

Regression Xiaolan 0418

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2023-04-20

Preparation

The **expected profit** of crop i in province j and year t is defined as

$$E\pi_{ijt} = \tilde{y}_{ijt}(\tilde{p}_{it} - c_{ijt}) + \tilde{d}_{ijt}$$

where:

- \tilde{p}_{it} : future price (yuan per kilogram) averaged in March for November delivery in year t
- c_{ijt} : the realized cost (yuan per kilogram) of crop i in province j and year t
- \tilde{y}_{ijt} : the yield (kilogram per mu) of crop i in province j averaged in the past three years, $\{t-3, t-2, t-1\}$.
- \tilde{d}_{ijt} : the expected subsidy (yuan per mu) of crop i in province j weighted for the past two years, with $\tilde{d}_{ijt} = 0.67 * d_{ij,t-1} + 0.33 * d_{ij,t-2}$

The **realized profit** of crop i in province j and year t is defined as

$$\pi_{ijt} = y_{ijt}(p_{ijt} - c_{ijt}) + d_{ijt}$$

where p_{ijt} is the realized price (yuan per kilogram) for crop i in province j and year t .

Thus, the expected revenue of crop i in province j and year t is

$$Er_{ijt} = \tilde{y}_{ijt}\tilde{p}_{it} + \tilde{d}_{ijt} = E\pi_{ijt} + \tilde{y}_{ijt}c_{ijt}$$

We define the relative revenue of crop i to a baseline crop wheat as:

$$rr_{ijt} = r_{ijt}/r_{3jt}$$

OLS regression

Suppose s_{ijt} is the share of cropland area for crop i in province j and year t . Let $s_{0jt} = 1 - \sum_{i=1}^3 s_{ijt}$.

We define $z_{ijt} = \log(s_{ijt}/s_{0jt})$ as the dependent variable.

Model 1 : Use expected profit as explanatory variable

$$z_{ijt} = \beta_{i0} + \sum_{k=1}^3 E\pi_{kjt}\beta_{ik} + u_j + \epsilon_{ijt}$$

where

- u_j : fixed effect for province j .
- ϵ_{ijt} : random error, assumed i.i.d. with normal distribution

Model 2 : Use expected revenue

$$z_{ijt} = \beta_{i0} + \sum_{k=1}^3 Er_{kjt}\beta_{ik} + u_j + \epsilon_{ijt}$$

Model 3: Use expected relative revenue

$$z_{ijt} = \beta_{i0} + \sum_{k=1}^2 Err_{kjt}\beta_{ik} + u_j + \epsilon_{ijt}$$

Some figures:

- (1) Expected profit against acreage share for corn:
- (2) Expected revenue against acreage share:
- (3) Logarithm of expected revenue against acreage share:

Model 1 Regression

```
lm_corn_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
  data = regdat %>% filter(crop == "corn"))

lm_rice_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
  data = regdat %>% filter(crop == "rice"))

lm_soy_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
  data = regdat %>% filter(crop == "soybean"))

stargazer(lm_corn_pf, lm_rice_pf, lm_soy_pf, title = "Model 1 Results", column.labels = c("Corn", "Rice", "Soybean"))
```

```
##
## Model 1 Results
## =====
##
##                y2
##           Corn  Rice  Soybean
##           (1)   (2)   (3)
## -----
## pfex_corn    -0.0005 -0.0003 -0.001
```

```
##                (0.0003)  (0.0004)  (0.0004)
##
## pfex_rice      -0.001*** -0.001***  0.0001
##                (0.0001)  (0.0001)  (0.0001)
##
## pfex_soy       0.0002    0.0001    0.001*
##                (0.0004)  (0.0005)  (0.0005)
##
## regionNeimenggu 0.316*** -3.190*** -1.529***
##                (0.116)  (0.128)  (0.136)
##
## regionJilin    1.854***    0.116   -1.161***
##                (0.095)  (0.105)  (0.111)
##
## regionLiaoning 1.273***   -0.234** -2.134***
##                (0.096)  (0.106)  (0.113)
##
## regionHeilongjiang 1.615***  0.959***  0.798***
##                (0.102)  (0.112)  (0.119)
##
## -----
## Observations      80        80        80
## R2                0.901      0.968      0.941
## Adjusted R2       0.892      0.965      0.936
## Residual Std. Error (df = 73) 0.328    0.362    0.384
## F Statistic (df = 7; 73)  94.975*** 314.206*** 166.889***
## =====
## Note:                *p<0.1; **p<0.05; ***p<0.01
##
## Model 1 Results
## =
## 3
## -
```

```
lm_corn_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
  data = regdat %>% filter(crop == "corn"))

lm_rice_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
  data = regdat %>% filter(crop == "rice"))

lm_soy_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
  data = regdat %>% filter(crop == "soybean"))

stargazer(lm_corn_rev, lm_rice_rev, lm_soy_rev, title = "Model 2 Results", column.labels = c("Corn", "Rice", "Soybean"))
```

Model 2 Regression

```
##
## Model 2 Results
```

```
## =====
##                               y2
##                               Rice
##                               Soybean
##                               (1)  (2)  (3)
## -----
## revex_corn                    0.001*   0.0005   -0.001
##                               (0.0004) (0.0004) (0.0004)
##
## revex_rice                    0.001***  0.001**   0.001**
##                               (0.0004) (0.0004) (0.0004)
##
## revex_soy                    0.002***  0.001**   0.001
##                               (0.001)  (0.001) (0.001)
##
## regionNeimenggu              -4.164*** -6.522*** -3.099***
##                               (0.773)  (0.831) (0.890)
##
## regionJilin                  -2.853*** -3.381*** -2.788***
##                               (0.767)  (0.824) (0.882)
##
## regionLiaoning               -3.576*** -3.847*** -3.917***
##                               (0.811)  (0.872) (0.934)
##
## regionHeilongjiang           -2.734*** -2.275*** -0.779
##                               (0.721)  (0.775) (0.830)
## -----
## Observations                  80         80         80
## R2                           0.902      0.970      0.943
## Adjusted R2                  0.892      0.967      0.938
## Residual Std. Error (df = 73) 0.327      0.351      0.376
## F Statistic (df = 7; 73)      95.850*** 334.140*** 174.003***
## =====
## Note:                        *p<0.1; **p<0.05; ***p<0.01
##
## Model 2 Results
## =
## 3
## -
```

```
lm_corn_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region, # rc_corn + rc_rice + rc_soy +
  data = regdat %>% filter(crop == "corn"))

lm_rice_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region,
  data = regdat %>% filter(crop == "rice"))

lm_soy_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region,
  data = regdat %>% filter(crop == "soybean"))

stargazer(lm_corn_rr, lm_rice_rr, lm_soy_rr, title = "Model 3 Results", column.labels = c("Corn", "Rice"
```

