Chapter 1
The Multi-product Newsvendor Problem: Review, Extensions, and Directions for Future Research

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$(\ = 1, \ldots, \ )$

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$F(\cdot)$.

$$E[\Pi({}^*_1, {}^*_2, .., {}^*)] = \sum$$

$$\frac{\partial}{\partial} = \sum_{=1} - . \qquad (1.\ )$$

(1.) 0, o *

$$^{*} = F^{-1}\left(\frac{- \quad - \lambda \quad +}{- \quad +}\right), \qquad (1.10)$$

$\lambda \geq 0.$

(1.), ($\bar{E}$).

$$\bar{E} = [\; - \; + \;][1 - F(\;^*)] - [\; - \;]F(\;^*). \tag{1.14}$$

$\bar{E}$ / λ.

(2004) ( )

$(\sum_{=1} \leq \;_G)$.

( ),

λ

λ

Threshold 2:

$$ {}^{(2)}_{G} = \sum_{=1} F^{(-1)}\left(\frac{-(\theta^{-}+1) \quad +}{- \quad +} \right), \qquad (1.1\ ) $$

$$ \theta = \frac{+ \quad -(\quad - \quad + \quad)F(0)}{} - 1. \qquad (1.1\ ) $$

$$ F(\ ^{*}) = \frac{(\quad - \quad + \quad)}{(\quad - \quad + \quad)}. \qquad (1.20) $$

$$ F(\ ^{*}) = \frac{-(\theta+1) \quad +}{- \quad +}. \qquad (1.21) $$

(1.1)

(2000)

$$ {}_{G,} = \sum_{=1}^{\prime} F^{-1}\left(\frac{-(\theta+1) \quad +}{- \quad +} \right) < {}_{G}. \qquad (1.22) $$

[illegible] (1) [illegible] (2) [illegible] (3) [illegible] (1) [illegible] (2). [illegible] (2) [illegible]

[illegible] (200[illegible]) [illegible] ( ) = (− + (+)F( )), [illegible] ≥ 0 [illegible] 1 − − ≤ ( ) < 0. [illegible]

[illegible] (∗∗) [illegible] (∗∗) = ( ) [illegible] (∗∗) [illegible] 1 − − ≤ (∗∗) < 0 [illegible] (∗∗) [illegible]

[illegible] (2010) [illegible] ( ) [illegible] ([illegible]

(200). $\pi_2 = \sum_{=1} [(\; - \;) + (\; - \;) -$
$(\; - \;) \int_0^{+} F(\;)$

(1.24)

(2011)

(2010), (2011) (2010)

(2010)

[illegible]

1.3.1 One-Way Substitution

(1.31)

(1.32)

(2010

$$+ \int_0^{\ 1}\int_{\ 2}^{\infty}(\ 1 - \ 1)\ (\ 1,\ 2)\ \ 2\ \ 1\Big]$$

$$- \ 1\ \ 1 - \ 2\ \ 2 + \ 1\Big[\int_0^{\ 1}\int_0^{\ 2}(\ 1 - \ 1)\ (\ 1,\ 2)\ \ 2\ \ 1$$

$$+ \int_0^{\ 1+\ 2-\ 2}\int_{\ 2}^{\ 1+\ 2}(\ 1 + \ 2 - \ 1 - \ 2)\ (\ 1,\ 2)\ \ 2\ \ 1\Big]$$

$$+ \ 2\int_0^{\ 2}(\ 2 - \ 2)\ 2(\ 2)\ \ 2 - \ 1\int_{\ 1}^{\infty}(\ 1 - \ 1)\ 1(\ 1)\ \ 1$$

$$- \ 2\Big[\int_{\ 1}^{\infty}\int_{\ 2}^{\infty}(\ 2 - \ 2)\ 1(\ 1,\ 2)\ \ 2\ \ 1$$

$$+ \int_0^{\ 1}\int_{\ 1+\ 2-\ 1}^{\infty}(\ 1 + \ 2 - \ 1 - \ 2)\ (\ 1,\ 2)\ \ 2\ \ 1\Big]. \quad (1.35)$$

