

# Estimation and Welfare Codes for the MDCEV model with Triple Constraints

(Version 1.1: Endogenous time allocation model)

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## Sample files

File name	Description
MDCEV_TC.g	GAUSS code for estimation
MDCEV_TC.out	Output file of estimation
DEMAND_TC.g	GAUSS code for demand and welfare prediction
DEMAND_TC.out	Output file of prediction
data.txt	sample data (text file)
data.xls	sample data (Excel file)

## Sample data set

Column	Variable	Description
1	ID	ID Number
2-4	X_Inside_S	Consumption of inside goods in weekends ( $x_{Sk} = x_k$ )
5-7	X_Inside_L	Consumption of inside goods in long holidays ( $x_{Lk} = x_{k+K}$ )
8-10	Psi1	Individual or good specific attributes (Psi1: constant, $\mathbf{q_k}$ )
11-13	Psi2	Individual or good specific attributes ( $\mathbf{q_k}$ )
14-16	Psi3	Individual or good specific attributes ( $\mathbf{q_k}$ )
17	Income	Respondents' income ( $E$ )
18-20	Price	Price of inside goods ( $p_k$ )
21	Max_TS	Total time of weekends ( $T_S$ )
22	Max_TL	Total time of long holidays ( $T_L$ )
23-25	Time	Time consumption of inside goods ( $t_k$ )

## Preference Specification

$$\begin{aligned}
 U(x) &= u_{z1}(z_1) + u_{z2}(z_2) + u_{z3}(z_3) + \sum_{k=1}^K u_{xSk}(x_{Sk}) + \sum_{k=1}^K u_{xLk}(x_{Lk}) \\
 &= (x) = \sum_{m=1}^3 \frac{\psi_{zm}}{\alpha_{zm}} z_m^{\alpha_{zm}} + \sum_{k=1}^{2K} \frac{\gamma_{xk} \psi_{xk}}{\alpha_{xk}} \left[ \left( \frac{x_k}{\gamma_{xk}} + 1 \right)^{\alpha_{xk}} - 1 \right] \\
 \psi_{z1} &= \exp(\xi_1 + \varepsilon_{z1}), \psi_{z2} = \exp(\xi_2 + \varepsilon_{z2}), \psi_{z3} = \exp(\xi_3 + \varepsilon_{z3}), \\
 \psi_{xk} &= \exp(\delta_{xk} \mathbf{q}_k + \varepsilon_{xk}), \alpha_{xk} = 1 - \exp(\alpha_{xk}^*), \gamma_{xk} = \exp(\gamma_{xk}^*), \\
 z_1 + \sum_{k=1}^{2K} p_k x_k &= E, z_2 + \sum_{k=1}^{2K} s_k t_k x_k = T_S, z_3 + \sum_{k=1}^{2K} [1 - s_k] t_k x_k = T_L.
 \end{aligned} \tag{1}$$

Example 1:  $\alpha$ -profile model

$$U(x) = \frac{\exp(\varepsilon_{z1})}{\alpha_{z1}} z_1^{\alpha_{z1}} + \frac{\exp(\varepsilon_{z2})}{\alpha_{z2}} z_2^{\alpha_{z2}} + \frac{\exp(\varepsilon_{z3})}{\alpha_{z3}} z_3^{\alpha_{z3}} + \sum_{k=1}^{2K} \frac{\psi_{xk}}{\alpha_{xk}} [(x_k + 1)^{\alpha_{xk}} - 1]. \tag{2}$$

$\xi_1 = \xi_2 = \xi_3 = 0$ .  $\alpha_{xk}$  is the fixed effect for inside goods ( $\alpha_{xk} = \alpha_{x(k+K)}$ ).  $\gamma_k$  is not estimated.

