Longevity Seminar

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Canadian Pensioners Mortality Improvement Rates, with Data as at December 31, 2012

Presenter(s):

Louis Adam
Canadian Pensioners Mortality Improvement Rates, with Data as at December 31, 2012
Outline

1. Introduction
2. Data, Acronyms
3. 2009-2011 Mortality Rates $q_x$
4. Recent MIR, Canadian Pensioners
5. Materiality: $\ddot{a}_x, \ddot{a}_x^{(12)}, \dot{e}_x$
6. Conclusion
1.1 Introduction

- Larger project: “Canadian Pensioners Mortality Trends by Region, Income and Cohort as at December 31\textsuperscript{st}, 2012”
- Split larger project in smaller sections
- Work in Progress: data validation, measurement of level and trends, extrapolation,…
- Focus of this talk on part of this larger project: \textbf{Mortality Improvement Rates in Canada at the beginning of the 21\textsuperscript{st} century: observations and issues}
- Some figures subject to change: impact on low pensions for small % of total data.

Note: \textbf{MIR} = Mortality Improvement Rates
1.2 Acknowledgements

- Help from Étienne Vanasse
  - graduate student, School of Actuarial Science, Laval University
- Funding
  - Chaire d’actuariat, Laval University
- Data and support
  - Canada Pension Plan, Office of the Chief Actuary, Ottawa (CPP)
  - Quebec Pension Plan, Régie des rentes du Québec, Québec (QPP)
1.3 Messages

1. Specific subsets of population exhibit different pattern of MIR compared to general population
2. Data quality and relevance are important: use caution in relying on “other” results
3. Long term MIR are difficult to predict: consensus?
4. Future Short Term MIR should reflect recent experience, then converge to Long Term MIR
5. This might be relevant and material to you, your pension plan or a specific line of annuity business
6. Humility and simplicity are good qualities for setting assumptions
1.4 Outcomes

1. Share with audience what is observed from Canadian Pensioners data
2. Share concerns on methodology
3. Check reasonableness of choices
4. Learn from questions and comments on the relevance of topics presented
5. Keep hubris in check...
2.1 Data, Acronyms

1. CPM: Canadian Pensioners Mortality

2. Administrative data as at December 31\textsuperscript{st}, 2012
   - Individual dates: birth, retirement, death
   - Exact exposure, deaths by integer age
   - Combined for 2009-2011 triennial period

3. CPM results by variables:
   - Age: 60 to 115
   - Calendar year or period: from 1967 to 2012
   - Data source, or region
   - Income Level, then Income Class
   - Gender

4. 30 Tables for triennial period 2009-2011, centered 2010
### 2.2 30 Subsets: CAN-4-M…

1. **Data source:** 3 subsets
   - **CPP:** Canada Pension Plan
   - **QPP:** Quebec Pension Plan
   - **CAN:** CPP + QPP

2. **Income Class:** 5 subsets
   1. Pension < 35 % Maximum Pension: Low income
   2. 35 %–94 %: Mid income (< Cdn Avg Wage)
   3. ≥ 95 %: High income
   4. ≥ 35 %: 2+3. Proxy for Private Pension Plans
   5. All income: 1+2+3. Comparable to CPP, QPP, general population

3. **Genders:** 2 subsets
   - Males (M), Females (F)
### 2.3 2009-2011 Exposure: 15.6 M

- **By gender**
  - Males: 7.69 Million life-years
  - Females: 7.92 M
  - Total: 15.61 M

- **By data source**
  - CPP
    - Males: 73.6 %
    - Females: 73.5 %
  - QPP
    - Males: 26.4 %
    - Females: 26.5 %

- **By Income Class**
  - Class 1
    - Males: 11 %
    - Females: 40 %
  - Class 2
    - Males: 46 %
    - Females: 49 %
  - Class 3
    - Males: 43 %
    - Females: 11 %

- Exposure varies with calendar year
  - CAN-5-M 2001: 1.9 M, 2011: 2.7 M
  - Lower % of total population at higher age for females due to shift in labor force participation
## 2.4 2009-2011 Exposure: table

