INDONESIAN ACTUARIAL CONFERENCE

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READI

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Presentation

VALUATION OF DEPOSIT INSURANCE WITH A REGIME-SWITCHING VOLATILITY (OPTION-BASED MODEL) TO SUPPORT A BETTER FINANCIAL NET SYSTEM IN INDONESIA

RESEARCH BACKGROUND

1 Financial crisis

Instability and lost of public confidence

Financial crisis in 1998 in Indonesia, a blanket guarantee system is proven to restore public confidence in the banking system although an additional fiscal burden is arisen and a potential moral hazard exposed.

2 Deposit insurance-option model

Adopted deposit insurance

Modelling deposit insurance as a put option model, assumes constant volatility

3 Dynamic economic condition

Good and bad economic condition

The economic changes between two states, good and bad. The change is represented by a regime-swicthing volatility based on Markov process.

RESEARCH GOALS

THERE ARE 3 MAIN GOALS IN THIS RESEARCH

MISSION 1

to develop a new valuation model of a deposit insurance with a regime-switching volatility

MISSION 2

to obtain solution of the new model analytically or semi-analytically using transform methods

MISSION 3

to implement the valuation by providing simulation studies to know the behavior of the model and a dashboard system to provide informations and to analyze the results to be able to provide some justifications about the insurance product.

Experiencing a financial crisis in 1998 in Indonesia, a financial safety net system is important to hedge the financial stability from the crisis and to recover the public confidence to the banking and financial system.

1

A deposit insurance is one of the part of the financial safety net system which value requires to be determined

2

This research provides better valuation or pricing of the deposit insurance will lead to better protection.

3

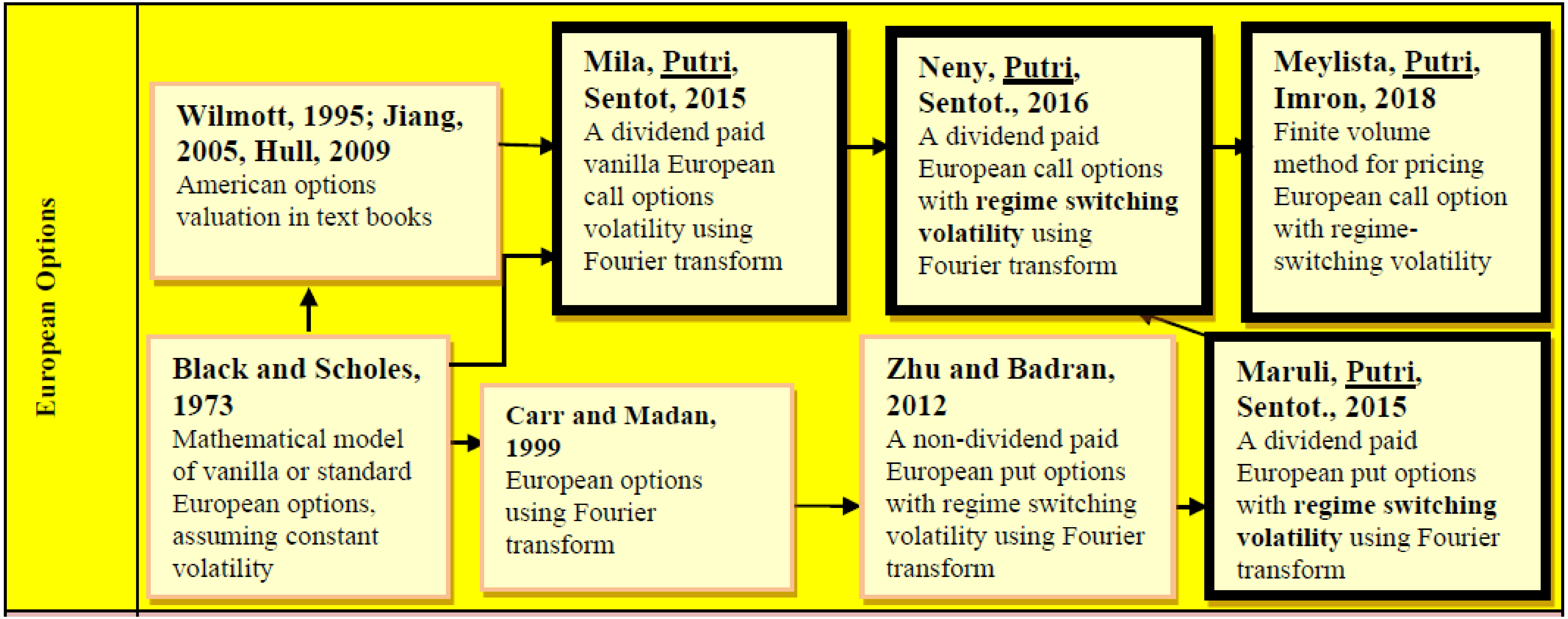
IMPORTANCE OF THE RESEARCH

Considering that the **economic condition** in Indonesia **changes** due to some factors, a constant volatility model can not reflect the changes.

Therefore, we propose **a new model of a deposit insurance valuation incorporating a regime-switching volatility** in order to provide a more realistic model

LITERATURE REVIEW

Peta Riset


European Options
Wilmott, 1995; Jiang, 2005, Hull, 2009
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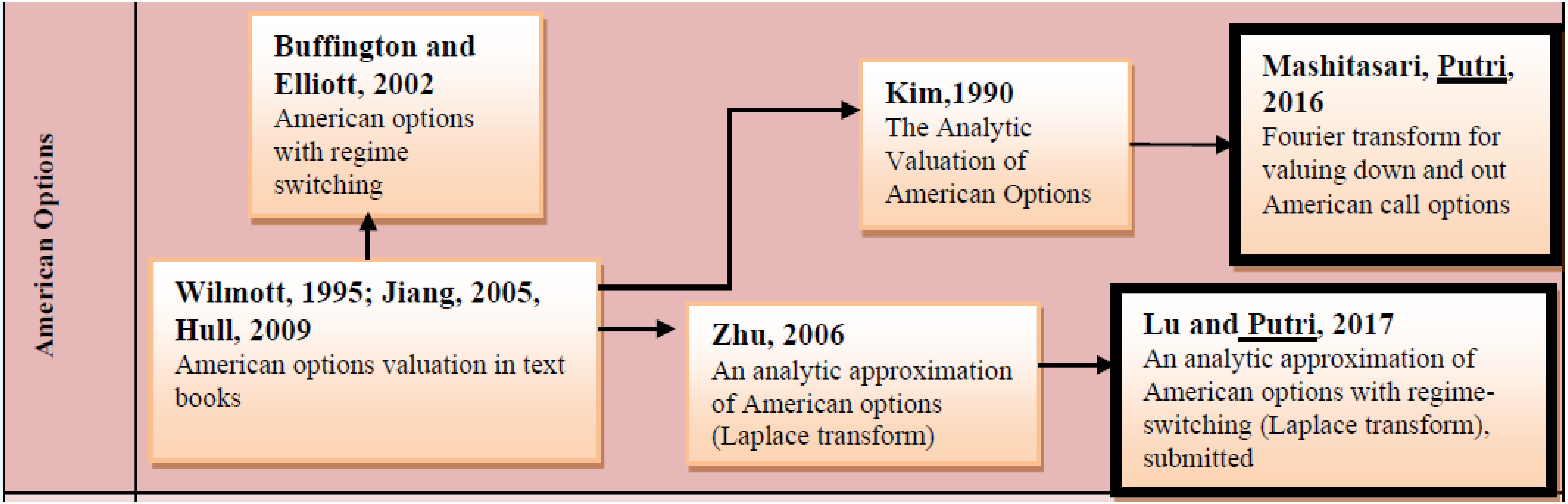
A dividend paid European put options with regime switching volatility using Fourier transform

