罰則付き回帰: LASSO

機械学習

川田恵介 (keisukekawata@iss.u-tokyo.ac.jp)

Table of contents

1 データ主導の単純化

- 「事例数に応じて、モデルを適度に複雑化する」を人力で行うことは難しい

    - 特に X が多いケースでは、事実上困難

- データとパソコンに任せよう!!!

1.1 単純 VS 複雑なモデル

- 線型モデル:

$$f(X) = \beta_0 + \underbrace{\beta_1 X_1 + .. + \beta_L X_L}_{複雑性の要因}$$

    - X の数が増えると複雑し、限られた事例数のもとではデータに適合しすぎる

        * 極端な事例の影響を強く受けすぎる

- 単純すぎるモデル:

$$f(X) = \underbrace{\beta_0}_{データ全体の平均}$$

    - $\beta_1 = .. = \beta_L = 0$ と"強制"している

1.2 アイディア

- 過剰適合を抑制しながら、複雑なモデルを推定できないか?

    - 過度の複雑性を抑制する仕組みを導入する

1.3 LASSO

- 以下を最も小さくするように推定する

$$(Y - f(X))^2 の平均値$$

$$+ \underbrace{\lambda}_{Hyperparameter} \times (\beta_1 の絶対値 + .. + \beta_L の絶対値)$$

- OLS: 以下を最も小さくするように β を推定する

$$(Y - f(X))^2 の平均値$$

1.4 経済学的解釈: 複雑さへの" 課税"

- 複雑性への課税: $\beta_1, .., \beta_L$ の" せいで"、複雑性が発生している

    - 単純すぎるモデル: 複雑性を禁止している

        * 例: 水銀排出の禁止

    - LASSO: 複雑性への課税/簡潔性への" 補助金"

        * 例: 炭素税

1.5 Hyper parameter の影響

- $\lambda = 0$ であれば、OLS と同じモデルを推定

- $\lambda \to \infty$ であれば、$\beta_1 = .. = \beta_L = 0$ となり単純平均と同じモデルを推定

- $0 < \lambda < \infty$ であれば、その中間的なモデルとなる

    - データへの適合にあまり貢献しない変数については、β は厳密に 0 になる

        * モデルから実質的に除外されている

1.6 例

- OLS で推定:
$$Price = 0.1 + 2 \times Size + 0.1 \times Distance$$

- LASSO で推定:
$$Price = 0.5 + 1.5 \times Size + "0" \times Distance$$
$$= 0.5 + 1.5 \times Size$$

1.7 数値例: 課税の影響
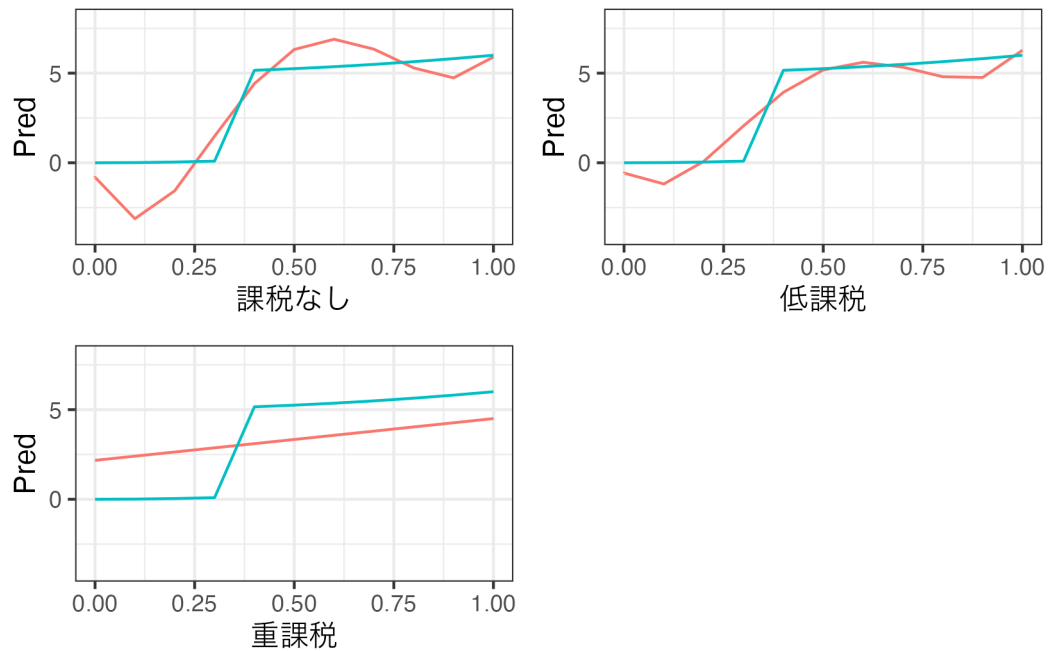
1.8 課税額の設定

- いろいろな方法が提案されている

    – 全て推定されるモデルの予測性能を改善することを念頭に設計されている

    – 本講義では、hdm package で実装されている理論的指標を用いる

        * 母平均に近いモデルが推定されやすいように設定

1.9 数値例
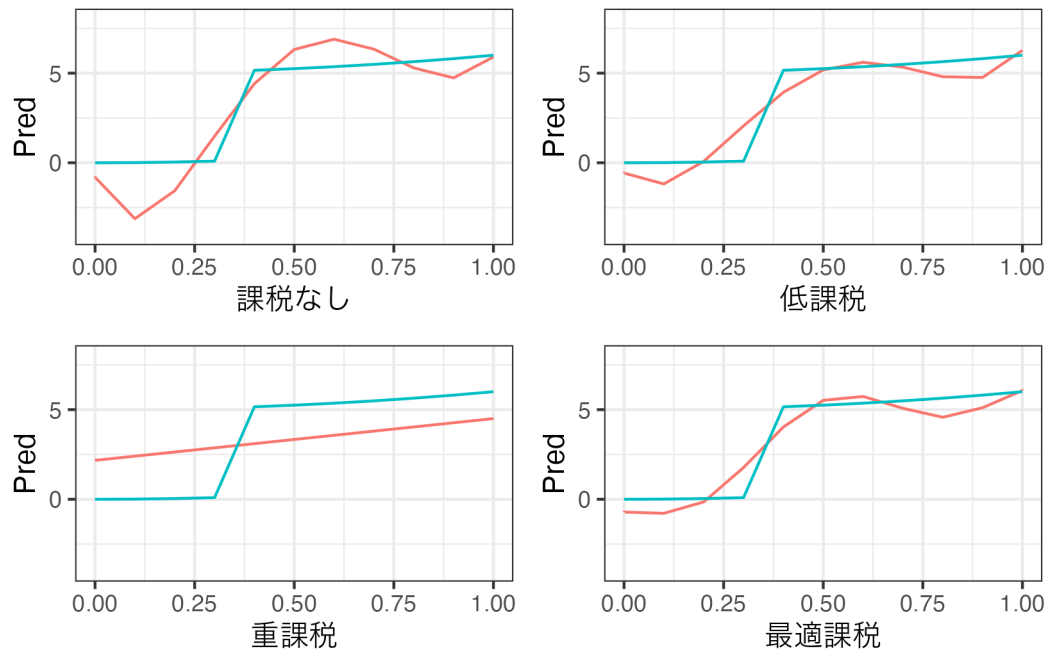
1.10 事例数

- 復習: 事例数が増えれば、複雑なモデルを OLS 推定することが有効になる

    - LASSO においても、課税額を減らし、複雑なモデルを生み出す必要がある

        * 多くの実装で、事例数に応じて Hyper parameter が低下するようになっている

1.11 数値例: 事例数
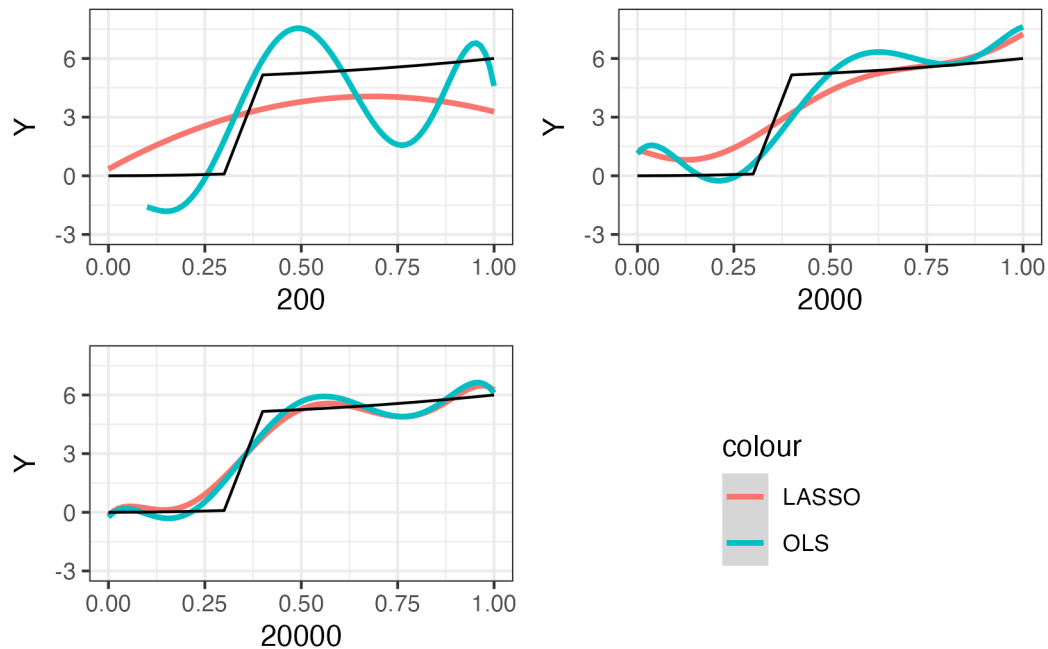
1.12 まとめ: OLS VS LASSO

- OLS: 母平均のシンプルなモデル (β の数が少ない) の推定に向いている

    - 複雑なモデル (β の数が多い) を推定しようとすると、深刻な過剰適合が発生

- LASSO: 母平均の複雑なモデル も推定できる

    - 過剰適合を緩和

- 必ずしも LASSO が OLS よりも優れたモデルを生み出せるとは限らない

    - テストデータによる評価が必要

1.13 付論

- 予測においては、X を標準化 (scale(X)) することが望ましい

$$scale(X) = \frac{X - X\text{の平均}}{X\text{の分散}}$$

2 実例

2.1 準備

```r
set.seed(111) # シード値固定
library(tidyverse)



Data = read_csv("Public/Example.csv") |>
  filter(
    TradeY == 2023
  )# データ取り込み



N = nrow(Data) # 事例数の計算


NumT = round(0.5*N) # 訓練データの数


Group = sample(
  1:N,
  NumT
  ) # 訓練/テストへの分割


Train = Data[Group,] # 訓練
Test = Data[-Group,] # テスト
```