<table>
<thead>
<tr>
<th>Income Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male CPP</td>
<td>0.62</td>
<td>2.54</td>
<td>2.49</td>
<td>5.04</td>
<td>5.66</td>
</tr>
<tr>
<td>Male QPP</td>
<td>0.24</td>
<td>0.99</td>
<td>0.80</td>
<td>1.79</td>
<td>2.03</td>
</tr>
<tr>
<td>Male CAN</td>
<td>0.86</td>
<td>3.53</td>
<td>3.30</td>
<td>6.83</td>
<td>7.69</td>
</tr>
<tr>
<td>Female CPP</td>
<td>2.29</td>
<td>2.91</td>
<td>0.62</td>
<td>3.53</td>
<td>5.82</td>
</tr>
<tr>
<td>Female QPP</td>
<td>0.93</td>
<td>0.94</td>
<td>0.22</td>
<td>1.16</td>
<td>2.10</td>
</tr>
<tr>
<td>Female CAN</td>
<td>3.22</td>
<td>3.85</td>
<td>0.85</td>
<td>4.70</td>
<td>7.92</td>
</tr>
</tbody>
</table>

In millions of life-years (rounded)
### 2.5 2009-2011 Deaths: 488 k

- **By gender**
  - Males: 277,902
  - Females: 209,772
  - Total: 487,674

- **By data source**
  - CPP
    - Males: 74.9 %
    - Females: 76.4 %
  - QPP
    - Males: 25.1 %
    - Females: 23.6 %

- **By Income Class**
  - Class 1
    - Males: 12 %
    - Females: 47 %
  - Class 2
    - Males: 44 %
    - Females: 43 %
  - Class 3
    - Males: 44 %
    - Females: 10 %

- Deaths and Exposure: \( \frac{3}{4} \text{ CPP} - \frac{1}{4} \text{ QPP} \)
- **Low Income**
  - Males: 11 % of exposure, 12 % of deaths
  - Females: 40 % of exposure, 47 % of deaths
## 2.6 2009-2011 Deaths: table

<table>
<thead>
<tr>
<th>Income Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male CPP</td>
<td>24.2</td>
<td>89.0</td>
<td>95.0</td>
<td>184.0</td>
<td>208.2</td>
</tr>
<tr>
<td>Male QPP</td>
<td>9.4</td>
<td>31.8</td>
<td>28.5</td>
<td>60.3</td>
<td>69.7</td>
</tr>
<tr>
<td>Male CAN</td>
<td>33.6</td>
<td>120.8</td>
<td>123.6</td>
<td>244.3</td>
<td>277.9</td>
</tr>
<tr>
<td>Female CPP</td>
<td>72.7</td>
<td>71.8</td>
<td>15.8</td>
<td>87.7</td>
<td>160.3</td>
</tr>
<tr>
<td>Female QPP</td>
<td>25.2</td>
<td>19.6</td>
<td>4.6</td>
<td>24.2</td>
<td>49.4</td>
</tr>
<tr>
<td>Female CAN</td>
<td>97.9</td>
<td>91.4</td>
<td>20.4</td>
<td>111.9</td>
<td>209.8</td>
</tr>
</tbody>
</table>

In thousands of deaths (rounded)
2.7 Comments on Data

1. Canadian
2. Recent: up to year 2011
3. Reliable and accurate: administrative data, actual pensions paid
4. Relevant: covers only pensioners
5. Consistent measures over time: 1967-2012
6. Some limitations:
   1. Age 60-115: no info under age 60
   2. Income ≥ Maximum pension: no refinement by income
   3. Plan inception and minimum age
   4. Coverage for women, work force participation
   5. Pensioners only
7. All data sources have limitations: possibly the most accurate for Canadian Pensioners
3.1 2009-2011 $q_x$

1. Focus of this presentation on MIR
2. Info on static mortality curves, centered in 2010
3. Mortality trend by age
4. Confidence intervals, graduated vs. observed rates
5. Shape of mortality over age 90
6. Mortality differential by data source
7. Mortality differential by Income Class
3.2 Mortality by Age: CAN-4-M, 65-80

CAN-4-M, 2009-2011, graduated qx

- Qx, observed
- Qx before spline
- Qx with spline
- Upper bound
- Lower Bound
3.3 Graduation: QPP-3-M, 65-80

QPP-3-M, 2009-2011, graduated qx
3.4 Graduation: CAN-4-M, 75-90

CAN-4-M, 2009-2011, graduated qx

<table>
<thead>
<tr>
<th>Year</th>
<th>Qx, observed</th>
<th>Qx before spline</th>
<th>Qx with spline</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>76</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>77</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>78</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>79</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>80</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>81</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>82</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>83</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>84</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>85</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
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<tr>
<td>86</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
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<tr>
<td>87</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>88</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>89</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
<tr>
<td>90</td>
<td>Qx observed</td>
<td>Qx before spline</td>
<td>Qx with spline</td>
</tr>
</tbody>
</table>

