energyFinancialModel_v1_Anchor

October 1, 2019

[1]:
```
# Note: TODOs are prioritized for model v1 and model v2. For example:

# TODO add Electraseed cut of initial investment logic
# TODO2 add impact as measure
```

1 Electraseed Energy Financial Model - Version 1: Anchor

1.1 Purpose

The energy financial model version 1 evaluates the financial performance of an aggregated pool of loans to clean energy developers, and the resulting outcomes for the investor, the developers, the Electraseed Fund, and any 3rd party actors.

1.2 Structure

The basic structure is comprised of the following components:

Inputs
* Library Import
* Input Definition

Actors
* Actor Class Definition
* Actor Creation

Loan Creations
* Loan Menu Creation
* Portfolio Optimizer
* Loan Matching

Investment Projections
* Investment Math
* Risk Projections

Outputs
* Output Aggregation
* Output Dashboard

1.3 Energy Model

1.3.1 Library Import

Import libraries requried for energy financial model

[2]:
```
import numpy as np
import pandas as pd
import scipy.optimize as sco
import random
import math
import matplotlib.pyplot as plt
from matplotlib.font_manager import FontProperties
```

1.3.2 Input Definition

Inputs are entered here as described above

[3]:
```
# Invididual Energy Asset Information
# TODO2 get names of individual projects
# TODO2 get actual numbers
dea_names = ['Polarstern', 'MaxSolar', 'Solartainer', 'SOLShare'] # name of dea
dea_locations = ['Germany', 'Germany', 'Mali', 'Bangladesh'] # location of dea
dea_classifications = ['developed', 'developed', 'developing', 'developing'] #␣
↪classification of economy
dea_loansizerequests = [2000000,1000000,700000,500000] # euros loan requested
dea_rateappetites = [0.04, 0.07, 0.10, 0.16] # % annual interest appetite
dea_defaultrates = [0.04, 0.05, 0.15, 0.20] # % annual risk of default
dea_paymentfreqs = [1, 12*5, 1, 12] # months between interest payments
dea_loanperiods = [15, 15, 10, 15] # years of loan period

# Investor Information
investor_names = ['inv_altruistic', 'inv_impact1', 'inv_impact2',␣
↪'inv_impact3', 'inv_monopolyman'] # name of investor
investor_investment_requests = [1000000, 1000000, 1000000, 1000000, 1000000] #␣
↪euros investment
investor_ratefloors = [0.00, 0.05, 0.04, 0.03, 0.07] # % annual interest minimum
investor_riskappetites = [0.08, 0.04, 0.06, 0.06, 0.02] # % annual risk of␣
↪default
investor_riskfreerates = [0.01, 0.01, 0.01, 0.01, 0.01]

# Underwriter Information
uw_names = ['uw_Germany', 'uw_Mali', 'uw_Bang1', 'uw_Bang2']
uw_locations = ['Germany', 'Mali', 'Bangladesh', 'Bangladesh']
uw_maxloans = [5000000, 600000, 200000, 400000] # euros max underwrite
uw_rateinvs = [0.03, 0.09, 0.11, 0.11] # % annual interest rate OFFER
uw_ratedeas = [0.035, 0.10, 0.12, 0.12] # % annual interest minimum LOAN OUT
uw_riskappetites = [0.03, 0.15, 0.15, 0.15] # % annual risk of default appetite
```

```
# spv Information
spv_names = 'Electraseed'
spv_interestratios = [0.15]

# NPV Calculation
NPV_rate = 0.01

# Covariance Values for estimated covariance definition
location_same_cov = 0.15 # cov impact if in same location
location_dif_cov = 0. # cov impact if in different location
classification_same_cov = 0.15 # cov impact if same classification
classification_dif_cov = -0.1 # cov impact if different classification
same_borrower_dif_cov = 0.9
```

1.3.3 Actor Class Definition

Define digital energy asset, investor, and other actor classes

[4]:
```
# Digital Energy Asset (DEA) class
class dea_:
    def __init__(self, name, location, classification, loansizerequest,␣
 ↪rateappetite, defaultrate, paymentfreq, loanperiod):
        # attributes
        self.name = name
        self.location = location
        self.classification = classification
        self.loansizerequest = loansizerequest
        self.rateappetite = rateappetite
        self.defaultrate = defaultrate
        self.paymentfreq = paymentfreq
        self.loanperiod = loanperiod
        # loan tracking
        self.activeloanamount = 0
        self.indexnum = None
        # TODO3 add energy data

# Investor class
class investor_:
    def __init__(self, name, investment_request, ratefloor, riskappetite,␣
 ↪riskfreerate):
        self.name = name
        self.investment_request = investment_request
        self.ratefloor = ratefloor
        self.riskappetite = riskappetite
        self.riskfreerate = riskfreerate
        # TODO2 add optimization metric
```

```
# Underwriter class
class underwriter_:
    def __init__(self, name, location, maxloan, rateinv, ratedea, riskappetite):
        self.name = name
        self.location = location
        self.maxloan = maxloan
        self.rateinv = rateinv
        self.ratedea = ratedea
        self.riskappetite = riskappetite
        # loan tracking
        self.activedealoanamount = 0
        self.activespvloanamount = 0

# Elecraseed class
class spv_:
    def __init__(self, name, interestratio):
        self.name = name
        self.interestratio = interestratio
```

1.3.4 Actor Creation

Create the actual entities involved in our ecosystem, filling out their appropriate attributes. Each of the entities are placed in a list of all existing entities of that class

[5]:
```
# Digital Energy Assets
deas = []
for i in range(len(dea_names)):
    deas.append(dea_(dea_names[i], dea_locations[i], dea_classifications[i],␣
 ↪dea_loansizerequests[i], dea_rateappetites[i], dea_defaultrates[i],␣
 ↪dea_paymentfreqs[i], dea_loanperiods[i]))
    deas[i].indexnum = i # set index num for later reference

# Investors
investors = []
for i in range(len(investor_names)):
    investors.append(investor_(investor_names[i],␣
 ↪investor_investment_requests[i], investor_ratefloors[i],␣
 ↪investor_riskappetites[i], investor_riskfreerates[i]))

# Underwriters
underwriters = []
for i in range(len(uw_locations)):
    underwriters.append(underwriter_(uw_names[i], uw_locations[i],␣
 ↪uw_maxloans[i], uw_rateinvs[i], uw_ratedeas[i], uw_riskappetites[i]))

# spvs
```

```
spvs = [spv_(spv_names, spv_interestratios)]
```

