

## [Help](#)

```
#include <stdlib.h>
#include "
href../../mod/mer1d/mer1d_pad/mer1d_pad_h_src.pdfmer1d_pad.h"
#include "pnl/pnl_vector.h"
#include "pnl/pnl_matrix.h"
#include "pnl/pnl_complex.h"
#include "pnl/pnl_mathtools.h"
#include "pnl/pnl_fft.h"
#include "
href../../common/math/ap_fusai_levy/DiscreteAsianFMM_h_src.pdfmath/ap_fusai_1

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2012+2) //The "#els
static int CHK_OPT(AP_Asian_FMMMER)(void *Opt, void *Mod)
{
    return NONACTIVE;
}
int CALC(AP_Asian_FMMMER)(void *Opt, void *Mod, PricingMethod *Met)
{
    return AVAILABLE_IN_FULL_PREMIA;
}
#else

//-----
static dcomplex cfMerton(double dt, dcomplex g, PnlVect *Parameters)
{
    //-----
    // Merton Characteristic Function
    //-----
    double sg, lambda, mu, gamma2;
    dcomplex term1, term2;
    dcomplex charexp;

    sg = pnl_vect_get(Parameters, 0) * sqrt(dt);
    lambda = pnl_vect_get(Parameters, 1) * dt;
    mu = pnl_vect_get(Parameters, 2);
    gamma2 = pnl_vect_get(Parameters, 3);
    term1 = Cmul(Complex(0., mu), g);
    term2 = Cmul(g, g);
    term2 = Cmul(Complex(0.5 * gamma2, 0.), term2);
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    term1 = Csub(term1, term2);
    term1 = Cexp(term1);
    charexp = RCmul(lambda, Csub(term1, Complex(1., 0.)));
    charexp = Cexp(Cadd(RCmul(-sg * sg / 2, Cmul(g, g)), charexp));

    return charexp;
}
//-----
static double MomentsMerton(int moment, double rf, double dt, PnlVect *Parameters)
{
    //-----
    // compute moments of the Merton model
    //-----
    double sg, lambda, mu, gamma2;
    double mom = 0.;

    sg = pnl_vect_get(Parameters, 0);
    lambda = pnl_vect_get(Parameters, 1);
    mu = pnl_vect_get(Parameters, 2);
    gamma2 = pnl_vect_get(Parameters, 3);

    if (moment == 1)
    {
        mom = dt * (mu * lambda - lambda * (-1 + exp(mu + 0.5 * gamma2))) + rf - 0.;
    }
    if (moment == 2)
    {
        mom = dt * (lambda * (mu * mu + gamma2) + sg * sg) + 0.25 * dt * dt * SQR(

    return mom;
}
//-----
static dcomplex charfunction(double r, double divid, double dt, dcomplex g, PnlVect *Parameters)
{
    //-----
    // Levy Characteristic Function
    //-----

    double m;
    dcomplex result, mdtg, temp;

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temp = cfMerton(dt, Complex(0., -1.), Parameters);
m = Creal(Csub(Complex((r - divid) * dt, 0.), Clog(temp)));
mdtg = Cmul(Complex(0., m), g);
temp = cfMerton(dt, g, Parameters);
result = Cmul(Cexp(mdtg), temp);

return result;
}

//-----
static double BoundUpperTailLevy(double x, double rf, double divid, double dt,
{
    //-----
    // compute upper truncation
    //-----
    double minup, bound;
    int i;

    minup = 1.0;
    for (i = 1; i < maxmoment + 1; i++)
    {
        bound = Creal(charfunction(rf, divid, dt, Complex(0, -i), Parameters)) / e
        minup = MIN(minup, bound);
    }
    return minup;
}

//-----
static double BoundLowerTailLevy(double x, double rf, double divid, double dt,
{
    //-----
    // compute lower truncation
    //-----
    double minlow, bound;
    int i;
    minlow = 1.0;

    for (i = 1; i < maxmoment + 1; i++)
    {
        bound = Creal(charfunction(rf, divid, dt, Complex(0, i), Parameters)) / ex

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        minlow = MIN(minlow, bound);
    }
    return minlow;
}

//-----
static double truncate(double r, double divid, double dt, PnlVect *Parameters)
{
    //-----
    // find u for which cf(u)<10^-10
    //-----

    double abs_cf, step, umax;
    dcomplex cf;

    step = 1.5;
    umax = 5.0;
    cf = charfunction(r, divid, dt, Complex(umax, 0), Parameters);
    abs_cf = sqrt(Creal(cf) * Creal(cf) + Cimag(cf) * Cimag(cf));

    while (abs_cf > POW(10., -10.))
    {
        umax = umax * step;
        cf = charfunction(r, divid, dt, Complex(umax, 0), Parameters);
        abs_cf = sqrt(Creal(cf) * Creal(cf) + Cimag(cf) * Cimag(cf)); //compute ab
    }

    return (umax + umax / step) / 2;
}

//-----
static void kernel(double r, double divid, double dt, long N, double b, PnlVect
{
    //-----
    // Compute the transition density function by using the Fractional Fourier Tra
    //-----

    int j;
    double wj, eta, alpha, dx, umax;
    dcomplex term1, ft, aa, a, cgyz;
    PnlVectComplex *y1, *y2;

    y1 = pnl_vect_complex_create(2 * N);
    y2 = pnl_vect_complex_create(2 * N);

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// bound of characteristic function grid
umax = truncate(r, divid, dt, Parameters);

// bound of the density function grid
b = b * 1.25;

// grids's steps
eta = umax / N;
dx = 2 * b / N;
alpha = eta * dx / (2 * M_PI);

