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CURRENCY AMOUNTS IN THE SDR BASKET— PROPOSED CHANGES TO THE ROUNDING METHODOLOGY

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CURRENCY AMOUNTS IN THE SDR BASKET—PROPOSED CHANGES TO THE ROUNDING METHODOLOGY

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INTRODUCTION

1. Currency amounts are used to determine the daily value of the SDR.¹ Currency amounts are the number of units of each currency in the SDR basket. The value of the SDR (in U.S. dollars) is the sum of these amounts, valued at daily exchange rates of the currencies against the U.S. dollar.² These currency amounts are determined on the last business day before the new SDR basket becomes effective (transition date) such that they correspond to the currency weights determined by the IMF Executive Board in the context of the SDR Review, and remain fixed over the SDR valuation period.³ To facilitate SDR users in adjusting their portfolios to the new basket, the IMF publishes illustrative currency amounts in the lead up to the transition date.

2. As a long standing principle, the method of calculating currency amounts is designed to ensure continuity in the value of the SDR when a new basket enters into effect. The current methodology is laid out in the SDR Valuation Decision and further details to arrive at the currency amounts were explained in several staff papers in the 1970s and '80s, when the methodology was first introduced (see Box 1).⁴ The methodology provides continuity and stability in the value of the SDR during transitions between valuation baskets thereby ensuring a smooth functioning of the SDR market. In particular, it ensures that the value of the SDR in U.S. dollars (and thus in all other currencies) is the same on the transition day under the old and new baskets; i.e., there is no discontinuity in the value of the SDR caused by the transition. No change in this principle is proposed.

3. However, the current rounding methodology for determining currency amounts has some drawbacks. As has been recognized in the past, the methodology involves applying a complex procedure to determine the precise final currency amounts that SDR users have found difficult to replicate. Moreover, the rounding methodology can result in initial currency weights that deviate significantly from the Board-determined weights, albeit within the limits allowed in the Decision.

4. This paper proposes an amendment to the rounding methodology to make it less complex and more closely align the initial currency weights with those approved by the Board. The proposed new methodology would preserve the basic principles that have guided currency amount calculations since the inception of the standard basket approach to valuing the SDR. By simplifying the final step of rounding currency amounts, it would eliminate complex iterations, making currency amounts easier to compute. The resulting currency weights would also

¹ Currency amounts are also used to determine the SDR interest rate (SDRi).

² Rounded to six significant digits. See Rule O-1 and O-2(a), and Decision No. 15891-(15/109), adopted November 30, 2015, henceforth referred to as the SDR Valuation Decision or Decision.

³ Since currency amounts are fixed over the valuation period, currency weights in the SDR basket implicitly change daily with exchange rate movements. See, for example, [Review of the Method of Valuation of the SDR](#), 10/26/2010, p.10.

⁴ See Box 1.

be much closer to the Board-adopted weights, further enhancing the transparency and replicability of final currency amounts in the SDR. Staff has consulted with major SDR users, who welcomed the proposed changes and did not raise any substantive issues. The proposed change to the SDR valuation Decision does not represent a change in the principle of valuation or a fundamental change in the application of the principle in effect, and therefore may be adopted with a 70 percent majority of the total voting power.⁵

CURRENT PRACTICE OF DETERMINING ROUNDED CURRENCY AMOUNTS

5. Currency amounts refer to amounts of each currency in the SDR basket and play a central role in the daily valuation of the SDR. They are determined on the last business day before the new SDR basket becomes effective (i.e., September 30, 2016 for the next SDR basket) and remain fixed over the SDR valuation period. Each day during the valuation period, the value of the SDR (in U.S. dollars) is calculated as the sum of the currency amounts, valued at daily exchange rates of the currencies against the U.S. dollar.

6. A key requirement in determining currency amounts is that the value of the SDR under the old basket equals the SDR value under the new basket on the transition day (*equality condition*). Currency amounts are determined such that the value of the SDR in U.S. dollar terms (and thus in each of the other SDR basket currencies) on the transition date is the same under the old and the new baskets.⁶ In other words, the sum of the new currency amounts in U.S. dollars must produce the exact same SDR value (in U.S. dollars) as that prevailing on the transition day. The *equality condition* ensures that there is no discontinuity in the SDR value on the transition date, a key requirement for the smooth functioning of the SDR market.

