Actuarial Valuation of the Canada Pension Plan

Modeling Uncertainty and Properly Disclosing the Results

Session 125: Social Insurance Projections – Methods and Models
Jean-Claude Ménard
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- Canada Pension Plan (CPP)
- Cash Flow Formula
- Demographic Model (Population Projections)
- Economic Model (Contributions)
- Expenditures
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- International Actuarial Standards of Practice
Canada Pension Plan

- Came into force on 1 January 1966.
- National Career Adjusted Earnings Defined Benefit Plan.
- The CPP includes virtually all members of the labour force in Canada, including both employees and self-employed persons between the ages of 18 and 70 with employment earnings, other than those covered by the Québec Pension Plan (QPP).
- Financed by employees’ and employers’ contributions (12.5 million contributors in 2009) and in the future, by investment earnings.
- Provides retirement, disability, survivor, child, and death benefits (5.2 million beneficiaries in 2009).
Cash Flow Formula

Definitions

\(A_t\) : Assets at the end of year \(t\).
\(CF_t\) : Net Cash Flow in Year \(t\)
\(I_t\) : Annual investment income in year \(t\)
\(Co_t\) : Annual contribution income in year \(t\) (excluding interest income)
\(E_t\) : Annual expenditures in year \(t\) (benefits + administrative expenses)
\(i_t\) : Rate of Return in year \(t\)

Formulas

\[A_t = A_{t-1} + Co_t + I_t - E_t\]
\[CF_t = Co_t - E_t\]
\[I_t = i_t A_{t-1} + [(1 + i_t)^{1/2} - 1] \cdot Co_t - [(1 + i_t)^{1/2} - 1] \cdot E_t\]
\[A_t = (1 + i_t) A_{t-1} + [(1 + i_t)^{1/2} \cdot (Co_t - E_t)] = (1 + i_t) A_{t-1} + [(1 + i_t)^{1/2} \cdot CF_t]\]
Cash Flow: The Big Picture

**DEMOGRAPHIC MODEL**
- General Population
  - Labour Force
  - Population of Contributors
    - Eligible/Electing Population (by Benefits)
- Administrative Expenses

**FINANCIAL MODEL**
- Various Macro-Economic Variables
  - Average Wage
  - Average Contributory Earnings
    - Total Contributions (9.9%)
  - Total Contributory Earnings
  - Total Amount of Benefit Costs
- Average Amount (by Benefits)

**PROJECTIONS**
- Cash Flow
Demographic Model

Major Assumptions
• Mortality
• Migration
• Fertility
Contributions

• CPP contribution rate is applicable to annual earnings between
  – a minimum amount called the “Year’s Basic Exemption" (YBE)
  – and a maximum amount called the “Year’s Maximum Pensionable Earnings” (YMPE).

• Contributions are based on
  – Employment earnings from salary or wages; and
  – Self-employment earnings.

• The employer matches each employee’s contributions (4.95%).

• Those who are self-employed pay both shares (9.9%)
Contributions Model

Major Assumptions
- Labour Force Participation Rates
- Unemployment Rates
- Employment Rates
- Proportion of Earners
- Proportion of Contributors
- Average and Total Employment Earnings
- Average and Total Pensionable Earnings
- Average and Total Contributory Earnings
- Earners and Earnings Distributions (%)
Expenditures

Source: Actuarial Report on the CPP as at 31 December 2006
Retirement Benefit Calculation

Population

Proportion Eligible to Retire

Proportion that Elect to Retire

Number of New Retirees

Total Initial Monthly Pension Benefit

Calculation done for each year, age and sex

Earnings

Contributions

Contributory Period

Monthly Base Pension Benefit

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Total Retirement Expenditures

Retired Population (year -1)

Proportion that Survive*

Total Initial Monthly Pension Benefit (x12)

Indexation Factor Since Retired

Retirement Benefits for In-pay Retirees

Total Retirement Benefits

Total Initial Monthly Pension Benefit

Number of Months in First Retirement Year

Retirement Benefits for Newly Retired

* Specific CPP Beneficiaries Mortality
Survivor Benefit Calculation

Calculation done for each year, age and sex
Total Survivor Expenditures

1. Survivor Population (year -1)
2. Proportion that Survive*
3. Total Initial Monthly Survivor Benefit (x12)
4. Indexation Factor Since Survivor
5. Survivor Benefits for In-pay Survivors
6. Total Survivor Benefits
7. Total Initial Monthly Survivor Benefit
8. Number of Months in First Survivor Year
9. Survivor Benefits for Newly Retired

