

Enron POI Classifier EDA

Initializing and checking versions

In [3]:

```
%cd C:\Users\damia\OneDrive\Dokumente\Udacity\DataAnalyst\EnronFinal\final_project
import sys
import sklearn
print "sklearn", sklearn.__version__
print "python", sys.version
```

```
C:\Users\damia\OneDrive\Dokumente\Udacity\DataAnalyst\EnronFinal\final_pro
ject
sklearn 0.17.1
python 2.7.12 |Anaconda 4.1.1 (64-bit)| (default, Jun 29 2016, 11:07:13)
[MSC v.1500 64 bit (AMD64)]
```

Loading and exploring the data

In [4]:

```
import sys
import pickle
with open("final_project_dataset.pkl", "r") as data_file:
    data_dict = pickle.load(data_file)
```

Remove outlier "TOTAL" data point

We saw in the course, that the financial data contains a total row. This creates an obvious outlier. We remove it because it is non-sensical for our purpose.

In [5]:

```
del data_dict['TOTAL']
```

Number of data points

In [6]:

```
N = len(data_dict)
print N
```

145

Number of POI data point

In [7]:

```
n = sum([1 if d['poi'] else 0 for d in data_dict.values()])  
print n
```

18

Percentage of POI data points

In [8]:

```
1.0 * n / N
```

Out[8]:

0.12413793103448276

We see that we have a limited amount of data and the two classes poi/non-poi are highly unbalanced. This implies that we cannot use accuracy as performance metric in our model and that we have to use some sort of randomized cross-validation in order to get reliable performance measures.

Number of features (including label)

In [9]:

```
len(data_dict['ALLEN PHILLIP K'].keys())
```

Out[9]:

21

Names of Persons

In [11]:

```
print "\n".join(sorted(data_dict.keys()))
```

ALLEN PHILLIP K
BADUM JAMES P
BANNANTINE JAMES M
BAXTER JOHN C
BAY FRANKLIN R
BAZELIDES PHILIP J
BECK SALLY W
BELDEN TIMOTHY N
BELFER ROBERT
BERBERIAN DAVID
BERGSIEKER RICHARD P
BHATNAGAR SANJAY
BIBI PHILIPPE A
BLACHMAN JEREMY M
BLAKE JR. NORMAN P
BOWEN JR RAYMOND M
BROWN MICHAEL
BUCHANAN HAROLD G
BUTTS ROBERT H
BUY RICHARD B
CALGER CHRISTOPHER F
CARTER REBECCA C
CAUSEY RICHARD A
CHAN RONNIE
CHRISTODOULOU DIOMEDES
CLINE KENNETH W
COLWELL WESLEY
CORDES WILLIAM R
COX DAVID
CUMBERLAND MICHAEL S
DEFFNER JOSEPH M
DELAINEY DAVID W
DERRICK JR. JAMES V
DETMERING TIMOTHY J
DIETRICH JANET R
DIMICHELE RICHARD G
DODSON KEITH
DONAHUE JR JEFFREY M
DUNCAN JOHN H
DURAN WILLIAM D
ECHOLS JOHN B
ELLIOTT STEVEN
FALLON JAMES B
FASTOW ANDREW S
FITZGERALD JAY L
FOWLER PEGGY
FOY JOE
FREVERT MARK A
FUGH JOHN L
GAHN ROBERT S
GARLAND C KEVIN
GATHMANN WILLIAM D
GIBBS DANA R
GILLIS JOHN
GLISAN JR BEN F
GOLD JOSEPH
GRAMM WENDY L
GRAY RODNEY
HAEDICKE MARK E
HANNON KEVIN P
HAUG DAVID L

HAYES ROBERT E
HAYSLETT RODERICK J
HERMANN ROBERT J
HICKERSON GARY J
HIRKO JOSEPH
HORTON STANLEY C
HUGHES JAMES A
HUMPHREY GENE E
IZZO LAWRENCE L
JACKSON CHARLENE R
JAEDICKE ROBERT
KAMINSKI WINCENTY J
KEAN STEVEN J
KISHKILL JOSEPH G
KITCHEN LOUISE
KOENIG MARK E
KOPPER MICHAEL J
LAVORATO JOHN J
LAY KENNETH L
LEFF DANIEL P
LEMAISTRE CHARLES
LEWIS RICHARD
LINDHOLM TOD A
LOCKHART EUGENE E
LOWRY CHARLES P
MARTIN AMANDA K
MCCARTY DANNY J
MCCLELLAN GEORGE
MCCONNELL MICHAEL S
MCDONALD REBECCA
MCMAHON JEFFREY
MENDELSON JOHN
METTS MARK
MEYER JEROME J
MEYER ROCKFORD G
MORAN MICHAEL P
MORDAUNT KRISTINA M
MULLER MARK S
MURRAY JULIA H
NOLES JAMES L
OLSON CINDY K
OVERDYKE JR JERE C
PAI LOU L
PEREIRA PAULO V. FERRAZ
PICKERING MARK R
PIPER GREGORY F
PIRO JIM
POWERS WILLIAM
PRENTICE JAMES
REDMOND BRIAN L
REYNOLDS LAWRENCE
RICE KENNETH D
RIEKER PAULA H
SAVAGE FRANK
SCRIMSHAW MATTHEW
SHANKMAN JEFFREY A
SHAPIRO RICHARD S
SHARP VICTORIA T
SHELBY REX
SHERRICK JEFFREY B
SHERRIFF JOHN R

SKILLING JEFFREY K
STABLER FRANK
SULLIVAN-SHAKLOVITZ COLLEEN
SUNDE MARTIN
TAYLOR MITCHELL S
THE TRAVEL AGENCY IN THE PARK
THORN TERENCE H
TILNEY ELIZABETH A
UMANOFF ADAM S
URQUHART JOHN A
WAKEHAM JOHN
WALLS JR ROBERT H
WALTERS GARETH W
WASAFF GEORGE
WESTFAHL RICHARD K
WHALEY DAVID A
WHALLEY LAWRENCE G
WHITE JR THOMAS E
WINOKUR JR. HERBERT S
WODRASKA JOHN
WROBEL BRUCE
YEAGER F SCOTT
YEAP SOON

Lets look at 'The travel agency in the park'

In [14]:

```
sorted(data_dict['THE TRAVEL AGENCY IN THE PARK'].items())
```

Out[14]:

```
[('bonus', 'NaN'), ('deferral_payments', 'NaN'), ('deferred_income', 'NaN'), ('director_fees', 'NaN'), ('email_address', 'NaN'), ('exercised_stock_options', 'NaN'), ('expenses', 'NaN'), ('from_messages', 'NaN'), ('from_poi_to_this_person', 'NaN'), ('from_this_person_to_poi', 'NaN'), ('loan_advances', 'NaN'), ('long_term_incentive', 'NaN'), ('other', 362096), ('poi', False), ('restricted_stock', 'NaN'), ('restricted_stock_deferred', 'NaN'), ('salary', 'NaN'), ('shared_receipt_with_poi', 'NaN'), ('to_messages', 'NaN'), ('total_payments', 362096), ('total_stock_value', 'NaN')]
```

It looks like this is not relevant for our purposes, as it is not a person and also not a POI. So lets remove it. (The insider PDF also has a footnote regarding this data point.)

