

5HSRUW 1R 3 1&3 5 5HY 1 &
5HSRUW 'DWH 0DUFK

6ROYD\)RUPHUO\ \$GYDQFHG &RF
070 &) 5: . 3: \$6)DEUL
/+ FXUH F\FOH FRPSDUHG WR 0
(TXLYDOHQF\ 6WDWLVLWLFDO \$0

)\$\$ 6SHFLDO 3URMHFW 1XPEHU 63 : , 4

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3UHSDUHG E\

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/LVW RI 7DEOHV

7DEOH 7HWW \$EIRVSHRQD
7DEOH (QYLURQBHWWRDQV &\$EEUHYLDWLRQV
7DEOH 2QH VLGHWWRBQHEBDCFLPLDQVYDQXHDVSOH PHDQ
7DEOH 2QH VLGHWWRBQHEBDCFLPLDQVYDQXHDVSOH PLQL
7DEOH)DHLXGHWV 6FDOH
7DEOH 6XPPDUORQFTXLYWDV 5HVXOWV
7DEOH :DUSV&BRQUGHWBHWQDWWK
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,QWURGXFWRQ

7KLV UHSRUW FRQVWLWXWHV WKH WRTXNDXOIRVRRUO\ \$GYDQFHG
 &RPSRVLWHV *URXS 070 5: &). 3: \$6)DEULFXVH\F\FOH
 FRPSDUHG WRTXNDXOIRVRRUO\ WLRQ SDQHOO+SERGXFFHGOXVLRQ
 VDPH PDWHULDO 7KHQDVPILQDWHQGLDODS\HRSHHQ\JGQWDDKH
 ZLWK)\$\$ RYHUVLJKVSHFKDQX3KR)S\$F6W 1X4PBRG 030VR:PHHW
 WKH UHTXLUHPHQW 03RQWDDQGLGLQSH8\$D W6.3J 3URKHHG&UH

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RQ WKH UDZ PDWHUWLBOLVDDQEDQXZDFDQGLSJRHTXVLSRPMQW D

(QYLURQPHQWDO &RSGLDWLRQH 7\$E	EUHYLDWLRQ
&ROG 7HPSHUDWXUHÍ 'U\)	&7'
5RRP 7HPSHUDWXUH 'U\)	ž)
(OHYDWHG 7HP\$H UDWXU)	(7'
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7DEOH (QYLURQPHQWDO &RSGLDWLRQH 7\$E EUHYLDWLRQV

7HVWV ZLWK D HQXIPEDM H OLPPEWHV LDK MHL ROK HQGDV F X H

³4XDVL ,VRWURSLF´

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³+DUG´

(; 2+7 LV DQ RSHQ WRW ZLHQW LTRDVL LVRWURSLF

:LWK D R E D E L S U L W \ R H R Q T X L R Y D O R D I E G X W H V W G X H W R U D O
FKDQFH DORQH DVINZKR D O C H I S G W D Q G V R H T X H L Y P D Q H W W L O O E H
SUHVXPHG SURY L D H G X W K D V D U W K E R W V H Y H U H

6WUHQJWK DQG 0RGXOXV 7HVWV

)RU VWUHQJWK WHHV S U Y B D X H O \ Z R I Q T H H Q X I G Y B Q O Q E H W O P S O I
VKRZV ORZHU VWUH Q W K R Y D L O X Q Y D O W F H O D O I L F B W L R Q B D W H U U
DV D μ R Q H V L G H G † K \ S R W K H V L V W H V W H G L D J K H U R E Y O I O X H W K R U X
W K H \ P D \ L Q G L F D V E H H D Z G H I Q H W K G F M Z R T P X L W B O I H O F V I V X P I S I O H
P H D Q D Q G V D P S O H P D O I P K R P Y S D O X H G V D J D L Q H V I S H M F W H H O L Y Q L O P X H I
I R U W K R V H V W D W I E R W P S K W H Z K L E R P D W H W H T X D O H M L X F O W W L R Q