* Specific CPP Beneficiaries Mortality

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Disability Benefit Calculation

Population

Proportion Eligible For Disability Benefits

Disability Incidence Rate

Number of New Disabled Beneficiaries

Total Initial Monthly Disability Benefit

Earnings

Contributions

Contributory Period

Monthly Base Disability Benefit

Calculation done for each year, age and sex
Total Disability Expenditures

Disability Population (year -1)

Proportion that Survive*

Total initial Monthly Disability Benefit (x12)

Indexation Factor Since Disabled

Disability Benefits for In-pay Disabled

Total Disability Benefits

Total Initial Monthly Disability Benefit

Number of Months in First Year of Disability

Disability Benefit for Newly Disabled

* Specific CPP Disabled Termination Rates (Mortality and Recovery)
Assets Projection

Real RoR by Asset Class

Inflation

Nominal RoR by Asset Class

Portfolio Asset Mix

Assets at the Beginning of Year

+ Contributions

- Expenditures

+ Investment Earnings

Assets at the End of Year

Net Portfolio Nominal RoR (i)

Investment Expenses
Reporting the Results
(Purpose of the Actuarial Report)

• Prepared in compliance with the timing and information requirements of the Canada Pension Plan.
  – Must be prepared every three years (Section 115).
  – 2008 amendments (Bill C-36) highlight that the Plan is subject to two financing objectives:
    • Steady-state funding which replaces the original pay-as-you-go financing to build a reserve of assets and stabilize the ratio of assets to expenditures over time.
    • Incremental full funding which requires that changes to the CPP that increase benefits or add new benefits be fully funded.

• To inform contributors and beneficiaries of the current and projected financial status of the Plan.
Projected Asset/Expenditure Ratio

Evolution of the Asset/Expenditure Ratio

Source: Actuarial Report on the CPP as at 31 December 2006

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9.9% Legislated rate

9.82% minimum contribution rate
(9.80% steady-state + 0.02% full funding)

Target Years 2019 and 2069
## International Actuarial Standards of Practice (IASP 1) of the International Actuarial Association (IAA)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
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<td>Executive Summary</td>
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<td>2.</td>
<td>Introduction</td>
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<td>Analysis of projection results</td>
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<td>10.</td>
<td>Attestations</td>
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<td>11.</td>
<td>Actuary’s name, position and date</td>
</tr>
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</table>

**IASP 1 – Guidelines of Actuarial Practice for Social Security Programs**

IAA Guidelines:
Information to be Included in Actuarial Reports

1. Executive Summary
   – Purpose of the report and identification of the program
   – Identification of key assumptions
   – Main results of financial projections and main conclusions

2. Introduction
   – To whom the report is addressed
   – Starting and ending dates of the projection period
   – Reference to the relevant preceding reports
   – Contemplated date of next report

3. Description of the provisions of the SSP concerned
   – Include a description of the provisions of the program materially relevant to the projections:
     • Coverage, Financing and Benefits
IAA Guidelines
Information to be Included in Actuarial Reports

4. Data
– Obtain reliable and sufficiently complete data:
– Assess and comment on accuracy of data, and any limitations

5. Assumptions
– The actuary should describe in the report the rationale used for the determination of all assumptions used for the projections.

6. Methodology
– Described in a manner that provides sufficient information for an actuary or other person with relevant expertise to assess the results of the report.
IAA Guidelines
Information to be Included in Actuarial Reports

7. Results
   – Sections on data, methodology and assumptions
     (a) Population by age groups and sex and in total
     (b) Dependency ratios
     (c) Employment earnings by age groups, sex, and averages
     (d) Contributory earnings by age groups, sex, and averages
     (e) Pensionable earnings by age groups, sex, and averages
     (f) Covered payroll and workforce by sector of economic activity

   – Section on cash flow financial projections
     (g) Contribution rate
     (h) Pay-as-you-go rate
     (i) Contributions
     (j) Investment earnings
     (k) Other income
     (l) Total income
     (m) Benefits
     (n) Administrative expenses
     (o) Total expenditures
     (p) Assets
8. Analysis of projection results

- Report should present:
  - Sensitivity analyses, showing the effects on the main projection results of variations in key assumptions
  - Reconciliation with the previous report
  - Explanations of the pattern of financial projections, e.g., ageing of the population, maturing of the program, recent changes in the program financing or benefit provisions
  - Effect on the financial projections of events subsequent to the beginning of the projection period
IAA Guidelines:
Information to be Included in Actuarial Reports