In [15]:

```
del data_dict['THE TRAVEL AGENCY IN THE PARK']
```

Lets look at one person

In [18]:

```
sorted(data_dict['ALLEN PHILLIP K'].items())
```

Out[18]:

```
[('bonus', 4175000), ('deferral_payments', 2869717), ('deferred_income', -3081055), ('director_fees', 'NaN'), ('email_address', 'phillip.allen@enron.com'), ('exercised_stock_options', 1729541), ('expenses', 13868), ('from_messages', 2195), ('from_poi_to_this_person', 47), ('from_this_person_to_poi', 65), ('loan_advances', 'NaN'), ('long_term_incentive', 304805), ('other', 152), ('poi', False), ('restricted_stock', 126027), ('restricted_stock_deferred', -126027), ('salary', 201955), ('shared_receipt_with_poi', 1407), ('to_messages', 2902), ('total_payments', 4484442), ('total_stock_value', 1729541)]
```

Check calculation of total payments

In [24]:

```
def val(value):
    if value == 'NaN': return 0
    return int(value)

def check_inconsistencies():
    for name, data in sorted(data_dict.items()):
        total_payments = val(data['salary'])
        total_payments += val(data['bonus'])
        total_payments += val(data['long_term_incentive'])
        total_payments += val(data['deferred_income'])
        total_payments += val(data['deferral_payments'])
        total_payments += val(data['loan_advances'])
        total_payments += val(data['other'])
        total_payments += val(data['expenses'])
        total_payments += val(data['director_fees'])
        if total_payments != val(data['total_payments']):
            print name, 'total payments difference, calculated', total_payments, '!= data', val(data['total_payments'])
        total_stock_value = val(data['exercised_stock_options'])
        total_stock_value += val(data['restricted_stock'])
        total_stock_value += val(data['restricted_stock_deferred'])
        if total_stock_value != val(data['total_stock_value']):
            print name, 'total stock value difference, calculated', total_stock_value, '!= data', val(data['total_stock_value'])

check_inconsistencies()
```

```
BELFER ROBERT total payments difference, calculated -99215 != data 102500
BELFER ROBERT total stock value difference, calculated 47378 != data -4409
3
BHATNAGAR SANJAY total payments difference, calculated 275728 != data 1545
6290
BHATNAGAR SANJAY total stock value difference, calculated 15456290 != data
0
```

In [22]:

```
sorted(data_dict['BELFER ROBERT'].items())
```

Out[22]:

```
[('bonus', 'NaN'), ('deferral_payments', -102500), ('deferred_income', 'NaN'), ('director_fees', 3285), ('email_address', 'NaN'), ('exercised_stock_options', 3285), ('expenses', 'NaN'), ('from_messages', 'NaN'), ('from_poi_to_this_person', 'NaN'), ('from_this_person_to_poi', 'NaN'), ('loan_advances', 'NaN'), ('long_term_incentive', 'NaN'), ('other', 'NaN'), ('poi', False), ('restricted_stock', 'NaN'), ('restricted_stock_deferred', 44093), ('salary', 'NaN'), ('shared_receipt_with_poi', 'NaN'), ('to_messages', 'NaN'), ('total_payments', 102500), ('total_stock_value', -44093)]
```

In [23]:

```
sorted(data_dict['BHATNAGAR SANJAY'].items())
```

Out[23]:

```
[('bonus', 'NaN'), ('deferral_payments', 'NaN'), ('deferred_income', 'NaN'), ('director_fees', 137864), ('email_address', 'sanjay.bhatnagar@enron.com'), ('exercised_stock_options', 2604490), ('expenses', 'NaN'), ('from_messages', 29), ('from_poi_to_this_person', 0), ('from_this_person_to_poi', 1), ('loan_advances', 'NaN'), ('long_term_incentive', 'NaN'), ('other', 137864), ('poi', False), ('restricted_stock', -2604490), ('restricted_stock_deferred', 15456290), ('salary', 'NaN'), ('shared_receipt_with_poi', 463), ('to_messages', 523), ('total_payments', 15456290), ('total_stock_value', 'NaN')]
```

Cross-referencing the insider payment pdf file, correct the values

In [33]:

```
belfer = data_dict['BELFER ROBERT']
belfer['deferred_income'] = -102500
belfer['deferral_payments'] = 'NaN'
belfer['expenses'] = 3285
belfer['exercised_stock_options'] = 'NaN'
belfer['director_fees'] = 102500
belfer['restricted_stock'] = 44093
belfer['restricted_stock_deferred'] = -44093
belfer['total_payments'] = 3285
belfer['total_stock_value'] = 'NaN'

bhatnagar = data_dict['BHATNAGAR SANJAY']
bhatnagar['expenses'] = 137864
bhatnagar['director_fees'] = 'NaN'
bhatnagar['other'] = 'NaN'
bhatnagar['total_payments'] = 137864
bhatnagar['exercised_stock_options'] = 15456290
bhatnagar['restricted_stock'] = 2604490
bhatnagar['restricted_stock_deferred'] = -2604490
bhatnagar['total_stock_value'] = 15456290
```

Check again for inconsistencies

In [34]:

```
check_inconsistencies()
```

Feature names

In [35]:

```
print '\n'.join(sorted(data_dict['ALLEN PHILLIP K'].keys()))
```

```
bonus
deferral_payments
deferred_income
director_fees
email_address
exercised_stock_options
expenses
from_messages
from_poi_to_this_person
from_this_person_to_poi
loan_advances
long_term_incentive
other
poi
restricted_stock
restricted_stock_deferred
salary
shared_receipt_with_poi
to_messages
total_payments
total_stock_value
```

Group features in categories

In [9]:

```
financial_features = ['bonus',
                     'deferral_payments',
                     'deferred_income',
                     'director_fees',
                     'exercised_stock_options',
                     'expenses',
                     'loan_advances',
                     'long_term_incentive',
                     'other',
                     'restricted_stock',
                     'restricted_stock_deferred',
                     'salary',
                     'total_payments',
                     'total_stock_value']
email_features = ['email_address',
                  'from_messages',
                  'from_poi_to_this_person',
                  'from_this_person_to_poi',
                  'shared_receipt_with_poi',
                  'to_messages']
label = ['poi']
```

Code for exploring features

In [36]:

```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np

def collect_feature(feature):
    return [d[feature] for d in data_dict.values()]

def collect_feature_poi(feature):
    return [float(d[feature]) for d in data_dict.values() if d['poi'] and d[feature] !=
'NaN']

def collect_feature_non_poi(feature):
    return [float(d[feature]) for d in data_dict.values() if not d['poi'] and
d[feature] != 'NaN']

def explore_feature(feature):
    data = collect_feature(feature)
    missing = sum([1 for d in data if d == 'NaN'])
    print 'missing values', missing, 'of', len(data), '(%0.1f%%)' % (100.0 * missing / l
en(data))
    data = [float(d) for d in data if d != 'NaN']
    print 'min', np.min(data), 'max', np.max(data)
    print '25%', np.percentile(data, 25), '50%', np.percentile(data, 50), '75%', np.per
centile(data, 75)
    print 'mean', np.mean(data), 'std', np.std(data)

def graph_feature(feature):
    data_poi = collect_feature_poi(feature)
    data_non_poi = collect_feature_non_poi(feature)
    x1 = min(data_poi + data_non_poi)
    x2 = max(data_poi + data_non_poi)
    plt.figure(1)

    plt.subplot(211)
    plt.title('poi')
    plt.xlim(x1, x2)
    plt.hist(data_poi, 30)

    plt.subplot(212)
    plt.title('non-poi')
    plt.xlim(x1, x2)
    plt.hist(data_non_poi, 30)

    plt.show()

def detect_outliers(feature):
    data = [float(d) for d in collect_feature(feature) if d != 'NaN']
    m = np.median(data)
    iqr = np.percentile(data, 75) - np.percentile(data, 25)
    a, b = m - 1.5 * iqr, m + 1.5 * iqr
    outliers = []
    for value in data:
        if a <= value <= b: continue
        for k, d in data_dict.items():
            if d[feature] == value:
```

```

        outliers.append((value, ('POI ' if d['poi'] else ' ') + k))
    for outlier, name in sorted(outliers, reverse=True):
        if outlier < a:
            print '%12.3f %-25s %s' % (outlier, '[' + str(a) + ' ' + str(b) + ']',
name)
        else:
            print '%-25s %12.3f %s' % ('[' + str(a) + ' ' + str(b) + ']', outlier,
name)

def explore(feature):
    explore_feature(feature)
    graph_feature(feature)
    detect_outliers(feature)

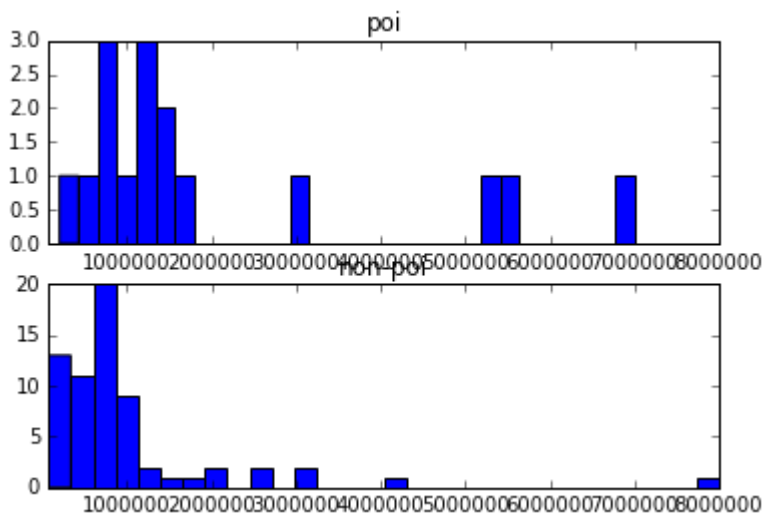
```

