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/*COS method for European option, Black-Scholes model*/
/*Developed by F.Fang, C.W.Oosterlee (2008), implemented by B.Zhang*/

#include <pnl/pnl_mathtools.h>
#include <pnl/pnl_complex.h>
#include <pnl/pnl_vector.h>
#include "bs1d_std.h"

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

static int CHK_OPT(AP_Cosine_Euro)(void *Opt, void *Mod)
{
    return NONACTIVE;
}
int CALC(AP_Cosine_Euro)(void *Opt, void *Mod, PricingMethod *Met)
{
    return AVAILABLE_IN_FULL_PREMIA;
}
#else

static void Valomega(int N, double a, double b, PnlVect *omega)
{
    int j;

    for (j = 0; j < N; j++)
    {
        pnl_vect_set(omega, j, ((double)j)*M_PI / (b - a));
    }
}

static void Valcf(int N, PnlVect *omega, double x, double a, double c1, double
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        pnl_vect_complex_set(cf, j, Cexp(CRsub(Cadd(Complex(0, omegaj * c1), Compl
    }
}

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static void cf0(PnlVectComplex *cf)
{
    pnl_vect_complex_set_real(cf, 0, 0.5 * pnl_vect_complex_get_real(cf, 0));
    pnl_vect_complex_set_imag(cf, 0, 0.5 * pnl_vect_complex_get_imag(cf, 0));
}

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static void VjtM(int N, double a, double b, double K, PnlVect *omega, PnlVect *V)
{
    int j;

    for (j = 0; j < N; j++)
    {
        double omegaj = pnl_vect_get(omega, j);
        pnl_vect_set(V, j, (-pow((1 + pow(omegaj, 2)), -1) * (cos((-a)*omegaj) - e
    }
}

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static void VjtM0(double a, double b, double K, PnlVect *V)
{
    pnl_vect_set(V, 0, (exp(a) - 1.0 - a) * (2.0 / (b - a))*K);
}

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static void VecRe(int N, double r, double T, PnlVect *V, PnlVect *omega,
                  PnlVectComplex *cf, PnlVect *fcvec)
{
    int j;

    for (j = 0; j < N; j++)
    {
        double Vj = pnl_vect_get(V, j);
        pnl_vect_set(fcvec, j, exp(-r * T)*Vj * pnl_vect_complex_get_real(cf, j));
    }
}

```

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static void par(double r, double q, double S0, double T, double K, double *vopt)
{
    *vopt += S0 * exp(-q * T) - K * exp(-r * T);
}

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}

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static int Cosine(double S0, double K, double T, double r, double q, double
                sigma, int iscall, double *prix)
{
    /* Values of N and L are chosen from the point of view of both speed and
     * accuracy. Please do not change them. */
    double x, a, b, c1, c2, c4;
    PnlVect *omega, *V, *fcvec;
    PnlVectComplex *cf;
    int N = 128;
    int L = 10;

    omega = pnl_vect_create(N);
    V = pnl_vect_create(N);
    fcvec = pnl_vect_create(N);
    cf = pnl_vect_complex_create(N);

    /*Transform the stock price to log-asset domain: x=log(S/K)*/
    x = log(S0 / K);

    /*Cumulants*/
    c1 = (r - q - 0.5 * pow(sigma, 2)) * T;
    c2 = pow(sigma, 2) * T;
    c4 = 0;

    /*Truncation range*/
    a = c1 - L * pow(c2 + pow(c4, 0.5), 0.5) + x;
    b = c1 + L * pow(c2 + pow(c4, 0.5), 0.5) + x;

    Valomega(N, a, b, omega);

    /*Characteristic function of Black-Scholes model*/
    Valcf(N, omega, x, a, c1, c2, cf);

    cf0(cf);

    /* Fourier Cosine Coefficient of option price at expiry*/
    VjtM(N, a, b, K, omega, V);
    VjtMO(a, b, K, V);

```

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/* Taking the real part of characteristic function and mulitiply with
 * Fourier Cosine Coefficiencie of option value at expiry*/
VecRe(N, r, T, V, omega, cf, fcvec);

/* Sum up the Fourier Cosine series */
*prix = pnl_vect_sum(fcvec);

/* The value of a call option is obtained from that of a put option, by put-ca
if (iscall == TRUE) par(r, q, S0, T, K, prix);

pnl_vect_free(&omega);
pnl_vect_free(&V);
pnl_vect_free(&fcvec);
pnl_vect_complex_free(&cf);

return OK;
}

static int CALC(AP_Cosine_Euro)(void *Opt, void *Mod, PricingMethod *Met)
{
    double r, divid;
    int iscall;
    TYPEOPT *ptOpt = (TYPEOPT *)Opt;
    TYPEMOD *ptMod = (TYPEMOD *)Mod;

    iscall = FALSE;
    if (ptOpt->PayOff.Val.V_NUMFUNC_1->Compute == &Call) iscall = TRUE;

    r = log(1. + ptMod->R.Val.V_DOUBLE / 100.);
    divid = log(1. + ptMod->Divid.Val.V_DOUBLE / 100.);
    Met->Res[1].Val.V_DOUBLE = 0.;
    return Cosine(ptMod->S0.Val.V_PDOUBLE,
                  ptOpt->PayOff.Val.V_NUMFUNC_1->Par[0].Val.V_PDOUBLE,
                  ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE, r, divid,
                  ptMod->Sigma.Val.V_PDOUBLE, iscall,
                  &(Met->Res[0].Val.V_DOUBLE));
}

static int CHK_OPT(AP_Cosine_Euro)(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

static int MET(Init)(PricingMethod *Met, Option *Opt)
{
    if (Met->init == 0)
    {
        Met->Par[0].Val.V_PDOUBLE = 0.1;
        Met->init = 1;
        Met->HelpFilenameHint = "ap_cosine_bs_euro";
    }
    return OK;
}

PricingMethod MET(AP_Cosine_Euro) =
{
    "AP_Cosine_Euro",
    {{ " ", PREMIA_NULLTYPE, {0}, FORBID}},
    CALC(AP_Cosine_Euro),
    { {"Price", DOUBLE, {100}, FORBID},
      { " ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CHK_OPT(AP_Cosine_Euro),
    CHK_ok,
    MET(Init)
};

```