1.3.5 Loan Menu Creation

Create the 'menu' of loans available to investors
Create the Loan Class

[6]:
```
# Loan class
class subloan_:
    def __init__(self, investor, rateinv_precut, rateinv_postcut, amount):
        self.investor = investor
        self.rateinv_precut = rateinv_precut
        self.rateinv_postcut = rateinv_postcut
        self.amount = amount
        # payment tracker
        # inv precut
        self.payment_inv_precut = None
        self.payment_interest_inv_precut = []
        self.payment_principal_inv_precut = []
        # inv postcut
        self.payment_inv_postcut = None
        self.payment_interest_inv_postcut = []
        self.payment_principal_inv_postcut = []


class loan_:
    def __init__(self, dea, underwriter, amount, ratedea, paymentfreq,␣
 ↪loanperiod, defaultrate):
        self.dea = dea
        self.underwriter = underwriter
        self.amount = amount
        self.ratedea = ratedea
        self.paymentfreq = paymentfreq
        self.loanperiod = loanperiod
        self.defaultrate = defaultrate
        # loan tracking
        self.amountfinanced = 0
        self.subloans = []
        # payment tracker
        # dea
        self.payment_dea = None
        self.payment_interest_dea = []
        self.payment_principal_dea = []
```

Loan Requests Fracturing and Loan Menu Creation Fracture the loan requests based on the underwriter's loan offerings.
Add each of these to a loan 'menu' to pair with investors

```
[7]: # Underwriter - DEA loan matching

# match deas to underwriters if loan is possible
loan_menu = []
total_loan_amount_requested = 0
total_amount_in_loan_options = 0
for dea in deas:
    total_loan_amount_requested += dea.loansizerequest
    if dea.activeloanamount < dea.loansizerequest: # check if loan needed
        for underwriter in underwriters:
            # TODO2 add sorting script for loan rates
            if underwriter.location == dea.location: # check if eligible to loan
                if underwriter.ratedea <= dea.rateappetite: # check rate␣
↪eligible
                    ratedea = underwriter.ratedea # rate is underwriters offer␣
↪to dea
                    rateinv = underwriter.rateinv
                    amount = min(underwriter.maxloan-underwriter.
↪activedealoanamount, dea.loansizerequest-dea.activeloanamount) # amount is␣
↪what dea asks for or max underwriter offer
                    loan = loan_(dea, underwriter, amount, ratedea, dea.
↪paymentfreq, dea.loanperiod, dea.defaultrate)
                    underwriter.activedealoanamount += amount # track active␣
↪loans
                    dea.activeloanamount += amount # track active loan amount
                    total_amount_in_loan_options += amount #
                    loan_menu.append(loan) # track active loans in loan menu

print("Total loan amount requested:", total_loan_amount_requested)
print("Number of loan options created:", len(loan_menu))
print("Total loan amount fundable:", total_amount_in_loan_options)
```

```
Total loan amount requested: 4200000
Number of loan options created: 5
Total loan amount fundable: 4100000
```

Covariance Matrix Definition Create the covariance matrix for risk of the projected loans

```
[8]: # Create covariance matrix
def covariance_matrix_creator(loans):
    cov_matrix = np.zeros((len(loans), len(loans))) # initialize covariance␣
↪matrix
    for i in range(len(loans)):
        for j in range(i, len(loans)):
            if i == j:
                cov_matrix[i][j] = 1 # set diagonal to 1
            else:
```

```
                if loans[i].dea.name == loans[j].dea.name: # check if same name
                    cov_matrix[i][j] = same_borrower_dif_cov
                    cov_matrix[j][i] = same_borrower_dif_cov
                else:
                    if loans[i].dea.location == loans[j].dea.location: # check␣
↪for location cov
                        cov_matrix[i][j] += location_same_cov
                        cov_matrix[j][i] = cov_matrix[i][j]
                    else:
                        cov_matrix[i][j] += location_dif_cov
                        cov_matrix[j][i] = cov_matrix[i][j]
                    if loans[i].dea.classification == loans[j].dea.
↪classification: # check for economy classification cov
                        cov_matrix[i][j] += classification_same_cov
                        cov_matrix[j][i] = cov_matrix[i][j]
                    else:
                        cov_matrix[i][j] += classification_dif_cov
                        cov_matrix[j][i] = cov_matrix[i][j]
    return cov_matrix

cov_matrix = covariance_matrix_creator(loan_menu)
```

1.3.6 Portfolio Optimizer Definition

Before we can match loans to investors, we need to create 'optimal' portfolio math based on investor-specific inputs

[9]:
```
# define function to calculate portfolio performance
def portfolio_performance(weights, returns, stds, cov_matrix):
    p_ret = np.sum(weights * np.asarray(returns)) # calculate return
    # calculate std using 'modern portfolio theory', calculations available on␣
↪wiki
    p_std = 0
    for i in range(len(weights)): # summation of each weights^2 and std^2
        p_std += (weights[i]**2)*(stds[i])**2
    for i in range(len(weights)): # summation of covariance calculation
        for j in range(len(weights)):
            if i != j:
                p_std += weights[i]*weights[j]*stds[i]*stds[j]*cov_matrix[i][j]
    p_std = np.sqrt(p_std) # sqrt for variance --> std
    # TODO check risk calculation for type of loan
    return p_std, p_ret

# define function to get sharpe ratio for optimization measure
def neg_sharpe_ratio(weights, returns, stds, cov_matrix, risk_free_rate):
    p_std, p_ret = portfolio_performance(weights, returns, stds, cov_matrix) #␣
↪get std and return
```

```
    return -(p_ret - risk_free_rate) / p_std # calculate sharpe ratio

#TODO define function to get social / environmental optimization

# define function to find optimal portfolio weights
def portfolio_optimizer(loan_menu, cov_matrix, investor, return_rates, stds,␣
↪amounts):
    # TODO2 optimize for impact
    # TODO2 instead return efficient frontier, maybe then can optimize further␣
↪for impact?
    # set investor investment amount to min amount remaining against requested␣
↪amount
    investor.investment = min(investor.investment_request, np.sum(amounts))
    num_assets = len(loan_menu)
    args = (return_rates, stds, cov_matrix, investor.riskfreerate)
    # set helper functions for constraints
    def portfolio_risk(weights):
        return portfolio_performance(weights, return_rates, stds, cov_matrix)[0]
    def portfolio_return(weights):
        return portfolio_performance(weights, return_rates, stds, cov_matrix)[1]
    # define constraints
    constraints = ({'type': 'eq', 'fun': lambda x: np.sum(x) - 1}, # weights␣
↪sum to 1
                   {'type': 'ineq', 'fun': lambda x: amounts - x * investor.
↪investment}, # investor investment <= requested loan amount
                   {'type': 'ineq', 'fun': lambda x: investor.riskappetite -␣
↪portfolio_risk(x)}, # portfolio risk <= investor risk appetite
                   {'type': 'ineq', 'fun': lambda x: portfolio_return(x) -␣
↪investor.ratefloor}) # portfolio return >= investor rate floor

    bound = (0.0, 1.0) # set bounds for the portfolio weights
    bounds = tuple(bound for asset in range(num_assets))
    # run actual optimization on negative sharpe ratio (will move to impact␣
↪ratio)
    result = sco.minimize(neg_sharpe_ratio, num_assets*[1./num_assets],␣
↪args=args, method='SLSQP', bounds=bounds, constraints=constraints)
    return result

def optimize_portfolio(loan_menu, cov_matrix, investor, return_rates,␣
↪return_rates_investor, stds, amounts):
    opt = portfolio_optimizer(loan_menu, cov_matrix, investor,␣
↪return_rates_investor, stds, amounts) # get optimal portfolio base on inputs
    weights = opt.x # extract output weights
    # print some relevant outputs
    print('--------')
    print('investor:', investor.name)
```

```
    print('investment:',np.round(investor.investment),"of",investor.
↪investment_request,"requested")
    print('risk tol:', investor.riskappetite, 'rate floor:', investor.
↪ratefloor, 'risk free:', investor.riskfreerate)
    if opt.success:
        print('optimal portfolio found:')
    else:
        print('not all constraints met. Best we could do:')
    p_std, p_ret = portfolio_performance(weights, return_rates, stds,␣
↪cov_matrix) # get optimal portfolio performance
    print('\ttot_risk:',np.round(p_std*100,2),'%,', 'tot_return:',np.
↪round(p_ret*100,2),'%,', 'tot_sharpe:', np.round((p_ret-investor.
↪riskfreerate)/p_std,2))
    p_std, p_ret = portfolio_performance(weights, return_rates_investor, stds,␣
↪cov_matrix) # get optimal portfolio performance
    print('\tinv_risk:',np.round(p_std*100,2),'%,', 'inv_return:',np.
↪round(p_ret*100,2),'%,', 'inv_sharpe:', np.round((p_ret-investor.
↪riskfreerate)/p_std,2))
    print('\tportfolio weights', np.round(weights,2))
    print('\tportfolio investments', np.round(weights*investor.investment))
    print('\tloan requested', np.round(amounts))
    return opt.success, weights
```

