Table detection and ROI cell extraction using line detection and structure based

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Abstract **The** ***algorithm based on the inference that the tables have distinct columns, which implies that gaps between the fields are substantially larger than the gaps between the words in text lines.***

Table detection steps:

The table detection algorithm depends primarily on:

1. Preprocessing
2. Formation of word blobs in text lines and
3. Finding out the set of consecutive text lines which would form a table
4. Vertical threshold between table lines.
5. Forming table cells
6. Processing table region of index

1. Preprocessing

A typical document image analysis contains image filtering techniques such as de-noising, skew-correction is applied on the document image. The input image is converted into gray scale and then it is converted into binary image.

2. Formation of word blobs in text lines.

Formation of text line is done by joining the word blobs in the line. A text-line would be converted to a single rectangular block while a row of a table would consist of multiple

smaller blocks. Such a word grouping depends on measuring the average word-gaps

and finding out distance between consecutive connected components in a single text-line.

Connected components in a single text-line is obtained by using the formula:

$$f(Ca,\ Cb) = \begin{cases} 1\ if\ \left(T\ (Ca) \leq\ B(Cb) \text{ and } B(Ca) \geq\ T\ (Cb)\right) \\ 0, otherwise \end{cases}$$

Where, Ca, Cb: two blobs.

T(Ca), B(Ca): Top and bottom of a rectangular blob.

Word blobs are formed by finding out by Histogram of inter-word gap between consecutive connected components in every text-line.
Distance between consecutive connected components Ca and Cb are obtained by using the formula:

$$D\ (Ca, Cb) = L(Cb) - R(Ca)$$

Where,

L(Ca), R(Ca): Left and Right of a rectangular blob.

The histogram of gap between two consecutive blobs mainly contains two humps, if the document image is non uniform font it may have more than two humps. The second peak of the histogram is word gap. Finally, morphological closing operation with a line-structuring element using second peak value forms the text-lines.

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3. Finding out the set of consecutive text lines which would form a table.

This stage groups the candidate table lines from text-lines, which will be used for the identification of table 'region of index'. For a table row it is identified that word-gap between elements (column fields) are larger than word gap in the text-lines.

Morphological closing with second peak joins all the word-gap among text-lines except table lines, thus they are considered as candidate table lines, so based on this observation it is possible to separate table rows from text-lines.

Figure shows masking to text-lines from table rows

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4. Vertical threshold between table lines.

It may be noted that the primary selection is not strong enough to detect all potential candidate lines; we may miss some of the rows of the tables. For this, gap between successive text-lines are compared and a maximum threshold value is formulated.
If g(a) is the vertical gap between lines:

Then, g(a) = T(TELa1) – B(TELa)

where,
TEL :- table candidate line
T(TELa1): top of table-line following TELa
B(TELa): bottom of table-line

the upper-bound of the prominent peak of the histogram of g(a) gives the vertical threshold. There could be a possibility that consecutive text-lines are too far apart. This larger gap may affect the threshold calculation, so very high peaks in the vertical gap are eliminated.

Table-lines whose vertical gap is less than or equal to the threshold gap are grouped. Every group of text-lines form a table.

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5. Forming table cells.

For forming cells, midpoint between successive rows as well as columns will be calculated from the text-line rectangles.