Model 3 Regression

```
##
## Model 3 Results
## =====
##               y2
##           Corn  Rice  Soybean
##           (1)   (2)   (3)
## -----
## rr_corn        0.535***  0.484**  -0.166
##                (0.190)  (0.194)  (0.205)
##
## rr_rice        -0.268*** -0.187***  0.022
##                (0.031)  (0.031)  (0.033)
##
## regionNeimenggu -0.268   -3.820*** -1.321***
##                (0.382)  (0.390)  (0.413)
##
## regionJilin     1.283***   -0.425  -0.937***
##                (0.260)  (0.265)  (0.280)
##
## regionLiaoning  0.802***  -0.690*** -1.914***
##                (0.239)  (0.244)  (0.258)
##
## regionHeilongjiang 1.131***  0.474*  0.972***
##                (0.267)  (0.272)  (0.288)
## -----
## Observations      80        80        80
## R2                 0.878      0.966      0.938
## Adjusted R2        0.868      0.963      0.933
## Residual Std. Error (df = 74) 0.362      0.369      0.391
## F Statistic (df = 6; 74)  88.750*** 351.123*** 186.964***
## =====
## Note:                *p<0.1; **p<0.05; ***p<0.01
##
## Model 3 Results
## =
## 3
## -
```

Model 4

use the last year's true profit

```
lm_corn_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_ soy + region,
  data = regdat %>% filter(crop == "corn"))

lm_rice_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_ soy + region,
  data = regdat %>% filter(crop == "rice"))

lm_ soy_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_ soy + region,
  data = regdat %>% filter(crop == "soybean"))
```

```
stargazer(lm_corn_pftr, lm_rice_pftr, lm_soy_pftr, title = "Model 4 Results", column.labels = c("Corn",
```

```
##
## Model 4 Results
## =====
##
##              Corn          y2          Soybean
##              (1)          (2)          (3)
## -----
## pftr_corn          -0.002**    -0.001**    -0.001
##                   (0.001)    (0.001)    (0.0005)
##
## pftr_rice           0.001**     0.0005    -0.001*
##                   (0.0004)    (0.0004)    (0.0003)
##
## pftr_soy            0.001       0.0002     0.001
##                   (0.001)    (0.001)    (0.001)
##
## regionNeimenggu    -0.448***   -3.622***   -1.330***
##                   (0.162)    (0.144)    (0.124)
##
## regionJilin         0.970***   -0.414***   -1.000***
##                   (0.162)    (0.144)    (0.124)
##
## regionLiaoning      0.335*     -0.783***   -1.925***
##                   (0.179)    (0.160)    (0.137)
##
## regionHeilongjiang  0.851***     0.508***     0.956***
##                   (0.144)    (0.128)    (0.110)
##
## -----
## Observations           80           80           80
## R2                     0.780         0.953         0.944
## Adjusted R2            0.759         0.949         0.939
## Residual Std. Error (df = 73)  0.489         0.436         0.374
## F Statistic (df = 7; 73)    36.949***    213.016***    175.621***
## =====
## Note:                  *p<0.1; **p<0.05; ***p<0.01
##
## Model 4 Results
## =
## 3
## -
```

Model 5

use the expected relative revenue, but set rice as baseline

```
lm_corn_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region, # rc_corn + rc_rice + rc_soy +
  data = regdat %>% filter(crop == "corn"))
```

```
lm_rice_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region,
  data = regdat %>% filter(crop == "rice"))

lm_soy_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region,
  data = regdat %>% filter(crop == "soybean"))

stargazer(lm_corn_rr2, lm_rice_rr2, lm_soy_rr2, title = "Model 5 Results", column.labels = c("Corn", "Ri
```

```
##
## Model 5 Results
## =====
##
```

	y2		
	Corn	Rice	Soybean
	(1)	(2)	(3)
rr_corn2	0.312 (0.720)	0.076 (0.712)	-1.252* (0.723)
rr_soy2	2.695** (1.116)	2.110* (1.104)	1.439 (1.122)
regionNeimenggu	-1.226*** (0.172)	-4.237*** (0.170)	-1.289*** (0.173)
regionJilin	0.053 (0.172)	-1.137*** (0.170)	-0.975*** (0.173)
regionLiaoning	-0.446*** (0.167)	-1.436*** (0.165)	-1.999*** (0.168)
regionHeilongjiang	-0.055 (0.157)	-0.200 (0.155)	0.934*** (0.157)
Observations	80	80	80
R2	0.865	0.965	0.941
Adjusted R2	0.854	0.962	0.936
Residual Std. Error (df = 74)	0.381	0.377	0.383
F Statistic (df = 6; 74)	78.798***	336.412***	195.100***

```
## =====
## Note: *p<0.1; **p<0.05; ***p<0.01
##
## Model 5 Results
## =
## 3
## -
```

Prediction Results True Result in 2021

```
share_true %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pandrer::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	48.09	71.14	62.93	43.31
rice	1.77	13.53	12.03	25.67
soybean	10.22	4.08	2.4	25.81

Model 1 Prediction

```
share_est_pf %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	43.21	68.54	62.06	42.75
rice	1.46	12.99	14.46	23.5
soybean	9.68	4.97	3.16	23.58

Model 2 Prediction

```
share_est_rev %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	59.4	77.73	70.61	52.26
rice	1.67	12.13	14.3	24.36
soybean	6.15	2.72	2.21	16.69

Model 3 Prediction

```
share_est_rr %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	49.81	68.25	58.61	42.53
rice	1.52	13.12	14.34	23.45
soybean	8.25	4.57	3.1	23.45

Model 4 Prediction

```
share_est_pftr %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	26.95	59.42	56.45	31.44
rice	1.1	13.12	14.25	21.47

	Neimenggu	Jilin	Liaoning	Heilongjiang
soybean	12.04	6.33	3.66	33.75

Model 5 prediction

```
share_est_rr2 %>% data.frame() %>% "colnames<-"(unique(regdat$region)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

	Neimenggu	Jilin	Liaoning	Heilongjiang
corn	55.88	74.68	65.63	51.1
rice	1.63	12.71	14.9	24.87
soybean	6.27	3.09	2.54	16.8

```
MSE1 <- rowMeans((share_true - share_est_pf)^2)
MSE2 <- rowMeans((share_true - share_est_rev)^2)
MSE3 <- rowMeans((share_true - share_est_rr)^2)
MSE4 <- rowMeans((share_true - share_est_pftr)^2)
MSE5 <- rowMeans((share_true - share_est_rr2)^2)

cbind(MSE1, MSE2, MSE3, MSE4, MSE5) %>% "colnames<-"(paste0("Model", 1:5)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()
```

MSE Results

	Model1	Model2	Model3	Model4	Model5
corn	7.911	77.61	7.645	191.8	35.3
rice	2.75	2.21	2.624	5.796	2.392
soybean	1.659	25.41	2.545	18.25	24.45