Peta Riset


American Options
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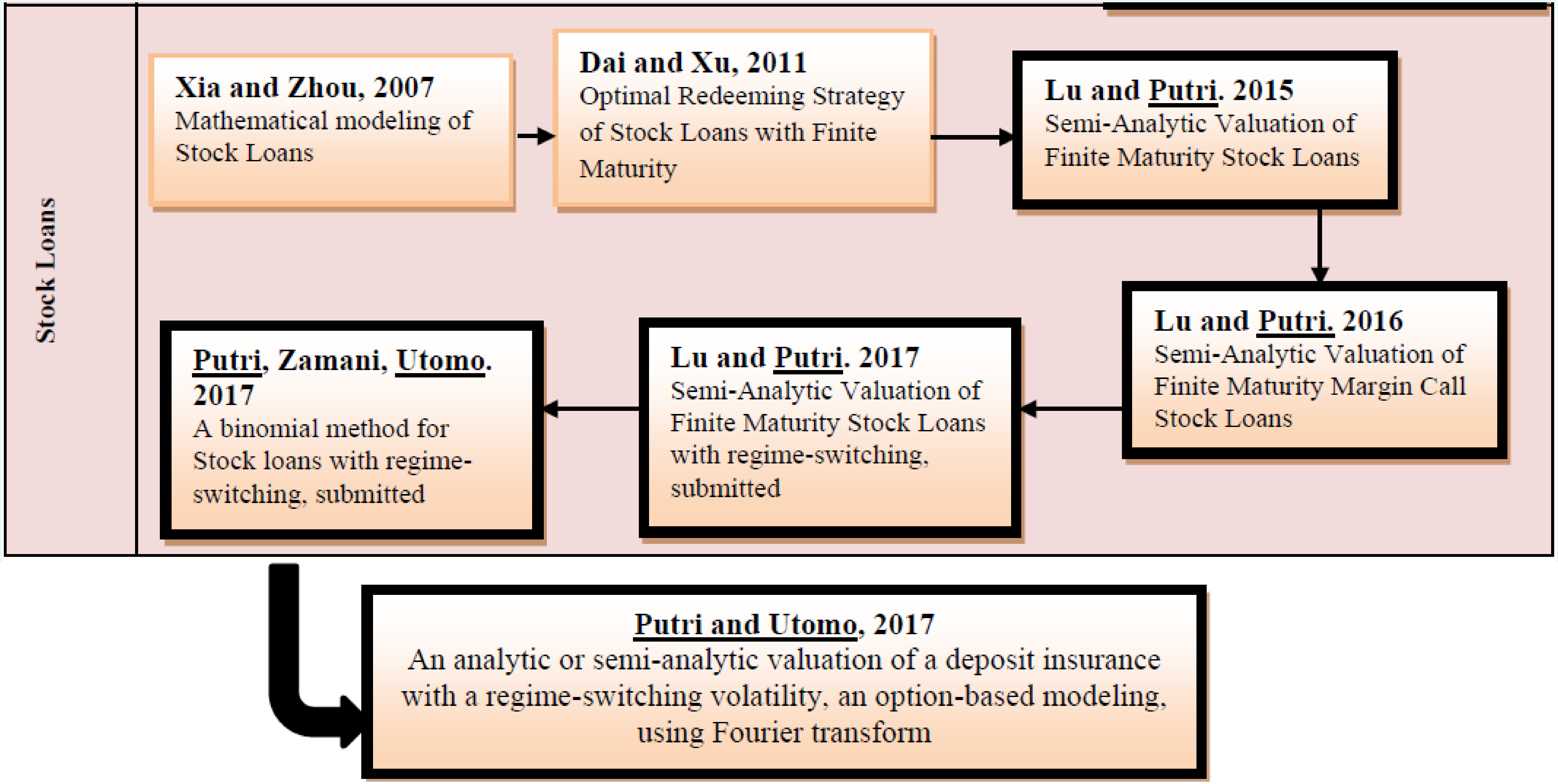
Peta Riset



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Lu and Putri, 2016
Semi-Analytic Valuation of Finite Maturity Margin Call Stock Loans
Lu and Putri, 2017
Semi-Analytic Valuation of Finite Maturity Stock Loans with regime-switching, submitted
Putri, Zamani, Utomo, 2017
A binomial method for Stock loans with regime-switching, submitted
Putri and Utomo, 2017
An analytic or semi-analytic valuation of a deposit insurance with a regime-switching volatility, an option-based modeling, using Fourier transform

Contribution and Novelty

Developed a new model to value a deposit insurance incorporating the economic change as a regime-switching volatility model.

1

This model better reflects the economic change which is assumed to be constant in the existing model

2

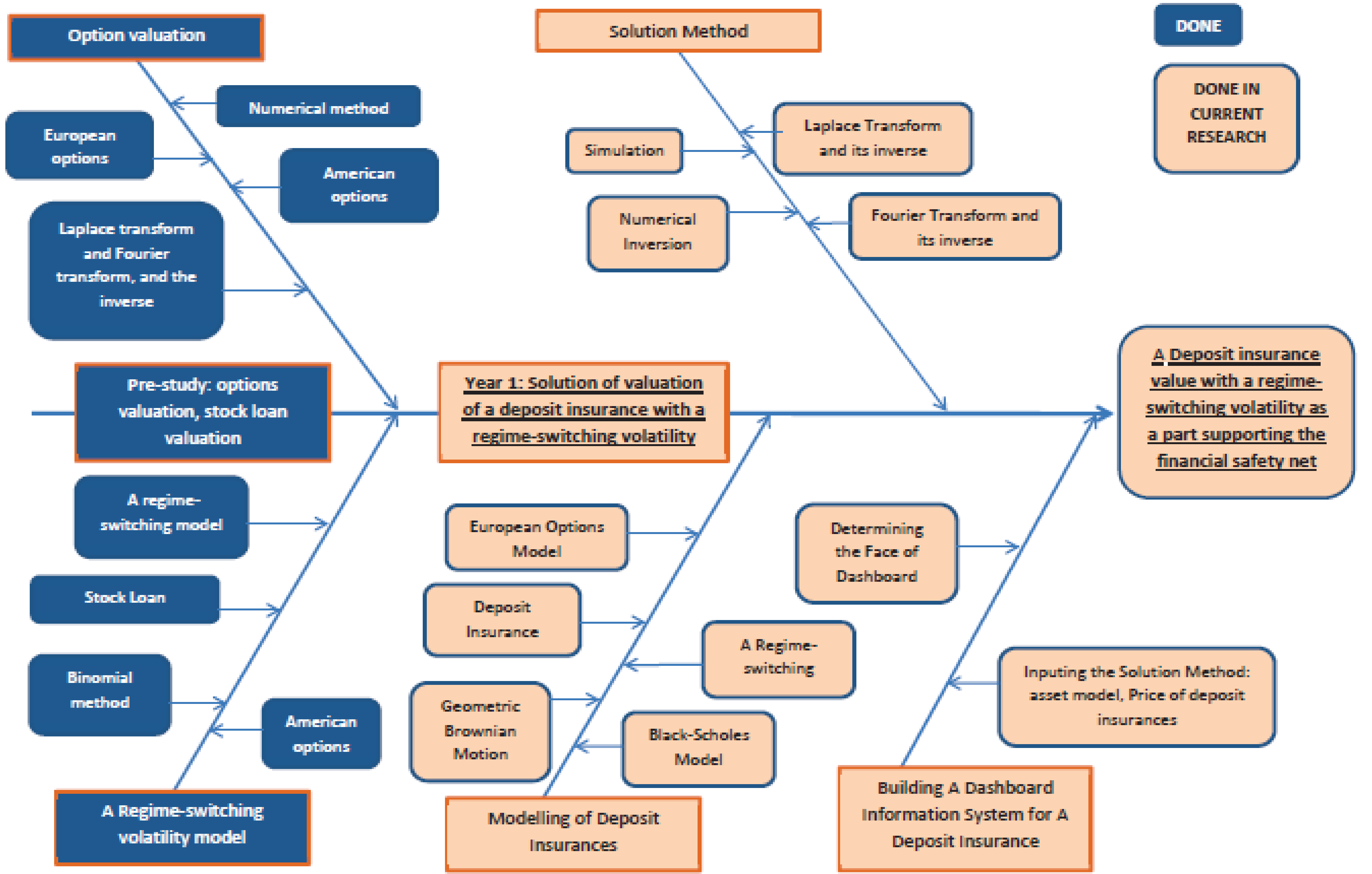
a dashboard information system is built for the implementation.

