LSE RICAFE 2

Working Paper NO. 076

Valuing Legal Inefficiencies in Emerging Market Economies

Milos Bozovic
Universitat Pompeu Fabra, SECCF and
Laboratory for Quantitative Finance, Institute of Physics

Rasa Karapandza
Universitat Pompeu Fabra, SECCF and
Laboratory for Quantitative Finance, Institute of Physics

Branko Urosevic
University of Belgrade, SECCF and
Laboratory for Quantitative Finance, Institute of Physics

February 2009

RICAFE2 - Regional Comparative Advantage and Knowledge Based Entrepreneurship

A project financed by the European Commission, DG Research
under the 'Citizens and governance in a knowledge-based society' (FP6) programme
Contract No : grant CIT5-CT-2006-028942.

Financial Markets Group, London School of Economics and Political Science, LSE, UK
Dipartimento di Scienze Economiche e Finanziarie Prato, Università di Torino, TORINO, Italy
Centre for Financial Studies, CFS, Germany
Haute Etudes Commerciales, HEC, France
Baltic International Center for Economic Policy Studies, BICEPS, Latvia
Amsterdam University, UVA, Netherlands
Neaman Institute for Advanced Studies in Science and Technology at Technion, TECHNION, Israel
Indian School of Business, ISB, India
Tilburg University, UTIL.CER, Netherlands
University of Southern Switzerland, USI, Switzerland
The Institute of Physics, IBP, Serbia

Valuing Legal Inefficiencies in Emerging Market Economies*

Milos Bozovic[♣,♦,♥], Rasa Karapandza[♣,♦,♥] and Branko Urosevic[♠,♦,♥]

Abstract

In this paper, we develop a new option pricing method that allows us to explicitly price legal inefficiency in closed form in an economy where agents are risk neutral and collateral follows geometric Brownian motion. The methodology presented here is general enough so that it can be readily implemented in a variety of market settings, including emerging markets. To the best of our knowledge this is the first paper that quantifies the effects of legal inefficiency in closed form solution. On the example of mortgage insurance contracts we demonstrate that these effects can be quite significant. In particular, in emerging markets where legal inefficiencies are typically quite large and time to repossession of the real estate can take as much as 4 years. It turns out that by decreasing the repossession time from four to two years the actuarially fair price of MI contract can be reduced to 55% of the original price.

---

* We appreciate the financial support from European Commission in the form of CIT5-CT-2006-028942.

♣ Department of Economics, Universitat Pompeu Fabra, Ramon Trias Fargas 25-27, 08005 Barcelona, Spain.

♦ South-European Center for Contemporary Finance (SECCF),Andricev Venac 2, 11000 Belgrade, Serbia.

♥ Laboratory for Quantitative Finance, Institute of Physics, Pregrevica 118, 11080 Belgrade, Serbia

♠ Faculty of Economics - University of Belgrade, Kamenicka 6, 11000 Belgrade, Serbia

Non-technical Summary

In this paper, we develop a new option pricing method that allows us to explicitly price legal inefficiency in closed form in an economy where agents are risk neutral. The methodology presented here is general enough so that it can be readily implemented in a variety of market settings, including emerging markets. To the best of our knowledge this is the first paper that quantifies the effects of legal inefficiency in closed form solution. On the example of mortgage insurance contracts we demonstrate that these effects can be quite significant. In particular, in emerging markets where legal inefficiencies are typically quite large and time to repossession of the real estate can take as much as 4 years. It turns out that by decreasing the repossession time from four to two years the price of MI contract can be reduced to 55% of the original price.

In the United States and other developed countries, mortgage insurance played an important role in the functioning of the housing finance market since it reduced the risk exposure of lenders and facilitated the creation of secondary mortgage markets. The inability of banks to properly measure the risk of secondary mortgage markets is considered as one of the main reasons for the current crisis. In other words, as stated in the Declaration of G20 related to the crisis during a period of strong global growth, growing capital flows, and prolonged stability earlier this decade, market participants sought higher yields without an adequate appreciation of the risks and failed to exercise proper due diligence. The existence of asset-backed securities is not undesirable by it self, but the widespread usage should be preceded by the understanding of the risks that they carry. The need for similar risk-sharing mechanisms exists in emerging markets as well. But in the case of emerging markets situation is additionally complicate with unclear property rights and inefficient legal systems [see, for example, Arunada (2003)]. In order to have a viable mortgage insurance (MI) scheme, it is necessary to know how to properly price MI contracts. The pricing of such

contracts is a rather challenging task even when data are available (i.e., in developed countries). The task is all the more challenging in case of emerging markets, where, in the case of borrower default, the process of the repossession of loan collateral can last several years, and where data on housing and mortgage markets are either unavailable or of poor quality.

As a first step to determine the fair price of mortgage insurance contract we follow Bardhan, et al. (2006). We price an MI contract as the actuarially fair value of the contract, adjusted by the gross profit margin necessary for the operation of the mortgage insurance company. The actuarially fair value is determined as the sum of the present values of the expected loss for each year of the mortgage life. In turn, the expected loss, for any given year of the life of a mortgage, is equal to the expected loss in the case when the default occurs during that year (we refer to this as the severity of loss), weighted by the exogenously determined probability that the loss will occur during that year. Our model shares these features with DKY (and any other actuarial pricing model). On the other hand, in our model the severity of loss is determined in a completely different fashion from DKY. In their model, the severity of loss is, simply, a constant fraction of the loan balance. In contrast, we take into account both the fact that the realized loss for the insurer in case of the borrower's default can be represented as a portfolio of put options on the borrower's collateral, as well as the fact that additional losses may occur from a delay in the repossession of the collateral by the lender, i.e., as a result of legal inefficiency. Assuming that agents in the economy are risk neutral, that the collateral value follows a geometric Brownian motion process and that a risk-free asset in the economy exists and has a constant return, we represent the severity of loss as a portfolio of standard Black-Scholes put option prices (see Black and Scholes [1973]). (Identical results for the severity of loss are obtained if the assumption of risk neutrality of agents is relaxed and insurance contracts are assumed to be traded on the market).

The actuarially fair price turns out to be a linear combination of Black and Scholes European put option prices with a constant dividend yield. Therefore, we can use the standard results on option Greeks to analyze the comparative statics for variables of interest [see Hull (1999), Chapter 13]. As a result, the comparative statics results are, in contrast to most of the previous literature, available analytically. One can easily convince oneself that the MI premium increases, ceteris paribus, with an increase in volatility of the collateral, the probability of default, the mortgage contract rate (or, equivalently, mortgage installment payments), or the time delay in the repossession of the collateral. While the first three properties are quite intuitive, let us explain why the last one that deals with legal inefficiency holds. First of all, an increase in t increases the time to maturity, which makes both options in our model more valuable. On the other hand, since a put option is always monotonically increasing in the strike price and the strike price of the first option is higher than the strike price of the second option and monotonically increasing in t the difference between the two put options monotonically increases in t.