Explore financial features

In [37]:

```
explore('bonus')
```

missing values 63 of 144 (43.8%)
min 70000.0 max 8000000.0
25% 425000.0 50% 750000.0 75% 1200000.0
mean 1201773.07407 std 1432752.54483

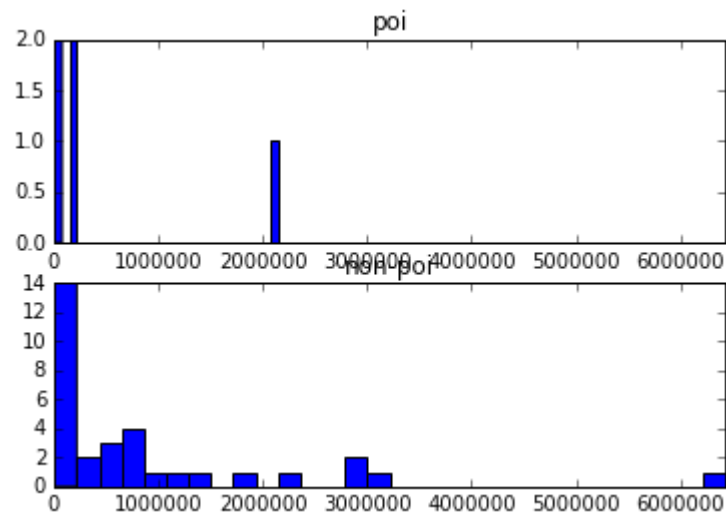


[-412500.0 1912500.0]	8000000.000	LAVORATO JOHN J
[-412500.0 1912500.0]	7000000.000	POI LAY KENNETH L
[-412500.0 1912500.0]	5600000.000	POI SKILLING JEFFREY K
[-412500.0 1912500.0]	5249999.000	POI BELDEN TIMOTHY N
[-412500.0 1912500.0]	4175000.000	ALLEN PHILLIP K
[-412500.0 1912500.0]	3100000.000	KITCHEN LOUISE
[-412500.0 1912500.0]	3000000.000	POI DELAINEY DAVID W
[-412500.0 1912500.0]	3000000.000	POI DELAINEY DAVID W
[-412500.0 1912500.0]	3000000.000	WHALLEY LAWRENCE G
[-412500.0 1912500.0]	3000000.000	WHALLEY LAWRENCE G
[-412500.0 1912500.0]	2600000.000	MCMAHON JEFFREY
[-412500.0 1912500.0]	2500000.000	FALLON JAMES B
[-412500.0 1912500.0]	2000000.000	SHANKMAN JEFFREY A
[-412500.0 1912500.0]	2000000.000	SHANKMAN JEFFREY A
[-412500.0 1912500.0]	2000000.000	FREVERT MARK A
[-412500.0 1912500.0]	2000000.000	FREVERT MARK A

In [38]:

```
explore('deferral_payments')
```

missing values 107 of 144 (74.3%)
min 7961.0 max 6426990.0
25% 85430.0 50% 227449.0 75% 875307.0
mean 867118.810811 std 1279692.05864

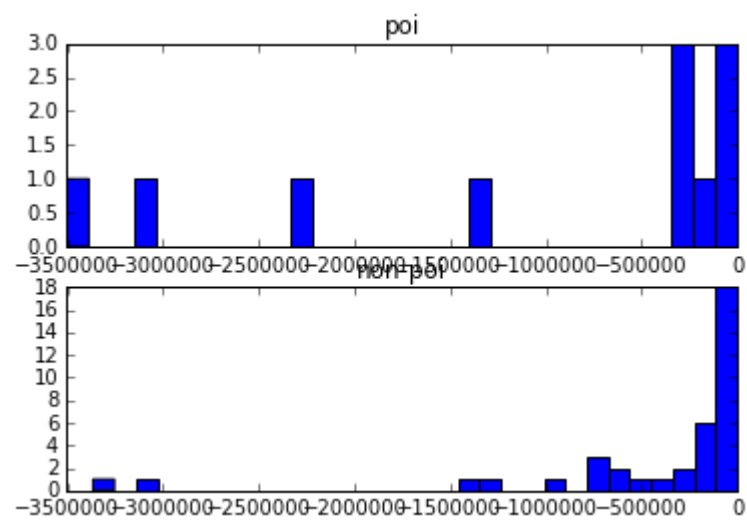


[-957366.5 1412264.5]	6426990.000	FREVERT MARK A
[-957366.5 1412264.5]	3131860.000	HORTON STANLEY C
[-957366.5 1412264.5]	2964506.000	HUMPHREY GENE E
[-957366.5 1412264.5]	2869717.000	ALLEN PHILLIP K
[-957366.5 1412264.5]	2157527.000	HAEDICKE MARK E
[-957366.5 1412264.5]	2144013.000	POI BELDEN TIMOTHY N
[-957366.5 1412264.5]	1848227.000	MEYER ROCKFORD G

In [39]:

```
explore('deferred_income')
```

missing values 95 of 144 (66.0%)
min -3504386.0 max -833.0
25% -583325.0 50% -144062.0 75% -38346.0
mean -571283.489796 std 925127.788811

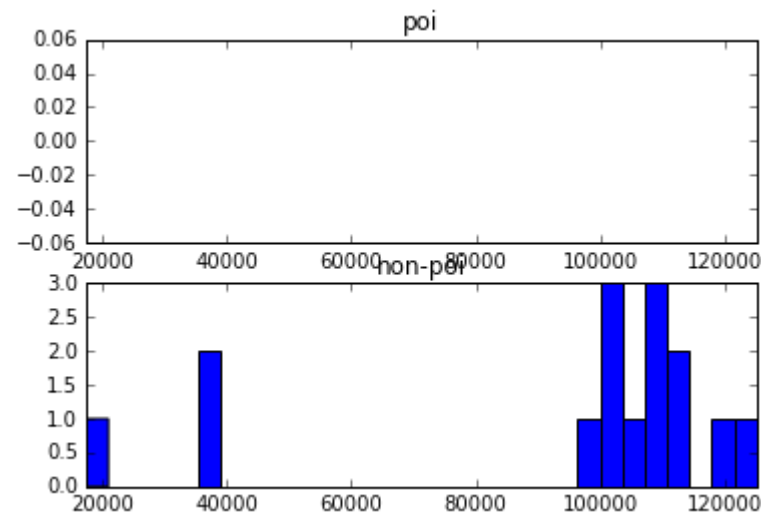


-1284000.000	[-961530.5 673406.5]	DERRICK JR. JAMES V
-1386055.000	[-961530.5 673406.5]	POI FASTOW ANDREW S
-1386055.000	[-961530.5 673406.5]	POI FASTOW ANDREW S
-1386055.000	[-961530.5 673406.5]	BAXTER JOHN C
-1386055.000	[-961530.5 673406.5]	BAXTER JOHN C
-2334434.000	[-961530.5 673406.5]	POI BELDEN TIMOTHY N
-3081055.000	[-961530.5 673406.5]	ALLEN PHILLIP K
-3117011.000	[-961530.5 673406.5]	POI HANNON KEVIN P
-3367011.000	[-961530.5 673406.5]	FREVERT MARK A
-3504386.000	[-961530.5 673406.5]	POI RICE KENNETH D

In [40]:

```
explore('director_fees')
```

missing values 129 of 144 (89.6%)
min 17500.0 max 125034.0
25% 100017.0 50% 103750.0 75% 110895.0
mean 93234.466667 std 32190.251172