1.3.7 SPV Business Case

Addd tool to adjust rate that investor sees to allow for SPV revenue from interest payments.

[10]:
```
# calculate new interest rate for investor based on spv cut
def investor_interest_after_spv_cut(rates, spv):
    investor_rates = np.asarray(rates) * (1.-spv.interestratio[0]) # cut␣
↪interest rates by ratio
    return investor_rates
```

1.3.8 Loan Matching

Tinder for loans

[11]:
```
# run portfolio optimization for each investor

# next iterate through each investor to find optimal portfolio
for investor in investors:
    # first get return rates, stds, and loan amounts requested from the loan␣
↪options
    return_rates = []
    stds = []
    amounts = []
    for loan_option in loan_menu:
```

```
        amount = loan_option.amount - loan_option.amountfinanced # get loan␣
↪amount requested
        amounts.append(amount)
        # if there is no more money requested, make that loan give 0% return to␣
↪trick model
        if amount > 1:
            return_rates.append(loan_option.underwriter.rateinv) # get return␣
↪rate for investors
            stds.append(loan_option.defaultrate) # get risk rate
        else:
            return_rates.append(0.)
            stds.append(1.)
    return_rates_investor = investor_interest_after_spv_cut(return_rates,␣
↪spvs[0])
    # optimize the portfolio under the constraints
    success, weights = optimize_portfolio(loan_menu, cov_matrix, investor,␣
↪return_rates, return_rates_investor, stds, amounts)
    # update investor tracker
    investor.bestportfolio = weights
    investor.optimalportfoliofound = success
    # update loan menu with amount invested
    i = 0
    for loan_option in loan_menu:
        amount = weights[i] * investor.investment
        loan_option.amountfinanced += amount
        rateinv_postcut = investor_interest_after_spv_cut(loan_option.
↪underwriter.rateinv, spvs[0])
        subloan = subloan_(investor, loan_option.underwriter.rateinv,␣
↪rateinv_postcut, amount)
        if subloan.amount >= 1:
            loan_option.subloans.append(subloan)
        i += 1
    # TODO adjust loan menu based on investment
```

```
--------
investor: inv_altruistic
investment: 1000000 of 1000000 requested
risk tol: 0.08 rate floor: 0.0 risk free: 0.01
optimal portfolio found:
        tot_risk: 3.83 %, tot_return: 4.72 %, tot_sharpe: 0.97
        inv_risk: 3.83 %, inv_return: 4.01 %, inv_sharpe: 0.79
        portfolio weights [0.48 0.27 0.14 0.05 0.05]
        portfolio investments [475807. 273155. 144083.  53477.  53477.]
        loan requested [2000000 1000000  600000  200000  300000]
--------
investor: inv_impact1
investment: 1000000 of 1000000 requested
```

```
risk tol: 0.04 rate floor: 0.05 risk free: 0.01
not all constraints met. Best we could do:
        tot_risk: 5.46 %, tot_return: 5.88 %, tot_sharpe: 0.89
        inv_risk: 5.46 %, inv_return: 5.0 %, inv_sharpe: 0.73
        portfolio weights [0.36 0.23 0.24 0.09 0.09]
        portfolio investments [355661. 225116. 235718.  91753.  91753.]
        loan requested [1524193.  726845.  455917.  146523.  246523.]
--------
investor: inv_impact2
investment: 1000000 of 1000000 requested
risk tol: 0.06 rate floor: 0.04 risk free: 0.01
optimal portfolio found:
        tot_risk: 3.83 %, tot_return: 4.72 %, tot_sharpe: 0.97
        inv_risk: 3.83 %, inv_return: 4.01 %, inv_sharpe: 0.79
        portfolio weights [0.48 0.27 0.14 0.05 0.05]
        portfolio investments [475876. 273133. 144060.  53441.  53490.]
        loan requested [1168533.  501729.  220199.   54770.  154770.]
--------
investor: inv_impact3
investment: 1000000 of 1000000 requested
risk tol: 0.06 rate floor: 0.03 risk free: 0.01
optimal portfolio found:
        tot_risk: 3.54 %, tot_return: 4.28 %, tot_sharpe: 0.93
        inv_risk: 3.54 %, inv_return: 3.64 %, inv_sharpe: 0.75
        portfolio weights [0.59 0.23 0.08 0.   0.1 ]
        portfolio investments [592657. 228596.  76139.   1329. 101280.]
        loan requested [692657. 228596.  76139.   1329. 101280.]
--------
investor: inv_monopolyman
investment: 100000.0 of 1000000 requested
risk tol: 0.02 rate floor: 0.07 risk free: 0.01
not all constraints met. Best we could do:
        tot_risk: 4.0 %, tot_return: 3.0 %, tot_sharpe: 0.5
        inv_risk: 4.0 %, inv_return: 2.55 %, inv_sharpe: 0.39
        portfolio weights [1. 0. 0. 0. 0.]
        portfolio investments [100000.      0.      0.      0.      0.]
        loan requested [100000.     -0.     -0.      0.      0.]
```