@ Alpha: 4 x 1, if ALPHAKFIX = 0. (3 + N\_INSIDE) x 1, if ALPHAKFIX = 1. @

@ 1: estimate, 0: not estimate (alpha = 0), -1: estimated alphas are constrained to be equal to alphak @

```
ALPHA_EST = {
    1, @ alhpa1 (money) @
    1, @ alpha2 (time1: weekend) @
    1, @ alpha3 (time2: long holiday) @
    1, 1, 1 @ alphak of inside goods @
};
```

@ gamma: 1 x 1, if GAMMAKFIX = 0. N\_INSIDE x 1, if GAMMAKFIX = 1. @

@ 1: estimate, 0: not estimate (gammak = 1) @

```
GAMMA_EST = {
    0 @ gammak of inside goods @
}; @ gamma1, gamma2, and gamma3 are always fixed at 0 @
```

@ Sigma: 4 x 1, if SIGKFIX = 0. (3 + N\_INSIDE) x 1, if SIGKFIX = 1. @

@ 1: estimate, 0: not estimate (sig = 0), -1: estimated sigmas are constrained to be equal to sigk @

```
SIG_EST = {
    1, @ sig1 @
    1, @ sig2 @
    1 @ sig3 @
}; @ sigk of inside goods is always estimated @
```

@ XI ESTIMATION (3 x 1) @

@ 1: estimate, 0: not estimate (use 0) @

```
XI_EST = {
```

```

0, @ xi1: money @
0, @ xi2: time of the weekend @
0 @ xi3: time of the long holiday @
};

```

```

@ OTHER SETTING OF PARAMETERS @
@ 1: good specific fixed effect, 0: equal to all indside goods @
ALPHA_KFIX = 1; @ 1: alphak is fixed effect, 0: otherwise @
GAMMA_KFIX = 0; @ 1: gammak is fixed effect, 0: otherwise @
SIGMA_KFIX = 0; @ 1: sigk is fixed effect, 0: otherwise @

```

Estimation of  $\alpha$ -profile model

Parameters	Estimates	t stat.	p value
PSI01 ( $\delta_{x1}$ )	-2.0035	-2.184	0.029
PSI02 ( $\delta_{x2}$ )	0.7645	15.583	0.000
PSI03 ( $\delta_{x3}$ )	-0.9609	-17.433	0.000
Xi1( $\xi_1$ )	0.0000	.	.
XiS( $\xi_s$ )	0.0000	.	.
XiL( $\xi_L$ )	0.0000	.	.
AlpOut01( $\alpha_{z1}$ )	-0.5880	-4.641	0.000
AlpOut02( $\alpha_{z2}$ )	-0.5798	-2.696	0.007
AlpOut03( $\alpha_{z3}$ )	-0.1907	-0.857	0.391
AlpIn01( $\alpha_{x1}$ )	-0.1768	-5.652	0.000
AlpIn02( $\alpha_{x2}$ )	-0.1705	-5.479	0.000
AlpIn03( $\alpha_{x3}$ )	-0.1555	-4.730	0.000
GamIn01 ( $\gamma$ )	1.0000	.	.
SigOut01( $\sigma_{z1}$ )	0.8373	19.350	0.000
SigOut02( $\sigma_{z2}$ )	-0.8550	-5.881	0.000
SigOut03( $\sigma_{z3}$ )	-0.4515	-0.769	0.442
SigIn01( $\sigma_x$ )	-1.9740	-19.184	0.000

Example 2:  $\gamma$ -profile model

$$U(x) = \exp(\varepsilon_{z1}) \ln z_1 + \exp(\varepsilon_{z2}) \ln z_2 + \exp(\varepsilon_{z3}) \ln z_3 + \sum_{k=1}^{2K} \gamma_{xk} \psi_{xk} \ln \left( \frac{x_k}{\gamma_{xk}} + 1 \right). \quad (3)$$

$\xi_1 = \xi_2 = \xi_3 = 0$ .  $\alpha_{z1}, \alpha_{z2}, \alpha_{z3}$  and  $\alpha_{xk}$  are not estimated.  $\gamma_{xk}$  is the fixed effect for inside goods ( $\gamma_{xk} = \gamma_{x(k+K)}$ ).