3

The proposed approach offers alternative method for valuing the deposit insurance as a part to support a better financial safety net system, and furthermore the model can be used for the case in Indonesia such as the Deposit Insurance Company (LPS-Lembaga Penjaminan Simpanan) by Indonesia Government

METHODOLOGY

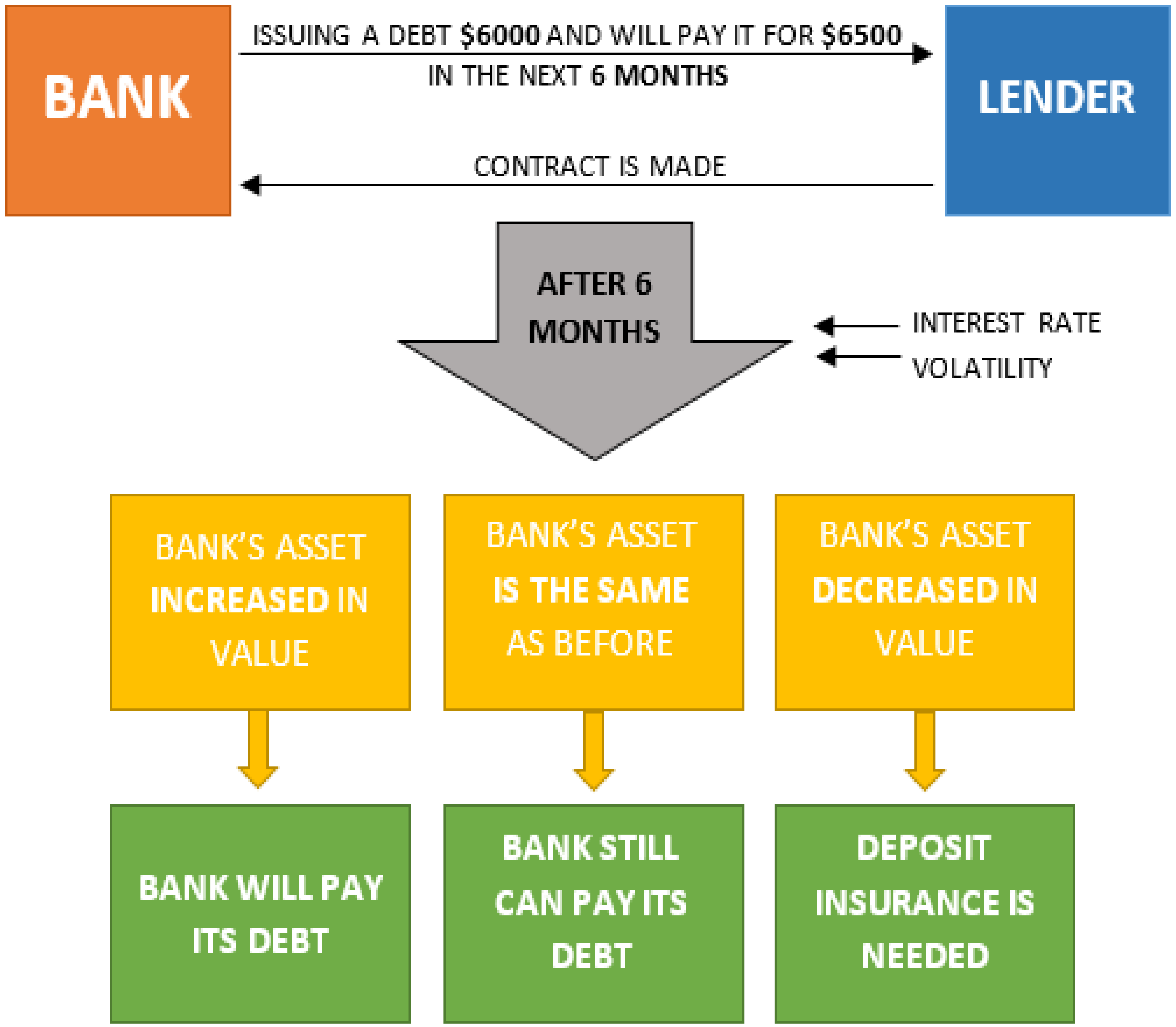
RESEARCH METHODOLOGY



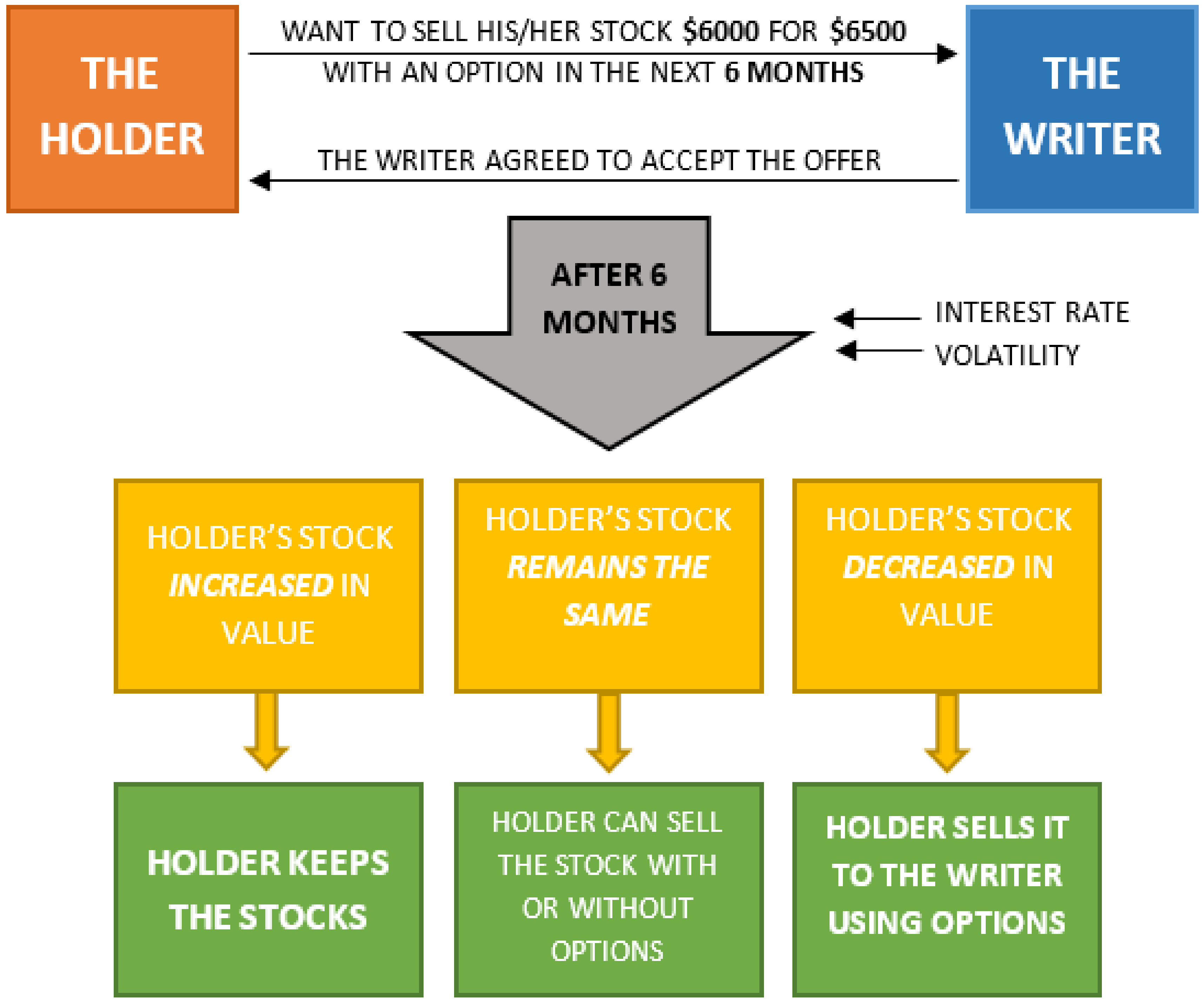
RESULT 1

AN ANALYTIC VALUATION OF A DEPOSIT INSURANCE-NON SWITCHING

DEPOSIT INSURANCE MECHANISM



PUT OPTIONS MECHANISM



RESULT 1

AN ANALYTIC VALUATION OF A DEPOSIT INSURANCE-NON SWITCHING

DEPOSIT INSURANCE

BANK'S ASSET DYNAMIC

$$dV = \mu V\, dt + \sigma V\, dW$$

PORTFOLIO

$$\Pi = -G + \frac{\partial G}{\partial V} V.$$

ITO'S LEMMA

$$dG = \left(\frac{\partial G}{\partial V} \mu V + \frac{\partial G}{\partial t} + \frac{1}{2} \frac{\partial^2 G}{\partial V^2} \sigma^2 V^2 \right) dt + \frac{\partial G}{\partial V} \sigma V\, dW.$$

