**Provisional Application for United States Patent**

**TITLE:** Unified ATOMS™ Index Return and Price Algorithms

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**APPLICATION NUMBER** 62482281

## BACKGROUND

Home mortgages are usually organized, optimized by groups and structured into mortgage backed securities (MBS). These MBS are bought and sold on the bond market. Determining the returns from these securities in a highly transparent and efficient manner is important to all the entities involved in creating, buying, selling, servicing, and holding these securities. Originators, underwriters, issuers, trustees, investment bankers, fund managers, broker-dealers, servicers, investors all need tools to determine the implied value the securities they are trading or holding.

## BRIEF SUMMARY OF THE INVENTION

The Available TBA-Only MBS Supply Index (ATOMS™) is a mortgage backed securities tracking index that market participants can use to track the composition and performance of the freely-tradable generic TBA-Only population of fixed rate MBS pools guaranteed by Fannie Mae (FNMA), Freddie Mac (FHLMC), and Ginnie Mae (GNMA).

The ATOMS™ Index is constituted of the about 175,000 (daily average) TBA-Only MBS pools that are not purposely held from the overall secondary market supply by central banking authorities, committed to structured investment trusts, or would traditionally be traded in the specified pool market. The details of the criteria that that determine which pools are included

in the ATOMS™ Index can be found in the "Available TBA-Only MBS Supply (ATOMS) Index" patent application # 62171265.

For each pool in the ATOMS™ Index the Month-To-Date (MTD) Total Return is calculated from the 3 revenue sources: Coupon, Carry Adjusted Price, Paydown, as shown in Fig 1, using formula (1) ~ (15). These values are then aggregated to produce the ATOMS™ Index Return, as shown in Fig 2, using formula (16) ~ (22). For each ATOMS™ pool, we use RScore, DScore and Day-To-Date(DTD) Total Return to calculate a price that is fair to both buyer and seller, and this price is called ATOMS™ Price. See Fig 4 and formula (23) ~ (42). A weighted average ATOMS™ Price is called ATOMS™ Index Price, see Fig 5 and formula (43) ~ (44). Formula (45) ~ (52) is used for missing TBA price.

The ATOMS™ Index is designed so that market participants will have a practical, real-world way to track the MBS market with an index that reflects the tradable TBA-Only universe.

## ATOMS™ MTD Total Return Flow Chart

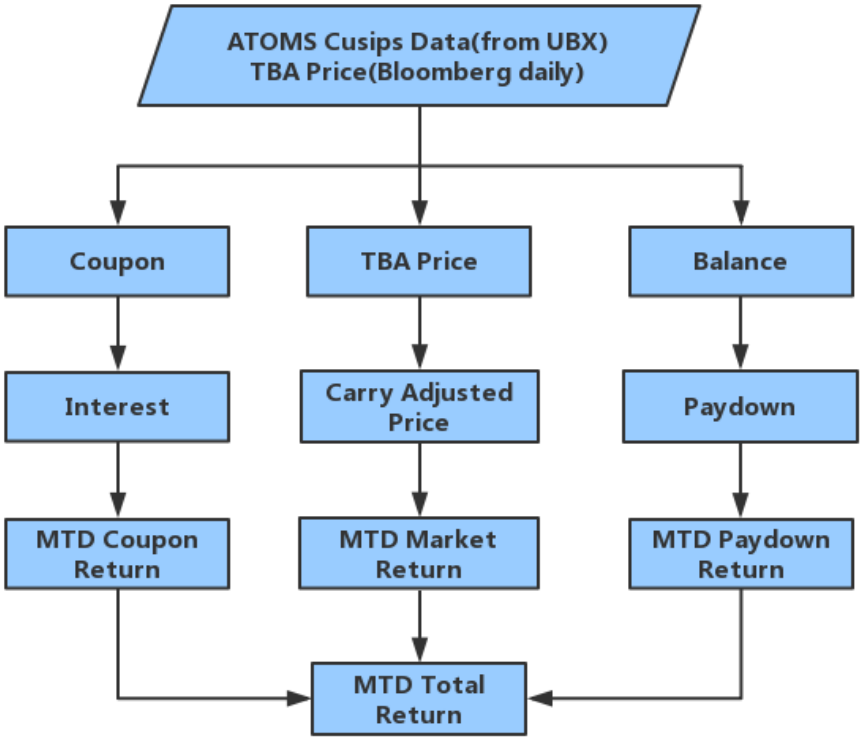


Fig 1

# ATOMS™ Index Return Flow Chart

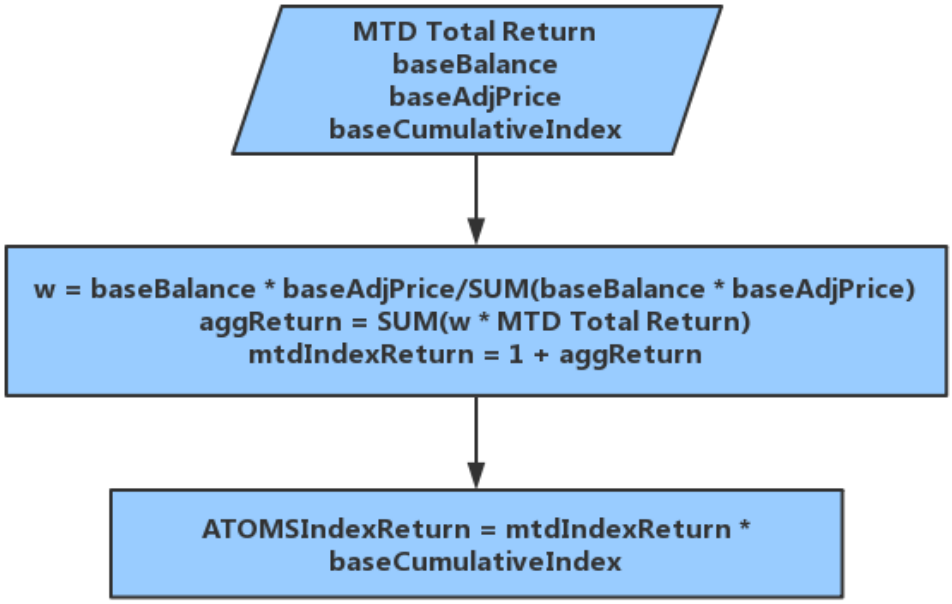


Fig 2

# ATOMS™ Index Return

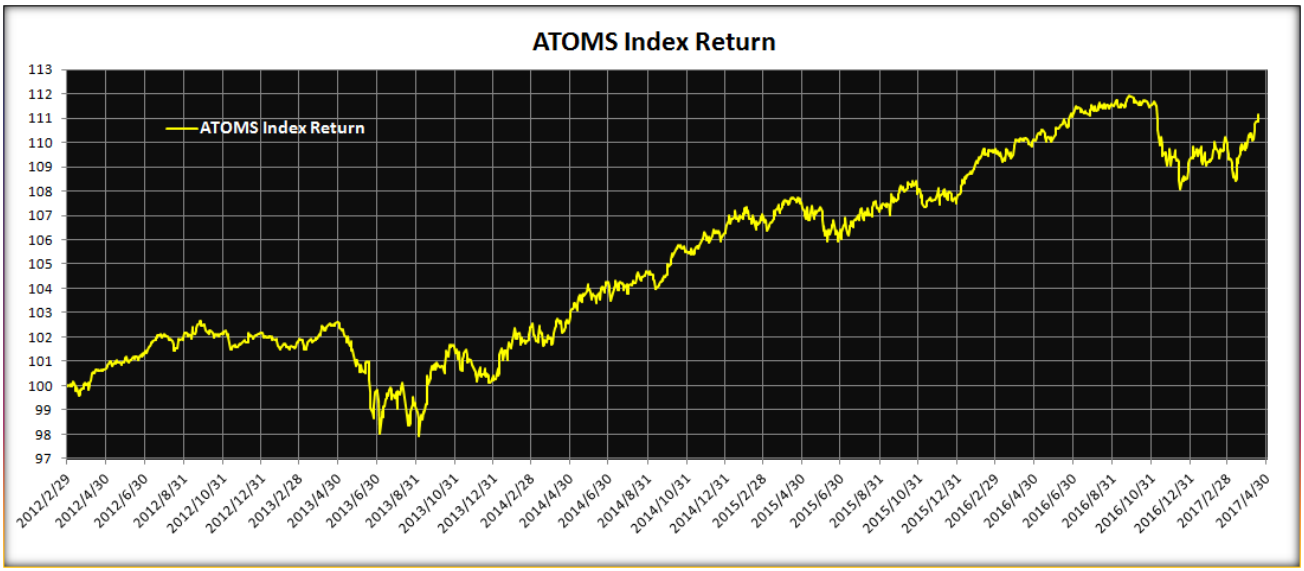


Fig 3

# ATOMS™ Price Flow Chart

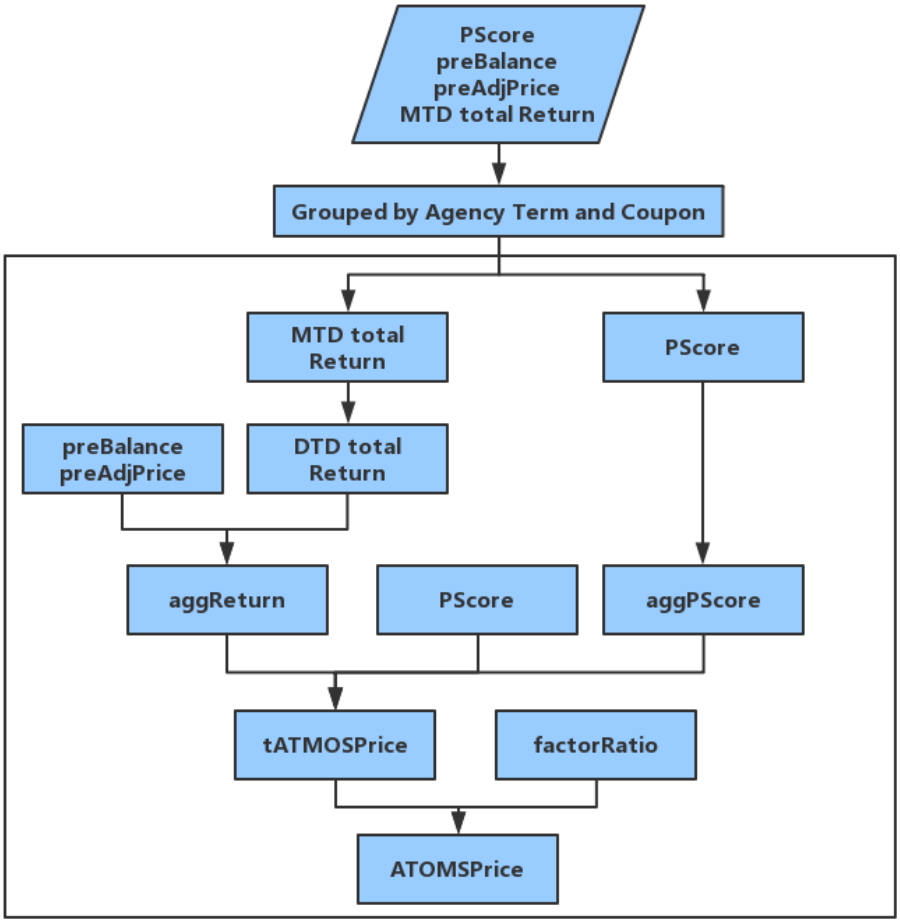


Fig 4

# ATOMS™ Index Price Flow Chart

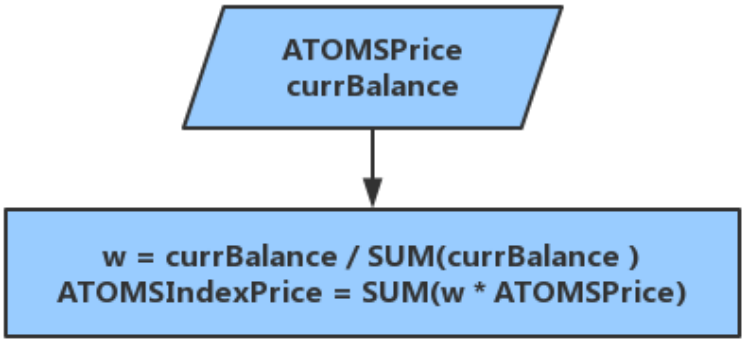


Fig 5

## DETAILED DESCRIPTION AND BEST MODE OF IMPLEMENTATION

The Unified ATOMS™ Index Return and Price are implemented as a set of computer programs running the following Algorithms.

### Variable Definition

$uTBAPrice$ – TBA Price for Discounting

$priceDate$ – Price Date

$carryAdjPrice$ – Price Discounted by TBA Price

$baseAdjPrice$ – $carryAdjPrice$ of Last Business Day of Prevoius Month

$preAdjPrice$ – $carryAdjPrice$ of Previous Business Day

$coupon$ – TBA Coupon

$settleDateCurr$ – Current Month's TBA Settle Date

$settleDateNext$ – Next Month's TBA Settle Date

$notifyDate$ – Current Month's Notification Date

$pmtDateCurr$ – Current Month's Payment Date

$pmtDateNext$ – Next Month's Payment Date

$1mLibor$ – 1 month Libor

$currBal$ – Current Month's Balance

$baseBal$ – Previous Month's Balance

$preBal$ – Previous Business Day's Balance

$currFactor$ − Current Month's Pool Factor

$preFactor$ − Previous Month's Pool Factor

$RScore*$ −Score of voluntarily Prepayment

$DScore*$ −Score of involuntarily Prepayment

$PScore*$ −Score of Prepayment

* See US patent: Unified deconvolution approach to compute financial systemic risk scores. Patent application # 62134667.

## Month-to-Date Total Return for One Single ATOMS™ Pool

We will compute the Month-to-Date return for every single ATOMS pool every business day. The process is as following:

- Find TBA price by the pool's agency, term and coupon.
- Discount the TBA price to current day, and denote as $carryAdjPrice$.
- Compute the Month-to-Date return relative to the $carryAdjPrice$ of last day of previous month.

MTD total return consists of three terms: 1) MTD market return, 2) MTD paydown return and 3) MTD coupon return.

### A) Month-to-Date Market Return

$$daysToSettle = \begin{cases} settleDateCurr - priceDate, & priceDate \leq notifyDate \\ settleDateNext - priceDate, & priceDate > notifyDate \end{cases} \quad (1)$$

$$daysToNextPmt = pmtDateNext - priceDate \quad (2)$$

$$TBASettleAccr = \begin{cases} (DAY(settleDateCurr) - 1) * \dfrac{coupon}{360}, priceDate \leq notifyDate \\ (DAY(settleDateNext) - 1) * \dfrac{coupon}{360}, priceDate > notifyDate \end{cases} \quad (3)$$

$$cashAccr = (DAY(priceDate) - 1) * \frac{coupon}{360} \quad (4)$$

$$TBAPricePlusAccr = uTBAPrice + TBASettleAccr \quad (5)$$

$$survFactor = \frac{currFactor}{preFactor} \quad (6)$$

If $priceDate \leq notifyDate$:

$$carryAdjPrice = \frac{TBAPricePlusAccr}{(1 + 1mLibor/360)^{daysToSettle}} - cashAccr \quad (7)$$

If $priceDate > notifyDate$:

$$carryAdjPrice = survFactor * \frac{TBAPricePlusAccr}{(1 + 1mLibor/360)^{daysToSettle}} + (1 - survFacor) * \frac{100}{(1 + 1mLibor/360)^{daysToNextPmt}} + \frac{\frac{coupon}{12}}{(1 + 1mLibor/360)^{daysToNextPmt}} - cashAccr \quad (8)$$

$$mtdMktReturn = \frac{carryAdjPrice - baseAdjPrice}{baseAdjPrice + \frac{coupon}{12}} \quad (9)$$

**B) <u>Month-to-Date Paydown Return</u>**

$$daysToCurrPmt = \begin{cases} pmtDateCurr - priceDate, priceDate \leq pmtDateCurr \\ 0, priceDate > pmtDateCurr \end{cases} \quad (10)$$

$$paydownValue = \frac{(1 - survFactor) * (100 - carrAdjPrice - cashAccr)}{(1 + 1mLibor/360)^{daysToCurrPmt}} \quad (11)$$

$$mtdPaydownReturn = \frac{paydownValue}{baseAdjPrice + \frac{coupon}{12}} \quad (12)$$

**C) <u>Month-to-Date Coupon Return</u>**

$$couponValue = cashAccr + \frac{\frac{coupon}{12}}{(1 + 1mLibor/360)^{daysToCurrPmt}} - \frac{coupon}{12} \quad (13)$$

$$mtdCouponReturn = \frac{couponValue}{baseAdjPrice + \frac{coupon}{12}} \quad (14)$$

**D) <u>Month-to-Date Total Return</u>**

$$mtdTotalReturn = mtdMktReurn + mtdPaydownReturn + mtdCouponReturn \quad (15)$$

## ATOMS™ Index Return

### A) Return for Aggregation of All ATOMS™ Pools

$$aggReturn = \sum_{pool \in S} w_{pool} * mtdTotalReturn_{pool} \quad (16)$$

$$w_{pool} = \frac{baseBal * \left(baseAdjPrice + \frac{coupon}{12}\right)}{\sum_{pool \in S} baseBal * \left(baseAdjPrice + \frac{coupon}{12}\right)} \quad (17)$$

where

$$POOL = \{pool | \text{TBA pool this month}\} \quad (18)$$

$$POOL_{base} = \{pool | \text{TBA pool previous month}\} \quad (19)$$

$$S = POOL \cap POOL_{base} \quad (20)$$

### B) ATOMS™ Index Return

$$mtdIndexReturn = 1 + aggReturn \quad (21)$$

$$ATOMS^{TM}\,IndexReturn = mtdIndexReturn * baseCumulativeIndex \quad (22)$$

where

$baseCumulativeIndex$ is the $ATOMS^{TM}\,IndexReturn$ of last business day of previous month.

## ATOMS™ Index Price

### A) ATOMS™ Price for One Single ATOMS™ Pool

$$COUPON = \{2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7\} \quad (23)$$

$$AGENCY = \{fh, fn, g1, g2\} \quad (24)$$

$$TERM = \{15, 30\} \quad (25)$$

$$POOL_{ag\_tm\_cp} = \{pool \in POOL \cap POOL_{base} | agency = ag, term = tm, coupon = cp\} \quad (26)$$

$$PScoreQ1_{ag\_tm\_cp} \equiv the\ first\ quartile's\ PScore\ for\ pool\ in\ POOL_{ag\_tm\_cp} \quad (27)$$

$$QPOOL_{ag\_tm\_cp} = \{pool \in POOL_{ag\_tm\_cp} | PScore < PScoreQ1_{ag\_tm\_cp}\} \quad (28)$$

where $ag \in AGENCY, tm \in TERM, cp \in COUPON$

If $priceDate$ and previous business day are in the same month:

$$dtdTotalReturn = \frac{mtdTotalReturn - mtdTotalReturn_{pre}}{1 + mtdTotalReturn_{pre}} \quad (29)$$

where $mtdTotalReturn_{pre}$ is $mtdTotalReturn$ of previous business day.

Else:

$$dtdTotalReturn = mtdTotalReturn \quad (30)$$

$$aggReturn_{ag\_tm\_cp} = \sum_{platc \in POOL_{ag\_tm\_cp}} w_{platc} * dtdTotalReturn \quad (31)$$

where

$$w_{platc} = \frac{currBal}{\sum_{platc \in POOL_{ag\_tm\_cp}} currBal} \quad (32)$$

$$aggPScore_{ag\_tm\_cp} = \sum_{platc \in QPOOL_{ag\_tm\_cp}} w_{qplatc} * PScore \quad (33)$$

Where

$$w_{qplatc} = \frac{currBal}{\sum_{platc \in QPOOL_{ag\_tm\_cp}} currBal} \tag{34}$$

For a single ATOMS$^{TM}$ pool in $POOL_{ag\_tm\_cp}$, we use the following formulas to compute its ATOMS$^{TM}$ price.

$$ratio = \frac{PScore}{aggPScore_{ag\_tm\_cp}} \tag{35}$$

$$tot = aggReturn_{ag\_tm\_cp} \tag{36}$$

$$discount = (1 + libor/360)^{daysToCurrPmt} \tag{37}$$

If $priceDate$ and previous business day are in the same month:

$$\begin{aligned} &mATOMS^{TM}Price \\ &= \left(preAdjPrice + cashAccr_{pre}\right) * tot + preAdjPrice - cashAccr \\ &+ cashAccr_{pre} \end{aligned} \tag{38}$$

where $cashAccr_{pre}$ is the interest accrual of previous business day.

Else:

$$\begin{aligned} &mATOMS^{TM}Price \\ &= \frac{(1 + tot - mtdCouponReturn) * \left(baseAdjPrice + \frac{coupon}{12}\right) * discount}{discount - 1 + survFactor} \\ &+ \frac{(cashAccr - 100) * (1 - survFactor)}{discount - 1 + survFactor} \\ &- \frac{coupon * discount/12}{discount - 1 + survFactor} \end{aligned} \tag{39}$$

If $carryAdjPrice - 3 \leq mATOMSPrice \leq carrAdjPrice + 3$:

$$mATOMS^{TM}Price = \ carryAdjPrice \tag{40}$$

For a single ATOMS$^{TM}$ pool in $POOL - POOL_{base}$, its $mATOMS^{TM}Price$ is $carryAdjPrice$.

$$tATOMS^{TM}Price = mATOMS^{TM}Price * exp^{sratio*ratio-ratio*pow(ratio,xratio)} \quad (41)$$

*Where the sratio is the following table*:

| | *G1 15* | *G2 15* | *FN 15* | *FH 15* | *G1 30* | *G2 30* | *FN 30* | *FH 30* |
|---|---|---|---|---|---|---|---|---|
| *2* | 0.005 | 0.05 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| *2.5* | 0.15 | 0.08 | 0.008 | 0.03 | 0.005 | 0.005 | 0.12 | 0.005 |
| *3* | 0.2 | 0.04 | 0.0075 | 0.005 | 0.04 | 0.002 | 0.08 | 0.03 |
| *3.5* | 0.15 | 0.04 | 0.035 | 0.05 | 0.038 | 0.037 | 0.08 | 0.04 |
| *4* | 0.12 | 0.3 | 0.09 | 0.1 | 0.15 | 0.06 | 0.026 | 0.09 |
| *4.5* | 0.1 | 0.3 | 0.07 | 0.12 | 0.075 | 0.2 | 0.08 | 0.036 |
| *5* | 0.15 | 0.005 | 0.05 | 0.09 | 0.145 | 0.2 | 0.2 | 0.045 |
| *5.5* | 0.075 | 0.005 | 0.005 | 0.02 | 0.005 | 0.2 | 0.14 | 0.005 |
| *6* | 0.15 | 0.005 | 0.005 | 0.02 | 0.005 | 0.005 | 0.005 | 0.06 |
| *6.5* | 0.15 | 0.005 | 0.005 | 0.005 | 0.005 | 0.008 | 0.005 | 0.005 |
| *7* | 0.15 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |

Table 1

*Where the xraito is the following table*:

| | *G1 15* | *G2 15* | *FN 15* | *FH 15* | *G1 30* | *G2 30* | *FN 30* | *FH 30* |
|---|---|---|---|---|---|---|---|---|
| *2* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *2.5* | 0 | 0 | 0 | 0 | 0 | 0 | 0.25 | 0 |
| *3* | 0 | 0 | 0 | 0 | 0.35 | 0 | 0.5 | 0 |
| *3.5* | 0 | 0 | 0.25 | 0.1 | 0 | 0.2 | 0.6 | 0 |
| *4* | 0 | 0 | 0.35 | 0.1 | 0.15 | 0.1 | 0.1 | 0.19 |
| *4.5* | 0 | 0 | 0 | 0 | 0.15 | 0.5 | 0 | 0 |
| *5* | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.35 | 0 |
| *5.5* | 0 | 0 | 0 | 0.6 | 0 | 0 | 0 | 0 |
| *6* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *6.5* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *7* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2

$$ATOMS^{TM}Price = \frac{tATOMS^{TM}Price}{exp^{(1-currFactor)*factorRatio}} \quad (42)$$

*Where the* $factorRatio$ *is the following table*:

| | *G1 15* | *G2 15* | *FN 15* | *FH 15* | *G1 30* | *G2 30* | *FN 30* | *FH 30* |
|---|---|---|---|---|---|---|---|---|
| *2* | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| *2.5* | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| *3* | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 |
| *3.5* | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| *4* | 0.002 | 0.001 | 0.001 | 0.015 | 0.001 | 0.001 | 0.001 | 0.001 |
| *4.5* | 0.002 | 0.001 | 0.0065 | 0.009 | 0.001 | 0.005 | 0.0045 | 0.001 |
| *5* | 0.001 | 0.001 | 0.002 | 0.005 | 0.002 | 0.005 | 0.001 | 0.001 |
| *5.5* | 0.001 | 0.001 | 0.001 | 0.003 | 0.005 | 0.001 | 0.001 | 0.001 |
| *6* | 0.001 | 0.001 | 0.001 | 0.015 | 0.005 | 0.001 | 0.001 | 0.001 |
| *6.5* | 0.001 | 0.001 | 0.001 | 0.001 | 0.005 | 0.001 | 0.001 | 0.003 |
| *7* | 0.001 | 0.001 | 0.001 | 0.001 | 0.005 | 0.001 | 0.001 | 0.001 |

Table 3

**B) <u>ATOMS™ Index Price</u>**

$$ATOMS^{TM}IndexPrice = \sum_{pr \in POOL \cap POOL_{base}} w_{pr} * ATOMS^{TM}Price \quad (43)$$

where

$$w_{pr} = \frac{currBal}{\sum_{pr \in POOL \cap POOL_{base}} currBal} \quad (44)$$

## Score-Based Prepayment Model

The model for R/D Scores also produces the probability of corresponding events, such as prepayment, delinquency, default, etc.

Monthly probability of an event, based on the model, is

$$P_m = \frac{1}{1+\exp\left(\frac{S_m - S_0}{S_s}\right)}$$

where $P_m$ and $S_m$ are the scores for month m respectively, and,
$S_0$ and $S_s$ are the model parameters for score constant and slope for the collateral types, respectively.

Based the probabilities, we can compute the projected CPRs at months 1, 3, 6, and 12, for the short term forecast.

For longer term forecast, the aging and seasonality curves for the specific collateral types can be merged with the above CPRs.

## Estimate Missing TBA Price

TBA prices of pools with same agency, term and coupon are the same. Sometimes TBA price is missing at certain coupon level. In such cases, we use least square regression to estimate those missing TBA prices.

### A) Least Square Regression

$$ag\_tm_{miss} = \{cp \in COUPON | TBA\ Price\ is\ missing\ when\ agency = ag, term = tm\ and\ coupon = cp\} \quad (45)$$

Where $ag \in AGENCY, tm \in TERM$

With term and agency given, we use the following least square regression functions:

$$min\left(\sum_{cp\in COUPON-ag\_tm_{miss}}\left(TBAPrice_{ag\_tm\_cp}-eTBAPrice_{ag\_tm\_cp}\right)^2\right) \quad (46)$$

$$eTBAPrice_{ag\_tm\_cp}=a_{ag\_tm}*cp+b_{ag\_tm} \quad (47)$$

**B) <u>Correction</u>**

$uTBAPrice$: TBA Price for discounting

$$err_{ag\_tm}=\frac{\sum_{cp\in COUPON-ag\_tm_{miss}}|TBAPrice_{ag\_tm\_cp}-eTBAPrice_{ag\_tm\_cp}|}{|COUPON-ag\_tm_{miss}|} \quad (48)$$

If $cp\in COUPON-ag\_tm_{miss}$ :

$$uTBAPrice_{ag\_tm\_cp}=TBAPrice_{ag\_tm\_cp} \quad (49)$$

If $cp\in ag\_tm_{miss}\ and\ a_{ag\_tm\_cp}<0$:

$$uTBAPrice_{ag\_tm\_cp}=eTBAPrice_{ag\_tm\_cp} \quad (50)$$

If $cp\in ag\_tm_{miss}-\{2,2.5\}\ and\ a_{ag\_tm\_cp}\geq 0$:

$$uTBAPrice_{ag\_tm\_cp}=eTBAPrice_{ag\_tm\_cp}-err_{ag\_tm} \quad (51)$$

If $cp\in ag\_tm_{miss}\cap\{2,2.5\}\ and\ a_{ag\_tm\_cp}\geq 0$:

$$uTBAPrice_{ag\_tm\_cp}=eTBAPrice_{ag\_tm\_cp} \quad (52)$$

**CLAIMS:**

A method to compute the ATOMS™ Index Return and ATOMS™ Index Price based on the Algorithms above.