7. The calculations also ensure that currency amounts correspond to the weights determined by the Board within certain limits (the so-called *tolerance limit*). The Decision provides that currency amounts be determined such that, using average exchange rates for the three-month period ending on the transition date, the share of each currency in the SDR corresponds to its weight as determined by the IMF.⁷ The Decision allows the initial weights implied by the new currency amounts to deviate from the Board-determined weights by up to half a percentage point (the tolerance limit).⁸

⁵ See Article XV. Similar changes to the methodology as proposed now were adopted in 1980 and 1985, also with a 70 percent majority of the total voting power.

⁶ See paragraph 5 of the SDR Valuation Decision.

⁷ See paragraph 3 of the SDR Valuation Decision.

⁸ See paragraph 5(a) of the SDR Valuation Decision.

8. Under the existing Decision, the rounding and selection of final currency amounts involve three other considerations. The first is the *uniform significant digits requirement*, according to which final amounts of all the currencies in the basket should have the same number of significant digits.⁹ The second stipulates that currency amounts should have between *two and four significant digits*, with a preference for lower significant digits, which reflected the lower number of significant digits in currency weights at the time the Decision was adopted in 1974, as well as when it was amended in the 1980s. The third consideration applies when there are more than one set of possible currency amounts that meet the equality condition and produce weights within the tolerance limit. In such cases, the set of currency amounts with the *smallest average deviation* of rounded currency amounts from unrounded ones should be selected. In practice and as explained in previous staff reports, the smallest average deviation has been interpreted as the smallest root mean squared deviation.

9. The current methodology involves the following steps:

- **Step 1 – Calculating unrounded currency amounts.** Unrounded currency amounts, C_i , are calculated using the formula below:

$$C_i = \left(\frac{W_i}{BEX_i} \right) \frac{USD/SDR}{\sum_{i=1}^n \frac{W_i}{BEX_i} TEX_i}$$

where W_i is the weight of currency i as determined by the Board, BEX_i is the base exchange rate for currency i against the U.S. dollar i.e.; the three-month average exchange rate against the U.S. dollar; TEX_i is the transition date exchange rate for currency i against the U.S. dollar and USD/SDR is the U.S. dollar per SDR on the transition date, expressed in six significant digits.¹⁰ This equation ensures that each currency's share in the new basket is equal to its Board-determined weight and the equality condition for capturing the value of the SDR prevailing on the transition date is met.

- **Step 2 - Rounding.** The unrounded currency amounts are then truncated at 2 significant digits, and a range of alternative currency amounts are generated by adding to and subtracting from the last digit of the truncated currency amounts. These iterated currency amounts are combined into potential SDR baskets, which are then tested against the equality condition and the tolerance limit. If no solution is found, these steps are repeated for 3, and if needed, 4 significant digits. If multiple solutions are found at any step, the set of currency amounts with the least root mean square deviation is chosen as the final currency amounts.

⁹ See Box 2 for a brief discussion of significant digits and their use in the SDR valuation.

¹⁰ The exchange rates used in the calculations are collected as per Decision [6709-(80/189) S, 3/9/2000, for the purposes of Rule O-2(a)]. All exchange rates are expressed in U.S. dollars per currency unit, except for the Japanese yen and the Chinese renminbi, which are expressed in currency units per U.S. dollars.

10. Besides its complexity, the current methodology can result in initial weights that deviate significantly from the weights adopted by the Board. The tolerance limit of half a percentage point was deemed reasonable and adopted at a time when weights were expressed as whole numbers (integers). However, in the last two SDR Reviews, the Board adopted weights with more precision (with 1 or 2 decimal places), against which a deviation of up to half a percentage point appears relatively large. In fact, the currency amounts adopted in 2010 for the current valuation period did imply deviations from the Board-adopted weights for the U.S. dollar and the euro that were close to the full tolerance limit of half a percentage point (Table 1).