DEPOSIT INSURANCE

PDE SYSTEM

$$\begin{cases} \dfrac{\partial G}{\partial t} + \dfrac{1}{2}\sigma^2 V^2 \dfrac{\partial^2 G}{\partial V^2} + \dfrac{\partial G}{\partial V} rV - rG = 0 \\ G(0,t) = Be^{-r(T-t)} \\ G(V,T) = (B-V)^+ \\ \lim\limits_{V\to\infty} G(V,t) = 0 \end{cases}$$

FOURIER TRANSFORM

$$\mathcal{F}\{g\} = \int_{-\infty}^{\infty} e^{i\zeta x} g(x)\, dx = f(\zeta)$$

1. $\mathcal{F}\{bg + ch\} = b\mathcal{F}\{g\} + c\mathcal{F}\{h\}$
2. $\mathcal{F}\{g'\} = -i\zeta f(\zeta)$, if $\lim\limits_{|x|\to\infty} g(x) = 0$
3. $\mathcal{F}\{g''\} = -\zeta^2 f(\zeta)$, if $\lim\limits_{|x|\to\infty} g'(x) = 0.$

DEPOSIT INSURANCE

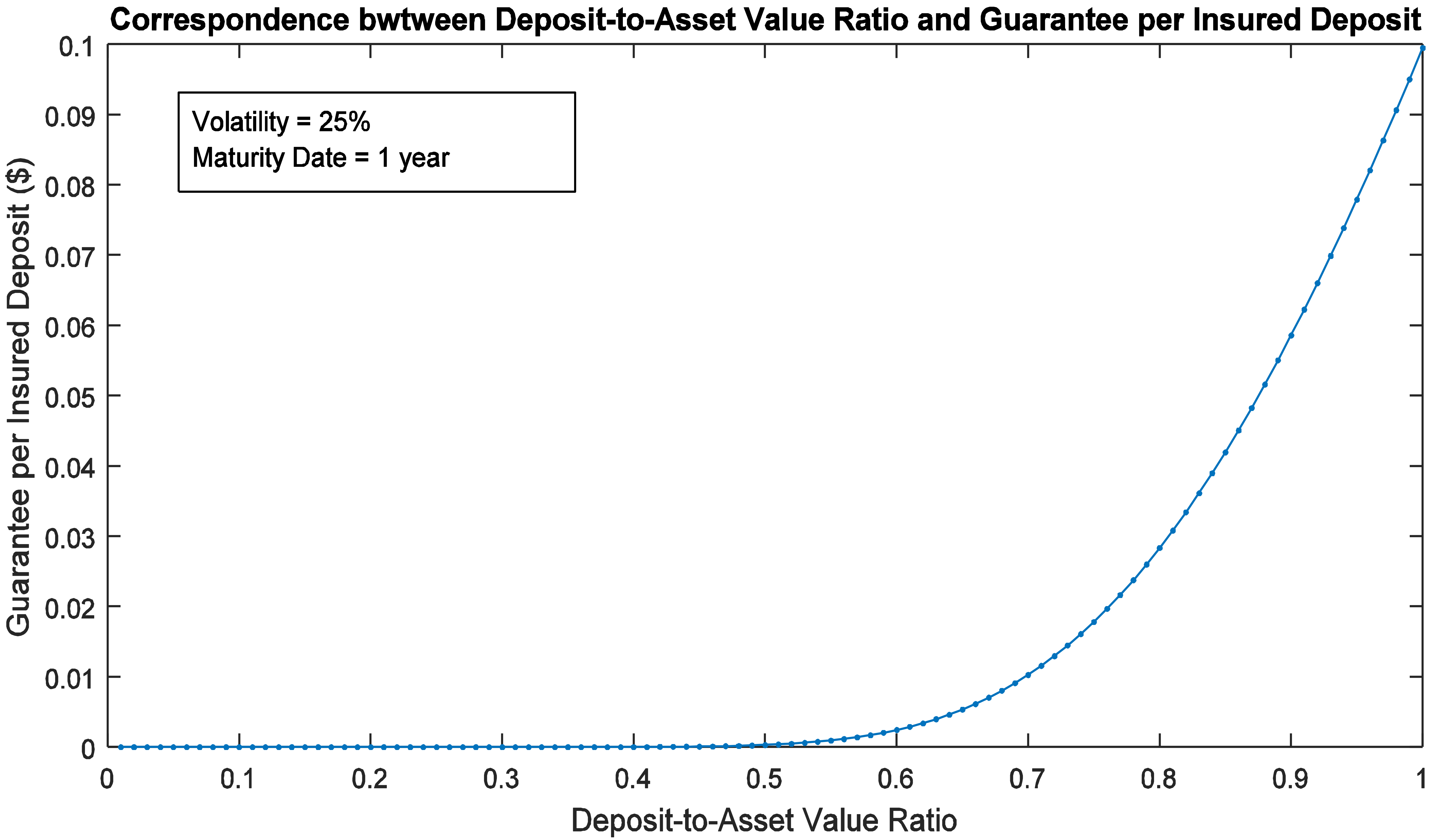
SOLUTION AFTER INVERSION WITH DIMENSION

$$G(V,t) = Be^{-r(T-t)}\Phi(z_2) - V\Phi(z_1)$$

$$z_1 = \frac{\ln(B/V) - \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}}$$

$$z_2 = z_1 + \sigma\sqrt{T-t}$$

HASIL SIMULASI



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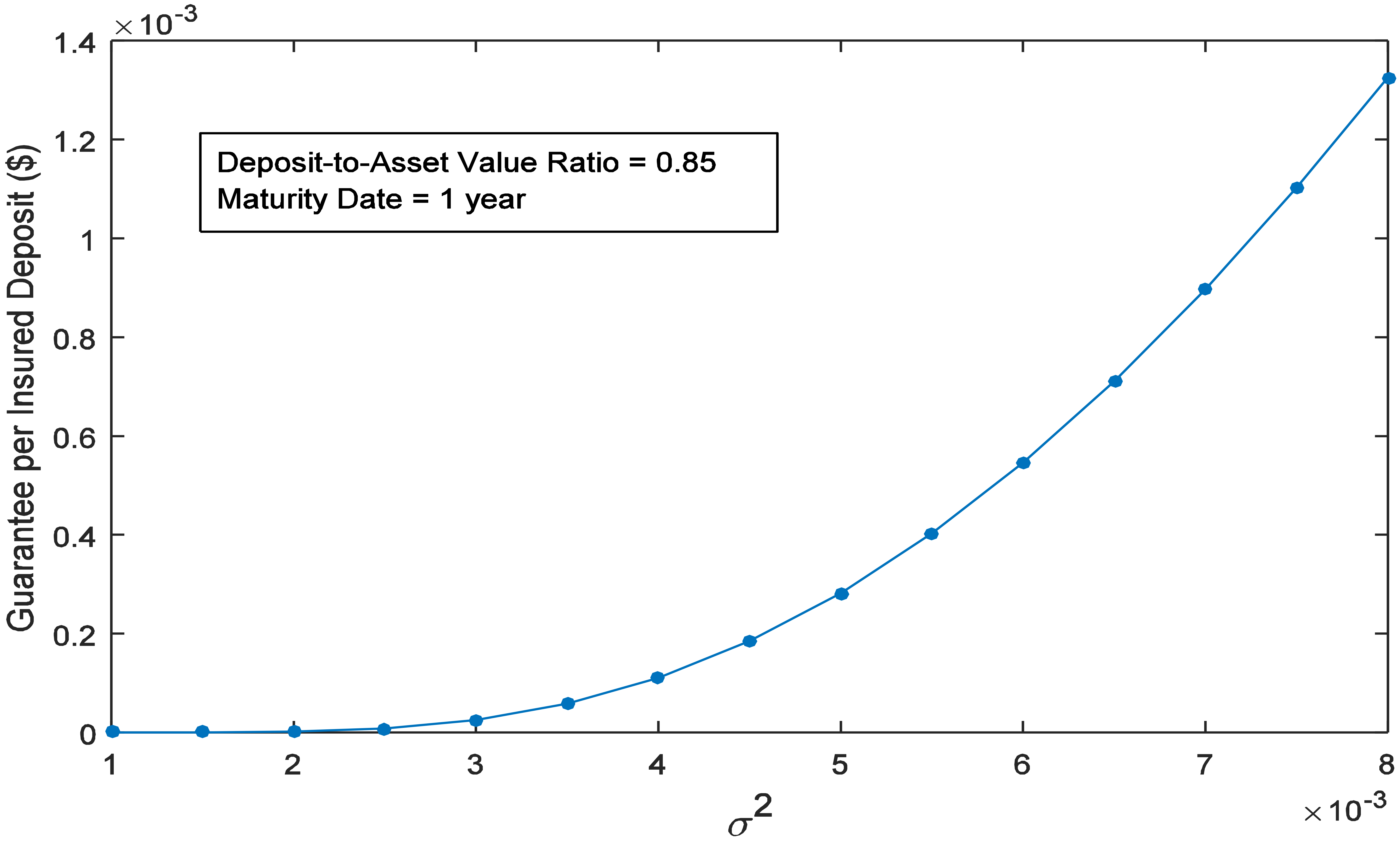


