOND_SPATIAL_DERIVATIVE_CENTERED_SET(j, 2,
        factor * M.delta * pow(M.nu_s / wz * (M.N3 - 1), 2)*s->deltaT);

    MIXED_SECOND_SPATIAL_DERIVATIVE_CENTERED_BOUCHUT_SET(j, 1, 0,
        factor * fv * bv / (wx * wy) * (M.N1 - 1) * (M.N2 - 1)*s->deltaT);

    MIXED_SECOND_SPATIAL_DERIVATIVE_CENTERED_BOUCHUT_SET(j, 2, 0,
        factor * fv * dv / (wx * wz) * (M.N1 - 1) * (M.N3 - 1)*s->deltaT);
}

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    MIXED_SECOND_SPATIAL_DERIVATIVE_CENTERED_BOUCHUT_SET(j, 2, 1,
        factor * 2 * M.nu_s * M.nu_f * sqrt(M.alpha * M.delta) *
        (M.rho1 * M.rho2 + M.rho12 * sqrt(1 - pow(M.rho1, 2))) / (wz * wy) * (M.N2

    return 0;
}

//////////////////////////////////////////
// Explicit scheme
//
static int ex_eq_def_c(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    eq_first_def(j);
    eq_second_def(j);

    return 0;
}

static int ex_eq_apply_c(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j, 1.);

    eq_first_apply(s, j, c, d, 1.0);
    eq_second_apply(s, j, c, d, 1.0);

    return 0;
}

static int ex_eq_def_n(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    return 0;
}

static int ex_eq_apply_n(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j, 1.);

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```

    return 0;
}

////////////////////////////////////////
// Crank-Nicolson scheme
//
static int cn_eq_def_c(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    eq_first_def(j);
    eq_second_def(j);

    return 0;
}

static int cn_eq_apply_c(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j, 1.);

    eq_first_apply(s, j, c, d, 1.0);
    eq_second_apply(s, j, c, d, 0.5);

    return 0;
}

static int cn_eq_def_n(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    eq_second_def(j);

    return 0;
}

static int cn_eq_apply_n(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j, 1.);

    eq_second_apply(s, j, c, d, -0.5);
}

```



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    return 0;
}

////////////////////////////////////////
// Implicit scheme
//

/*static int im_eq_def_c(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    return 0;
}*/

/*static int im_eq_apply_c(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j,1.);

    return 0;
}*/

/*static int im_eq_def_n(FDOperatorJam *j, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_MASK(j);

    eq_first_def(j);
    eq_second_def(j);

    return 0;
}*/

/*static int im_eq_apply_n(FDSolver *s, FDOperatorJam *j, unsigned *c, void *d)
{
    FIRST_TIME_DERIVATIVE_FORWARD_SET(j,1.);

    eq_first_apply(s,j,c,d,-1.0);
    eq_second_apply(s,j,c,d,-1.0);

    return 0;
}*/