9. Conclusion
- Main objective of an actuarial report:
  • estimate of the costs and projected financial status of the existing program and/or proposed
    changes therein
- Ensure readers will have a sound understanding of the future financial prospects for the
  Program concerned, and the inevitable uncertainties in making projections
- Provide an indication of eroding effect of inflation

10. Attestations / Actuarial Opinion
- In the report, the actuary should provide an opinion regarding the:
- Sufficiency and reliability of data.
- Reasonableness of assumptions.
- Appropriateness of the methodology and its consistency with sound actuarial principles.
- Report's compliance with, and departures from, any local standards and guidelines and
  the IAA Guidelines of Actuarial Practice.

11. Actuary's Name, Signature, Position Held and Date
Peer Review Process

• Internal peer review (before tabling of the report)
• External Peer Review (after tabling of the report)
  – OCA commissions external peer review
  – Federal, provincial, and territorial finance ministers endorsed peer review of CPP reports
  – External peer reviewers: 3 actuaries enrolled with the CIA and Fellows of the Society of Actuaries
  – UK Government Actuary’s Department (GAD)
    • Selects independent Canadian actuaries
    • Provides an opinion on the work done by peer reviewers
Peer Review Process

• External Peer Review
  – Provides opinions on:
    • Professional experience of Chief Actuary and staff
    • Compliance with professional standards and statutory requirements
    • Accessibility to information required to perform valuation
    • Reasonableness of actuarial methods and assumptions
    • Communication of results through Actuarial Report
  – Also provide recommendations for future reports
Annex

• Reporting System in Excel
• Other Uses of CPP Model
• Child Benefits
• Death Benefits
• Best-Estimate Assumptions
Reporting System in Excel

• The Actucan Data Reporting System (ADRS) produces about two hundred files that can be imported into Excel
• Comma Separated Files (.CSV)
• Converted into Pivot tables for ease of viewing
• CD-Rom Distributed to Stakeholders
# Reporting in Excel

**Actuarial Variable** [AdsTable02]

**Workbook Name** [AdsCPP23_Cpp23Table02.xls]

**Table 02 Population by Year, Age Group, Sex and Territory (Canada, Quebec and Canada less Quebec) in (thousands)**

<table>
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<th>ReportList</th>
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<td>[CPP-23] Table 03 Economic and Investment Assumptions</td>
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<td>[CPP-23] Table 04 Contributions</td>
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<td>[CPP-23] Table 05 Beneficiaries (thousands)</td>
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<td>[CPP-23] Table 06 Beneficiaries by Sex (thousands)</td>
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<td>[CPP-23] Table 07 Expenditures ($ million)</td>
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<td>[CPP-23] Table 08 Expenditures (millions of 2007 constant dollars)</td>
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<tr>
<td>[CPP-23] Table 09 Expenditures as Percentage of Contributory Earnings (pay-as-you-go rates)</td>
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<td>[CPP-23] Table 10 Historical Results ($ million)</td>
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<td>[CPP-23] Table 11 Financial Status ($ million)</td>
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<td>[CPP-23] Table 12 Financial Status (millions of 2007 constant dollars)</td>
</tr>
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<td>[CPP-23] Table 13 Sources of Revenue and Funding of Expenditures ($ billion)</td>
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<td>[CPP-23] Table 14 Total Fertility Rates</td>
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<td>[CPP-23] Table 15 Annual Mortality Improvement Rates</td>
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<td>[CPP-23] Table 16 Mortality Rates (annual deaths per 1,000 people)</td>
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<td>[CPP-23] Table 17 Life Expectancies, without improvements after the year shown</td>
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<tr>
<td>[CPP-23] Table 18 Life Expectancies, with improvements</td>
</tr>
</tbody>
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Reporting in Excel