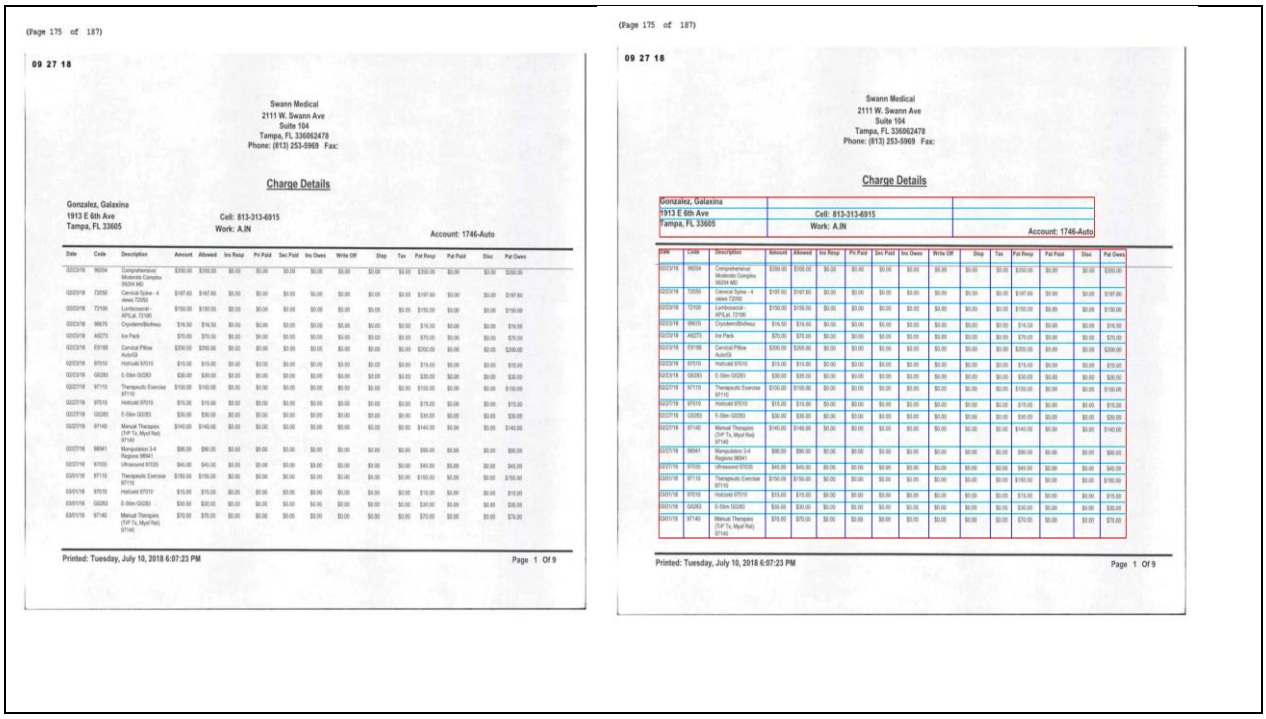
If Vr(a) is the vertical midpoint between every table rows and Hr(a) is the horizontal midpoint between each column.

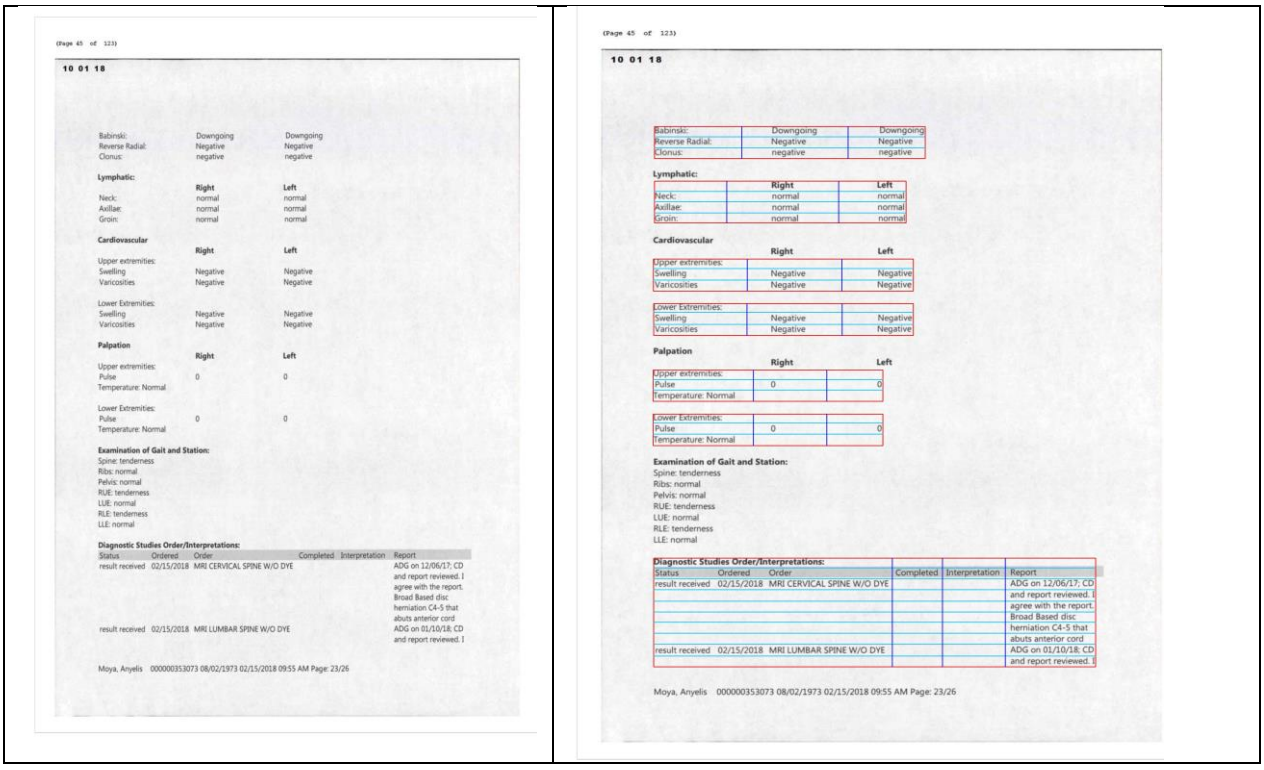
gap ={L(TELa1) – R(TELa)} / 2
Vr(a) = R(TELa) + gap

