Lasso (GDP)

Shuofan Zhang

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Detailed description

Given the data set we use (Stock & Watson 2016), when thresh=1E-16, the difference in sum of squared errors between OLS and Lasso ($\lambda = 0$) is 1.81e-06, while when thresh=1E-7, the difference is 0.005. But the difference when λ is nonzero is not very significant, so to reduce the computational burden, we choose to use 1E-10 with the maxit (maximum number of passes over the data for all lambda values) to be 10^9.

All the monthly data was aggregated into quarterly data.

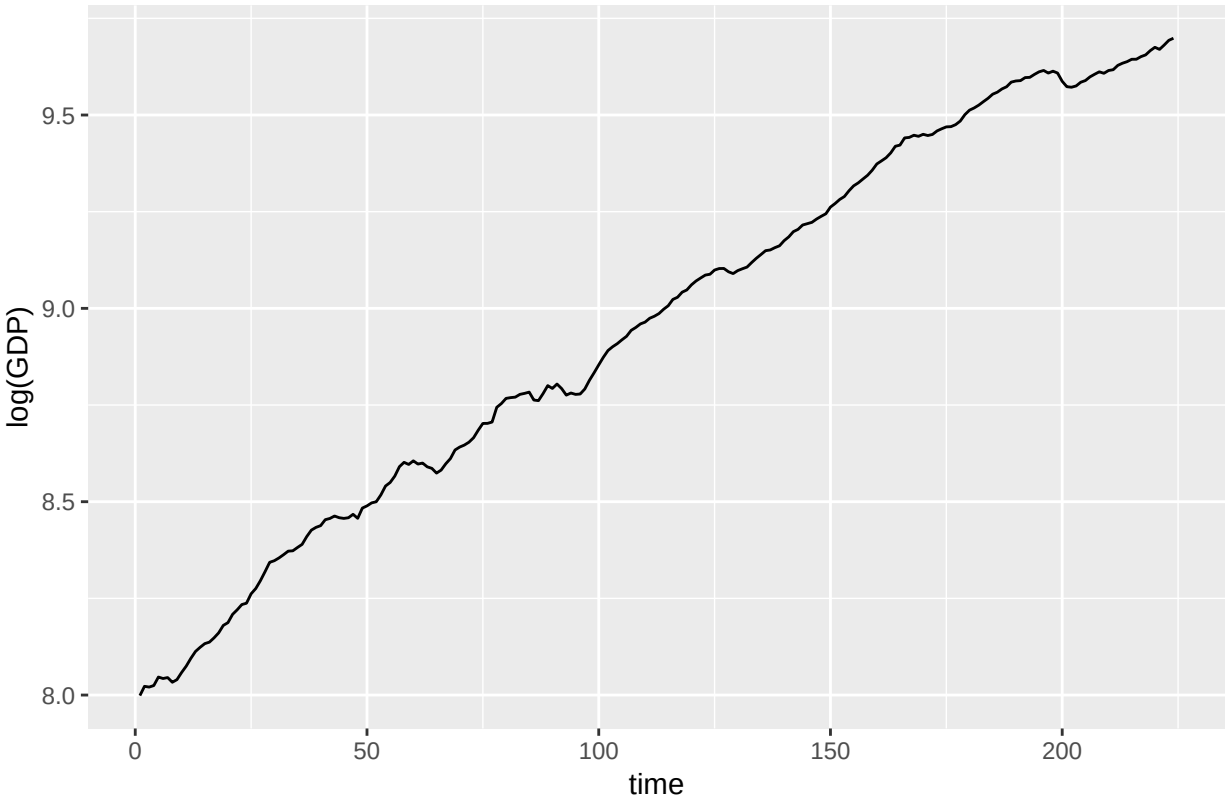
Each series was standardized (centered, sd=1) before put into regression.

118 series were transformed by log().

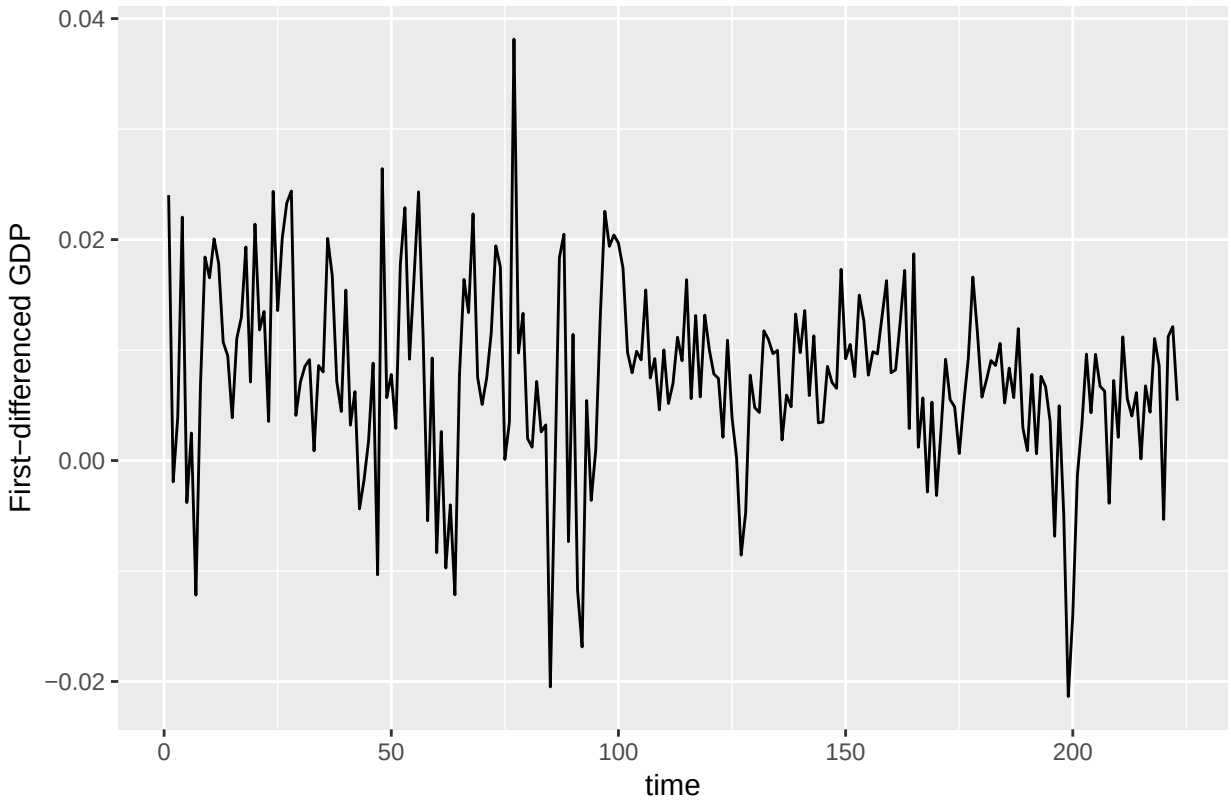
GDP growth rate is used as the dependent variable.

$$y_t = log(GDP_t)$$

$$\Delta y_t = log(GDP_t) - log(GDP_{t-1})$$



Time plot of log(GDP).



Time plot of differenced log(GDP).

Lasso 1

The regression being estimated is:

$$\Delta y_t = I(0)_{t-1} + I(1)_{t-1} + \Delta I(2)_{t-1}$$

1, 144 series were used as explanatory variables;

2, I(2) series were first differenced, no change to I(0) and I(1) series;

3, all explanatory variables are lagged by 1 quarter;

4, after first difference and one lag, we have 222 observations (lost 2).