Actuarial Tables 23rd CPP Report as at 31/12/2006
(Step Number: CPP23-11E)
Table 02 Population
(thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>3 Age 20-64</th>
<th>4 Age 65 and Over</th>
<th>5 Ratio of 20-64 to 65 and Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>10,376</td>
<td>1,936</td>
<td>5.4</td>
</tr>
<tr>
<td>2008</td>
<td>10,410</td>
<td>1,999</td>
<td>5.2</td>
</tr>
<tr>
<td>2009</td>
<td>10,562</td>
<td>2,063</td>
<td>5.1</td>
</tr>
<tr>
<td>2010</td>
<td>10,650</td>
<td>2,129</td>
<td>5.0</td>
</tr>
<tr>
<td>2011</td>
<td>10,747</td>
<td>2,204</td>
<td>4.9</td>
</tr>
<tr>
<td>2012</td>
<td>10,805</td>
<td>2,302</td>
<td>4.7</td>
</tr>
<tr>
<td>2013</td>
<td>10,859</td>
<td>2,393</td>
<td>4.5</td>
</tr>
<tr>
<td>2014</td>
<td>10,913</td>
<td>2,492</td>
<td>4.4</td>
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<tr>
<td>2015</td>
<td>10,954</td>
<td>2,506</td>
<td>4.2</td>
</tr>
<tr>
<td>2016</td>
<td>11,005</td>
<td>2,602</td>
<td>4.1</td>
</tr>
<tr>
<td>2017</td>
<td>11,046</td>
<td>2,775</td>
<td>4.0</td>
</tr>
<tr>
<td>2018</td>
<td>11,072</td>
<td>2,879</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Other Uses of CPP Model

• The CPP model is primarily used to project cash flows, but it can also be used to determine the:
  – Unfunded obligation
  – Balance sheet
  – Funded ratio

(Actuarial Study #8 Technical Aspects of the Financing of the Canada Pension Plan
Unfunded Obligations of the CPP

- Unfunded Obligation = Liabilities - Assets
- Related measure: Funded Ratio = Assets/Liabilities
- Different approaches to valuing measures based on:
  - Participant Group: Closed versus Open
  - Future Benefit Accruals: With or Without
- Closed group  ➔ current participants only, no new entrants permitted
- Open group  ➔ current and all future participants
Unfunded Obligations of the CPP (cont.)

- Future benefit accruals
  - participants continue to contribute and accrue benefits
  - can apply to either a closed or open group.
- No future benefit accruals
  - participants do not continue to contribute and accrue benefits
  - can only apply to a closed group.

Current CPP methodology to value its liabilities: closed group without future benefit accruals
### CPP Groups With or Without Future Benefit Accruals – Balance Sheet at 31 December 2006 (9.9% contribution rate)

<table>
<thead>
<tr>
<th>Present Value as at 31 Dec. (in $ billion)*</th>
<th>Excluding Future Benefit Accruals</th>
<th>Including Future Benefit Accruals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current CPP (closed group)</td>
<td>Closed Group</td>
</tr>
<tr>
<td><strong>Assets and Contributions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Assets</td>
<td>114</td>
<td>114</td>
</tr>
<tr>
<td>Future Contributions</td>
<td>0</td>
<td>590</td>
</tr>
<tr>
<td><strong>Total Assets (a)</strong></td>
<td>114</td>
<td>704</td>
</tr>
<tr>
<td><strong>Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Benefits</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Future Benefits</td>
<td>484</td>
<td>815</td>
</tr>
<tr>
<td><strong>Total Liabilities (b)</strong></td>
<td>734</td>
<td>1,065</td>
</tr>
<tr>
<td><strong>Unfunded Obligation (b) – (a)</strong></td>
<td>620</td>
<td>361</td>
</tr>
<tr>
<td><strong>Funded Ratio (a)/(b)</strong></td>
<td>15%</td>
<td>66%</td>
</tr>
</tbody>
</table>

* Benefit values shown include associated administrative expenses.
Open Group Modified Balance Sheet – Description and Purpose

• Open group balance sheet may be presented in alternative format: split out into pay-as-you-go and funded components of the Plan
• Modified balance sheet emphasizes hybrid nature of partial (steady-state) funding of the Plan and thus allows for better understanding of how future expenditures are financed
Open Group Modified Balance Sheet – Formation: Step 1

• Separate out present values of contributions and expenditures on assets and liabilities sides of balance sheet

• As at 31 December 2006, 9.9% contribution rate, $ billion:

\[ \text{Assets and Future Contributions:} \quad \text{Liabilities: Present Value of Future Benefits} \]

\[ \begin{align*}
\text{Present Value of Future Contributions that Cover Future Expenditures} & \quad \text{Present Value of Future Expenditures Covered by Future Contributions} \\
$1,389 & \quad $1,389 \\
\end{align*} \]

\[ \begin{align*}
\text{Present Value of Future Contributions in Excess of Future Expenditures} & \quad \text{Present Value of Future Expenditures Not Covered by Future Contributions} \\
$29 & \quad $140 \\
\end{align*} \]

\[ \begin{align*}
\text{Current Assets} & \\
$114 & \\
\end{align*} \]
Open Group Modified Balance Sheet – Formation: Step 2

- Regroup present values into pay-as-you-go and funded components

As at 31 December 2006, 9.9% contribution rate, $ billion:

**Pay-As-You-Go**

- **ASSETS**
  - Present Value of Future Contributions that Cover Future Expenditures: $1,389

- **LIABILITIES**
  - Present Value of Future Expenditures Covered by Future Contributions: $1,389

**Funded**

- **ASSETS**
  - Present Value of Future Contributions in Excess of Future Expenditures + Current Assets:
    - Present Value: $29
    - Current Assets: $114

- **LIABILITIES**
  - Present Value of Future Expenditures Not Covered by Future Contributions:
    - Present Value: $140

Unfunded Obligation: -$3
Child Benefits

• Two types of child benefits
  – Disability
  – Survivor

• Monthly flat-rate payable until
  – age 18 (assumed at school full time), or
  – age 25 if at school full time

• Data aggregated on year, age and sex
Child benefit Calculation

- Number of New CPP Disabled Beneficiaries
- Number of Child per Disabled Beneficiaries
- Proportion of Child at School

New Child Disability Beneficiaries

Flat Benefit Rate

Total Initial Monthly Child Disability Benefit

Also applies for child survivor benefits
Total Child Benefit Expenditures

- Child Beneficiaries (year -1)
  - Proportion still Eligible
  - Total Initial Monthly Child Disability Benefit (x12)
    - Indexation Factor Since Receiving Benefits
      - Disability Benefits for In-pay Child Beneficiaries
        - Total Child Disability Benefits
          - Total Initial Monthly Child Disability Benefit
            - Number of Months in First Year of Disability
              - New Child Disability Benefits

Death Benefits – Basic Principles

• Deceased contributor who meets the contributory requirements is entitled to lump sum death benefit:
  – Minimum of $2,500 and 6 times the basic monthly pension

• To be eligible, the deceased contributor must have contributed for the lesser of 10 calendar years, or one-third of the number of years in the member’s contributory period, but not for less than 3 years.
Total Death Benefit Expenditures

- Population
- Number of Deaths in a given Year
- Mortality Assumption
- Proportion of Population Eligible to Death Benefits
- Number of Death Benefits
- Average Death Benefit Amount
- Total Death Benefits ($)
Best-Estimate Demographic and Economic Assumptions

<table>
<thead>
<tr>
<th></th>
<th>23rd Report (as at 31 December 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canada</strong></td>
<td></td>
</tr>
<tr>
<td>Total fertility rate</td>
<td>1.6 (2010+)</td>
</tr>
<tr>
<td>Mortality</td>
<td>2000-02 Life Tables for Canada with future improvements</td>
</tr>
<tr>
<td>Canadian life expectancy</td>
<td></td>
</tr>
<tr>
<td>at birth in 2007</td>
<td>Males 84.5 years Females 87.7 years</td>
</tr>
<tr>
<td>at age 65 in 2007</td>
<td>Males 19.3 years Females 22.0 years</td>
</tr>
<tr>
<td>Net migration rate</td>
<td>0.50% of population to 2015</td>
</tr>
<tr>
<td></td>
<td>0.54% of population for 2020+</td>
</tr>
<tr>
<td>Participation rate (aged 15-69)</td>
<td>74.2% (2030)</td>
</tr>
<tr>
<td>Employment rate (aged 15-69)</td>
<td>69.9% (2030)</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>6.3% (2006+)</td>
</tr>
<tr>
<td>Rate of increase in prices</td>
<td>2.5% (2016+)</td>
</tr>
<tr>
<td>Real-wage differential</td>
<td>1.3% (2015+)</td>
</tr>
<tr>
<td>Real rates of return</td>
<td>4.2% (2016+)</td>
</tr>
<tr>
<td>Retirement rates for cohort at age 60</td>
<td>Males 40.0% (2009+) Females 45.0% (2009+)</td>
</tr>
<tr>
<td>CPP disability incidence rates (per 1,000 eligible)</td>
<td>Males 3.1 (2011+) Females 3.5 (2011+)</td>
</tr>
</tbody>
</table>