The related literature is extensive. Clauretie and Jameson (1990), Jackson and Kaserman (1980), and Swan (1982) review early literature on mortgage default insurance and the determinants of foreclosure. Kau et al. (1992, 1993, 1995), and Kau and Keenan (1995, 1999), among many others, develop backward pricing models in which mortgage insurance prices are obtained numerically as a by-product of the pricing of mortgages. In this literature there are typically two state variables: the interest rate and the collateral value process. Furthermore, prepayments and defaults are typically determined endogenously within the model. Despite their certain theoretical appeal, there are reasons why such models are a less-than-perfect choice for pricing MI contracts with legal inefficiencies. On the one hand, the implementation of these models requires rather complex numerical procedures since no

closed form expressions exist. On the other hand, this complexity may not be warranted from the point of view of fitting the model to the data. Indeed, while it is far from clear how people really make decisions on default or prepayment [see Ambrose et al. (2001)], the existing empirical evidence [see Deng et al. (2000), for example] is inconsistent with the feature inherent in models with endogenous prepayment/default decisions, namely, that people always choose to default or prepay strategically. In contrast to these models, in our model there is only one state variable, namely the collateral value. Not including the interest rate as a state variable is consistent with the empirical findings reported in Hendershott and Van Order (1987), Section 3 (and the literature cited therein), who provide evidence that mortgage insurance premiums are not very sensitive to interest rate volatility. In addition, the unconditional probabilities of default in our model are given exogenously, rather than determined endogenously. DKY and Schwartz and Torous (1992), among others, also model the unconditional probability of default exogenously. Our model is well defined for arbitrary exogenously specified probabilities of default. One way of estimating these probabilities is by using actuarial mortgage default and prepayment experience or their proxies, if the appropriate data is unavailable. It is important to note that actuarial (historical) distributions, by construction, contain both strategic and non-strategic prepayment and default decisions by borrowers. Moreover, as long as past prepayment and default experience is a decent predictor of future prepayment and default experience (a reasonable assumption in stable economies), such an approach is guaranteed to work, i.e., on average, modeled unconditional probabilities of default would coincide with the observed ones [for more sophisticated models of empirical estimation of hazard rates see, e.g., Schwartz and Torous (1992)].

The main innovation of this paper is that we look at the time to repossession of the collateral in the case of the borrower's default is a measure of the inefficiency of the legal system. Thus far in the literature it was implicitly assumed that, at the moment when default is

declared, the transfer from the borrower to the lender and/or sale of the collateral is instantaneous. In practice, of course, this is never the case. The average time required for the repossession of the collateral in case of a borrower's default varies from country to country and, within the United States, from state to state. For example, in Spain the average time to repossession is around 3 years, while in Denmark, on the other hand, it is only 6 months.

We calibrate the model to price a typical Serbian government-backed mortgage insurance contract and show that one of the key factors affecting the affordability of MI in Serbia is precisely the cost of legal inefficiency that can be accounted for 45% of the total price of MI. Similar conclusion holds, no doubt, in most emerging markets or any other country where it can often take several years for the repossession of the collateral to take place. For this reason, one of the key factors that would contribute to the success of a mortgage insurance scheme in such markets is, therefore, a comprehensive legal reform that would shorten the time delay in repossession of the collateral in case of borrower default.

1 Introduction and motivation

It is well known that the development of the housing sector is a key component of general economic development. There are both direct and indirect effects that housing activity has on a society. Direct impact is easily understood: in most countries and, in particular, in less developed and transition economies, real estate is typically the most valuable asset that households possess. An entire working life is often necessary for the average household to acquire a real estate asset. In addition, the state of the construction, maintenance, durable goods and other related industries is seen as an excellent leading indicator of general economic activity. Not only do direct new expenditures in the housing sector itself stimulate the economy and generate jobs but also a substantial portion of such generated income is plowed back into the economy, leading to an additional, multiplier effect. Apart from its direct economic impact on society, housing activity has significant institutional, socio-economic and political fallout. A well-developed housing market, for example, allows for greater mobility of the labor force, and thus, its more efficient allocation within a country. The social value creation by housing, such as increasing social stability, developing functional neighbourhoods, civil society, reducing crime, and generally enhancing welfare, has been well recognized. Beside the tractability, these are the main reasons for which we study effects of legal inefficiency on the price of mortgage insurance premium.

Two key factors that often impede the creation of a vigorous housing market are: a) inefficiencies of the legal system and b) Non-existence or under-development of housing finance. As for the former, very often property rights in transition economies are poorly defined and mutually conflicting (see, for example, Aruñada (2003)). In this paper, we model the impact of repossession delays on mortgage insurance costs Well-functioning mortgage markets, besides their positive impact on the development of the real estate

industry also have a critical effect on the functioning of the banking sector and the finance industry as a whole. Jaffee and Renaud (1997) discuss the potential economic benefits of a functioning mortgage system for transition economies and study the reasons underlying the underdevelopment of mortgage markets in those countries. They argue that apart from improving the legal environment in these countries (clearing of property titles, speeding up of collateral repossession, etc), it may also be necessary to create secondary mortgage markets in such countries (see, also, Jaffee and Renaud (1995) and Hardt, J. and J. Lichtenberger (2001)), which can lead to lenders/originators freeing up their capital and significantly reducing the risk profile of their business in order to offer new rounds of mortgages. They suggest that agencies, initially owned and financed by the state in order to overcome coordination problems, should play a pivotal role in generating investor confidence in mortgage products.

In many developing and transitioning countries, the combined forces of liberalization and globalization are creating an environment that is conducive to the establishment and development of housing finance markets and institutions. Foreign banks are entering the market. Domestic and foreign banks are indicating interest in offering mortgage products but are voicing concerns over several important issues: a) Unclear property rights and the inefficient legal system; b) Absence of mortgage insurance that would protect banks from excessive losses given the volatile economic and political environment, and c) Maturity risk.

While the problem of property rights is paramount, we argue that the other two issues can be successfully addressed with the creation of a government-sponsored agency that would provide mortgage insurance for qualified mortgages, and, at a later stage, help create the secondary mortgage market. Mortgage insurance would directly reduce risk exposure of participating banks: In case of an adverse macro-economic shock, the agency would bear a

large fraction of the loss not covered by the repossession of the collateral, thus significantly reducing the chances of banking system collapse.

The experience of many developed countries shows that mortgage markets take off significantly faster after such agencies are created. Because of coordination failure problems, such agencies are not likely to emerge endogenously in budding, poorly capitalized markets and may have to be initiated by the state. Also, in an environment fraught with uncertainty, informational shortcomings and adverse selection, credit rationing is rampant and private mortgage insurers are unlikely to have sufficient economies of scale to enter the market in small countries until after the mortgage market has reached a certain level of development. Moreover, such companies may be simply wiped out during a downturn in the economy. This has happened even in the United States in the early stages of development of the mortgage industry.[1]

Of course, such involvement by the state is neither cost-less nor risk-less. It is therefore critical to carefully analyze both the benefits as well as the costs involved. The purpose of this paper is to provide a practical policy structure for such an evaluation. We commence by proposing a framework that calculates the mortgage insurance premium that a state agency would fairly charge, and utilize it to determine the expected future profits and losses of a

[1] See Dennis et al (1997)

hypothetical mortgage insurance scheme. While the proposed framework is quite general, it has been calibrated to a particular emerging market, Serbia. We show that: a) Setting up a mortgage insurance agency would be very costly in terms of the expected future losses; b) One of the key factors of success of the scheme lies in a comprehensive legal reform that would clear the land titles and shorten the time for the repossession of collateral. We also apply a simple, intuitive approach to construct a static framework for quantifying beneficial macroeconomic effects of developing mortgage insurance, and by extension, of mortgage markets.

2. WHAT IS MORTGAGE INSURANCE?

Mortgage insurance (MI) is a contract that promises to compensate a creditor (a bank) in case of an insolvent borrower.[2] Clauses of a typical mortgage insurance contract specify under which conditions payment to the creditor is due and what percentage of the loss (called the loss ratio, or L_R) is covered by the contract. Insurance schemes depend substantially on whether insurance is provided by a private insurer or a state agency.[3] In developed countries, private insurers cover only a relatively small fraction of the loss (e.g. $L_R \leq 25\%$). On the other hand, government insurance schemes often offer full protection

---

[2] When MI is purchased, premium is paid by the borrower and eventually reaches the insurance agency. On the other hand, in case of borrower's insolvency, money from the insurance agency reaches the creditor.
[3] See Dennis et al (1997) for more details.