Time consumption of  $z_2$  and  $z_3$  are assumed to be not random ( $\varepsilon_{z2} = \varepsilon_{z3} = 0$ ).

```

@ Alpha: 4 x 1, if ALPHA_KFIX = 0. (3 + N_INSIDE) x 1, if ALPHA_KFIX = 1. @
@ 1: estimate, 0: not estimate (alpha = 0), -1: estimated alphas are constrained to be equal
to alphak @
ALPHA_EST = {
    0, @ alhpa1 (money) @
    0, @ alpha2 (time1: weekend) @
    0, @ alpha3 (time2: long holiday) @
    0 @ alphak of inside goods @

```

```

};

@ gamma: 1 x 1, if GAMMAKFIX = 0. N_INSIDE x 1, if GAMMAKFIX = 1. @
@ 1: estimate, 0: not estimate (gammak = 1) @
GAMMA_EST = {
    1, 1, 1 @ gammak of inside goods @
};    @ gamma1, gamma2, and gamma3 are always fixed at 0 @

@ Sigma: 4 x 1, if SIGKFIX = 0. (3 + N_INSIDE) x 1, if SIGKFIX = 1. @
@ 1: estimate, 0: not estimate (sig = 0), -1: estimated sigmas are constrained to be equal to
sigk @
SIG_EST = {
    1, @ sig1 @
    0, @ sig2 @
    0 @ sig3 @
};    @ sigk of inside goods is always estimated @

@ XI ESTIMATION (3 x 1) @
@ 1: estimate, 0: not estimate (use 0) @
XI_EST = {
    0, @ xi1: money @
    0, @ xi2: time of the weekend @
    0 @ xi3: time of the long holiday @
};

@ OTHER SETTING OF PARAMETERS @
@ 1: good specific fixed effect, 0: equal to all indside goods @
ALPHA KFIX = 0; @ 1: alphak is fixed effect, 0: otherwise @
GAMMA KFIX = 1; @ 1: gammak is fixed effect, 0: otherwise @
SIG KFIX = 0; @ 1: sigk is fixed effect, 0: otherwise @

```

Estimation of  $\gamma$ -profile model

Parameters	Estimates	t stat.	p value
PSI01 ( $\delta_{x1}$ )	-1.4154	-4.716	0.000
PSI02 ( $\delta_{x2}$ )	1.2533	26.263	0.000
PSI03 ( $\delta_{x3}$ )	-2.0731	-35.687	0.000
Xi1( $\xi_1$ )	0.0000	.	.
XiS( $\xi_s$ )	0.0000	.	.
XiL( $\xi_L$ )	0.0000	.	.
AlpOut01( $\alpha_{z1}$ )	0.0000	.	.
AlpOut02( $\alpha_{z2}$ )	0.0000	.	.
AlpOut03( $\alpha_{z3}$ )	0.0000	.	.
AlpIn01( $\alpha_x$ )	0.0000	.	.
GamIn01( $\gamma_{x1}$ )	0.5605	4.415	0.000
GamIn02( $\gamma_{x2}$ )	0.5372	4.124	0.000
GamIn03( $\gamma_{x3}$ )	0.6158	3.910	0.000
SigOut01( $\sigma_{z1}$ )	2.3492	62.245	0.000
SigOut02( $\sigma_{z2}$ )	0.0000	.	.
SigOut03( $\sigma_{z3}$ )	0.0000	.	.
SigIn01( $\sigma_x$ )	-1.4124	-15.036	0.000

Example 3:  $\alpha\gamma$ -profile model

$$U(x) = \frac{\exp(\varepsilon_{z1})}{\alpha_{z1}} z_1^{\alpha_{z1}} + \frac{\exp(\xi_2 + \varepsilon_{z2})}{\alpha_{z2}} z_2^{\alpha_{z2}} + \frac{\exp(\xi_3 + \varepsilon_{z3})}{\alpha_{z3}} z_3^{\alpha_{z3}} + \sum_{k=1}^{2K} \gamma \psi_{xk} \ln\left(\frac{x_k}{\gamma} + 1\right). \quad (4)$$