2.2 モデルの推定: OLS 推定

```r
lm(Price ~ scale(Size) + scale(Tenure) + District,
   Train)



Call:
lm(formula = Price ~ scale(Size) + scale(Tenure) + District,
    data = Train)


Coefficients:
      (Intercept)        scale(Size)       scale(Tenure)  District 世田谷区
```

75.970	19.419	-9.626	-15.484
District 中野区	District 北区	District 台東区	District 品川区
-18.398	-30.157	-19.909	-7.277
District 大田区	District 杉並区	District 板橋区	District 江戸川区
-27.770	-21.509	-35.901	-45.079
District 江東区	District 目黒区	District 練馬区	District 荒川区
-25.123	-1.599	-34.424	-30.749
District 葛飾区	District 豊島区	District 足立区	District 墨田区
-46.603	-15.239	-48.232	-27.712

2.3 モデルの推定: LASSO 推定

```
hdm::rlasso(Price ~ scale(Size) + scale(Tenure) + District,
            Train,
            post = FALSE) # LASSO を使用
```

```
Call:
rlasso.formula(formula = Price ~ scale(Size) + scale(Tenure) +
    District, data = Train, post = FALSE)
```

```
Coefficients:
```

(Intercept)	scale(Size)	scale(Tenure)	District 世田谷区
70.5007	17.8477	-9.3672	-7.1268
District 中野区	District 北区	District 台東区	District 品川区
-8.4679	-21.5150	-12.4526	0.0000
District 大田区	District 杉並区	District 板橋区	District 江戸川区
-19.5506	-13.9290	-27.9950	-36.1083
District 江東区	District 目黒区	District 練馬区	District 荒川区
-17.2041	0.4192	-25.9626	-21.7934
District 葛飾区	District 豊島区	District 足立区	District 墨田区
-37.3930	-7.4964	-39.5459	-19.9153

2.4 予測: OLS を使用

```
OLS = lm(Price ~ scale(Size) + scale(Tenure) + District,
         Train)
predict(OLS, Test)
```

	1	2	3	4	5	6
	78.8826183	56.0567042	88.2603106	88.2603106	104.6455034	72.5062857
	7	8	9	10	11	12
	80.3511038	71.5401907	21.1479790	41.5393126	90.1281118	79.4493975
	13	14	15	16	17	18
	45.9447691	57.3577262	111.4855404	88.6596263	27.5887003	78.9470070
	19	20	21	22	23	24
	20.4137362	88.2603106	41.7067761	47.9800339	36.7989290	94.5335684
	25	26	27	28	29	30
	66.0011757	79.4493975	78.8826183	73.9103825	94.5335684	65.0994695
	31	32	33	34	35	36
	81.8195893	99.6732676	83.1206113	62.3299620	103.1770179	75.3788680
	37	38	39	40	41	42
	64.5326902	120.2964535	103.1770179	86.0575823	96.0020539	103.9112607
	43	44	45	46	47	48
	86.0575823	110.1845184	86.0575823	67.4696612	86.0575823	103.1770179
	49	50	51	52	53	54
	103.9112607	93.0650828	107.4150109	84.9884125	103.9112607	76.6798900
	55	56	57	58	59	60
	83.8548541	109.2828121	48.9461288	103.7437971	103.7437971	103.9112607
	61	62	63	64	65	66
	110.9187612	61.5957192	38.7698051	43.9738931	88.2603106	75.0439410
	67	68	69	70	71	72
	24.6517292	64.7001537	21.8822217	80.7504195	68.6032197	43.7420409
	73	74	75	76	77	78
	43.7420409	49.6159829	51.4837841	64.7001537	93.9667891	98.9390249
	79	80	81	82	83	84
	37.3013196	75.9456473	95.8345903	73.0086762	74.6446253	92.4983036
	85	86	87	88	89	90
	68.9381468	110.3519819	61.5957192	36.5670768	44.7081358	106.5133046
	91	92	93	94	95	96
	21.8822217	58.6587482	101.5410689	104.6455034	92.8976193	96.7362966
	97	98	99	100	101	102
	55.1549979	91.4291338	64.7001537	81.6521258	77.0792057	114.5899749
	103	104	105	106	107	108
	68.9381468	86.4568980	98.0373186	43.8064296	70.8059480	94.5335684
	109	110	111	112	113	114
	101.5410689	102.8420909	66.0011757	38.0355624	107.4150109	88.8270898
	115	116	117	118	119	120
	57.1902627	71.1408750	77.4141328	112.3872467	103.9112607	78.7151548

121	122	123	124	125	126
88.0928471	50.7495414	90.1281118	62.3299620	55.8892407	40.8050699

127	128	129	130	131	132
76.5124265	118.0937252	82.2189050	37.5331718	65.0994695	65.4343965

133	134	135	136	137	138
95.8345903	75.7781838	65.6662487	23.9174865	63.6309839	37.5331718

139	140	141	142	143	144
82.3863685	83.6873905	83.6873905	83.6873905	119.5622107	92.3308401

145	146	147	148	149	150
53.8539759	20.4137362	56.8553356	25.3859720	36.5670768	90.3599640

151	152	153	154	155	156
82.4507572	60.1272337	82.9531478	77.4785215	52.5529539	93.8637143

157	158	159	160	161	162
77.0792057	48.9461288	50.0152986	59.6248431	72.4418970	56.4560199

163	164	165	166	167	168
68.0364405	96.5688331	88.8270898	19.6794935	107.2475474	115.1567542

169	170	171	172	173	174
112.9540259	101.5410689	78.7151548	100.8068261	102.2753116	84.4216333

175	176	177	178	179	180
107.2475474	101.5410689	84.4216333	67.3021977	107.2475474	90.8623546

181	182	183	184	185	186
34.0294215	91.5965973	73.7429190	73.7429190	56.7909470	43.7420409

187	188	189	190	191	192
47.4776433	57.1902627	70.2391687	90.6948911	119.5622107	68.2682927

193	194	195	196	197	198
87.4229930	46.7434006	36.7989290	104.4780399	115.3242177	36.0646863

199	200	201	202	203	204
49.5129081	65.4343965	36.0646863	93.0650828	114.5899749	37.3013196

205	206	207	208	209	210
28.8897223	58.8906004	45.0430629	38.2674146	69.3374625	98.2047821

211	212	213	214	215	216
107.2475474	73.7429190	108.7160329	91.7640608	78.2127642	97.4705394

217	218	219	220	221	222
56.8553356	18.2110080	85.3233396	103.1770179	114.5899749	86.0575823

223	224	225	226	227	228
108.7160329	20.4137362	103.0095544	68.6032197	51.1488571	73.0086762

229	230	231	232	233	234
68.6032197	89.3938691	79.6168610	37.3013196	89.5613326	80.1836403

235	236	237	238	239	240
63.7984475	55.1549979	63.2316682	100.8068261	30.3582078	95.8345903

241	242	243	244	245	246
55.1549979	72.2744335	75.7781838	20.4137362	58.0919689	58.0919689

247	248	249	250	251	252
101.5410689	84.4216333	96.5688331	52.9522697	58.0919689	36.0646863

253	254	255	256	257	258
46.9108641	93.2325464	58.9936752	91.7640608	30.6931348	57.5251897

259	260	261	262	263	264
55.3224614	73.1761398	88.2603106	39.0016573	70.9734115	22.6164645

265	266	267	268	269	270
53.9183646	86.0575823	61.0289400	51.0844684	48.9461288	29.0571858

271	272	273	274	275	276
110.0170549	50.1827622	56.4560199	121.0306962	73.9747712	97.4705394

277	278	279	280	281	282
56.0567042	66.0655644	53.6865124	89.9606483	89.9606483	94.7654206

283	284	285	286	287	288
55.1549979	54.6526074	77.6459850	94.7654206	83.6873905	51.4837841

289	290	291	292	293	294
71.3727272	104.6455034	50.9170049	40.9725334	62.5618142	55.1549979

295	296	297	298	299	300
46.8464754	100.8068261	48.7142766	80.3511038	86.0575823	105.3797462

301	302	303	304	305	306
69.5693147	52.4498791	70.2391687	54.5882187	94.5335684	53.2871967

