

[Help](#)

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#include "hes1d_std.h"
#include "enums.h"

#include "pnl/pnl_random.h"
#include "pnl/pnl_cdf.h"

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion < (2015+2) //The "#els
static int CHK_OPT(MC_HybridTree_Heston)(void *Opt, void *Mod)
{
    return NONACTIVE;
}
int CALC(MC_HybridTree_Heston)(void *Opt, void *Mod, PricingMethod *Met)
{
    return AVAILABLE_IN_FULL_PREMIA;
}
#else

static double **V;
static double **f;
static int **f_down,**f_up;
static double **pu_f,**pd_f;

/*Memory Allocation*/
static int memory_allocation(int Nt)
{
    int i;

    V=(double**)calloc(Nt+1,sizeof(double*));
    if (V==NULL)
        return MEMORY_ALLOCATION_FAILURE;
    for (i=0;i<Nt+1;i++)
    {
        V[i]=(double *)calloc(Nt+1,sizeof(double));
        if (V[i]==NULL)
            return MEMORY_ALLOCATION_FAILURE;
    }
}
```

```
pu_f=(double**)calloc(Nt+1,sizeof(double*));
if (pu_f==NULL)
    return MEMORY_ALLOCATION_FAILURE;
for (i=0;i<Nt+1;i++)
{
    pu_f[i]=(double *)calloc(Nt+1,sizeof(double));
    if (pu_f[i]==NULL)
        return MEMORY_ALLOCATION_FAILURE;
}

pd_f=(double**)calloc(Nt+1,sizeof(double*));
if (pd_f==NULL)
    return MEMORY_ALLOCATION_FAILURE;
for (i=0;i<Nt+1;i++)
{
    pd_f[i]=(double *)calloc(Nt+1,sizeof(double));
    if (pd_f[i]==NULL)
        return MEMORY_ALLOCATION_FAILURE;
}

f=(double**)calloc(Nt+1,sizeof(double*));
if (f==NULL)
    return MEMORY_ALLOCATION_FAILURE;
for (i=0;i<Nt+1;i++)
{
    f[i]=(double *)calloc(Nt+1,sizeof(double));
    if (f[i]==NULL)
        return MEMORY_ALLOCATION_FAILURE;
}

f_down=(int**)calloc(Nt+1,sizeof(int*));
if (f_down==NULL)
    return MEMORY_ALLOCATION_FAILURE;
for (i=0;i<Nt+1;i++)
{
    f_down[i]=(int *)calloc(Nt+1,sizeof(int));
    if (f_down[i]==NULL)
        return MEMORY_ALLOCATION_FAILURE;
}
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f_up=(int**)calloc(Nt+1,sizeof(int*));
if (f_up==NULL)
    return MEMORY_ALLOCATION_FAILURE;
for (i=0;i<Nt+1;i++)
{
    f_up[i]=(int *)calloc(Nt+1,sizeof(int));
    if (f_up[i]==NULL)
        return MEMORY_ALLOCATION_FAILURE;
}

return OK;
}
```

```
static void free_memory(int Nt)
{
    int i;

    for (i=0;i<Nt+1;i++)
        free(V[i]);
    free(V);

    for (i=0;i<Nt+1;i++)
        free(pu_f[i]);
    free(pu_f);

    for (i=0;i<Nt+1;i++)
        free(pd_f[i]);
    free(pd_f);

    for (i=0;i<Nt+1;i++)
        free(f[i]);
    free(f);

    for (i=0;i<Nt+1;i++)
        free(f_up[i]);
    free(f_up);

    for (i=0;i<Nt+1;i++)
        free(f_down[i]);
    free(f_down);
}
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    return;
}

static double compute_f(double r, double omega)
{
    return 2.*sqrt(r) / omega;
}

static double compute_v(double R, double omega)
{
    double val;

    val = SQR(R) * SQR(omega) / 4.;
    if (R > 0.)
        val = SQR(R) * SQR(omega) / 4.;
    else
        val = 0.0;
    return val;
}