Predicted Shares

$$y_{2,corn} = \log(s_{corn}/s_{other}) \Rightarrow \exp(y_{2,corn}) = s_{corn}/s_{other}$$

$$s_{corn}/s_{other} + s_{rice}/s_{other} + s_{soy}/s_{other} + 1 = 1/s_{other}$$

```
alldat <- rbind(regdat, preddat) %>%
  arrange(region, crop, year)

share_true = c(alldat$share[1:63], alldat$other[64:84],
               alldat$share[(1:63) + 84], alldat$other[(64:84) + 84],
               alldat$share[(1:63) + 84 * 2], alldat$other[(64:84) + 84 * 2],
               alldat$share[(1:63) + 84 * 3], alldat$other[(64:84) + 84 * 3]) %>%

matrix(., ncol = 4)
```

```

# model 1: predict y2 first
pd_corn_pf_all <- predict(lm_corn_pf, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "corn"))
pd_rice_pf_all <- predict(lm_rice_pf, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "rice"))
pd_soy_pf_all <- predict(lm_soy_pf, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "soybean"))

# model 1: transform back to share
# Neimenggu 2001, Neimenggu 2002, ..., Neimenggu 2021,
s_other_pf <- 1/(exp(pd_corn_pf_all) + exp(pd_rice_pf_all) + exp(pd_soy_pf_all) + 1)
s_corn_pf <- s_other_pf * exp(pd_corn_pf_all)
s_rice_pf <- s_other_pf * exp(pd_rice_pf_all)
s_soy_pf <- s_other_pf * exp(pd_soy_pf_all)

# model 2: predict y2 first
pd_corn_rev_all <- predict(lm_corn_rev, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "corn"))
pd_rice_rev_all <- predict(lm_rice_rev, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "rice"))
pd_soy_rev_all <- predict(lm_soy_rev, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "soybean"))

# model 2: transform back to share
s_other_rev <- 1/(exp(pd_corn_rev_all) + exp(pd_rice_rev_all) + exp(pd_soy_rev_all) + 1)
s_corn_rev <- s_other_rev * exp(pd_corn_rev_all)
s_rice_rev <- s_other_rev * exp(pd_rice_rev_all)
s_soy_rev <- s_other_rev * exp(pd_soy_rev_all)

# model 3: predict y2 first
pd_corn_rr_all <- predict(lm_corn_rr, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "corn"))
pd_rice_rr_all <- predict(lm_rice_rr, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "rice"))
pd_soy_rr_all <- predict(lm_soy_rr, newdata = rbind(regdat, preddat) %>%
  arrange(region, crop, year) %>% filter(crop == "soybean"))

# model 3: relative revenue
# Neimenggu 2001, Neimenggu 2002, ..., Neimenggu 2021,
s_other_rr <- 1/(exp(pd_corn_rr_all) + exp(pd_rice_rr_all) + exp(pd_soy_rr_all) + 1)
s_corn_rr <- s_other_rr * exp(pd_corn_rr_all)
s_rice_rr <- s_other_rr * exp(pd_rice_rr_all)
s_soy_rr <- s_other_rr * exp(pd_soy_rr_all)

# combine the results
predshare <- data.frame(region = rep(rep(c("Neimenggu", "Jilin", "Liaoning", "Heilongjiang"), each = 21),
  crop = rep(c("corn", "rice", "soybean", "other"), each = 84),
  year = rep(2001:2021, 16),
  share_true = c(share_true[1:21, ], share_true[22:42, ],
    share_true[43:63, ], share_true[64:84, ]),

```

```
share_pf = round(100 * c(s_corn_pf, s_rice_pf, s_soy_pf, s_other_pf), 2),
share_rev = round(100 * c(s_corn_rev, s_rice_rev, s_soy_rev, s_other_rev), 2),
share_rr = round(100 * c(s_corn_rr, s_rice_rr, s_soy_rr, s_other_rr), 2))
```

Cross Validation

We will use cross validation to compare the models.

```
# combine two datasets
alldat <- rbind(regdat, preddat) %>% arrange(region, crop, year)

alldat <- alldat %>%
  mutate(ex_revenue = yield_lag * ex_price + subsidy_lag,
         tcost = yield_lag * cost,
         rcratio = (yield_lag * ex_price + subsidy_lag)/(yield_lag * cost))

alldat <- alldat %>%
  mutate(share_wheat = alldat %>% filter(crop == "wheat") %>% "$"(share) %>%
         matrix(., nrow = 21) %>% # use 21 here since we have 21 years
         kronecker(rep(1, 4), .) %>% as.vector()) %>%
  mutate(y2 = log(share/(other + share_wheat))) # get new y2 since now we combine other

alldat <- alldat %>%
  mutate(pfex_corn = alldat %>% filter(crop == "corn") %>% "$"(profit_ex) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pfex_rice = alldat %>% filter(crop == "rice") %>% "$"(profit_ex) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pfex_soy = alldat %>% filter(crop == "soybean") %>% "$"(profit_ex) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pfex_wheat = alldat %>% filter(crop == "wheat") %>% "$"(profit_ex) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),

         pftr_corn = alldat %>% filter(crop == "corn") %>% "$"(profit_true_lag) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pftr_rice = alldat %>% filter(crop == "rice") %>% "$"(profit_true_lag) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pftr_soy = alldat %>% filter(crop == "soybean") %>% "$"(profit_true_lag) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         pftr_wheat = alldat %>% filter(crop == "wheat") %>% "$"(profit_true_lag) %>%
         matrix(., nrow = 21) %>% # "+"(400) %>% log() %>%
         kronecker(rep(1, 4), .) %>% as.vector(),

         revex_corn = alldat %>% filter(crop == "corn") %>% "$"(ex_revenue) %>%
         matrix(., nrow = 21) %>%
         kronecker(rep(1, 4), .) %>% as.vector(),
         revex_rice = alldat %>% filter(crop == "rice") %>% "$"(ex_revenue) %>%
```

```

matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),
revex_soy = alldat %>% filter(crop == "soybean") %>% "$"(ex_revenue) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),
revex_wheat = alldat %>% filter(crop == "wheat") %>% "$"(ex_revenue) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),

tcost_corn = alldat %>% filter(crop == "corn") %>% "$"(tcost) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),
tcost_rice = alldat %>% filter(crop == "rice") %>% "$"(tcost) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),
tcost_soy = alldat %>% filter(crop == "soybean") %>% "$"(tcost) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector(),
tcost_wheat = alldat %>% filter(crop == "wheat") %>% "$"(tcost) %>%
matrix(., nrow = 21) %>%
kronecker(rep(1, 4), .) %>% as.vector())%>%
mutate(rr_corn = revex_corn/revex_soy,
rr_rice = revex_rice/revex_soy,
rc_corn = tcost_corn/tcost_soy,
rc_rice = tcost_rice/tcost_soy,
rr_corn2 = revex_corn/revex_rice,
rr_soy2 = revex_soy/revex_rice)

```

Start the cross validation:

```

RMSE1_list <- NULL
RMSE2_list <- NULL
RMSE3_list <- NULL
RMSE4_list <- NULL
RMSE5_list <- NULL
for(i in 2001:2021)
{
  # Step 1: select regdat and preddat
  regdat <- alldat %>% filter(year != i)
  preddat <- alldat %>% filter(year == i)

  # Step 2: get the true share
  share_true <- preddat$share %>% matrix(., nrow = 4) %>% "["(-4,)

  # Step 3: run all the models

  # model 1
  lm_corn_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
    data = regdat %>% filter(crop == "corn"))

  lm_rice_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
    data = regdat %>% filter(crop == "rice"))