```

```

static double f_exp(double y, double z)
{
    return exp(y + z);
}

static int FD_FPS2D(double x0, double y0, double z0, double T, double r, double
{
    double K;
    int k, h, offset, call_or_put;
    double Vleft, Vright;

    K = p->Par[0].Val.V_DOUBLE;
    if ((p->Compute) == &Call)
        call_or_put = 1;
    else
        call_or_put = 0;
    M.boundary = call_or_put ? call_boundary : put_boundary;

    FDSolver s;
    FDSolverVectorFiller ic_f, b_f;
    FDSolverCoMatricesFiller AcBcf, AnBnf;
    FDOperatorJamCoMatricesFillerData jfdc_ex, jfdn_ex;
    FDOperatorJamCoMatricesFillerData jfdc_cn, jfdn_cn;

    M.r = r - divid;
    M.m_f = m_f;
    M.m_s = m_s;
    M.nu_f = nu_f;
    M.nu_s = nu_s;
    M.rho1 = rho1;
    M.rho2 = rho2;
    M.rho12 = rho12;
    M.K = K;
    M.T = T;
    M.f = f_exp;
    M.x0 = x0;
    M.y0 = y0;
    M.z0 = z0;
    M.alpha = alpha;
    M.delta = delta;

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M.N1 = N1 % 2 ? N1 : N1 + 1;
M.N2 = N2 % 2 ? N2 : N2 + 1;
M.N3 = N3 % 2 ? N3 : N3 + 1;

setup(&M);

offset = (N1 - 2) * (N2 - 2) * (M.offz - 1) + (N1 - 2) * (M.offy - 1) + M.offx;
s.dim = 3;
s.is_A_symmetric = FALSE;

// Evaluate CFL for explicit method
// Assumption: f(y,z) is increasing in its arguments
s.deltaT = pow(M.xR - M.xL, 2) / (0.5 * pow(((M.N1 - 1) * M.xR * M.f(M.yR, M.zR) - M.xL * M.f(M.yL, M.zL)), 2));

if (pow(M.yR - M.yL, 2) / (M.alpha * pow(((M.N2 - 1) * M.yR * M.f(M.xR, M.zR) - M.yL * M.f(M.xL, M.zL)), 2)) < s.deltaT)
    s.deltaT = pow(M.yR - M.yL, 2) / (M.alpha * pow(((M.N2 - 1) * M.yR * M.f(M.xR, M.zR) - M.yL * M.f(M.xL, M.zL)), 2));

if (pow(M.zR - M.zL, 2) / (M.alpha * pow(((M.N3 - 1) * M.zR * M.f(M.xR, M.yR) - M.zL * M.f(M.xL, M.yL)), 2)) < s.deltaT)
    s.deltaT = pow(M.zR - M.zL, 2) / (M.alpha * pow(((M.N3 - 1) * M.zR * M.f(M.xR, M.yR) - M.zL * M.f(M.xL, M.yL)), 2));

s.deltaT = 0.01 * s.deltaT;

s.size[0] = M.N1;
s.size[1] = M.N2;
s.size[2] = M.N3;

ic_f.init = NULL;
ic_f.next_elem = ic_f_next_elem;
ic_f.finish = NULL;
ic_f.free = NULL;

b_f.init = NULL;
b_f.next_elem = b_f_next_elem;
b_f.finish = NULL;
b_f.free = NULL;

s.b_filler = &b_f;

// Explicit

s.is_fully_explicit = TRUE;

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s.is_fully_implicit = FALSE;

FDOperatorJamCoMatricesFillerSet(&AcBcf, &jfdc_ex, ex_eq_def_c,
                                   ex_eq_apply_c, NULL);
FDOperatorJamCoMatricesFillerSet(&AnBnf, &jfdn_ex, ex_eq_def_n,
                                   ex_eq_apply_n, NULL);

if (FDSolverInit(&s, &ic_f, &AcBcf, &AnBnf)) return 1;

k = 1;

for (; k <= 20; k++) FDSolverStep(&s);

// Crank-Nicolson

s.is_fully_explicit = FALSE;
s.is_fully_implicit = FALSE;

h = (int)ceil((1.0 - s.t) / (sqrt(s.deltaT)));
s.deltaT = (1.0 - s.t) / h;

FDOperatorJamCoMatricesFillerSet(&AcBcf, &jfdc_cn, cn_eq_def_c,
                                   cn_eq_apply_c, NULL);
FDOperatorJamCoMatricesFillerSet(&AnBnf, &jfdn_cn, cn_eq_def_n,
                                   cn_eq_apply_n, NULL);

if (FDSolverResetMatrices(&s, &AcBcf, &AnBnf)) return 1;

for (; k <= h + 20; k++) FDSolverStep(&s);

/*Price*/
v_s2m(&M, s.t, V_GetCmp(s.xc, offset), ptprice);

/*Delta*/
v_s2m(&M, s.t, V_GetCmp(s.xc, offset - 1), &Vleft);
v_s2m(&M, s.t, V_GetCmp(s.xc, offset + 1), &Vright);

*ptdelta = M.N1 * (Vright - Vleft) / (2.0 * (M.xR - M.xL));

FDSolverFree(&s);
return OK;

```

```

}
#endif //PremiaCurrentVersion

extern "C" {
#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2008+2) //The "#els
    static int CHK_OPT(FD_NataliniBrianiFPS2D)(void *Opt, void *Mod)
    {
        return NONACTIVE;
    }
    int CALC(FD_NataliniBrianiFPS2D)(void *Opt, void *Mod, PricingMethod *Met)
    {
        return AVAILABLE_IN_FULL_PREMIA;
    }
#else
    int CALC(FD_NataliniBrianiFPS2D)(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 FD_FPS2D(ptMod->S0.Val.V_PDOUBLE,
                        ptMod->InitialSlow.Val.V_DOUBLE, ptMod->InitialFast.Val.V_DO
                        ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE,
                        r,
                        divid, ptOpt->PayOff.Val.V_NUMFUNC_1,
                        ptMod->MeanReversionSlow.Val.V_PDOUBLE, ptMod->MeanReversion
                        ptMod->LongRunVarianceSlow.Val.V_DOUBLE, ptMod->LongRunVaria
                        ptMod->SigmaSlow.Val.V_PDOUBLE, ptMod->SigmaFast.Val.V_PDOUB
                        ptMod->Rho1.Val.V_DOUBLE, ptMod->Rho2.Val.V_DOUBLE, ptMod->R
                        Met->Par[0].Val.V_INT, Met->Par[1].Val.V_INT, Met->Par[2].Va
                        &(Met->Res[0].Val.V_DOUBLE),
                        &(Met->Res[1].Val.V_DOUBLE)
                    );
    }
}

static int CHK_OPT(FD_NataliniBrianiFPS2D)(void *Opt, void *Mod)
{

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        if ((strcmp(((Option *)Opt)->Name, "CallEuro") == 0) || (strcmp(((Option *)Opt)->Name, "PutEuro") == 0))
            return OK;

        return WRONG;
    }

#endif //PremiaCurrentVersion

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

        Met->Par[0].Val.V_INT2 = 31;
        Met->Par[1].Val.V_INT2 = 31;
        Met->Par[2].Val.V_INT2 = 31;
    }

    return OK;
}

PricingMethod MET(FD_NataliniBrianiFPS2D) =
{
    "FD_NataliniBriani_FPS2d",
    { {"SpaceStepNumber 1 ", INT2, {100}, ALLOW}, {"SpaceStepNumber 2 ", INT2, {100}, ALLOW}, {" " ", PREMIA_NULLTYPE, {0}, FORBID} },
    CALC(FD_NataliniBrianiFPS2D),
    { {"Price", DOUBLE, {100}, FORBID}, {"Delta", DOUBLE, {100}, FORBID}, {" " ", PREMIA_NULLTYPE, {0}, FORBID} },
    CHK_OPT(FD_NataliniBrianiFPS2D),
    CHK_ok,
    MET(Init)
};
}

```