Hgap = {T(TELa1) – B(TELa)} / 2
Hr(a) = B (TELa) + gap

Results:

1. Table detection results without lines in image.





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10 01 18

Babinski:	Downgoing	Downgoing
Reverse Radial:	Negative	Negative
Clonus:	negative	negative

Lymphatic:

	Right	Left
Neck:	normal	normal
Axillae:	normal	normal
Groin:	normal	normal

Cardiovascular

	Right	Left
Upper extremities:		
Swelling	Negative	Negative
Varicosities	Negative	Negative
Lower Extremities:		
Swelling	Negative	Negative
Varicosities	Negative	Negative

Palpation

	Right	Left
Upper extremities:		
Pulse	0	0
Temperature: Normal		
Lower Extremities:		
Pulse	0	0
Temperature: Normal		

Examination of Gait and Station:
Spine: tenderness
Ribs: normal
Pelvis: normal
RUE: tenderness
LUE: normal
RLE: tenderness
LLE: normal

Diagnostic Studies Order/Interpretations:

Status	Ordered	Order	Completed	Interpretation	Report
result received	02/15/2018	MRI CERVICAL SPINE W/O DYE			ADG on 12/06/17: CD and report reviewed. I agree with the report. Broad Based disc herniation C4-5 that abuts anterior cord
result received	02/15/2018	MRI LUMBAR SPINE W/O DYE			ADG on 01/10/18: CD and report reviewed. I

Moya, Anyelis 000000353073 08/02/1973 02/15/2018 09:55 AM Page: 23/26

(Page 45 of 123)

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2. Table detection results with lines:

Data tables

1. E-Government Development Index

Rank	Country	EGDI	Online Service Component	Telecomm. Infrastructure Component	Human Capital Component
173	Afghanistan	0.1900	0.1811	0.1472	0.2418
84	Albania	0.5046	0.4488	0.3548	0.7100
136	Algeria	0.3106	0.0787	0.1989	0.6543
43	Andorra	0.6426	0.4331	0.7671	0.7277
140	Angola	0.2970	0.2992	0.0978	0.4941
60	Antigua and Barbuda	0.5927	0.4173	0.5938	0.7669
46	Argentina	0.6306	0.5512	0.4835	0.8571
61	Armenia	0.5897	0.6142	0.3889	0.7660
2	Australia	0.9103	0.9291	0.8041	0.9978
20	Austria	0.7912	0.7480	0.7597	0.8660
68	Azerbaijan	0.5472	0.4331	0.4605	0.7480
92	Bahamas	0.4900	0.3386	0.4176	0.7138
18	Bahrain	0.8089	0.9370	0.7055	0.7840
148	Bangladesh	0.2757	0.3465	0.0941	0.3866
59	Barbados	0.5933	0.2205	0.6730	0.8865
55	Belarus	0.6053	0.3228	0.6069	0.8861
25	Belgium	0.7564	0.6772	0.6988	0.8932
120	Belize	0.3774	0.3780	0.1530	0.6012
180	Benin	0.1685	0.1102	0.1196	0.2756
143	Bhutan	0.2829	0.2441	0.1755	0.4290
103	Bolivia (Plurinational State of)	0.4562	0.3937	0.2324	0.7424
97	Bosnia and Herzegovina	0.4707	0.2835	0.3998	0.7288
112	Botswana	0.4198	0.3071	0.2969	0.6555
57	Brazil	0.6008	0.5984	0.4668	0.7372
86	Brunei Darussalam	0.5042	0.3622	0.3690	0.7815
73	Bulgaria	0.5421	0.2362	0.5941	0.7960
178	Burkina Faso	0.1804	0.2992	0.0842	0.1578
172	Burundi	0.1928	0.0157	0.0233	0.5393
139	Cambodia	0.2999	0.1732	0.2075	0.5189
144	Cameroon	0.2782	0.1969	0.0958	0.5421
11	Canada	0.8418	0.9134	0.7168	0.8952
127	Cape Verde	0.3551	0.1654	0.2966	0.6032
187	Central African Republic	0.1257	0.0394	0.0280	0.3099
189	Chad	0.1076	0.0472	0.0415	0.2341
33	Chile	0.7122	0.8189	0.4940	0.8236

UNITED NATIONS E-GOVERNMENT SURVEY 2014

Annexes

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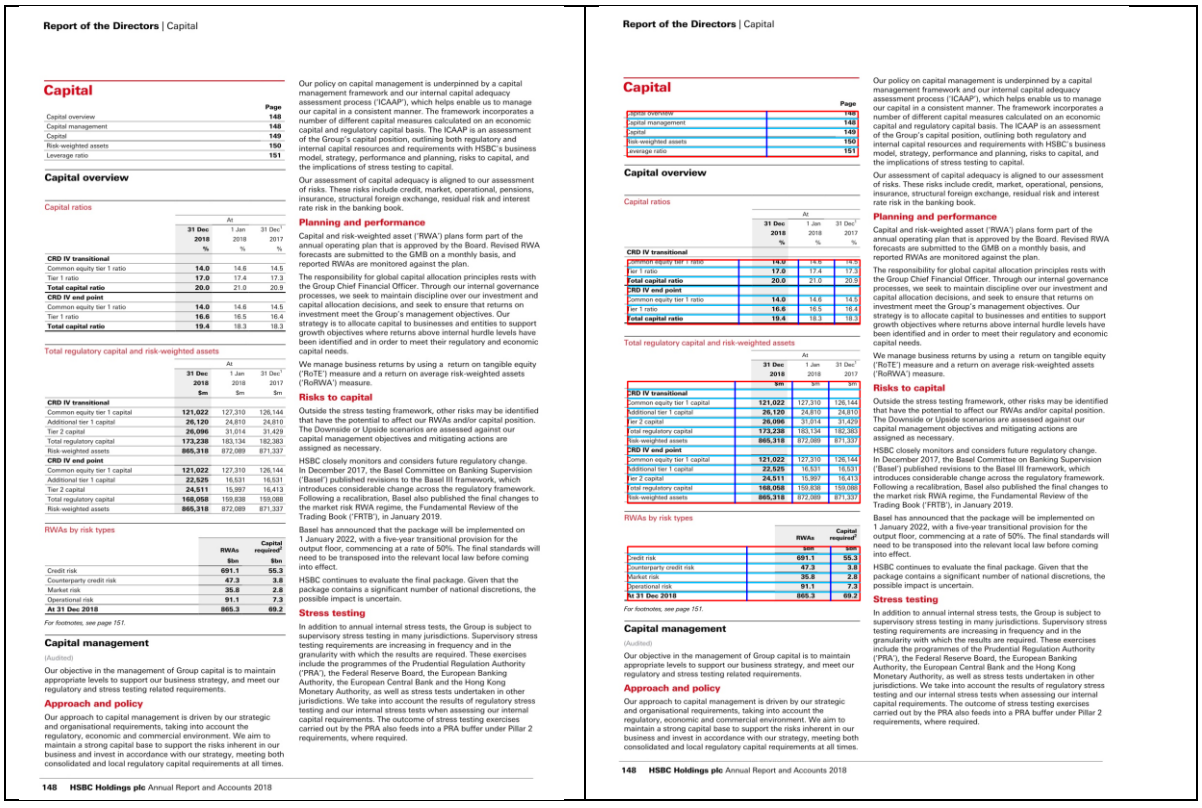