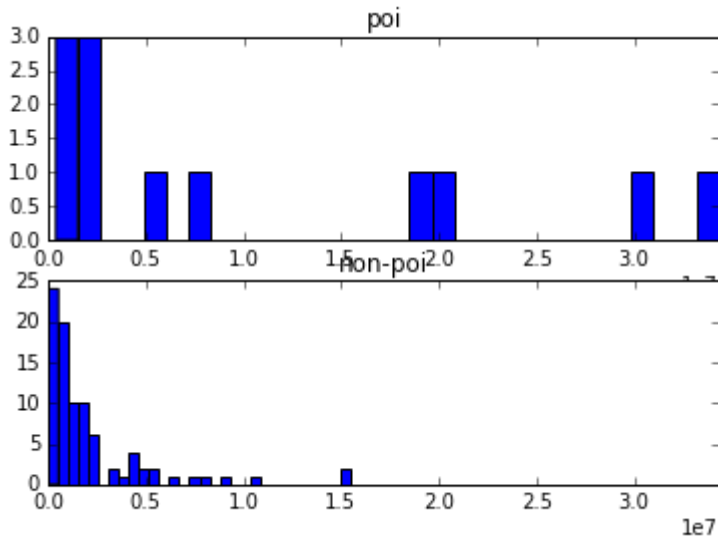


[87433.0 120067.0]	125034.000	SAVAGE FRANK
38346.000 [87433.0 120067.0]		MEYER JEROME J
36666.000 [87433.0 120067.0]		URQUHART JOHN A
17500.000 [87433.0 120067.0]		POWERS WILLIAM

In [41]:

```
explore('exercised_stock_options')
```

missing values 44 of 144 (30.6%)
min 9803.0 max 34348384.0
25% 570128.75 50% 1310813.5 75% 2544450.0
mean 3117640.0 std 5629563.29093

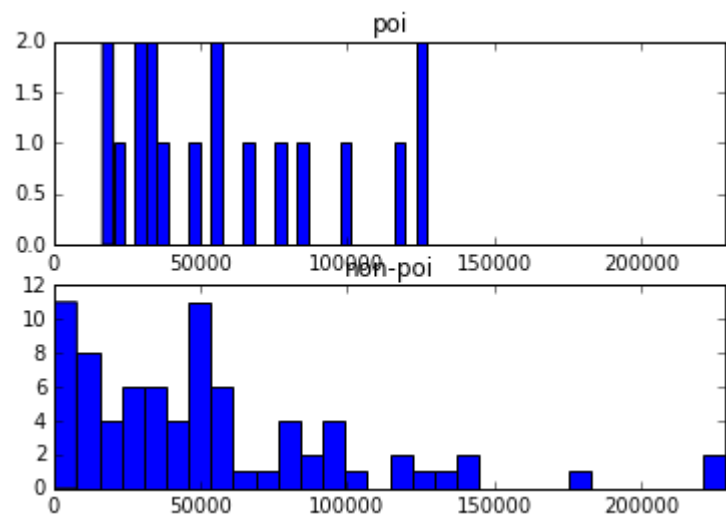


min	q1	q2	q3	max	poi	name
-1650668.375	4272295.375	34348384.000	POI	LAY KENNETH L		
-1650668.375	4272295.375	30766064.000	POI	HIRKO JOSEPH		
-1650668.375	4272295.375	19794175.000	POI	RICE KENNETH D		
-1650668.375	4272295.375	19250000.000	POI	SKILLING JEFFREY K		
-1650668.375	4272295.375	15456290.000		BHATNAGAR SANJAY		
-1650668.375	4272295.375	15364167.000		PAI LOU L		
-1650668.375	4272295.375	10433518.000		FREVERT MARK A		
-1650668.375	4272295.375	8831913.000		DERRICK JR. JAMES V		
-1650668.375	4272295.375	8308552.000	POI	YEAGER F SCOTT		
-1650668.375	4272295.375	8191755.000		DIMICHELE RICHARD G		
-1650668.375	4272295.375	7509039.000		REDMOND BRIAN L		
-1650668.375	4272295.375	6680544.000		BAXTER JOHN C		
-1650668.375	4272295.375	5538001.000	POI	HANNON KEVIN P		
-1650668.375	4272295.375	5266578.000		OVERDYKE JR JERE C		
-1650668.375	4272295.375	5210569.000		HORTON STANLEY C		
-1650668.375	4272295.375	5127155.000		CHRISTODOULOU DIOMEDES		
-1650668.375	4272295.375	4890344.000		ELLIOTT STEVEN		
-1650668.375	4272295.375	4452476.000		THORN TERENCE H		
-1650668.375	4272295.375	4346544.000		WALLS JR ROBERT H		

In [42]:

```
explore('expenses')
```

missing values 48 of 144 (33.3%)
min 148.0 max 228763.0
25% 22140.5 50% 46547.5 75% 79252.25
mean 54533.3125 std 46468.8193656

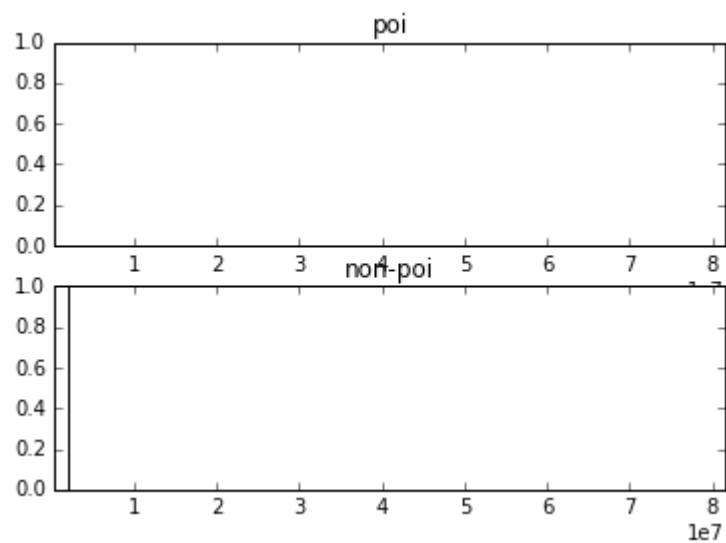


[-39120.125 132215.125]	228763.000	MCCLELLAN GEORGE
[-39120.125 132215.125]	228656.000	URQUHART JOHN A
[-39120.125 132215.125]	178979.000	SHANKMAN JEFFREY A
[-39120.125 132215.125]	137864.000	BHATNAGAR SANJAY
[-39120.125 132215.125]	137767.000	SHAPIRO RICHARD S
[-39120.125 132215.125]	137108.000	MCMAHON JEFFREY

In [43]:

```
explore('loan_advances')
```

missing values 141 of 144 (97.9%)
min 400000.0 max 81525000.0
25% 1200000.0 50% 2000000.0 75% 41762500.0
mean 27975000.0 std 37871201.6797

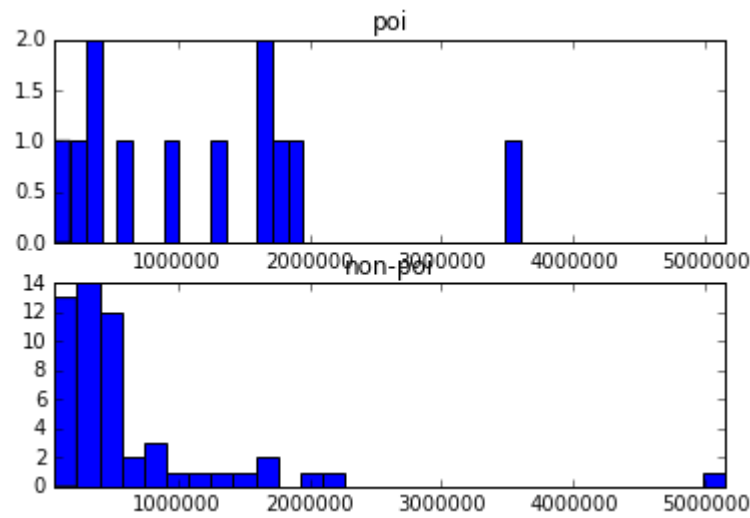


[-58843750.0 62843750.0]	81525000.000	POI LAY KENNETH L
--------------------------	--------------	-------------------

In [44]:

```
explore('long_term_incentive')
```

missing values 79 of 144 (54.9%)
min 69223.0 max 5145434.0
25% 275000.0 50% 422158.0 75% 831809.0
mean 746491.2 std 856253.866853