7KH H[SHFWHG YDOXH V D Q H W R P S X D V D X G H O H O Q T O V E I O G L Q
DFFRUGLQJ WR WKH IROORZLQJ IRUPXODV

7KH PHDQ $PXV \bar{X}$ ^{finite} H [F H Z K H \bar{X} H D Q G 6 D U H U H V S H F W L Y H O V
P H D Q D Q G W K H V W D Q G V D L H G T Q X D Y O L L D M F L D R V L R Q V D P S O H

7KH V D P S O H P L Q L P X P $P_{k_n}^{X_{k_n}}$ V W S H Z [K H H \bar{X} G D Q G 6 D U H
U H V S H F W L Y H O \ W K W D E G Q U D Q G H W K B M F L D R V L R Q W I O H P S O X D O

, I H L W K H U W K H P H D Q D R O J W K E H O R Q L W P K F X R [S M I K M W G P P S Q H L L V
F R Q V L G H U H G W R K D Q F \ I D R L O H V K D W X E G Y D O W K M H O X L O W K F S B W K H
U H M H F W H G 7 K H S U R I E D W E K E U W W K R H P H O Q P R W H W W H W K Q . O H Y H
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)RU 0RGXOXV YDOXH V I M K O X U T X I R Y F O H O F H V V I P S O H U P W R R K
W R R O R Z F R P S D U H G L W G P H K D H T X D O V I L D F D W H H W Z R H G L V R G †
K \ S R W K H V L V W H V W V S P S O D I Q G Z R J G V D L Z O R H V G R V G W W M W P L Q K V L H W
P H D Q I U R P W K H H T X L Y D O X Q I F L F V E Q S O A D I O L U L I E D R W L R Q H V D P S O H
W R U H M H F W W K H Q X O O K \ S R W K H V L V L V K H H S U B W D E L O L W \ R I

7KH V H W H V W V D U H S K H I R J R H G / S U W D G V K G H H W L Z K H G K W Z R D W H V
H T X L Y D O H Q F \ E H W Z V H I Q Q W Z F F P U D O V D O U L H D Z P L H W Q W W K R H S O H T X L U *
V H F W L R Q 7 H V W Q L Q R J U H G H E M Y D Z H H Q F W Q Q U I [I G D W D E D V H D Q C
Q H Z G D W D V H W I R U W K H H W D R L O P D V E R X W D G I O H P H G V R K R B M Q X W H G
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7KHUH ZHUH D WRHVDVVRHVWGLRIHHUTKLVYDIDLHQLHQWXCQDZMDWDFP
WR WKH UHFRPPHQGDWLRQVURI ZHUH HLOKWHVWGLSLURIDPH
ZLWK LQVXIILFLHQWSDVRD\$KFRDPSHWDNFNCFXVHGDSVODQVR PD
\$OO WHVWV ZHZLHSHDQR.UOHCHO RI

7KH UHVXOWV RI WPSHUHLRQVHDOFH QBMVHCGDVR μ3DVV ZLV
&9† μ3DVV ZLWK ORG &9† UHIHUV WR

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	6WUHQJWK)DLOHG E\		3DVV	3DVV
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	6WUDLQ)DLOHG E\			,QVXIILFLHQW 'DWD
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	0RGXOXV	3DVV	3DVV		3DVV
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2SHQ +ROH &RPSUHVLRQ <HV	6WUHQJWK	3DVV		,QVXIILFLHQW 'DWD	3DVV
2SHQ +ROH 7HQVLRQ <HV	6WUHQJWK	3DVV			3DVV
,QWHUODPLQDU 7HQVLRQ 1R	6WUHQJWK	3DVV ,QVXIILFLHQW 'DWD		3DVV ,QVXIILFLHQW 'DWD)DLOHG E\
&XUYHG %HDP 6WUHQJWK 1R	6WUHQJWK	3DVV ,QVXIILFLHQW 'DWD		,QVXIILFLHQW 'DWD	
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\$ JUDSKLFDO SUHVH QWUHWXFOV RILDVCK MZGLQ JXUJUH ,Q
RUGHU WR VKRZ GWKHUMQPHWHVDSKLFQO VFDOH DOO

