Help

```
#include <stdlib.h>
#include  "bs1d_pad.h"

/*  diffusion coefficient C(x,t) */
static  double coef(double x,double r,double sig,double t,
    double del)
{
  double z;
  double  sigma2=0.5*SQR(sig);

  if ((r-del)==0.)
    {
      z=(x+t);
      z=sigma2*SQR(z);
    }
  else
    {
      z=(x+(1-exp((-r+del)*t))/(r-del));
      z=sigma2*SQR(z);
    }
  return z;

}

/*  right-hand-side R(x,t) of the PDE satisfied by the
    correction term */
static double fixe(double x,double r,double t,double sig,
    double del)
{
  double eta,y;
  double  sigma2=0.5*SQR(sig);
  /* double  drift=r-del;*/
  double  drift3=pow(r-del,3.);

  if ((r-del)==0.)
    {
      eta=sig*sig*t*t*t/6.;
      y=(x+2.*t);
      y=y*sigma2*x;
      y=y*exp(-(x*x)/(4.*eta));
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      y=y/(2.*sqrt(M_PI*eta));
    }
  else {
    eta=(-3.+2.*(r-del)*t+4.*exp((-r+del)*t)-exp(-2*(r-del)
    *t));
    eta=eta*sigma2/(2*drift3);
    y=(x+2.*(1-exp(-(r-del)*t))/(r-del));
    y=y*sigma2*x;
    y=y*exp(-(x*x)/(4.*eta));
    y=y/(2.*sqrt(M_PI*eta));
  }

  return y;
}

/*  Computation of f0 */
static double f0(double x,double r,double t,double sig,
    double del)
{
  double eta,y;
  double  sigma2;
  double  drift3;


  sigma2=SQR(sig);
  drift3=pow(r-del,3.0);
  if ((r-del)==0.)
    { eta=sig*sig*t*t*t/6.;
      y=-x/2.*(1.+cdf_nor(-x/(2.*sqrt(eta))))+sqrt(eta)/sq
    rt(M_PI)*exp(-x*x/(4.*eta));
    }
  else {
    eta=(-3+2*(r-del)*t+4*exp((-r+del)*t)-exp(-2.*(r-del)*
    t));
    eta=eta*sigma2/(4.*drift3);
    y=-x*(cdf_nor(-x/(sqrt(2.*eta))))+sqrt(eta)/sqrt(M_PI)*
    exp(-x*x/(4*eta));
  }
  return y;
}
```

```
/*  derivative of f0 w.r.t. S */
static double Residu0(double x,double r,double to,double T,
    double sig,double del )
{
  double eta,z;
  double  sigma2=SQR(sig);
  /* double  drift=r-del; */
  double  drift3=pow(r-del,3.);

  if ((r-del)==0.)
    {
      eta=sig*sig*to*to*to/6.;
      z=to/T*(cdf_nor(-x/(sqrt(2.*eta))))+sqrt(eta/M_PI)/T*
    exp(-x*x/(4*eta));
    }
  else
    { eta=(-3+2*(r-del)*to+4*exp((-r+del)*to)-exp(-2*(r-de
    l)*to));
      eta=eta*sigma2/(4.*drift3);
      z=(1-exp(-(r-del)*to))/((r-del)*T)*(cdf_nor(-x/(sqrt(
    2.*eta))))+sqrt(eta/M_PI)/T*exp(-x*x/(4*eta));

    }
  return z;
}

/*  tridiagonal matrix  */

static void Coef(double *U,double *D,double *L,double *G,
    double *Y,double *coorx,int nb,double t,double r,double sig,
    double del,double dt,double dx)
{
  int i;
  double t2,coeff,coeff1;
  double *D1,*U1,*L1;
  double dt_dx=dt/(dx*dx);

  t2=t+dt/2.;

  U1= malloc((nb-1)*sizeof(double));
  L1= malloc((nb-1)*sizeof(double));
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  D1= malloc(nb*sizeof(double));

  for (i=0;i<nb-1;i++)
    {
      coeff=coef(coorx[i],r,sig,t2,del);
      coeff1=coef(coorx[i+1],r,sig,t2,del);

      D[i]=1+dt_dx*coeff;
      L[i]=-0.5*dt_dx*coeff1;
      U[i]=-0.5*dt_dx*coeff;

      D1[i]=1.-dt_dx*coeff;
      L1[i]=0.5*dt_dx*coeff1;
      U1[i]=0.5*dt_dx*coeff;
    }

  D[nb-1]=1.+dt_dx*coef(coorx[nb-1],r,sig,t2,del);
  D1[nb-1]=1.-dt_dx*coef(coorx[nb-1],r,sig,t2,del);

  G[0]=D1[0]*Y[0]+U1[0]*Y[1]+dt*fixe(coorx[0],r,t2,sig,del)
    ;
  for (i=1;i<(nb-1);i++)
    {
      G[i]=dt*fixe(coorx[i],r,t2,sig,del);
      G[i]=G[i]+L1[i-1]*Y[i-1]+D1[i]*Y[i]+U1[i]*Y[i+1];
    }
  G[nb-1]=dt*fixe(coorx[nb-1],r,t2,sig,del)+L1[nb-2]*Y[nb-2
    ]+D1[nb-1]*Y[nb-1];


  free(D1);
  free(L1);
  free(U1);

}

/*   resolution of the system */
static void Gauss(double *X,double *L,double *U,double *D,
    double *G,int nb)
{
  int i;
```

```
  /*  BackWard Pass */
  for(i=nb-2;i>=0;i--)
    {
      D[i]=D[i]-U[i]*L[i]/D[i+1];
      G[i]=G[i]-U[i]*G[i+1]/D[i+1];
    }

  /*  Forward Pass   */
  X[0]=G[0]/D[0];
  for(i=1;i<nb;i++)
    {
      X[i]=(G[i]-L[i-1]*X[i-1])/D[i];
    }

}


static void derivee(double *X,double *Y,int nbx,double dx)
{
  int i;
  for(i=1;i<(nbx-1);i++)
    {
      Y[i]=(X[i+1]-X[i-1])/(2*dx);
    }
}


/* correction  DELTA  */
static double correction_DELTA(double f,double df,double x,
    double T,double t,double r,double del)
{
  double cor;
  if(r-del==0)
    cor=1/T*f-1/T*(x+t)*df;
  else
    cor=1/T*f-1/T*(x+1/(r-del)*(1-exp(-(r-del)*t)))*df;

  return cor;
}
```

```
int Zhang_FixedAsian(double pseudo_stock,double pseudo_stri
    ke,NumFunc_2  *po,double T,double r,double divid,double si
    gma,double *ptprice,double *ptdelta)
{

  double CTtK,PTtK,Dlt,Plt;
  int k,i,p,nbx,nbt;
  double dx,dt,Xmin,prix,prix_exact;
  double resi,resi_exact,correc_resi;
  double *Y,*Coorx,*Coort,*D,*L,*U,*G,*X,*DX;
  double xi,l,t;

  int pyr;

  /*Discretization Time and Space Step Number*/
  nbt=100;
  nbx=100;

  /*Memory Allocation*/
  Coorx= malloc((nbx)*sizeof(double));
  Coort= malloc(nbt*sizeof(double));
  D= malloc((nbx)*sizeof(double));
  L= malloc((nbx)*sizeof(double));
  U= malloc((nbx)*sizeof(double));
  X= malloc(nbx*sizeof(double));
  G= malloc(nbx*sizeof(double));
  Y= malloc(nbx*sizeof(double));
  DX= malloc((nbx)*sizeof(double));

 for(i=0;i<nbx;i++)
   Y[i]=0.;

  dt=T/nbt;

  /*  New variables xi and T */
  if ((r-divid)==0.)