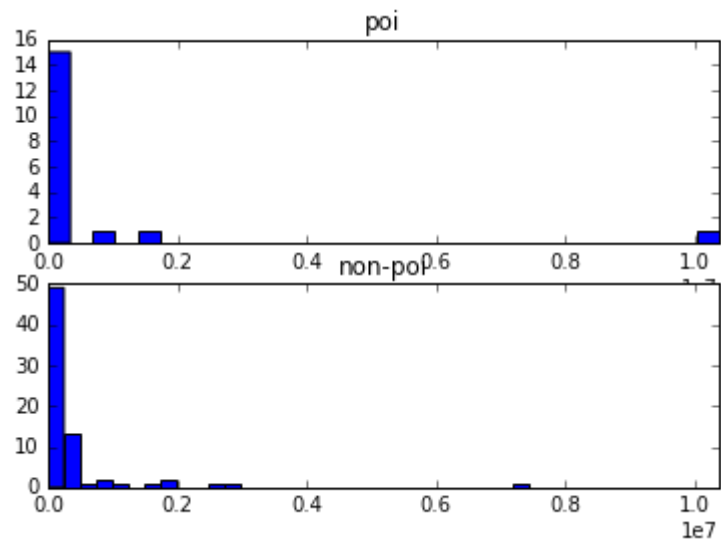


[-413055.5 1257371.5]	5145434.000	MARTIN AMANDA K
[-413055.5 1257371.5]	3600000.000	POI LAY KENNETH L
[-413055.5 1257371.5]	2234774.000	ECHOLS JOHN B
[-413055.5 1257371.5]	2035380.000	LAVORATO JOHN J
[-413055.5 1257371.5]	1920000.000	POI SKILLING JEFFREY K
[-413055.5 1257371.5]	1736055.000	POI FASTOW ANDREW S
[-413055.5 1257371.5]	1725545.000	MULLER MARK S
[-413055.5 1257371.5]	1617011.000	POI RICE KENNETH D
[-413055.5 1257371.5]	1617011.000	POI RICE KENNETH D
[-413055.5 1257371.5]	1617011.000	POI RICE KENNETH D
[-413055.5 1257371.5]	1617011.000	POI HANNON KEVIN P
[-413055.5 1257371.5]	1617011.000	POI HANNON KEVIN P
[-413055.5 1257371.5]	1617011.000	POI HANNON KEVIN P
[-413055.5 1257371.5]	1617011.000	FREVERT MARK A
[-413055.5 1257371.5]	1617011.000	FREVERT MARK A
[-413055.5 1257371.5]	1617011.000	FREVERT MARK A
[-413055.5 1257371.5]	1586055.000	BAXTER JOHN C
[-413055.5 1257371.5]	1387399.000	LEFF DANIEL P
[-413055.5 1257371.5]	1294981.000	POI DELAINEY DAVID W

In [45]:

```
explore('other')
```

missing values 54 of 144 (37.5%)
min 2.0 max 10359729.0
25% 1197.0 50% 38570.0 75% 344027.0
mean 470061.033333 std 1396941.62285

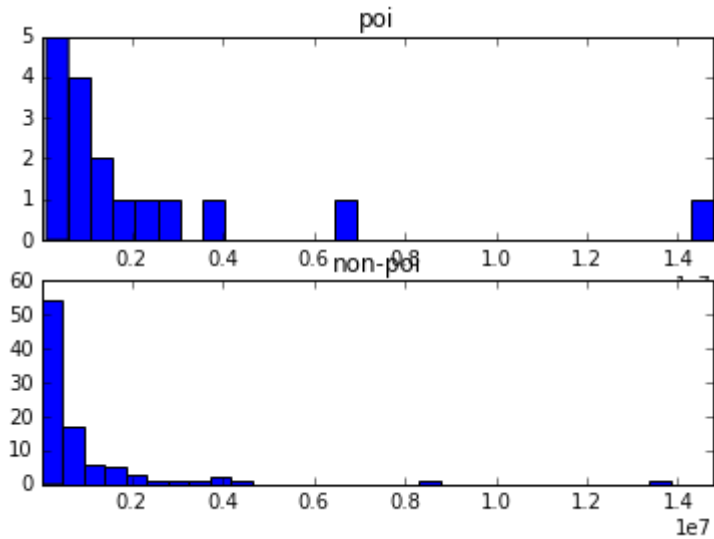


[-475675.0 552815.0]	10359729.000	POI	LAY KENNETH L
[-475675.0 552815.0]	7427621.000		FREVERT MARK A
[-475675.0 552815.0]	2818454.000		MARTIN AMANDA K
[-475675.0 552815.0]	2660303.000		BAXTER JOHN C
[-475675.0 552815.0]	1852186.000		SHERRIFF JOHN R
[-475675.0 552815.0]	1829457.000		PAI LOU L
[-475675.0 552815.0]	1573324.000	POI	SHELBY REX
[-475675.0 552815.0]	1553729.000		IZZO LAWRENCE L
[-475675.0 552815.0]	1085463.000		WHITE JR THOMAS E
[-475675.0 552815.0]	907502.000	POI	KOPPER MICHAEL J
[-475675.0 552815.0]	864523.000		BANNANTINE JAMES M
[-475675.0 552815.0]	819288.000		GOLD JOSEPH
[-475675.0 552815.0]	680833.000		GRAY RODNEY

In [46]:

```
explore('restricted_stock')
```

missing values 34 of 144 (23.6%)
min 32460.0 max 14761694.0
25% 254018.0 50% 451740.0 75% 1002369.75
mean 1184748.17273 std 2206907.91665

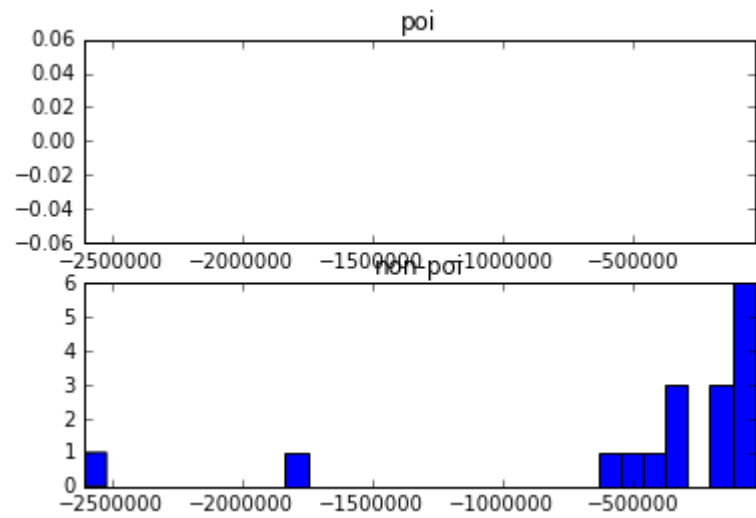


[-670787.625 1574267.625]	14761694.000	POI	LAY KENNETH L
[-670787.625 1574267.625]	13847074.000		WHITE JR THOMAS E
[-670787.625 1574267.625]	8453763.000		PAI LOU L
[-670787.625 1574267.625]	6843672.000	POI	SKILLING JEFFREY K
[-670787.625 1574267.625]	4188667.000		FREVERT MARK A
[-670787.625 1574267.625]	4131594.000		KEAN STEVEN J
[-670787.625 1574267.625]	3942714.000		BAXTER JOHN C
[-670787.625 1574267.625]	3654808.000		IZZO LAWRENCE L
[-670787.625 1574267.625]	3576206.000	POI	YEAGER F SCOTT
[-670787.625 1574267.625]	2796177.000		WHALLEY LAWRENCE G
[-670787.625 1574267.625]	2748364.000	POI	RICE KENNETH D
[-670787.625 1574267.625]	2604490.000		BHATNAGAR SANJAY
[-670787.625 1574267.625]	2502063.000	POI	CAUSEY RICHARD A
[-670787.625 1574267.625]	2217299.000		HAUG DAVID L
[-670787.625 1574267.625]	2046079.000		HORTON STANLEY C
[-670787.625 1574267.625]	2041016.000		OVERDYKE JR JERE C
[-670787.625 1574267.625]	1794412.000	POI	FASTOW ANDREW S
[-670787.625 1574267.625]	1788391.000		ELLIOTT STEVEN
[-670787.625 1574267.625]	1787380.000		DERRICK JR. JAMES V
[-670787.625 1574267.625]	1757552.000		BANNANTINE JAMES M

In [47]:

```
explore('restricted_stock_deferred')
```

missing values 127 of 144 (88.2%)
min -2604490.0 max -32460.0
25% -409554.0 50% -153686.0 75% -82782.0
mean -445693.411765 std 672734.425329