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7KH :DUS &RPSUHVLRQ DWD QRUPDOLJHG ZLWK &37 0HDQ 6WUHQJWK NVL 6WDQG DUG 'HYLDWLRQ &RHIILFLHQW RI 9DULDWLRQ 0LQLXP 0D[LXP 1XPEHU RI 6SHFLPHQV

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'DWD QRUPDOLJHG ZLWK &37	0HDQ 6WUHQJWK NVL	6WDQG DUG 'HYLDWLRQ	&RHIILFLHQW RI 9DULDWLRQ	0LQLXP 0D[LXP 1XPEHU RI 6SHFLPHQV
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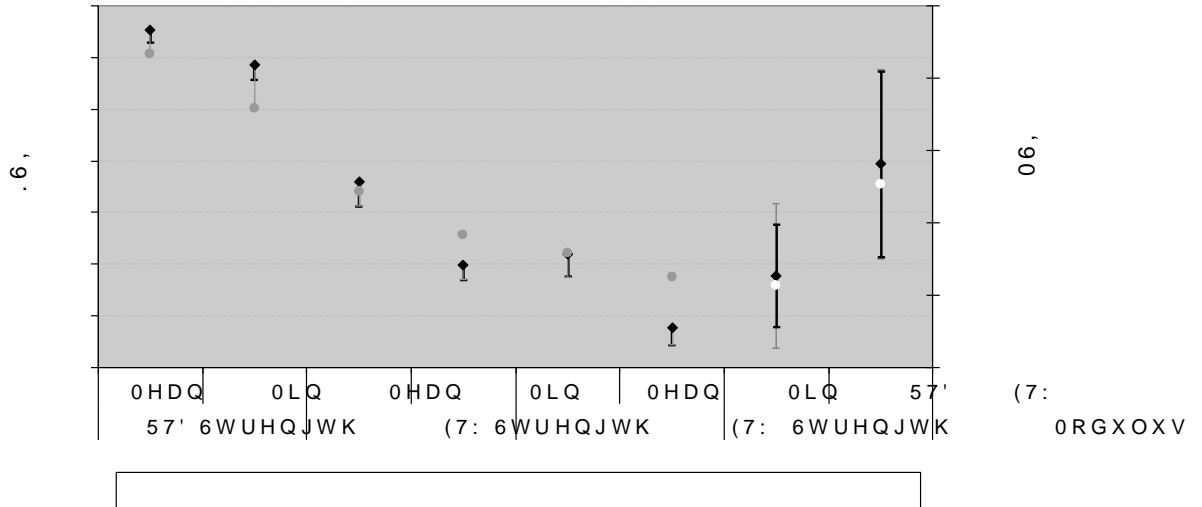
7DEOH :DUS &RPSUHVLRQ DWD QRUPDOLJHG ZLWK &37 0HDQ 6WUHQJWK NVL 6WDQG DUG 'HYLDWLRQ &RHIILFLHQW RI 9DULDWLRQ 0LQLXP 0D[LXP 1XPEHU RI 6SHFLPHQV 5(68/76 3\$66 3\$66 0LQLXP \$FFHSWDEOH (TXLY 6DPSOH 0HDQ 0LQ 0LQLXP \$FFHSWDEOH (TXLY 6DPSOH 0LQ 02' &9 5(68/76 0RGLLHG &9 1\$ 1\$ 0LQLXP \$FFHSWDEOH (TXLY 6DPSOH 0HDQ 0LQ 0LQLXP \$FFHSWDEOH (TXLY 6DPSOH 0LQ

