Napassorn Dechnitirat 6004641475

Assignment 2
Simultaneous Equations Model

Due: 1/9/2020

Demand and Supply Equations

$$\ln S_t = \beta_{10} + \beta_{11} \ln P_{Dt} + \beta_{12} \ln P_{X2t} + \beta_{13} \ln P_{X3t} + \beta_{14} \ln P_{X4t} + \varepsilon_{1t} \quad (1)$$

$$\ln D_t = \beta_{20} + \beta_{21} \ln P_{Dt} + \beta_{22} \ln GDP_t + \varepsilon_{2t} \quad (2)$$

where: S_t = Domestic Supply at time t

D_t = Domestic Demand at time t

P_{Dt} = Domestic Price at time t = $P_{Mt} + T_t$

T_t = Tariff at time t

P_{X2t} = Price of Input 2 at time t

P_{X3t} = Price of Input 3 at time t

P_{X4t} = Price of Input 4 at time t

GDP_t = Gross Domestic Product (Representing Income) at time t

Endogenous variables in this system include S_t, D_t, and P_{Dt}
Exogenous variables in this system include P_{X2t}, P_{X3t}, P_{X4t}, and GDP_t

From Data `Assignment 2.dta`:

1. State reduce form model of these system models.
2. Estimate reduce form model using OLS and prediction of the endogenous variables.
3. Estimate structural form using predicted endogenous variables as independent variables in the structural form model.
4. Estimate the structural models of these system equations using OLS, 2SLS, 3SLS, and I3SLS. Concerning on the asymptotic property, which model is the most appropriated model? Why?
5. What do β_{21} and β_{22} mean?

1. Structural Form

$$\ln S_t = \beta_{10} + \beta_{11}\ln P_{Dt} + \beta_{12}\ln P_{X2t} + \beta_{13}\ln P_{X3t} + \beta_{14}\ln P_{X4t} + \varepsilon_{1t}$$

$$\ln D_t = \beta_{20} + \beta_{21}\ln P_{Dt} + \beta_{22}\ln GDP_t + \varepsilon_{2t}$$

Reduce form

$$\ln S_t = \Pi_{10} + \Pi_{11}\ln P_{X2t} + \Pi_{12}\ln P_{X3t} + \Pi_{13}\ln P_{X4t} + \Pi_{14}\ln GDP_t + u_{1t}$$

$$\ln D_t = \Pi_{20} + \Pi_{21}\ln P_{X2t} + \Pi_{22}\ln P_{X3t} + \Pi_{23}\ln P_{X4t} + \Pi_{24}\ln GDP_t + u_{2t}$$

2.

```
. g lndt = ln(dt)

. g pd = pm+t

. g lnpd = ln(pd)

. g lnpx2 = ln(px2)

. g lnpx3 = ln(px3)

. g lnpx4 = ln(px4)

. g lngdp = ln(gdp)

. reg lnst lnpx2 lnpx3 lnpx4 lngdp
```

Source	SS	df	MS
Model	4.64569724	4	1.16142431
Residual	.529104674	17	.031123804
Total	5.17480192	21	.246419139

Number of obs	=	22
F(4, 17)	=	37.32
Prob > F	=	0.0000
R-squared	=	0.8978
Adj R-squared	=	0.8737
Root MSE	=	.17642

lnst	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnpx2	-.4503744	.1515961	-2.97	0.009	-.7702142	-.1305347
lnpx3	-.9242052	.2783356	-3.32	0.004	-1.511442	-.3369685
lnpx4	-.3883793	.4222332	-0.92	0.371	-1.279214	.5024549
lngdp	.3438812	.1913463	1.80	0.090	-.0598242	.7475865
_cons	24.65741	5.309757	4.64	0.000	13.4548	35.86002

```
. predict lnsthat
(option xb assumed; fitted values)

. reg lndt lnpx2 lnpx3 lnpx4 lngdp
```

Source	SS	df	MS
Model	3.4026552	4	.850663799
Residual	.54721789	17	.032189288
Total	3.94987309	21	.188089195

Number of obs	=	22
F(4, 17)	=	26.43
Prob > F	=	0.0000
R-squared	=	0.8615
Adj R-squared	=	0.8289
Root MSE	=	.17941

lndt	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnpx2	-.4887365	.1541691	-3.17	0.006	-.8140049	-.1634682
lnpx3	-.7243134	.2830597	-2.56	0.020	-1.321517	-.1271097
lnpx4	-.577921	.4293997	-1.35	0.196	-1.483875	.3280333
lngdp	.1265855	.194594	0.65	0.524	-.2839719	.5371429
_cons	27.18614	5.399879	5.03	0.000	15.79339	38.57889

```
. predict lndthat
(option xb assumed; fitted values)

. reg lnpd lnpx2 lnpx3 lnpx4 lngdp
```