```

```

lm_soy_pf <- lm(y2 ~ 0 + pfex_corn + pfex_rice + pfex_soy + region,
               data = regdat %>% filter(crop == "soybean"))

# model 2
lm_corn_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
                 data = regdat %>% filter(crop == "corn"))

lm_rice_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
                 data = regdat %>% filter(crop == "rice"))

lm_soy_rev <- lm(y2 ~ 0 + revex_corn + revex_rice + revex_soy + region,
                 data = regdat %>% filter(crop == "soybean"))

# model 3
lm_corn_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region, # rc_corn + rc_rice + rc_soy +
                 data = regdat %>% filter(crop == "corn"))

lm_rice_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region,
                 data = regdat %>% filter(crop == "rice"))

lm_soy_rr <- lm(y2 ~ 0 + rr_corn + rr_rice + region,
                 data = regdat %>% filter(crop == "soybean"))

# model 4
lm_corn_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_soy + region,
                  data = regdat %>% filter(crop == "corn"))

lm_rice_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_soy + region,
                  data = regdat %>% filter(crop == "rice"))

lm_soy_pftr <- lm(y2 ~ 0 + pftr_corn + pftr_rice + pftr_soy + region,
                  data = regdat %>% filter(crop == "soybean"))

# model 5
lm_corn_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region, # rc_corn + rc_rice + rc_soy +
                 data = regdat %>% filter(crop == "corn"))

lm_rice_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region,
                 data = regdat %>% filter(crop == "rice"))

lm_soy_rr2 <- lm(y2 ~ 0 + rr_corn2 + rr_soy2 + region,
                 data = regdat %>% filter(crop == "soybean"))

# Step 4: calculate the predict share:

# model 1
pd_corn_pf <- predict(lm_corn_pf, newdata = preddat %>% filter(crop == "corn"))
pd_rice_pf <- predict(lm_rice_pf, newdata = preddat %>% filter(crop == "rice"))
pd_soy_pf <- predict(lm_soy_pf, newdata = preddat %>% filter(crop == "soybean"))

```

```

y_pred_pf <- rbind(pd_corn_pf, pd_rice_pf, pd_soy_pf)

share_est_pf <- round(sweep(exp(y_pred_pf), MARGIN = 2, FUN = "/", STATS =
                        colSums(exp(y_pred_pf)) + 1) * 100, 2)

# model 2
pd_corn_rev <- predict(lm_corn_rev, newdata = preddat %>% filter(crop == "corn"))
pd_rice_rev <- predict(lm_rice_rev, newdata = preddat %>% filter(crop == "rice"))
pd_soy_rev <- predict(lm_soy_rev, newdata = preddat %>% filter(crop == "soybean"))

y_pred_rev <- rbind(pd_corn_rev, pd_rice_rev, pd_soy_rev)

share_est_rev <- round(sweep(exp(y_pred_rev), MARGIN = 2, FUN = "/", STATS =
                        colSums(exp(y_pred_rev)) + 1) * 100, 2)

# model 3:
pd_corn_rr <- predict(lm_corn_rr, newdata = preddat %>% filter(crop == "corn"))
pd_rice_rr <- predict(lm_rice_rr, newdata = preddat %>% filter(crop == "rice"))
pd_soy_rr <- predict(lm_soy_rr, newdata = preddat %>% filter(crop == "soybean"))

y_pred_rr <- rbind(pd_corn_rr, pd_rice_rr, pd_soy_rr)

share_est_rr <- round(sweep(exp(y_pred_rr), MARGIN = 2, FUN = "/", STATS =
                        colSums(exp(y_pred_rr)) + 1) * 100, 2)

# model 4:
pd_corn_pftr <- predict(lm_corn_pftr, newdata = preddat %>% filter(crop == "corn"))
pd_rice_pftr <- predict(lm_rice_pftr, newdata = preddat %>% filter(crop == "rice"))
pd_soy_pftr <- predict(lm_soy_pftr, newdata = preddat %>% filter(crop == "soybean"))

y_pred_pftr <- rbind(pd_corn_pftr, pd_rice_pftr, pd_soy_pftr)

share_est_pftr <- round(sweep(exp(y_pred_pftr), MARGIN = 2, FUN = "/", STATS =
                        colSums(exp(y_pred_pftr)) + 1) * 100, 2)

# model 5:
pd_corn_rr2 <- predict(lm_corn_rr2, newdata = preddat %>% filter(crop == "corn"))
pd_rice_rr2 <- predict(lm_rice_rr2, newdata = preddat %>% filter(crop == "rice"))
pd_soy_rr2 <- predict(lm_soy_rr2, newdata = preddat %>% filter(crop == "soybean"))

y_pred_rr2 <- rbind(pd_corn_rr2, pd_rice_rr2, pd_soy_rr2)

share_est_rr2 <- round(sweep(exp(y_pred_rr2), MARGIN = 2, FUN = "/", STATS =
                        colSums(exp(y_pred_rr2)) + 1) * 100, 2)

# Step 5: calculate the RMSE
RMSE1 <- rowMeans((share_true - share_est_pf)^2) %>% sqrt()
RMSE2 <- rowMeans((share_true - share_est_rev)^2) %>% sqrt()
RMSE3 <- rowMeans((share_true - share_est_rr)^2) %>% sqrt()
RMSE4 <- rowMeans((share_true - share_est_pftr)^2) %>% sqrt()
RMSE5 <- rowMeans((share_true - share_est_rr2)^2) %>% sqrt()

```

```

# Step 6: combine the results
RMSE1_list <- rbind(RMSE1_list, RMSE1)
RMSE2_list <- rbind(RMSE2_list, RMSE2)
RMSE3_list <- rbind(RMSE3_list, RMSE3)
RMSE4_list <- rbind(RMSE4_list, RMSE4)
RMSE5_list <- rbind(RMSE5_list, RMSE5)
}

RMSE1_avg <- colMeans(RMSE1_list)
RMSE2_avg <- colMeans(RMSE2_list)
RMSE3_avg <- colMeans(RMSE3_list)
RMSE4_avg <- colMeans(RMSE4_list)
RMSE5_avg <- colMeans(RMSE5_list)

```

The RMSE table:

```

cbind(RMSE1_avg, RMSE2_avg, RMSE3_avg, RMSE4_avg, RMSE5_avg) %>%
  "colnames<-"(paste0("Model", 1:5)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()

```

	Model1	Model2	Model3	Model4	Model5
corn	3.964	4.234	4.818	7.639	5.013
rice	1.747	1.857	1.761	2.503	1.824
soybean	2.342	2.724	2.818	3.411	2.565