(i.e., for such schemes $L_R = 100\%$). In most emerging markets, government would be reluctant to provide full insurance and may require instead a coverage ratio less than 100%. In such a way, default risk is at least partially shared between the lender and the agency. This somewhat alleviates the adverse selection problem of insuring lemons and, at the same time, reduces the total risk exposure of the agency. On the other hand of course, the absence of full protection means that lenders in such schemes are facing a non-zero default risk.

Let us denote by B_0 the initial loan value: $B_0 = LTV \cdot V_0$, where LTV is the initial loan-to-value ratio and V_0 is the initial value of the loan collateral. For simplicity, we assume that the mortgage loan is a simple amortizing loan with a fixed contract rate c; assume further that it is paid off on yearly basis.[4] Finally, let the time to maturity be T. In that case, it is well known (see, for example, Bruggeman and Fisher (1997)), that the yearly loan payment would read:

$$y = \frac{cB_0}{(1 - \frac{1}{(1+c)^T})} = \frac{cB_0(1+c)^T}{[(1+c)^T - 1)]}. \qquad (1)$$

Loan balance at time t is, then, given by the following expression:[5]

[4] Adjusting our formalism to incorporate monthly instead of yearly payments is trivial; Somewhat less trivially, one can extend these considerations to the case of adjustable rate mortgages as well.

[5] In order to verify this expression note that when *t*=0, (2) yields the initial loan value, while when *t*=*T* we have:

$$B_t = B_0(1+c)^t - y\frac{(1+c)^t - 1}{c}. \qquad (2)$$

Now, suppose that a borrower defaults at time t. Let us denote the value of the collateral at time t as V_t. The amount a lender would receive from the insurance agency depends on the shape of the insurance contract. Below we present two standard ways in which such payments are determined. The first scheme is presented in Figure 1. In what follows, we refer to this scheme as the Two-Option Scheme (the reasons shall be clear below).

$$B_T = B_0(1+c)^T - y\frac{(1+c)^T - 1}{r} \Leftrightarrow$$

$$\Leftrightarrow B_0(1+c)^T - \frac{cB_0(1+c)^T}{[(1+c)^T - 1)]}\frac{(1+c)^T - 1}{c} = 0$$

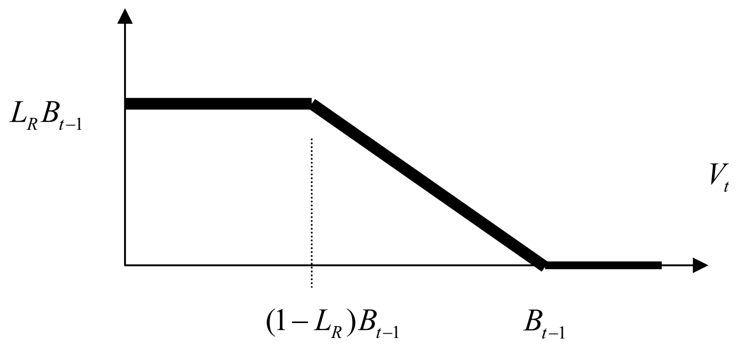


Figure 1: Value of payment to the creditor as a function of the real estate price (Two-Option Scheme)

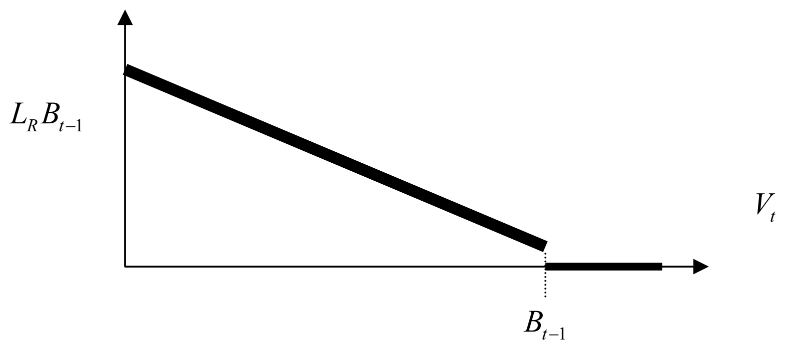
In the case of the Two-Option Scheme, the insurance company's loss function at the time of default:

$$Loss_t = \max(0, \min(B_{t-1} - V_t, L_R B_{t-1})) \qquad (3)$$

Expression (3) is not difficult to understand. If the collateral value is greater than the remaining loan balance, after the collateral is sold the lender sustains no loss and, therefore,

the payoff from the insurance agency is zero.6 Now consider the situation when the collateral value does not cover the loan balance (i.e. that $B_{t-1} > V_t$). In that case, the lender would receive hundred percent of the difference from the insurance agency until a cap is reached at $L_R B_{t-1}$. Thus, the maximum loss that the insurance agency can sustain in the Two-Option Scheme is not greater than $L_R B_{t-1}$. Below that level, the insurance company would cover the whole loss of the lender, i.e. the amount $B_{t-1} - V_t$. The Two-Option Scheme is popular with private insurance companies. In case of One-Option Scheme, payoff from the insurance company to the lender would read:

$$Loss_t = L_R \cdot \max(0, (B_{t-1} - V_t) \qquad (4)$$



---

[6] Here we do not take into account delays related to inefficient court system. We discuss that later in the text.

Figure 2: Value of payment to the creditor as a function of the real estate price (One-Option Scheme)

In expression (4), when the property value is greater than the remaining loan balance, the lender again does not receive any payment from the insurance agency. On the other hand, if the collateral value is below the loan balance ($B_{t-1} > V_t$), lender receives $L_R(B_{t-1} - V_t)$. In other words, in the case of One-Option Scheme, the lender is never fully reimbursed.

3. PRICING OF MORTGAGE INSURANCE IN EMERGING MARKETS

After commenting on the design of MI contracts, we now focus on their pricing in emerging markets. This is an important question since the appropriate pricing of such contracts ensures both the proper level of protection of the parties involved, as well as the attractiveness of such products to the public.[7] Pricing of MI contracts is a challenging task even when data are available (i.e. in developed countries). In many emerging markets, where mortgages are not

[7] In general of course, there is always a trade-off between the affordability of the insurance policy, on one hand, and the degree of protection that such a product provides, on the other.

yet issued, there is no historical default or prepayment experience to speak of and, oftentimes, historical time series on housing prices are not available either. Even those developing countries where mortgages are issued, it is a fairly recent activity. What can be done in such situations to get a decent first approximation of a fair mortgage insurance pricing scheme?

In principle, there are several possible ways of valuing mortgage insurance, ranging from purely empirical to completely theoretical approaches.[8] However, since the experience is non-existent and pricing data are not available, a purely empirical model cannot be implemented. We therefore turn to theoretical models of mortgage insurance.

Three main strains of the literature can be identified. From a theoretical standpoint the most comprehensive approach is the option-based approach. Some of the prominent work in that

[8] Review of the earlier literature on mortgage default insurance including the pricing of default insurance, determinants of foreclosure and discussion of the early option pricing approaches can be found in Clauretie and Jameson (1990), Jackson and Kaserman (1980) and Swan (1982), among others.

area are papers by Kau et al (1992) and Kau et al (1993), among many others.[9] There, both the collateral and the interest rate are modeled as correlated stochastic processes: the collateral is assumed to follow Geometric Brownian motion, while the interest rate follows the so-called CIR process (see Cox et al (1985)). It is important to note that in this approach borrowers choose when to default or prepay strategically (and thus, these decisions cannot be made independently). Valuation of the mortgage contract as well as the insurance premium is then performed using the so-called backward approach (for more details and the review of the literature see Kau and Keenan (1995)).[10] It should be noted that a rather complicated backward approach is required if both defaults and prepayments are strategic. While these models are certainly very appealing from a theoretical standpoint, their complexity is a drawback in terms of their implementation. In addition, in a comprehensive empirical test of the option-based approach, Deng et al (2000) find that despite the overall decent fit with the theory, a substantial percentage of borrowers does not seem to behave

---

[9] We thank James Kau for useful discussions on that literature.