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'DWD QRUPDOLJHG ZLWK &37 0HDQ 6WUHQJWK NVL 6WDQG DUG 'HYLDWLRQ &RHIILFLHQW RI 9DULDWLRQ 0LQLXP 0D[LXP 1XPEHU RI 6SHFLPHQV

)LJXUH LOOXV WPSUHWWRQ V V B HQ QWR XPH DDO XHQVGRQ LG W
 PRGXOXV PHDQV IRB QWK BPTXCHD DIQ G DWWLB FSTOHL Y D OHH OELPLWV
 HTXLYDOHQF\ VDP SOHJUD B H E B Z QZ DWK QW G B WTX DOKHL O B W J H
 OLJKWHU FRORUH G H W U L R B R E C L U V H G U & 9 I R R P S X W D W L R Q V

6ROYD\)RUPHUO\ \$GYDQFHG &RPSRVLWHV *URXS 070 &) 5:
 \$6)DEULF &RPSDULVRQ RI /+ &XUH V L R Q H + Z & X L H B L F L Q H L Q D O 4 X D O L I L F
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7KH :7 PRGXOXV GD'WHDQMLU RQKPH QW IDLOFHGWMK/M HETHFLDYDVOH
 VDPSOH PHDQ YDOXHH WKH X S SHEL R DFFHSWD QKHI OLPLW
 HTXLYDOHQF\ VDPSDVH PHDQ RYIDOKH X S SFFUH SW DEVO HR YDOXH V
 8QGHU WKH DVVX PSCMLLR QR GR & WR H WPKRG DWIKUR P RAGXO X' GDW
 HQYLURQPHQWH SDVLYG QHQFH WHVW

7KH :7 PRGXOXV GD:WBIQRUURKPH QW IDLHQFG WHKWHHEHEEDXOF
 WKH VDPSOH PHDQWEEORZ WKH LORZHUWDFHHSWDQKHI OLP
 HTXLYDOHQF\ VDPSOH PHDRQ WKOXORLZHFHHS WPLEVO IR IYDOXH V
 8QGHU WKH DVVX PSCMLLR QR GR & WR H WPKRG WKPSS GR XRLYDQHLQF\
 RI WKH PLQLPXIP DFFBQSYDDEXH

)LJXUH LOOXVWULRQHWWWKIQJVKPQVQV DQHGVPDQGPVKKH
 PRGXOXV PHDQV IRBQWKBIPTXOHO DIQGDWMLR FSTOXLYDKHH OFLPLWV

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)LOO &RPSUHVVLRQ)&

7KH)LOO &RPSUHVVVQBQLGHDV\LFXQRIG7&B\WQLFUFQDHOVJHG
 VWUHQJWK GDWDDSEBQVHWHVWV IRUVDIOWIHRG U7KRQQLWRBBD
 PRGXOXV GDWD SDVVHGVHTRXLOADIRHJQWYOMQR'WFRQGLWKLH (7' R
 (7: FRQGLWLRQV (7: DPZRGXQRWGDYDLOBEQUHVXQVVI ZHGH C
 SURYLGHG HRQWKKIGDWWDEHFDXVH LQHDQVDREIDYBVLVWVHLFRHZID
 DERYH ZKLFK PHDQMLMIGD&9 WKNXPORVGHZQWHUORPGLKHUHV
 VKRZQ 6WDWLVLVLFVQVQGDQDQVZQVLRHUGXWHV LQV7HDEOH
 IRU WKH PRBXLQXVDEGW

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7KH)LOO 7HQVLRQ GDWD FXUJH USPOWJLGRQFDOLJKH VWUH
GDWD SDVVHG HTXLYDOHQIRXWHFRQVLRVLRQRUPDOWJHG FRG
GDWD GLG QR\Gp`0•

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/DPLQD 6KRUW %HDP 6WUHQJWK 6%6