for (j = 0; j <= N - 1; j++)
{
    // trapezoidal quadrature weights
    if ((j == 0) || j == (N - 1))
    {
        wj = 0.5 * eta;
    }
    else
    {
        wj = eta;
    }
    a = Complex(cos(SQR(j) * alpha * M_PI), sin(SQR(j) * alpha * M_PI));
    pnl_vect_complex_set(y2, j, a);
    aa = Complex(cos(SQR(N - j) * alpha * M_PI), sin(SQR(N - j) * alpha * M_PI));
    pnl_vect_complex_set(y2, j + N, aa);

    ft = charfunction(r, divid, dt, Complex(j * eta, 0), Parameters);
    term1 = Cexp(Complex(0, b * eta * j));
    ft = Cmul(term1, ft);
    pnl_vect_complex_set(y1, j, Cmul(RCdiv(wj, a), ft));
    pnl_vect_complex_set(y1, j + N, CZERO);
}
pnl_fft_inplace(y1);
pnl_fft_inplace(y2);
pnl_vect_complex_mult_vect_term(y1, y2);

//FFT inversion
pnl_ifft_inplace(y1);
for (j = 0; j <= N - 1; j++)

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    {
        a = Complex(cos(SQR(j) * alpha * M_PI), sin(SQR(j) * alpha * M_PI));
        cgyz = Cdiv(pnl_vect_complex_get(y1, j), CRmul(a, M_PI));
        pnl_vect_set(logk, j, -b + j * dx);
        pnl_vect_set(inv, j, Creal(cgyz));
    }
    pnl_vect_complex_free(&y1);
    pnl_vect_complex_free(&y2);
}

//-----
//-----
static double findlowuplimit(double rf, double dt, PnlVect *Parameters)
{
    //-----
    // Truncate the transition density domain
    //-----

    double mom1, mom2, levylow, levyup, bound;
    int maxnummoments, lowfactor, upfactor;

    maxnummoments = 10;
    lowfactor = 5;
    upfactor = 5;

    mom1 = MomentsMerton(1, rf, dt, Parameters);
    mom2 = MomentsMerton(2, rf, dt, Parameters);

    levylow = mom1 - lowfactor * POW(mom2 - mom1 * mom1, 0.5);
    bound = BoundLowerTailLevy(-levylow, rf, 0., dt, maxnummoments, Parameters);
    while (bound > POW(10.0, -8.0))
    {
        lowfactor = lowfactor + 1;
        levylow = mom1 - lowfactor * POW(mom2 - mom1 * mom1, 0.5);
        bound = BoundLowerTailLevy(-levylow, rf, 0., dt, maxnummoments, Parameters);
    }

    levyup = mom1 + upfactor * POW(mom2 - mom1 * mom1, 0.5);
    bound = BoundUpperTailLevy(levyup, rf, 0., dt, maxnummoments, Parameters);
    while (bound > POW(10.0, -8.0))
    {
        upfactor = upfactor + 1;
    }
}

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        levyup = mom1 + upfactor * POW(mom2 - mom1 * mom1, 0.5);
        bound = BoundUpperTailLevy(levyup, rf, 0., dt, maxnummoments, Parameters);
    }

    return MAX(ABS(levylow), levyup);
}

static int FMMMER_Aasian(double pseudo_stock, double pseudo_strike, NumFunc_2 *p
{
    //Compute price and delta of an Asian call option under the Merton process
    // RECURSIVE PROCEDURE
    //-----
    //Recursive approach proposed in
    //Fusai, Marazzina, Marena, SIAM JOURNAL OF FINANCIAL MATHEMATICS, 2011
    //-----
    int c, i, j, Ni, start, count, flag, startcol, max_len_b;
    long nfft;
    double dt, low, up, b, x, y, xy, h, price, delta;
    PnlVect *CoeffLambda, *abscissa, *weights, *a_temp, *w_temp, *xdens, *dens, *P
    PnlMat *Kmatrix;
    int flagCP = 0, asian_type = 0;
    //-----
    //Call Fixed
    if ((po->Compute) == &Call_OverSpot2)
    {
        flagCP = 0;
        asian_type = 0;
    }
    //Put Fixed
    else if ((po->Compute) == &Put_OverSpot2)
    {
        flagCP = 1;
        asian_type = 0;
    }
    //Call Floating
    else if ((po->Compute) == &Call_StrikeSpot2)
    {
        flagCP = 0;
        asian_type = 1;
    }
}

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//Put Floating
else if ((po->Compute) == &Put_StrikeSpot2)
{
    flagCP = 1;
    asian_type = 1;
}
Parameters = pnl_vect_create_from_list(4, sigma, lambda, mu, gamma2);
// STEP 0: PREPARE GRID AND COEFFICIENTS
//-- payoff coefficients
if (asian_type == 0)
{
    CoeffLambda = pnl_vect_create_from_double(2, 1. / (M + 1));
    pnl_vect_set(CoeffLambda, 0, pnl_vect_get(CoeffLambda, 0) - pseudo_strike
    c = 0;
}
else
{
    CoeffLambda = pnl_vect_create_from_double(2, -1. / (M + 1));
    c = -1;
}

//-- price grid
low = -(3. / 2 + 30. / M); //lower bound
up = pnl_vect_get(CoeffLambda, 1); //upper bound
//-- generate abscissa and weights for quadrature
if (asian_type == 0)
{
    Ni = N; //number of nodes for x<0
    N = Ni + N; //total number of nodes
    abscissa = pnl_vect_create_from_zero(N);
    weights = pnl_vect_create_from_zero(N);
    a_temp = pnl_vect_create_from_zero(Ni);
    w_temp = pnl_vect_create_from_zero(Ni);
    gauleg_pn(low, 0, a_temp, w_temp, Ni);
    for (i = 0; i < Ni; i++)
    {
        x = pnl_vect_get(a_temp, i);
        y = pnl_vect_get(w_temp, i);
        pnl_vect_set(abscissa, i, x);
        pnl_vect_set(weights, i, y);
        //--- we consider the same number of nodes
    }
}