1.3.9 Investment Math

Calculate payments and amortization schedule, to define which parties are getting which amounts at which time. #### Loan Status
Print existing loan information for reference

[12]:
```
# print useful information about loans and subloans
for loan in loan_menu:
    print("dea:",loan.dea.name,", underwriter:",loan.underwriter.name)
```

```
    print("financed:",np.round(loan.amountfinanced),"of",loan.
↪amount,"with",len(loan.subloans),"subloans:")
    for subloan in loan.subloans:
        print("\t","investor:",subloan.investor.name,"amount:",np.round(subloan.
↪amount),"rate_precut:",subloan.rateinv_precut,"rate_postcut:",subloan.
↪rateinv_postcut)
    print("-----------")
```

```
dea: Polarstern , underwriter: uw_Germany
financed: 2000000.0 of 2000000 with 5 subloans:
         investor: inv_altruistic amount: 475807.0 rate_precut: 0.03
rate_postcut: 0.0255
         investor: inv_impact1 amount: 355661.0 rate_precut: 0.03 rate_postcut:
0.0255
         investor: inv_impact2 amount: 475876.0 rate_precut: 0.03 rate_postcut:
0.0255
         investor: inv_impact3 amount: 592657.0 rate_precut: 0.03 rate_postcut:
0.0255
         investor: inv_monopolyman amount: 100000.0 rate_precut: 0.03
rate_postcut: 0.0255
-----------
dea: MaxSolar , underwriter: uw_Germany
financed: 1000000.0 of 1000000 with 4 subloans:
         investor: inv_altruistic amount: 273155.0 rate_precut: 0.03
rate_postcut: 0.0255
         investor: inv_impact1 amount: 225116.0 rate_precut: 0.03 rate_postcut:
0.0255
         investor: inv_impact2 amount: 273133.0 rate_precut: 0.03 rate_postcut:
0.0255
         investor: inv_impact3 amount: 228596.0 rate_precut: 0.03 rate_postcut:
0.0255
-----------
dea: Solartainer , underwriter: uw_Mali
financed: 600000.0 of 600000 with 4 subloans:
         investor: inv_altruistic amount: 144083.0 rate_precut: 0.09
rate_postcut: 0.0765
         investor: inv_impact1 amount: 235718.0 rate_precut: 0.09 rate_postcut:
0.0765
         investor: inv_impact2 amount: 144060.0 rate_precut: 0.09 rate_postcut:
0.0765
         investor: inv_impact3 amount: 76139.0 rate_precut: 0.09 rate_postcut:
0.0765
-----------
dea: SOLShare , underwriter: uw_Bang1
financed: 200000.0 of 200000 with 4 subloans:
         investor: inv_altruistic amount: 53477.0 rate_precut: 0.11
rate_postcut: 0.0935
```

```
        investor: inv_impact1 amount: 91753.0 rate_precut: 0.11 rate_postcut:
0.0935
        investor: inv_impact2 amount: 53441.0 rate_precut: 0.11 rate_postcut:
0.0935
        investor: inv_impact3 amount: 1329.0 rate_precut: 0.11 rate_postcut:
0.0935
-----------
dea: SOLShare , underwriter: uw_Bang2
financed: 300000.0 of 300000 with 4 subloans:
        investor: inv_altruistic amount: 53477.0 rate_precut: 0.11
rate_postcut: 0.0935
        investor: inv_impact1 amount: 91753.0 rate_precut: 0.11 rate_postcut:
0.0935
        investor: inv_impact2 amount: 53490.0 rate_precut: 0.11 rate_postcut:
0.0935
        investor: inv_impact3 amount: 101280.0 rate_precut: 0.11 rate_postcut:
0.0935
-----------
```