[10] Kau and Keenan (1999) extend this approach to jump diffusion processes, thus modeling catastrophy insurance.

strategically when it comes to prepayment or default.[11] Similar conclusions are reached by Ambrose et al (2001) in a recent study of default patterns.

The second approach is a modified option-pricing approach, such as in Schwartz and Torous (1992). The idea here is to preserve the specification of the interest rate and the collateral value as stochastic processes, but to assume instead, exogenous prepayment and default patterns. A practical advantage of such an approach is that one can use so-called forward pricing (the Monte Carlo method), which is much easier to implement than the backward method. In addition, the forward method can be made to fit the data more readily. A drawback of this method is that we cannot explicitly capture within the model the notion of strategic terminations.

Finally, a rather unique (and particularly useful for our purposes) is the approach in Dennis et al (1997). While most of the models in the literature turn to pricing mortgage insurance as an afterthought to pricing mortgages themselves, this paper offers a deceptively simple

[11] Theirs was the first empirical study of the option-based approach that simultaneously tested for prepayment and default.

method for pricing mortgage insurance directly. It utilizes historical default and prepayment trends but completely ignores the issue of the collateral and the stochastic nature of the interest rate (or, even the term structure of the interest rate). Importantly however, while the model has obvious shortcomings from a theoretical standpoint, the estimates obtained using it fit the actual U.S. mortgage insurance pricing data quite well. Additionally, the model is very easy to understand and implement.

Our model can be thought of as something of a cross between the more traditional forward option pricing models and the simple pricing model by Dennis et al (1997). Like Dennis et al (1997), we develop a model that directly prices mortgage insurance and utilize exogenous default and prepayment experience, while ignoring the stochastic nature of interest rates.[12] On the other hand, in keeping with many other option pricing models, collateral is stochastic and described by a Geometric Brownian Process. Selection of a forward method seems entirely justified in the case of emerging markets. In many transition and developing

[12] Relaxing the second of these assumptions along the lines of Cox et al (1985) would not be difficult in principle but would lead to less tractable expressions.

economies, and certainly in Serbia, transaction costs of strategic termination would be quite high, especially at the early stages of development of the market. In addition, strategic default may also be unlikely because of the perceived social costs of such an act.

COLLATERAL VALUE PROCESS

In keeping with the option-based models (and in contrast with Dennis et al (1997)), collateral in our model is stochastic and follows a Geometric Brownian motion:

$$dV / V = (\mu - s)dt + \sigma dz . \qquad (5)$$

Here, μ is the expected annual return on holding the property, s is the percentage of the collateral value that needs to be expended on repair and maintenance and σ. is the collateral price volatility. In our model, therefore, collateral value V is the sole state variable. In contrast, backward models such as Kau et al (1992) have interest rate as an additional state variable. The idea behind our pricing methodology is quite simple: the present value of the insurance policy should be equal to the present value of the expected loss, adjusted for the gross profit margin (for safeguarding against unexpected losses and providing for the coverage of costs of agency operations).

DEFAULT AND PREPAYMENT PROBABILITES

Let us now introduce conditional probabilities of default d_t and prepayment p , where the index t signifies the year of mortgage termination. These are probabilities that a default

(prepayment) would occur at year t, given that it did not occur until that time. Following Dennis et al (1997), we assume that these probabilities are constants, one pair for each year of the mortgage. In their paper, they use data from the Price Waterhouse (1997) study of the 1996 actuarial experience of the Federal Housing Administration (FHA) mortgage insurance scheme. While ideally each country should collect and process their own actuarial data, in the case of Serbia and many other developing and transition counties, where there are no mortgages in place, that is clearly not possible at present. In that case, one needs to use proxies. Such proxies give useful benchmarks of the likely actuarial curves. Conditional probability of staying current at time t, (i.e. that the borrower has neither defaulted nor prepaid at time t) given that the borrower was current at time t-1, reads:

$$c_t = 1 - d_t - p_t \qquad (6)$$

Now, we can define the unconditional probability of staying current at time t as well as the probability of defaulting at time t, respectively, as:

$$\begin{aligned} P_c(t) &= c_1 c_2 ... c_{t-1} c_t \\ P_d(t) &= c_1 c_2 ... c_{t-1} d_t \end{aligned} \qquad (7)$$

The first of these formulas implies that the borrower stayed current in each of the periods 1…, t, while the second one implies that he stayed current only until time t-1, and then defaulted at time t.

MARKET INTEREST RATE

In order to complete the specification of the basic ingredients of the model it remains to specify the interest rate process. As mentioned above, generally speaking interest rates are stochastic and correlated with the collateral value process (5). In this model, however, we ignore both the stochastic nature of the interest rates as well as the term structure and require that the annually compounded annual interest rate R is a constant. This shall be the interest rate at which the insurance agency discounts the cash flows and, at the same time, the interest rate at which it invests its proceeds. The continuously compounded return on the risk-free asset is given by $r = \ln(1+R)$.

3. 1 ACCUMULATED EXPECTED LOSS

Now we are ready to present the model. We start first with the expected loss at time t, where t is an arbitrary year between year 1 and T. The key towards obtaining the expected value of loss is to recognize that the expressions for the realized loss (see the expressions (3) and (4)) are equivalent to payoffs of a simple portfolio of options. In such options, collateral value V_t plays the role of the underlying asset. In fact, for the Two-Option scheme, the expression for the loss (3) is equal to the following:

$$\begin{aligned} & Loss_t = \max(K_1 - \tilde{V}_t, 0) - \max(K_2 - \tilde{V}_t, 0) \\ & K_1 = B_{t-1}, \quad K_2 = (1 - L_R) B_{t-1} \end{aligned} \qquad (8)$$

which is equivalent to a long position in a put option with the strike price $K_1 = B_{t-1}$ and a short position in a put option with the strike price $K_2 = \left(1 - L_R\right) B_{t-1}$. In expression (8), the tilde is there to remind us that the collateral value is a random variable. Along the same lines, in case of the One-Option scheme, the payoff (4) is equivalent to the payoff of the portfolio of L_R long put options with the strike price B_{t-1}.

After recognizing these facts, our next step is to calculate the expected loss given the default at time t. This is relatively straightforward because of our specification of the collateral value process as a Geometric Brownian motion, since in that case, we can use (with a slight modification) the well-known option pricing results of Black-Scholes (1973). Suppose that the borrower defaults at time t. The expected value of the insurance company loss would be given by the following discounted expectations:

$$\begin{aligned} CL_t &= e^{-rt} E_0(\max(K_1 - \tilde{V}_t, 0) - \max(K_2 - \tilde{V}_t, 0)) && \text{Two-Option Scheme} \\ CL_t &= L_R e^{-rt} E_0(\max(K_1 - \tilde{V}_t, 0)) && \text{One-Option Scheme} \end{aligned} \qquad (9)$$

Here, definitions of K_1 and K_2 are given in (7) and the expectation is taken with respect to the natural probability measure generated by the stochastic process (5). In the standard texts on option pricing (see, for example, Hull (1999)), it is explained that the standard exchange-traded European calls and puts can be priced taking the discounted expectation w.r.t. the risk-neutral probability measure Q. The stochastic process (5) then becomes:

$$dV^Q / V^Q = (r - s)dt + \sigma dz \qquad (10)$$

If we were to take the expectation in (9) vis-à-vis the risk neutral measure (10) we could have immediately written down the answer since we would have obtained a portfolio of standard Black-Scholes put option prices. However, in our case, we have to take the expectation vis-à-vis the natural measure (generated by expression (5)) instead. Luckily, the latter calculation can be easily mapped into the former by noting that:

$$\begin{aligned} & dV / V = (\mu - s)dt + \sigma dz = (r - r + \mu - s)dt + \sigma dz = \\ & \equiv (r - D)dt + \sigma dz, \text{ where } D = r - \mu + s \end{aligned} .$$