Report of the Directors | Capital

Capital

Capital overview

Capital ratios

	At 31 Dec 2018 %	1 Jan 2018 %	31 Dec[1] 2017 %
CRD IV transitional			
Common equity tier 1 ratio	14.0	14.6	14.5
Tier 1 ratio	17.0	17.4	17.3
Total capital ratio	20.0	21.0	20.9
CRD IV end point			
Common equity tier 1 ratio	14.0	14.6	14.5
Tier 1 ratio	16.6	16.5	16.4
Total capital ratio	19.4	18.3	18.3

Total regulatory capital and risk-weighted assets

	At 31 Dec 2018 $m	1 Jan 2018 $m	31 Dec[1] 2017 $m
CRD IV transitional			
Common equity tier 1 capital	121,022	127,310	126,144
Additional tier 1 capital	26,120	24,810	24,810
Tier 2 capital	26,096	31,014	31,429
Total regulatory capital	173,238	183,134	182,383
Risk-weighted assets	865,318	872,089	871,337
CRD IV end point			
Common equity tier 1 capital	121,022	127,310	126,144
Additional tier 1 capital	22,525	16,531	16,531
Tier 2 capital	24,511	15,997	16,413
Total regulatory capital	168,058	159,838	159,088
Risk-weighted assets	865,318	872,089	871,337

RWAs by risk types

	RWAs $bn	Capital required[2] $bn
Credit risk	691.1	55.3
Counterparty credit risk	47.3	3.8
Market risk	35.8	2.8
Operational risk	91.1	7.3
At 31 Dec 2018	865.3	69.2

For footnotes, see page 151.

Capital management

(Audited)

Our objective in the management of Group capital is to maintain appropriate levels to support our business strategy, and meet our regulatory and stress testing related requirements.

Approach and policy

Our approach to capital management is driven by our strategic and organisational requirements, taking into account the regulatory, economic and commercial environment. We aim to maintain a strong capital base to support the risks inherent in our business and invest in accordance with our strategy, meeting both consolidated and local regulatory capital requirements at all times.

Our policy on capital management is underpinned by a capital management framework and our internal capital adequacy assessment process ('ICAAP'), which helps enable us to manage our capital in a consistent manner. The framework incorporates a number of different capital measures calculated on an economic capital and regulatory capital basis. The ICAAP is an assessment of the Group's capital position, outlining both regulatory and internal capital resources and requirements with HSBC's business model, strategy, performance and planning, risks to capital, and the implications of stress testing to capital.

Our assessment of capital adequacy is aligned to our assessment of risks. These risks include credit, market, operational, pensions, insurance, structural foreign exchange, residual risk and interest rate risk in the banking book.

Planning and performance

Capital and risk-weighted asset ('RWA') plans form part of the annual operating plan that is approved by the Board. Revised RWA forecasts are submitted to the GMB on a monthly basis, and reported RWAs are monitored against the plan.