Lasso 2

The regression being estimated is:

$$\begin{aligned}\Delta y_t = {} & y_{t-1} \\ & + \Delta y_{t-1} + \Delta y_{t-2} + \Delta y_{t-3} + \Delta y_{t-4} \\ & + I(0)_{t-1} + I(1)_{t-1} + \Delta I(2)_{t-1}\end{aligned}$$

1, 149 series were used as explanatory variables, $log(GDP_{t-1})$ $\Delta log(GDP_{t-1})$ $\Delta log(GDP_{t-2})$ $\Delta log(GDP_{t-3})$ $\Delta log(GDP_{t-4})$ were added on the top of the Lasso 1;

2, I(2) series were first differenced;

3, all explanatory variables are lagged by 1 quarter;

4, after first difference and four lags, we have 219 observations (lost 5);

Lasso 3

Some notes: in this section, the number of parameters exceeds the number of observations, but glmnet still works when $\lambda = 0$ (why), and "lm" also works unless we set "singular.ok = FALSE".

The regression being estimated is:

$$\begin{aligned}\Delta y_t = & \, y_{t-1} \\ & + \Delta y_{t-1} + \Delta y_{t-2} + \Delta y_{t-3} + \Delta y_{t-4} \\ & + I(0)_{t-1} + I(0)_{t-2} + I(0)_{t-3} + I(0)_{t-4} \\ & + \Delta I(1)_{t-1} + \Delta I(1)_{t-2} + \Delta I(1)_{t-3} + \Delta I(1)_{t-4} \\ & + \Delta^2 I(2)_{t-1} + \Delta^2 I(2)_{t-2} + \Delta^2 I(2)_{t-3} + \Delta^2 I(2)_{t-4}\end{aligned}$$

1, 581 (1+4*145) series were used as explanatory variables;

I(1) series were first-differenced;

I(2) series were second-differenced;

2, all explanatory variables are now I(0) and lagged by 4 quarters;

3, after first difference, second difference and four lags, we have 218 observations (lost 6).

Lasso 4

The regression being estimated is:

$$\begin{aligned}\Delta y_t = & \, y_{t-1} \\ & + \Delta y_{t-1} + \Delta y_{t-2} + \Delta y_{t-3} \\ & + I(0)_{t-1} + I(0)_{t-2} + I(0)_{t-3} \\ & + \Delta I(1)_{t-1} + \Delta I(1)_{t-2} + \Delta I(1)_{t-3} \\ & + \Delta^2 I(2)_{t-1} + \Delta^2 I(2)_{t-2} + \Delta^2 I(2)_{t-3}\end{aligned}$$

1, 436 (1+3*145) series were used as explanatory variables;

I(1) series were first-differenced;

I(2) series were second-differenced;

2, all explanatory variables are now I(0) and lagged by 3 quarters;

3, after first difference, second difference and 3 lags, we have 219 observations (lost 5).

Lasso 5

The regression being estimated is:

$$\begin{aligned}\Delta y_t = & \, y_{t-1} \\ & + \Delta y_{t-1} + \Delta y_{t-2} \\ & + I(0)_{t-1} + I(0)_{t-2} \\ & + \Delta I(1)_{t-1} + \Delta I(1)_{t-2} \\ & + \Delta^2 I(2)_{t-1} + \Delta^2 I(2)_{t-2}\end{aligned}$$

1, 291 (1+2*145) series were used as explanatory variables;

I(1) series were first-differenced;

I(2) series were second-differenced;

2, all explanatory variables are now I(0) and lagged by 2 quarters;

3, after first difference, second difference and 2 lags, we have 219 observations (lost 5).

Lasso 6

The regression being estimated is:

$$\Delta y_t = y_{t-1} + \Delta y_{t-1} + I(0)_{t-1} + \Delta I(1)_{t-1} + \Delta^2 I(2)_{t-1}$$

1, 146 (1+145) series were used as explanatory variables;

I(1) series were first-differenced;

I(2) series were second-differenced;

2, all explanatory variables are now I(0) and lagged by 1 quarters;

3, after first difference, second difference and 1 lag, we have 221 observations (lost 3).

Lasso 7

The regression being estimated is:

$$\begin{aligned}\Delta y_t = &\Delta y_{t-1} + \Delta y_{t-2} + \Delta y_{t-3} + \Delta y_{t-4} \\ &+ I(0)_{t-1} + I(0)_{t-2} + I(0)_{t-3} + I(0)_{t-4} \\ &+ \Delta I(1)_{t-1} + \Delta I(1)_{t-2} + \Delta I(1)_{t-3} + \Delta I(1)_{t-4} \\ &+ \Delta^2 I(2)_{t-1} + \Delta^2 I(2)_{t-2} + \Delta^2 I(2)_{t-3} + \Delta^2 I(2)_{t-4} \\ &+ I(1)_{t-1} + \Delta I(2)_{t-1}\end{aligned}$$

1, 697 series were used as explanatory variables;

I(1) series were first-differenced;

I(2) series were second-differenced;

2, all explanatory variables are now I(0) and lagged by 4 quarters;

3, after first difference, second difference and 4 lags, we have 218 observations (lost 6).

Lasso 8 (no spread)

"tb6m_tb3m, GS1_tb3m, GS10_tb3m, CP_Tbill Spread" were omitted to prevent from multicollinearity. "CP3FM" was added. (file path of data file is changed in "datain_all.m", 24th Oct)

This model is same with the lasso 1, only difference is the removed four I(0) series, and the added one I(1) series.

Among the four non-zero coefficients, two of them are I(1), the other two are I(0) according to ADF test. However, the linear combination (using the estimated coefficients) of the two I(1) is not I(0).