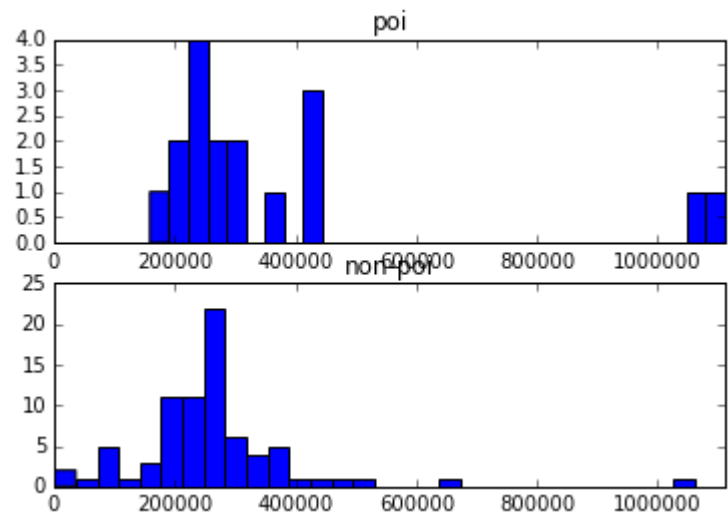


-1787380.000 [-643844.0 336472.0]	DERRICK JR. JAMES V
-2604490.000 [-643844.0 336472.0]	BHATNAGAR SANJAY

In [48]:

```
explore('salary')
```

missing values 50 of 144 (34.7%)
min 477.0 max 1111258.0
25% 211802.0 50% 258741.0 75% 308606.5
mean 284087.542553 std 176186.40936

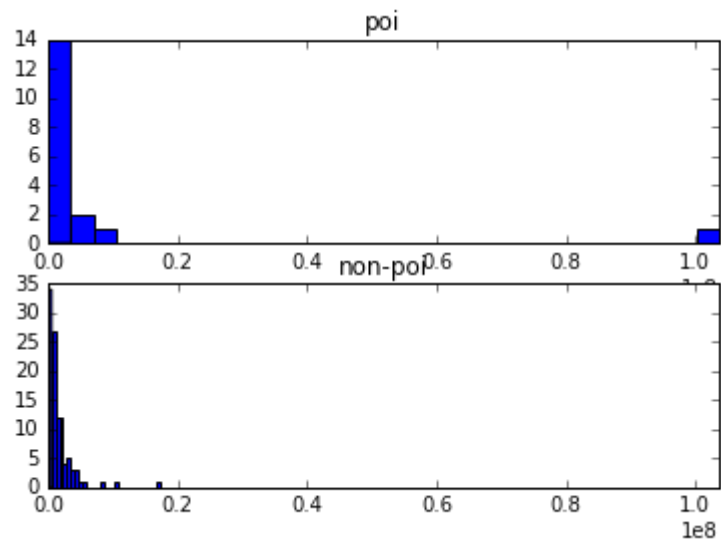


[113534.25 403947.75]	1111258.000	POI	SKILLING JEFFREY K
[113534.25 403947.75]	1072321.000	POI	LAY KENNETH L
[113534.25 403947.75]	1060932.000		FREVERT MARK A
[113534.25 403947.75]	655037.000		PICKERING MARK R
[113534.25 403947.75]	510364.000		WHALLEY LAWRENCE G
[113534.25 403947.75]	492375.000		DERRICK JR. JAMES V
[113534.25 403947.75]	440698.000	POI	FASTOW ANDREW S
[113534.25 403947.75]	428780.000		SHERRIFF JOHN R
[113534.25 403947.75]	420636.000	POI	RICE KENNETH D
[113534.25 403947.75]	415189.000	POI	CAUSEY RICHARD A
[113534.25 403947.75]	404338.000		KEAN STEVEN J
96840.000 [113534.25 403947.75]			REDMOND BRIAN L
94941.000 [113534.25 403947.75]			OVERDYKE JR JERE C
85274.000 [113534.25 403947.75]			IZZO LAWRENCE L
80818.000 [113534.25 403947.75]			BAZELIDES PHILIP J
76399.000 [113534.25 403947.75]			REYNOLDS LAWRENCE
63744.000 [113534.25 403947.75]			WESTFAHL RICHARD K
6615.000 [113534.25 403947.75]			GRAY RODNEY
477.000 [113534.25 403947.75]			BANNANTINE JAMES M

In [49]:

```
explore('total_payments')
```

missing values 21 of 144 (14.6%)
min 148.0 max 103559793.0
25% 377387.5 50% 1099100.0 75% 2064694.5
mean 2516459.26016 std 9417357.59503

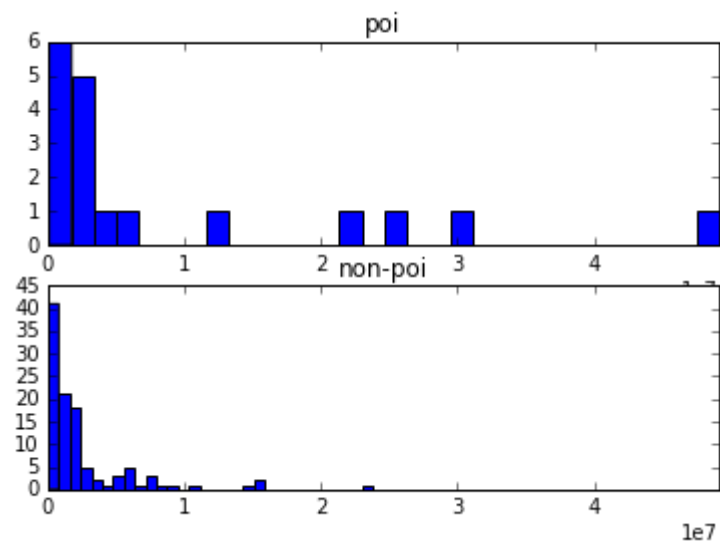


[-1431860.5 3630060.5]	103559793.000	POI	LAY KENNETH L
[-1431860.5 3630060.5]	17252530.000		FREVERT MARK A
[-1431860.5 3630060.5]	10425757.000		LAVORATO JOHN J
[-1431860.5 3630060.5]	8682716.000	POI	SKILLING JEFFREY K
[-1431860.5 3630060.5]	8407016.000		MARTIN AMANDA K
[-1431860.5 3630060.5]	5634343.000		BAXTER JOHN C
[-1431860.5 3630060.5]	5501630.000	POI	BELDEN TIMOTHY N
[-1431860.5 3630060.5]	4747979.000	POI	DELAINEY DAVID W
[-1431860.5 3630060.5]	4677574.000		WHALLEY LAWRENCE G
[-1431860.5 3630060.5]	4484442.000		ALLEN PHILLIP K
[-1431860.5 3630060.5]	4335388.000		SHERRIFF JOHN R
[-1431860.5 3630060.5]	4099771.000		MCMAHON JEFFREY
[-1431860.5 3630060.5]	3859065.000		HAEDICKE MARK E
[-1431860.5 3630060.5]	3676340.000		FALLON JAMES B

In [50]:

```
explore('total_stock_value')
```

missing values 19 of 144 (13.2%)
min 28798.0 max 49110078.0
25% 495633.0 50% 1110705.0 75% 3064208.0
mean 3476076.088 std 6587987.65245