Upper bound
Lower Bound
3.5 CAN-4-F Graduation, 75-90

CAN-4-F, 2009-2011, graduated qx

- Qx, observed
- Qx before spline
- Qx with spline

Upper bound
Lower bound
3.6 QPP-3-F Graduation, 75-90

QPP-3-F, 2009-2011, graduated qx

Qx, observed
Qx before spline
Qx with spline
Upper bound
Lower bound
3.7 End of Table, C&K, CAN-5-M

Coale & Kisker, CAN-5-M

- Observed
- CI 97.5%
- CI 2.5%
- Coale & Kisker

$q_x$

90 95 100 105

age
3.8 End of Table, C&K, CAN-5-F

Coale & Kisker, CAN-5-F

- Observed
- CI 97.5%
- CI 2.5%
- Coale & Kisker

$q_x$ vs. age

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3.9 Mortality Difference by Source: M

Male graduated $q(x, 2010)$ in % of CAN-4-M
3.10 Mortality Difference by Source: F

Female graduated $q(x,2010)$ in % of CAN-4-F

- CPP-4-F
- QPP-4-F
3.11 Mortality Difference by Income

Male graduated $q(x, 2010)$ in % of CAN-4-M

- CAN-1-M
- CAN-2-M
- CAN-3-M
- CAN-5-M
3.12 Male $q(x,2010)$ vs. CAN-4-M

Male graduated $q(x, 2010)$ in % of CAN-4-M
3.13 Female q(x,2010) vs. CAN-4-F

Female graduated q(x,2010) in % of CAN-4-F
3.14 Comments on $q(\Theta)$

1. $q(\Theta)$ is not only a function of age and gender
2. Data source seems less material, but the dynamics over time of $q(\Theta)$ suggest a separate treatment:
   $q($age, gender, source$)$
3. Income is clearly material:
   $q($age, gender, source, income class$)$
4. Exclusion of Income Class 1 for private plans. Use at least Income Class 4, or 2+3, etc.
5. $q(\Theta)$ also a function of time. Need for MIR:
   $q($age, gender, source, income class, year$)$
4.1 Recent MIR, Canadian Pensioners

1. Data as at 2012-12-31, End in 2011 here
2. Recent past: 2001-2011, beginning of 21st century
3. Example at age 70: how MIR is measured
4. Example for one subset: CAN-4-M, 15 & 10-year
5. Comparison by subsets:
   1. Gender
   2. Data source or region
   3. Income Class
6. Issues
4.2 Illustration: CPM-4-M q_{70}, 1996-2011

CAN-4-M, Age 70, Trend 1996-2011
15-yr avg MIR: 3.22 %, $R^2=98.5\%$, bounds: 3.00 % - 3.44 %
10-yr avg MIR: 3.40 %, $R^2=97.7\%$, bounds: 3.01 % - 3.78 %
5-yr avg MIR: 3.37 %

2009-2011 $q_{70}$: Observed=0.019089, Graduated=0.019459
4.3 CAN-4-M 1996-2011 10-yr MIR

CPM CAN-4-M M.I.R.
Weighted Linear Regression, 2001-2011 10-year Period

Age 70: 3.40%, Bounds: 3.01%-3.78%, R² = 97.7 %
4.4 CAN-4-M MIR Short term

CAN-4M

- Observed rates 2001-2011
- Lower Bound
- Upper Bound
- B-Spline
- Rule of three

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4.5 CAN-5-M, MIR

CAN-5M

Observed rates 2001-2011  ············ Lower Bound  ············ Upper Bound  ············ B-Spline

-1.0%  0.0%  1.0%  2.0%  3.0%  4.0%  5.0%  6.0%

60 65 70 75 80 85 90 95 100

CAN-5M
4.6 CAN-5-F, MIR

CAN-5F

- Observed rates 2001-2011
- Lower Bound
- Upper Bound
- B-Spline
4.7 CAN-3-M, MIR

CAN-3M

[Graph showing observed rates 2001-2011, lower bound, upper bound, and B-Spline for CAN-3M mortality improvement rates.]
4.8 CPP-3-M, MIR

CPP-3M

- Observed rates 2001-2011
- Lower Bound
- Upper Bound
- B-Spline
- Rule of three