[illegible] (2004) [illegible] $G(\ 1,\ 2) = \int_0^{\ 1}\int_0^{\ 1+\ 2-\ 1}(\ 1,\ 2)\ \ 2\ \ 1$, [illegible]

$$F_1(\ ^*_1) + \frac{(\ 2+\ 2) - \ 1)}{(\ 1+\ 1) - (\ 2+\ 2)}G(\ ^*_1,\ ^*_2) = \frac{(\ 1+\ 1) - \ 1}{(\ 1+\ 1) - (\ 2+\ 2)}, \quad (1.36)$$

$$F_2(\ ^*_2) + \frac{(\ 2+\ 2) - \ 1)}{(\ 2+\ 2) - \ 2)}\Big[G(\ ^*_1,\ ^*_2) - F(\ ^*_1,\ ^*_2)\Big] = \frac{(\ 2+\ 2) - \ 1}{(\ 2+\ 2) - \ 2}. \quad (1.3\ )$$

$F(\ ^*)$ [illegible] $G(\ ^*_1,\ ^*_2)$ [illegible] 1 [illegible] 2. $F(\ ^*_1,\ ^*_2) = \int_0^{\ 1}\int_0^{\ 2}(\ 1,\ 2)\ \ 2\ \ 1$ [illegible] $F_2(\ ^*_2) + G(\ ^*_1,\ ^*_2) - F(\ ^*_1,\ ^*_2)$ [illegible] 2 [illegible] 1 [illegible] $^*_1$ [illegible] $^*_2$ [illegible] $^*_2$ [illegible] 2 [illegible] 2 [illegible] 1 [illegible] 2. [illegible] 3 [illegible] 4 [illegible] 5 [illegible].

Table 1.1

$+$	
$(\ _0)$	
β	$\sigma = \beta\sigma_1$
	$= + K\sigma$
K	
$0 < \alpha < 1$	
$(\ _0)$	
$G\ (\ )$	

1.3.2 Two-Way Substitution

(1,) (1, 4) 0 1, $\sigma = \beta\sigma 1.$ $= + K\sigma$ $E\ C = \sigma G\ (K).$ 1.1.

$G\ (\ ) = \int^{\infty} (\ _0 - \ )\ (\ _0)\ _0,$ $\frac{G\ (K)}{K} = - \ \geq (K).$ $K \quad 0,$ $\geq (K*) =$ $= 1, \ldots, N$ $(\ _0) = \ \geq (\ _0) + G\ (\ _0),$

$$E\ C(K_1^*, K_2^*, .., K^*) = \frac{1}{2}\ ^2 + \sigma_1\ (K^*) \sum_{=1}^{N} \beta . \qquad (1.3\ \ )$$

$= 1,$

[illegible]

$$
\begin{cases}
1.\ \sum_{=1}^{2}[\ \ -\ \ +\ (\ -\ )] & 1 \le\ 1\ \ 2 \le\ 2\\
2.\ \ 1\ 1 + \ 2\ 2 - \sum_{=1}^{2} + (\ 1-\ 1,\ 2-\ 2) & 1 >\ 1\ \ 2 \le\ 2\\
\quad +\ 2[(\ 2-\ 2)-(\ 1-\ 1)]^{+} -\ 1[(\ 1-\ 1)-(\ 2-\ 2)]^{+} & \\
.\ \ 1\ 1 + \ 2\ 2 - \sum_{=1}^{2} + (\ 2-\ 2,\ 1-\ 1) & 1 \le\ 1\ \ 2 >\ 2\\
\quad +\ 1[(\ 1-\ 1)-(\ 2-\ 2)]^{+} -\ 2[(\ 2-\ 2)-(\ 1-\ 1)]^{+} & \\
.\ \sum_{=1}^{2}\ \ -\ \ -\ (\ -\ ) & 1 >\ 1\ \ 2 >\ 2
\end{cases}
\tag{1.41}
$$