Thus, simply changing $s \to D = r + s - \mu$ in the Black-Scholes formula with constant dividend yields leaves us with the desired expression for the expectation with respect to the natural measure generated by (5). In case of the Two-Option scheme, the conditional expected loss at time t reads:

$$\begin{aligned} & CL_t = e^{-rt} E_0(\max(K_1 - V_t, 0) - \max(K_2 - V_t, 0)) = Put(K_1, t) - Put(K_2, t) \\ & Put(K_i, t) = K_i e^{-rt} N(-d_2(K_i)) - V_0 e^{-Dt} N(-d_1(K_i)), \quad i = 1, 2 \end{aligned} \qquad (11)$$

In the case of One-Option scheme we obtain:

$$CL_t = L_R \cdot e^{-rt} \cdot E_0 \cdot \max(K - V_t, 0) = L_R \cdot Put(K_1, t) \qquad (12)$$

In expressions (11) and (12) we utilize the following notation:

$$d_1(K_i) = \frac{\ln(V_0 / K_i) + (r - D + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} = \frac{\ln(V_0 / K_i) + (\mu - s + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} \qquad (13)$$
$$d_2(K_i) = d_1(K_i) - \sigma\sqrt{t}$$

Expressions (11) and (12) determine the expected loss that the insurer would sustain if it were known with certainty that the borrower would default at time t. In reality, no one knows with certainty when default will occur. As a result, the expected loss at time t would be equal to the conditional expected loss at times t weighted by the probability of defaulting at time t, $P_d\left(t\right)$ (see the second equation in (7)). Thus, the expected loss at time t is equal to $EL_t = P_d\left(t\right)CL_t$. Finally, the expected accumulated loss up to time t is the sum of the expected losses up to that time. In summary, the present value of expected accumulated loss sustained until moment t reads:

$$EAL_t = \sum_{t=1}^{T} P_d(t)CL_t \qquad (14)$$

Here, the expressions CL_t for the conditional loss are given by (11) for the Two-Option scheme, and by (12) for the One-Option scheme, respectively. Notice that the form of the

expression (14) is identical to the equation (1) in Dennis et al (1997). Having said that, there is a very substantial difference here: our equation (14), in contrast to their formalism, contains a complex option structure hidden in the expression for the conditional expected loss. In addition, their expressions do not depend on the value of the collateral, a feature that is certainly not desirable from the perspective of realism.[13]

3.2 COST OF LEGAL DELAYS AND INEFFICIENCY

An inefficient legal structure adversely impacts profitability of the proposed insurance scheme. Apart from the obvious drawback, namely, that the very existence of a mortgage market presupposes the adequate clarity of property rights, no existing pricing formulas incorporate the cost of delayed repossession. So far we have implicitly assumed that the collateral is immediately transferred to the lender in case of borrower's default. We now consider the situation when that is not the case, namely when there is a lag between the

---

[13] However, one can easily check that when $\mu \to -\infty$, expression (14) coincides with expression (1) in Dennis et al (1997). Thus, their formalism is contained in ours as the special case when the value of the collateral is equal to zero.

stoppage of payments and the repossession of the collateral by the bank. Such delays are a major source of additional expenses to the insurer.[14]

Suppose, as before, that the balance remaining at the time of default is B_{t-1}. When default occurs, the lender starts up the court procedure, in order to come into possession of the property. Suppose that the court procedure (i.e. the time until repossession) is τ . During that time, the lender is facing the opportunity cost of lending the amount B_{t-1} to another borrower (at the interest equal to c). Normally an insurance agency would be required by law to compensate the lender for the losses thus accumulated (if any). Consider, for simplicity, only the One-Option scheme. In that case, the insurance company would have to pay the lender the amount equal to:

$$Loss_{t+\tau} = L_R \max\left(B_{t-1} \cdot (1+c)^{\tau} - V_{t+\tau}, 0\right) \qquad (15)$$

---

[14] The average lag time to repossession varies significantly from country to country (and, in the United States, from state to state). Anecdotal evidence shows that in Denmark, for example, average time to repossession is around 6 months. On the other hand, in Spain it is around 3 years. Most transition and developing economies are plagued by an inefficient legal system. Thus, it is likely that in such countries delays would be significant.

Notice that (15) coincides with (4) when $\tau = 0$. On the other hand, this loss is partially offset by the gains that the agency has by not paying off the claim right away. Such gain would be equal to:

$$Gain_{t+\tau} = L_R \cdot \left(1+R\right)^{\tau} \cdot \max\left(B_{t-1} - V_t, 0\right) \qquad (16),$$

Both (15) and (16) are expressed in terms of money at time $t+\tau$ i.e., moment in time when the court procedure ends. Net loss from legal inefficiency is obtained by subtracting (16) from (15) (clearly, net loss is 0 when τ=0). Using the same method of calculation as Section 3.1, one can check that the expected present value of the net loss is equal to:

$$LCL_t = L_R[Put\left(K_1, T_1\right) - \left(1+R\right)^{\tau} \cdot Put\left(K_2, T_2\right)] \qquad (17)$$

Here, strike prices and maturities are defined as follows:

$$\begin{aligned} &K_1 = B_{t-1} \cdot \left(1+c\right)^{\tau}, K_2 = B_{t-1}, \\ &T_1 = t+\tau, T_2 = t \end{aligned}$$

In order to properly take into account this extra loss, we need to update our premium computation of Section 3 by substituting $CL_t \to CL_t + LCL_t$ in (11) and (12).

3. 3 MORTGAGE INSURANCE PREMIUM

Next we derive the formula for the mortgage insurance premium. There are several ways in which insurance premium can be collected and the price of the premium, for the same expected loss, will depend on which of these methods is used (see Dennis et al (1997) for more details). In this paper we describe only the simplest method, namely upfront fee

collection with no refund in case of prepayment. Other methods (annualized fees, prepayment refunds, etc) can be dealt with in a similar manner. Assume that the insurance agency incorporates a gross profit margin q into the price. Such a gross profit margin should provide, among other things, a cushion against unexpected losses as well as provide sufficient funds for covering operating expenses of the agency. In that case the insurance premium would be equal to:

$$Pm = (1+q)EAL_T \qquad (18)$$

Thus, the insurance premium in that case is equal to the expected accumulated loss up to time t=T, i.e. for the duration of the mortgage contract, adjusted for the gross margin. Since mortgage insurance is a complex portfolio of put options, mortgage insurance premium is priced as the price of such a portfolio (vis-à-vis the natural probability measure).

4. CALIBRATING THE MODEL

Ultimately, determining the price of mortgage insurance premium is a process, not just simply a method or development of a model. When the right pricing model is developed, it needs to be calibrated, and all input values defined. In countries with developed financial institutions and instruments, where mortgage markets have a long tradition, model calibration may be complex, but in principle is still relatively straightforward. In the case of Serbia and other transition and developing countries, on the other hand, lack of almost any relevant data, particularly those related to mortgage default and prepayment experience, makes this process a true challenge.