The standard deviation of RMSE

```

RMSE1_sd <- apply(RMSE1_list, MARGIN = 2, FUN = sd)
RMSE2_sd <- apply(RMSE2_list, MARGIN = 2, FUN = sd)
RMSE3_sd <- apply(RMSE3_list, MARGIN = 2, FUN = sd)
RMSE4_sd <- apply(RMSE4_list, MARGIN = 2, FUN = sd)
RMSE5_sd <- apply(RMSE5_list, MARGIN = 2, FUN = sd)

cbind(RMSE1_sd, RMSE2_sd, RMSE3_sd, RMSE4_sd, RMSE5_sd) %>%
  "colnames<-"(paste0("Model", 1:5)) %>%
  "rownames<-"(unique(regdat$crop)[-4]) %>% pander::pander()

```

	Model1	Model2	Model3	Model4	Model5
corn	0.9372	3.028	1.655	3.18	1.869
rice	0.6454	0.6957	0.7443	0.8889	0.7277
soybean	1.65	1.862	1.909	1.736	1.607

```
print(predshare)
```

```

##      region  crop year share_true share_pf share_rev share_rr
## 1  Neimenggu  corn 2001    26.61    24.35    26.56    20.67
## 2  Neimenggu  corn 2002    26.54    25.27    27.12    20.77
## 3  Neimenggu  corn 2003    27.66    26.51    26.58    23.28

```

## 4	Neimenggu	corn	2004	28.28	28.60	28.74	31.10
## 5	Neimenggu	corn	2005	29.05	28.69	25.37	26.95
## 6	Neimenggu	corn	2006	30.44	31.39	27.07	31.14
## 7	Neimenggu	corn	2007	29.76	29.15	28.99	35.29
## 8	Neimenggu	corn	2008	34.11	29.77	36.53	37.99
## 9	Neimenggu	corn	2009	35.38	30.53	32.63	31.57
## 10	Neimenggu	corn	2010	35.50	33.61	31.38	38.73
## 11	Neimenggu	corn	2011	37.55	37.36	40.90	45.92
## 12	Neimenggu	corn	2012	39.61	41.23	42.07	46.86
## 13	Neimenggu	corn	2013	43.97	43.72	52.68	45.18
## 14	Neimenggu	corn	2014	45.84	42.56	48.99	45.22
## 15	Neimenggu	corn	2015	45.02	46.92	47.51	46.88
## 16	Neimenggu	corn	2016	42.91	49.35	34.17	39.23
## 17	Neimenggu	corn	2017	41.23	48.92	40.53	40.64
## 18	Neimenggu	corn	2018	42.41	44.63	42.79	41.12
## 19	Neimenggu	corn	2019	42.50	45.28	42.56	42.06
## 20	Neimenggu	corn	2020	43.05	43.99	48.62	43.42
## 21	Neimenggu	corn	2021	48.09	43.21	59.40	49.81
## 22	Jilin	corn	2001	53.36	49.66	50.10	47.46
## 23	Jilin	corn	2002	55.03	50.70	51.02	48.20
## 24	Jilin	corn	2003	55.70	52.43	50.58	51.10
## 25	Jilin	corn	2004	59.17	53.38	54.22	58.30
## 26	Jilin	corn	2005	56.02	53.91	53.51	57.36
## 27	Jilin	corn	2006	57.79	54.41	55.35	58.76
## 28	Jilin	corn	2007	57.72	55.72	60.62	61.52
## 29	Jilin	corn	2008	58.47	56.66	64.80	63.05
## 30	Jilin	corn	2009	58.24	59.42	59.77	61.53
## 31	Jilin	corn	2010	58.35	61.85	59.72	63.55
## 32	Jilin	corn	2011	60.02	63.96	66.23	67.74
## 33	Jilin	corn	2012	61.79	67.17	65.76	67.97
## 34	Jilin	corn	2013	64.64	70.06	69.82	68.29
## 35	Jilin	corn	2014	65.83	69.70	68.96	67.93
## 36	Jilin	corn	2015	66.91	70.93	67.91	68.52
## 37	Jilin	corn	2016	69.96	71.44	59.31	64.01
## 38	Jilin	corn	2017	68.42	68.63	67.67	65.19
## 39	Jilin	corn	2018	69.59	67.45	69.98	66.03
## 40	Jilin	corn	2019	68.98	68.75	69.18	66.28
## 41	Jilin	corn	2020	69.70	69.27	71.89	66.25
## 42	Jilin	corn	2021	71.14	68.54	77.73	68.25
## 43	Liaoning	corn	2001	39.52	41.32	40.43	40.68
## 44	Liaoning	corn	2002	37.58	42.37	41.52	41.42
## 45	Liaoning	corn	2003	38.58	43.36	41.90	43.36
## 46	Liaoning	corn	2004	42.94	43.84	47.56	49.91
## 47	Liaoning	corn	2005	47.21	44.53	47.05	47.96
## 48	Liaoning	corn	2006	52.65	45.50	47.16	48.80
## 49	Liaoning	corn	2007	53.96	45.66	50.42	52.03
## 50	Liaoning	corn	2008	50.72	47.69	56.35	54.52
## 51	Liaoning	corn	2009	50.12	49.06	50.93	52.56
## 52	Liaoning	corn	2010	51.38	55.88	51.58	54.71
## 53	Liaoning	corn	2011	51.49	56.19	53.38	59.16
## 54	Liaoning	corn	2012	52.41	59.32	53.31	59.22
## 55	Liaoning	corn	2013	53.35	59.85	58.07	60.14
## 56	Liaoning	corn	2014	55.96	57.54	60.48	59.76
## 57	Liaoning	corn	2015	57.27	60.74	59.35	60.24