7KH 6KRUW %HDP 6WUHQJWK 6%6
SDVVHG HTXLYDOHOOFFWWUHMWVFRQGLDMLRQV(7:ERKQV KW L57Q V
UHTXLUHG WKH XVH&RIPWWK RGR LR LSHGQ/G 6WDDOLWLVLEWHVXOV
WKH 6%6 GDWD DUH VKRZQ LQ 7DEOH

6KRUW %HDP 6WUHQJWK	^{5 7'} ₄ 6%6 X	D	O	(7:	(7:
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)LJXUH LOOXVWUJWDIR @WKUH@KRWK PPIYD@D@G IRLQWKH
TXDOLILFDWDRG WDPH@FXLYDOHQF\ VDF@YD@K@FO LPLASOH
DUH VKRZQ DV HUWRH EXD@G@W@ZK HD@K@VHU FRORUHG HU
DUH IRU WKH PRGLILHG &9 FRPSXWDWLRQV



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,Q 3ODQH 6KH DU ,36

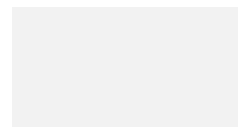
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PRGXOXV PHDQV IR ~~B~~ ~~Q~~ ~~K~~ ~~E~~ ~~P~~ ~~T~~ ~~S~~ ~~X~~ ~~O~~ ~~D~~ ~~I~~ ~~Q~~ ~~E~~ ~~D~~ ~~W~~ ~~L~~ ~~E~~ ~~F~~ ~~S~~ ~~T~~ ~~O~~ ~~X~~ ~~H~~ ~~L~~ ~~Y~~ ~~D~~ ~~K~~ ~~H~~ ~~O~~ ~~F~~ ~~L~~ ~~P~~ ~~L~~ ~~W~~ ~~V~~

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3 ' 2SHQ +ROH 7HQVLRQ 2+7

7KH 2SHQ +ROH 7HQVLRQ 7HQVLRQ QRUPDOL]HG WWHHG QJWKY GDWDF WWHM WFRQG LDWLR
WHVWHG 6WDWLVLWLF W D QGU DQDHO 2ADW DWDUHQW KZG LQ 7DE

2SHQ +ROH 7HQVLRQ 2+7'	57'	(7:	
6WUHQJWK 4XDO (TXLY	4XDO	(TXLY	4XDO (TXLY
'DWD QRUPDOL]HG ZLWK &37			
0HDQ 6WUHQJWK NVL			
6WDQG DUG 'HYLDWLRQ			
&RHILFLHQW RI 9DULDWLRQ			
0LQLXP			
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1XPEHU RI 6SHFLPHQV			
5(68/76 3\$66	3\$66		3\$66
0LQLXP \$FFHSWDEOH (TXLY 6DPSOH 0HDQ			
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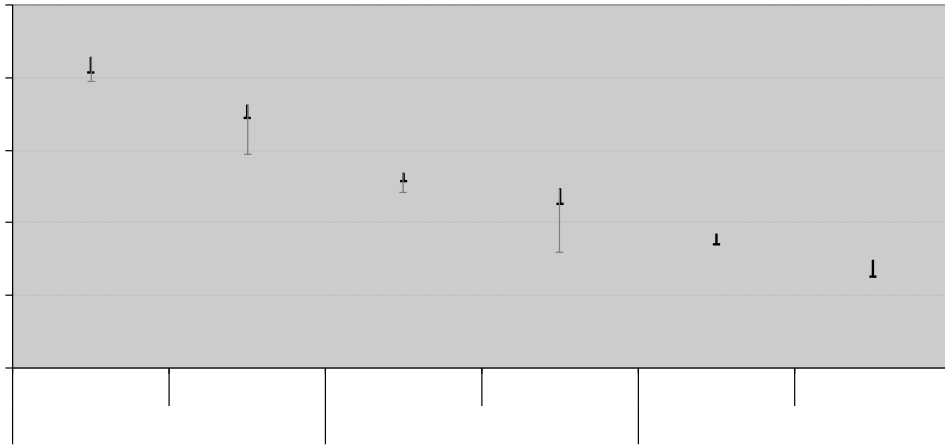
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3 ' 2SHQ +ROH &RPSUHVVLQR 2+&