When option pricing is used as a method for pricing mortgage insurance, we assume that the price of collateral is stochastic and that it follows a Geometric Brownian motion, as described in equation (5). Therefore, in order to calibrate the model we have to determine parameters that describe the price movement process (i.e. μ and σ). The only source of available data on residential real estate prices in Serbia is provided to us by “KROV” (a magazine published by the Association of Real Estate Agents of Serbia). This has monthly data on the aggregate real estate transaction prices from 2000-2002. Some of the data points are missing and had to be supplemented by our survey. These data served as a basis for our forecast of the pricing process. We estimate historic volatility to be quite high (around 20%). This is due to the very uncertain environment of the Serbian economy in the last several years. While determining the value of σ is relatively simple, it is much harder to determine the mean μ. Since our time series is short (only 3 years), the historical mean is almost certainly an incorrect measure of future price appreciation. In particular, a positive political shock in Serbia three years ago led to doubling of real estate prices. However, we

do not believe that this trend can continue forever. In order to protect the insurance agency we make a very conservative projection of the price appreciation mean and let it be, in the base case scenario, equal to -10%.[15]

Besides the parameters that describe underlying property price movements, default and prepayment rates play a significant role in determination of MI premium (see (12)). In countries where long time-series data are collected on mortgage prepayment and default (such as U.S. and Sweden, for example) one can use such data to forecast empirically future values of these variables. On the other hand, in a significant number of countries, there are only rudiments of a mortgage system and, as a consequence, no reliable data is available about default or prepayment. Yet, in order to price MI we need to somehow find plausible guesstimates. We suggest a comparables method. We start by analyzing historical prepayment and default probability experience in the United States since the data is readily

[15] Of course, in order to determine μ and σ with greater accuracy, one would need to develop a system of collection, processing and forecasting of real estate prices (the latter could rely on hedonic pricing techniques that are becoming standard in developed economies). Using such a system for a few years, μ and σ and the fair price of MI could be determined more accurately.

available for that market (see, for example, Dennis et al (1997)). It is well known that both prepayment and default curves have an inverted U profile, so we assume that the target experience curves (for Serbia) would also have a similar shape. Just as the term structure of interest rates can be subjected to various types of deformation (parallel shift, elongation, etc) so can the default and prepayment term structure. In our model we allow for various ways in which these two curves can be deformed. In addition, we impose some natural constraints. For example, we assume that conditional probability of default in Serbia in the foreseeable future shall be higher than in our benchmark US experience, but smaller than US experience during 1929 crisis.[16] On Figure 4 we depict both the American default experience for 30year residential mortgages in 1996 and the best estimate for Serbia on a 20-year scale in order to comply with the current mortgage market.

---

[16] Again this is done in order to make as conservative an estimate as possible. Some emerging markets (India and Eastern Europe, for example) have actual default rates that are much smaller than the corresponding American default rates. Basically, in the absence of mortgage insurance banks give credit only to the least risky prospects. On the other hand, upon the introduction of MI the situation may change as banks may find it profitable to issue credit to a much wider cross-section of households. Thus, MI would likely lead to an initial increase in default rates in such countries.

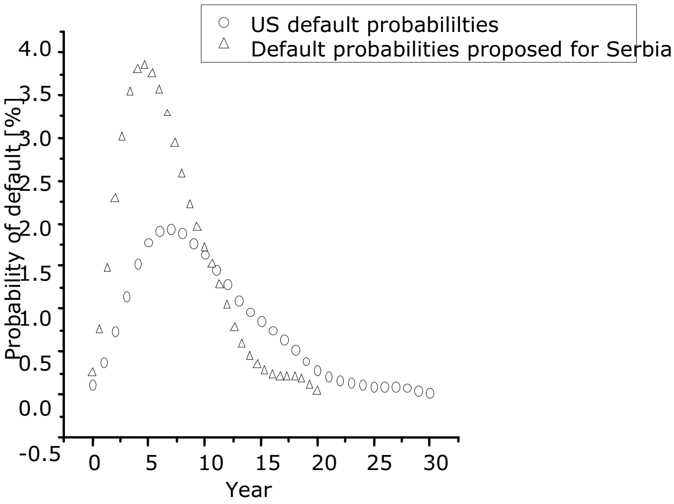


Figure 4
Conditional probabilities of default (actual U.S. 1996 experience) and estimated default experience for Serbia (Estimate by SECCF)

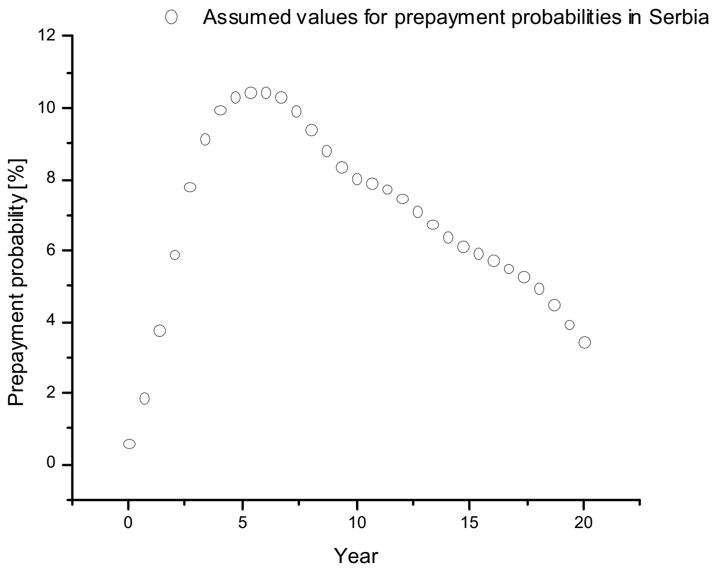


Figure 5
Conditional probabilities of prepayment for Serbia (Estimate by SECCF)

Other parameters required by the model are: mortgage amortization period, LTV ratio L_R, gross profit margin, contract rate, reinvestment rate and the average time to repossession. Banks in Serbia, and indeed in many other developing and transition countries, are not willing to issue mortgages with amortization periods greater than 20 years, so we use that value in this model. When we come to LTV and L_R, these values depend on the amount of risk that the insurance agency is willing to take. In the case of Serbia, the Serbian Housing Corporation (SHC) proposes LTV=70% and $L_R = 75\%$, ratios that are quite common in other emerging market countries. These are therefore the values we use in the base case scenario.

We select the required margin to be g = 10%. (This is the margin protecting against unexpected losses). SHC estimates the realistic reinvestment rate to be 5% and the mortgage contract rate to be around 10%. This last value is high vis-à-vis developed countries, reflecting the perceived risk of a sharp downturn in Serbian economy, as well as inflationary expectations and political uncertainty.

At present, the Serbian legal system makes it impossible for a lender to repossess collateral without a lawsuit that could typically last several years. However, there is strong pressure from both the government as well as business circles (domestic and foreign) to significantly simplify and speed up such processes. It is estimated that in a couple of years, the Serbian repossession experience may be in line with the best European practices.

In Table 1 we present a summary of all the input values required for pricing and calibrating the model that we develop for this base case scenario.

Parameter	Value
μ Expected annual return of a real estate	-10%
σ Volatility of the value of a real estate	20%
s Yearly amortization rate	1%
Mortgage amortization period	20 years
LTV	70%
LR	75%
q gross profit margin	10%
c contract rate	10%
r reinvestment rate	5%
average time to repossession	0.5 year

Table 1
Input parameters in the model

For values in Table 1, price of MI in two cases studied in this paper (as a proportion of the loan size) are given in Table 2.

	Price of premium as

	a percentage of loan
One option model	3.43%
Two options model	4.35%

Table 2: MI premium prices

Sensitivity analysis and Comparative Statics

To obtain the most realistic price of the MI premium one needs to combine two things: a good pricing model and input parameters that are required by that model. As we mentioned before some of those parameters are not easy to obtain for Serbia and most other emerging markets so it is crucial to know comparative statics. Clearly, the most significant influence on the price of MI is due to expected annual return of real estate μ, volatility of the collateral value σ, default rate probability term structure and the average time to repossession τ . In **Figure 6** we present the sensitivity of mortgage price toward the change of μ , fixing the rest of the parameters as in Table 1.