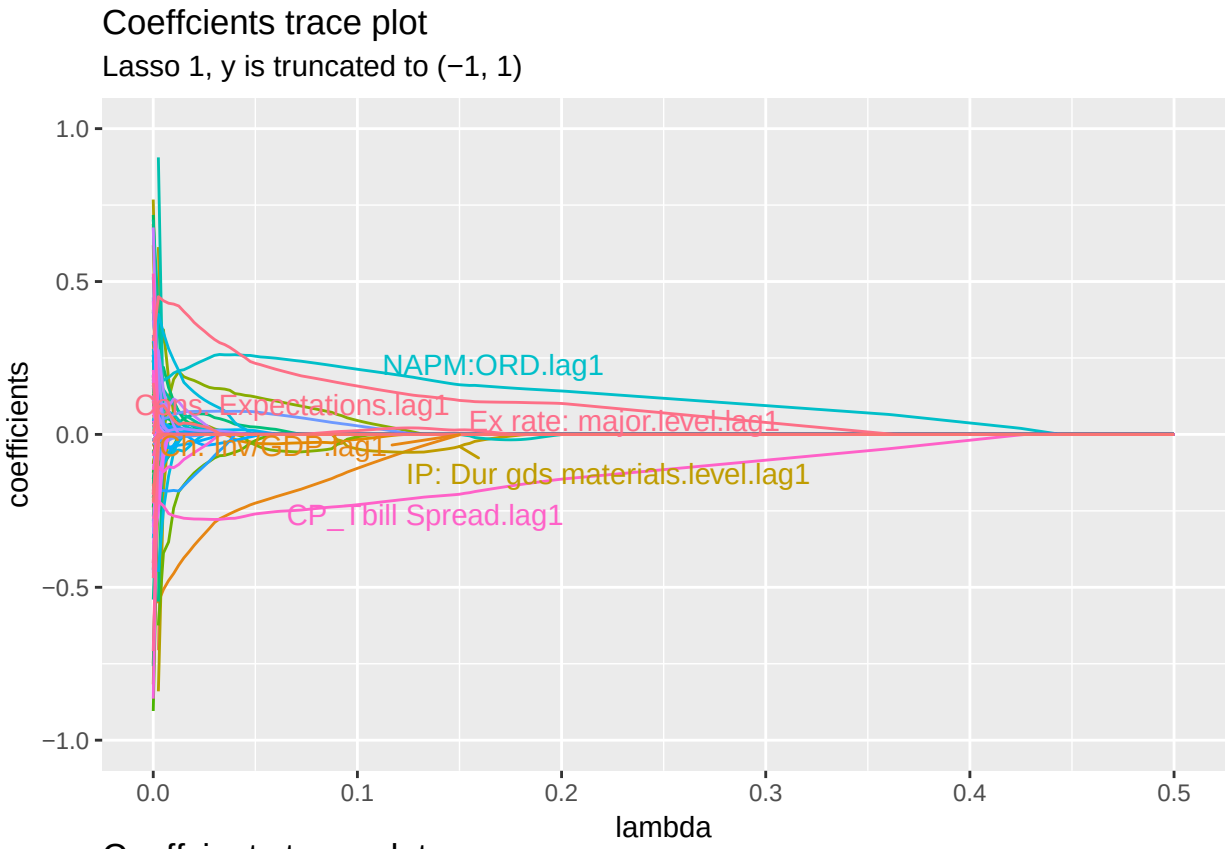
Lasso 9

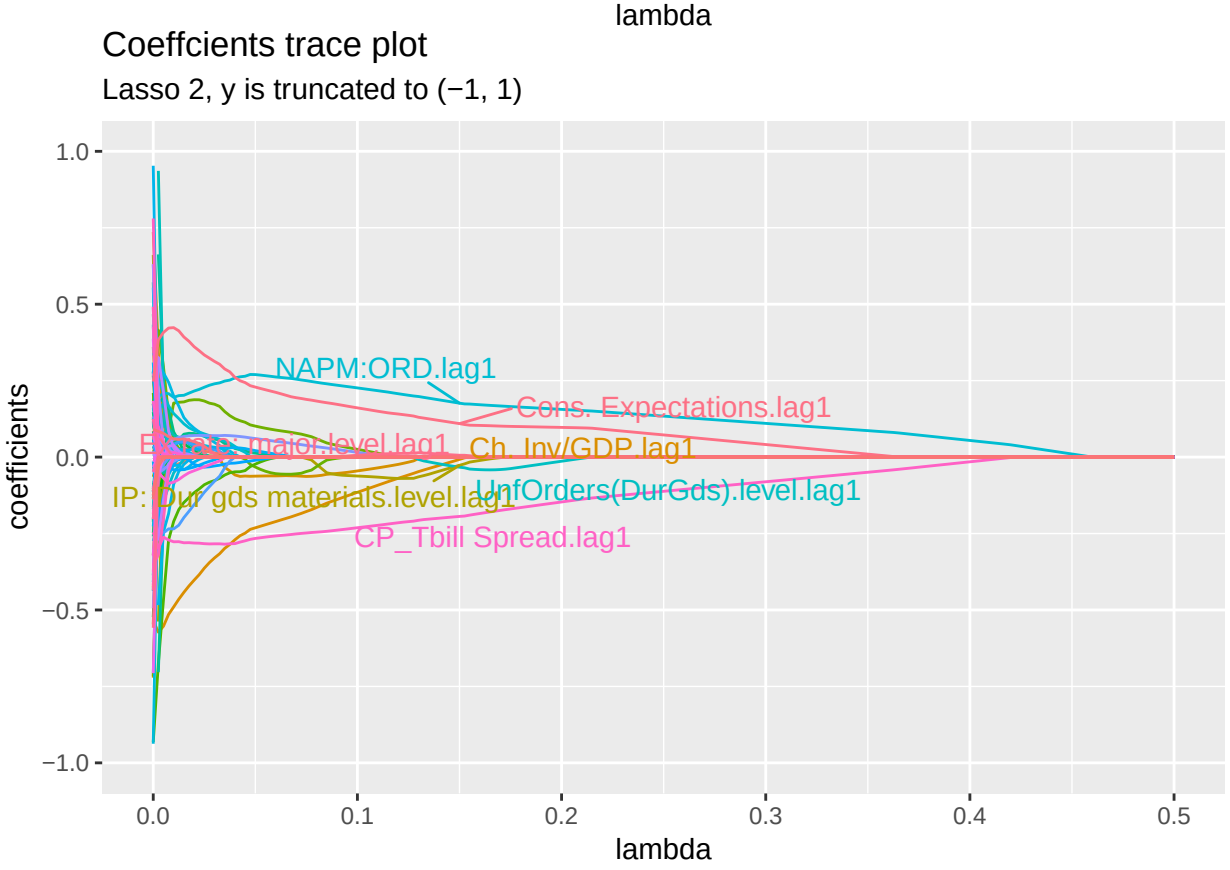
Investigation of the non-zero coefficients