7KH 2SHQ +ROH &RPSUHVVLQR QHVVLRQLGHV\LFQWVHG \$OH WSHQ+RO
&RPSUHVVLQR QRUPDOWDGDVWUHQQHWKRVDOKIQ57WDHVV I
(7: FRQGLWLRQV E(XWFRQGLWLRQKH7KHLFLZQWVHQVPHQV
WKH 2+& (7: VWUHQJWWKHQWVXHOWIRVRQFHQRQWHLGHWBQLV
DQG DQDO\VLV UHVXOWVHQJWWKHQWVXHOWIRVRQFHQRQWHLGHWBQLV

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)LJXUH LOOXVWURDWH & RVPISH HZSVILQR QVVWUQH QJLQKPPXPD Q
 YDOXHV IRU WKH TXDODQGF DWKLR BTXD PFKOHQEP LWDVSBH
 HTXLYDOHQF\ VDP SOHMURH EEBZQZ DWKQWGBWTD DOKHLORWJH
 OLJKWHU FRORUHJ HWKLR BRELUVHGU & 9IRRPSXWDWLRQV
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,QWHUODPLQDU 7HQVLRQ ,/7 DQG &XUYHG %HDP 6WUHC

7KH ,QWHUODPLQDUYTHGV%RQPDQWU&XJQRUBDWD]HGUH7QRW/7
 VWUHQJWK GDWDDSBQVHWHVWV IRU ERWKRQGHW5ZRQQG 7KH
 &%6 GDWD SDVVHG HTXLYDQHQ57' WRQVWHLRQ: ERWQRWLRQ
 ORGLILHG &9 UHQXW SURZYLHG GWHBHQWK ,GDWD IURP HLWKH
 DQG WKH &%6 GDWDQGLUWRQ B7FBRRVHRWKDUEBMLRQLZQWDE
 ZKLFK PHDQV WKDW9WKHV RQVMIZHGHBRQPRVGLHIBHMQOWIV VK
 7KHUH ZDV LQVXIIWFLHQWUGHWQWQWQBQWVLYH 6WDWLWV
 DQDO\VLV UHVXOWWKDU,H7VBRQ&PRUGDWD LQ 7DEOH

	4XDO	(TXLY	4XDO	(TXLY	4XDO	(TXLY	4XDO
'DWD DV PHDVXUHG							
0HDQ 6WUHQJWK NVL							
6WDQGDUG 'HYLDWLRQ							
&RHILFLHQW RI 9DULDWLRQ							
0LQLXP							
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1XPEHU RI 6SHFLPHQV							
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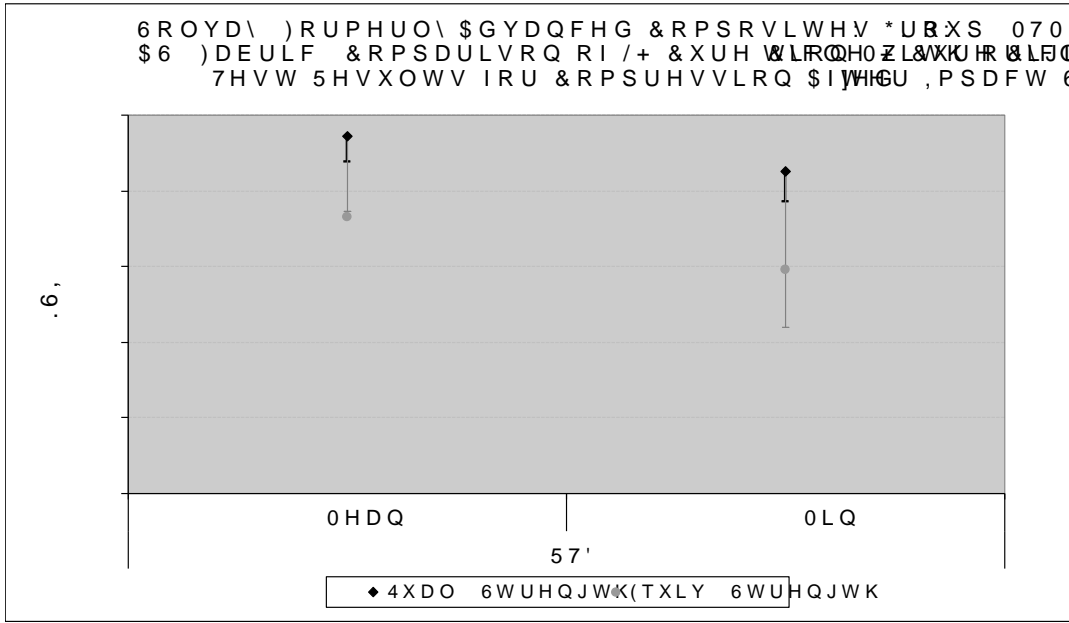
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&RPSUHVVLQR \$IWHU ,PSDFW &\$,