11. In addition, some of the rounding details are not explicitly laid out in the Decision, adding to the difficulty faced by SDR users in easily replicating the calculations. For instance, the Decision and earlier staff reports are silent on the range for generating iterated currency amounts in Step 2 above. Since 2005, staff's calculations have iterated currency amounts by +/-9 units. With a five-currency basket these iterations can involve up to 7.5 million potential combinations of currency amounts (2.5 million combinations per significant digit). Such a large number of combinations cannot be tested in one spreadsheet file. Further, as discussed above, in selecting among multiple solutions, the Decision states that the one with the "smallest average deviation" would be chosen, but only in the staff reports is it explained that this term should be interpreted as "minimum root mean squared deviation."

Table 1. Adopted and Implied Currency Weights in the 2010 SDR Review

Currency	2010 Review Weights (Percent)	Adopted Currency Amounts (12/30/2010)	Implied Weights (Percent)	Implied Weights Deviation from Board-approved (pct point)
U.S. Dollar	41.9	0.660	42.39	0.49
Euro	37.4	0.423	36.92	-0.48
Japanese Yen	9.4	12.1	9.42	0.02
Pound Sterling	11.3	0.111	11.27	-0.03

Source: [Review of the Method of Valuation of the SDR, 10/26/2010](#); Supplement 2 and IMF Staff Calculations.

STAFF PROPOSAL

12. A simpler and more transparent calculation methodology that adheres more closely to Board-adopted weights would be desirable. A number of SDR users, more so than in previous transition periods, have expressed interest in illustrative currency amounts during the current transition period, as they prepare for the expanded 5-currency SDR basket including the Chinese renminbi (RMB). A clearer and simpler methodology, which can be easily replicated in a spreadsheet,

and a methodology that better captures the Board-adopted weights would aid SDR users in their portfolio adjustments and help facilitate a smooth transition to the new SDR basket.

13. Staff's preferred approach is to simplify Step 2 of the calculations above to a rounding procedure based on an increased number of significant digits. A number of alternatives were considered, including clarifying the range for iterations, truncating at different significant digits or rounding currency amounts by decimals rather than significant digits. In staff's judgment, rounding at more significant digits uniformly across the currencies strikes the best balance between the objectives of simplifying the calculations and more closely capturing Board-determined weights. As with the current methodology, the proposal will continue to ensure continuity in the SDR value by meeting the equality condition.

14. Staff proposes that all final currency amounts be rounded to five significant digits.

Under the proposed approach, Step 1 of the current methodology would remain unchanged: unrounded currency amounts (C_i) would continue to be calculated following the formula in ¶19, ensuring that Board-adopted weights are captured and the equality principle is met. In Step 2, instead of the iterative process of looking for a solution in two to four significant digits, under the proposed approach, C_i would simply be rounded to five significant digits based on the sixth significant digit.

15. As long as the USD/SDR exchange rate is above 1, a solution would be found with five significant digits. The value of the SDR in U.S. dollars is specified in six significant digits, which corresponds to five decimals as long as the USD/SDR rate is above 1. Currency amounts rounded to five significant digits would result in an SDR value that has five decimals and meets the equality condition. If rounded currency amounts do not produce an SDR value that meets the equality condition, one of the rounded currency amounts would be adjusted, as described below, such that the condition is met. If the USD/SDR rate were to fall below 1, which has a low likelihood, finding a solution would likely require rounding currency amounts to six significant digits.¹¹

16. In cases where an adjustment is needed to observe the equality condition, the currency amount for one currency would be adjusted as needed.¹² Staff proposes to make the adjustment to the currency with the largest weight in the SDR basket, i.e., the U.S. dollar. This will ensure that the adjustment would have the least impact on relative weights, and the adjustment would be conceptually similar to the procedure followed for the adjustments to currency weights under paragraph 4(c) of the Decision. An adjustment to the currency amount of the U.S. dollar, i.e., the numeraire, would also be operationally the simplest approach, as adjustments to the U.S. dollar

¹¹ The USD/SDR rate has fallen below 1 only for a few weeks in early 1985 since 1981. From its current level, it would take very large depreciations of a number of the basket currencies against the U.S. dollar for the rate to fall below 1.