307	308	309	310	311	312
33.1277153	94.3661048	89.3938691	38.0355624	53.1841219	45.7773056

313	314	315	316	317	318
64.7645424	73.0086762	55.3868501	43.0077981	32.5609360	102.4427751

319	320	321	322	323	324
101.7085324	78.7151548	104.3105764	98.2047821	31.2599140	59.7923067

325	326	327	328	329	330
80.9178830	56.4560199	101.7085324	98.9390249	79.4493975	48.3149609

331	332	333	334	335	336
82.3863685	44.7081358	84.4216333	72.1069700	68.2039040	76.7442787

337	338	339	340	341	342
89.5613326	96.0020539	105.3797462	53.8539759	72.4418970	66.7354185

343	344	345	346	347	348
34.0294215	18.9452507	24.8191928	89.3938691	51.1488571	58.8262117

349	350	351	352	353	354
53.1197332	63.2960569	38.7698051	93.6318621	64.1977632	39.7359001

355	356	357	358	359	360
80.0161768	75.3788680	81.0853466	83.1206113	103.1770179	87.5260678

361	362	363	364	365	366
52.3854904	60.2946972	78.5476913	96.0020539	96.0020539	39.3365843
367	368	369	370	371	372
71.3727272	88.2603106	96.7362966	65.8337122	55.1350491	25.3016345
373	374	375	376	377	378
30.2738703	46.0922838	63.7784986	14.8547724	45.7573568	47.5607693
379	380	381	382	383	384
71.1209262	26.0358772	61.1764547	33.3783048	77.3941840	84.0023687
385	386	387	388	389	390
25.3660232	52.5330051	46.8265266	1.9733298	33.3783048	44.7912618
391	392	393	394	395	396
62.6449402	72.5894117	61.9106974	50.4977404	57.5052409	50.8970561
397	398	399	400	401	402
80.1636915	29.7714797	70.2192199	19.9944717	54.2333428	60.1072849
403	404	405	406	407	408
48.6943278	26.7701200	63.9459622	70.2192199	84.0023687	43.1553128
409	410	411	412	413	414
45.3580411	31.9098193	38.9173198	64.6802049	32.6440620	21.7978842
415	416	417	418	419	420
73.8904337	23.0989062	36.2122010	47.6251580	79.4294487	71.5202419
421	422	423	424	425	426
79.4294487	68.0164917	26.7701200	79.0301330	25.5334867	67.2822489
427	428	429	430	431	432
92.4783548	81.0653977	38.0156135	75.3589192	48.6943278	67.5561626
433	434	435	436	437	438
64.0524124	16.2622446	32.6474374	72.3609349	53.2062345	47.4997560
439	440	441	442	443	444
75.4653694	67.5561626	3.3808020	70.3256701	29.0792985	22.1361866
445	446	447	448	449	450
51.0035063	34.1159229	9.2547441	85.9766202	36.4861147	61.6822206
451	452	453	454	455	456
59.0801766	48.2339988	49.7024843	59.8144193	42.9268360	30.3803204
457	458	459	460	461	462
18.4005842	30.3803204	50.2692635	52.8713075	83.3745762	41.0590347
463	464	465	466	467	468
71.2273764	72.5283984	47.8990717	63.3181696	46.0312705	33.5491437
469	470	471	472	473	474
22.7029659	39.8224014	55.2414993	50.1018000	10.7232296	40.4922555
475	476	477	478	479	480
68.1229418	23.2053564	40.4922555	39.0881587	62.9699544	65.7394619

481	482	483	484	485	486
40.1440403	80.0893900	74.3829115	52.8580194	74.3829115	67.2079474
487	488	489	490	491	492
40.1440403	57.2634759	54.4939684	71.6134040	56.5292332	61.5014689
493	494	495	496	497	498
68.6764330	74.3829115	60.5997626	90.0338615	52.6905559	60.5997626
499	500	501	502	503	504
35.9704360	25.9615758	53.5922621	47.1515409	33.2009285	80.2568535
505	506	507	508	509	510
80.2568535	73.0818895	48.1176358	33.2009285	90.2013251	24.3900154
511	512	513	514	515	516
55.4600634	55.2925998	86.3626478	16.5838835	67.0404839	67.0404839
517	518	519	520	521	522
28.7954720	43.1454000	82.2921183	76.4181762	61.3340054	1.8990284
523	524	525	526	527	528
77.1524190	56.5292332	59.2987407	81.3904120	47.7183201	77.7191982
529	530	531	532	533	534
73.6486687	63.5367337	40.2084290	78.6209045	16.6482722	50.8227546
535	536	537	538	539	540
63.5367337	78.6209045	36.7046788	73.0818895	84.3273830	46.6491503
541	542	543	544	545	546
70.7116977	58.9638136	9.4733081	47.5508566	70.1449185	35.9704360
547	548	549	550	551	552
35.9704360	58.7319614	59.8655199	60.5997626	53.0898716	79.3551472
553	554	555	556	557	558
78.6209045	62.0682482	84.4948465	77.8866617	83.0263610	77.3198825
559	560	561	562	563	564
54.4939684	56.5292332	84.4948465	85.0616258	84.3273830	67.9421902
565	566	567	568	569	570
61.5014689	42.3467686	83.0263610	77.8866617	72.7469624	84.4948465
571	572	573	574	575	576
78.7883680	72.9144260	65.0052192	65.1726827	61.6689324	30.0964940
577	578	579	580	581	582
30.0964940	30.0964940	74.3829115	70.1449185	42.4111573	86.3626478
583	584	585	586	587	588
80.6561692	63.5367337	86.3626478	72.1801832	72.9144260	70.1449185
589	590	591	592	593	594
75.8513970	87.2643540	61.5014689	77.1524190	66.7055569	78.6209045
595	596	597	598	599	600
70.7116977	51.5569974	65.7394619	47.8857836	70.7116977	74.9496907

601	602	603	604	605	606
56.3617696	25.1242582	30.0964940	80.2568535	-9.8488557	73.0818895

607	608	609	610	611	612
62.8024909	74.7822272	62.2357117	45.3481283	46.0823711	46.8166138

613	614	615	616	617	618
58.2295709	68.5089694	67.7747267	72.0127197	45.9149075	75.1171542

619	620	621	622	623	624
73.4812052	74.2154480	55.4600634	41.6769145	65.5719984	57.2634759

625	626	627	628	629	630
88.7328395	51.9563131	62.0682482	69.4106757	70.1449185	35.2361932

631	632	633	634	635	636
76.4102418	24.5495445	75.2766833	78.4455066	52.4507692	63.1938722

637	638	639	640	641	642
43.1374656	51.2141359	35.2282588	35.2282588	103.0748332	67.9342558

643	644	645	646	647	648
68.8359621	59.1233427	101.6063477	90.1933906	31.1577293	95.8998692

649	650	651	652	653	654
95.8998692	97.3683547	91.6618762	79.5146764	98.1025974	12.4023447

655	656	657	658	659	660
70.1369841	107.3128262	78.7804336	97.7676704	65.9633797	29.5217803

661	662	663	664	665	666
83.7526694	89.4591479	62.3952408	84.4869121	29.5217803	61.6609980

667	668	669	670	671	672
55.2202767	16.8078013	76.4102418	31.4926564	67.0325495	26.7522728

673	674	675	676	677	678
71.6054696	48.1097014	52.8500850	77.7112638	19.5773088	87.8231989

679	680	681	682	683	684
72.3397123	103.6416124	8.7311310	73.4732708	50.3124297	57.9897842

685	686	687	688	689	690
41.2696644	77.3119481	13.1365875	59.5226584	102.9073697	97.2008912

691	692	693	694	695	696
98.6693767	93.6971409	93.6971409	71.2705425	94.4313837	77.3119481

697	698	699	700	701	702
56.7531509	60.9911440	96.4666484	90.7601699	84.8862278	70.5362998

703	704	705	706	707	708
84.8862278	106.5785835	56.5212987	103.8090760	79.3472128	99.9703987

709	710	711	712	713	714
56.0189082	92.7954346	55.8514447	59.3551949	92.7954346	78.6129701

715	716	717	718	719	720
91.3269491	88.5574416	90.9276334	79.9139921	92.3961189	60.1925125

721	722	723	724	725	726
68.5010350	59.4582698	71.4380060	78.1105795	85.7879341	74.2075135
727	728	729	730	731	732
72.9064916	48.1097014	44.6059511	102.9073697	80.0814556	9.4653737
733	734	735	736	737	738
64.8298212	19.4098453	93.6971409	72.0047853	21.9475006	52.3476944
739	740	741	742	743	744
73.4453079	89.0962580	38.1372670	42.8776506	64.8018584	93.6691781
745	746	747	748	749	750
87.7952360	66.6696596	95.5369793	94.2359573	47.9142750	60.8987924
751	752	753	754	755	756
98.0746346	41.9759443	99.3756566	105.6489143	99.3756566	63.8357634
757	758	759	760	761	762
37.4030243	83.3897795	66.2703439	97.7397076	17.3466177	52.3197316
763	764	765	766	767	768
69.5422420	104.3478923	46.0464738	100.8441421	57.2275786	69.9415577
769	770	771	772	773	774
94.2359573	69.9415577	62.3672779	84.4589493	99.3756566	74.4114029
775	776	777	778	779	780
59.6621591	51.6885636	94.4034208	51.6885636	106.2156936	101.5783848
781	782	783	784	785	786
88.6969423	43.2769663	52.9895856	58.3611371	37.4030243	56.8186758
787	788	789	790	791	792
24.0482902	31.2232542	35.6930994	39.1968497	30.8883272	61.6234481
793	794	795	796	797	798
65.8614411	47.8402992	92.5260325	63.9936399	48.2396150	49.3087848
799	800	801	802	803	804
62.3576908	57.9522343	36.0280265	71.0011404	76.1408397	65.2946619
805	806	807	808	809	810
64.7278826	57.3854551	13.9363551	44.3365490	72.3021624	13.2021124
811	812	813	814	815	816
78.7428836	24.0482902	16.1390834	5.8596848	11.7336269	14.6705979
817	818	819	820	821	822
24.0482902	22.4123412	56.6512123	65.8614411	52.9799985	21.9099506
823	824	825	826	827	828
71.1686039	51.6789765	63.0919336	54.4484840	71.1686039	76.1408397
829	830	831	832	833	834
16.8733262	16.8733262	71.1686039	25.4137009	15.4692293	32.3568127
835	836	837	838	839	840
52.2457558	66.7631474	58.8539406	70.2668976	31.9574970	51.5115130