Source	SS	df	MS
Model	.17707359	4	.044268398
Residual	.111247189	17	.006543952
Total	.288320779	21	.013729561

Number of obs	=	22
F(4, 17)	=	6.76
Prob > F	=	0.0019
R-squared	=	0.6142
Adj R-squared	=	0.5234
Root MSE	=	.08089

lnpd	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnpx2	.1318015	.0695123	1.90	0.075	-.0148567	.2784596
lnpx3	.0939842	.127627	0.74	0.472	-.1752851	.3632535
lnpx4	.4939641	.1936093	2.55	0.021	.0854842	.9024439
lngdp	.1632779	.0877392	1.86	0.080	-.0218357	.3483914
_cons	2.87652	2.434717	1.18	0.254	-2.260283	8.013322

```
. predict lnpdhat
(option xb assumed; fitted values)
```

3.

```
. reg lnst lnpdhat lnpx2 lnpx3 lnpx4

      Source |       SS           df       MS      Number of obs   =        22
-------------+----------------------------------   F(4, 17)        =     37.32
       Model |  4.64569773         4  1.16142443   Prob > F        =    0.0000
    Residual |  .529104183        17  .031123775   R-squared       =    0.8978
-------------+----------------------------------   Adj R-squared   =    0.8737
       Total |  5.17480192        21  .246419139   Root MSE        =    .17642

------------------------------------------------------------------------------
        lnst |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lnpdhat |   2.106112   1.171903     1.80   0.090    -.3663879    4.578612
       lnpx2 |   -.727963   .1840856    -3.95   0.001     -1.11635   -.3395762
       lnpx3 |  -1.122146   .2824139    -3.97   0.001    -1.717988   -.5263052
       lnpx4 |  -1.428722   .4751381    -3.01   0.008    -2.431176   -.4262679
       _cons |   18.59912   8.546622     2.18   0.044     .5673274    36.63092
------------------------------------------------------------------------------

. reg lndt lnpdhat lngdp

      Source |       SS           df       MS      Number of obs   =        22
-------------+----------------------------------   F(2, 19)        =     44.99
       Model |  3.26129847         2  1.63064924   Prob > F        =    0.0000
    Residual |  .688574614        19  .036240769   R-squared       =    0.8257
-------------+----------------------------------   Adj R-squared   =    0.8073
       Total |  3.94987309        21  .188089195   Root MSE        =    .19037

------------------------------------------------------------------------------
        lndt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lnpdhat |  -2.574157   .5697943    -4.52   0.000     -3.76675   -1.381563
       lngdp |   .5212927   .1344816     3.88   0.001     .2398194     .802766
       _cons |   35.93498   7.189835     5.00   0.000     20.88648    50.98347
------------------------------------------------------------------------------
```

4

```
. reg3 (lnst lnpd lnpx2 lnpx3 lnpx4) (lndt lnpd lngdp), ols inst (lnpx2 lnpx3 lnpx4 lngdp)
```

Multivariate regression

Equation	Obs	Parms	RMSE	"R-sq"	F-Stat	P
lnst	22	4	.1652258	0.9103	43.14	0.0000
lndt	22	2	.1391259	0.9069	92.53	0.0000

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnst						
lnpd	-1.111835	.4515147	-2.46	0.019	-2.027549	-.1961207
lnpx2	-.4189546	.1431634	-2.93	0.006	-.7093034	-.1286059
lnpx3	-.9424196	.2585266	-3.65	0.001	-1.466736	-.4181034
lnpx4	-.521346	.3441643	-1.51	0.139	-1.219344	.1766516
_cons	41.4946	3.661911	11.33	0.000	34.0679	48.9213
lndt						
lnpd	-2.181329	.2946999	-7.40	0.000	-2.779008	-1.58365
lngdp	.5776586	.0887536	6.51	0.000	.397658	.7576593
_cons	31.03578	3.761201	8.25	0.000	23.40771	38.66385

```
. reg3 (lnst lnpd lnpx2 lnpx3 lnpx4) (lndt lnpd lngdp), 2sls inst (lnpx2 lnpx3 lnpx4 lngdp)
```

Two-stage least-squares regression

Equation	Obs	Parms	RMSE	"R-sq"	F-Stat	P
lnst	22	4	.329951	0.6424	10.67	0.0000
lndt	22	2	.1454858	0.8982	77.04	0.0000

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnst						
lnpd	2.10611	2.191774	0.96	0.343	-2.339013	6.551233
lnpx2	-.7279628	.3442892	-2.11	0.041	-1.426214	-.0297119
lnpx3	-1.122146	.528189	-2.12	0.041	-2.193363	-.0509293
lnpx4	-1.428722	.8886357	-1.61	0.117	-3.230959	.3735147
_cons	18.59914	15.98447	1.16	0.252	-13.81886	51.01715
lndt						
lnpd	-2.574157	.4354519	-5.91	0.000	-3.457295	-1.69102
lngdp	.5212921	.1027745	5.07	0.000	.3128558	.7297283
_cons	35.93499	5.494663	6.54	0.000	24.7913	47.07868