RESULT 2

AN ANALYTIC VALUATION OF DEPOSIT INSURANCE WITH A REGIME-SWITCHING VOLATILITY

DEPOSIT INSURANCEWITH REGIME-SWITCHING VOLATILITY

ASSET DYNAMICS

$$\frac{dV}{V} = \mu dt + \sigma_{\overline{\varepsilon}} dW_t$$

$$\overline{\varepsilon}(t) = \begin{cases} 1, & \text{good economy} \\ 2, & \text{bad economy} \end{cases}$$

$$P(t^*_{jk} > t) = e^{-\lambda_{jk}t}, \;\; j,k = 1,2, j \neq k$$

DEVELOP PDE

$$dG = \begin{cases} G_1(S(t+dt), t+dt) - G_1(S(t),t), & \text{for } \; p = 1 - \lambda_{12}dt, \\ G_2(S(t+dt), t+dt) - G_1(S(t),t), & \text{for } \; p = \lambda_{12}dt. \end{cases}$$

$$dG = \begin{cases} dG_1, & \text{for } \; p = 1 - \lambda_{12}dt, \\ dG_2 + G_2 - G_1, & \text{for } \; p = \lambda_{12}dt. \end{cases}$$

DEPOSIT INSURANCEWITH REGIME-SWITCHING VOLATILITY

DEVELOP PDE

$$\Pi = G - \Delta V$$

$$d\Pi = dG - \Delta dV$$

$$d\Pi = \begin{cases} dG_1 - \Delta dV, & \text{for } \ p = 1 - \lambda_{12} dt, \\ dG_2 + G_2 - G_1, & \text{for } \ p = \lambda_{12} dt. \end{cases}$$

DEVELOP PDE

$$E[d\Pi] = dG_1 - \Delta dV + \lambda_{12} dt \left(dG_2 - dG_1 + G_2 - G_1 \right)$$

$$E[d\Pi] = dG_2 - \Delta dV + \lambda_{21} dt \left(dG_1 - dG_2 + G_1 - G_2 \right)$$

$$dG_1 = \sigma_1 V \frac{\partial G_1}{\partial V} dW + \left\{ \mu V \frac{\partial G_1}{\partial V} + \frac{1}{2} \sigma_1^2 V^2 \frac{\partial^2 G_1}{\partial V^2} + \frac{\partial G_1}{\partial t} \right\} dt$$
$$dG_2 = \sigma_2 V \frac{\partial G_2}{\partial V} dW + \left\{ \mu V \frac{\partial G_2}{\partial V} + \frac{1}{2} \sigma_2^2 V^2 \frac{\partial^2 G_2}{\partial V^2} + \frac{\partial G_2}{\partial t} \right\} dt$$

DEPOSIT INSURANCEWITH REGIME-SWITCHING VOLATILITY

PDE OF DEPOSIT INSURANCE

$$\begin{cases} \dfrac{\partial G_1}{\partial t} + \dfrac{1}{2}\sigma_1^2 S^2 \dfrac{\partial^2 G_1}{\partial S^2} + rV\dfrac{\partial G_1}{\partial V} - rG_1 = \lambda_{12}(G_1 - G_2) \\ G_1(V,T) = (B-V)^+ \\ \lim\limits_{V\to\infty} G_1(V,t) = 0 \\ G_1(0,t) = Be^{-r(T-t)} \end{cases}$$

$$\begin{cases} \dfrac{\partial G_2}{\partial t} + \dfrac{1}{2}\sigma_2^2 S^2 \dfrac{\partial^2 G_2}{\partial S^2} + rV\dfrac{\partial G_2}{\partial V} - rG_2 = \lambda_{21}(G_2 - G_1) \\ G_2(V,T) = (B-V)^+ \\ \lim\limits_{V\to\infty} G_2(V,t) = 0 \\ G_2(0,t) = Be^{-r(T-t)} \end{cases}$$

DEPOSIT INSURANCE WITH REGIME-SWITCHING VOLATILITY

FOURIER TRANSFORM

$$q_1(x,\tau_1) = \frac{e^{-2\gamma_+\tau_+ - \frac{\tau_+}{4} - \beta_+\tau_+}}{2\pi} \int_{-\infty}^{\infty} e^{-i\omega(x+\gamma_+\tau_+)} exp\left(-\tau_+[(\omega + \frac{3i}{2})^2]\right)$$

$$\left[\left(1 + \frac{\alpha_+}{-(\omega+\frac{3i}{2})^2 - \frac{1}{4}}\right)\frac{e^{g(\omega)\tau_-} - e^{-g(\omega)\tau_-}}{2g(\omega)} + \frac{e^{g(\omega)\tau_-} + e^{-g(\omega)\tau_-}}{2\left(-\left(\omega+\frac{3i}{2}\right)^2 - \frac{1}{4}\right)}\right] d\omega$$

SOLUTION

$$G_1(V,t) =$$

$$Be^{-r(T-t)} + \frac{1}{4\pi\sqrt{2}}\sqrt{VB}e^{-\frac{1}{2}\left(r+D+\lambda_{12}+\lambda_{21}+\frac{\sigma_1^2+\sigma_2^2}{8}\right)(T-t)} \times \int_0^\infty \left\{\frac{2f_1(\rho)(\lambda_{12}+\lambda_{21})}{(\rho^4+\frac{1}{16})M(\rho)(\sigma_1^2-\sigma_2^2)}\right.$$

$$\left\{e^{X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+\phi(\rho)-Y(\rho)) - \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)+\phi(\rho)-Y(\rho))\right]\right.$$

$$\left.- e^{-X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+\phi(\rho)+Y(\rho)) - \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)+\phi(\rho)+Y(\rho))\right]\right\}$$

$$+ \frac{2f_1(\rho)}{M(\varrho)}\left\{e^{X(\rho)}\left[\sin(f_2(\rho)+\phi(\rho)-Y(\rho)) + \cos(f_2(\rho)+\phi(\rho)-Y(\rho))\right]\right.$$

$$\left.- e^{-X(\rho)}\left[\sin(f_2(\rho)+\phi(\rho)+Y(\rho)) + \cos(f_2(\rho)+\phi(\rho)+Y(\rho))\right]\right\}$$

$$+ \frac{f_1(\rho)}{\rho^4+\frac{1}{16}} \times \left\{e^{X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)-Y(\rho)) + \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)-Y(\rho))\right]\right.$$

$$\left.\left. + \left\{e^{-X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+Y(\rho)) + \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)+Y(\rho))\right]\right\}\right\}d\rho \qquad (5.56)$$

