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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 Novermber 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) Logriathm 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"
```

```
##
## 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", "R
```

Model 2 Regression

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

```
## ===============================================================
##                                          y2
##                                  Corn       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
## ===============================================================
##                                          y2
##                                  Corn       Rice      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"))
```

```r
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     0.076     -1.252*
##                                  (0.720)   (0.712)    (0.723)
##
## rr_soy2                          2.695**    2.110*     1.439
##                                  (1.116)   (1.104)    (1.122)
##
## regionNeimenggu                -1.226*** -4.237***  -1.289***
##                                  (0.172)   (0.170)    (0.173)
##
## regionJilin                       0.053   -1.137***  -0.975***
##                                  (0.172)   (0.170)    (0.173)
##
## regionLiaoning                 -0.446*** -1.436***  -1.999***
##                                  (0.167)   (0.165)    (0.168)
##
## regionHeilongjiang               -0.055     -0.200    0.934***
##                                  (0.157)   (0.155)    (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

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

```r
# 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"))
```

```r
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"))
```

```r
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
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## 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
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## 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
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## 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
```