/*Calibration of the tree v*/
static int tree_v(double tt, double v02, double kappa2, double theta2, double om
{
    int i, j;
    int z;
    double Ru, Rd;
    double mu_r, v_curr;
    double dt, sqrt_dt;

    /*Fixed tree for R=f*/
    f[0][0] = compute_f(v02, omega2);

    dt = tt / (double)Nt;
    sqrt_dt = sqrt(dt);

    V[0][0] = compute_v(f[0][0], omega2);
    f[1][0] = f[0][0] - sqrt_dt;
    f[1][1] = f[0][0] + sqrt_dt;
    V[1][0] = compute_v(f[1][0], omega2);
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V[1][1] = compute_v(f[1][1], omega2);
for (i = 1; i < Nt; i++)
  for (j = 0; j <= i; j++)
  {
    f[i + 1][j] = f[i][j] - sqrt_dt;
    f[i + 1][j + 1] = f[i][j] + sqrt_dt;
    V[i + 1][j] = compute_v(f[i + 1][j], omega2);
    V[i + 1][j + 1] = compute_v(f[i + 1][j + 1], omega2);
  }

for (i = 1; i < Nt; i++)
  for (j = 0; j <= i; j++)

    /*Evolve tree for f*/
    for (i = 0; i < Nt; i++)
    {
      for (j = 0; j <= i; j++)
      {
        /*Compute mu_f*/
        v_curr = V[i][j];

        mu_r = kappa2 * (theta2 - v_curr);

        z = 0;
        while ((V[i][j] + mu_r * dt < V[i + 1][j - z])
               && (j - z >= 0))
        {
          z = z + 1;
        }
        f_down[i][j] = -z;
        Rd = V[i + 1][j - z];

        if (z > 0)
          z = 0;
        else z = 1;

        while ((V[i][j] + mu_r * dt > V[i + 1][j + z])
               && (j + z <= i))
        {
          z = z + 1;

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    }

    Ru = V[i + 1][j + z];

    f_up[i][j] = z;
    pu_f[i][j] = (V[i][j] + mu_r * dt - Rd) / (Ru - Rd);

    if ((Ru - 1.e-9 > V[i + 1][i + 1]) || (j + f_up[i][j] > i + 1))
    {
        pu_f[i][j] = 1;

        f_up[i][j] = i + 1 - j;
        f_down[i][j] = i - j;
    }
    if ((Rd + 1.e-9 < V[i + 1][0]) || (j + f_down[i][j] < 0))
    {
        pu_f[i][j] = 0.;
        f_up[i][j] = 1 - j;
        f_down[i][j] = 0 - j;
    }
    pd_f[i][j] = 1. - pu_f[i][j];
}

}
return 1;
}

/*Compute Price Option*/
int MCHybridTree_Heston(double s0, NumFunc_1 *p, double tt, double r, double di
{