SOLUTION

$$G_2(V,t) =$$

$$Be^{-r(T-t)} + \frac{1}{4\pi\sqrt{2}}\sqrt{VB}e^{-\frac{1}{2}\left(r+D+\lambda_{12}+\lambda_{21}+\frac{\sigma_1^2+\sigma_2^2}{8}\right)}(T-t) \times \int_0^\infty \left\{ \frac{(-1)2f_1(\rho)(\lambda_{12}+\lambda_{21})}{(\rho^4+\frac{1}{16})M(\rho)(\sigma_1^2-\sigma_2^2)} \right.$$

$$\left\{ e^{-X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+\phi(\rho)+Y(\rho)) - \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)+\phi(\rho)+Y(\rho))\right]\right.$$

$$\left. - e^{X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+\phi(\rho)-Y(\rho)) - \left(2\rho^2+\frac{1}{2}\right)cos(f_2(\rho)+\phi(\rho)-Y(\rho))\right]\right\}$$

$$+ \frac{2f_1(\rho)}{M(\varrho)}\left\{ e^{-X(\rho)}\left[\sin(f_2(\rho)+\phi(\rho)+Y(\rho)) + \cos(f_2(\rho)+\phi(\rho)+Y(\rho))\right]\right.$$

$$\left. - e^{X(\rho)}\left[\sin(f_2(\rho)+\phi(\rho)-Y(\rho)) + \cos(f_2(\rho)+\phi(\rho)-Y(\rho))\right]\right\}$$

$$+ \frac{f_1(\rho)}{\rho^4+\frac{1}{16}} \times \left\{ e^{-X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)+Y(\rho)) + \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)+Y(\rho))\right]\right.$$

$$\left.\left. + \left\{ e^{X(\rho)}\left[\left(2\rho^2-\frac{1}{2}\right)\sin(f_2(\rho)-Y(\rho)) + \left(2\rho^2+\frac{1}{2}\right)\cos(f_2(\rho)-Y(\rho))\right]\right\}\right\} d\rho \qquad (5.57)$$

HASIL NUMERIK

Table 5.1: Bond ($100) more than Asset ($90) in one year with $\lambda_{12} = \lambda_{21} = 1$

σ_1	σ_2	Interest Rate	Deposit-to-Asset Value Ratio	Black-Scholes in State 1 ($)	Guarantee in State 1($)	Guarantee in State 2 ($)	Black-Scholes in State 2 ($)
10%	20%	5%	1.06	6.799	7.878	9.349	10.178
		7%	1.04	5.495	6.627	8.146	8.995
		9%	1.02	4.351	5.505	7.049	7.906
	30%	5%	1.06	6.799	9.136	12.136	13.661
		7%	1.04	5.495	7.903	10.959	12.497
		9%	1.02	4.351	6.789	9.8656	11.404
	40%	5%	1.06	6.799	10.467	14.994	17.083
		7%	1.04	5.495	9.241	13.819	15.913
		9%	1.02	4.351	8.126	12.714	14.802

HASIL NUMERIK

Table 5.2: Bond ($100) equal to Asset ($100) in one year with $\lambda_{12} = \lambda_{21} = 1$

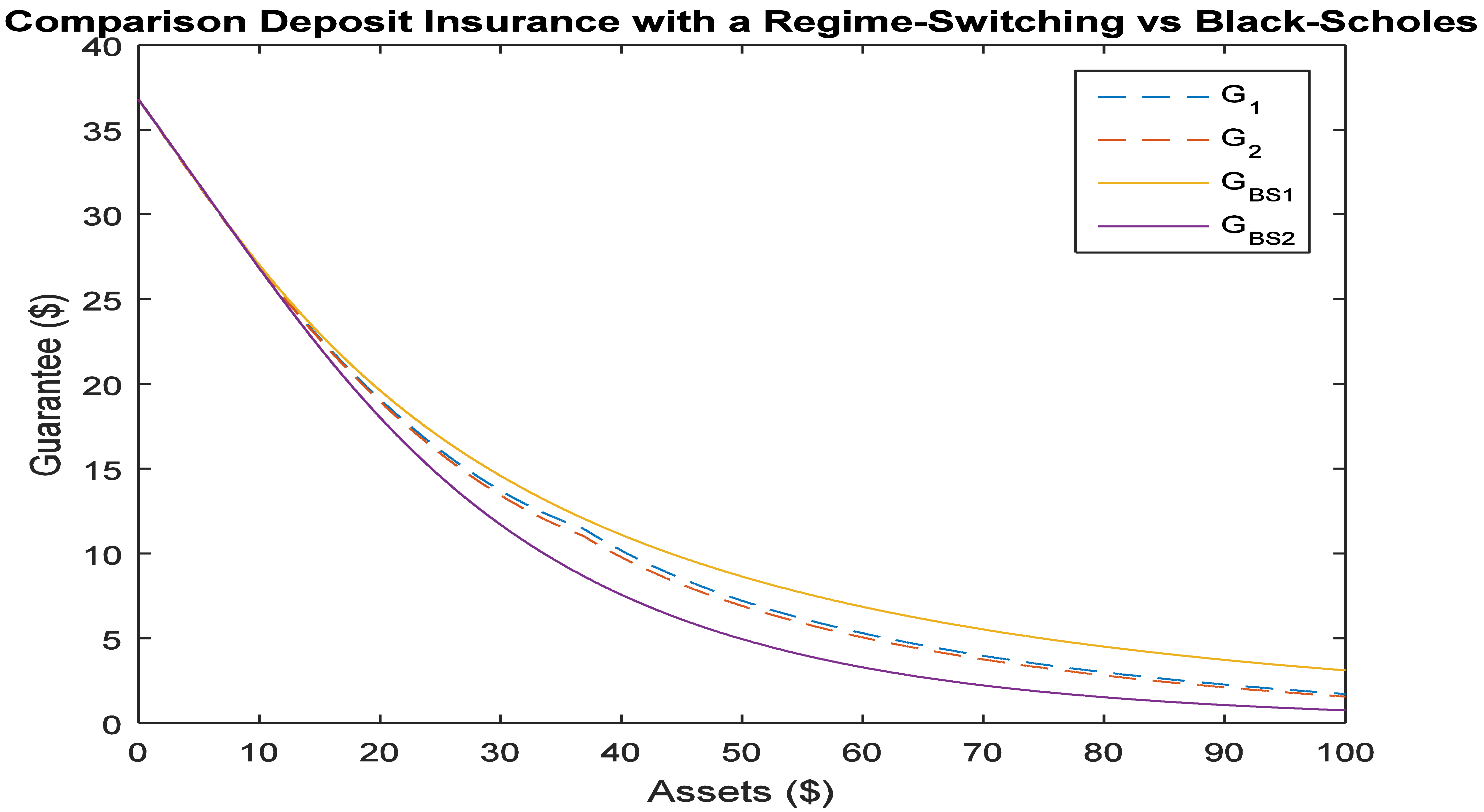
σ_1	σ_2	Interest Rate	Deposit-to-Asset Value Ratio	Black-Scholes in State 1 ($)	Guarantee in State 1($)	Guarantee in State 2 ($)	Black-Scholes in State 2 ($)
10%	20%	5%	1.06	1.924	3.0803	4.652	5.537
		7%	1.04	1.375	2.439	3.907	4.746
		9%	1.02	0.956	1.913	3.258	4.042
	30%	5%	1.06	1.924	4.417	7.607	9.229
		7%	1.04	1.375	3.718	6.759	8.328
		9%	1.02	0.956	3.122	5.987	7.495
	40%	5%	1.06	1.924	5.827	10.630	12.851
		7%	1.04	1.375	5.085	9.709	11.879
		9%	1.02	0.956	4.439	8.855	10.963