The responsibility for global capital allocation principles rests with the Group Chief Financial Officer. Through our internal governance processes, we seek to maintain discipline over our investment and capital allocation decisions, and seek to ensure that returns on investment meet the Group's management objectives. Our strategy is to allocate capital to businesses and entities to support growth objectives where returns above internal hurdle levels have been identified and in order to meet their regulatory and economic capital needs.

We manage business returns by using a return on tangible equity ('RoTE') measure and a return on average risk-weighted assets ('RoRWA') measure.

Risks to capital

Outside the stress testing framework, other risks may be identified that have the potential to affect our RWAs and/or capital position. The Downside or Upside scenarios are assessed against our capital management objectives and mitigating actions are assigned as necessary.

HSBC closely monitors and considers future regulatory change. In December 2017, the Basel Committee on Banking Supervision ('Basel') published revisions to the Basel III framework, which introduces considerable change across the regulatory framework. Following a recalibration, Basel also published the final changes to the market risk RWA regime, the Fundamental Review of the Trading Book ('FRTB'), in January 2019.

Basel has announced that the package will be implemented on 1 January 2022, with a five-year transitional provision for the output floor, commencing at a rate of 50%. The final standards will need to be transposed into the relevant local law before coming into effect.

HSBC continues to evaluate the final package. Given that the package contains a significant number of national discretions, the possible impact is uncertain.

Stress testing

In addition to annual internal stress tests, the Group is subject to supervisory stress testing in many jurisdictions. Supervisory stress testing requirements are increasing in frequency and in the granularity with which the results are required. These exercises include the programmes of the Prudential Regulation Authority ('PRA'), the Federal Reserve Board, the European Banking Authority, the European Central Bank and the Hong Kong Monetary Authority, as well as stress tests undertaken in other jurisdictions. We take into account the results of regulatory stress testing and our internal stress tests when assessing our internal capital requirements. The outcome of stress testing exercises carried out by the PRA also feeds into a PRA buffer under Pillar 2 requirements, where required.

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Capital

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Capital overview

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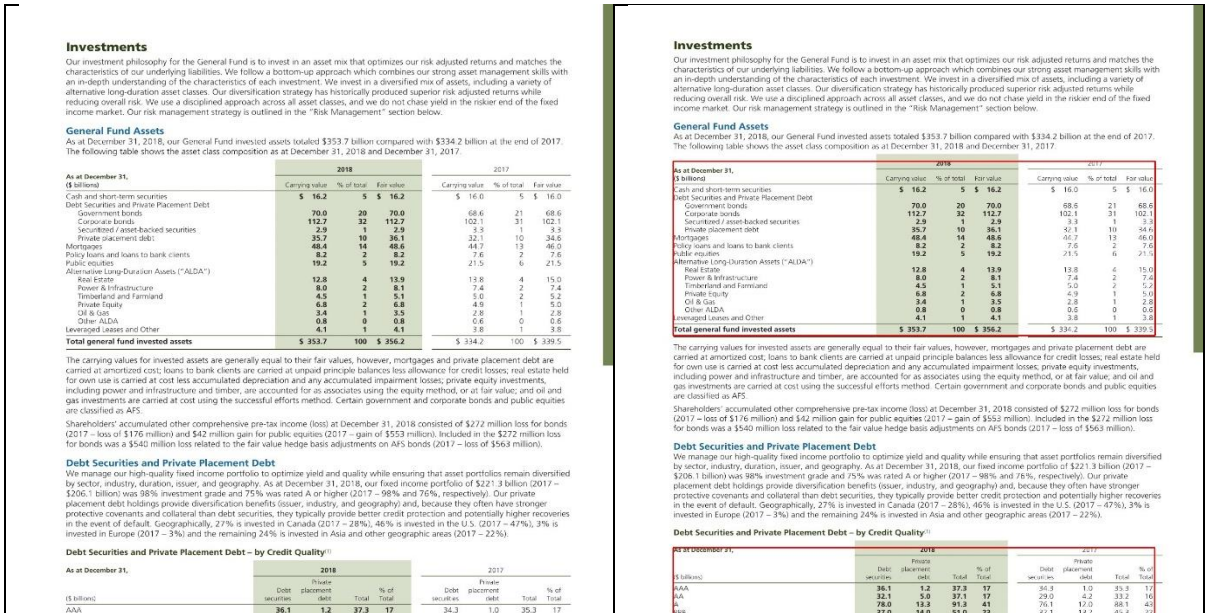
3. Table detection results having multi table structured ROI