¹² Staff back-testing of the proposal indicates a low probability of needing such an adjustment. The only historical case where such an adjustment would have been needed is the 1995 Review. Applied to the weights and exchange rates on the transition date of that Review, December 31, 1995, the rounded currency amounts under the proposed methodology would have given 1.48648 USD/SDR, while the value of the SDR prevailing on that day was 1.48689 USD/SDR. In that case, the rounded USD currency amount would have been adjusted up by 0.00001, from 0.58210 to 0.52811, to meet the equality condition.

currency amount would lead to an equivalent change in the calculated SDR value, thus allowing for an exact adjustment to be made such that the equality condition holds.

17. The proposed rounding methodology has several advantages:

- ***Simplicity.*** Rather than complex iterations, it is based on simple rounding, which is easy to replicate using basic spreadsheets. From staff's consultations with SDR users, there is also no indication that the expanded number of significant digits would pose problems for users' operating systems.
- ***Closer adherence to Board-adopted weights.*** Owing to the higher number of significant digits, the resulting currency amounts produce initial currency weights that are very close to Board-adopted weights (Table 2).
- ***Single solution.*** By backing out the final set of currency amounts to meet the equality condition when otherwise the rounded currency amounts would not meet the condition, the proposed approach always results in one set of final currency amounts. This eliminates the cumbersome steps described above where first millions of potential sets of currency amounts are generated and are then evaluated. It also renders the tolerance limit irrelevant, since this single solution produces weights that are very close to the Board-adopted weights. Accordingly, staff proposes to eliminate the tolerance limit in the Decision as it would become redundant under the proposed approach.
- ***Continuing to ensure continuity and stability in the SDR value.*** The proposed methodology will continue to ensure that the equality condition is met, so that the transition from the old to the new basket does not create a discontinuity in the value of the SDR. It also maintains the uniformity of significant digits across currencies in the existing Decision.

18. If the attached proposed decision is approved by the Executive Board, paragraph 5 of the 2015 SDR Valuation Decision would be amended with immediate effect.¹³ Should the proposed decision be approved, the method of rounding currency amounts set out therein will also be used to derive illustrative currency amounts that would be published to assist users of the SDR in preparing for the changeover to the new SDR valuation on October 1, 2016. In addition, staff plans to publish a spreadsheet file that describes the illustrative currency amount calculations in detail, further facilitating SDR users in the transition to the new SDR basket.

¹³ See Annex for redlined version of paragraph 5 of the SDR Valuation Decision.

Table 2. Weights Implied by Currency Amounts: Current and Proposed Methodologies^{1/}

SDR Valuation Review	Currency	Board-adopted Weights	Current Methodology		Proposed Methodology	
			Currency Amounts ^{2/}	Deviation (in pct. pts.) ^{3/}	Currency Amounts	Deviation (in pct. pts.) ^{3/}
1980	US dollar	42	0.54	0.182	0.53760	-0.000049
	Deutsche mark	19	0.46	-0.147	0.46352	-0.000012
	Japanese yen	13	34	-0.379	35.016	0.000085
	French franc	13	0.74	0.109	0.73376	-0.000024
	Pound Sterling	13	0.071	0.235	0.069730	-0.000001
1985	US dollar	42	0.452	0.068	0.45126	-0.000357
	Deutsche mark	19	0.527	-0.024	0.52768	0.000086
	Japanese yen	15	33.4	-0.012	33.427	0.000151
	French franc	12	1.02	0.033	1.0172	0.000153
	Pound Sterling	12	0.0893	-0.065	0.089785	-0.000034
1990	US dollar	40	0.572	-0.077	0.57310	-0.000079
	Deutsche mark	21	0.453	0.042	0.45210	0.000118
	Japanese yen	17	31.8	-0.019	31.835	-0.000199
	French franc	11	0.800	0.029	0.79793	0.000079
	Pound Sterling	11	0.0812	0.025	0.081017	0.000082
1995	US dollar	39	0.582	-0.006	0.58211	0.000620
	Deutsche mark	21	0.446	0.000	0.44601	-0.000162
	Japanese yen	18	27.2	-0.033	27.250	-0.000196
	French franc	11	0.813	0.055	0.80900	-0.000012
	Pound Sterling	11	0.105	-0.015	0.10514	-0.000250
2005	US dollar	44	0.632	0.070	0.63100	-0.000145
	Euro	34	0.410	-0.015	0.41019	0.000024
	Japanese yen	11	18.4	-0.060	18.502	0.000196
	Pound Sterling	11	0.0903	0.006	0.090251	-0.000075
2010	US dollar	41.9	0.660	0.492	0.65243	0.000250
	Euro	37.4	0.423	-0.479	0.42854	0.000320
	Japanese yen	9.4	12.1	0.017	12.079	-0.000332
	Pound Sterling	11.3	0.111	-0.030	0.11131	-0.000238
2015	US dollar	41.73	0.584	-0.028	0.58440	-0.000133
	Euro	30.93	0.390	0.036	0.38955	-0.000039
	Japanese yen	8.33	14.3	0.021	14.265	0.000160
	Pound Sterling	8.09	0.0731	0.005	0.073056	0.000016
	Renminbi	10.92	0.966	-0.033	0.96893	-0.000004