## 58	Liaoning	corn	2016	65.76	63.02	49.87	54.12
## 59	Liaoning	corn	2017	64.52	58.89	59.32	54.65
## 60	Liaoning	corn	2018	64.49	60.26	62.86	54.82
## 61	Liaoning	corn	2019	63.43	61.54	61.38	55.49
## 62	Liaoning	corn	2020	62.95	60.98	64.52	56.23
## 63	Liaoning	corn	2021	62.93	62.06	70.61	58.61
## 64	Heilongjiang	corn	2001	21.48	24.03	25.16	21.44
## 65	Heilongjiang	corn	2002	23.18	24.68	25.48	22.02
## 66	Heilongjiang	corn	2003	20.95	27.02	24.93	25.51
## 67	Heilongjiang	corn	2004	22.04	27.85	26.39	30.88
## 68	Heilongjiang	corn	2005	22.02	28.66	25.95	28.64
## 69	Heilongjiang	corn	2006	31.57	28.18	28.57	29.13
## 70	Heilongjiang	corn	2007	32.64	28.31	33.40	33.36
## 71	Heilongjiang	corn	2008	29.73	29.90	36.53	36.00
## 72	Heilongjiang	corn	2009	33.06	32.29	32.52	33.61
## 73	Heilongjiang	corn	2010	35.94	34.52	33.37	36.84
## 74	Heilongjiang	corn	2011	37.53	37.10	40.23	42.50
## 75	Heilongjiang	corn	2012	42.42	40.28	40.49	42.80
## 76	Heilongjiang	corn	2013	44.65	41.98	42.84	42.76
## 77	Heilongjiang	corn	2014	44.50	40.77	41.47	42.19
## 78	Heilongjiang	corn	2015	47.35	43.18	42.47	43.22
## 79	Heilongjiang	corn	2016	44.02	45.24	34.39	37.57
## 80	Heilongjiang	corn	2017	39.70	40.96	40.24	38.50
## 81	Heilongjiang	corn	2018	43.06	40.59	41.95	38.39
## 82	Heilongjiang	corn	2019	39.77	43.72	41.71	38.57
## 83	Heilongjiang	corn	2020	36.76	44.03	44.83	39.33
## 84	Heilongjiang	corn	2021	43.31	42.75	52.26	42.53
## 85	Neimenggu	rice	2001	1.51	1.09	1.14	1.02
## 86	Neimenggu	rice	2002	1.53	1.11	1.15	0.99
## 87	Neimenggu	rice	2003	1.16	1.15	1.14	1.10
## 88	Neimenggu	rice	2004	1.37	1.20	1.18	1.19
## 89	Neimenggu	rice	2005	1.36	1.19	1.10	1.17
## 90	Neimenggu	rice	2006	1.14	1.26	1.14	1.31
## 91	Neimenggu	rice	2007	1.18	1.21	1.19	1.47
## 92	Neimenggu	rice	2008	1.43	1.22	1.36	1.39
## 93	Neimenggu	rice	2009	1.47	1.24	1.29	1.33
## 94	Neimenggu	rice	2010	1.32	1.30	1.24	1.43
## 95	Neimenggu	rice	2011	1.27	1.37	1.43	1.50
## 96	Neimenggu	rice	2012	1.25	1.43	1.45	1.51
## 97	Neimenggu	rice	2013	1.05	1.47	1.61	1.45
## 98	Neimenggu	rice	2014	1.06	1.46	1.56	1.47
## 99	Neimenggu	rice	2015	1.04	1.52	1.54	1.49
## 100	Neimenggu	rice	2016	1.21	1.55	1.29	1.31
## 101	Neimenggu	rice	2017	1.36	1.53	1.43	1.40
## 102	Neimenggu	rice	2018	1.70	1.48	1.48	1.43
## 103	Neimenggu	rice	2019	1.81	1.49	1.46	1.40
## 104	Neimenggu	rice	2020	1.81	1.47	1.55	1.40
## 105	Neimenggu	rice	2021	1.77	1.46	1.67	1.52
## 106	Jilin	rice	2001	14.05	13.09	13.05	12.77
## 107	Jilin	rice	2002	14.21	13.12	13.10	12.59
## 108	Jilin	rice	2003	11.47	13.27	13.07	13.14
## 109	Jilin	rice	2004	12.24	13.23	13.18	12.94
## 110	Jilin	rice	2005	13.20	13.34	13.19	13.14
## 111	Jilin	rice	2006	13.17	13.39	13.32	13.48

## 112	Jilin	rice	2007	13.55	13.44	13.46	13.51
## 113	Jilin	rice	2008	13.18	13.32	13.35	13.13
## 114	Jilin	rice	2009	13.01	13.45	13.43	13.44
## 115	Jilin	rice	2010	12.90	13.40	13.38	13.37
## 116	Jilin	rice	2011	13.24	13.39	13.27	13.39
## 117	Jilin	rice	2012	13.19	13.22	13.29	13.44
## 118	Jilin	rice	2013	13.42	13.03	13.09	13.37
## 119	Jilin	rice	2014	13.30	13.09	13.18	13.48
## 120	Jilin	rice	2015	13.41	13.00	13.21	13.45
## 121	Jilin	rice	2016	13.20	12.87	13.31	13.15
## 122	Jilin	rice	2017	13.49	13.19	13.28	13.38
## 123	Jilin	rice	2018	13.81	13.24	13.19	13.61
## 124	Jilin	rice	2019	13.74	13.04	13.19	13.40
## 125	Jilin	rice	2020	13.61	12.99	12.93	13.20
## 126	Jilin	rice	2021	13.53	12.99	12.13	13.12
## 127	Liaoning	rice	2001	13.00	13.67	13.36	13.57
## 128	Liaoning	rice	2002	14.61	13.77	13.52	13.41
## 129	Liaoning	rice	2003	13.46	13.90	13.55	13.92
## 130	Liaoning	rice	2004	14.62	13.88	14.14	14.00
## 131	Liaoning	rice	2005	14.97	13.98	14.16	14.06
## 132	Liaoning	rice	2006	16.59	14.10	14.17	14.47
## 133	Liaoning	rice	2007	17.84	14.12	14.44	14.71
## 134	Liaoning	rice	2008	17.73	14.20	14.75	14.44
## 135	Liaoning	rice	2009	16.76	14.37	14.46	14.62
## 136	Liaoning	rice	2010	16.63	14.61	14.43	14.68
## 137	Liaoning	rice	2011	15.91	14.64	14.35	14.85
## 138	Liaoning	rice	2012	15.72	14.64	14.33	14.82
## 139	Liaoning	rice	2013	15.42	14.65	14.51	14.72
## 140	Liaoning	rice	2014	13.50	14.73	14.65	14.84
## 141	Liaoning	rice	2015	12.91	14.71	14.63	15.00
## 142	Liaoning	rice	2016	11.23	14.52	14.26	14.42
## 143	Liaoning	rice	2017	11.81	14.65	14.90	14.64
## 144	Liaoning	rice	2018	11.61	14.58	14.96	14.72
## 145	Liaoning	rice	2019	12.02	14.53	14.86	14.42
## 146	Liaoning	rice	2020	12.14	14.50	14.77	14.31
## 147	Liaoning	rice	2021	12.03	14.46	14.30	14.34
## 148	Heilongjiang	rice	2001	15.78	18.60	18.96	17.29
## 149	Heilongjiang	rice	2002	15.87	18.77	18.97	17.17
## 150	Heilongjiang	rice	2003	13.17	19.82	19.05	19.09
## 151	Heilongjiang	rice	2004	16.06	19.78	19.48	20.14
## 152	Heilongjiang	rice	2005	16.37	20.31	19.39	19.86
## 153	Heilongjiang	rice	2006	19.03	20.40	20.37	20.81
## 154	Heilongjiang	rice	2007	18.94	20.66	21.84	22.34
## 155	Heilongjiang	rice	2008	19.78	20.67	22.48	22.42
## 156	Heilongjiang	rice	2009	20.29	21.78	21.67	22.44
## 157	Heilongjiang	rice	2010	22.78	22.25	22.08	23.26
## 158	Heilongjiang	rice	2011	24.10	23.09	23.95	24.64
## 159	Heilongjiang	rice	2012	25.09	23.80	24.01	24.60
## 160	Heilongjiang	rice	2013	26.03	24.17	24.27	24.42
## 161	Heilongjiang	rice	2014	26.22	23.73	24.10	24.66
## 162	Heilongjiang	rice	2015	25.60	24.17	24.34	24.79
## 163	Heilongjiang	rice	2016	26.47	24.01	22.09	22.39
## 164	Heilongjiang	rice	2017	26.74	23.30	23.23	22.84
## 165	Heilongjiang	rice	2018	25.78	23.54	23.46	22.96