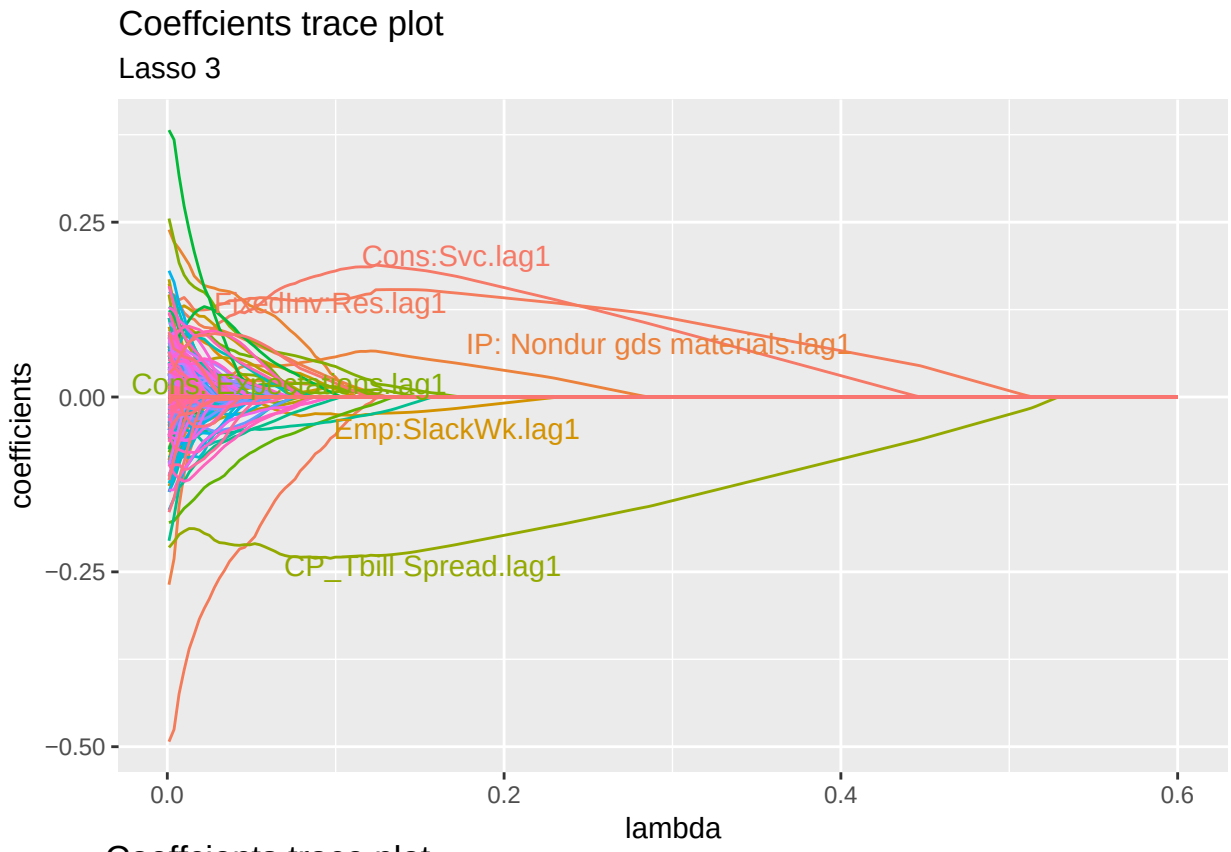
Investigation of the all variables

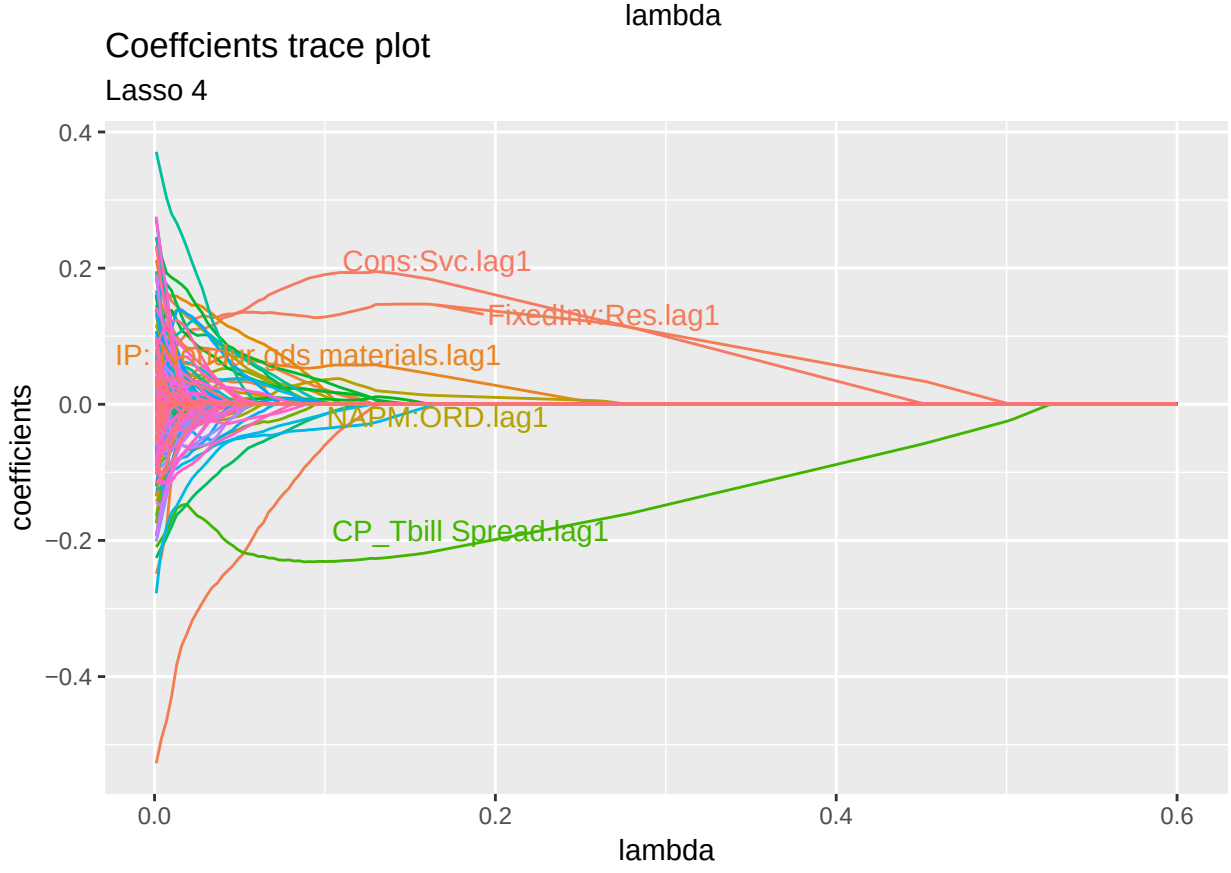
```
##                    Series Conclusion  Type Lags
## 1                    PCED       I(1) trend    6
## 2                PCED_LFE       I(1) trend    6
## 3                GDP Defl       I(1) trend    3
## 4               GPDI Defl       I(1) trend    4
## 5             BusSec Defl       I(1) trend    3
## 6              PCED_Goods       I(1) trend    6
## 7           PCED_DurGoods       I(1) trend   13
## 8          PCED_NDurGoods       I(1) trend    6
## 9               PCED_Serv       I(1) trend    5
## 10 PCED_HouseholdServices       I(1) trend    5
## 11          PCED_MotorVec       I(1) trend    3
## 12      PCED_DurHousehold       I(1) trend    2
## 13        PCED_Recreation       I(1) trend    3
## 14         PCED_OthDurGds       I(1) trend    7
## 15          PCED_Food_Bev       I(1) trend   13
## 16          PCED_Clothing       I(1) trend    6
## 17         PCED_Gas_Enrgy       I(1) trend    2
## 18        PCED_OthNDurGds       I(1) trend    3
## 19 PCED_Housing-Utilities       I(1) trend    6
## 20        PCED_HealthCare       I(1) trend    4
## 21          PCED_TransSvg       I(1) trend   10
## 22       PCED_RecServices       I(0) trend    8
## 23     PCED_FoodServ_Acc.       I(1) trend   11
## 24              PCED_FIRE       I(1) trend    2
## 25     PCED_OtherServices       I(1) trend    8
## 26                    CPI       I(0) trend    5
## 27                CPI_LFE       I(1) trend    5
## 28             PPI:FinGds       I(1) trend    5
## 29         PPI:FinConsGds       I(1) trend    5
## 30   PPI:FinConsGds(Food)       I(1) trend   14
## 31             PPI:IndCom       I(1) trend    2
## 32             PPI:IntMat       I(1) trend    2
```