841	842	843	844	845	846
81.6798547	36.8266579	63.2593971	5.3572943	13.2665011	43.7697698

847	848	849	850	851	852
66.0289046	61.6234481	63.6587128	61.7909116	75.4065969	57.9522343

853	854	855	856	857	858
5.3572943	55.7495060	64.7922713	25.3493122	44.3365490	77.6093252

859	860	861	862	863	864
77.2743981	99.1062450	92.4980602	43.5099453	81.9868094	43.0075547

865	866	867	868	869	870
44.6435038	18.7131551	56.6232400	87.5258244	67.6368814	94.7007885

871	872	873	874	875	876
48.3147175	33.7973259	69.1697556	46.3438415	52.3852470	40.9722900

877	878	879	880	881	882
70.4063889	60.8612331	78.1481321	68.2036606	79.6166177	82.7210522

883	884	885	886	887	888
50.9167615	70.0714618	73.7426756	52.9520263	78.3155957	61.1961601

889	890	891	892	893	894
36.0000542	74.7087706	89.1617735	104.0784808	68.3711241	90.2953319

895	896	897	898	899	900
79.0498384	78.8823749	89.8960162	84.1895377	80.1833969	76.5121831

901	902	903	904	905	906
38.4346347	80.5183239	76.1128674	87.6932880	14.8744778	51.0842250

907	908	909	910	911	912
31.4271342	68.3711241	76.8471102	15.6087206	87.6932880	37.7003919

913	914	915	916	917	918
47.5804748	81.0851032	64.6999103	91.7638175	47.0780842	77.5813529

919	920	921	922	923	924
97.4702960	62.4971821	66.0009323	82.3861252	21.3151991	70.4707776

925	926	927	928	929	930
73.9101391	62.6646456	83.8546107	106.2812090	68.9379034	78.3155957

931	932	933	934	935	936
30.5254279	81.9868094	72.2741901	98.9387815	87.9251402	57.5249463

937	938	939	940	941	942
63.2314248	78.1481321	82.5535887	76.6796466	70.9731681	66.5677116

943	944	945	946	947	948
32.8956197	32.8956197	41.7065327	81.6518824	89.7285527	88.0926037

949	950	951	952	953	954
105.5469663	99.8404878	57.0225558	94.1340092	40.4698994	78.1481321

955	956	957	958	959	960
61.7629393	28.4901631	97.1356123	45.2749151	22.4490010	88.2603106

961	962	963	964	965	966
36.0646863	23.1832437	113.8557322	108.1492537	75.2757932	77.9809120

967	968	969	970	971	972
113.1214894	34.3643486	111.4855404	96.0020539	53.8539759	58.8906004

973	974	975	976	977	978
47.6451069	57.5251897	51.4837841	90.6948911	86.7918251	17.4767652

979	980	981	982	983	984
79.6168610	75.0439410	55.8892407	17.4767652	68.2039040	71.7720429

985	986	987	988	989	990
46.9108641	38.0999510	43.9738931	79.6812497	63.6309839	37.3013196

991	992	993	994	995	996
46.1766213	58.2594325	62.4974255	94.3661048	29.0571858	80.0161768

997	998	999	1000	1001	1002
89.3938691	65.3313217	44.7081358	87.1911408	82.3863685	90.3175955

1003	1004	1005	1006	1007	1008
101.8980160	90.4850590	43.9315245	9.1902628	52.7424376	40.4277743

1009	1010	1011	1012	1013	1014
34.7212957	63.0862248	39.6935315	6.4207553	86.9813087	14.1624986

1015	1016	1017	1018	1019	1020
47.0359591	57.5472098	52.5749741	70.4286524	25.1761399	58.1139891

1021	1022	1023	1024	1025	1026
63.2536884	57.5472098	86.9813087	98.3942658	59.4150111	62.3519821

1027	1028	1029	1030	1031	1032
44.0989880	75.9676674	52.2400470	69.1276304	23.5401909	62.3519821

1033	1034	1035	1036	1037	1038
47.2678113	44.6657673	67.6591449	48.9681490	14.7292778	43.2616704

1039	1040	1041	1042	1043	1044
31.0500820	34.8887592	48.9037603	79.0721019	79.0721019	30.9413742

1045	1046	1047	1048	1049	1050
31.6112283	77.4305200	41.7875521	38.2194131	36.0810735	70.6548717

1051	1052	1053	1054	1055	1056
−6.2344679	36.0810735	65.1158567	70.9897987	75.9620345	35.1149786

1057	1058	1059	1060	1061	1062
75.9620345	18.7297858	46.5923243	49.1299796	7.5486809	25.3379706

1063	1064	1065	1066	1067	1068
78.5640785	24.8355800	74.3260855	43.9258916	68.7870705	73.7593062

1069	1070	1071	1072	1073	1074
47.8289576	56.6398707	44.8919866	49.8642224	31.7786918	51.3327079

1075	1076	1077	1078	1079	1080
−0.5279894	12.5209167	77.4305200	22.2979247	17.4931524	83.1369985

1081	1082	1083	1084	1085	1086
50.8303173	49.5292953	80.0325640	30.1427428	73.4243792	17.8280795

1087	1088	1089	1090	1091	1092
83.7037778	64.2141504	68.6196070	48.7950526	57.3741134	70.6548717

1093	1094	1095	1096	1097	1098
80.2000275	23.5345580	39.5204351	25.0030435	61.6121064	73.5918427

1099	1100	1101	1102	1103	1104
28.1681816	56.8680378	25.9654534	92.0086152	56.4687221	62.4070528

1105	1106	1107	1108	1109	1110
57.6022805	69.9169439	34.4414394	62.9738320	43.8191317	78.3929299

1111	1112	1113	1114	1115	1116
66.4131936	37.8808010	99.3510427	19.1254164	86.4696002	69.0152376

1117	1118	1119	1120	1121	1122
102.1205502	67.8816791	80.5956581	23.3634094	82.6309229	79.1271726

1123	1124	1125	1126	1127	1128
23.5308729	82.6309229	53.3642875	50.5947800	33.4753444	65.5114873

1129	1130	1131	1132	1133	1134
61.4409578	5.7415833	30.8733005	18.6230258	69.1827011	72.6864514

1135	1136	1137	1138	1139	1140
65.8464144	29.4048149	76.9244444	59.8050088	41.7838670	74.1549369

1141	1142	1143	1144	1145	1146
68.6159219	93.6445642	23.0284824	37.8808010	58.1690598	45.6225442

1147	1148	1149	1150	1151	1152
96.4140717	6.6432895	30.9376891	62.0077371	37.8808010	18.7904893

1153	1154	1155	1156	1157	1158
102.1205502	80.0288789	62.5745163	8.6785543	77.6586871	44.5533745

1159	1160	1161	1162	1163	1164
73.7545318	63.6425968	67.8805898	60.5381622	41.9502412	77.2582821

1165	1166	1167	1168	1169	1170
71.5518036	50.5936907	49.1252052	16.0198925	47.0899404	63.8100603

1171	1172	1173	1174	1175	1176
46.5231612	52.7964190	61.2724050	36.5786897	54.0974410	16.6897466

1177	1178	1179	1180	1181	1182
55.7333900	67.3138106	85.1674889	66.5795678	20.1934969	22.3962251

1183	1184	1185	1186	1187	1188
70.0833181	32.7400124	53.3631982	53.6981252	42.6844839	65.8453250

1189	1190	1191	1192	1193	1194
63.4751333	36.5786897	34.7752771	65.6778615	16.7541353	43.6505789

1195	1196	1197	1198	1199	1200
35.9088356	21.4945188	37.3773211	18.2226208	45.7889184	75.2230173

