Help

```
#include <stdlib.h>
#include  "bs1d_doublim.h"
#include "error_msg.h"

/*Initial Mesh*/
static double initial_dmesh(double refinement,double x_min,
    double x_max,double x0,int upordown)
{

  double atrois;
  double acinq;
  double temp;
  double x;
  double inref;


  inref=1./refinement;
  x=(x0-x_min)/(x_max-x_min)-0.5;

  temp=x;

  if (inref>=0.2)
    {

      acinq = 8*(2.0*inref + 1.0/inref - 3.0);
      atrois = 2*(5.0 - 4.0*inref - 1.0/inref);
      if (upordown)
  x = x/2.0+0.25;
      else
  x = x/2.0-0.25;
      temp = inref*x + atrois*x*x*x + acinq*x*x*x*x*x;
      if (upordown)
  temp = 2.0*temp-0.5;
      else
  temp = 2.0*temp+0.5;
    }
  return (temp+0.5)*(x_max-x_min)+x_min;
}

/*New Mesh*/
```

```
static void new_dmesh(double time,double *old_x,double z,
    double *new_x,int N)
{
  double new_x_min,new_x_max,rho;
  int i;

  new_x_min = old_x[0] + z*time;
  new_x_max = old_x[N] + z*time;
  rho = (new_x_max - new_x_min)/(old_x[N]-old_x[0]);
  for (i=0; i<=N;i++)
    new_x[i] = new_x_min + rho*(old_x[i]-old_x[0]);

  return;
}

static int Fem_Out(int am,double s,NumFunc_1  *p,NumFunc_1
     *L, NumFunc_1  *U,double rebate,double t,double r,double
    divid,double sigma,int N,int M,double theta,double refinemen
    t,double *ptprice,double *ptdelta)
{
  int      i,TimeIndex,upordown;
  double   vv,z,Dir_low,Dir_up,sigma2;
  double   time_mesh,x_min,x_max,x0;
  double   *alpha,*beta,*gamma,*alpha1,*beta1,*gamma1,*old_
    x;
  double   *new_x,*V,*Vp,*beta_p,*P_New,*P_Old,*temp;

  /*Memory Allocation*/
  alpha= malloc((N+1)*sizeof(double));
  if (alpha==NULL)
    return MEMORY_ALLOCATION_FAILURE;

  beta= malloc((N+1)*sizeof(double));
  if (beta==NULL)
    return MEMORY_ALLOCATION_FAILURE;

  gamma= malloc((N+1)*sizeof(double));
  if (gamma==NULL)
    return MEMORY_ALLOCATION_FAILURE;

  alpha1= malloc((N+1)*sizeof(double));
```

```
if (alpha1==NULL)
  return MEMORY_ALLOCATION_FAILURE;

beta1= malloc((N+1)*sizeof(double));
if (beta1==NULL)
  return MEMORY_ALLOCATION_FAILURE;

gamma1= malloc((N+1)*sizeof(double));
if (gamma1==NULL)
  return MEMORY_ALLOCATION_FAILURE;

old_x= malloc((N+1)*sizeof(double));
if (old_x==NULL)
  return MEMORY_ALLOCATION_FAILURE;

new_x= malloc((N+1)*sizeof(double));
if (new_x==NULL)
  return MEMORY_ALLOCATION_FAILURE;

V= malloc((N+1)*sizeof(double));
if (V==NULL)
  return MEMORY_ALLOCATION_FAILURE;

Vp= malloc((N+1)*sizeof(double));
if (Vp==NULL)
  return MEMORY_ALLOCATION_FAILURE;

beta_p= malloc((N+1)*sizeof(double));
if (beta_p==NULL)
  return MEMORY_ALLOCATION_FAILURE;

P_New= malloc((N+1)*sizeof(double));
if (P_New==NULL)
  return MEMORY_ALLOCATION_FAILURE;

P_Old= malloc((N+1)*sizeof(double));
if (P_Old==NULL)
  return MEMORY_ALLOCATION_FAILURE;

temp= malloc((N+1)*sizeof(double));