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with Data as at December 31, 2012
4.9 QPP-3-M, MIR

QPP-3M

- Observed rates 2001-2011
- Lower Bound
- Upper Bound
- B-Spline
- Rule of three

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4.10 CPP-3-F, MIR

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4.11 Issues with MIR

1. What is the Long Term MIR?
   a) 0.80 %, b) 1.00 %, c) 1.20 % d) Other rate...

2. Length of transition: 15, 20, 23, 30 years?

3. Shape of transition curve over time:
   1. constant at beginning: 0, 3, 5 years ?
   2. shape of curve after: see examples next slide
   3. Other, bumps ?

4. Same pattern for all subsets?

5. Treatment of difference by income: faster convergence? See example on second next slide

6. Other patterns by age, cohort, subset?

7. Uncertainties, economic constraints (age >90)
4.12 Various Convergence over 20 years

Example of convergence with 3rd degree polynomial
with K % at 10 years, 20-year horizon, various values of K
4.13 Diff. of (QPP-3-M) – (QPP-4-M)

QPP-3-M MIR, Age 65

- QPP-3-M
- QPP-4-M
4.14 Diff. of (QPP-3-M) – (QPP-4-M)

QPP-3-M MIR, Age 80

<table>
<thead>
<tr>
<th>Year</th>
<th>QPP-3-M</th>
<th>QPP-4-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>3.0%</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td>1.5%</td>
<td></td>
</tr>
<tr>
<td>2031</td>
<td>1.0%</td>
<td></td>
</tr>
</tbody>
</table>
4.15 “3-D” Representation of MIR

1. X-axis: calendar year from 2011 to 2035
2. Y-axis: age from 65 to 100
3. Z-axis: MIR(age, year)
4. Ultimate MIR based on current CPM-B scale
   • Subject to change: constant value, end value...
5. Initial MIR specific to subset, constant 3 years
6. 20-Year interpolation from 2013 to 2033: 3rd degree polynomial with null slopes at both end year
4.16 “3-D” MIR: CAN-4-M

Illustration of MIR, CAN-4-M
4.17 “3-D” MIR: CAN-4-F

Illustration of MIR, CAN-4-F

[3D Diagram showing mortality improvement rates for CAN-4-F, with age on the x-axis and year on the y-axis.]
4.18 “3-D” MIR: QPP-4-M

Illustration of MIR, QPP-4-M
4.19 “3-D” MIR: QPP-3-M

Illustration of MIR, QPP-3-M
5.1 Materiality

1. Valuation date: Jan. 1\textsuperscript{st}, 2015
2. Interest rate: 4 \% /year, constant
3. Life Annuity-Due, no guarantee, no reversion
4. $1,000 per year, payable annually or monthly (U.D.D.)
5. Male, Age 65
6. Compare present value for various combination of initial static tables and MIR
7. Figures in $ and \% increase: assess materiality
8. Complete Life Expectancies: Males and Females
5.2 Results, Present Value

- CIA CPM2014 Composite (CPM-B scale): $14,674
- Impact of using same MIR: CPM-B scale
- Impact of using MIR tailored to each subset
- Materiality: 0% to 5%
- Vary by age, gender, annuity form, etc.

<table>
<thead>
<tr>
<th>Subset</th>
<th>CIA CPM-B Scale</th>
<th>Table-Specific Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-4-M</td>
<td>14,011 (100 %)</td>
<td>14,101 (+0.64 %)</td>
</tr>
<tr>
<td>CAN-3-M</td>
<td>14,328 (+2.26 %)</td>
<td>14,502 (+3.50 %)</td>
</tr>
<tr>
<td>CPP-3-M</td>
<td>14,311 (+2.14 %)</td>
<td>14,424 (+2.95 %)</td>
</tr>
<tr>
<td>QPP-3-M</td>
<td>14,380 (+2.63 %)</td>
<td>14,684 (+4.80 %)</td>
</tr>
</tbody>
</table>
5.3 Results, Present Value

- CIA CPM2014 Composite (CPM-B scale): $14,211
- Impact of using same MIR: CPM-B scale
- Impact of using MIR tailored to each subset
- Materiality: 0 % to 5 %...