$\xi_1 = 0$ .  $\gamma_{xk}$  is assumed to be equal for all inside goods ( $\gamma_{xk} = \gamma$ ).

```
@ Alpha: 4 x 1, if ALPHAKFIX = 0. (3 + N_INSIDE) x 1, if ALPHAKFIX = 1. @
@ 1: estimate, 0: not estimate (alpha = 0), -1: estimated alphas are constrained to be equal
to alphak @
ALPHA_EST = {
    1, @ alhpa1 (money) @
    0, @ alpha2 (time1: weekend) @
    0, @ alpha3 (time2: long holiday) @
    0 @ alphak of inside goods @
};

@ gamma: 1 x 1, if GAMMAKFIX = 0. N_INSIDE x 1, if GAMMAKFIX = 1. @
@ 1: estimate, 0: not estimate (gammak = 1) @
GAMMA_EST = {
    1 @ gammak of inside goods @
}; @ gamma1, gamma2, and gamma3 are always fixed at 0 @

@ Sigma: 4 x 1, if SIGKFIX = 0. (3 + N_INSIDE) x 1, if SIGKFIX = 1. @
@ 1: estimate, 0: not estimate (sig = 0), -1: estimated sigmas are constrained to be equal to
sigk @
SIG_EST = {
    1, @ sig1 @
    0, @ sig2 @
    0 @ sig3 @
}; @ sigk of inside goods is always estimated @

@ XI ESTIMATION (3 x 1) @
@ 1: estimate, 0: not estimate (use 0) @
XI_EST = {
    0, @ xi1: money @
    1, @ xi2: time of the weekend @
    1 @ xi3: time of the long holiday @
};

@ OTHER SETTING OF PARAMETERS @
@ 1: good specific fixed effect, 0: equal to all indside goods @
ALPHAKFIX = 0; @ 1: alphak is fixed effect, 0: otherwise @
GAMMAKFIX = 0; @ 1: gammak is fixed effect, 0: otherwise @
SIGKFIX = 0; @ 1: sigk is fixed effect, 0: otherwise
```

Estimation of  $\alpha\gamma$ -profile model

Parameters	Estimates	t stat.	p value
PSI01 ( $\delta_{x1}$ )	-4.5289	-13.071	0.000
PSI02 ( $\delta_{x2}$ )	0.4222	34.318	0.000
PSI03 ( $\delta_{x3}$ )	-0.3132	-16.572	0.000
Xi1( $\xi_1$ )	0.0000	.	.
XiS( $\xi_s$ )	1.8740	5.815	0.000
XiL( $\xi_L$ )	-1.4803	-4.880	0.000
AlpOut01( $\alpha_{z1}$ )	-0.3888	-9.116	0.000
AlpOut02( $\alpha_{z2}$ )	0.0000	.	.
AlpOut03( $\alpha_{z3}$ )	0.0000	.	.
AlpIn01( $\alpha_x$ )	0.0000	.	.
GamIn01 ( $\gamma$ )	1.0527	21.484	0.000
SigOut01( $\sigma_{z1}$ )	1.0442	39.937	0.000
SigOut02( $\sigma_{z2}$ )	0.0000	.	.
SigOut03( $\sigma_{z3}$ )	0.0000	.	.
SigIn01( $\sigma_x$ )	-2.5072	-25.595	0.000

### *Demand and Welfare Analysis*

Set the estimation results of the parameter vector (B) and the variance-covariance matrix (VCOV) in the prediction code (DEMAND\_TC.g). The demand and WTPs for three scenarios are estimated. Scenario setting of the sample code is as follows:

```
@-----@
@          SCENARIOS          @
@-----@
@ Scenario #1: Add five days in a weekend @

PSIDATA_S1 = PSIDATA_S;
PSIDATA_L1 = PSIDATA_L;
PRICE_S1 = PRICE_S;
PRICE_L1 = PRICE_L;
MAX_TS1 = MAX_TS + 5 * 24;
MAX_TL1 = MAX_TL;
TTIME_S1 = TTIME_S;
TTIME_L1 = TTIME_L;
CSET_INSIDE_S1 = CSET_INSIDE_S;
CSET_INSIDE_L1 = CSET_INSIDE_L;

@ Scenario #2: Add five days in a long vacation @
PSIDATA_S2 = PSIDATA_S;
PSIDATA_L2 = PSIDATA_L;
PRICE_S2 = PRICE_S;
PRICE_L2 = PRICE_L;
MAX_TS2 = MAX_TS;
MAX_TL2 = MAX_TL + 5 * 24;
```

```

TTIME_S2 = TTIME_S;
TTIME_L2 = TTIME_L;
CSET_INSIDE_S2 = CSET_INSIDE_S;
CSET_INSIDE_L2 = CSET_INSIDE_L;

@ Scenario #3: Closure of site #1 in a long holiday@
PSIDATA_S3 = PSIDATA_S;
PSIDATA_L3 = PSIDATA_L;
PRICE_S3 = PRICE_S;
PRICE_L3 = PRICE_L;
PRICE_L3[.,1] = 100000000*ones(N_OBS,1);
MAX_TS3 = MAX_TS;
MAX_TL3 = MAX_TL;
TTIME_S3 = TTIME_S;
TTIME_L3 = TTIME_L;
CSET_INSIDE_S3 = CSET_INSIDE_S;
CSET_INSIDE_L3 = CSET_INSIDE_L;