1201	1202	1203	1204	1205	1206
20.9277396	33.1393281	63.8100603	68.4473690	35.5095199	48.3909624
1207	1208	1209	1210	1211	1212
49.4601322	66.7217584	59.9461101	66.7217584	50.9033448	60.2810371
1213	1214	1215	1216	1217	1218
48.1338373	8.4203399	54.8064108	4.9165896	8.4203399	-4.4611027
1219	1220	1221	1222	1223	1224
-3.8943235	42.9941380	77.2330092	21.8685616	-1.5241317	42.0924318
1225	1226	1227	1228	1229	1230
20.9024667	80.1699802	59.9461101	78.8689582	54.4070951	51.0708083
1231	1232	1233	1234	1235	1236
47.9663738	20.9024667	42.2598953	53.1060731	47.3995946	18.1329592
1237	1238	1239	1240	1241	1242
72.4282369	71.5265307	48.1338373	68.7570231	62.4837654	30.8990101
1243	1244	1245	1246	1247	1248
67.2762208	78.6891779	81.4586854	67.2762208	0.8981320	16.7165455
1249	1250	1251	1252	1253	1254
22.1911719	18.0175675	18.0175675	23.3247303	44.8496224	-2.0388391
1255	1256	1257	1258	1259	1260
-8.4795603	61.5697423	67.2762208	22.5904876	16.8840091	32.5349591
1261	1262	1263	1264	1265	1266
23.8915096	35.4719301	57.1642858	19.4860530	44.1153797	6.0378312
1267	1268	1269	1270	1271	1272
57.7310650	-2.6056183	19.4860530	8.0730960	1.6323747	50.1567852
1273	1274	1275	1276	1277	1278
51.4578072	64.3392498	40.6116294	27.3952598	39.5424596	73.5494786
1279	1280	1281	1282	1283	1284
-13.4517961	-0.9696693	58.4653078	75.5847433	69.8782648	68.0104636
1285	1286	1287	1288	1289	1290
39.7099232	42.2475785	54.3947783	62.8707643	13.6121110	74.4511849
1291	1292	1293	1294	1295	1296
67.2762208	8.6398752	53.6605355	66.5419781	66.5419781	62.7033008
1297	1298	1299	1300	1301	1302
59.9337933	13.2127953	72.2484566	65.8155619	48.5286628	72.6555989
1303	1304	1305	1306	1307	1308
54.2351414	70.2210185	16.4925200	77.7952982	5.8138057	39.1509705
1309	1310	1311	1312	1313	1314
40.6194561	27.2356229	63.6128337	45.9910075	-7.7374910	60.1090834
1315	1316	1317	1318	1319	1320
62.3118117	82.3682183	61.4101054	16.4925200	51.2981703	80.1654900

1321	1322	1323	1324	1325	1326
47.4594930	18.8627117	59.9416199	62.7111274	43.7238906	43.7238906
1327	1328	1329	1330	1331	1332
49.4303691	23.8993362	83.6692403	30.3400575	58.3056709	49.8296848
1333	1334	1335	1336	1337	1338
33.6763442	47.0601773	49.2629056	63.0460544	69.4867757	45.9910075
1339	1340	1341	1342	1343	1344
64.9138557	43.2215000	67.5158996	42.4872573	63.1104431	0.5066429
1345	1346	1347	1348	1349	1350
63.7802972	64.1796129	46.3259346	62.3118117	25.7027487	-5.5347627
1351	1352	1353	1354	1355	1356
54.9693841	68.0182902	52.7666559	63.0460544	60.1090834	60.6758626
1357	1358	1359	1360	1361	1362
-6.6683212	59.5423042	56.4378696	5.8138057	83.6692403	67.8508267
1363	1364	1365	1366	1367	1368
67.2840474	59.1825921	57.5466431	10.6581816	-7.9941282	54.9445991
1369	1370	1371	1372	1373	1374
42.7973993	50.7066061	49.8048998	59.7493713	31.0495152	27.7776171
1375	1376	1377	1378	1379	1380
43.3641785	14.3293953	14.3293953	22.4060656	50.7066061	49.9723633
1381	1382	1383	1384	1385	1386
54.7771356	50.7066061	50.7066061	-14.0355338	22.2386021	54.9445991
1387	1388	1389	1390	1391	1392
-21.2104978	33.8190227	47.6021715	35.4549717	-11.8328055	67.6585781
1393	1394	1395	1396	1397	1398
36.2536032	56.2456211	40.5946710	67.6585781	56.2456211	38.2244792
1399	1400	1401	1402	1403	1404
31.2169787	52.0076281	31.2169787	60.6510776	58.4483493	54.9445991
1405	1406	1407	1408	1409	1410
48.5038778	52.7418708	54.9445991	54.7771356	19.1341676	43.9309577
1411	1412	1413	1414	1415	1416
10.9931086	34.8881925	30.3152724	34.8881925	30.3152724	48.5038778
1417	1418	1419	1420	1421	1422
48.5038778	42.6299358	54.0428928	66.9243354	29.5810297	38.3919427
1423	1424	1425	1426	1427	1428
34.3145934	52.9025145	52.9025145	-6.6999260	56.2388013	50.1330070
1429	1430	1431	1432	1433	1434
-4.8321248	-0.4266683	41.8888732	43.3573587	34.8813727	52.7350510
1435	1436	1437	1438	1439	1440
1.0418172	38.5525864	39.2868292	47.0285725	0.8743537	38.3851229

```
        1441        1442        1443        1444        1445        1446
51.6014925  51.6014925  56.5737283  51.6014925  51.6014925  33.4128872
        1447        1448        1449        1450        1451        1452
49.9655435  -4.0978820  35.2162997  46.4617932  55.6720220  43.5248222
        1453        1454        1455        1456        1457        1458
44.2590650   5.4472738  24.7694376  45.8950140  35.2162997  64.3154716
        1459        1460        1461        1462        1463        1464
52.9025145  50.3648592 -13.4755743  53.6367573  31.3776224  37.0841009
        1465        1466        1467        1468        1469        1470
19.6297383  31.0426954  45.6155558  44.1470703  54.9932481  43.5802911
        1471        1472        1473        1474        1475        1476
33.1334290  18.7835009 -27.6025700 -27.6025700  58.0976827  36.9721063
        1477        1478        1479        1480        1481        1482
49.4542331  52.0562771  40.6433201  58.4969984  50.9227187  40.6433201
        1483        1484        1485        1486        1487        1488
 3.1325509  59.2312412  26.8601712  59.2312412  66.4062052  56.6291972
        1489        1490        1491        1492        1493        1494
50.7552551  20.9862292  38.0412761  16.5807727  34.6019145  40.3083930
        1495        1496        1497        1498        1499        1500
-2.5739276  53.1254469  53.1254469  58.0976827  20.2519865  58.0976827
        1501        1502        1503        1504        1505        1506
39.9090773  43.2453641  52.3912042  58.0976827  58.8319254  53.8596897
        1507        1508        1509        1510        1511        1512
16.0139934  30.6988485  51.6569614  38.4405918  52.2237406  38.6080553
        1513        1514        1515        1516        1517        1518
 9.5732722  57.3634399  51.6569614  41.3775628  48.7199904  71.5459045
        1519
53.1254469
```

2.5 予測: LASSO を使用

```
LASSO = hdm::rlasso(Price ~ scale(Size) + scale(Tenure) + District,
        Train,
        post = FALSE)


predict(LASSO, Test)
```

```
        [,1]
1    73.0733392
```

2	52.3013161
3	81.9664814
4	81.9664814
5	96.8054715
6	64.9714831
7	74.5533938
8	65.6730662
9	18.2344311
10	38.2279828
11	82.7321382
12	73.0861539
13	42.6681465
14	53.0541581
15	102.0241067
16	81.2520836
17	24.1674642
18	70.9045162
19	17.4944038
20	81.9664814
21	38.9551954
22	44.1610158
23	32.3333939
24	87.1723019
25	61.2072730
26	73.0861539
27	73.0733392
28	68.6203607
29	87.1723019
30	59.7400332
31	76.0334484
32	92.3524930
33	76.7862904
34	57.5071366
35	95.3254169
36	70.1004153
37	59.7272185
38	110.9044342
39	95.3254169
40	79.7463996
41	88.6523565

42	96.0654442
43	79.7463996
44	101.2712647
45	79.7463996
46	62.6873276
47	79.7463996
48	95.3254169
49	96.0654442
50	85.6922473
51	99.0383681
52	77.5519471
53	96.0654442
54	70.8532573
55	77.5263177
56	99.8040248
57	43.4594327
58	95.3382316
59	95.3382316
60	96.0654442
61	102.0112920
62	56.7671093
63	35.9950862
64	39.0064542
65	81.9664814
66	68.6459901
67	21.2073550
68	60.4544310
69	18.9744584
70	73.8389959
71	62.7129571
72	40.4480647
73	40.4480647
74	46.3682830
75	47.1339397
76	60.4544310
77	87.1594872
78	91.6124657
79	34.5150316
80	70.1132300
81	87.9251439

82	67.1531208
83	69.3603880
84	85.6794326
85	64.1673822
86	101.9984772
87	56.7671093
88	33.7750043
89	39.7464815
90	97.5711282
91	18.9744584
92	53.8070001
93	93.1181497
94	96.8054715
95	84.9650348
96	89.3923838
97	50.8340762
98	83.4849802
99	60.4544310
100	75.3062358
101	70.1388594
102	105.7114284
103	64.1673822
104	79.0320017
105	90.1452258
106	38.2792416
107	64.9330390
108	87.1723019
109	93.1181497
110	93.8709917
111	61.2072730
112	35.2550589
113	99.0383681
114	81.9792962
115	52.3269455
116	66.3874641
117	71.5932846
118	103.4913466
119	96.0654442
120	72.3461266
121	81.2392689

```
122    46.3939124
123    82.7321382
124    57.5071366
125    51.5741035
126    37.4879555
127    70.1260447
128   108.6843523
129    75.3190505
130    33.0734212
131    59.7400332
132    61.1944583
133    87.9251439
134    69.3860174
135    59.7528479
136    20.4673277
137    58.2599786
138    33.0734212
139    76.0462631
140    76.7991051
141    76.7991051
142    76.7991051
143   110.1644069
144    84.9522200
145    50.0812342
146    17.4944038
147    50.8725204
148    21.9473823
149    33.7750043
150    81.2905277
151    73.8774401
152    55.2870547
153    76.0590778
154    69.4244616
155    49.3283922
156    84.2634516
157    70.1388594
158    43.4594327
159    45.6538852
160    53.1054170
161    67.1403061
```