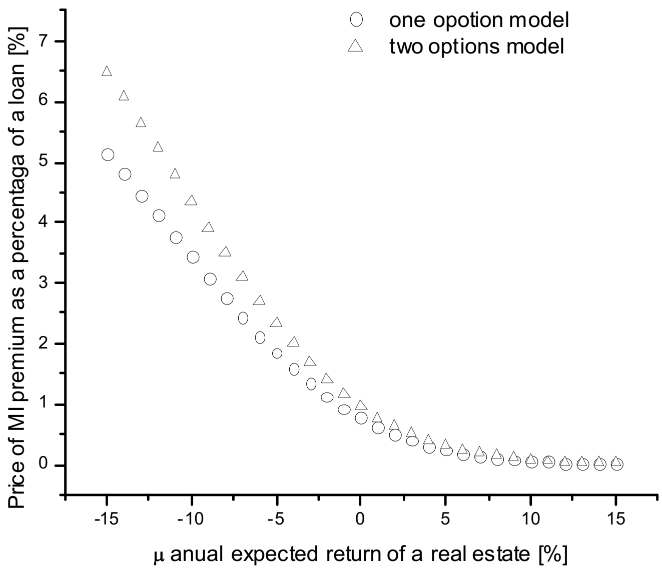


Figure 6
Mortgage insurance price as a function of μ

One can observe that when $\mu = 0\%$, the required insurance premium is similar to values in the U.S. (see Dennis et al (1997)). On the other hand, in our conservative base case scenario, insurance in Serbia would be more expensive than in the U.S. Another factor that greatly influences the price of the MI premium is σ. In Figure 7 we show how changes in σ influence the price of MI.

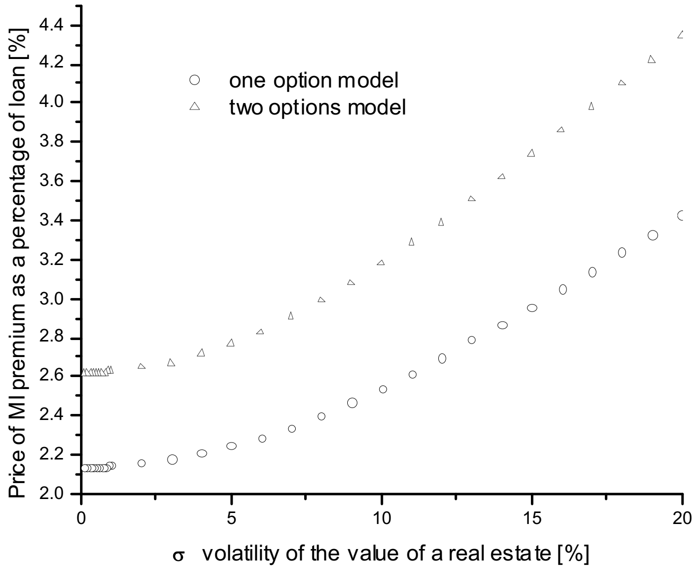


Figure 7
Price of the mortgage insurance as a function of housing price volatility

Using transformations of Figure 4 as outlined above, one can obtain a variety of plausible default experiences. Suppose, for simplicity, that we use a simple stretching transformation. In that case we can propose the Serbian default experience to be a simple multiple of the American default experience. Sensitivity of the price of the MI premium to changes in the US default probabilities multiplier is presented in Figure 8.

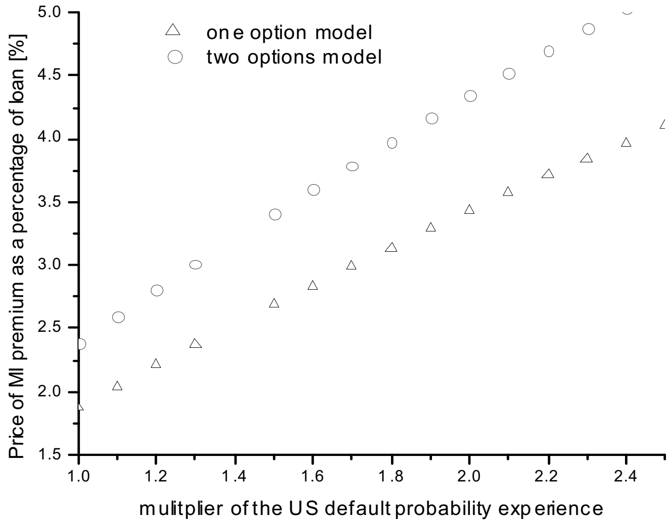


Figure 8
Price of MI as a function of the multiplier of the U.S. default experience

Finally, in Figure 9 we see how the price of MI premium depends on the average time to repossession.

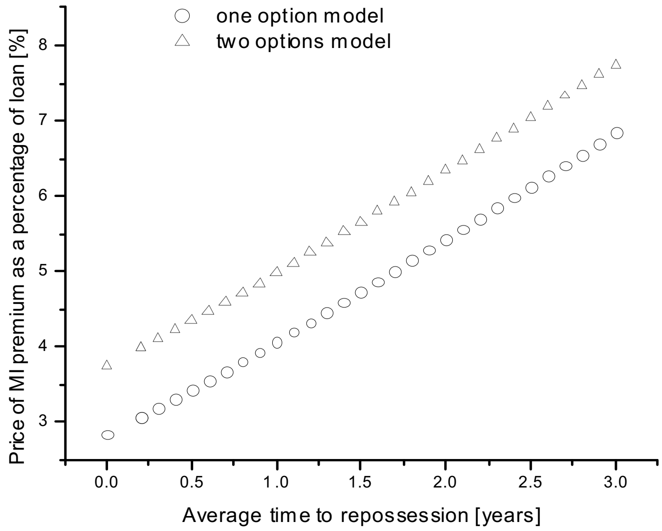


Figure 9: Influence of legal inefficiency and delays on the price of MI

5. ESTIMATING MACROECONOMIC-BENEFITS

Improving operational efficiency of the real estate market and creating a well functioning mortgage market may play a fundamental role in the development of an economy. This is of particular relevance to transitioning and developing economies. In this section we provide a simple, practical tool for estimating such an impact. As a proxy for its quantitative evaluation we select a variable especially dear to policy makers: the number of new jobs created as a direct or indirect consequence of the establishment of the mortgage insurance agency, since the latter leads to the development of a mortgage market, which in turn stimulates the housing sector and the economy.

It is important to note that mortgage loans have a direct influence on the building of new properties as well as on the ability to trade in existing properties. Both these activities lead to job creation. Suppose the average work life is λ years and that, for simplicity, salary S during that time is fixed and equal to the average annual wage in the country under consideration. In that case, the present value of a person's life-long earnings (including year zero) is given by the following annuity expression:

$$PV(S) = S + \frac{S}{R}[1 - 1/\left(1+R\right)^{\lambda}] \quad (19)$$

We use (25) to convert economic value addition *EVA,* into new job creation, by dividing the former into the latter, i.e. by calculating the ratio *EVA/PV(S).*

JOB CREATION FROM BUILDING NEW REAL ESTATE

Total "economic value addition" in the case of newly built properties is equal to the market value of the property, since the entire value chain is taken into account. One can break down this value into the contribution from the construction industry itself (that value added is equal to the cost of the new construction) and the difference between the market value and

the construction cost (that value added is the contribution from the post-construction, supporting industries).