```

N\_KR is the number of iteration of the Krinsky-Robb simulation for the confidence interval. The point estimate is generated for N\_KR = 1. Estimation results of  $\alpha\gamma$ -profile model using sample data is as follows:

```

*****
Point Estimates of Demand, WTP, and VLT
*****

```

```

Time (in minutes):           0.34480000
Total Generated Draws:       2500.0000
Discarded as Burn-in:       500.00000
Using Every nth Draw,      n =: 10.000000
Total Draws Used for Solving: 200.00000

```

```

Mean for Demand
  BASELINE      SCENARIO #1      SCENARIO #2      SCENARIO #3
  19.680000     19.804277     19.889563     18.452327

  GOODS      BASELINE      SCENARIO #1      SCENARIO #2      SCENARIO #3
  1.0000000   2.0800000   2.1316642   2.0736393   2.1435594
  2.0000000   2.2800000   2.3291306   2.2631460   2.3976008
  3.0000000   3.0600000   3.1493116   3.0309821   3.1944100
  4.0000000   3.1800000   3.1698127   3.2358056   0.0000000
  5.0000000   4.3500000   4.3332722   4.3965689   4.6798252
  6.0000000   4.7300000   4.6910855   4.8894207   6.0369317
(Good 1-3: consumption in weekend, good 4-6: consumption in long vacations)

```

```

Mean for WTP
  SCENARIO #1      SCENARIO #2      SCENARIO #3
  965.15296      80.670669     -3866.3656

```

```

Mean for Lambda1      Lambda2      Lambda3      VLTS      VLTL
  11017.095      0.0027462800      0.00016954569      8.8537838      0.75378398

```

## Krinsky-Robb Simulation

\*\*\*\*\*

### Krinsky-Robb Monte Carlo Simulation

\*\*\*\*\*

Time (in minutes): 71.803167  
 Number of Krinsky-Robb Iterations: 200.00000  
 Total Genrated Draws: 2500.0000  
 Discarded as Burn-in: 500.00000  
 Using Every nth Draw, n =: 10.000000  
 Total Draws Used for Solving: 200.00000

Demand (Scenario #0 means the baseline)

SCENARIO	MEAN	SD	95%lower	95%upper
0.00000000	19.680000	7.7112762e-014	19.680000	19.680000
1.00000000	19.804259	0.0062450599	19.792238	19.816010
2.00000000	19.892238	0.037475630	19.819837	19.968505
3.00000000	18.455862	0.035137415	18.388644	18.520357

Demand for Each Good (Scenario #0 means the baseline)

SCENARIO	GOOD	MEAN	SD	95%lower	95%upper
0.00000000	1.00000000	2.08000000	2.7600829e-015	2.08000000	2.08000000
0.00000000	2.00000000	2.28000000	1.1492076e-014	2.28000000	2.28000000
0.00000000	3.00000000	3.06000000	5.9647316e-016	3.06000000	3.06000000
0.00000000	4.00000000	3.18000000	2.1955355e-015	3.18000000	3.18000000
0.00000000	5.00000000	4.35000000	6.4602097e-015	4.35000000	4.35000000
0.00000000	6.00000000	4.73000000	1.4888983e-014	4.73000000	4.73000000
1.00000000	1.00000000	2.1317238	0.0015482111	2.1285729	2.1346424
1.00000000	2.00000000	2.3285013	0.0023227121	2.3220944	2.3318861
1.00000000	3.00000000	3.1492775	0.0019323695	3.1454153	3.1527411
1.00000000	4.00000000	3.1699341	0.00092861425	3.1681900	3.1717024
1.00000000	5.00000000	4.3332579	0.00070619618	4.3317684	4.3346216
1.00000000	6.00000000	4.6915641	0.0033148575	4.6856339	4.6980154
2.00000000	1.00000000	2.0735135	0.0011102865	2.0709626	2.0755623
2.00000000	2.00000000	2.2627118	0.0032177830	2.2550440	2.2683124
2.00000000	3.00000000	3.0303978	0.0050503870	3.0186531	3.0396778
2.00000000	4.00000000	3.2370794	0.0098761719	3.2185599	3.2563313
2.00000000	5.00000000	4.3953901	0.0098496946	4.3768868	4.4125836
2.00000000	6.00000000	4.8931455	0.028716240	4.8385924	4.9499605
3.00000000	1.00000000	2.1433635	0.0020823884	2.1393051	2.1478730
3.00000000	2.00000000	2.3974218	0.0038909879	2.3900764	2.4050912
3.00000000	3.00000000	3.1935220	0.0078913828	3.1786082	3.2091781
3.00000000	4.00000000	0.00000000	0.00000000	0.00000000	0.00000000
3.00000000	5.00000000	4.6806930	0.0054073835	4.6714075	4.6926350
3.00000000	6.00000000	6.0408621	0.041004957	5.9604145	6.1191802