Loan Payment Calculations Calculate payments by deas and underwriters

[13]:
```
# function to get the payments based on loan structure
def get_payments(num_periods, rate, amount, paymentfreq):
    payments = np.empty(num_periods+1, [('month', int), ('payment', float),␣
 ↪('principal', float), ('interest', float)])
    payments[0]['month'] = 0
    payments[0]['principal'] = 0
    payments[0]['interest'] = 0
    payments[0]['payment'] = 0
    for period in range(0,int(num_periods)):
        payments[period+1]['month'] = (period+1)*paymentfreq
        principal = -np.ppmt(rate, period, num_periods, amount) # principal␣
 ↪payment calc
        payments[period+1]['principal'] = principal
        interest = -np.ipmt(rate, period, num_periods, amount) # interest␣
 ↪payment calc
        payments[period+1]['interest'] = interest
        payment = principal + interest
        payments[period+1]['payment'] = payment
    return payments

# iterate through loans and subloans to get payments for each party
for loan in loan_menu:
    num_periods = int(loan.loanperiod * (12./loan.paymentfreq)) # get number of␣
 ↪periods
    ratedea = loan.ratedea / (12./loan.paymentfreq) # get dea rate
    amount = loan.amountfinanced # get dea amount to pay
```

```
    # get payments for dea
    payments_dea = get_payments(num_periods, ratedea, amount, loan.paymentfreq)
    payments_dea[0]['principal'] = -amount
    payments_dea[0]['payment'] = -amount
    loan.payments_dea = payments_dea
    print(loan.dea.name,"borrowing from",loan.underwriter.name)
    print("dea m payment:",np.round(payments_dea[1]['payment']),"amount:",np.
↪round(loan.amount),"rate:",loan.ratedea, "period:",loan.loanperiod)
    print("Subloans:")
    # get payments for subloans from underwriter to investors
    for subloan in loan.subloans:
        amount = subloan.amount # get subloan amount
        rateinv_precut = subloan.rateinv_precut / (12./loan.paymentfreq) # get␣
↪precut investor rate
        rateinv_postcut = subloan.rateinv_postcut / (12./loan.paymentfreq) #␣
↪get postcut investor rate
        # calculate interest and principle
        # for investor precut
        payments_inv_precut = get_payments(num_periods, rateinv_precut, amount,␣
↪loan.paymentfreq)
        payments_inv_precut[0]['principal'] = -amount
        payments_inv_precut[0]['payment'] = -amount
        subloan.payments_inv_precut = payments_inv_precut
        # for investor postcut
        payments_inv_postcut = get_payments(num_periods, rateinv_postcut,␣
↪amount, loan.paymentfreq)
        payments_inv_postcut[0]['principal'] = -amount
        payments_inv_postcut[0]['payment'] = -amount
        subloan.payments_inv_postcut = payments_inv_postcut
        print("\t","investor:",subloan.investor.name)
        print("\t","amount:",np.round(subloan.amount),"rate_pre:",subloan.
↪rateinv_precut,"rate_post:",subloan.rateinv_postcut)
        print("\t","uw m pay:",np.round(payments_inv_precut[1]['payment']),"inv:
↪",np.round(payments_inv_postcut[1]['payment']),"es:",np.
↪round(payments_inv_precut[1]['payment']-payments_inv_postcut[1]['payment']))
        print("\t","-----------------------")
```

```
Polarstern borrowing from uw_Germany
dea m payment: 14298.0 amount: 2000000 rate: 0.035 period: 15
Subloans:
         investor: inv_altruistic
         amount: 475807.0 rate_pre: 0.03 rate_post: 0.0255
         uw m pay: 3286.0 inv: 3184.0 es: 102.0
         -----------------------
         investor: inv_impact1
         amount: 355661.0 rate_pre: 0.03 rate_post: 0.0255
         uw m pay: 2456.0 inv: 2380.0 es: 76.0
```

```
          -----------------------
          investor: inv_impact2
          amount: 475876.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 3286.0 inv: 3184.0 es: 102.0
          -----------------------
          investor: inv_impact3
          amount: 592657.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 4093.0 inv: 3966.0 es: 127.0
          -----------------------
          investor: inv_monopolyman
          amount: 100000.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 691.0 inv: 669.0 es: 21.0
          -----------------------
MaxSolar borrowing from uw_Germany
dea m payment: 456245.0 amount: 1000000 rate: 0.035 period: 15
Subloans:
          investor: inv_altruistic
          amount: 273155.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 119636.0 inv: 115197.0 es: 4439.0
          -----------------------
          investor: inv_impact1
          amount: 225116.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 98595.0 inv: 94937.0 es: 3659.0
          -----------------------
          investor: inv_impact2
          amount: 273133.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 119626.0 inv: 115187.0 es: 4439.0
          -----------------------
          investor: inv_impact3
          amount: 228596.0 rate_pre: 0.03 rate_post: 0.0255
          uw m pay: 100120.0 inv: 96405.0 es: 3715.0
          -----------------------
Solartainer borrowing from uw_Mali
dea m payment: 7929.0 amount: 600000 rate: 0.1 period: 10
Subloans:
          investor: inv_altruistic
          amount: 144083.0 rate_pre: 0.09 rate_post: 0.0765
          uw m pay: 1825.0 inv: 1722.0 es: 104.0
          -----------------------
          investor: inv_impact1
          amount: 235718.0 rate_pre: 0.09 rate_post: 0.0765
          uw m pay: 2986.0 inv: 2817.0 es: 169.0
          -----------------------
          investor: inv_impact2
          amount: 144060.0 rate_pre: 0.09 rate_post: 0.0765
          uw m pay: 1825.0 inv: 1721.0 es: 104.0
          -----------------------
          investor: inv_impact3
```

```
          amount: 76139.0 rate_pre: 0.09 rate_post: 0.0765
          uw m pay: 964.0 inv: 910.0 es: 55.0
          -----------------------
SOLShare borrowing from uw_Bang1
dea m payment: 29365.0 amount: 200000 rate: 0.12 period: 15
Subloans:
          investor: inv_altruistic
          amount: 53477.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 7437.0 inv: 6772.0 es: 665.0
          -----------------------
          investor: inv_impact1
          amount: 91753.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 12760.0 inv: 11619.0 es: 1141.0
          -----------------------
          investor: inv_impact2
          amount: 53441.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 7432.0 inv: 6767.0 es: 664.0
          -----------------------
          investor: inv_impact3
          amount: 1329.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 185.0 inv: 168.0 es: 17.0
          -----------------------
SOLShare borrowing from uw_Bang2
dea m payment: 44047.0 amount: 300000 rate: 0.12 period: 15
Subloans:
          investor: inv_altruistic
          amount: 53477.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 7437.0 inv: 6772.0 es: 665.0
          -----------------------
          investor: inv_impact1
          amount: 91753.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 12760.0 inv: 11619.0 es: 1141.0
          -----------------------
          investor: inv_impact2
          amount: 53490.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 7439.0 inv: 6774.0 es: 665.0
          -----------------------
          investor: inv_impact3
          amount: 101280.0 rate_pre: 0.11 rate_post: 0.0935
          uw m pay: 14084.0 inv: 12825.0 es: 1259.0
          -----------------------
```

1.3.10 Risk Projections

Get confidence intervals on the return of the investment math based on loan default projections. This could be a good test case / playground for some simple cadCAD implementation