Let us denote by NH_t the number of new units added at year *t* to the market as a result of the existence of mortgage insurance. The agency may influence that number by introducing a target ratio $\alpha = NH_t / ENO_t$ i.e. by requiring that α percentage of the insured mortgages be meant for new housing construction. Here, ENO_t is the total number of mortgage transactions, both for new and existing houses. Since we assume, for simplicity, that properties are of uniform value equal to V_0, the expected number of new full time jobs created can be easily seen from (15) and (25) to read:

$$ENJ_t = \frac{V_0 \alpha_t ENO_t}{PV(S)} \qquad (20)$$

As one can see from (26), the number of new jobs created as a result of insuring mortgages increases in the level of real estate prices and the number of new construction loans, and is inversely proportional to the present value of the labor income.

JOB CREATION FROM FINANCING TRADE IN THE EXISTING PROPERTIES

In the case of financing the trade in existing properties, value is added in two principle ways: through decreasing the barriers to trade between the parties and through home improvements. Let us consider the contributions of the two factors separately. Since the expected number of the existing units financed is given by $(1-\alpha)ENO_t$ and the representative property value is assumed to be V_0, if the broker's commission ratio is equal to b , we can estimate that part of the value added to be: $(1-\alpha)bV_0ENO_t$. On the other hand, if we assume that on average, each property has been improved by investing *h* percentage of the value of the property, the expected economic value added from home improvements is easily seen to be: $(1-\alpha)hV_0ENO_t$. Putting the two expressions together we obtain the number of new jobs as the result of trade and improvement of old housing that can be attributed to the existence of the mortgage insurance agency:

$$EOJ_t = \frac{V_0(1-\alpha)(b+h)ENO_t}{PV(S)} \qquad (21)$$

Combining (26) and (27) still does not fully account for the beneficial impact that these industries have on job creation, however. What needs to be added to this story is what is commonly known as the multiplier effect. Suppose that the economic value added in the primary channel (explained so far) was 1 unit of account. Suppose, further, that for each 1

unit paid as wages and profits, MPC percent is expended and stays in the country. (We estimate it that in most transition and developing economies this ratio can easily be as high as 90%, both due to low savings and the closed nature of the economies. Since these are mostly closed economies, the marginal propensity to consume is basically the marginal propensity to consume domestic goods and services. In addition to this is the general acceptance of the fact that most real estate related goods and services are localized and domestic, and hence there is very little leakage out of the country). Since the worker in the primary channel spends MPC percent in domestic goods and services, this pays wages to another worker who, in turn, leaves MPC percents of his wage as a wage of another person in the country, and so on. As a result, one unit of value multiplies and the total wages in the economy, as a result of the initial one unit consumption shock are given by the following expression:

$$x = 1 + MPC + (MPC)^2 + ... = \frac{1}{1 - MPC} \qquad (22)$$

Total economic value added and the corresponding number of new jobs expected to be created in the economy as a result of the introduction of the mortgage insurance system is, therefore, estimated to be:

$$EVA_t = [\alpha + (1-\alpha)(b+h)]V_0 ENO_t x$$
$$EJ_t = \frac{EVA_t}{PV(S)} \quad (23)$$

6. CONCLUDING REMARKS

In this paper we present a comprehensive model for pricing of mortgage insurance contracts and for the introduction of a government-sponsored mortgage insurance system in transitioning and developing economies. Our framework calculates the mortgage insurance premium that such an agency would fairly charge, and utilize it to determine the expected future profits and losses of a hypothetical mortgage insurance scheme. We show that this procedure of setting up of a mortgage insurance agency would not have to be very costly in terms of the expected future losses and that a key factor in the success of the scheme lies in a comprehensive legal reform shortens the time for repossession of collateral. Our framework, although quite general and applicable to different countries, has been calibrated, wherever possible, to the actual data for Serbia. We also present a static, simple and intuitive process for estimating the beneficial macroeconomic impact of a housing mortgage insurance system.

References

Ambrose, B., Capone, C., and Deng, Y., (2001) Optimal Put Exercise: An Empirical Examination of Conditions for Mortgage Foreclosure. *Journal of Real Estate Finance and Economics,* 23(2): 213-234.

Aruñada, B., (2003) Property Rights as Organized Consent. Mimeo: Universitat Pompeu Fabra.

Black, F., and Scholes, M., (1973) The Pricing of Options and Corporate Liabilities. *Journal of Political Economy,* 81: 637-654.

Bluhm, C., Overback, L., and Wagner, C., (2002) *An Introduction to Credit Risk Modeling,* Florida: Chapman & Hall.

Brueggeman, W. and Fisher, J., (1997) *Real Estate Finance and Investments,* New York: Irwin-McGraw-Hill.

Clauretie, T. and Jameson, M., (1990) Interest Rates and the Foreclosure Process: An Agency Problem in FHA Mortgage Insurance, *Journal of Risk and Insurance*, 57:701-711.

Cox, J., Ingersoll, J. and Ross, S., (1985) A Theory of the Term Structure of Interest Rates, *Econometrica,* 53: 385-407.

Deng, Y., Quigley, J., and Van Order, R., (2000) Mortgage Terminations, Heterogeneity and the Exercise of Mortgage Options, *Econometrica*, 68(2): 275-307.

Dennis, B., Kuo, C. and Yang, T., (1997) Rationales of Mortgage Insurance Premium Structures, *Journal of Real Estate Research*, 14(3): 359-378.

Hardt, J. and J. Lichtenberger, (2001) The Economic and Financial Importance of Mortgage Bonds in Europe, *Housing Finance International*, No. 4: 19-29.

Hull, J., (1999) *Options, Futures, and Other Derivative Securities* Upper Saddle River, NJ: Prentice Hall.

Jackson, J. and Kaserman, D., (1980) Default Risk on Home Mortgage Loans: A Test of Competing Hypotheses, *Journal of Risk and Insurance*, 47: 678-690.

Jaffee, D. and Renaud, B., (1995) Securitization in European Mortgage Markets. Paper presented at the First International Real Estate Conference, Stockholm, Sweden.

Jaffee, D. and Renaud, B., (1997) Strategies to Develop Mortgage Markets in Transition Economies. In *Financial Sector Reform and Privatization in Transition Economies*, (Doukas, J., Murinde, V. and Wihlborg, C., Editors) Elsevier Science Publishers: 69-93.

Kau, J. and Keenan, D., (1999) Catastrophic Default and Credit Risk for Lending Institutions, *Journal of Financial Services Research*, 15(2): 87-102.

Kau, J. and Keenan, D., (1995) Am Overview of the Option-Theoretic Pricing of Mortgages, *Journal of Housing Research*, 6(2): 217-244.

Kau, J., Keenan, D., and Muller, W., (1993) An Option-Based Pricing Model of Private Mortgage Insurance, *The Journal of Risk and Insurance*, 60 (2): 288-299.

Kau, J., Keenan, D., Muller, W., Epperson, J., (1992) A Generalized Valuation Model for Fixed-Rate Residential Mortgages, *Journal of Money, Credit and Banking*, 24: 280-299.

Swan, C., (1982) Pricing Private Mortgage Insurance, *Journal of the American Real Estate and Urban Economics Association*, 10: 276-296.

National Bank of Serbia, (2002) A market survey of the Serbian banks on mortgage markets.

Price Waterhouse LLP, (1997) An actuarial review for Fiscal Year 1996 of the Federal Housing Administration' Mutual Mortgage Insurance Fund (FHA, Arlington, VA).

Schwartz, E. and Torous, W., (1992) Prepayment, Default, and the Valuation of Mortgage pass-through Securities, 65(2): 221-239.

USAID, (1997) Building on Progress: The Future of Housing Finance in Poland (A study commissioned by the USAID).

JP Morgan, (2001) Emerging Markets Research. Yugoslavia's Quest for Stability and Reform