NUMERICAL IMPLEMENTATION

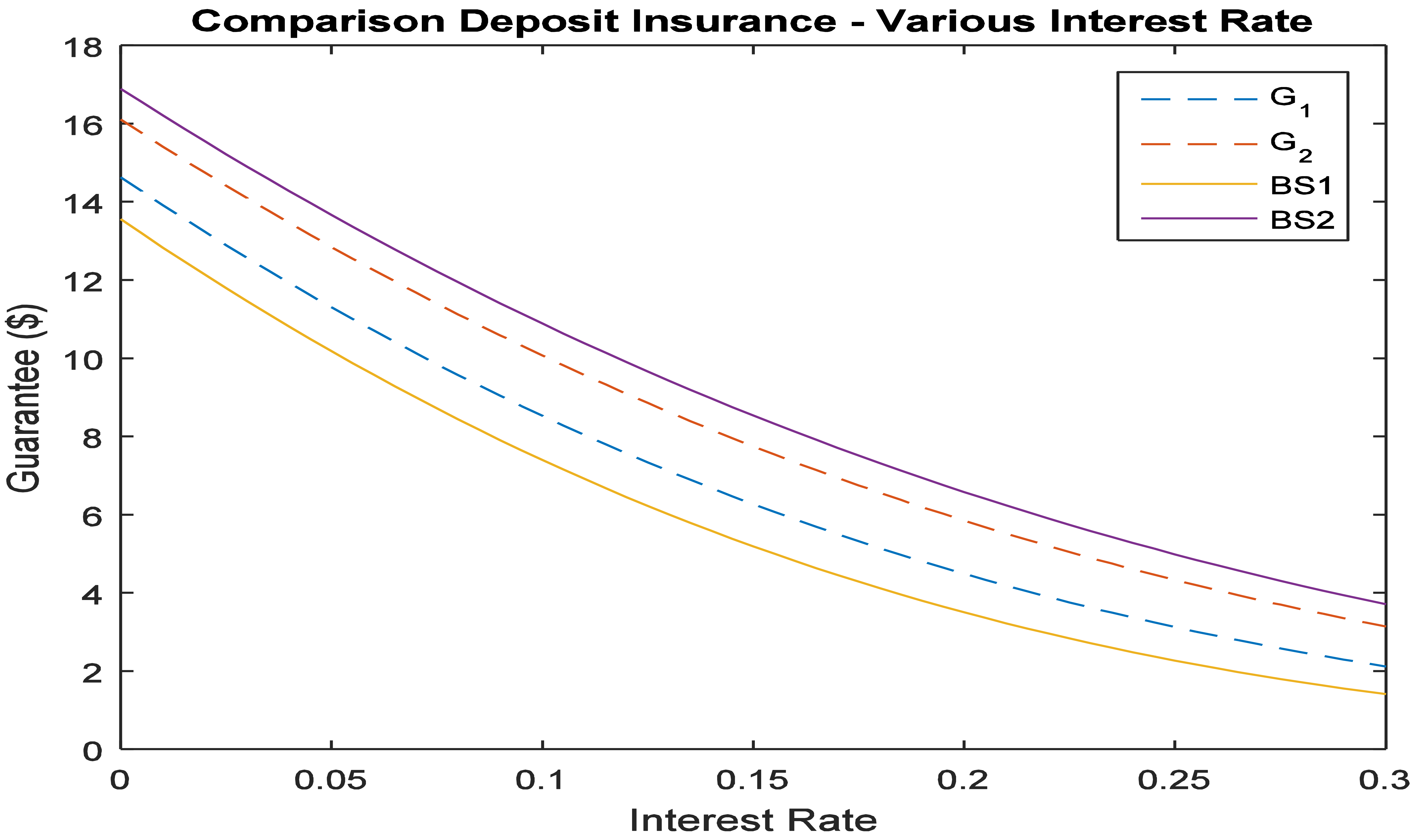
Table 5.3: Bond (\$90) less than Asset (\$100) in one year with $\lambda_{12} = \lambda_{21} = 1$

σ_1	σ_2	Interest Rate	Deposit-to-Asset Value Ratio	Black-Scholes in State 1 (\$)	Guarantee in State 1(\$)	Guarantee in State 2 (\$)	Black-Scholes in State 2 (\$)
10%	20%	5%	1.06	0.238	0.816	1.714	2.284
		7%	1.04	0.146	0.620	1.387	1.890
		9%	1.02	0.086	0.469	1.115	1.553
	30%	5%	1.06	0.238	1.753	3.948	5.206
		7%	1.04	0.146	1.468	3.455	4.628
		9%	1.02	0.086	1.230	3.015	4.102
	40%	5%	1.06	0.238	2.871	6.482	8.343
		7%	1.04	0.146	2.519	5.873	7.648
		9%	1.02	0.086	2.212	5.313	6.999