1.3.11 Output Aggregation

Gather relevant outputs #### NPV Calculation

[14]:
```
# Calculate NPVs for each party
Outputs = {}
Outputs['dea'] = {}
Outputs['underwriter'] = {}
Outputs['investor'] = {}
Outputs['spv'] = {}
# setup dea outputs
for dea in deas:
    Outputs['dea'][dea.name] = {}
    Outputs['dea'][dea.name]['NPV'] = 0
    Outputs['dea'][dea.name]['Value'] = 0
    #Outputs['dea'][dea.name]['Plan'] = []
# setup underwriter outputs
for underwriter in underwriters:
    Outputs['underwriter'][underwriter.name] = {}
    Outputs['underwriter'][underwriter.name]['NPV'] = 0
    Outputs['underwriter'][underwriter.name]['Value'] = 0
    #Outputs['underwriter'][underwriter.name]['Plan'] = []
# setup investor outputs
for investor in investors:
    Outputs['investor'][investor.name] = {}
    Outputs['investor'][investor.name]['NPV'] = 0
    Outputs['investor'][investor.name]['Value'] = 0
    #Outputs['investor'][investor.name]['Plan'] = []
# setup spv outputs
for spv in spvs:
    Outputs['spv'][spv.name] = {}
    Outputs['spv'][spv.name]['NPV'] = 0
    Outputs['spv'][spv.name]['Value'] = 0
    #Outputs['spv'][spv.name]['Plan'] = []

# get NPV and values populated
for loan in loan_menu:
    # for dea payments in loan
    npv = np.npv(NPV_rate/(12/loan.paymentfreq), loan.payments_dea['payment'])
    value = np.sum(loan.payments_dea['payment'])
    # update dea values
    Outputs['dea'][loan.dea.name]['NPV'] -= npv
    Outputs['dea'][loan.dea.name]['Value'] -= value
    #Outputs['dea'][loan.dea.name]['Plan'] = -loan.payments_dea['payment']
    # update underwriter values
    Outputs['underwriter'][loan.underwriter.name]['NPV'] += npv
    Outputs['underwriter'][loan.underwriter.name]['Value'] += value
```

```
    #Outputs['underwriter'][loan.underwriter.name]['Plan'] = loan.
↪payments_dea['payment']
    # for underwriter payments to investors
    for subloan in loan.subloans:
        # for underwriter payments in loan
        npv_precut = np.npv(NPV_rate/(12/loan.paymentfreq), subloan.
↪payments_inv_precut['payment'])
        value_precut = np.sum(subloan.payments_inv_precut['payment'])
        # update underwriter values
        Outputs['underwriter'][loan.underwriter.name]['NPV'] -= npv_precut
        Outputs['underwriter'][loan.underwriter.name]['Value'] -= value_precut
        #Outputs['underwriter'][loan.underwriter.name]['Plan'] = -subloan.
↪payments_inv_precut['payment']
        # for investor receipts in loan
        npv_postcut = np.npv(NPV_rate/(12/loan.paymentfreq), subloan.
↪payments_inv_postcut['payment'])
        value_postcut = np.sum(subloan.payments_inv_postcut['payment'])
        # update investor values
        Outputs['investor'][subloan.investor.name]['NPV'] += npv_postcut
        Outputs['investor'][subloan.investor.name]['Value'] += value_postcut
        #Outputs['investor'][subloan.investor.name]['Plan'] = subloan.
↪payments_inv_postcut['payment']
        # for electraseed benefit in loan
        npv_spv = npv_precut - npv_postcut
        value_spv = value_precut - value_postcut
        # update dea values
        Outputs['spv'][spv.name]['NPV'] += npv_spv
        Outputs['spv'][spv.name]['Value'] += value_spv
        #Outputs['spv'][spv.name]['Value'] = subloan.
↪payments_inv_precut['payment'] - subloan.payments_inv_postcut['payment']
print(Outputs)
```


```
{'dea': {'Polarstern': {'NPV': -388935.985212193, 'Value': -573577.1488315732},
'MaxSolar': {'NPV': -242466.95444424055, 'Value': -368733.5208296728},
'Solartainer': {'NPV': -305099.4506757565, 'Value': -351485.3055486856},
'SOLShare': {'NPV': -517862.8967584237, 'Value': -601181.7973637697}},
'underwriter': {'uw_Germany': {'NPV': 130953.81908308165, 'Value':
142285.8791345457}, 'uw_Mali': {'NPV': 37497.98328583056, 'Value':
39419.734546893684}, 'uw_Bang1': {'NPV': 21515.788826646814, 'Value':
23277.00035812006}, 'uw_Bang2': {'NPV': 32273.683236487384, 'Value':
34915.50053313689}}, 'investor': {'inv_altruistic': {'NPV': 229991.99794554815,
'Value': 328432.5537030892}, 'inv_impact1': {'NPV': 299881.40958620736, 'Value':
399740.21125433245}, 'inv_impact2': {'NPV': 229970.70948668208, 'Value':
328409.6365886079}, 'inv_impact3': {'NPV': 209158.4345658091, 'Value':
307121.792153525}, 'inv_monopolyman': {'NPV': 11804.77883792267, 'Value':
20446.18429425208}}, 'spv': {'Electraseed': {'NPV': 251316.6822363981, 'Value':
270929.2800071985}}}
```

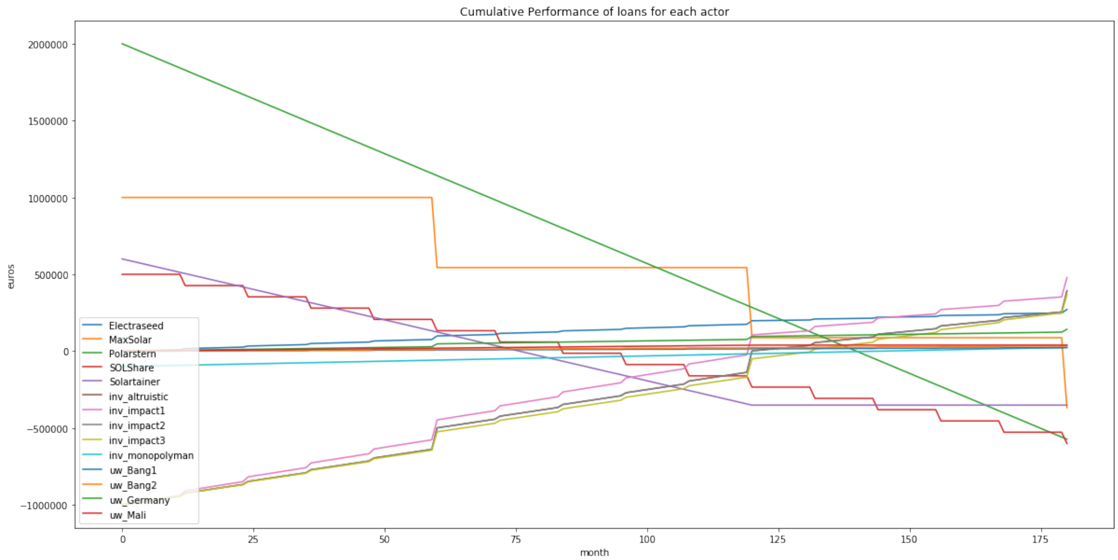
Setup Graph Outputs

[15]:
```
# helper function to add a df column to the dataframe
def add_df_column(df, payments, ind, name):
    add = pd.DataFrame(data=payments, index=ind) # create column to add
    add.columns = [name] # set column names
    df = pd.concat([df, add], axis=1, sort=False) # add column
    return df

# setup graph outputs
months = range(int(max((12/np.asarray(dea_paymentfreqs))*dea_loanperiods))) #␣
↪get largest number of loan months span
df = pd.DataFrame(data=np.asarray(months)) # setup months array
loan_dfs = [] # create array of loan specific dfs
for loan in loan_menu:
    loan_df = pd.DataFrame(data=np.asarray(months))
    # add dea payments
    df = add_df_column(df, -loan.payments_dea['payment'], loan.
↪payments_dea['month'], loan.dea.name)
    loan_df = add_df_column(loan_df, -loan.payments_dea['payment'], loan.
↪payments_dea['month'], loan.dea.name)
    # add underwriter receipts from dea
    df = add_df_column(df, loan.payments_dea['payment'], loan.
↪payments_dea['month'], loan.underwriter.name)
    loan_df = add_df_column(loan_df, loan.payments_dea['payment'], loan.
↪payments_dea['month'], loan.underwriter.name)
    # for subloans
    for subloan in loan.subloans:
        # add underwriter payments
        df = add_df_column(df, -subloan.payments_inv_precut['payment'], subloan.
↪payments_inv_precut['month'], loan.underwriter.name)
        loan_df = add_df_column(loan_df, -subloan.
↪payments_inv_precut['payment'], subloan.payments_inv_precut['month'], loan.
↪underwriter.name)
        # add inv receipts from underwriter
        df = add_df_column(df, subloan.payments_inv_precut['payment'], subloan.
↪payments_inv_precut['month'], subloan.investor.name)
        loan_df = add_df_column(loan_df, subloan.
↪payments_inv_precut['payment'], subloan.payments_inv_precut['month'],␣
↪subloan.investor.name)
        # add electraseed receipts
        df = add_df_column(df, subloan.payments_inv_precut['payment']-subloan.
↪payments_inv_postcut['payment'], subloan.payments_inv_precut['month'], spv.
↪name)
        loan_df = add_df_column(loan_df, subloan.
↪payments_inv_precut['payment']-subloan.payments_inv_postcut['payment'],␣
↪subloan.payments_inv_precut['month'], spv.name)
```