Endogenous variables: lnst lnpd lndt
Exogenous variables: lnpx2 lnpx3 lnpx4 lngdp

```
. reg3 (lnst lnpd lnpx2 lnpx3 lnpx4) (lndt lnpd lngdp), 3sls inst (lnpx2 lnpx3 lnpx4 lngdp)

Three-stage least-squares regression
----------------------------------------------------------------------
Equation          Obs   Parms        RMSE    "R-sq"       chi2        P
----------------------------------------------------------------------
lnst               22       4    .2963642    0.6266      57.47   0.0000
lndt               22       2     .135203    0.8982     178.41   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lnst         |
        lnpd |   2.171576   1.926095     1.13   0.260    -1.603501    5.946652
       lnpx2 |  -.7990055   .2985983    -2.68   0.007    -1.384247   -.2137635
       lnpx3 |  -1.329743   .4560002    -2.92   0.004    -2.223487   -.4359989
       lnpx4 |  -1.171403    .775654    -1.51   0.131    -2.691657     .348851
       _cons |   17.84948   14.04122     1.27   0.204    -9.670808    45.36976
-------------+----------------------------------------------------------------
lndt         |
        lnpd |  -2.574157   .4046743    -6.36   0.000    -3.367304    -1.78101
       lngdp |   .5212921   .0955104     5.46   0.000     .3340951     .708489
       _cons |   35.93499   5.106302     7.04   0.000     25.92682    45.94316
------------------------------------------------------------------------------
Endogenous variables:  lnst lnpd lndt
Exogenous variables:   lnpx2 lnpx3 lnpx4 lngdp
------------------------------------------------------------------------------
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```
. reg3 (lnst lnpd lnpx2 lnpx3 lnpx4) (lndt lnpd lngdp), 3sls ireg3 inst(lnpx2 lnpx3 lnpx4 lngdp)

Iteration 1:   tolerance =   .1059484
Iteration 2:   tolerance =  .04569793
Iteration 3:   tolerance =  .01846611
Iteration 4:   tolerance =  .00725496
Iteration 5:   tolerance =  .00281814
Iteration 6:   tolerance =  .00108981
Iteration 7:   tolerance =  .00042072
Iteration 8:   tolerance =  .00016231
Iteration 9:   tolerance =   .0000626
Iteration 10:   tolerance =  .00002414
Iteration 11:   tolerance = 9.310e-06
Iteration 12:   tolerance = 3.590e-06
Iteration 13:   tolerance = 1.384e-06
Iteration 14:   tolerance = 5.339e-07
```

Three-stage least-squares regression, iterated

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
lnst	22	4	.3022006	0.6117	54.83	0.0000
lndt	22	2	.135203	0.8982	178.41	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnst						
lnpd	2.212666	2.005956	1.10	0.270	-1.718936	6.144268
lnpx2	-.8435967	.3049354	-2.77	0.006	-1.441259	-.2459342
lnpx3	-1.460044	.4623671	-3.16	0.002	-2.366267	-.5538216
lnpx4	-1.009892	.7998393	-1.26	0.207	-2.577548	.557764
_cons	17.37893	14.61488	1.19	0.234	-11.26571	46.02357
lndt						
lnpd	-2.574157	.4046743	-6.36	0.000	-3.367304	-1.78101
lngdp	.5212921	.0955104	5.46	0.000	.3340951	.708489
_cons	35.93499	5.106302	7.04	0.000	25.92682	45.94316

Endogenous variables: lnst lnpd lndt
Exogenous variables: lnpx2 lnpx3 lnpx4 lngdp

Hausman Test

```
. hausman twostage ols
```

	Coefficients (b) twostage	(B) ols	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lnpd	2.10611	-1.111835	3.217945	2.144762
lnpx2	-.7279628	-.4189546	-.3090082	.3131123
lnpx3	-1.122146	-.9424196	-.1797266	.4605948
lnpx4	-1.428722	-.521346	-.907376	.8192828

b = consistent under Ho and Ha; obtained from reg3
B = inconsistent under Ha, efficient under Ho; obtained from reg3

Test: Ho: difference in coefficients not systematic

chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 2.25
Prob>chi2 = 0.6897 > 0.05

According to 95% confidence level, H_0 is not rejected. There is no endogeneity bias. Therefore, OLS is more appropriated than alternative models.

5. β_{21} is price elasticity of demand.

It means if domestic price increases by 1, quantity demanded will increase by β_{21}.

β_{22} is income elasticity of demand.

It means if GDP increases by 1, quantity demanded will increase by β_{22}.