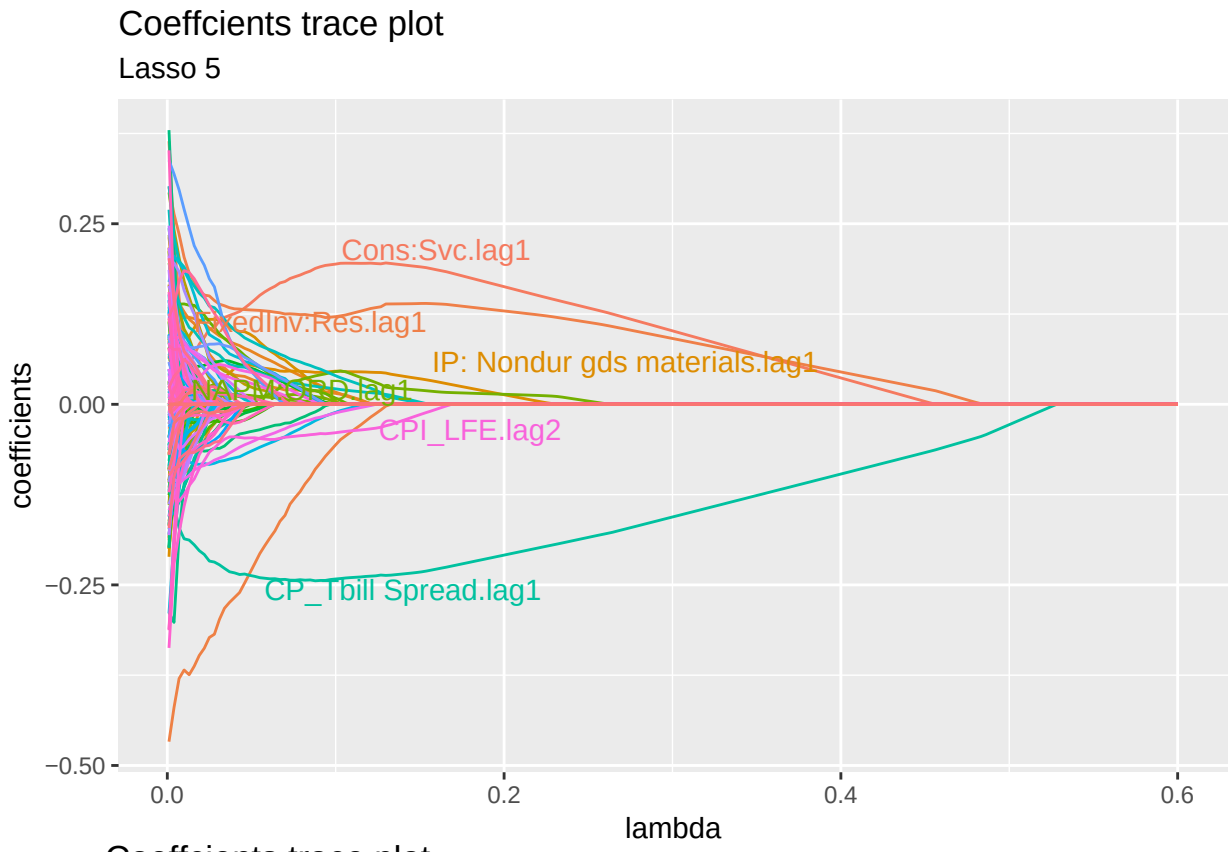
Graphs

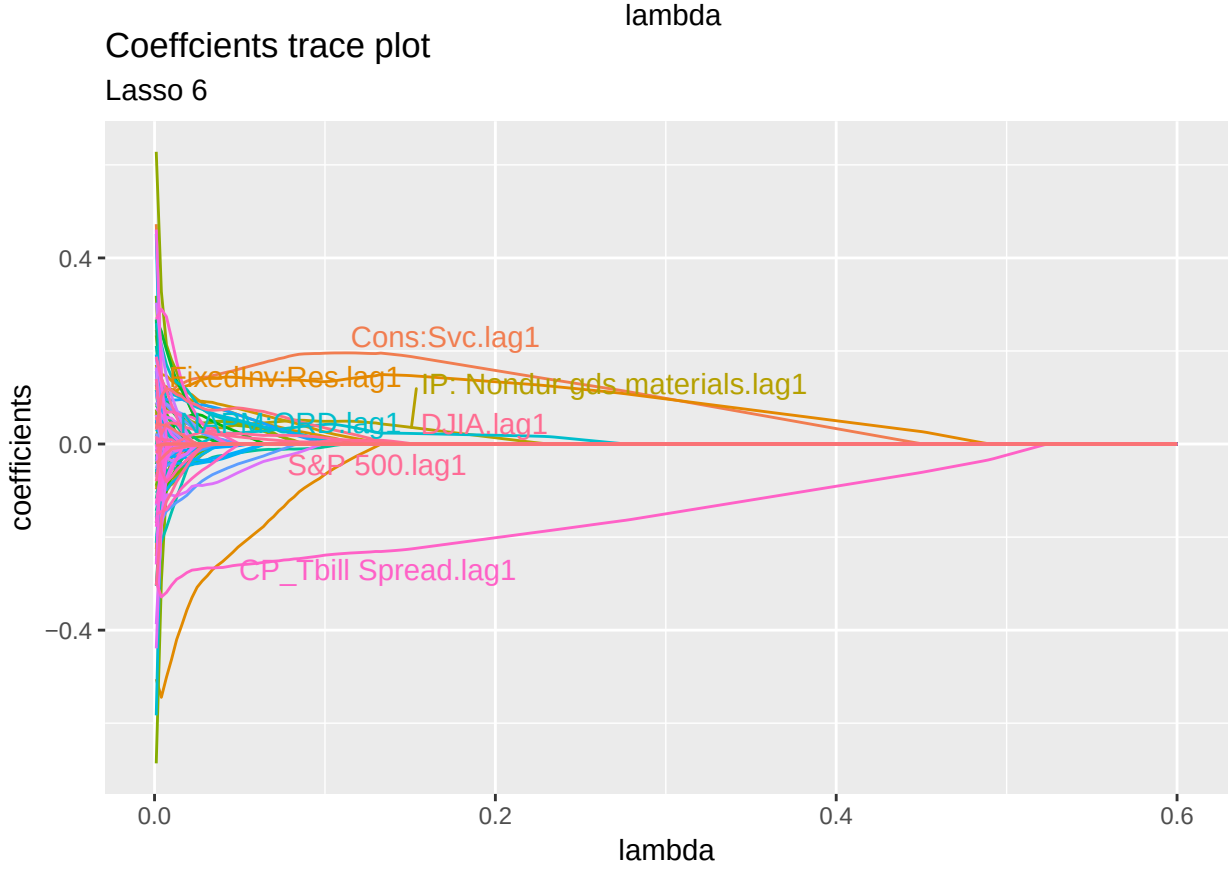

Coeffcients trace plot
Lasso 1, y is truncated to (−1, 1)
coefficients
lambda
NAPM:ORD.lag1
Cons. Expectations.lag1
Ex rate: major.level.lag1
Ch. Inv/GDP.lag1
IP: Dur gds materials.level.lag1
CP_Tbill Spread.lag1