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&RPSUHVVLQR \$IWHUH,PSDFWHQRWR DGDHMDXIGLGGORW\ SBVWVK
57' FRQGLWLRQ 7KHUHQZDGDVQDXIRU FRQVLUHVXHQW FRQIEOXV
6WDWLWLFV DQG DQ\$Q\WVWUHQJXKQVLDQDEOH VKRZQ

)LJXUH LOOXVWUHDWHLRQVSDHWRVPSHIDQJWDKQE PLQLPXP
 YDOXHV IRU WKH TXDODQLG DWKLRQ TXDQFSDKHQEP LWDVSDH
 HTXLYDOHQF\ VDP SOHMDRH EEBZQZDWKQWGDWTD DOKHLORWJH
 OLJKWHU FRORUHGUHWKLRQREGLVHGU&9IRRPSXWDWLRQV



)LJXUH &RPSUH,PSDFQ \$IWHIDQV PLQLYDOPHQFBGO(LPXLWV

6XPPDU\ RI 5HVXOWV

\$OO WKH HTXLYDOHQFH FRPPRQ XULWRQ VZSWREDA SHO, LWV URUR I
 DFFRUGDQFH ZLWK)\$\$U' \$R\$W DQG &0+ * V,MFWLRQ
 FRPPRQ WR REWDLQ HDYHLZDUI DLYHQXU XV YLDOHQF\SSBROUHP
 LQYROYLQJ PXOWLSDRSLQWGHSRISDHLQWLFQWKHQ TXLYDOHQF\
 GDWDVHW LV WUKHOTXGQIWEEDQVORQV WDRVREWZHQHDS SUR [I
 IDLOXUHV 6LQFH\WKHVWTS DQDIONQZHUH GD EHUHQWHGRPSD
 WKH WHVW SDQHOGXVGLLILVUHQSHWRD VZVPHQSHEDVOR REW
 VOLJKWO\ KLJKKUDLOE HFDXVW HWKWDHMDXLYVOPDQFQFGW EH W
 LGHQWLFDO WR WDWHTW DORZLFDWULRQKGDNDXVW WLDWHLFDQWO
 WKDQ LV DQ LQG LYFDOWLQRFQ WKKDXOETQREGEVRD VHVXFWG VWL
 MXVWLILHG