```



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        pnl_vect_set(abscissa, i + Ni, (x - low)*up / (-low));
        pnl_vect_set(weights, i + Ni, y * up / (-low));
    }
    pnl_vect_free(&a_temp);
    pnl_vect_free(&w_temp);
}
else
{
    abscissa = pnl_vect_create_from_zero(N);
    weights = pnl_vect_create_from_zero(N);
    gauleg_pn(low, up, abscissa, weights, N);
    Ni = N;
}

/-- time grid
dt = t / M;

/-- compute the transition density
b = findlowuplimit(r, dt, Parameters);
nfft = 32768;
dens = pnl_vect_create_from_zero(nfft); //contains the density
xdens = pnl_vect_create_from_zero(nfft); //contains the abscissa of the density
kernel(r, divid, dt, nfft, b, Parameters, dens, xdens);

// STEP 2: CREATE MATRICES AND VECTORS
vector = pnl_vect_create_from_zero(N);
for (j = 0; j <= N - 1; j++)
{
    x = pnl_vect_get(abscissa, j) - (double)c;
    if (x > 0.0)
        pnl_vect_set(vector, j, x);
}

// MATRIX
startcol = 0;
max_len_b = 0;
count = 0;
Kmatrix = pnl_mat_create_from_double(Ni, N + 2, 0.0);
for (i = 0; i <= Ni - 1; i++)
{
    flag = 0;