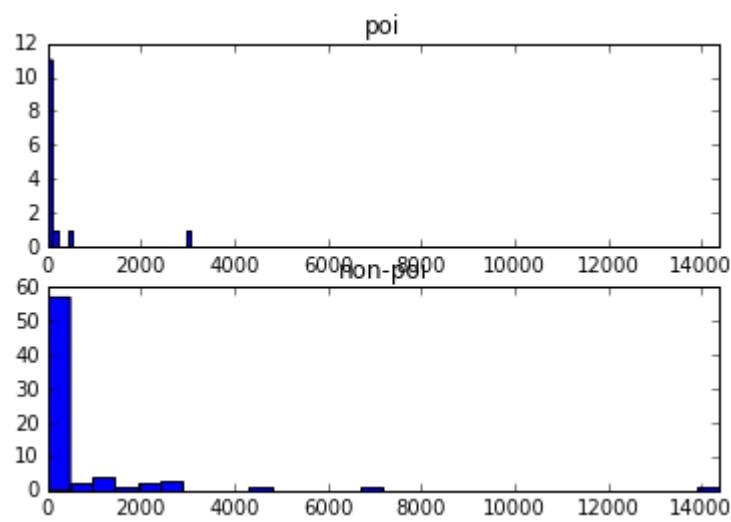
[-2742157.5 4963567.5]	49110078.000	POI	LAY KENNETH L
[-2742157.5 4963567.5]	30766064.000	POI	HIRKO JOSEPH
[-2742157.5 4963567.5]	26093672.000	POI	SKILLING JEFFREY K
[-2742157.5 4963567.5]	23817930.000		PAI LOU L
[-2742157.5 4963567.5]	22542539.000	POI	RICE KENNETH D
[-2742157.5 4963567.5]	15456290.000		BHATNAGAR SANJAY
[-2742157.5 4963567.5]	15144123.000		WHITE JR THOMAS E
[-2742157.5 4963567.5]	14622185.000		FREVERT MARK A
[-2742157.5 4963567.5]	11884758.000	POI	YEAGER F SCOTT
[-2742157.5 4963567.5]	10623258.000		BAXTER JOHN C
[-2742157.5 4963567.5]	8831913.000		DERRICK JR. JAMES V
[-2742157.5 4963567.5]	8317782.000		DIMICHELE RICHARD G
[-2742157.5 4963567.5]	7890324.000		REDMOND BRIAN L
[-2742157.5 4963567.5]	7307594.000		OVERDYKE JR JERE C
[-2742157.5 4963567.5]	7256648.000		HORTON STANLEY C
[-2742157.5 4963567.5]	6678735.000		ELLIOTT STEVEN
[-2742157.5 4963567.5]	6391065.000	POI	HANNON KEVIN P
[-2742157.5 4963567.5]	6153642.000		KEAN STEVEN J
[-2742157.5 4963567.5]	6079137.000		WHALLEY LAWRENCE G
[-2742157.5 4963567.5]	6077885.000		CHRISTODOULOU DIOMEDES
[-2742157.5 4963567.5]	5898997.000		WALLS JR ROBERT H
[-2742157.5 4963567.5]	5819980.000		IZZO LAWRENCE L
[-2742157.5 4963567.5]	5243487.000		BANNANTINE JAMES M
[-2742157.5 4963567.5]	5167144.000		LAVORATO JOHN J

Explore email features

In [51]:

```
explore('from_messages')
```

missing values 58 of 144 (40.3%)
min 12.0 max 14368.0
25% 22.75 50% 41.0 75% 145.5
mean 608.790697674 std 1830.29896602

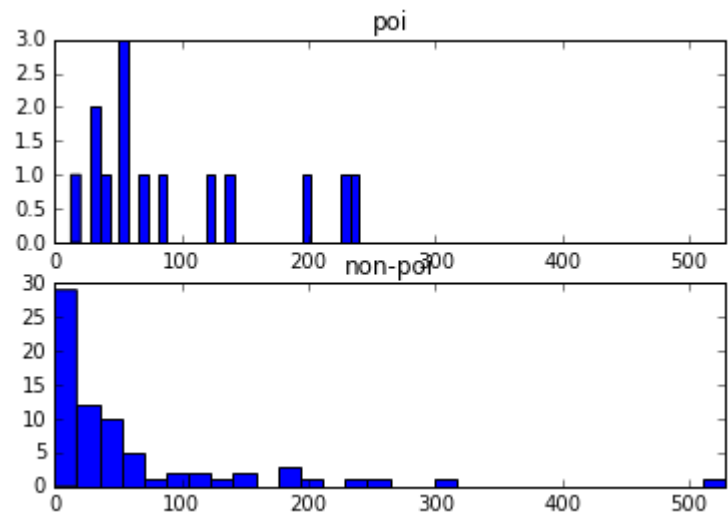


[-143.125 225.125]	14368.000	KAMINSKI WINCENTY J
	6759.000	KEAN STEVEN J
	4343.000	BECK SALLY W
	3069.000	POI DELAINEY DAVID W
	2742.000	MCCONNELL MICHAEL S
	2681.000	SHANKMAN JEFFREY A
	2585.000	LAVORATO JOHN J
	2195.000	ALLEN PHILLIP K
	1941.000	HAEDICKE MARK E
	1728.000	KITCHEN LOUISE
	1215.000	SHAPIRO RICHARD S
	1073.000	HORTON STANLEY C
	1061.000	HAYSLETT RODERICK J
	1053.000	BUY RICHARD B
	909.000	DERRICK JR. JAMES V
	556.000	WHALLEY LAWRENCE G
	484.000	POI BELDEN TIMOTHY N
	230.000	MARTIN AMANDA K

In [52]:

```
explore('from_poi_to_this_person')
```

missing values 58 of 144 (40.3%)
min 0.0 max 528.0
25% 10.0 50% 35.0 75% 72.25
mean 64.8953488372 std 86.4720722586

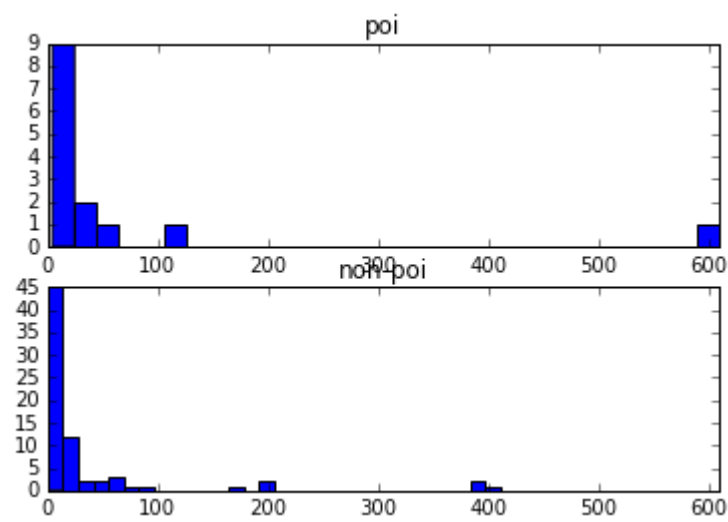


[-58.375 128.375]	528.000	LAVORATO JOHN J
[-58.375 128.375]	305.000	DIETRICH JANET R
[-58.375 128.375]	251.000	KITCHEN LOUISE
[-58.375 128.375]	242.000	FREVERT MARK A
[-58.375 128.375]	240.000	POI COLWELL WESLEY
[-58.375 128.375]	228.000	POI BELDEN TIMOTHY N
[-58.375 128.375]	204.000	REDMOND BRIAN L
[-58.375 128.375]	199.000	POI CALGER CHRISTOPHER F
[-58.375 128.375]	188.000	DONAHUE JR JEFFREY M
[-58.375 128.375]	186.000	WHALLEY LAWRENCE G
[-58.375 128.375]	180.000	HAEDICKE MARK E
[-58.375 128.375]	156.000	BUY RICHARD B
[-58.375 128.375]	144.000	BECK SALLY W
[-58.375 128.375]	140.000	POI BOWEN JR RAYMOND M
[-58.375 128.375]	140.000	POI BOWEN JR RAYMOND M
[-58.375 128.375]	140.000	KEAN STEVEN J
[-58.375 128.375]	140.000	KEAN STEVEN J

In [53]:

```
explore('from_this_person_to_poi')
```

missing values 58 of 144 (40.3%)
min 0.0 max 609.0
25% 1.0 50% 8.0 75% 24.75
mean 41.2325581395 std 99.4895897813