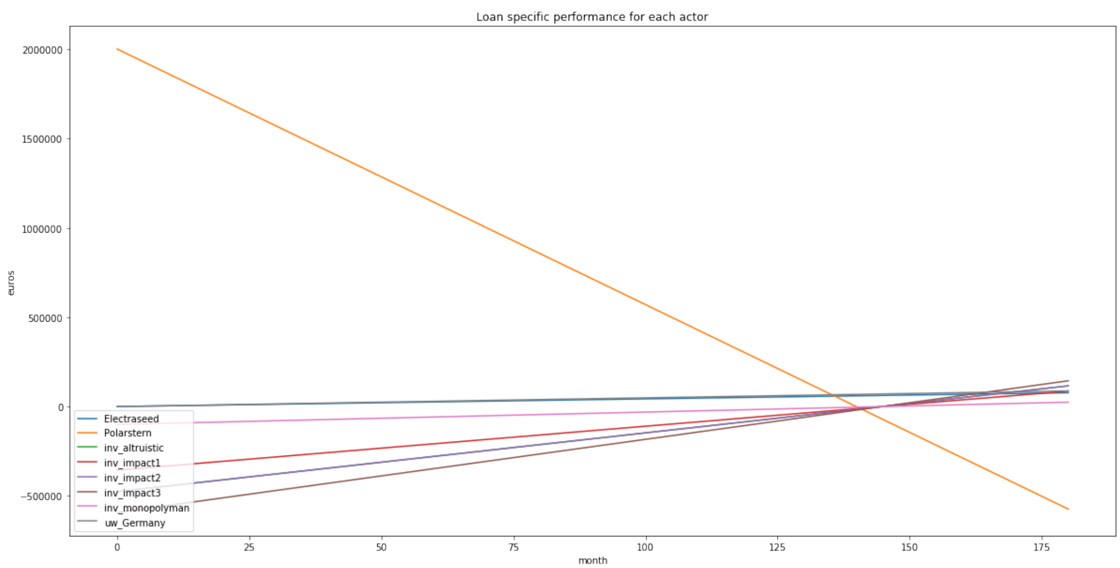
```
    loan_df = loan_df.drop(columns=[0]) # get rid of extra month column
    loan_df = loan_df.groupby(lambda x:x, axis=1).sum() # group all different␣
 ↪adds/subtracts and add them
    loan_df_cumsum = loan_df.cumsum() # get cumulative sum
    loan_dfs.append(loan_df_cumsum.copy()) # append df to tracker
    del loan_df
    del loan_df_cumsum
df = df.drop(columns=[0]) # get rid of extra month column
df = df.groupby(lambda x:x, axis=1).sum() # group all different adds/subtracts␣
 ↪and add them
df_cumsum = df.cumsum() # get cumulative sum
```

Graph Outputs

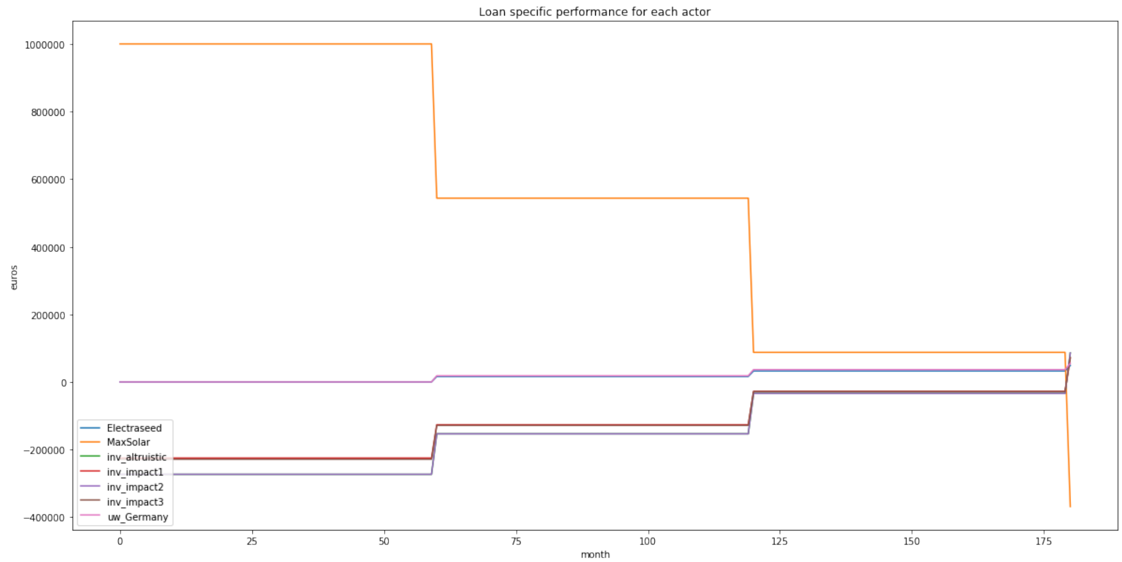
[16]:
```
# TODO make this pretty - decide what we want to plot. Maybe one chart for each␣
 ↪investor?
plt.rcParams["figure.figsize"] = (20,10)

# plot all on same axis
df_cumsum.plot(kind='line')
plt.xlabel('month')
plt.ylabel('euros')
plt.legend(loc=3, prop={'size': 10})
plt.title('Cumulative Performance of loans for each actor')
plt.show()

# plots for individual loans
for df in loan_dfs:
    df.plot(kind='line')
    plt.xlabel('month')
    plt.ylabel('euros')
    plt.legend(loc=3, prop={'size': 10})
    plt.title('Loan specific performance for each actor')
    plt.show()
```