if (temp==NULL)
```

```
  return MEMORY_ALLOCATION_FAILURE;


/*Time Step*/
time_mesh=t/(double)M;

/*Space Localisation*/
sigma2=sigma*sigma;
vv=0.5*sigma2;
z=(r-divid);

/*Terminal Values*/
x_min=log(((L->Compute)(L->Par,t))/s)-z*t;
x_max=log(((U->Compute)(U->Par,t))/s)-z*t;

for(i=0;i<N/2;i++)
  {
    x0=x_min+((double)i)*(x_max-x_min)/(double)N;
    upordown=1;
    old_x[i]=initial_dmesh(refinement,x_min,x_min+(x_max-
  x_min)/2.,x0,upordown);
    P_Old[i]=exp(-r*t)*(p->Compute)(p->Par,s*exp(old_x[i]
  +z*t));
  }
for(i=N/2;i<=N;i++)
  {
    x0=x_min+((double)i)*(x_max-x_min)/(double)N;
    upordown=0;
    old_x[i]=initial_dmesh(refinement,x_min+(x_max-x_min)
  /2.,x_max,x0,upordown);
    P_Old[i]=exp(-r*t)*(p->Compute)(p->Par,s*exp(old_x[i]
  +z*t));
  }
P_Old[0]=exp(-r*t)*rebate;
P_Old[N]=exp(-r*t)*rebate;

/*Finite Difference Cycle*/
for(TimeIndex=1;TimeIndex<=M;TimeIndex++)
  {
    /*New Mesh Computing*/
    x_min=log(((L->Compute)(L->Par,t-(double)TimeIndex*
```

```
  time_mesh))/s)-z*(t-(double)TimeIndex*time_mesh);
    x_max=log(((U->Compute)(U->Par,t-(double)TimeIndex*
  time_mesh))/s)-z*(t-(double)TimeIndex*time_mesh);
    new_dmesh(time_mesh,old_x,z,new_x,N);

    /*Computation of Lhs coefficients*/
    for(i=1;i<N;i++)
{
  alpha[i]=(-vv*theta*time_mesh*(1.+2.0/(new_x[i]-new_x[
  i-1]))
      -theta*(old_x[i-1]-new_x[i-1]));
  beta[i]=(new_x[i+1]-new_x[i-1]
     +sigma2*theta*time_mesh*(1.0/(new_x[i+1]-new_x[i])
           +1.0/(new_x[i]-new_x[i-1])));
  gamma[i]=(vv*theta*time_mesh*(1.-2.0/(new_x[i+1]-new_x
  [i]))
      +theta*(old_x[i+1]-new_x[i+1]));
}

    /*Computation of Rhs coefficients*/
    for(i=1;i<N;i++)
{
  alpha1[i]=(vv*(1.0-theta)*time_mesh*(1.+2.0/(old_x[i]-
  old_x[i-1]))
       +(1.0-theta)*(old_x[i-1]-new_x[i-1]));
  beta1[i]=(old_x[i+1]-old_x[i-1]
      -sigma2*(1.0-theta)*time_mesh*(1.0/(old_x[i+1]-ol
  d_x[i])
            +1.0/(old_x[i]-old_x[i-1])));
  gamma1[i]=(-vv*(1.0-theta)*time_mesh*(1.-2.0/(old_x[i+
  1]-old_x[i]))
       -(1.0-theta)*(old_x[i+1]-new_x[i+1]));
}

    /*Right factor*/
    for (i=1;i<=N-1;i++)
V[i]=alpha1[i]*P_Old[i-1]+beta1[i]*P_Old[i]+gamma1[i]*P_
  Old[i+1];

    /*Dirichlet Boundary Condition*/
    Dir_low=exp(-r*(t-(double)TimeIndex*time_mesh))*reb
```

```
  ate;

    V[1]-=alpha[1]*Dir_low;


    Dir_up=exp(-r*(t-(double)TimeIndex*time_mesh))*rebate
  ;

    V[N-1]-=gamma[N-1]*Dir_up;

    /*Gauss method*/
    Vp[N-1]=V[N-1];
    beta_p[N-1]=beta[N-1];

    for(i=N-2;i>=1;i--)
{
  beta_p[i]=beta[i]-gamma[i]*alpha[i+1]/beta_p[i+1];
  Vp[i]=V[i]-gamma[i]*Vp[i+1]/beta_p[i+1];
}
    P_New[1]=Vp[1]/beta_p[1];

    for (i=2;i<=N-1;i++)
P_New[i]=(Vp[i]-alpha[i]*P_New[i-1])/beta_p[i];

    /*Splitting for the american case*/
    if(am)
for (i=1;i<=N-1;i++)