[illegible]

$$
\begin{aligned}
E[\pi(\ 1,\ 2)] = E\Big[&[\ 1\ (\ 1,\ 1) +\ 2\ [\ 2,\ 2 + (\ 1-\ 1)^{+}] -\ 1\ 1 -\ 2\ 2\\
&+\ 1[\ 1-\ 1-(\ 2-\ 2)^{+}]^{+} +\ 2(\ 2-\ 2)^{+} -\ 1(\ 1-\ 1)^{+}\\
&-\ 2[\ 2-\ 2-(\ 1-\ 1)^{+}]^{+}\Big]\\
=\ &1\Big[\int_0^{1}\ 1\ 1(\ 1)\ 1 + \int_{1}^{\infty}\ 1\ 1(\ 1)\ 1\\
&+\int_0^{1}\int_{2}^{\infty}(\ 2-\ 2)\ (\ 1,\ 2)\ 2\ 1\Big]\\
&+\ 2\Big[\int_0^{2}\ 2\ 2(\ 2)\ 2 + \int_{2}^{\infty}\ 2\ 2(\ 2)\ 2\\
&+\int_0^{1}\int_{2}^{\infty}(\ 1-\ 1)\ (\ 1,\ 2)\ 2\ 1\Big]\\
&-\ 1\ 1 -\ 2\ 2 +\ 1\Big[\int_0^{1}\int_0^{2}(\ 1-\ 1)\ (\ 1,\ 2)\ 1\ 2\\
&+\int_0^{1+\ 2-\ 2}\int_{2}^{1+\ 2}(\ 1+\ 2-\ 1-\ 2)\ (\ 1,\ 2)\ 1\ 2\Big]\\
&+\ 2\Big[\int_0^{1}\int_0^{2}(\ 2-\ 2)\ (\ 1,\ 2)\ 2\ 1
\end{aligned}
$$

$$+ \int_0^{1+2-1} \int_{(1}^{1+2} (1 + 2 - 1 - 2)(1, 2)\, 2 \quad 1 \Big]$$

$$- 1 \Big[\int_1^{\infty} \int_2^{\infty} (1 - 1)(1, 2)\, 1 \quad 2$$

$$\frac{\partial E[\Pi]}{\partial \;_{2}} = -$$

[illegible]

$$ {}_1({}_1, {}_2) = \frac{2\ 1 + \ 2}{2(\ 1\ 2 - \ 2)}, \tag{1.60} $$

$$ {}_2({}_1, {}_2) = \frac{1\ 2 + \ 1}{2(\ 1\ 2 - \ 2)}, \tag{1.61} $$

[illegible] $1 = (\ 1 + \ 1\ 1) - \int_1^1 (\varepsilon_1 - \ 1)\ (\varepsilon_1)\ \varepsilon_1 - \ 2 + \mu_1$ [illegible] $2 = (\ 2 + \ 2\ 2) - \int_2^2 (\varepsilon_2 - \ 2)\ (\varepsilon_2)\ \varepsilon_2 - \ 1 + \mu_2$.

$$- (+ - +)$$
$$= (-)(+ -) - (-) + (-)\mu$$
$$-(- +)\int (\varepsilon -) (\varepsilon) \varepsilon, \quad (1.63)$$

$= -(+ -).$ o $E[\Pi(_1, _2, _1, _2)] = E[\Pi_1)] + E[\Pi_2]$

$$\frac{\partial E[\Pi]}{\partial} = (-) + (-) + (- +)[1 - F( )](1 -) + - \{(-) + (- +)[1 - F( )]\}. \quad (1.64)$$

$$\frac{\partial^2 E[\Pi]}{\partial^2} = -(- +)(1 -)^2 ( ) - (- +)^2 ( ), \quad (1.65)$$

$$\frac{\partial^2 E[\Pi]}{\partial_1 \partial_2} = -(_1 - _1 + _1)(1 - _1) (_1) - (_2 - _2 + _2)(1 - _2) (_2). \quad (1.66)$$

$, | _1| < 0, | _2| = _1 _2[(1 - _1)(1 - _2) - ^2]^2 > 0,$ $= (- +) ( )$

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