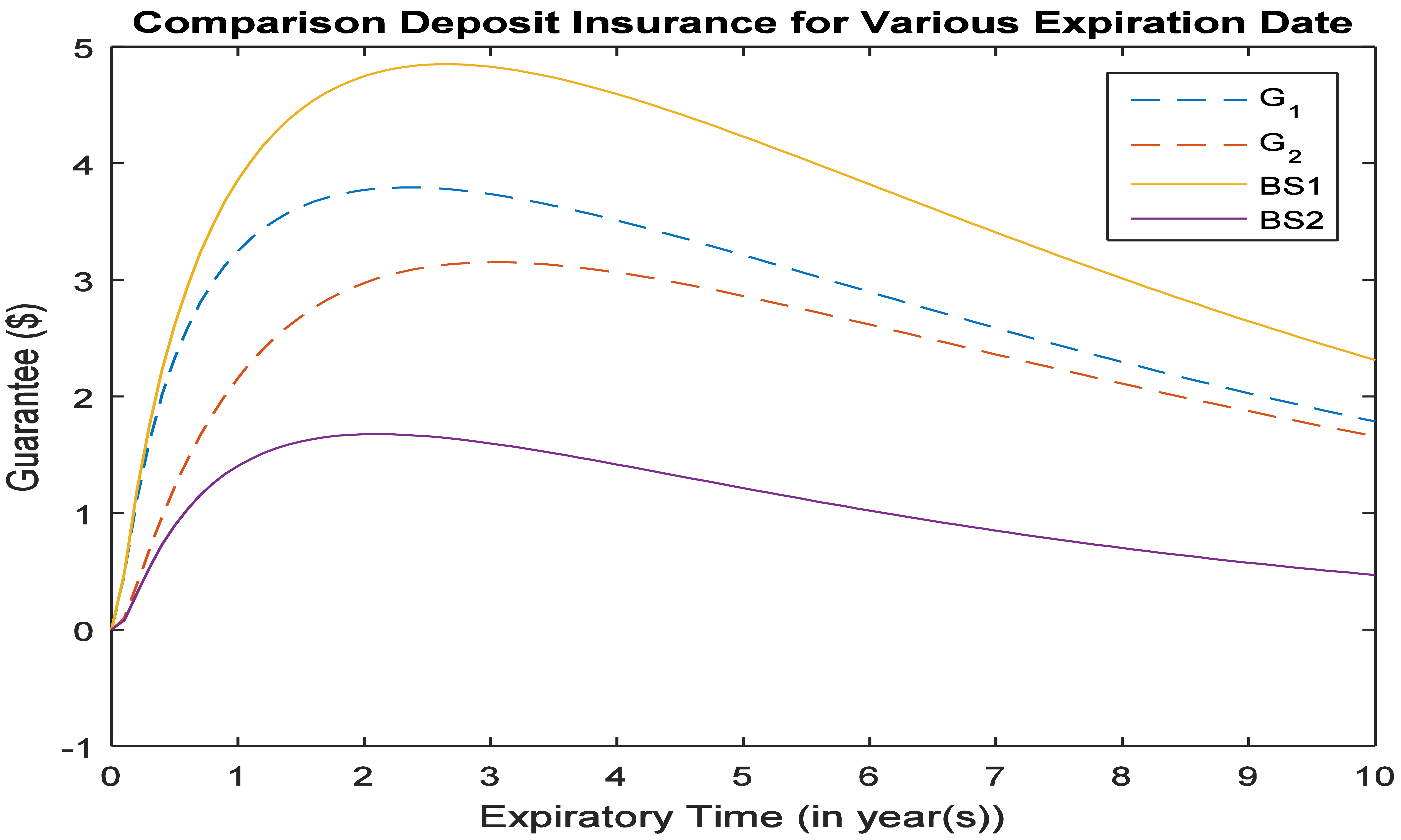
GRAPHICAL RESULTS



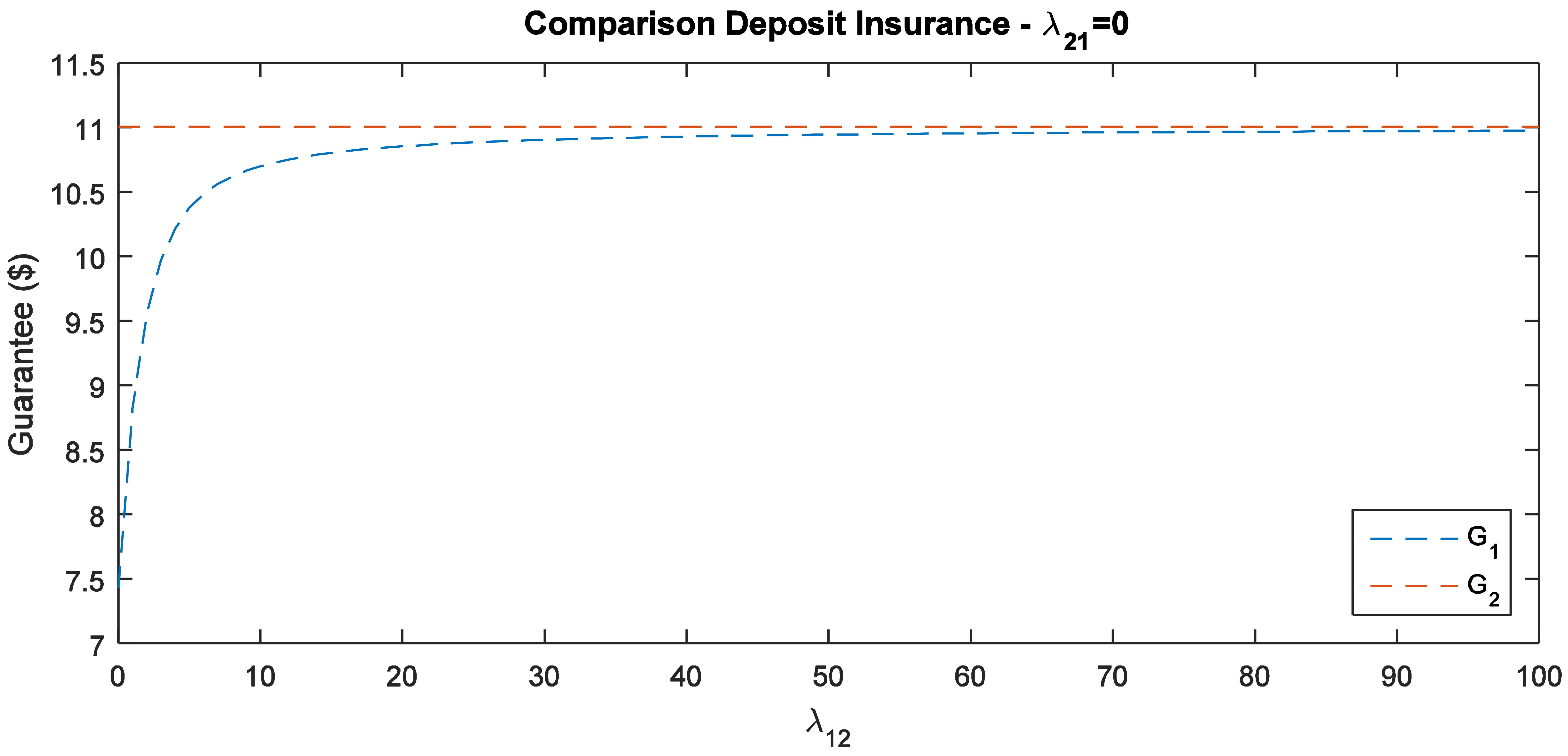
GRAPHICAL RESULTS



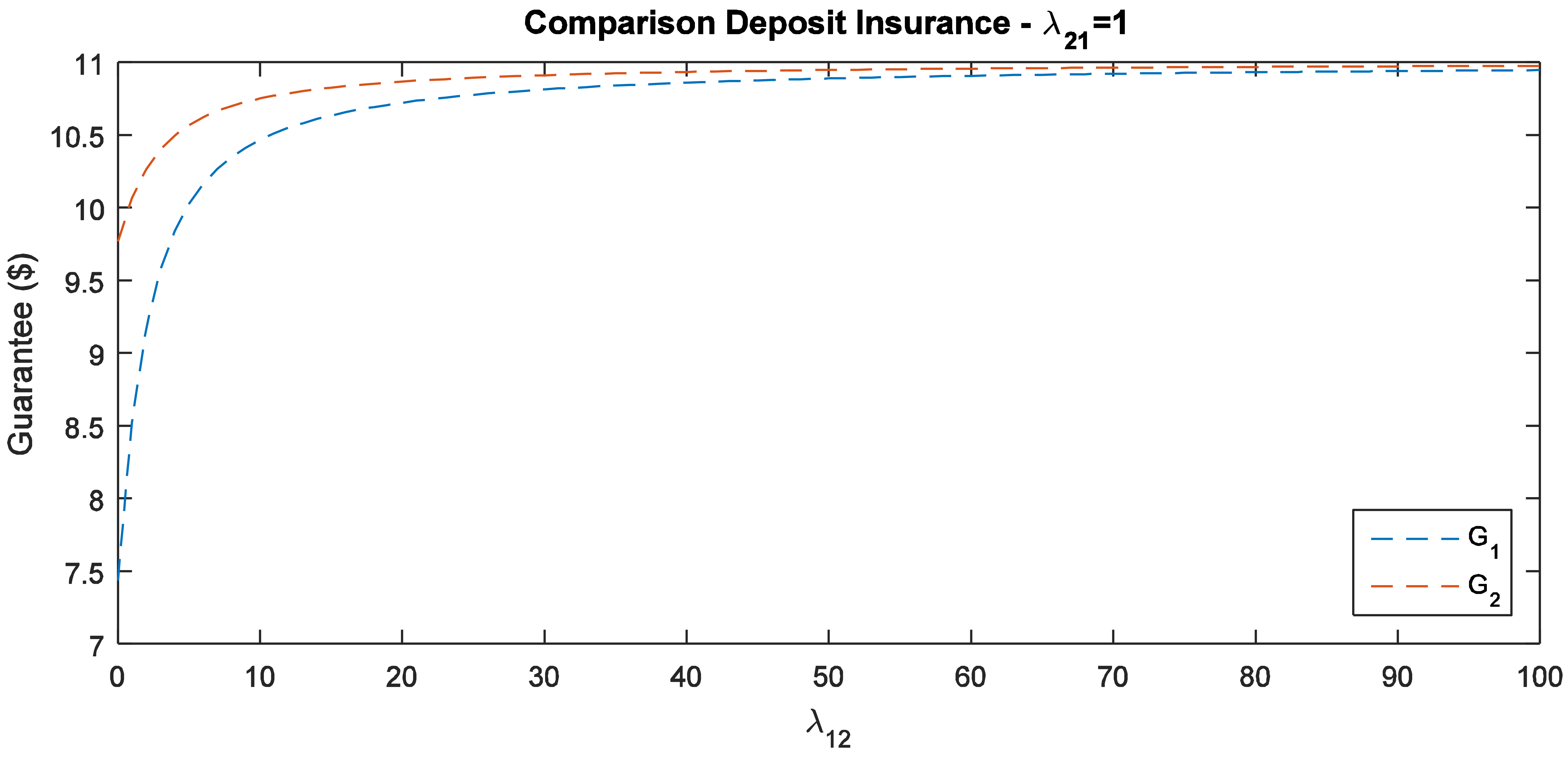
GRAPHICAL RESULTS



GRAPHICAL RESULTS



GRAPHICAL RESULTS



CONCLUSION

ABOUT METHOD

- The analytical valuation of a deposit insurance has been derived.
- The solution formula for both state of a regime-switching volatility is in the form of integral with a real integrand which is obtained by analytical inversion of Fourier transform.
- The integral is easy to calculate to implement the solution.
- A dashboard information system is developed.

ABOUT DEPOSIT INSURANCE

- The cost of deposit insurance with regime-switching are between the constant volatility ones.
- The effect of volatility to the cost of deposit insurance is that the volatility increases the cost.
- The interest rate decreases the cost of deposit insurance.
- For a long maturity date, the cost of deposit insurance shows a decreasing trend

OUR OBSTACLES

- Data availability is not provided to validate our developed model.
- Good and Bad Economy Condition often affect bank assets.
- This model is only valid on single asset in financial market.

ACKNOWLEDGEMENT

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谢谢

THANKS