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start = 0;
x = pnl_vect_get(abscissa, i);
for (j = startcol; j <= N - 1; j++)
{
    y = pnl_vect_get(abscissa, j);
    xy = log(x / (y - pnl_vect_get(CoeffLambda, 1)));
    if (ABS(xy) <= b)
    {
        if (flag == 0)
        {
            flag = 1; // start to fill the row
            pnl_mat_set(Kmatrix, i, 0, j); // first element of the band
            startcol = j;
            count = 1;
        }
        count = count + 1;
        xy = MAX(interp_lin(xy, nfft, &start, xdens, dens), 0.0);
        pnl_mat_set(Kmatrix, i, count, -exp(-r * dt)*xy * (x / SQR(y - pnl
        if (j == N - 1) // stop to fill the row (since it is finished)
        {
            pnl_mat_set(Kmatrix, i, 1, (N - 1) - (int)pnl_mat_get(Kmatrix,
            max_len_b = MAX(max_len_b, (int)pnl_mat_get(Kmatrix, i, 1));
        }
    }
    else if (flag == 1) // stop to fill the row
    {
        pnl_mat_set(Kmatrix, i, 1, (j - 1) - (int)pnl_mat_get(Kmatrix, i,
        max_len_b = MAX(max_len_b, (int)pnl_mat_get(Kmatrix, i, 1));
        break;
    }
}
}
}

```

// STEP 3: RECURSIVE APPROACH

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vector1 = pnl_vect_create_from_zero(Ni);
if (asian_type == 0)
{
    for (i = 0; i < M; i++)
    {
        pnl_vect_mult_vect_term(vector, weights);
    }
}

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        bmat_mult_vect(Kmatrix, vector, vector1, Ni, N + 2);
        for (j = 0; j < Ni; j++)
            pnl_vect_set(vector, j, pnl_vect_get(vector1, j));
        xy = pnl_vect_get(CoeffLambda, 1) * exp((r - divid) * dt) * (1 - exp((
        for (j = Ni; j < N; j++)
            pnl_vect_set(vector, j, exp(-r * (i + 1)*dt) * (pnl_vect_get(absciss
    }
}
else
{
    for (i = 0; i < M; i++)
    {
        pnl_vect_mult_vect_term(vector, weights);
        bmat_mult_vect(Kmatrix, vector, vector1, Ni, N + 2);
        pnl_vect_clone(vector, vector1);
    }
}

xy = interp_lin1(pnl_vect_get(CoeffLambda, 0), N, abscissa, vector);
price = pseudo_stock * xy;
if (asian_type == 0)
{
    h = exp((up - low) / N);
    x = (pseudo_stock - h) * interp_lin1(pnl_vect_get(CoeffLambda, 1) - pseudo
    y = (pseudo_stock + h) * interp_lin1(pnl_vect_get(CoeffLambda, 1) - pseudo
    xy = (y - x) / (2 * h);
}
delta = xy;

if (flagCP == 1)
{
    price = price - pseudo_stock * (pnl_vect_get(CoeffLambda, 0) * exp(-r * M
    delta = delta - (pnl_vect_get(CoeffLambda, 1) * exp(-r * M * dt) - c);
    for (i = 0; i < M; i++)
    {
        price = price - pseudo_stock * pnl_vect_get(CoeffLambda, 1) * exp(-r *
        delta = delta - pnl_vect_get(CoeffLambda, 1) * exp(-r * i * dt);
    }
}

*ptprice = price;

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```

*ptdelta = delta;
//-----DESTROY-----
pnl_vect_free(&xdens);
pnl_vect_free(&dens);
pnl_vect_free(&Parameters);
pnl_vect_free(&vector);
pnl_vect_free(&vector1);
pnl_mat_free(&Kmatrix);
pnl_vect_free(&abscissa);
pnl_vect_free(&weights);
pnl_vect_free(&CoeffLambda);

return OK;
}

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

    int return_value;
    double r, divid, time_spent, pseudo_spot, pseudo_strike;
    double t_0, T_0;

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

    T_0 = ptMod->T.Val.V_DATE;
    t_0 = (ptOpt->PathDep.Val.V_NUMFUNC_2)->Par[0].Val.V_PDOUBLE;

    if (T_0 < t_0)
    {
        Fprintf(TOSCREEN, "T_0 < t_0, untreated case\ n\ n\ n");
        return_value = WRONG;
    }
    /* Case t_0 <= T_0 */
    else
    {
        time_spent = (ptMod->T.Val.V_DATE - (ptOpt->PathDep.Val.V_NUMFUNC_2)->Par[0].Val.V_PDOUBLE) * ptMod->S0.Val.V_PDOUBLE;
        pseudo_spot = (1. - time_spent) * ptMod->S0.Val.V_PDOUBLE;
    }
}

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        pseudo_strike = (ptOpt->PayOff.Val.V_NUMFUNC_2)->Par[0].Val.V_PDOUBLE - ti

        return_value = FMMER_Aasian(pseudo_spot, pseudo_strike, ptOpt->PayOff.Val.
    }

    return return_value;
}

static int CHK_OPT(AP_Aasian_FMMER)(void *Opt, void *Mod)
{
    if ((strcmp(((Option *)Opt)->Name, "AsianCallFixedEuro") == 0) || (strcmp(((Op
        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 = 52;
        Met->Par[1].Val.V_INT2 = 3000;
    }
    return OK;
}

PricingMethod MET(AP_Aasian_FMMER) =
{
    "AP_Aasian_FMM_Mer",
    { {"Nb.of Monitoring Dates", INT2, {2000}, ALLOW },
      {"Nb.of Integration Points ", INT2, {1000}, ALLOW},
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CALC(AP_Aasian_FMMER),
    {{"Price", DOUBLE, {100}, FORBID}, {"Delta", DOUBLE, {100}, FORBID} , {" ", PR
    CHK_OPT(AP_Aasian_FMMER),
    CHK_ok,
    MET(Init)
};

```

