```
   Help
#include "kou1d_pad.h"
#include "pnl/pnl_fft.h"
#include "pnl/pnl_complex.h"
#include "pnl/pnl_vector.h"

#if defined(PremiaCurrentVersion) && PremiaCurrentVersion <
     (2010+2) //The "#else" part of the code will be freely av
    ailable after the (year of creation of this file + 2)
static int CHK_OPT(FFT_Kou_FixedLookback)(void *Opt, void *
    Mod)
{
  return NONACTIVE;
}
int CALC(FFT_Kou_FixedLookback)(void*Opt,void *Mod,Pricing
    Method *Met)
{
  return AVAILABLE_IN_FULL_PREMIA;
}
#else


// "resultat takes the product of a circulant matrix M(c)
    and a vextor x
static void circulante (PnlVectComplex *resultat, PnlVectC
    omplex *c, PnlVectComplex *x)
{
  PnlVectComplex *temp;
  int i,n;
  n = x->size;
  temp=pnl_vect_complex_create(n);

  pnl_fft (c, temp);
  pnl_fft (x,resultat);
  for (i=0;i<n;i++)
  {
    pnl_vect_complex_set (temp,i,Cmul (pnl_vect_complex_get
    (temp,i), pnl_vect_complex_get(resultat,i)));
  }
  pnl_ifft(temp,resultat);
  pnl_vect_complex_free(&temp);
```

```
}


// "r" takes the product of the toeplitz matrix   N(v,w)
    with holes and a vector x
static void toep (PnlVectComplex *v, PnlVectComplex *w, Pn
    lVectComplex *x, PnlVectComplex *r)
{
  int M, i;
  PnlVectComplex *temp;
  PnlVectComplex *temp2;
  PnlVectComplex *x2;
  M=v->size;
  temp=pnl_vect_complex_create(4*M);
  temp2=pnl_vect_complex_create(4*M);
  x2=pnl_vect_complex_create(4*M);
  pnl_vect_complex_set(temp,0,CRmul(CONE,0.5));
  for (i=1;i<2*M+1;i=i+2)
  {
    pnl_vect_complex_set(temp,i,pnl_vect_complex_get(v,(i-1
    )/2));
    pnl_vect_complex_set(temp,i+1,CZERO);
  }
  for ( i=2*M+1;i<4*M-1;i=i+2)
  {
    pnl_vect_complex_set(temp,i,pnl_vect_complex_get(w,(M-1
    )-((i-1)-2*M)/2));
    pnl_vect_complex_set(temp,i+1,CZERO);
  }
  pnl_vect_complex_set(temp,i,pnl_vect_complex_get(w,(M-1)-
    ((4*M-1-1)-2*M)/2));
  for ( i=0;i<2*M+1;i++)
    pnl_vect_complex_set(x2,i,pnl_vect_complex_get(x,i));
  for ( i=2*M+1;i<4*M;i++)
    pnl_vect_complex_set(x2,i,CZERO);
  circulante(temp2,temp,x2);
  for ( i=0;i<2*M+1;i++)
    pnl_vect_complex_set(r,i,pnl_vect_complex_get(temp2,i))
    ;
```

```
  pnl_vect_complex_free(& temp);
  pnl_vect_complex_free(& temp2);
  pnl_vect_complex_free(& x2);
}



// the characteristic function of the Kou's model
static dcomplex fi_kou (double t,double sigma,double d,
    double lambda,double lambdap,double lambdam,double p,dcomplex w,
    double signe)
{
  dcomplex temp1,temp2,u;
  u=CRmul(w,(double)signe);
  temp1=CRmul(CRsub(Cmul(CI,u),lambdam),-1);   //temp1=(I*
    u-lambdam)*(-1)
  temp1=Conj(temp1);                    //temp1=temp1.conj(
    );
  temp2=CRadd(Cmul(CI,u),lambdap);        //temp2=I*u+lambd