162	51.5869182
163	62.7001424
164	88.6651712
165	81.9792962
166	16.7543765
167	98.3111555
168	105.7242432
169	103.5041613
170	93.1181497
171	72.3461266
172	92.3781224
173	93.8581770
174	77.5391324
175	98.3111555
176	93.1181497
177	77.5391324
178	61.9601151
179	98.3111555
180	83.4721655
181	30.1004973
182	84.2121928
183	67.8931481
184	67.8931481
185	53.0413434
186	40.4480647
187	41.9793781
188	52.3269455
189	64.9202242
190	82.7449529
191	110.1644069
192	61.2585319
193	78.3304186
194	41.2393508
195	32.3333939
196	96.0782589
197	106.4514557
198	31.5933666
199	43.4722474
200	61.1944583
201	31.5933666

202	85.6922473
203	105.7114284
204	34.5150316
205	24.9203062
206	52.3653897
207	41.2009067
208	33.8134484
209	63.4529844
210	90.8724384
211	98.3111555
212	67.8931481
213	99.7912101
214	84.9394053
215	70.1644889
216	90.1324111
217	50.8725204
218	15.2743219
219	79.0063723
220	95.3254169
221	105.7114284
222	79.7463996
223	99.7912101
224	17.4944038
225	94.5982043
226	62.7129571
227	45.6795146
228	67.1531208
229	62.7129571
230	81.9921109
231	73.8133665
232	34.5150316
233	82.7193234
234	73.8261812
235	58.9871912
236	50.8340762
237	58.9743764
238	92.3781224
239	26.4003608
240	87.9251439
241	50.8340762

242	66.4130935
243	69.3860174
244	17.4944038
245	53.7941854
246	53.7941854
247	93.1181497
248	77.5391324
249	88.6651712
250	48.6139943
251	53.7941854
252	31.5933666
253	41.9665634
254	86.4194599
255	55.2614253
256	84.9394053
257	27.8547859
258	53.7813707
259	51.5612888
260	67.8803334
261	81.9664814
262	34.5534757
263	65.6602515
264	19.7144857
265	47.9124112
266	79.7463996
267	56.7542946
268	47.8483376
269	43.4594327
270	25.6475188
271	100.5440521
272	46.3810977
273	51.5869182
274	111.6444615
275	66.4515377
276	90.1324111
277	52.3013161
278	59.0384500
279	49.3540216
280	82.0049256
281	82.0049256

282	85.7306915
283	50.8340762
284	48.6524385
285	70.1516742
286	85.7306915
287	76.7991051
288	47.1339397
289	64.9458537
290	96.8054715
291	47.1211250
292	38.2151681
293	56.0655261
294	50.8340762
295	44.1353864
296	92.3781224
297	44.9010431
298	74.5533938
299	79.7463996
300	97.5454988
301	62.0113739
302	46.4323566
303	64.9202242
304	50.8212615
305	87.1723019
306	50.0684195
307	28.6332574
308	86.4450894
309	81.9921109
310	35.2550589
311	47.1723839
312	41.9409340
313	58.2856080
314	67.1531208
315	49.3924658
316	39.7080374
317	28.6204427
318	94.5853896
319	93.8453623
320	72.3461266
321	95.3510463

322	90.8724384
323	27.8676007
324	53.8326295
325	74.5662085
326	51.5869182
327	93.8453623
328	91.6124657
329	73.0861539
330	45.6154410
331	76.0462631
332	39.7464815
333	77.5391324
334	65.6858810
335	63.4273549
336	68.6844343
337	82.7193234
338	88.6523565
339	97.5454988
340	50.0812342
341	67.1403061
342	61.9473003
343	30.1004973
344	16.0143492
345	21.9345676
346	81.9921109
347	45.6795146
348	54.5342127
349	49.3412069
350	56.8055534
351	35.9950862
352	85.7050621
353	58.2727933
354	35.2935030
355	73.0989686
356	70.1004153
357	75.2934211
358	76.7862904
359	95.3254169
360	81.2264541
361	48.6011796

362	56.0142673
363	71.6189140
364	88.6523565
365	88.6523565
366	36.0079009
367	64.9458537
368	81.9664814
369	89.3923838
370	60.4800605
371	56.1934245
372	29.4755536
373	33.9285321
374	48.7547074
375	64.3465395
376	18.3879589
377	47.3002823
378	50.2347620
379	71.7468124
380	30.2155809
381	62.8408555
382	37.6158539
383	76.9526329
384	83.6128786
385	27.3067306
386	54.6877405
387	49.4947347
388	6.5218928
389	37.6158539
390	48.0018654
391	64.3209100
392	73.2268670
393	63.5808827
394	53.1948712
395	59.1407190
396	52.4804733
397	79.1855295
398	31.7468944
399	70.2795725
400	23.5681500
401	54.7261846

402	60.6464030
403	50.2603915
404	30.9556082
405	65.0737521
406	70.2795725
407	83.6128786
408	45.7945983
409	48.0146801
410	36.1357993
411	42.0816471
412	65.8137793
413	36.8758266
414	26.5026297
415	73.9797090
416	27.2554717
417	37.6799274
418	48.0659390
419	78.4455022
420	71.0324146
421	78.4455022
422	68.0594907
423	30.9556082
424	79.1599001
425	28.0339432
426	67.3194634
427	91.0387809
428	80.6527694
429	40.6144072
430	75.4597636
431	50.2603915
432	67.9970689
433	65.0241450
434	19.0911939
435	33.9301839
436	71.7228348
437	54.6509482
438	49.4579424
439	75.4101566
440	67.9970689
441	7.2251278

442	70.2299655
443	33.1260831
444	25.0114123
445	52.4308663
446	35.4102385
447	13.1453461
448	84.3289282
449	38.3575330
450	62.0768506
451	60.5711665
452	50.1979697
453	51.6780243
454	61.3111938
455	44.2905661
456	33.8789251
457	23.4800988
458	33.8789251
459	51.6908390
460	53.1965230
461	82.8232442
462	43.5249093
463	71.6972054
464	72.4500474
465	48.7435445
466	64.2841177
467	47.9778878
468	35.3974238
469	25.0242270
470	40.6032443
471	56.1438175
472	50.9636264
473	14.6254007
474	43.5120946
475	68.0098836
476	27.2058647
477	43.5120946
478	39.8632170
479	64.0352137
480	66.2681103
481	43.2631906

482	79.6142310
483	74.4212253
484	54.4020442
485	74.4212253
486	67.7481649
487	43.2631906
488	58.8422079
489	56.6093113
490	72.1883287
491	58.1021806
492	62.5551591
493	69.2282195
494	74.4212253
495	61.0879193
496	88.5201880
497	53.6748316
498	61.0879193
499	37.3814164
500	30.6442825
501	55.1420715
502	49.2090384
503	35.1485198
504	80.3414436
505	80.3414436
506	73.6683833
507	48.5074553
508	35.1485198
509	89.2474006
510	26.2681923
511	55.9077282
512	55.1805156
513	84.8200515
514	21.7511402
515	67.0209523
516	67.0209523
517	30.7083560
518	44.0544768
519	81.8343129
520	75.9140946
521	61.8279466

522	6.9505943
523	76.6541219
524	58.1021806
525	60.3350772
526	80.3670731
527	49.2218531
528	76.6669366
529	73.6811980
530	64.0480284
531	41.0943676
532	78.1341765
533	19.5823172
534	52.9091749
535	64.0480284
536	78.1341765
537	38.1214437
538	73.6683833
539	83.3271822
540	47.0274007
541	70.7210888
542	58.8806521
543	12.9092568
544	48.4946405
545	70.7082741
546	37.3814164
547	37.3814164
548	60.3222625
549	60.3478920
550	61.0879193
551	52.9604337
552	78.8742038
553	78.1341765
554	62.5679738
555	84.0543948
556	77.3941492
557	82.5743402
558	77.3813344
559	56.6093113
560	58.1021806
561	84.0543948

562	84.0672095
563	83.3271822
564	68.4881922
565	62.5551591
566	45.4832725
567	82.5743402
568	77.3941492
569	72.2139581
570	84.0543948
571	78.8613890
572	72.9411707
573	65.5280830
574	66.2552956
575	63.2823717
576	31.4611981
577	31.4611981
578	31.4611981
579	74.4212253
580	70.7082741
581	43.3144495
582	84.8200515
583	79.6270458
584	64.0480284
585	84.8200515
586	72.2011434
587	72.9411707
588	70.7082741
589	75.9012799
590	86.2872914
591	62.5551591
592	76.6541219
593	65.5665272
594	78.1341765
595	70.7210888
596	53.6492022
597	66.2681103
598	49.9490657
599	70.7210888
600	74.4340400
601	57.3749681

602	27.0082196
603	31.4611981
604	80.3414436
605	-4.8898424
606	73.6683833
607	63.3080011
608	73.7068274
609	63.2951864
610	46.2745587
611	47.0145859
612	47.7546132
613	58.1406248
614	68.5010069
615	67.7609796
616	71.4739308
617	46.2873734
618	75.1612526
619	72.9539854
620	73.6940127
621	55.9077282
622	42.5744222
623	65.5408977
624	58.8422079
625	87.7673460
626	52.9348043
627	62.5679738
628	69.9682468
629	70.7082741
630	36.6413891
631	76.7991051
632	27.8804154
633	76.7734757
634	78.2919744
635	56.0014526
636	63.4786138
637	44.9394873
638	53.0797875
639	37.5263996
640	37.5263996
641	101.9984772