## 166	Heilongjiang	rice	2019	25.81	23.86	23.33	22.63
## 167	Heilongjiang	rice	2020	25.97	23.54	23.61	22.60
## 168	Heilongjiang	rice	2021	25.67	23.50	24.36	23.45
## 169	Neimenggu	soybean	2001	13.23	13.36	13.42	13.62
## 170	Neimenggu	soybean	2002	10.13	13.54	13.83	14.04
## 171	Neimenggu	soybean	2003	12.12	12.80	13.02	13.02
## 172	Neimenggu	soybean	2004	12.71	12.07	12.62	12.28
## 173	Neimenggu	soybean	2005	12.82	12.78	12.55	12.53
## 174	Neimenggu	soybean	2006	14.94	10.78	11.81	11.32
## 175	Neimenggu	soybean	2007	11.19	11.32	11.05	10.04
## 176	Neimenggu	soybean	2008	9.74	12.58	10.95	10.31
## 177	Neimenggu	soybean	2009	12.13	11.48	11.95	11.15
## 178	Neimenggu	soybean	2010	11.60	11.62	10.71	10.02
## 179	Neimenggu	soybean	2011	9.67	10.01	8.79	8.89
## 180	Neimenggu	soybean	2012	8.62	9.87	8.44	8.72
## 181	Neimenggu	soybean	2013	7.83	9.80	8.21	9.26
## 182	Neimenggu	soybean	2014	6.85	9.23	8.52	9.13
## 183	Neimenggu	soybean	2015	7.00	7.79	8.08	8.80
## 184	Neimenggu	soybean	2016	6.87	7.44	10.93	10.74
## 185	Neimenggu	soybean	2017	10.97	8.96	10.29	10.00
## 186	Neimenggu	soybean	2018	12.40	9.19	10.06	9.81
## 187	Neimenggu	soybean	2019	13.39	9.61	9.83	9.90
## 188	Neimenggu	soybean	2020	13.53	10.05	9.05	9.74
## 189	Neimenggu	soybean	2021	10.22	9.68	6.15	8.25
## 190	Jilin	soybean	2001	8.85	10.18	9.99	10.40
## 191	Jilin	soybean	2002	8.85	10.05	10.11	10.40
## 192	Jilin	soybean	2003	9.12	9.09	9.46	9.20
## 193	Jilin	soybean	2004	10.72	9.31	8.58	7.49
## 194	Jilin	soybean	2005	10.19	8.52	8.58	7.59
## 195	Jilin	soybean	2006	4.86	8.15	7.88	6.97
## 196	Jilin	soybean	2007	9.00	7.71	6.73	6.21
## 197	Jilin	soybean	2008	9.15	8.31	6.06	6.03
## 198	Jilin	soybean	2009	8.61	6.88	6.88	6.25
## 199	Jilin	soybean	2010	7.22	6.33	6.46	5.74
## 200	Jilin	soybean	2011	5.84	5.46	4.46	4.56
## 201	Jilin	soybean	2012	4.33	4.74	4.45	4.47
## 202	Jilin	soybean	2013	3.96	3.84	3.83	4.42
## 203	Jilin	soybean	2014	3.80	3.86	4.05	4.46
## 204	Jilin	soybean	2015	2.84	3.47	4.02	4.31
## 205	Jilin	soybean	2016	3.30	3.67	6.51	5.75
## 206	Jilin	soybean	2017	3.62	4.03	4.97	5.28
## 207	Jilin	soybean	2018	4.59	4.52	4.37	4.91
## 208	Jilin	soybean	2019	5.64	4.63	4.47	4.96
## 209	Jilin	soybean	2020	5.22	4.52	4.12	5.09
## 210	Jilin	soybean	2021	4.08	4.97	2.72	4.57
## 211	Liaoning	soybean	2001	8.40	5.17	5.13	5.37
## 212	Liaoning	soybean	2002	7.49	5.19	5.23	5.39
## 213	Liaoning	soybean	2003	8.20	4.84	4.93	4.96
## 214	Liaoning	soybean	2004	7.95	5.36	4.62	4.26
## 215	Liaoning	soybean	2005	6.68	4.97	4.67	4.45
## 216	Liaoning	soybean	2006	3.42	4.50	4.39	4.18
## 217	Liaoning	soybean	2007	3.52	4.44	3.97	3.74
## 218	Liaoning	soybean	2008	4.87	4.82	3.61	3.56
## 219	Liaoning	soybean	2009	4.19	4.10	3.95	3.71

## 220	Liaoning soybean	2010	3.03	3.41	3.69	3.44
## 221	Liaoning soybean	2011	2.90	3.19	2.97	2.86
## 222	Liaoning soybean	2012	2.75	2.81	2.97	2.86
## 223	Liaoning soybean	2013	2.73	2.68	2.62	2.78
## 224	Liaoning soybean	2014	2.56	2.57	2.54	2.79
## 225	Liaoning soybean	2015	2.54	2.17	2.50	2.68
## 226	Liaoning soybean	2016	3.12	2.62	3.94	3.61
## 227	Liaoning soybean	2017	1.78	2.92	3.34	3.46
## 228	Liaoning soybean	2018	1.75	3.05	3.08	3.42
## 229	Liaoning soybean	2019	1.99	3.00	3.23	3.45
## 230	Liaoning soybean	2020	2.41	3.33	2.99	3.40
## 231	Liaoning soybean	2021	2.40	3.16	2.21	3.10
## 232	Heilongjiang soybean	2001	33.50	40.95	39.64	43.33
## 233	Heilongjiang soybean	2002	29.72	40.60	39.94	43.23
## 234	Heilongjiang soybean	2003	34.58	37.53	38.48	38.90
## 235	Heilongjiang soybean	2004	35.96	37.79	37.19	34.55
## 236	Heilongjiang soybean	2005	35.19	36.13	37.59	36.20
## 237	Heilongjiang soybean	2006	40.56	35.77	35.57	34.77
## 238	Heilongjiang soybean	2007	32.01	34.88	31.61	30.51
## 239	Heilongjiang soybean	2008	33.39	35.01	29.25	28.79
## 240	Heilongjiang soybean	2009	33.04	31.50	31.93	30.25
## 241	Heilongjiang soybean	2010	29.19	29.82	30.09	27.35
## 242	Heilongjiang soybean	2011	26.19	26.84	23.28	22.27
## 243	Heilongjiang soybean	2012	21.77	23.94	22.94	22.11
## 244	Heilongjiang soybean	2013	19.92	22.32	21.70	22.31
## 245	Heilongjiang soybean	2014	21.08	23.92	22.80	22.45
## 246	Heilongjiang soybean	2015	19.53	21.78	21.62	21.64
## 247	Heilongjiang soybean	2016	19.45	21.13	29.82	27.82
## 248	Heilongjiang soybean	2017	25.30	24.93	25.99	26.73
## 249	Heilongjiang soybean	2018	24.31	24.49	25.01	26.68
## 250	Heilongjiang soybean	2019	28.97	22.25	25.26	26.92
## 251	Heilongjiang soybean	2020	32.41	22.84	23.12	26.46
## 252	Heilongjiang soybean	2021	25.81	23.58	16.69	23.45
## 253	Neimenggu other	2001	50.51	61.20	58.88	64.69
## 254	Neimenggu other	2002	53.91	60.09	57.90	64.20
## 255	Neimenggu other	2003	53.54	59.54	59.26	62.60
## 256	Neimenggu other	2004	50.57	58.13	57.46	55.43
## 257	Neimenggu other	2005	49.36	57.34	60.99	59.35
## 258	Neimenggu other	2006	45.80	56.57	59.98	56.23
## 259	Neimenggu other	2007	49.98	58.32	58.77	53.20
## 260	Neimenggu other	2008	48.13	56.44	51.15	50.31
## 261	Neimenggu other	2009	43.40	56.74	54.13	55.95
## 262	Neimenggu other	2010	43.49	53.48	56.67	49.82
## 263	Neimenggu other	2011	43.52	51.26	48.89	43.69
## 264	Neimenggu other	2012	42.00	47.46	48.04	42.91
## 265	Neimenggu other	2013	39.23	45.01	37.51	44.11
## 266	Neimenggu other	2014	38.59	46.74	40.93	44.18
## 267	Neimenggu other	2015	39.49	43.77	42.88	42.82
## 268	Neimenggu other	2016	42.39	41.66	53.60	48.72
## 269	Neimenggu other	2017	38.96	40.60	47.75	47.96
## 270	Neimenggu other	2018	36.73	44.70	45.67	47.65
## 271	Neimenggu other	2019	36.24	43.62	46.14	46.65
## 272	Neimenggu other	2020	36.22	44.50	40.77	45.44
## 273	Neimenggu other	2021	34.86	45.65	32.78	40.42