    ap;
  temp2=Conj(temp2);                    //temp2=temp2.conj(
    );
  temp1=CRdiv(temp1,Csqr_norm(temp1));       //temp1=(temp1
    /temp1.norm());
  temp2=CRdiv(temp2,Csqr_norm(temp2));         //temp2=
    temp2/(temp2.norm());
  temp1=Cadd(CRmul(temp1,lambdam*p),CRsub(CRmul(temp2,lambd
    ap*(1-p)),1));    //temp1=temp1*lambdam*p+(temp2*lambdap*(1-
    p))-1;
  temp1=CRmul(temp1,-1); //temp1=temp1*-1;
  temp1=CRmul(temp1,lambda);  //temp1=temp1*l;
  temp2=Csub(CRdiv(CRmul(Cmul(u,u),sigma*sigma),2.),CRmul(
    Cmul(CI,u),d));  // temp2=u*u*s*s/2-I*u*d;
  temp1=Cadd(temp2,temp1);   //temp1=temp2+temp1;

  temp1=CRmul(temp1,(-t));    //temp1=temp1*(-t);
  temp1=Cexp(temp1); //temp1=temp1.expon();

  return temp1;
}
```

```
// the characteristic function of the Kou's model after th
    e Esscher transformation
static dcomplex fi_kou_star (double t,double sigma,double
    d,double lambda,double lambdap,double lambdam,double p,dcom
    plex u,double x,double signe)
{
  dcomplex b;
  dcomplex a;
  dcomplex c;
  a=CRmul(CI,-1);
  c= fi_kou ( t, sigma, d, lambda, lambdap, lambdam, p, Cad
    d(u,CRmul(a,x)), signe );
  b= fi_kou ( t, sigma, d, lambda, lambdap, lambdam, p, CR
    mul(a,x) , signe);
  a=Cdiv(c,b);

  return a;
}


//The diagonal matrix which attributes the corresponding
    coeficients to the calculation of F in the Kou's model
static void  F_diag_fi_kou (PnlVectComplex *v,double t,
    double sigma,double d,double lambda,double lambdap,double lambd
    am,double p,dcomplex h,double x,int M,double signe)
{
  int com;

  for (com=0;com<2*M+1;com++)
    pnl_vect_complex_set(v,com,Cmul(pnl_vect_complex_get(v,
    com),fi_kou_star(t,sigma,d,lambda,lambdap,lambdam,p,CRmul(h,(
    double)(M-com)),x,signe)));
}


//The diagonal matrix which attributes the corresponding
    coeficients to the calculation of G in the Kou's model
static void G_diag_fi_kou (PnlVectComplex *v,double t,
    double sigma,double d,double lambda,double lambdap,double lambd
    am,double p,dcomplex h, double x,int M,double signe)
```

```
{
  int i;

  for (i=0;i<2*M+1;i++)
    pnl_vect_complex_set(v,i,Cmul(pnl_vect_complex_get(v,i)
    ,fi_kou_star(t,sigma,d,lambda,lambdap,lambdam,p,Cadd(CRmu
    l(h,(double)(M-i)),CRmul(CI,x)),x, signe)));
}

// the estimation's algorithm  in the  Kou's model with "n_
    point" maximum observations, and  M point of the Hilbert's
    estimation
static dcomplex estiation_kou (double Xmaxmin, PnlVectCompl
    ex *G,double t,double sigma,double d,double lambda,double
    lambdap,double lambdam,double p,dcomplex h,double x,int M,
    int n_points,double signe)
{
  int i,j;
 double Xmax;
  dcomplex C,cte,a,k;
  PnlVectComplex *v,*w,*F,*tempg,*tempf;