^{1/} 2000 is excluded because the BEX and TEX series are no longer available.

^{2/} Based on adopted currency amounts for 1980-2010 and illustrative currency amounts for 2015 published in the 2015 SDR review paper.

^{3/} Deviation of weights implied by the currency amounts from Board-adopted weights.

Proposed Decision

The following decision, which may be adopted by a 70 percent majority of the total voting power, is proposed for adoption by the Executive Board:

Paragraph 5 of Decision No. 15891-(15/109), adopted November 30, 2015, shall be amended to read as follows:

5. The amounts of the currencies under paragraphs 3 and 4 above shall be determined in a manner that will ensure that the value of the special drawing right in terms of currencies on the last working day preceding the five-year period for which the determination is made will be the same under the valuation in effect before and after revision ("same value"), and shall be calculated in accordance with the following guidelines:

- (a) The currency amounts calculated for the new basket will be rounded to five significant digits based on the sixth significant digit. If necessary to achieve the same value, an adjustment will be made to the amount of the currency against which the values of the other SDR basket currencies are determined in accordance with Rule O-2.
- (b) If the calculations under (a) do not yield the same value in five significant digits, the calculations shall be made by applying the same guidelines but rounding currency amounts to six significant digits based on the seventh significant digit.

Box 1. Calculation of Currency Amounts in the SDR Basket: a Historical Perspective

Stability of the SDR value in terms of currencies is a long-standing key feature of the SDR valuation that is also reflected in the calculation of currency amounts (CA) in the SDR basket. The standard basket method of valuation of the SDR was adopted in 1974 as one that best ensures the stability of the SDR in terms of the major currencies under floating exchange rates.¹ In the same year, the Board decision on the method of calculating CA in the basket included two features aimed at ensuring stability of the SDR. First, the use of an average exchange rate of each currency relative to the US dollar during a three-month base period ending the last business day before a new basket comes into effect (the transition date) to convert Board-adopted currency weights (agreed weights) into CA so as to avoid the possible influence of currencies' transitory exchange rate fluctuations. Second, for continuity, maintaining equality in the value of the SDR under a new basket and the prevailing one on the transition date was required (*equality condition*). These features have remained principles embedded in the formula of calculating CA or in rounding guidelines.

The procedure for determining CA has been broadly unchanged over the years, except for some changes to the rounding principles made in the 1980s. From the inception of the SDR basket valuation method, there has been a preference for a small number of significant digits in CA. In the 1970s, CA uniformly rounded to two significant digits resulted in a solution meeting the equality principle with strict adherence to agreed weights. Staff's trial calculations revealed that this was no longer possible after the number of currencies in the SDR basket was reduced from 16 to five in 1980, prompting two changes introduced in the 1980 SDR valuation decision. First, relaxing the strict adherence to agreed weights by allowing a deviation within a *tolerance limit* of half a percentage point. Second, increasing the maximum number of significant digits allowed in the CA from two to four, with no requirement that the number of significant digits be uniform across currencies. The 1985 Decision introduced the uniformity of significant digits requirement to allow for measuring all currencies with the same precision. The *tolerance limit* and the rounding guidelines as of 1985 have since remained in effect.²

The changes of the 1980s were deemed necessary at the time, but also added complexity to CA determination while allowing somewhat larger deviations of initial currency weights from agreed weights. Their implementation necessitated the introduction of a search space using a range of several units above and below the last digit of each truncated CA to test for a solution that meets the established key principles. This is the origin of the cumbersome permutation steps that make the current procedure for calculating CA complex and the final CA derived from it non-transparent and difficult to replicate by SDR users.

¹See Decision No. 4233-(74/67) S, adopted June 13, 1974, effective July 1, 1974.

²See Decision No. 8160-(85/186) G/S, adopted December 23, 1985; and Decision No. 15891-(15/109), adopted November 30, 2015.

Box 2. Significant Digits and Use in SDR Valuation ^{1/}

“The number of significant digits (or significant figures) of a number “gives some idea of the precision or reliability of that number.” As most measures are approximate rather than exact, the number of significant digits conveys knowledge or confidence about the precision of the measures at hand.

The number of significant digits differs from the number of decimals. In an approximated number that includes decimals, significant digits are counted from the first non-zero digit and include all nonzero digits, any zeros sandwiched between two non-zero digits, and trailing zeros that come after a decimal. Leading zeros are never significant. The significance of trailing zeros in a number that is an integer is subject to interpretation.

The following examples help illustrate the counting of significant digits and the difference between the number of decimals and the number of significant digits in approximate numbers.

- “42”, “4.2”, and “0.0042” all have two significant digits and different numbers of decimals.
- 0.0402 has four decimals but only three significant digits. The first two zeros are leading zeros and are not significant. The third zero, sandwiched between “4” and “2”, is a significant digit.
- The number “3200” can have two or four significant digits depending on whether it was measured to the nearest 100 units or the nearest unit.

The SDR valuation has always used the notion of significant digits.

- The initial value of the SDR was set equal to 0.888671 grams of fine gold, equivalent to one U.S. dollar, expressed in six significant digits.
- Since the inception of the basket method of valuation, currency amounts have been expressed in two to four significant digits.
- The value of the USD/SDR under Rule O-2 is rounded to six significant digits.

^{1/} The discussion on significant digits is drawn from Lambert, Andrew (1993), *“Maths for Advanced Physics”*, Thomas Nelson and Sons Ltd, p. 14.

Annex I. Redlined Version of Proposed Decision

The following decision, which may be adopted by a 70 percent majority of the total voting power, is proposed for adoption by the Executive Board:

Paragraph 5 of Decision No. 15891-(15/109), adopted November 30, 2015, shall be amended to read as follows:

5. The ~~determination of the~~ amounts of the currencies under paragraphs 3 and 4 above shall be ~~made~~ determined in a manner that will ensure that the value of the special drawing right in terms of currencies on the last working day preceding the five-year period for which the determination is made will be the same under the valuation in effect before and after revision ("same value"), and shall be calculated in accordance with the following guidelines:

- (a) The currency amounts calculated for the new basket will be ~~expressed in two~~ rounded to five significant digits ~~based on the sixth significant digit, provided that the deviation of the percentage share of each currency in the value of the special drawing right, resulting from the application of the average exchange rates for July–September, from the percentage weight as determined under paragraphs 3 and 4(c) above is the minimum on average and will not exceed one half percentage point for any currency. If necessary to achieve the same value, an adjustment will be made to the amount of the currency against which the values of the other SDR basket currencies are determined in accordance with Rule O-2.~~
- (b) If ~~the calculations under a solution cannot be obtained by the application of the guidelines set forth in (a) do not yield the same value in five significant digits, above,~~ the calculations shall be made by applying the same guidelines but ~~expressing~~ rounding ~~the amount of each~~

currency ~~amounts in three to six~~ significant digits ~~based on the seventh significant digit, and~~
~~if no solution is found with three significant digits then the calculation shall be made~~
~~applying the same guidelines but expressing the amount of each currency in four significant~~
~~digits.~~

- ~~(c) — If more than one solution is found in the calculation at the level of two, three, or four~~
~~significant digits, the solution that has the smallest average deviation will be employed.~~