## 274	Jilin	other	2001	23.27	27.07	26.86	29.36
## 275	Jilin	other	2002	21.42	26.13	25.77	28.81
## 276	Jilin	other	2003	23.24	25.21	26.89	26.56
## 277	Jilin	other	2004	17.64	24.09	24.02	21.28
## 278	Jilin	other	2005	20.40	24.23	24.72	21.91
## 279	Jilin	other	2006	24.16	24.05	23.44	20.79
## 280	Jilin	other	2007	19.62	23.12	19.19	18.76
## 281	Jilin	other	2008	19.09	21.72	15.80	17.78
## 282	Jilin	other	2009	20.06	20.25	19.92	18.78
## 283	Jilin	other	2010	21.46	18.42	20.45	17.34
## 284	Jilin	other	2011	20.84	17.19	16.04	14.31
## 285	Jilin	other	2012	20.69	14.88	16.50	14.12
## 286	Jilin	other	2013	17.98	13.06	13.26	13.92
## 287	Jilin	other	2014	17.06	13.36	13.81	14.13
## 288	Jilin	other	2015	16.83	12.60	14.86	13.72
## 289	Jilin	other	2016	13.54	12.02	20.88	17.09
## 290	Jilin	other	2017	14.43	14.14	14.08	16.15
## 291	Jilin	other	2018	11.99	14.80	12.46	15.46
## 292	Jilin	other	2019	11.59	13.59	13.16	15.36
## 293	Jilin	other	2020	11.39	13.22	11.06	15.46
## 294	Jilin	other	2021	11.18	13.51	7.42	14.06
## 295	Liaoning	other	2001	37.95	39.85	41.09	40.38
## 296	Liaoning	other	2002	39.14	38.68	39.73	39.78
## 297	Liaoning	other	2003	39.28	37.90	39.62	37.75
## 298	Liaoning	other	2004	34.03	36.92	33.68	31.83
## 299	Liaoning	other	2005	30.58	36.52	34.12	33.54
## 300	Liaoning	other	2006	27.13	35.90	34.28	32.55
## 301	Liaoning	other	2007	24.35	35.78	31.17	29.53
## 302	Liaoning	other	2008	26.40	33.29	25.30	27.49
## 303	Liaoning	other	2009	28.71	32.47	30.66	29.11
## 304	Liaoning	other	2010	28.78	26.10	30.30	27.17
## 305	Liaoning	other	2011	29.53	25.98	29.30	23.13
## 306	Liaoning	other	2012	28.96	23.22	29.39	23.10
## 307	Liaoning	other	2013	28.37	22.82	24.80	22.36
## 308	Liaoning	other	2014	27.84	25.16	22.33	22.61
## 309	Liaoning	other	2015	27.15	22.38	23.52	22.08
## 310	Liaoning	other	2016	19.75	19.84	31.93	27.85
## 311	Liaoning	other	2017	21.80	23.54	22.43	27.24
## 312	Liaoning	other	2018	22.09	22.10	19.10	27.04
## 313	Liaoning	other	2019	22.50	20.94	20.53	26.64
## 314	Liaoning	other	2020	22.43	21.19	17.72	26.06
## 315	Liaoning	other	2021	22.58	20.31	12.88	23.95
## 316	Heilongjiang	other	2001	26.61	16.41	16.24	17.94
## 317	Heilongjiang	other	2002	28.58	15.96	15.62	17.58
## 318	Heilongjiang	other	2003	28.96	15.63	17.54	16.50
## 319	Heilongjiang	other	2004	23.36	14.58	16.94	14.43
## 320	Heilongjiang	other	2005	23.96	14.90	17.06	15.30
## 321	Heilongjiang	other	2006	6.51	15.66	15.48	15.29
## 322	Heilongjiang	other	2007	14.45	16.14	13.16	13.79
## 323	Heilongjiang	other	2008	15.12	14.43	11.74	12.79
## 324	Heilongjiang	other	2009	11.19	14.44	13.88	13.70
## 325	Heilongjiang	other	2010	9.79	13.41	14.46	12.55
## 326	Heilongjiang	other	2011	9.74	12.97	12.54	10.59
## 327	Heilongjiang	other	2012	9.00	11.99	12.57	10.49

## 328	Heilongjiang	other	2013	8.31	11.52	11.18	10.50
## 329	Heilongjiang	other	2014	7.01	11.58	11.63	10.70
## 330	Heilongjiang	other	2015	6.94	10.87	11.57	10.35
## 331	Heilongjiang	other	2016	9.52	9.62	13.71	12.22
## 332	Heilongjiang	other	2017	7.57	10.81	10.54	11.92
## 333	Heilongjiang	other	2018	6.10	11.38	9.57	11.97
## 334	Heilongjiang	other	2019	5.07	10.16	9.71	11.88
## 335	Heilongjiang	other	2020	4.53	9.59	8.45	11.62
## 336	Heilongjiang	other	2021	4.76	10.17	6.68	10.57