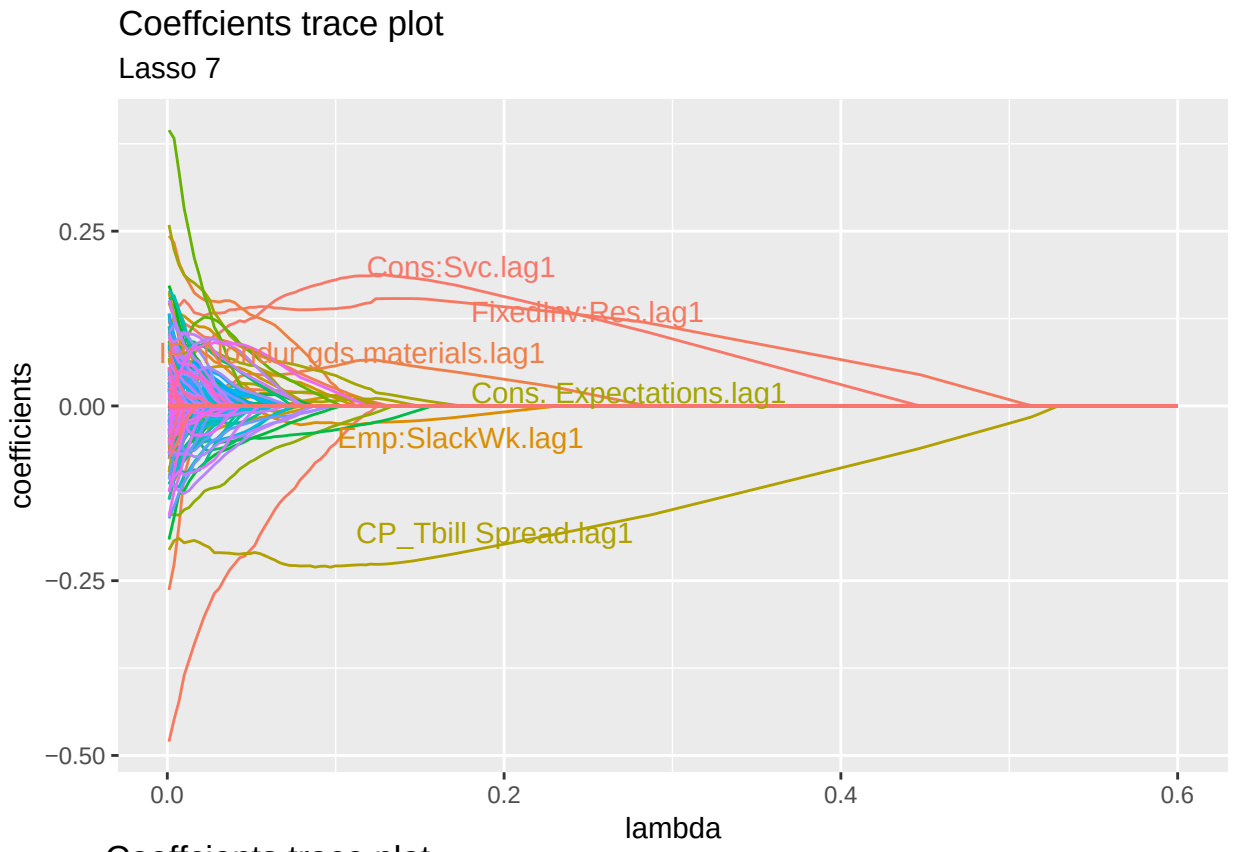

Coeffcients trace plot
Lasso 2, y is truncated to (−1, 1)
coefficients
lambda
NAPM:ORD.lag1
Cons. Expectations.lag1
Ch. Inv/GDP.lag1
UnfOrders(DurGds).level.lag1
IP: Dur gds materials.level.lag1
CP_Tbill Spread.lag1

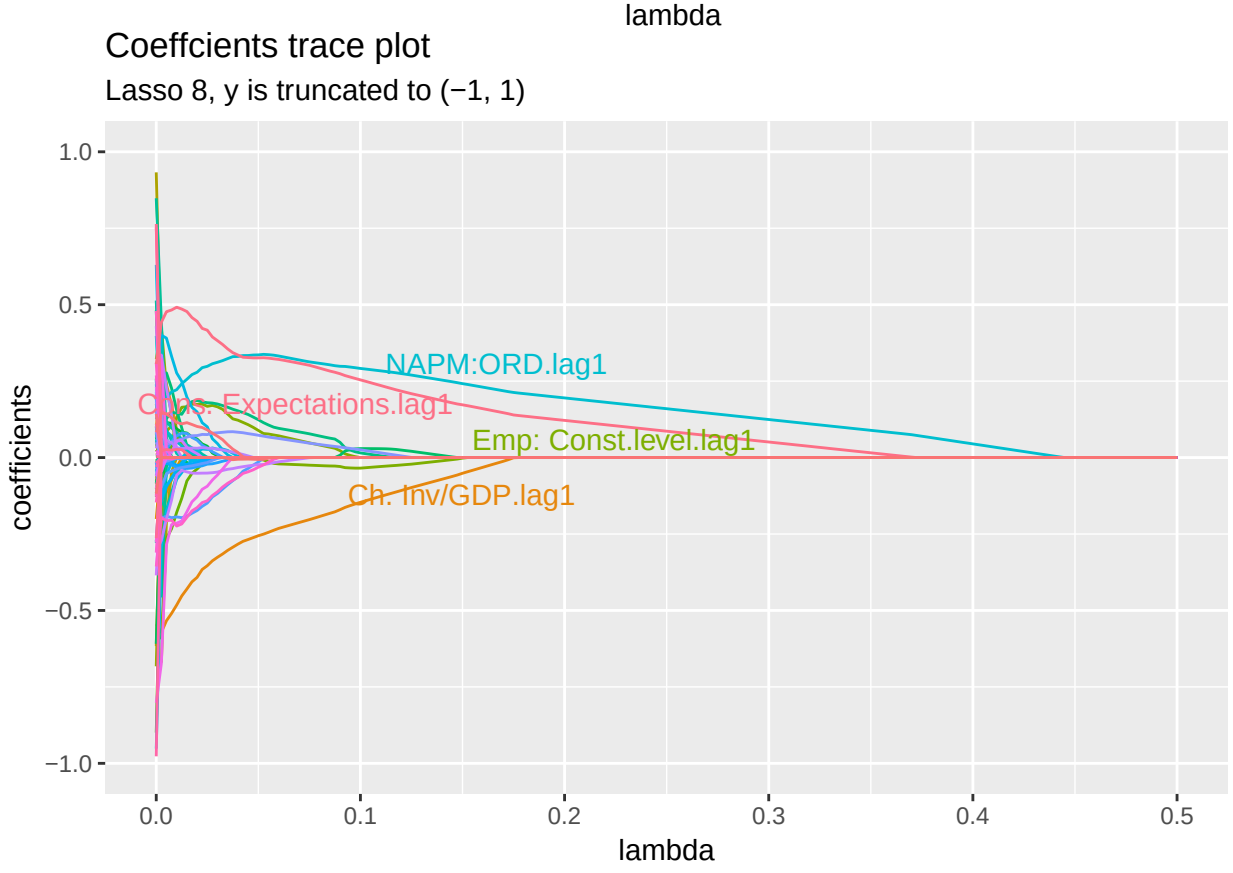

Coeffcients trace plot
Lasso 3
coefficients
0.25
0.00
−0.25
−0.50
Cons:Svc.lag1
FixedInv:Res.lag1
IP: Nondur gds materials.lag1
Cons: Expectations.lag1
Emp:SlackWk.lag1
CP_Tbill Spread.lag1
0.0
0.2
0.4
0.6
lambda