  P_New[i]=MAX(P_New[i],exp(-r*(t-(double)TimeIndex*
  time_mesh))*(p->Compute)(p->Par,s*exp(old_x[i]+z*(t-(double)
  TimeIndex*time_mesh))));

    P_New[N]=Dir_up;
    P_New[0]=Dir_low;

    for(i=0;i<=N;i++)
{
  temp[i]=P_Old[i];
  P_Old[i]=P_New[i];
  P_New[i]=temp[i];
  temp[i]=old_x[i];
  old_x[i]=new_x[i];
```

```
    new_x[i]=temp[i];
  }

    }/*End of Time Cycle*/

  i=0;
  while (old_x[i]<0) i++;

  /*Price*/
  *ptprice=((s-s*exp(old_x[i-1]))*P_Old[i]+(s*exp(old_x[i])
    -s)*P_Old[i-1])/
    (s*(exp(old_x[i])-exp(old_x[i-1])));

  /*Delta*/
  *ptdelta=(1.0/(s*(s*(exp(old_x[i+1])-exp(old_x[i-1])))))*
    ((s*(exp(old_x[i])-exp(old_x[i-1])))*((P_Old[i+1]-P_Old[i]
    )/(old_x[i+1]-old_x[i]))+s*((exp(old_x[i+1])-exp(old_x[i])
    ))*((P_Old[i]-P_Old[i-1])/(old_x[i]-old_x[i-1])));

  /*Memory Desallocation*/
  free(alpha);
  free(beta);
  free(gamma);
  free(alpha1);
  free(beta1);
  free(gamma1);
  free(old_x);
  free(new_x);
  free(V);
  free(Vp);
  free(beta_p);
  free(P_New);
  free(P_Old);
  free(temp);

  return OK;
}

int CALC(FD_Fem_Out)(void *Opt,void *Mod,PricingMethod *
    Met)
{
```

```
  TYPEOPT* ptOpt=(TYPEOPT*)Opt;
  TYPEMOD* ptMod=(TYPEMOD*)Mod;
  double r,divid,rebate;

  r=log(1.+ptMod->R.Val.V_DOUBLE/100.);
  divid=log(1.+ptMod->Divid.Val.V_DOUBLE/100.);
  rebate=((ptOpt->Rebate.Val.V_NUMFUNC_1)->Compute)((ptOpt-
    >Rebate.Val.V_NUMFUNC_1)->Par,ptMod->T.Val.V_DATE);

  return Fem_Out(ptOpt->EuOrAm.Val.V_BOOL,ptMod->S0.Val.V_
    PDOUBLE,ptOpt->PayOff.Val.V_NUMFUNC_1, ptOpt->LowerLimit.Val
    .V_NUMFUNC_1,ptOpt->UpperLimit.Val.V_NUMFUNC_1,rebate,pt
    Opt->Maturity.Val.V_DATE-ptMod->T.Val.V_DATE,r,divid,ptMod->
    Sigma.Val.V_PDOUBLE,Met->Par[0].Val.V_INT2,Met->Par[1].Val.
    V_INT2, Met->Par[2].Val.V_RGDOUBLE051,Met->Par[3].Val.V_RG
    DOUBLE14,&(Met->Res[0].Val.V_DOUBLE),&(Met->Res[1].Val.V_DOUBLE)
    );
}

static int CHK_OPT(FD_Fem_Out)(void *Opt, void *Mod)
{
  Option* ptOpt=(Option*)Opt;
  TYPEOPT* opt=(TYPEOPT*)(ptOpt->TypeOpt);

  if ((opt->OutOrIn).Val.V_BOOL==OUT)
    if ((opt->Parisian).Val.V_BOOL==WRONG)
      return OK;

  return  WRONG;
}

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

      Met->Par[0].Val.V_INT2=100;
      Met->Par[1].Val.V_INT2=100;
      Met->Par[2].Val.V_RGDOUBLE=0.5;
```

```
      Met->Par[3].Val.V_DOUBLE=1.5;
    }
  return OK;
}

PricingMethod MET(FD_Fem_Out)=
{
  "FD_Fem_Out",
  {{"SpaceStepNumber",INT2,{100},ALLOW    },{"TimeStepNumb
    er",INT2,{100},ALLOW},
   {"Theta",RGDOUBLE051,{100},ALLOW}, {"Refinement",RG
    DOUBLE14,{100},ALLOW},{" ",PREMIA_NULLTYPE,{0},FORBID}},
  CALC(FD_Fem_Out),
  {{"Price",DOUBLE,{100},FORBID},{"Delta",DOUBLE,{100},FORB
    ID} ,{" ",PREMIA_NULLTYPE,{0},FORBID}},
  CHK_OPT(FD_Fem_Out),
  CHK_split,
  MET(Init)
};
```

References