642	69.3732027
643	70.8404426
644	60.4928752
645	100.5184227
646	90.1324111
647	34.5406610
648	95.3254169
649	95.3254169
650	96.8054715
651	91.6124657
652	80.4864268
653	97.5454988
654	16.7543765
655	71.5932846
656	105.7114284
657	79.7463996
658	96.0910736
659	65.7115104
660	32.3333939
661	84.1993780
662	89.3923838
663	64.9074095
664	84.9394053
665	32.3333939
666	64.1673822
667	58.2343492
668	21.1945403
669	76.7991051
670	35.9950862
671	67.9059628
672	30.1004973
673	73.0733392
674	49.3924658
675	55.2870547
676	77.5519471
677	23.4274369
678	87.1851166
679	73.8133665
680	102.0112920
681	13.0542401

682	73.8389959
683	51.6125477
684	60.4672458
685	44.1738306
686	78.2663450
687	17.4944038
688	59.7784773
689	101.2712647
690	96.0782589
691	97.5583135
692	93.1053350
693	93.1053350
694	71.6189140
695	93.8453623
696	78.2663450
697	57.5455807
698	61.2585319
699	95.3382316
700	90.1452258
701	84.2250075
702	70.8788867
703	84.2250075
704	104.9714011
705	58.9871912
706	102.7385045
707	79.7592143
708	98.3111555
709	56.8055534
710	91.6380951
711	56.0783409
712	59.0512648
713	91.6380951
714	79.0191870
715	90.1580405
716	87.9251439
717	90.8724384
718	79.7720290
719	92.3524930
720	62.6873276
721	69.3860174

722	61.9473003
723	72.3461266
724	76.8375492
725	85.6922473
726	74.5790232
727	73.8261812
728	49.3924658
729	46.4195419
730	101.2712647
731	80.4992416
732	13.7942674
733	65.6858810
734	22.7002243
735	93.1053350
736	72.3589413
737	26.3747314
738	53.1054170
739	69.0652367
740	83.1641995
741	35.7127496
742	41.6073385
743	60.9121218
744	88.3315758
745	82.4113575
746	61.6777785
747	89.0972325
748	88.3443905
749	43.8914940
750	58.6535957
751	92.7717396
752	40.1400987
753	93.5245816
754	98.7304021
755	93.5245816
756	61.6137049
757	34.9727223
758	77.9711937
759	62.3921764
760	91.3173144
761	16.4335958

762	48.3316578
763	66.8067107
764	97.9775601
765	43.1258373
766	95.0046362
767	54.9534593
768	66.0923128
769	88.3443905
770	66.0923128
771	60.1336503
772	80.1656461
773	93.5245816
774	68.3636536
775	55.7319307
776	50.4876661
777	89.0716031
778	50.4876661
779	98.7432168
780	95.7446635
781	83.8785973
782	40.8929407
783	51.2405081
784	54.9790887
785	34.9727223
786	58.7157772
787	29.0377971
788	35.7108575
789	37.9821982
790	40.9551221
791	34.2564323
792	62.4415431
793	66.1544943
794	49.1082371
795	91.3538664
796	65.3888375
797	48.3938392
798	50.5882917
799	63.1815704
800	58.7414066
801	39.4366234

802	71.3346853
803	76.5148764
804	66.1416796
805	66.1288648
806	58.7285919
807	19.4046276
808	46.1353132
809	72.0875273
810	18.6646003
811	78.0205604
812	29.0377971
813	21.6247095
814	11.2643273
815	17.1845457
816	20.1446549
817	29.0377971
818	26.8305299
819	57.9885646
820	66.1544943
821	54.2884281
822	24.6488922
823	72.0618979
824	53.5355861
825	63.9215977
826	55.7684827
827	72.0618979
828	76.5148764
829	22.3647367
830	22.3647367
831	72.0618979
832	27.6218161
833	18.7158591
834	35.7364869
835	53.5484008
836	67.6217341
837	60.2086465
838	70.5946580
839	36.4508848
840	52.8083735
841	80.9806696

842	38.0078277
843	64.6488103
844	9.0826896
845	16.4957773
846	46.1224985
847	66.8817069
848	62.4415431
849	63.9344124
850	63.1687557
851	75.7748491
852	58.7414066
853	9.0826896
854	56.5213247
855	63.9600418
856	29.7906391
857	46.1353132
858	77.9949310
859	76.5405058
860	98.5845983
861	91.9243526
862	48.1345951
863	83.0055810
864	45.9529574
865	48.1602245
866	23.7008797
867	58.5590508
868	87.4713741
869	69.6594602
870	94.1444345
871	51.8603610
872	37.7870277
873	68.9706918
874	48.1986687
875	54.8460996
876	44.4600881
877	71.8923568
878	62.2720020
879	78.5782319
880	69.6722749
881	80.0582865

882	83.7456082
883	53.3660450
884	70.4379317
885	74.1380681
886	54.8589143
887	79.3054445
888	63.7264272
889	40.0071096
890	73.4364850
891	89.6786413
892	103.0375768
893	70.3994875
894	89.7042707
895	80.0454718
896	79.3182592
897	90.4186686
898	85.2256628
899	80.0711012
900	76.3709647
901	40.7855810
902	81.5255264
903	77.0853626
904	88.1985867
905	19.2735306
906	54.0932576
907	34.8397332
908	70.3994875
909	77.8253899
910	20.0135579
911	88.1985867
912	40.0455537
913	51.1203337
914	81.5383411
915	66.6993510
916	91.1843253
917	48.9386960
918	78.5654172
919	96.3773311
920	64.4792692
921	67.4521931