  F=pnl_vect_complex_create (2*M+1);
  v=pnl_vect_complex_create (M);    //the first colomn vec
    tor of  the Hilbert's matrix
  w=pnl_vect_complex_create (M);    //the first line vector
     of  the Hilbert's matrix
  tempg=pnl_vect_complex_create (2*M+1);
  tempf=pnl_vect_complex_create (2*M+1);
  //initialisation of v and w
  cte=CONE;
  C=CRmul(CI,M_1_PI); // 1/pi
  for (i=0;i<M;i=i+1)
    pnl_vect_complex_set (v,i,CRdiv(C,(double)(2*i+1)));
  for (i=0;i<M;i=i+1)
    pnl_vect_complex_set (w,i,CRdiv(C,(double)(-(2*i+1))));
  //intialisation  of G_1, F_1 and Cte_1
       Xmax=MAX(Xmaxmin,0);
   for(i=0;i<2*M+1;i++)
     {
       pnl_vect_complex_set (F,i,Cexp( Cmul(     CRmul( CR
    mul(h,(double)(i-M)) , Xmax ),CI)   ));
```

```
   pnl_vect_complex_set (G,i,Cexp(CRmul(CRadd(Cmul(CRmu
l(h,(double)(i-M)),CI),x),Xmax)));
 }
   F_diag_fi_kou (F, t, sigma, d, lambda, lambdap,lambd
am, p, h,x, M, signe);//G=( fi_kou(1)F(1),..,fi_kou(i)F(i),
..,fi_kou(2M+1)F(2M+1) )
   toep(v,w,F,tempf);
   pnl_vect_complex_clone(F,tempf);

   cte=CRmul(CRsub(pnl_vect_complex_get(F,M),1.0),-1);/
/1-f(0)


   G_diag_fi_kou (G,t, sigma, d, lambda, lambdap,lambd
am, p, h,x, M, signe);//G=( fi_kou(1)G(1),..,fi_kou(i)G(i),
..,fi_kou(2M+1)G(2M+1) )
   toep(v,w,G,tempg);//temp=C(H)*G
   pnl_vect_complex_clone (G,tempg);


 for (j=1;j<n_points;j++)
 {
   for(i=0;i<2*M+1;i++)
   {
      pnl_vect_complex_set (F,i,Cadd(cte,pnl_vect_
complex_get(F,i)));//F=F+cte
      pnl_vect_complex_set (G,i,Cadd(cte,pnl_vect_
complex_get(G,i)));//G=G+cte
   }
   F_diag_fi_kou (F, t, sigma, d, lambda, lambdap,lambd
am, p, h,x, M, signe);//G=( fi_kou(1)F(1),..,fi_kou(i)F(i),
..,fi_kou(2M+1)F(2M+1) )
   toep(v,w,F,tempf);//
   pnl_vect_complex_clone(F,tempf);//F=temp=H.Df*F

   G_diag_fi_kou (G,t, sigma, d, lambda, lambdap,lambd
am, p, h,x, M, signe);//G=( fi_kou(1)G(1),..,fi_kou(i)G(i),
..,fi_kou(2M+1)G(2M+1) )
   toep(v,w,G,tempg);//temp=C(H)*G
   pnl_vect_complex_clone (G,tempg);//G=temp=H.Dg*G
```

```
       cte=CRmul(CRadd(pnl_vect_complex_get(F,M),-1),-1);

      }

      k=RCmul(-1,CI);
      a=fi_kou ( n_points*t, sigma, d, lambda, lambdap,lam
    bdam, p,CRmul(k,x), signe);

      pnl_vect_complex_set (G,M,Cmul(Cadd(pnl_vect_
    complex_get (G,M),cte),a));

      pnl_vect_complex_free(&v);
      pnl_vect_complex_free(&w);
      pnl_vect_complex_free(&tempf);
      pnl_vect_complex_free(&tempg);
      pnl_vect_complex_free(&F);

      return pnl_vect_complex_get(G,M);
}


static int fft_kou_lookbackfixed(double s_maxmin,NumFunc_2*
    P,double S0,double T,double r,double divid,double sigma,
    double lambda,double lambdam,double lambdap,double p,int n_po
    ints,long M,double *ptprice)