    xi=T*pseudo_strike/pseudo_stock-T;
  else
    xi=T*pseudo_strike/pseudo_stock*exp(-(r-divid)*T)-(1-
    exp(-(r-divid)*T))/(r-divid);
```

```
/*Localization */
l=5.*sigma*pow(T,1.5);

Xmin=-l;


/****************************/
/* Discretization           */
/****************************/

dx=2.*l/(nbx+1.);



Coorx[0]=Xmin+dx;
for(i=1;i<nbx;i++)
  Coorx[i]=Coorx[i-1]+dx;


Coort[0]=0.;
for(k=1;k<nbt;k++)  Coort[k]=Coort[k-1]+dt;

/********************** Computation of the price  *******
  ****************/

/* Approximate price   */
prix=exp(-divid*T)*pseudo_stock/T*f0(xi,r,T,sigma,divid);

/*  Computation of the correction   */

Coef(U,D,L,G,Y,Coorx,nbx,Coort[0],r,sigma,divid,dt,dx);
Gauss(X,L,U,D,G,nbx);

for(p=1;p<nbt;p++)
  {
    t=Coort[p];
    Coef(U,D,L,G,X,Coorx,nbx,t,r,sigma,divid,dt,dx);
    Gauss(X,L,U,D,G,nbx);
  }

pyr=(int)floor((xi-Xmin)/dx);
```

```
prix_exact=prix+exp(-divid*T)*pseudo_stock/T*(X[pyr]+(X[
  pyr-1]-X[pyr])*(xi-Coorx[pyr])/(Coorx[pyr-1]-Coorx[pyr]));

/*  Call Price */
CTtK=prix_exact;

/*  Put Price from Parity*/
if(r==divid)
  PTtK=CTtK+pseudo_strike*exp(-r*t)-pseudo_stock*exp(-r*
  t);
else
  PTtK=CTtK+pseudo_strike*exp(-r*t)-pseudo_stock*exp(-r*
  t)*(exp((r-divid)*t)-1.)/(t*(r-divid));

/*Delta */

/* Computation of delta  */
resi=exp(-divid*T)*Residu0(xi,r,T,T,sigma,divid);

/*  correction of delta */
derivee(X,DX,nbx,dx);
correc_resi=correction_DELTA(X[pyr],DX[pyr],xi,T,T,r,div
  id);
correc_resi=exp(-divid*T)*correc_resi;

resi_exact=resi+correc_resi;

/*Delta for call option*/
Dlt=resi_exact;

/*Delta for put option*/
if(r==divid)
  Plt=Dlt-exp(-r*t);
else
  Plt=Dlt-exp(-r*t)*(exp((r-divid)*t)-1.0)/(t*(r-divid));

/*Price*/
if ((po->Compute)==&Call_OverSpot2)
  *ptprice=CTtK;
else
  *ptprice=PTtK;
```

```
  /*Delta */
  if ((po->Compute)==&Call_OverSpot2)
    *ptdelta=Dlt;
  else
    *ptdelta=Plt;

  /*Memory Desallocation*/
  free(Coorx);
  free(Coort);
  free(D);
  free(L);
  free(U);
  free(X);
  free(G);
  free(Y);
  free(DX);

  return OK;
}

int CALC(AP_FixedAsian_Zhang)(void *Opt,void *Mod,Pricing
    Method *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_PDOUB
    LE;


  if(T_0 < t_0)
    {
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      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)/(ptOpt->Maturity.Val.V_
    DATE-(ptOpt->PathDep.Val.V_NUMFUNC_2)->Par[0].Val.V_PDOUB
    LE);
      pseudo_spot=(1.-time_spent)*ptMod->S0.Val.V_PDOUBLE;
      pseudo_strike=(ptOpt->PayOff.Val.V_NUMFUNC_2)->Par[0]
    .Val.V_PDOUBLE-time_spent*(ptOpt->PathDep.Val.V_NUMFUNC_2)
    ->Par[4].Val.V_PDOUBLE;

      if (pseudo_strike<=0.){
  Fprintf(TOSCREEN,"ANALYTIC FORMULA{n{n{n");
  return_value=Analytic_KemnaVorst(pseudo_spot,pseudo_stri
    ke,time_spent,ptOpt->PayOff.Val.V_NUMFUNC_2,ptOpt->Maturit
    y.Val.V_DATE-ptMod->T.Val.V_DATE,r,divid,&(Met->Res[0].Val.
    V_DOUBLE),&(Met->Res[1].Val.V_DOUBLE));
      }
      else
  return_value=Zhang_FixedAsian(pseudo_spot,pseudo_strike,
    ptOpt->PayOff.Val.V_NUMFUNC_2,ptOpt->Maturity.Val.V_DATE-pt
    Mod->T.Val.V_DATE,r,divid,ptMod->Sigma.Val.V_PDOUBLE,&(Met->
    Res[0].Val.V_DOUBLE),&(Met->Res[1].Val.V_DOUBLE));
    }
  return return_value;

}

static int CHK_OPT(AP_FixedAsian_Zhang)(void *Opt, void *
    Mod)
{
  if ( (strcmp(((Option*)Opt)->Name,"AsianCallFixedEuro")==
    0) || (strcmp( ((Option*)Opt)->Name,"AsianPutFixedEuro")==
    0) )
    return OK;
  return WRONG;
}
```

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

  return OK;
}

PricingMethod MET(AP_FixedAsian_Zhang)=
{
  "AP_FixedAsian_Zhang",
  {{" ",PREMIA_NULLTYPE,{0},FORBID}},
  CALC(AP_FixedAsian_Zhang),
  {{"Price",DOUBLE,{100},FORBID},{"Delta",DOUBLE,{100},FORB
    ID} ,{" ",PREMIA_NULLTYPE,{0},FORBID}},
  CHK_OPT(AP_FixedAsian_Zhang),
  CHK_ok,
  MET(Init)
};
```

References