<table>
<thead>
<tr>
<th>Subset</th>
<th>CIA CPM-B Scale</th>
<th>Table-Specific Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-4-M</td>
<td><strong>13,548</strong> (100 %)</td>
<td>13,638 (+0.66 %)</td>
</tr>
<tr>
<td>CAN-3-M</td>
<td>13,864 (+2.33 %)</td>
<td>14,039 (+3.62 %)</td>
</tr>
<tr>
<td>CPP-3-M</td>
<td>13,847 (+2.21 %)</td>
<td>13,960 (+3.04 %)</td>
</tr>
<tr>
<td>QPP-3-M</td>
<td>13,917 (+2.72 %)</td>
<td><strong>14,221</strong> (+4.97 %)</td>
</tr>
</tbody>
</table>
5.4 Results, Life Expectancy, Male

- Valued as at Jan. 1\textsuperscript{st}, 2015
- With CPM2014 Composite (CPM-B scale): 22.19
- Impact of using same MIR: CPM-B scale
- Impact of using MIR tailored to each subset
- Materiality: 0 % to 7 %...

<table>
<thead>
<tr>
<th>Subset</th>
<th>CIA CPM-B Scale</th>
<th>Table-Specific Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-4-M</td>
<td>20.78 (100 %)</td>
<td>21.01 (+1.11 %)</td>
</tr>
<tr>
<td>CAN-3-M</td>
<td>21.38 (+2.89 %)</td>
<td>21.77 (+4.76 %)</td>
</tr>
<tr>
<td>CPP-3-M</td>
<td>21.36 (+2.79 %)</td>
<td>21.61 (+3.99 %)</td>
</tr>
<tr>
<td>QPP-3-M</td>
<td>21.45 (+3.22 %)</td>
<td>22.15 (+6.59 %)</td>
</tr>
</tbody>
</table>
5.5 Results, Life Expectancy, Female

- Valued as at Jan. 1st, 2015
- With CPM2014 Composite (CPM-B scale): 24.49
- Impact of using same MIR: CPM-B scale
- Impact of using MIR tailored to each subset
- Materiality: 0 % to 5 %

<table>
<thead>
<tr>
<th>Subset</th>
<th>CIA CPM-B Scale</th>
<th>Table-Specific Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-4-F</td>
<td><strong>23.58</strong> (100 %)</td>
<td>23.80 (+0.93 %)</td>
</tr>
<tr>
<td>CAN-3-F</td>
<td>24.03 (+1.91 %)</td>
<td>24.39 (+3.44 %)</td>
</tr>
<tr>
<td>CPP-3-F</td>
<td>23.93 (+1.48 %)</td>
<td>n.a.</td>
</tr>
<tr>
<td>QPP-3-F</td>
<td>24.35 (+3.27 %)</td>
<td>n.a.</td>
</tr>
</tbody>
</table>
5.6 Comments

- Materiality of different short term MIR is illustrated
- Also shown implicitly: different initial mortality table
- Impact if annuity with different parameters:
  - Age
  - Valuation date
  - Annuity form
  - Economic assumptions
- Sensitivity testing to be done:
  - Change in Long Term MIR
  - Other choices of convergence pattern...
- Underlying question: what is an appropriate choice of assumptions?
6. Conclusion

• Work in progress
• Data, model, errors, projections: humility
• Reliable, recent data with income and region shows various patterns by subsets of population
• Past MIRs vary by region, income on top of other variables
• Is it material?
• Is it acceptable in practice?
• Is it consistent with current thinking?
• Who pays the price if actual experience deviates from expectations?
Sensitivity Test: Change in LTR

- LTR = Ultimate Long Term Rate in 2033
- Initial Case: CPM-B Scale, 2014 Composite Table
- Alternative A:
  - 0.80 % constant from age 65 to age 90
  - 3rd-degree interpolation to 0 % at age 100
- Alternative B: same, but 1.0 % instead of 0.8 %
- Alternative C: same, but 1.2 % instead of 0.8 %
Alternative A, Males

Illustration of MIR, CAN-4-M LTR, Alternative A
Alternative B, Males

Illustration of MIR, CAN-4-M LTR, Alternative B
Alternative C, Males

Illustration of MIR, CAN-4-M
LTR, Alternative C
Alternative A, Females

Illustration of MIR, CAN-4-F
LTR, Alternative A

SOA Longevity Seminar, Canadian Pensioners Mortality Improvement with Data as at December 31, 2012
Alternative B, Females

Illustration of MIR, CAN-4-F
LTR, Alternative B
Alternative C, Females

Illustration of MIR, CAN-4-F
LTR, Alternative C