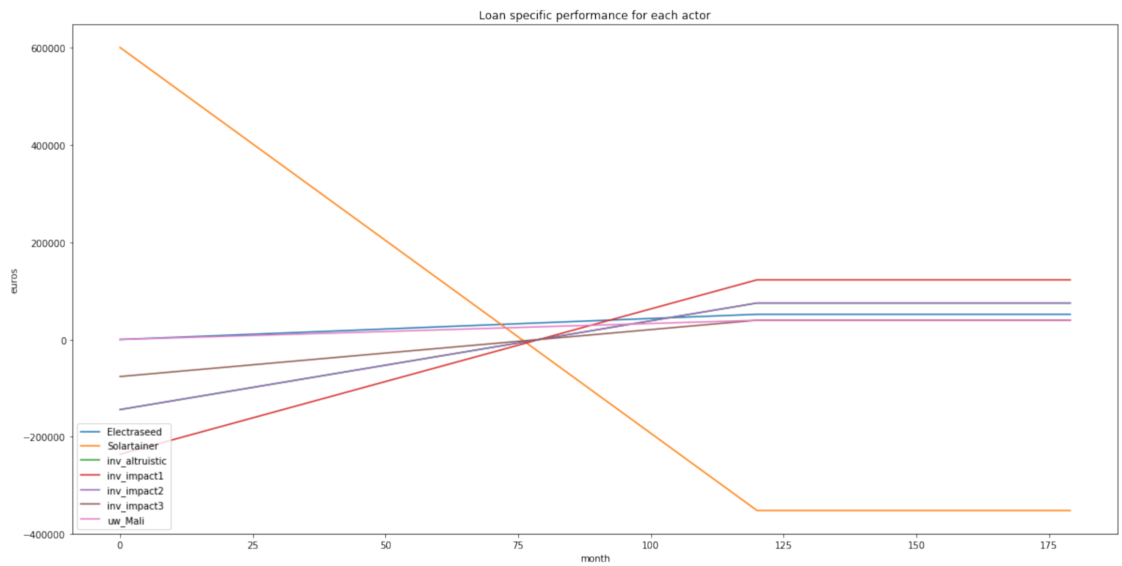
Cumulative Performance of loans for each actor
2000000
1500000
1000000
500000
0
−500000
−1000000
euros
0
25
50
75
100
125
150
175
month
Electraseed
MaxSolar
Polarstern
SOLShare
Solartainer
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
inv_monopolyman
uw_Bang1
uw_Bang2
uw_Germany
uw_Mali



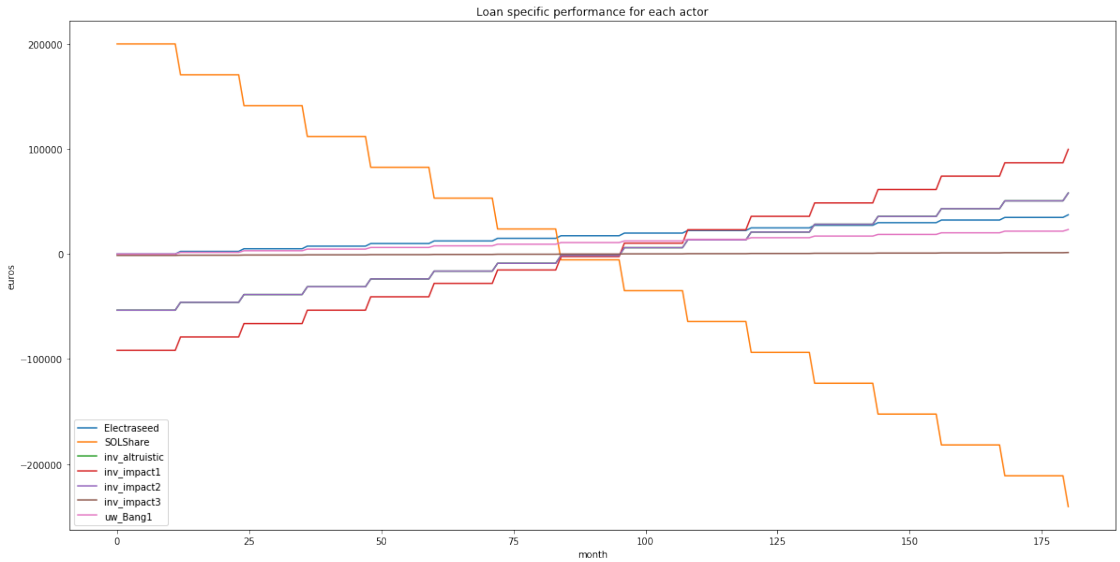
Loan specific performance for each actor
2000000
1500000
1000000
500000
0
−500000
euros
0
25
50
75
100
125
150
175
month
Electraseed
Polarstern
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
inv_monopolyman
uw_Germany

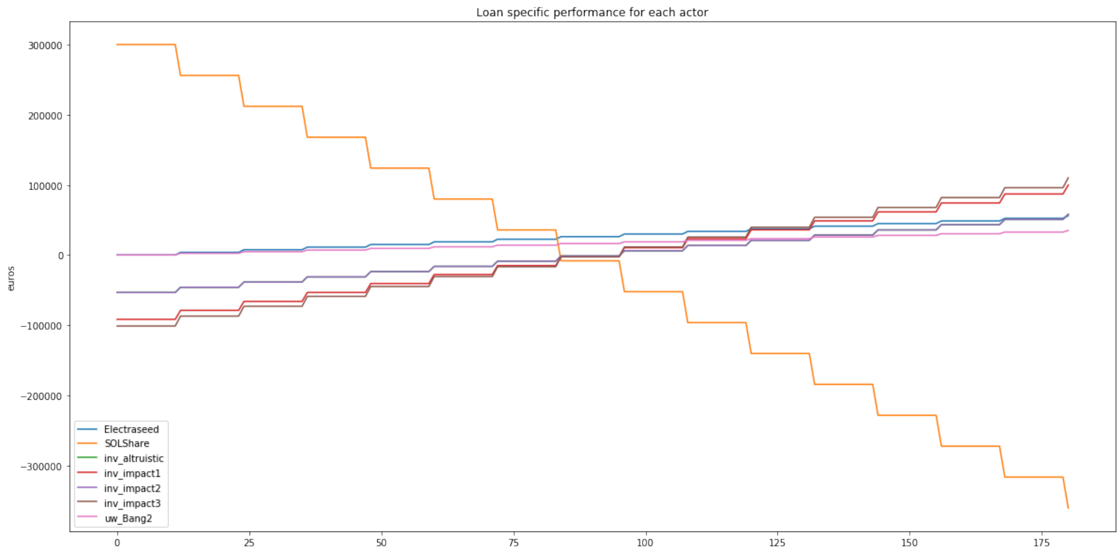


Loan specific performance for each actor
euros
month
1000000
800000
600000
400000
200000
0
−200000
−400000
0
25
50
75
100
125
150
175
Electraseed
MaxSolar
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
uw_Germany



Loan specific performance for each actor
euros
month
600000
400000
200000
0
−200000
−400000
0
25
50
75
100
125
150
175
Electraseed
Solartainer
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
uw_Mali


Loan specific performance for each actor
200000
100000
0
−100000
−200000
euros
0
25
50
75
100
125
150
175
month
Electraseed
SOLShare
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
uw_Bang1


Loan specific performance for each actor
300000
200000
100000
0
−100000
−200000
−300000
euros
0
25
50
75
100
125
150
175
month
Electraseed
SOLShare
inv_altruistic
inv_impact1
inv_impact2
inv_impact3
uw_Bang2

[ ]: