estimate the volatility in the GB markets over a given investment horizon and tenor of the underlying bond. Because no standardized benchmark currently exists that reflects the option-implied fair market value of expected GB volatility, traders, other market participants, and/or money managers currently trade options on GB futures and options to hedge other financial positions, facilitate market-making, and/or take particular investment positions related to market volatility. However, the strategies employed in attempting to hedge risk via the trading of options on GB futures do not necessarily lead to accurate profits and losses due to price dependency, i.e., the tendency to generate profits and losses that are affected by the path of price movements between trade inception and expiry dates rather than the absolute price level prevailing at the time of option expiry.

[0015] As such, some embodiments of the invention provide techniques for calculating an effective volatility index related to the GB market. Additionally, some embodiments of the invention provide techniques for instantiating and/or facilitating trading of derivative products based on such an index.

[0016] In some embodiments, techniques are provided for creating and disseminating one or more volatility indices calculated using data for options on government bond derivatives such as futures and forwards (i.e., an option granting its owner the right but not the obligation to enter into an underlying bond derivative contract), and facilitating the electronic creation and trading of derivative products based on one or more indices relating to volatility.

[0017] Additional features and advantages of the invention will be set forth in the description that follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and advantages of the invention will be realized and attained by the method that is particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0018] ~~To achieve these and other advantages, and in accordance with the purpose of the invention, as embodied and broadly described,~~According to a first aspect of the present invention, there is ~~provides~~ provided ~~a computer~~an electronic trading system for ~~calculating~~ trading derivative products based on a government bond volatility index, the electronic trading system comprising memory configured to store at least one program; and at least one processor communicatively coupled to the memory, in which the at least one program, when executed by the at least one processor, causes the at least one processor to perform operations comprising: ~~receive~~ receiving data regarding options on government bond derivatives; ~~calculate~~calculating, using the

data regarding options on government bond derivatives, the government bond volatility index; ~~and transmit~~transmitting data regarding the government bond volatility index; receiving an electronic order for a derivative product based on the government bond volatility index; and executing the electronic order .

[0019] In some embodiments, the data regarding options on government bond derivatives includes data regarding prices of options on government bond derivatives.

[0020] In one embodiment, the data regarding prices of options on government bond derivatives includes data regarding prices of options on government bond futures or government bond forwards.

[0021] In another embodiment, the data regarding prices of options on government bond derivatives includes data regarding prices of European style options on government bond forwards.

[0022] In some embodiments, the data regarding prices of options on government bond derivatives includes data regarding prices of options that are not European style options on government bond forwards.

[0023] In some embodiments, when the data regarding prices of options on government bond derivatives includes data regarding prices of options that are not European-style options on government bond forwards, converting the data regarding prices of options that are not European-style options on government forwards to data regarding prices of European style options on government bond forwards.

[0024] In some embodiments, calculating the government bond volatility index includes valuing a basket of options on the government bond derivatives required for model-independent pricing of a variance swap contract on the government bond derivatives.

[0025] In some embodiments, the government bond volatility index is calculated at time t according to the equation:

$$GB-VI(t,T,T_D,T_N) \equiv$$

$$100\times\sqrt{\frac{1}{(T-t)}\left[\frac{2}{P_t(T)}\left[\sum_{i:K_i<K_*}\frac{Put_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i+\sum_{i:K_i\geq K_*}\frac{Call_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i\right]-\left(\frac{F_t(T_D,T_N)-K_*}{K_*}\right)^2\right]}$$

wherein:

t denotes a time at which the government bond volatility index is calculated;

T denotes a time of expiry of options on government bond derivatives;

T_D denotes a time of maturity of government bond derivatives underlying the options where $T_D \geq T$;

price, a bid price, an offer price, or a trade price of the standardized exchange-traded derivative instrument.

[0031] ~~In another embodiment,~~According to a second aspect of the present invention, there is provided a non-transitory computer readable storage medium having computer-executable instructions recorded thereon that, when executed ~~on a~~by at least one computer, configure the at least one computer to perform operations for trading derivative products in an electronic trading system based on~~a method to calculate~~ a government bond volatility index, the ~~method~~ operations comprising receiving, by the electronic trading system, data regarding options on government bond derivatives; calculating, by the electronic trading system and using the data regarding options on government bond derivatives, the government bond volatility index; ~~and~~ transmitting, by the electronic trading system, data regarding the government bond volatility index; receiving, by the electronic trading system, an electronic order for a derivative product based on the government bond volatility index; and executing the electronic order.

[0032] In some embodiments of the non-transitory computer readable storage medium, the data regarding options on government bond derivatives includes data regarding prices of options on government bond derivatives.

[0033] In one embodiment of the non-transitory computer readable storage medium, the data regarding prices of options on government bond derivatives includes data regarding prices of options on government bond futures or government bond forwards.

[0034] In some embodiments of the non-transitory computer readable storage medium, the data regarding prices of options on government bond derivatives includes data regarding prices of European style options on government bond forwards.

[0035] In some embodiments of the non-transitory computer readable storage medium, the data regarding prices of options on government bond derivatives includes data regarding prices of options that are not European style options on government bond forwards.

[0036] In some embodiments of the non-transitory computer readable storage medium, when the data regarding prices of options on government bond derivatives includes data regarding prices of options that are not European-style options on government bond forwards, converting the data regarding prices of options that are not European-style options on government bond forwards to data regarding prices of European style options on government bond forwards.

[0037] In some embodiments of the non-transitory computer readable storage medium, calculating the government bond volatility index includes valuing a basket of options on the government bond derivatives required for model-independent pricing of a variance swap contract on the government bond derivatives.

WHAT IS CLAIMED IS:

1. ~~A~~ An electronic trading system ~~computer system~~ for trading derivative products based on ~~calculating~~ a government bond volatility index, the electronic trading system comprising:

memory configured to store at least one program; and

at least one processor communicatively coupled to the memory, in which the at least one program, when executed by the at least one processor, causes the at least one processor to perform operations comprising:

receiving ~~receive~~ data regarding options on government bond derivatives;

calculating~~calculate~~, using the data regarding options on government bond derivatives, the government bond volatility index; ~~and~~

transmitting ~~transmit~~ data regarding the government bond volatility index;

receiving an electronic order for a derivative product based on the government bond volatility index; and

executing the electronic order.

2. The electronic trading ~~computer~~ system of claim 1, wherein the data regarding options on government bond derivatives includes data regarding prices of options on government bond derivatives.

3. The electronic trading ~~computer~~ system of claim 2, wherein the data regarding prices of options on government bond derivatives includes data regarding prices of options on government bond futures or government bond forwards.

4. The electronic trading ~~computer~~ system of claim 3, wherein the government bond volatility index is calculated at time t according to the equation:

$$GB-VI(t,T,T_D,T_N) \equiv$$

$$100\times\sqrt{\frac{1}{(T-t)}\left[\frac{2}{P_t(T)}\left[\sum_{i:K_i<K_*}\frac{Put_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i+\sum_{i:K_i\geq K_*}\frac{Call_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i\right]-\left(\frac{F_t(T_D,T_N)-K_*}{K_*}\right)^2\right]}$$

wherein:

t denotes a time at which the government bond volatility index is calculated;

T denotes a time of expiry of options on government bond derivatives;

T_D denotes a time of maturity of government bond derivatives underlying the options where $T_D \geq T$;

T_N denotes a time of expiry of government bonds;

Z+1 denotes a total number of options used in the index calculation;

K_0 denotes the lowest strike of the Z+1 options;

K_i denotes the i^{th} highest strike of the Z+1 options;

K_Z denotes the highest strike of the Z+1 options;

$\Delta K_i = \frac{1}{2}(K_{i+1} - K_{i-1})$ for $i \geq 1$, and $\Delta K_0 = (K_1 - K_0), \Delta K_Z = (K_Z - K_{Z-1})$;

if the price is observable at time t, then $F_t(T_D,T_N)$ is a price at time t of a government bond derivative contract underlying the put and call options, expiring at T_D with an underlying government bond maturing at T_N;

if the price is not observable at time t, then $F_t(T_D,T_N)$ is the strike at which the difference between the put and call prices is smallest;

if there exists an option struck at $F_t(T_D,T_N)$, then K_* equals $F_t(T_D,T_N)$;

if there does not exist an option struck at $F_t(T_D,T_N)$, then K_* is the first available strike below $F_t(T_D,T_N)$;

$P_t(T)$ is a price at time t of a zero-coupon non-defaultable bond maturing at T;

$Put_t(K_i,T,T_D,T_N)$ is a price at time t of a put option, struck at K_i, expiring at T, and having an underlying government bond derivative expiring at T_D with an underlying bond maturing at T_N;

$Call_t(K_i,T,T_D,T_N)$ is a price at time t of a call option, struck at K_i, expiring at T, and having an underlying government bond derivative expiring at T_D with an underlying bond maturing at T_N; and

$GB-VI(t,T,T_D,T_N)$ is the value of the government bond volatility index at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N.

5. The electronic trading ~~computer~~ system of claim 3, wherein the government bond volatility index is calculated at time t according to the equation:

$$GB-VI^{bp}(t,T,T_D,T_N) \equiv$$

$$100^2 \times \sqrt{\frac{1}{(T-t)}\left[\frac{2}{P_t(T)}\left[\sum_{i:K_i<K_*} Put_t(K_i,T,T_D,T_N)\Delta K_i + \sum_{i:K_i \geq K_*} Call_t(K_i,T,T_D,T_N)\Delta K_i\right] - (F_t(T_D,T_N)-K_*)^2\right]}$$

wherein:

6. The electronic trading ~~computer~~ system of claim 3,

wherein, in the absence of accrued coupons at time T, the government bond volatility index is calculated at time t according to the equation:

$$GB-VI_Y^{bp}(t,T,T_D,T_N)\equiv 100\times \hat{P}^{-1}[\frac{GB-VI^{bp}(t,T,T_D,T_N)}{GB-VI(t,T,T_D,T_N)}]\times GB-VI(t,T,T_D,T_N)$$

where

$$\hat{P}(y)\equiv\sum_{i=1}^{N}\frac{C_i}{n}(1+\frac{y}{n})^{-i}+100(1+\frac{y}{n})^{-N};$$

and, wherein, in the presence of accrued coupons at time T with the next coupon due at t_j, the government bond volatility index is calculated at time t according to the equation:

$$GB-VI_Y^{bp}(t,T,T_D,T_N)\equiv 100\times \hat{P}_T^{-1}[\frac{GB-VI^{bp}(t,T,T_D,T_N)}{GB-VI(t,T,T_D,T_N)}]\times GB-VI(t,T,T_D,T_N)$$

where

$$\hat{P}_T(x)\equiv\sum_{i=j}^{N}\frac{C_i}{n}(1+x)^{\frac{dc(t_i-T)}{dc(year)}}+100(1+x)^{\frac{dc(t_N-T)}{dc(year)}}$$

and

$$GB-VI(t,T,T_D,T_N)\equiv$$
$$100\times\sqrt{\frac{1}{(T-t)}\left[\frac{2}{P_t(T)}\left[\sum_{i:K_i<K_*}\frac{Put_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i+\sum_{i:K_i\geq K_*}\frac{Call_t(K_i,T,T_D,T_N)}{K_i^2}\Delta K_i\right]-\left(\frac{F_t(T_D,T_N)-K_*}{K_*}\right)^2\right]}$$

and

$$GB-VI^{bp}(t,T,T_D,T_N)\equiv$$
$$100^2\times\sqrt{\frac{1}{(T-t)}\left[\frac{2}{P_t(T)}\left[\sum_{i:K_i<K_*}Put_t(K_i,T,T_D,T_N)\Delta K_i+\sum_{i:K_i\geq K_*}Call_t(K_i,T,T_D,T_N)\Delta K_i\right]-(F_t(T_D,T_N)-K_*)^2\right]}$$

wherein:

t denotes a time at which the government bond volatility index is calculated;

T denotes a time of expiry of options on government bond derivatives;

t_j is the first coupon payment on or after T;

T_D denotes a time of maturity of government bond derivatives underlying the options where $T_D \geq T$;

$\hat{P}_T(x)$ is a bond price at time T corresponding to a bond yield of a coupon-bearing government bond;

$\hat{P}_T^{-1}(x)$ is the functional inverse of $\hat{P}_T(x)$;

$dc(year)$ is the number of days in a year based on a day count convention used for the government bond;

$dc(T-t)$ is the number of days between t and T based on a day count convention used for the government bond;

$GB-VI_Y^{bp}(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of basis point yield volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N;

$GB-VI^{bp}(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of basis point price volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N; and

$GB-VI(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of percentage price volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N.

7. The electronic trading ~~computer~~ system of claim 3, wherein the government bond volatility index is calculated at time t according to the equation:

$$GB-VI_{Yd}^{bp}(t,T,T_D,T_N) \equiv \frac{100\times\left(1+\hat{P}_T^{-1}\left[\frac{GB-VI^{bp}(t,T,T_D,T_N)}{GB-VI(t,T,T_D,T_N)}\right]\right)\times GB-VI^{bp}(t,T,T_D,T_N)}{\sum_{i=j}^{N}\frac{C_i}{n}\left(1+\hat{P}_T^{-1}\left[\frac{GB-VI^{bp}(t,T,T_D,T_N)}{GB-VI(t,T,T_D,T_N)}\right]\right)^{\frac{dc(t_i-T)}{dc(year)}}\left(\frac{dc(t_i-T)}{dc(year)}\right)+100\left(1+\hat{P}_T^{-1}\left[\frac{GB-VI^{bp}(t,T,T_D,T_N)}{GB-VI(t,T,T_D,T_N)}\right]\right)^{\frac{dc(t_N-T)}{dc(year)}}\left(\frac{dc(t_N-T)}{dc(year)}\right)}$$

where

$$\hat{P}_T(x)\equiv\sum_{i=j}^{N}\frac{C_i}{n}(1+x)^{-\frac{dc(t_i-T)}{dc(year)}}+100(1+x)^{-\frac{dc(t_N-T)}{dc(year)}}$$

and

8. The electronic trading ~~computer~~ system of claim 1, wherein the at least one processor is further caused to:

create a standardized exchange-traded derivative instrument based on the government bond volatility index; and

transmit data regarding the standardized exchange-traded derivative.

9. The computer system of claim 8, wherein transmitting data regarding the standardized exchange-traded derivative instrument includes transmitting data regarding one or more of a settlement price, a bid price, an offer price, or a trade price of the standardized exchange-traded derivative instrument.

10. A non-transitory computer readable storage medium having computer-executable instructions recorded thereon that, when executed by at least one ~~on a~~ computer, configure the at least one computer to perform operations for trading derivative products in an electronic trading system based on ~~a method to calculate~~ a government bond volatility index, the ~~method~~ operations comprising:

receiving, by the electronic trading system, data regarding options on government bond derivatives;

calculating, by the electronic trading system and using the data regarding options on government bond derivatives, the government bond volatility index; ~~and~~

transmitting, by the electronic trading system, data regarding the government bond volatility index;

receiving, by the electronic trading system, an electronic order for a derivative product based on the government bond volatility index; and

executing the electronic order.

11. The non-transitory computer readable storage medium of claim 10, wherein the data regarding options on government bond derivatives includes data regarding prices of options on government bond derivatives.

12. The non-transitory computer readable storage medium of claim 11, wherein the data regarding prices of options on government bond derivatives includes data regarding prices of options on government bond futures or government bond forwards.

13. The non-transitory computer readable storage medium of claim 12, wherein the government bond volatility index is calculated at time t according to the equation:

$GB-VI_{Yd}^{bp}(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of basis point yield volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N;

$GB-VI^{bp}(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of basis point price volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N; and

$GB-VI(t,T,T_D,T_N)$ is the value of the government bond volatility index in terms of percentage price volatility at time t calculated based on options expiring at T on government bond derivatives expiring at T_D with an underlying bond maturing at T_N.

17. The non-transitory computer readable storage medium of claim 10, wherein the computer-executable instructions further comprise instructions that, when executed by the at least one computer, configure the at least one computer to perform operations comprising:~~processor is further caused to~~:

creating ~~create~~ a standardized exchange-traded derivative instrument based on the government bond volatility index; and

transmitting ~~transmit~~ data regarding the standardized exchange-traded derivative instrument.

18. The non-transitory computer readable storage medium of claim 17, wherein transmitting data regarding the standardized exchange-traded derivative instrument includes transmitting data regarding one or more of a settlement price, a bid price, an offer price, or a trade price of the standardized exchange-traded derivative instrument.