    double price_sample, mean_price, var_price;
    int init_mc, ipath, i, k2;
    int simulation_dim;
    double alpha, z_alpha;
    double pterror_price;
    double vol;
    double dt, sqrt_dt;
    double g1, w_t_1;
    double Yt, St;
    double rho3;

```

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double new_vol;
double mu_z;
double sigma_z;

/*Memory Allocation*/
if (memory_allocation(Nt) != OK) return FAIL;

//Tree construction for v
tree_v(tt, v02, kappa2, theta2, omega2, Nt);

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

/*Initialisation*/
mean_price= 0.0;
var_price= 0.0;

dt=tt/(double)Nt;
sqrt_dt=sqrt(dt);
/* Test after initialization for the generator */
simulation_dim =Nt;

/* MC sampling */
init_mc = pnl_rand_init(generator, simulation_dim, N_MC);
rho3=sqrt(1.-SQR(rhoSv));
for(ipath= 1;ipath<=N_MC;ipath++)
{
    vol=V[0][0];
    Yt=log(s0);
    k2=0;
    for(i=0;i<Nt;i++)
    {
        g1=pnl_rand_normal(generator);//V
        w_t_1=sqrt_dt*g1;//V

        //Simulate V
        if(pnl_rand_uni(generator)<pu_f[i][k2])
            k2+=f_up[i][k2];
        else
            k2+=f_down[i][k2];
    }
}

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    new_vol=V[i+1][k2];

    mu_z=r-divid-0.5*vol-rhoSv/omega2*kappa2*(theta2-vol);
    sigma_z=rho3*sqrt(vol);

    Yt+=mu_z*dt+sigma_z*w_t_1+rhoSv/omega2*(new_vol-vol);

    St=exp(Yt);

    vol=new_vol;
}

price_sample=exp(-r*tt)*(p->Compute)(p->Par,St);

/* Sum */
mean_price+=price_sample;

/* Sum of squares */
var_price+= SQR(price_sample);
}

*ptprice=(mean_price/(double)N_MC);
pterror_price= sqrt(var_price/(double)N_MC-SQR(*ptprice))/sqrt((double)N_MC-1)

/* Price Confidence Interval */
*inf_price= *ptprice - z_alpha*(pterror_price);
*sup_price= *ptprice + z_alpha*(pterror_price);

/*Memory Disallocation*/
free_memory(Nt);

return OK;
}

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

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```

double r,divid;

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

return MCHybridTree_Heston(ptMod->S0.Val.V_PDOUBLE,
                           ptOpt->PayOff.Val.V_NUMFUNC_1,
                           ptOpt->Maturity.Val.V_DATE - ptMod->T.Val.V_DATE,r,
                           ptMod->Sigma0.Val.V_PDOUBLE
                           , ptMod-> MeanReversion.Val.V_PDOUBLE,
                           ptMod->LongRunVariance.Val.V_PDOUBLE,
                           ptMod->Sigma.Val.V_PDOUBLE,
                           ptMod->Rho.Val.V_PDOUBLE,
                           Met->Par[0].Val.V_PINT,
                           Met->Par[1].Val.V_PINT,
                           Met->Par[2].Val.V_ENUM.value,
                           Met->Par[3].Val.V_PDOUBLE,
                           &(Met->Res[0].Val.V_DOUBLE), &(Met->Res[1].Val.V_DO
}

static int CHK_OPT(MC_HybridTree_Heston)(void *Opt, void *Mod)
{
    if ((strcmp(((Option *)Opt)->Name, "CallEuro") == 0) || (strcmp(((Option *)Opt
        return OK;
    return WRONG;
}
#endif //PremiaCurrentVersion

static int MET(Init)(PricingMethod *Met, Option *Opt)
{
    if (Met->init == 0)
    {
        Met->init = 1;
        Met->HelpFilenameHint = "mc_hybridtree_bates";
        Met->Par[0].Val.V_INT = 50;
        Met->Par[1].Val.V_INT = 50000;
        Met->Par[2].Val.V_ENUM.value = 0;
        Met->Par[2].Val.V_ENUM.members = &PremiaEnumMCRNGs;
        Met->Par[3].Val.V_DOUBLE = 0.95;
    }
}

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    return OK;
}

PricingMethod MET(MC_HybridTree_Heston) =
{
    "MC_HybridTree",
    { {"N steps time", INT, {100}, ALLOW},
      {"N Iterations", INT, {100}, ALLOW},
{"RandomGenerator", ENUM, {100}, ALLOW},
      {"Confidence Value", DOUBLE, {100}, ALLOW},
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CALC(MC_HybridTree_Heston),
    { {"Price", DOUBLE, {100}, FORBID},
{"Inf Price", DOUBLE, {100}, FORBID},
      {"Sup Price", DOUBLE, {100}, FORBID} ,
      {" ", PREMIA_NULLTYPE, {0}, FORBID}
    },
    CHK_OPT(MC_HybridTree_Heston),
    CHK_mc,
    MET(Init)
};
```