WTP

SCENARIO	MEAN	SD	95%lower	95%upper
1.0000000	979.85590	85.065189	819.69249	1155.5104
2.0000000	85.915965	23.954699	48.242819	139.09158
3.0000000	-2181.1540	1414.7084	-4412.4106	-115.89116

Lambda and Time Value

#1:lambda1, #2:lambda2, #3:lambda3, #4:VLTS, #5:VLSL

#	MEAN	SD	95%lower	95%upper
1.0000000	11920.954	11259.849	2666.1398	42123.393
2.0000000	0.0028979840	0.00091952116	0.0014035188	0.0048564284
3.0000000	0.00018033062	5.2552900e-005	0.00010087061	0.00028915089
4.0000000	9.0467993	0.87220575	7.4417193	10.863610
5.0000000	0.80647664	0.23388948	0.44734022	1.3225860

### Single and Double Constraint Models

The GAUSS codes (MDCEV\_TC.g and DEMAND\_TC.g) can also analyze the single and double constraint models.

@ Number of constraints (= Number of outside goods) @

N\_CONSTRAINTS = 3; @ 1: budget, 2: budget + time, 3: budget + time1 + time2 @

Estimation of  $\alpha\gamma$ -profile model with single and double constraints

Parameters	Single Constraint			Double Constraints		
	Estimates	t stat.	p value	Estimates	t stat.	p value
PSI01 ( $\delta_{x1}$ )	-2.2086	-2.777	0.006	-3.2253	-10.033	0.000
PSI02 ( $\delta_{x2}$ )	0.7645	19.544	0.000	0.4913	37.399	0.000
PSI03 ( $\delta_{3x}$ )	-0.8184	-16.055	0.000	-0.5253	-31.859	0.000
Xi1( $\xi_1$ )	0.0000	.	.	0.0000	.	.
XiS( $\xi_s$ )	0.0000	.	.	1.8151	6.391	0.000
XiL( $\xi_L$ )	0.0000	.	.	0.0000	.	.
AlpOut01( $\alpha_{z1}$ )	-0.8333	-5.407	0.000	-0.4826	-10.676	0.000
AlpOut02( $\alpha_{z2}$ )	0.0000	.	.	0.0000	.	.
AlpOut03( $\alpha_{z3}$ )	0.0000	.	.	0.0000	.	.
AlpIn01( $\alpha_x$ )	0.0000	.	.	0.0000	.	.
GamIn01 ( $\gamma$ )	1.4559	15.999	0.000	1.7131	29.840	0.000
SigOut01( $\sigma_{z1}$ )	0.7507	16.040	0.000	0.8493	38.432	0.000
SigOut02( $\sigma_{z2}$ )	0.0000	.	.	0.0000	.	.
SigOut03( $\sigma_{z3}$ )	0.0000	.	.	0.0000	.	.
SigIn01( $\sigma_x$ )	-2.2195	-13.857	0.000	-2.9742	-19.030	0.000

### *Reference*

Kuriyama, K., Y. Shoji, and T. Tsuge (2016) The Value of Leisure Time of Weekends and Long Holidays: The Multiple Discrete–Continuous Extreme Value (MDCEV) Choice Model with Triple Constraints. Working paper #1601, Natural Resource Economics, Kyoto University.

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