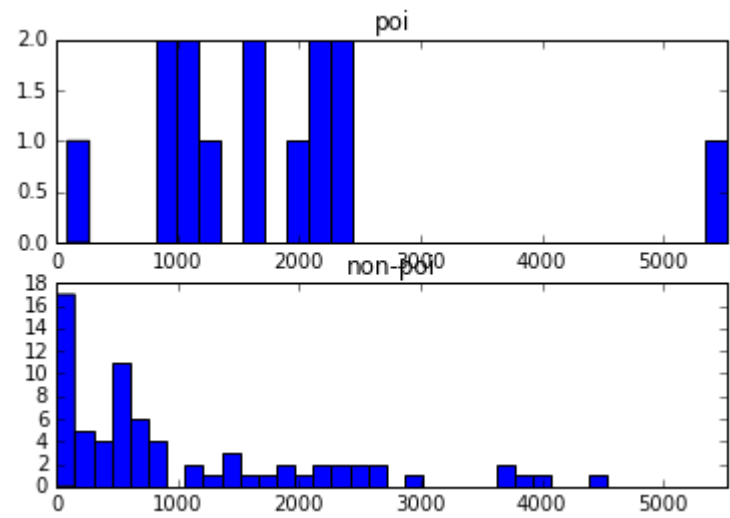


[-27.625 43.625]	609.000	POI	DELAINEY DAVID W
[-27.625 43.625]	411.000		LAVORATO JOHN J
[-27.625 43.625]	387.000		KEAN STEVEN J
[-27.625 43.625]	386.000		BECK SALLY W
[-27.625 43.625]	194.000		MCCONNELL MICHAEL S
[-27.625 43.625]	194.000		MCCONNELL MICHAEL S
[-27.625 43.625]	194.000		KITCHEN LOUISE
[-27.625 43.625]	194.000		KITCHEN LOUISE
[-27.625 43.625]	171.000		KAMINSKI WINCENTY J
[-27.625 43.625]	108.000	POI	BELDEN TIMOTHY N
[-27.625 43.625]	83.000		SHANKMAN JEFFREY A
[-27.625 43.625]	71.000		BUY RICHARD B
[-27.625 43.625]	65.000		SHAPIRO RICHARD S
[-27.625 43.625]	65.000		SHAPIRO RICHARD S
[-27.625 43.625]	65.000		ALLEN PHILLIP K
[-27.625 43.625]	65.000		ALLEN PHILLIP K
[-27.625 43.625]	61.000		HAEDICKE MARK E
[-27.625 43.625]	49.000		REDMOND BRIAN L
[-27.625 43.625]	48.000	POI	RIEKER PAULA H
[-27.625 43.625]	48.000	POI	RIEKER PAULA H
[-27.625 43.625]	48.000		PIPER GREGORY F
[-27.625 43.625]	48.000		PIPER GREGORY F

In [54]:

```
explore('shared_receipt_with_poi')
```

missing values 58 of 144 (40.3%)
min 2.0 max 5521.0
25% 249.75 50% 740.5 75% 1888.25
mean 1176.46511628 std 1171.44692579

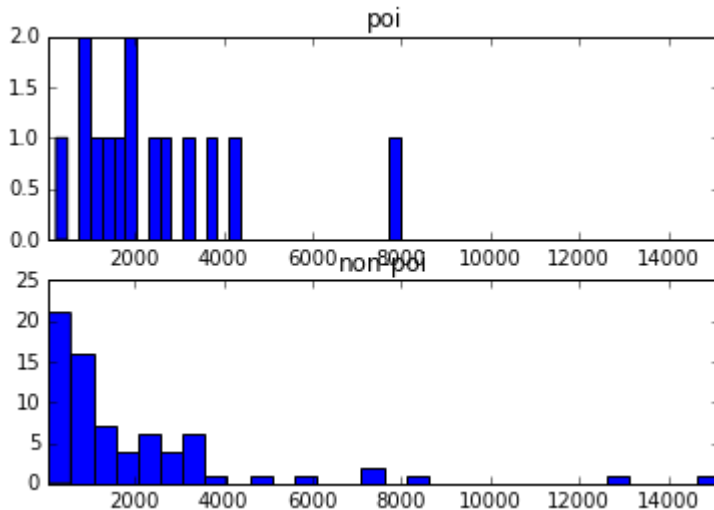


[-1717.25 3198.25]	5521.000	POI	BELDEN TIMOTHY N
[-1717.25 3198.25]	4527.000		SHAPIRO RICHARD S
[-1717.25 3198.25]	3962.000		LAVORATO JOHN J
[-1717.25 3198.25]	3920.000		WHALLEY LAWRENCE G
[-1717.25 3198.25]	3669.000		KITCHEN LOUISE
[-1717.25 3198.25]	3639.000		KEAN STEVEN J

In [55]:

```
explore('to_messages')
```

```
missing values 58 of 144 (40.3%)
min 57.0 max 15149.0
25% 541.25 50% 1211.0 75% 2634.75
mean 2073.86046512 std 2567.64137159
```



[-1929.25 4351.25]	15149.000	SHAPIRO RICHARD S
[-1929.25 4351.25]	12754.000	KEAN STEVEN J
[-1929.25 4351.25]	8305.000	KITCHEN LOUISE
[-1929.25 4351.25]	7991.000	POI BELDEN TIMOTHY N
[-1929.25 4351.25]	7315.000	BECK SALLY W
[-1929.25 4351.25]	7259.000	LAVORATO JOHN J
[-1929.25 4351.25]	6019.000	WHALLEY LAWRENCE G
[-1929.25 4351.25]	4607.000	KAMINSKI WINCENTY J

Create new email features

I am highly sceptical of the poi-related email features. Because if we have a fresh data set, we do not know any poi and thus cannot assign reasonable values to these features. But if we envisage an incremental approach, i. e. we do already know some poi and try to find some more, then we can use such features. Here, I create new features based on the poi-related features.

In [56]:

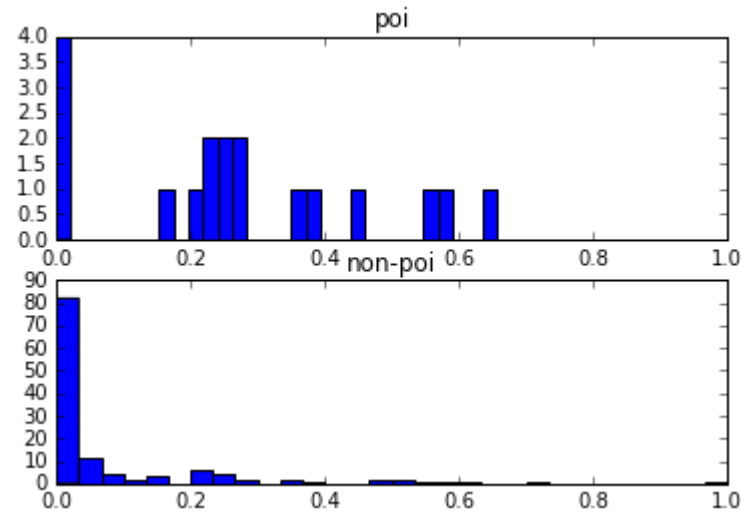
```
def fraction(subset, all):
    fraction = 0.0
    if all != 'NaN' and subset != 'NaN':
        fraction = float(subset) / float(all)
    return fraction

for data in data_dict.values():
    data['fraction_to_poi'] = fraction(data['from_this_person_to_poi'], data['from_messages'])
    data['fraction_from_poi'] = fraction(data['from_poi_to_this_person'], data['to_messages'])
```

In [57]:

```
explore('fraction_to_poi')
```

missing values 0 of 144 (0.0%)
min 0.0 max 1.0
25% 0.0 50% 0.0 75% 0.198826979472
mean 0.10992202398 std 0.185288112201



[-0.298240469208 0.298240469208]	1.000	HUMPHREY GENE E
[-0.298240469208 0.298240469208]	0.720	SHERRICK JEFFREY B
[-0.298240469208 0.298240469208]	0.656	POI HANNON KEVIN P
[-0.298240469208 0.298240469208]	0.614	GARLAND C KEVIN
[-0.298240469208 0.298240469208]	0.585	POI RIEKER PAULA H
[-0.298240469208 0.298240469208]	0.579	TILNEY ELIZABETH A
[-0.298240469208 0.298240469208]	0.556	POI BOWEN JR RAYMOND M
[-0.298240469208 0.298240469208]	0.542	MCMAHON JEFFREY
[-0.298240469208 0.298240469208]	0.500	FITZGERALD JAY L
[-0.298240469208 0.298240469208]	0.500	FITZGERALD JAY L
[-0.298240469208 0.298240469208]	0.500	DONAHUE JR JEFFREY M
[-0.298240469208 0.298240469208]	0.500	DONAHUE JR JEFFREY M
[-0.298240469208 0.298240469208]	0.493	FALLON JAMES B
[-0.298240469208 0.298240469208]	0.467	CARTER REBECCA C
[-0.298240469208 0.298240469208]	0.444	POI LAY KENNETH L
[-0.298240469208 0.298240469208]	0.375	POI GLISAN JR BEN F
[-0.298240469208 0.298240469208]	0.368	HAUG DAVID L
[-0.298240469208 0.298240469208]	0.359	POI SHELBY REX
[-0.298240469208 0.298240469208]	0.342	SUNDE MARTIN
[-0.298240469208 0.298240469208]	0.339	JACKSON CHARLENE R