{
  double pas,d,c,drift,nu,h_temp,x_maxmin,signe,beta,K;
  dcomplex h,res;
  PnlVectComplex *G;
  K=P->Par[0].Val.V_DOUBLE;
  beta=0.5826;
  pas=T/n_points;
  //the width of the estimation's strip
  d=MIN(lambdam,lambdap);
  // the optimal h : h(M)//
  nu=2;
  c=sigma*sigma/2;
  h_temp=pow(((M_PI*d)/(pas*c)),1.0/(1+nu))*pow((double)M,-
    nu/(1+nu));
  h=CRmul(CONE,h_temp);
  //martingal condition
```

```
  drift=r-divid-c+lambda*(1-((p*lambdam)/(lambdam-1))-(((1-
    p)*lambdap)/(lambdap+1)));
  G=pnl_vect_complex_create (2*M+1);

//CALL
  if ((P->Compute)==&Call_OverSpot2)
  {
    s_maxmin=MAX(s_maxmin,K);
    s_maxmin=exp(-beta*sigma*sqrt(T/n_points))*s_maxmin;
    signe=1;
    x_maxmin=signe*log ((s_maxmin/S0));
    res=estiation_kou(x_maxmin,G,pas,sigma,drift,lambda,lam
    bdap,lambdam,p,h,signe,M,n_points, signe);
    res= CRsub(CRmul(res,exp(beta*sigma*sqrt(T/n_points))*
    exp(-r*T)*S0),K*exp(-r*T));
  }
//PUT
  if ((P->Compute)==&Put_OverSpot2)
  {
    s_maxmin=MIN(s_maxmin,K);
    s_maxmin=exp(beta*sigma*sqrt(T/n_points))*s_maxmin;
    signe=-1;
    x_maxmin=signe*log ((s_maxmin/S0));
    res=estiation_kou(x_maxmin,G,pas,sigma,drift,lambda,lam
    bdap,lambdam,p,h,signe,M,n_points, signe);
    res= CRadd(CRmul(res,-S0*exp(-beta*sigma*sqrt(T/n_po
    ints))*exp(-r*T)),K*exp(-r*T));
  }
  *ptprice=Creal(res);

  pnl_vect_complex_free(&G);
  return OK;
}
int CALC(FFT_Kou_FixedLookback)(void*Opt,void *Mod,Pricing
    Method *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  fft_kou_lookbackfixed((ptOpt->PathDep.Val.V_
    NUMFUNC_2)->Par[4].Val.V_PDOUBLE,ptOpt->PayOff.Val.V_NUMFUNC_2,pt
    Mod->S0.Val.V_PDOUBLE,ptOpt->Maturity.Val.V_DATE-ptMod->T.Val
    .V_DATE,r,divid,ptMod->Sigma.Val.V_PDOUBLE,ptMod->Lambda.
    Val.V_PDOUBLE,ptMod->LambdaPlus.Val.V_PDOUBLE,ptMod->LambdaM
    inus.Val.V_PDOUBLE,ptMod->P.Val.V_PDOUBLE,Met->Par[0].Val.V_
    PINT,Met->Par[1].Val.V_LONG,&(Met->Res[0].Val.V_DOUBLE));
}

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

#endif //PremiaCurrentVersion
static int MET(Init)(PricingMethod *Met,Option *Mod)
{
  if ( Met->init == 0)
    {
      Met->init=1;
       Met->HelpFilenameHint = "ap_kou_lookbackfixed_fft";
      Met->Par[0].Val.V_PINT=100;
      Met->Par[1].Val.V_LONG=512;
    }
  return OK;
}

PricingMethod MET(FFT_Kou_FixedLookback)=
{
  "FFT_Kou_LookbackFixed",
  {{"Number of discretization steps",LONG,{100},ALLOW},{"N
    truncation level (a power of 2)",LONG,{100},ALLOW},{" ",PREM
    IA_NULLTYPE,{0},FORBID}},
  CALC(FFT_Kou_FixedLookback),
  {{"Price",DOUBLE,{100},FORBID},{" ",PREMIA_NULLTYPE,{0},
```

```
    FORBID}},
  CHK_OPT(FFT_Kou_FixedLookback),
  CHK_ok,
  MET(Init)
} ;
```

References