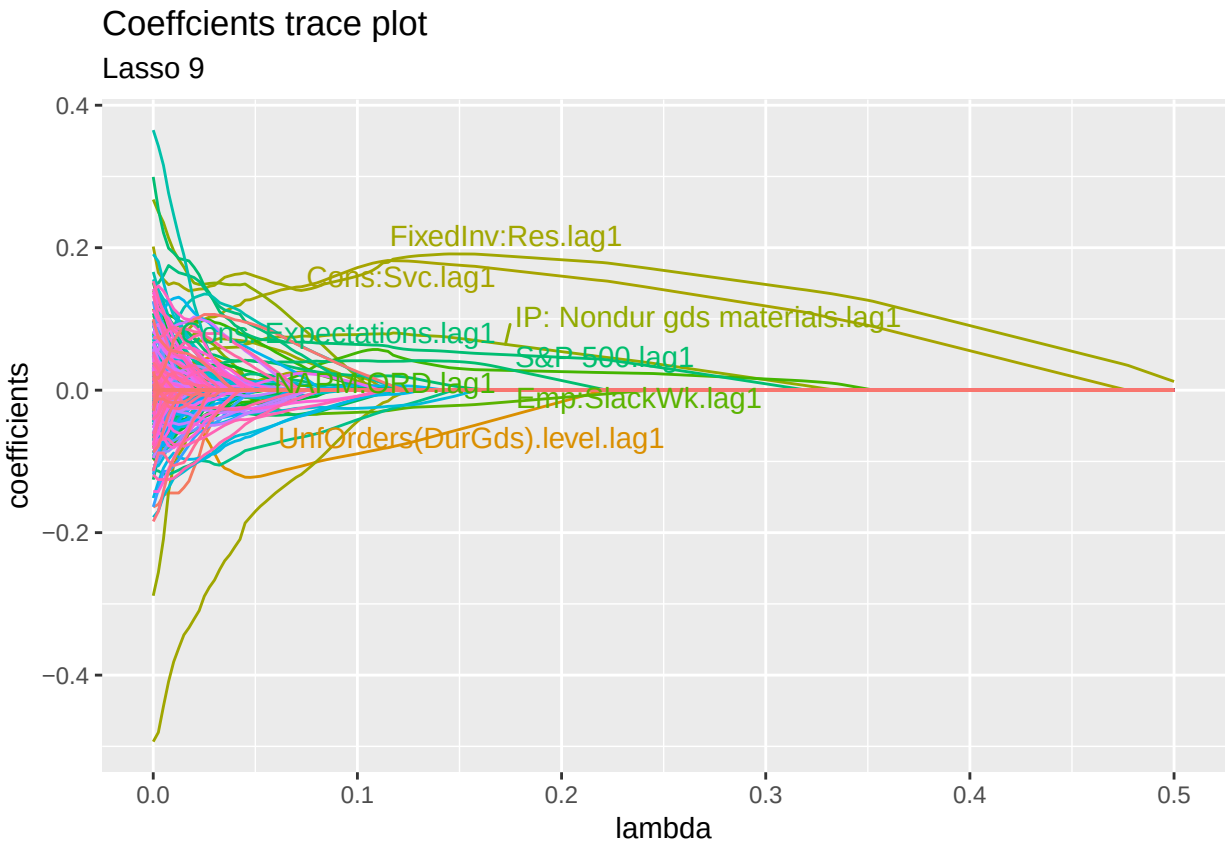

Coeffcients trace plot
Lasso 4
coefficients
0.4
0.2
0.0
−0.2
−0.4
Cons:Svc.lag1
FixedInv:Res.lag1
IP: Nondur gds materials.lag1
NAPM:ORD.lag1
CP_Tbill Spread.lag1
0.0
0.2
0.4
0.6
lambda


Coeffcients trace plot
Lasso 5
coefficients
0.25
0.00
−0.25
−0.50
0.0
0.2
0.4
0.6
lambda
Cons:Svc.lag1
FixedInv:Res.lag1
IP: Nondur gds materials.lag1
NAPM:ORD.lag1
CPI_LFE.lag2
CP_Tbill Spread.lag1


Coeffcients trace plot
Lasso 6
coefficients
0.4
0.0
−0.4
0.0
0.2
0.4
0.6
lambda
Cons:Svc.lag1
FixedInv:Res.lag1
IP: Nondur gds materials.lag1
NAPM:ORD.lag1
DJIA.lag1
S&P 500.lag1
CP_Tbill Spread.lag1


Coeffcients trace plot
Lasso 7
coefficients
lambda
Cons:Svc.lag1
FixedInv:Res.lag1
Cons. Expectations.lag1
Emp:SlackWk.lag1
CP_Tbill Spread.lag1
0.25
0.00
−0.25
−0.50
0.0
0.2
0.4
0.6


Coeffcients trace plot
Lasso 8, y is truncated to (−1, 1)
coefficients
lambda
NAPM:ORD.lag1
Cons. Expectations.lag1
Emp: Const.level.lag1
Ch. Inv/GDP.lag1
1.0
0.5
0.0
−0.5
−1.0
0.0
0.1
0.2
0.3
0.4
0.5



Data transformation table

Table 1: Number of series with 'No-transformation' is 12

tcode	short	long
I(0)	Ch. Inv/GDP	Ch. Inv/GDP
I(0)	AWH Man	Average Weekly Hours: Manufacturing
I(0)	VendPerf	ISM Manufacturing: Supplier Deliveries Index©
I(0)	NAPM:INV	ISM Manufacturing: Inventories Index©
I(0)	NAPM:ORD	ISM Manufacturing: New Orders Index©; Index;
I(0)	NAPM com price	ISM Manufacturing: Prices Paid Index©
I(0)	BAA_GS10	BAA-GS10 Spread
I(0)	tb6m_tb3m	tb6m-tb3m
I(0)	GS1_tb3m	GS1_Tb3m
I(0)	GS10_tb3m	GS10_Tb3m
I(0)	CP_Tbill Spread	CP3FM-TB3MS
I(0)	Cons. Expectations	Consumer expectations NSA (Copyright University of Michigan)

Table 2: Number of 'First-differenced' series is 15

tcode	short	long
I(1)	LF Part Rate	LaborForce Participation Rate (16 Over) SA
I(1)	Unemp Rate	Urate

tcode	short	long
I(1)	Urate_ST	Urate Short Term (< 27 weeks)
I(1)	Urate_LT	Urate Long Term (>= 27 weeks)
I(1)	Urate: Age16-19	Unemployment Rate - 16-19 yrs
I(1)	Urate:Age>20 Men	Unemployment Rate - 20 yrs. & over Men
I(1)	Urate: Age>20 Women	Unemployment Rate - 20 yrs. & over Women
I(1)	AWH Overtime	Average Weekly Hours: Overtime: Manufacturing
I(1)	FedFunds	Effective Federal Funds Rate
I(1)	TB-3Mth	3-Month Treasury Bill: Secondary Market Rate
I(1)	TM-6MTH	6-Month Treasury Bill: Secondary Market Rate
I(1)	TB-1YR	1-Year Treasury Constant Maturity Rate
I(1)	TB-10YR	10-Year Treasury Constant Maturity Rate
I(1)	AAA Bond	Moody's Seasoned Aaa Corporate Bond Yield
I(1)	BAA Bond	Moody's Seasoned Baa Corporate Bond Yield

Table 3: Number of 'First-differenced in logs' series is 86

tcode	short	long
log, I(1)	GDP	Real Gross Domestic Product 3 Decimal
log, I(1)	Consumption	Real Personal Consumption Expenditures
log, I(1)	Cons:Dur	Real Personal Consumption Expenditures: Durable Goods Quantity Index
log, I(1)	Cons:Svc	Real Personal Consumption Expenditures: Services Quantity Index
log, I(1)	Cons:NonDur	Real Personal Consumption Expenditures: Nondurable Goods Quantity Index
log, I(1)	Investment	Real Gross Private Domestic Investment 3 Decimal
log, I(1)	FixedInv	Real Private Fixed Investment Quantity Index
log, I(1)	Inv:Equip	Real Nonresidential Investment: Equipment Quantity Idenx
log, I(1)	FixInv:NonRes	Real Private Nonresidential Fixed Investment Quantity Index
log, I(1)	FixedInv:Res	Real Private Residential Fixed Investment Quantity Index
log, I(1)	Gov.Spending	Real Government Consumption Expenditures & Gross Investment 3 Decimal
log, I(1)	Gov:Fed	Real Federal Consumption Expenditures Quantity Index
log, I(1)	Gov:State&Local	Real State & Local Consumption Expenditures Quantity Index
log, I(1)	Exports	Real Exports of Goods & Services 3 Decimal
log, I(1)	Imports	Real Imports of Goods & Services 3 Decimal
log, I(1)	Disp-Income	Real Disposable Personal Income
log, I(1)	Ouput:NFB	Nonfarm Business Sector: Output
log, I(1)	Output:Bus	Business Sector: Output
log, I(1)	IP: Total index	IP: Total index
log, I(1)	IP: Final products	Industrial Production: Final Products (Market Group)
log, I(1)	IP: Consumer goods	IP: Consumer goods
log, I(1)	IP: Materials	Industrial Production: Materials
log, I(1)	IP: Dur gds materials	Industrial Production: Durable Materials