Investments

Our investment philosophy for the General Fund is to invest in an asset mix that optimizes our risk adjusted returns and matches the characteristics of our underlying liabilities. We follow a bottom-up approach which combines our strong asset management skills with an in-depth understanding of the characteristics of each investment. We invest in a diversified mix of assets, including a variety of alternative long-duration asset classes. Our diversification strategy has historically produced superior risk adjusted returns while reducing overall risk. We use a disciplined approach across all asset classes, and we do not chase yield in the riskier end of the fixed income market. Our risk management strategy is outlined in the "Risk Management" section below.

General Fund Assets

As at December 31, 2018, our General Fund invested assets totaled $353.7 billion compared with $334.2 billion at the end of 2017. The following table shows the asset class composition as at December 31, 2018 and December 31, 2017.

As at December 31, ($ billions)	2018 Carrying value	2018 % of total	2018 Fair value	2017 Carrying value	2017 % of total	2017 Fair value
Cash and short-term securities	$ 16.2	5	$ 16.2	$ 16.0	5	$ 16.0
Debt Securities and Private Placement Debt						
Government bonds	70.0	20	70.0	68.6	21	68.6
Corporate bonds	112.7	32	112.7	102.1	31	102.1
Securitized / asset-backed securities	2.9	1	2.9	3.3	1	3.3
Private placement debt	35.7	10	36.1	32.1	10	34.6
Mortgages	48.4	14	48.6	44.7	13	46.0
Policy loans and loans to bank clients	8.2	2	8.2	7.6	2	7.6
Public equities	19.2	5	19.2	21.5	6	21.5
Alternative Long-Duration Assets ("ALDA")						
Real Estate	12.8	4	13.9	13.8	4	15.0
Power & Infrastructure	8.0	2	8.1	7.4	2	7.4
Timberland and Farmland	4.5	1	5.1	5.0	2	5.2
Private Equity	6.8	2	6.8	4.9	1	5.0
Oil & Gas	3.4	1	3.5	2.8	1	2.8
Other ALDA	0.8	0	0.8	0.6	0	0.6
Leveraged Leases and Other	4.1	1	4.1	3.8	1	3.8
Total general fund invested assets	**$ 353.7**	**100**	**$ 356.2**	$ 334.2	100	$ 339.5

The carrying values for invested assets are generally equal to their fair values, however, mortgages and private placement debt are carried at amortized cost; loans to bank clients are carried at unpaid principle balances less allowance for credit losses; real estate held for own use is carried at cost less accumulated depreciation and any accumulated impairment losses; private equity investments, including power and infrastructure and timber, are accounted for as associates using the equity method, or at fair value; and oil and gas investments are carried at cost using the successful efforts method. Certain government and corporate bonds and public equities are classified as AFS.

Shareholders' accumulated other comprehensive pre-tax income (loss) at December 31, 2018 consisted of $272 million loss for bonds (2017 – loss of $176 million) and $42 million gain for public equities (2017 – gain of $553 million). Included in the $272 million loss for bonds was a $540 million loss related to the fair value hedge basis adjustments on AFS bonds (2017 – loss of $563 million).

Debt Securities and Private Placement Debt

We manage our high-quality fixed income portfolio to optimize yield and quality while ensuring that asset portfolios remain diversified by sector, industry, duration, issuer, and geography. As at December 31, 2018, our fixed income portfolio of $221.3 billion (2017 – $206.1 billion) was 98% investment grade and 75% was rated A or higher (2017 – 98% and 76%, respectively). Our private placement debt holdings provide diversification benefits (issuer, industry, and geography) and, because they often have stronger protective covenants and collateral than debt securities, they typically provide better credit protection and potentially higher recoveries in the event of default. Geographically, 27% is invested in Canada (2017 – 28%), 46% is invested in the U.S. (2017 – 47%), 3% is invested in Europe (2017 – 3%) and the remaining 24% is invested in Asia and other geographic areas (2017 – 22%).