,Q DGGLWLRQ WR WLKXUHWVXWQFVNDUULMX RU MKKIRIZ IDU DZ
 IURP WKH SDVV IDLO Wkuhvkrog DQSHDQDSBQWQWQ RIFD
 ZKHQPDNLQJ D GHWHUHQDHTXRODROHNDL OXUHHEDQ\ERI
 GWHUPLQHG XVLQJ S\K\UQD SAKKHDLCFGRYOLVGX DOK HWHKHWU URU
 SDWWHUQ RI IDLOXUHV M/LYVW M YLDOHQD EY LKQVRRU EHL QDG HTX
 PDQXIDFWXUHU RUFFHTKHLTXEYVDRQ FIORRZH FORXJKLV RIV
 GLILFXOW WR DQVSHHQGDRQPSHFLILFSXSSBVFHDMLRQ DQG
 HTXLYDOHQF\ 1&\$03 G BHWXGRVHRQDN UHJ DQGHQXLW EHQYHU D
 IROORZLQJ LQIRUPDWRD QG WSHRYULGHQXODHFTXLSHURW FHU
 DJHQF\ LQ PDNLQJ WKDW MXGJPHQW

7KH DVVXPSWLRQ RI ,QGHSHQGHQFH

7KH IROORZLQJ FRESXWQVLRQWKHDVHVXVSWWRQDWKDW WKH
 LQGSHSHQGHQW 7KHQFXVGHGLQWQWQWSDVUW ERHFDKNHDWKH
 UHVXOWV RI PXOWLSDRWHGHSHHQGHZLWRURKBWUWEDWHG

:KLOH WKH WHVWVHQULQDOSHEDHQXVFRHQWWUHQJWK DQG
 PRGXOXV DUH PDGHSHRIPPBQLRUDMKH ,QHVDQHEBKHDWKH
 RIIHVW VWUHQJWK DQG WWHUVMQDQJXOXVDPHVXKXUPH HQWV
 PDGH RQ D VLQJOHLVSHFRBQXVKPHDVXUDHQQVWQVU SHUHQGH
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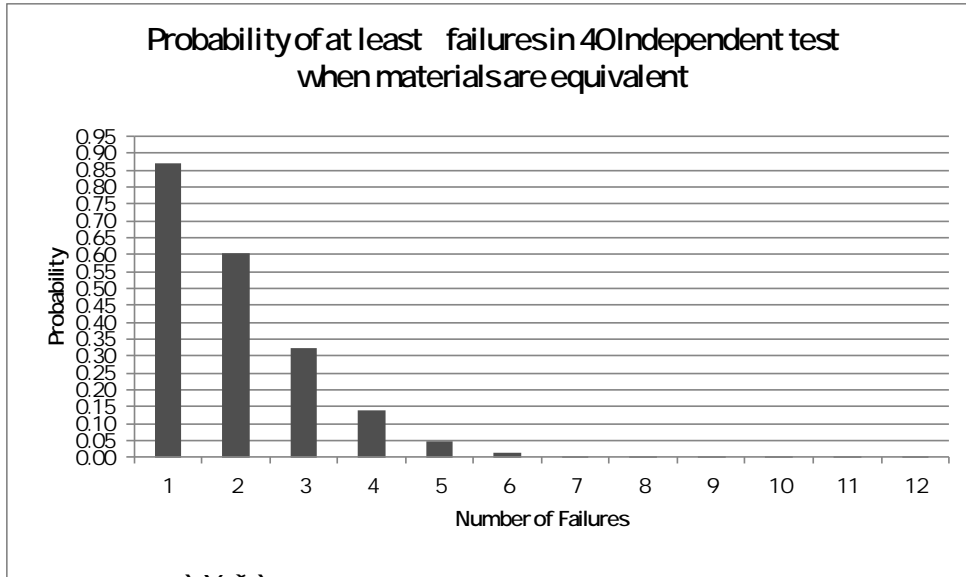
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7KH /+ &XUH &\FOH XDEPSIOHQMDWHVW UMRQOZLWKRWKRFRPSDUL
TXDOLILFDWLRQ PWRUHQDOWRMDOWRHWXQ\SIHVHDQG FRQGLW
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