```
   Help
#include <stdlib.h>
#define WITH_boundary 1
#include  "bs1d_lim.h"
#include "error_msg.h"
#define PRECISION 1.0e-7 /*Precision for the localization
    of FD methods*/

static int Cryer_DownIn(double s,NumFunc_1  *p,double l,
    double rebate,double t,double r,double divid,double sigma,int N,
    int M,double *ptprice,double *ptdelta)
{
  int      Index,PriceIndex,TimeIndex,ssl;
  double   k,vv,loc,h,z,alpha,beta,gamma,y,down,upwind_alp
    hacoef,price1;
  double   *Obst,*A,*B,*C,*P,*S,*Z,*Q,pricenh,pricen2h,
    priceph;

  /*Memory Allocation*/
  Obst= malloc((N+1)*sizeof(double));
  if (Obst==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  A= malloc((N+1)*sizeof(double));
  if (A==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  B= malloc((N+1)*sizeof(double));
  if (B==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  C= malloc((N+1)*sizeof(double));
  if (C==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  P= malloc((N+1)*sizeof(double));
  if (P==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  S= malloc((N+1)*sizeof(double));
  if (S==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  Z= malloc((N+1)*sizeof(double));
  if (Z==NULL)
    return MEMORY_ALLOCATION_FAILURE;
  Q= malloc((N+1)*sizeof(double));
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if (Q==NULL)
  return MEMORY_ALLOCATION_FAILURE;


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

/*Space Localisation*/
vv=0.5*sigma*sigma;
z=(r-divid)-vv;
loc=sigma*sqrt(t)*sqrt(log(1.0/PRECISION))+fabs(z*t);

/*Space Step*/
y=log(s);
down=log(l);
h=(y+loc-down)/(double)(N);

/*Peclet Condition-Coefficient of diffusion augmented */
if ((h*fabs(z))<=vv)
  upwind_alphacoef=0.5;
else {
  if (z>0.) upwind_alphacoef=0.0;
  else  upwind_alphacoef=1.0;
}
vv-=z*h*(upwind_alphacoef-0.5);

/*Lhs Factor of theta-schema*/
alpha=k*(-vv/(h*h)+z/(2.0*h));
beta=1.0+k*(r+2.*vv/(h*h));
gamma=k*(-vv/(h*h)-z/(2.0*h));

for(PriceIndex=0;PriceIndex<=N-2;PriceIndex++)
  {
    A[PriceIndex]=alpha;
    B[PriceIndex]=beta;
    C[PriceIndex]=gamma;
  }

/*Ternminal Values*/
y=log(s);
for (PriceIndex = 1; PriceIndex < N; PriceIndex++)
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    Obst[PriceIndex - 1]=(p->Compute)(p->Par,exp(down+
    PriceIndex* h));
  for (PriceIndex = 2; PriceIndex <= N - 2; PriceIndex++)
    {
      P[PriceIndex - 1] = alpha * Obst[PriceIndex - 2] +
  beta * Obst[PriceIndex - 1] + gamma * Obst[PriceIndex];
    }

  P[0] = beta * Obst[0] + gamma * Obst[1];
  P[N - 2] = alpha * Obst[N-3] + beta * Obst[N-2];

  for (PriceIndex = 0; PriceIndex <= N - 2; PriceIndex++)
    {
      S[PriceIndex] = 0.;
      Z[PriceIndex] = 0.;
    }
  ssl = false;

  /*Finite Difference Cycle*/
  for (TimeIndex= 1; TimeIndex<= M; TimeIndex++)
    {
      if (TimeIndex==1)
  for (PriceIndex = 0; PriceIndex <= N- 2; PriceIndex++)
    Z[PriceIndex] =rebate;
      else
  for (PriceIndex = 0; PriceIndex <= N- 2; PriceIndex++)
    Z[PriceIndex] =Z[PriceIndex]+Obst[PriceIndex];

      for (PriceIndex = 0; PriceIndex <= N - 2; PriceIndex+
    +)
  Q[PriceIndex]=P[PriceIndex]-Z[PriceIndex];

      price1=Boundary(l,p,(double)TimeIndex*k,r,divid,sigma
    );
      Q[0] += alpha*price1;
      Q[N-2]+=gamma*(p->Compute)(p->Par,exp(y+loc));

      AlgCrayer(N,Z,ssl,A,B,C,Q,S);

      for (PriceIndex = 0; PriceIndex <=N-2; PriceIndex++)
  S[PriceIndex] = Z[PriceIndex];
```

```
    ssl = true;
  }

for (PriceIndex = 0; PriceIndex <= N - 2; PriceIndex++)
  P[PriceIndex]=Z[PriceIndex]+Obst[PriceIndex];

Index=(int)floor((y-down)/h)-1;

/*Price*/
*ptprice=P[Index]+(P[Index+1]-P[Index])*(exp(y)-exp(down+
  h+Index*h))/(exp(down+h+(Index+1)*h)-exp(down+h+Index*h));

/*Delta*/
pricenh=P[Index+1]+(P[Index+2]-P[Index+1])*(exp(y+h)-exp(
  down+h+(Index+1)*h))/(exp(down+h+(Index+2)*h)-exp(down+h+(
  Index+1)*h));
if (Index>0)
  {
    priceph=P[Index-1]+(P[Index]-P[Index-1])*(exp(y-h)-
  exp(down+h+(Index-1)*h))/(exp(down+h+(Index)*h)-exp(down+h+(
  Index-1)*h));
    *ptdelta=(pricenh-priceph)/(2*s*h);
  }
else
  {
    pricen2h=P[Index+2]+(P[Index+3]-P[Index+2])*(exp(y+2*
  h)-exp(down+h+(Index+2)*h))/(exp(down+h+(Index+3)*h)-exp(
  down+h+(Index+2)*h));
    *ptdelta=(4*pricenh-pricen2h-3*(*ptprice))/(2*s*h);
  }

/*Memory Desallocation*/
free(Obst);
free(A);
free(B);
free(C);
free(P);
free(S);
free(Z);
free(Q);
```

```
  return OK;
}


int CALC(FD_Cryer_DownIn)(void *Opt,void *Mod,Pricing
    Method *Met)
{
  TYPEOPT* ptOpt=(TYPEOPT*)Opt;
  TYPEMOD* ptMod=(TYPEMOD*)Mod;
  double r,divid,limit,rebate;

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

  return Cryer_DownIn(ptMod->S0.Val.V_PDOUBLE,ptOpt->PayO
    ff.Val.V_NUMFUNC_1,
          limit,rebate, ptOpt->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->Res[0].Val.V_DOUBLE),&(Met->Res[1].Val.
    V_DOUBLE));
}

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

  if ((opt->Parisian).Val.V_BOOL==WRONG)
    if ( (strcmp( ((Option*)Opt)->Name,"CallDownInAmer")==0
    ) || (strcmp( ((Option*)Opt)->Name,"PutDownInAmer")==0) )
      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;
    }

  return OK;
}

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

References