922	82.2911831
923	25.2065637
924	69.7235338
925	74.8652807
926	65.2064817
927	83.7712377
928	105.2576586
929	70.4123022
930	79.3054445
931	33.3724934
932	83.0055810
933	72.6580135
934	97.8573857
935	86.7569763
936	60.0262907
937	65.2192965
938	78.5782319
939	83.0183957
940	77.0981773
941	71.9051715
942	67.4650078
943	36.3197878
944	36.3197878
945	45.2001154
946	81.5511558
947	89.6914560
948	87.4841889
949	104.5176313
950	99.3246256
951	57.8446529
952	94.1316198
953	42.2784503
954	78.5782319
955	63.7392419
956	31.8796241
957	88.6779860
958	39.7592962
959	18.9872731
960	81.9664814
961	31.5933666

```
962    19.7273004
963   104.9714011
964    99.7783954
965    67.2043797
966    71.6060993
967   104.2313738
968    31.5549224
969   102.0241067
970    88.6523565
971    50.0812342
972    52.3653897
973    42.7065907
974    53.7813707
975    47.1339397
976    82.7449529
977    80.4864268
978    14.5342946
979    73.8133665
980    68.6459901
981    51.5741035
982    14.5342946
983    63.4273549
984    64.2314558
985    41.9665634
986    33.0862359
987    39.0064542
988    71.6445435
989    58.2599786
990    34.5150316
991    41.2265361
992    54.5213980
993    58.2343492
994    86.4450894
995    25.6475188
996    73.0989686
997    81.9921109
998    58.2984227
999    39.7464815
1000   79.7720290
1001   76.0462631
```

```
1002   91.3233038
1003  102.4365279
1004   92.0505164
1005   49.0392303
1006   15.6995579
1007   57.9195578
1008   46.0663064
1009   40.8733006
1010   66.1111169
1011   45.3262791
1012   13.4666613
1013   89.0775925
1014   20.1525364
1015   52.7265521
1016   61.6453237
1017   57.1923453
1018   73.5113899
1019   31.2529458
1020   61.6581385
1021   66.8383295
1022   61.6453237
1023   89.0775925
1024   99.4636040
1025   62.4109805
1026   65.3710896
1027   49.7664429
1028   77.9771831
1029   55.7379201
1030   72.7585479
1031   29.0456786
1032   65.3710896
1033   51.2849416
1034   49.7792576
1035   71.2784933
1036   51.3233858
1037   20.1653511
1038   46.1303800
1039   37.1731642
1040   41.6005132
1041   53.4922088
```

```
1042   81.6645048
1043   81.6645048
1044   32.5033090
1045   35.4121593
1046   77.6834181
1047   42.8765059
1048   42.0724050
1049   37.6835001
1050   70.2959599
1051   -1.6148348
1052   37.6835001
1053   65.8301667
1054   71.7503851
1055   76.2033635
1056   38.3850832
1057   76.2033635
1058   23.5460932
1059   46.6022718
1060   50.2767788
1061   11.7184712
1062   30.2063388
1063   77.7090476
1064   28.0247011
1065   73.9960964
1066   47.2654108
1067   69.5303032
1068   73.9832817
1069   49.5239368
1070   58.4042643
1071   46.5638276
1072   51.0168061
1073   36.1393719
1074   52.4968607
1075    3.5781710
1076   16.1714497
1077   77.6834181
1078   24.3501941
1079   20.6244282
1080   82.8764239
1081   50.3152230
```

```
1082   49.5623809
1083   79.1891021
1084   33.9321047
1085   72.5288565
1086   22.0788533
1087   82.8892386
1088   64.3629268
1089   68.8030906
1090   48.8223537
1091   59.1442916
1092   70.2959599
1093   79.9163147
1094   27.2718591
1095   42.8252470
1096   28.7519137
1097   62.8572428
1098   73.2560691
1099   31.4972596
1100   58.1895011
1101   29.2771778
1102   90.8147756
1103   58.9038990
1104   62.6552943
1105   58.9295284
1106   70.7827798
1107   36.7030801
1108   62.6681090
1109   45.5962224
1110   78.2086822
1111   67.8098559
1112   41.8448270
1113   98.2150486
1114   24.0585425
1115   86.3489824
1116   69.3155399
1117  100.4479452
1118   69.2899105
1119   80.4287641
1120   27.7714937
1121   81.9216334
```

```
1122   78.9487095
1123   28.4987063
1124   81.9216334
1125   55.2165772
1126   52.9836806
1127   37.4046633
1128   66.3426161
1129   63.3568774
1130   10.0108387
1131   35.8989793
1132   21.8769048
1133   70.0427525
1134   73.0156764
1135   67.7970412
1136   34.4189247
1137   76.7286276
1138   61.1496103
1139   44.1033531
1140   74.4957310
1141   70.0299378
1142   93.0220428
1143   26.3170686
1144   41.8448270
1145   58.9423431
1146   48.5307021
1147   95.2549394
1148   11.4780785
1149   33.7301562
1150   63.3696922
1151   41.8448270
1152   22.6041174
1153  100.4479452
1154   80.4159494
1155   63.3825069
1156   12.9709479
1157   77.4686549
1158   46.3362497
1159   74.5504603
1160   64.9172908
1161   68.6302420
```

```
1162  61.2299690
1163  44.1708971
1164  77.5233842
1165  72.3303785
1166  52.3240121
1167  50.8439575
1168  19.7115523
1169  49.3510882
1170  65.6445034
1171  49.3382735
1172  54.5440940
1173  61.9699963
1174  40.4323165
1175  55.2969360
1176  22.6204026
1177  57.5042031
1178  68.6174273
1179  84.9364719
1180  67.8774000
1181  25.5933265
1182  27.8134084
1183  70.8503239
1184  36.0049675
1185  54.5569087
1186  56.0113338
1187  44.9109244
1188  67.1373727
1189  64.1900782
1190  40.4323165
1191  37.4978368
1192  66.4101601
1193  20.4515796
1194  44.2093413
1195  37.5234662
1196  26.3461685
1197  39.0035208
1198  21.9316342
1199  48.5982462
1200  76.0305149
1201  26.3333538
```

```
1202   35.2905696
1203   65.6445034
1204   68.6430567
1205   38.2378641
1206   50.1039302
1207   52.2983826
1208   68.3390119
1209   60.9515537
1210   68.3390119
1211   53.5128366
1212   62.4059789
1213   51.2799400
1214   13.4872891
1215   55.7713626
1216   10.5143652
1217   13.4872891
1218    1.6212230
1219    1.6340377
1220   46.0997489
1221   77.2577836
1222   25.3661700
1223    4.5813322
1224   44.6325091
1225   26.0677531
1226   80.2178928
1227   60.9515537
1228   79.4650508
1229   56.4857605
1230   54.2400492
1231   50.5527274
1232   26.0677531
1233   45.3597217
1234   55.7329185
1235   50.5399127
1236   23.8348565
1237   73.5320177
1238   72.0647778
1239   51.2799400
1240   69.8318812
1241   64.6260607
```

```
1242   31.7834658
1243   67.3304054
1244   77.7164169
1245   79.9493135
1246   67.3304054
1247    4.3383823
1248   19.1645577
1249   25.7991739
1250   19.9173997
1251   19.9173997
1252   25.8248033
1253   45.8439844
1254    1.3782732
1255   -4.5547599
1256   62.1373996
1257   67.3304054
1258   25.0847760
1259   19.8917702
1260   33.9907330
1261   25.8376180
1262   36.9508422
1263   57.6972358
1264   21.3974543
1265   45.1039571
1266    9.5185734
1267   57.7100505
1268    1.3654584
1269   21.3974543
1270   11.0114427
1271    5.0784096
1272   51.7513880
1273   52.5042300
1274   64.3702962
1275   42.1310332
1276   28.8105419
1277   39.9365808
1278   72.5362259
1279   -9.0077384
1280    3.5727256
1281   58.4500778
```

```
1282   74.0290952
1283   68.8360894
1284   68.0704327
1285   40.6637933
1286   44.3383004
1287   55.4643392
1288   62.8902416
1289   15.4772359
1290   74.0034657
1291   67.3304054
1292   11.0242574
1293   54.7243119
1294   66.5903781
1295   66.5903781
1296   62.1630290
1297   59.9301324
1298   16.1916338
1299   71.7833838
1300   66.4027238
1301   50.0964938
1302   71.6213590
1303   55.2894996
1304   70.8428875
1305   21.1585411
1306   76.8015500
1307   11.5125568
1308   41.2033516
1309   42.6834062
1310   28.6357023
1311   64.1826419
1312   46.4219868
1313   -3.2623596
1314   61.2097180
1315   63.4297999
1316   81.9689264
1317   61.9625600
1318   21.1585411
1319   52.3293904
1320   79.7488445
1321   47.9020414
```

```
1322   24.1058355
1323   60.4825054
1324   62.7154020
1325   46.3707279
1326   46.3707279
1327   51.5637337
1328   26.3899910
1329   82.7217684
1330   32.3230241
1331   58.2752382
1332   50.8493359
1333   34.5687354
1334   48.6164393
1335   50.8365211
1336   64.1698272
1337   70.1028602
1338   46.4219868
1339   64.9354839
1340   44.1890902
1341   66.4411679
1342   43.4490629
1343   62.0010041
1344    5.6051532
1345   64.9098544
1346   64.1954566
1347   47.8764120
1348   63.4297999
1349   29.3244707
1350   -1.0422778
1351   56.0295269
1352   68.6228056
1353   53.8094450
1354   64.1698272
1355   61.2097180
1356   61.2225327
1357   -1.0679072
1358   61.1969033
1359   57.5095815
1360   11.5125568
1361   82.7217684
```

```
1362   67.8955931
1363   67.8827783
1364   59.4924885
1365   57.2852213
1366   12.8195101
1367   -2.0707388
1368   55.7795373
1369   44.6534984
1370   52.0665861
1371   50.5993462
1372   59.5053032
1373   32.8130617
1374   28.3985274
1375   44.6663131
1376   16.5196465
1377   16.5196465
1378   24.6599468
1379   52.0665861
1380   51.3265588
1381   55.0523247
1382   52.0665861
1383   52.0665861
1384   -8.7181698
1385   23.9327342
1386   55.7795373
1387  -15.3912301
1388   35.0459583
1389   48.3792643
1390   37.2532255
1391   -6.4980879
1392   66.9183908
1393   35.8244298
1394   56.5323793
1395   42.4334165
1396   66.9183908
1397   56.5323793
1398   39.4861221
1399   33.5402743
1400   52.8194281
1401   33.5402743
```

```
1402   60.9725431
1403   58.7524612
1404   55.7795373
1405   49.8465042
1406   53.5594554
1407   55.7795373
1408   55.0523247
1409   20.2454124
1410   44.6791279
1411   14.2739352
1412   37.2404108
1413   32.0730344
1414   37.2404108
1415   32.0730344
1416   49.8465042
1417   49.8465042
1418   43.9262859
1419   54.3122974
1420   66.1783635
1421   31.3330071
1422   40.2133347
1423   37.1732267
1424   54.2322986
1425   54.2322986
1426   -1.3722662
1427   56.4780099
1428   51.9994020
1429   -0.6066095
1430    3.8335543
1431   43.1318892
1432   44.6119438
1433   37.1860414
1434   53.5050860
1435    5.3136089
1436   40.8861779
1437   41.6262052
1438   48.3120802
1439    4.5863963
1440   40.1589653
1441   53.4794566
```

```
1442   53.4794566
1443   57.9324351
1444   53.4794566
1445   53.4794566
1446   35.7059868
1447   51.2721894
1448    0.1334178
1449   38.6404665
1450   48.2992655
1451   56.4651952
1452   45.3391563
1453   46.0791836
1454    9.7537726
1455   27.5528719
1456   48.2864508
1457   38.6404665
1458   64.6183101
1459   54.2322986
1460   50.5577916
1461   -8.7597244
1462   54.9723259
1463   34.2131175
1464   39.4061233
1465   22.3726808
1466   32.7586923
1467   46.6366516
1468   45.1565970
1469   55.5297939
1470   45.1437823
1471   34.0561876
1472   20.7100669
1473  -21.5740066
1474  -21.5740066
1475   59.2171156
1476   38.4835367
1477   51.0640007
1478   52.5696847
1479   42.1836731
1480   58.5027177
1481   52.5440552
```

```
1482   42.1836731
1483    6.6111041
1484   59.2427450
1485   28.8503671
1486   59.2427450
1487   65.9158054
1488   57.7370610
1489   51.8168427
1490   22.9301488
1491   40.6779891
1492   18.4899850
1493   35.5362422
1494   40.7292480
1495    1.4180984
1496   54.7641371
1497   54.7641371
1498   59.2171156
1499   22.1901215
1500   59.2171156
1501   41.4436458
1502   43.6893571
1503   54.0241098
1504   59.2171156
1505   59.9571429
1506   55.5041644
1507   18.4771703
1508   33.2777162
1509   53.2840825
1510   39.9635912
1511   53.2968973
1512   40.6908038
1513   12.5441372
1514   58.4770883
1515   53.2840825
1516   42.9237004
1517   50.3239734
1518   71.0959965
1519   54.7641371
```

2.6　評価: OLS を評価

```
PredOLS = predict(OLS, Test)

mean((Test$Price - PredOLS)^2)
```

```
[1] 303.7457
```

2.7　評価: LASSO を評価

```
PredLASSO = predict(LASSO, Test)

mean((Test$Price - PredLASSO)^2)
```

```
[1] 328.7442
```

2.8　Reference