Debt Securities and Private Placement Debt – by Credit Quality[1]

As at December 31, ($ billions)	2018 Debt securities	2018 Private placement debt	2018 Total	2018 % of Total	2017 Debt securities	2017 Private placement debt	2017 Total	2017 % of Total
AAA	36.1	1.2	37.3	17	34.3	1.0	35.3	17
AA	32.1	5.0	37.1	17	29.0	4.2	33.2	16
A	78.0	13.3	91.3	41	76.1	12.0	88.1	43
BBB	37.0	14.0	51.0	23	32.1	13.2	45.3	22
BB	1.6	0.7	2.3	1	1.8	0.7	2.5	1
B & lower, and unrated	0.8	1.5	2.3	1	0.7	1.0	1.7	1
Total carrying value ($ billions)	**$ 185.6**	**$ 35.7**	**$ 221.3**	**100**	$ 174.0	$ 32.1	$ 206.1	100

Investments

Our investment philosophy for the General Fund is to invest in an asset mix that optimizes our risk adjusted returns and matches the characteristics of our underlying liabilities. We follow a bottom-up approach which combines our strong asset management skills with an in-depth understanding of the characteristics of each investment. We invest in a diversified mix of assets, including a variety of alternative long-duration asset classes. Our diversification strategy has historically produced superior risk adjusted returns while reducing overall risk. We use a disciplined approach across all asset classes, and we do not chase yield in the riskier end of the fixed income market. Our risk management strategy is outlined in the "Risk Management" section below.

General Fund Assets

As at December 31, 2018, our General Fund invested assets totaled $353.7 billion compared with $334.2 billion at the end of 2017. The following table shows the asset class composition as at December 31, 2018 and December 31, 2017.

As at December 31, ($ billions)	2018 Carrying value	2018 % of total	2018 Fair value	2017 Carrying value	2017 % of total	2017 Fair value
Cash and short-term securities	$ 16.2	5	$ 16.2	$ 16.0	5	$ 16.0
Debt Securities and Private Placement Debt						
Government bonds	70.0	20	70.0	68.6	21	68.6
Corporate bonds	112.7	32	112.7	102.1	31	102.1
Securitized / asset-backed securities	2.9	1	2.9	3.3	1	3.3
Private placement debt	35.7	10	36.1	32.1	10	34.6
Mortgages	48.4	14	48.6	44.7	13	46.0
Policy loans and loans to bank clients	8.2	2	8.2	7.6	2	7.6
Public equities	19.2	5	19.2	21.5	6	21.5
Alternative Long-Duration Assets ("ALDA")						
Real Estate	12.8	4	13.9	13.8	4	15.0
Power & Infrastructure	8.0	2	8.1	7.4	2	7.4
Timberland and Farmland	4.5	1	5.1	5.0	2	5.2
Private Equity	6.8	2	6.8	4.9	1	5.0
Oil & Gas	3.4	1	3.5	2.8	1	2.8
Other ALDA	0.8	0	0.8	0.6	0	0.6
Leveraged Leases and Other	4.1	1	4.1	3.8	1	3.8
Total general fund invested assets	**$ 353.7**	**100**	**$ 356.2**	$ 334.2	100	$ 339.5

The carrying values for invested assets are generally equal to their fair values, however, mortgages and private placement debt are carried at amortized cost; loans to bank clients are carried at unpaid principle balances less allowance for credit losses; real estate held for own use is carried at cost less accumulated depreciation and any accumulated impairment losses; private equity investments, including power and infrastructure and timber, are accounted for as associates using the equity method, or at fair value; and oil and gas investments are carried at cost using the successful efforts method. Certain government and corporate bonds and public equities are classified as AFS.

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References

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