tcode	short	long
log, I(1)	IP: Nondur gds materials	Industrial Production: nondurable Materials
log, I(1)	IP: Dur Cons. Goods	Industrial Production: Durable Consumer Goods
log, I(1)	IP: Auto	IP: Automotive products
log, I(1)	IP:NonDur Cons God	Industrial Production: Nondurable Consumer Goods
log, I(1)	IP: Bus Equip	Industrial Production: Business Equipment
log, I(1)	Emp:Nonfarm	Total Nonfarm Payrolls: All Employees
log, I(1)	Emp: Private	All Employees: Total Private Industries
log, I(1)	Emp: mfg	All Employees: Manufacturing
log, I(1)	Emp:Services	All Employees: Service-Providing Industries
log, I(1)	Emp:Goods	All Employees: Goods-Producing Industries
log, I(1)	Emp: DurGoods	All Employees: Durable Goods Manufacturing
log, I(1)	Emp: Nondur Goods	All Employees: Nondurable Goods Manufacturing
log, I(1)	Emp: Const	All Employees: Construction
log, I(1)	Emp: Edu&Health	All Employees: Education & Health Services
log, I(1)	Emp: Finance	All Employees: Financial Activities
log, I(1)	Emp: Infor	All Employees: Information Services
log, I(1)	Emp: Bus Serv	All Employees: Professional & Business Services
log, I(1)	Emp:Leisure	All Employees: Leisure & Hospitality
log, I(1)	Emp:OtherSvcs	All Employees: Other Services
log, I(1)	Emp: Mining/NatRes	All Employees: Natural Resources & Mining
log, I(1)	Emp:Trade&Trans	All Employees: Trade Transportation & Utilities
log, I(1)	Emp: Gov	All Employees: Government
log, I(1)	Emp:Retail	All Employees: Retail Trade
log, I(1)	Emp:Wholesal	All Employees: Wholesale Trade
log, I(1)	Emp: Gov(Fed)	Employment Federal Government
log, I(1)	Emp: Gov (State)	Employment State government
log, I(1)	Emp: Gov (Local)	Employment Local government
log, I(1)	Emp: Total (HHSurve)	Emp Total (Household Survey)
log, I(1)	U: Dur<5wks	Number Unemployed for Less than 5 Weeks
log, I(1)	U:Dur5-14wks	Number Unemployed for 5-14 Weeks
log, I(1)	U:dur>15-26wks	Civilians Unemployed for 15-26 Weeks
log, I(1)	U: Dur>27wks	Number Unemployed for 27 Weeks & over
log, I(1)	Emp:SlackWk	Employment Level - Part-Time for Economic Reasons All Industries
log, I(1)	EmpHrs:Bus Sec	Business Sector: Hours of All Persons
log, I(1)	EmpHrs:nfb	Nonfarm Business Sector: Hours of All Persons
log, I(1)	Orders (DurMfg)	Mfrs' new orders durable goods industries (bil. chain 2000 $)
log, I(1)	Orders(ConsumerGoods/Mat.)	Mfrs' new orders consumer goods and materials (mil. 1982 $)
log, I(1)	UnfOrders(DurGds)	Mfrs' unfilled orders durable goods indus. (bil. chain 2000 $)
log, I(1)	Orders(NonDefCap)	Mfrs' new orders nondefense capital goods (mil. 1982 $)
log, I(1)	Real_AHE:Const	Average Hourly Earnings: Construction Defl by PCE(LFE) Def
log, I(1)	Real_AHE:MFG	Average Hourly Earnings: Manufacturing Defl by PCE(LFE) Def
log, I(1)	CPH:NFB	Nonfarm Business Sector: Real Compensation Per Hour
log, I(1)	CPH:Bus	Business Sector: Real Compensation Per Hour

tcode	short	long
log, I(1)	OPH:nfb	Nonfarm Business Sector: Output Per Hour of All Persons
log, I(1)	OPH:Bus	Business Sector: Output Per Hour of All Persons
log, I(1)	ULC:Bus	Business Sector: Unit Labor Cost
log, I(1)	ULC:NFB	Nonfarm Business Sector: Unit Labor Cost
log, I(1)	UNLPay:nfb	Nonfarm Business Sector: Unit Nonlabor Payments
log, I(1)	Real_mbase	St. Louis Adjusted Monetary Base; Bil. of $; M; SA; Defl by PCE(LFE) Def
log, I(1)	Real_m1	M1 Money Stock Defl by PCE(LFE) Def
log, I(1)	Real_m2	M2SL Defl by PCE(LFE) Def
log, I(1)	Real_mzm	MZM Money Stock Defl by PCE(LFE) Def
log, I(1)	Real_C&Lloand	Commercial and Industrial Loans at All Commercial Banks Defl by PCE(LFE) Def
log, I(1)	Real_ConsLoans	Consumer (Individual) Loans at All Commercial Banks - Outlier Code because of change in data in April 2010 ... see FRB H8 Release Defl by PCE(LFE) Def
log, I(1)	Real_NonRevCredit	Total Nonrevolving Credit Outstanding Defl by PCE(LFE) Def
log, I(1)	Real_LoansRealEst	Real Estate Loans at All Commercial Banks Defl by PCE(LFE) Def
log, I(1)	Real_ConsuCred	Total Consumer Credit Outstanding Defl by PCE(LFE) Def
log, I(1)	S&P 500	S&P'S COMMON STOCK PRICE INDEX: COMPOSITE (1941-43=10)
log, I(1)	DJIA	COMMON STOCK PRICES: DOW JONES INDUSTRIAL AVERAGE
log, I(1)	Ex rate: major	FRB Nominal Major Currencies Dollar Index (Linked to EXRUS in 1973:1)
log, I(1)	IP: Energy Prds	IP: Consumer Energy Products
log, I(1)	Petroleum Stocks	U.S. Ending Stocks excluding SPR of Crude Oil and Petroleum Products (Thousand Barrels); SA using X11 in RATS
log, I(1)	Real_Price:Oil	PPI: Crude Petroleum Defl by PCE(LFE) Def

Table 4: Number of 'Second-differenced in logs' series is 32

tcode	short	long
log, I(2)	PCED	Personal Consumption Expenditures: Chain-type Price Index
log, I(2)	PCED_LFE	Personal Consumption Expenditures: Chain-type Price Index Less Food and Energy
log, I(2)	GDP Defl	Gross Domestic Product: Chain-type Price Index
log, I(2)	GPDI Defl	Gross Private Domestic Investment: Chain-type Price Index
log, I(2)	BusSec Defl	Business Sector: Implicit Price Deflator
log, I(2)	PCED_Goods	Goods
log, I(2)	PCED_DurGoods	Durable goods
log, I(2)	PCED_NDurGoods	Nondurable goods
log, I(2)	PCED_Serv	Services
log, I(2)	PCED_HouseholdServices	Household consumption expenditures (for services)

tcode	short	long
log, I(2)	PCED_MotorVec	Motor vehicles and parts
log, I(2)	PCED_DurHousehold	Furnishings and durable household equipment
log, I(2)	PCED_Recreation	Recreational goods and vehicles
log, I(2)	PCED_OthDurGds	Other durable goods
log, I(2)	PCED_Food_Bev	Food and beverages purchased for off-premises consumption
log, I(2)	PCED_Clothing	Clothing and footwear
log, I(2)	PCED_Gas_Enrgy	Gasoline and other energy goods
log, I(2)	PCED_OthNDurGds	Other nondurable goods
log, I(2)	PCED_Housing-Utilities	Housing and utilities
log, I(2)	PCED_HealthCare	Health care
log, I(2)	PCED_TransSvg	Transportation services
log, I(2)	PCED_RecServices	Recreation services
log, I(2)	PCED_FoodServ_Acc.	Food services and accommodations
log, I(2)	PCED_FIRE	Financial services and insurance
log, I(2)	PCED_OtherServices	Other services
log, I(2)	CPI	Consumer Price Index For All Urban Consumers: All Items
log, I(2)	CPI_LFE	Consumer Price Index for All Urban Consumers: All Items Less Food & Energy
log, I(2)	PPI:FinGds	Producer Price Index: Finished Goods
log, I(2)	PPI:FinConsGds	Producer Price Index: Finished Consumer Goods
log, I(2)	PPI:FinConsGds(Food)	Producer Price Index: Finished Consumer Foods
log, I(2)	PPI:IndCom	Producer Price Index: Industrial Commodities
log, I(2)	PPI:IntMat	Producer Price Index: Intermediate Materials: Supplies & Components