# Default Recovery Rates and Implied Default Probability Estimations: Evidence from the Argentinean Crisis

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# Default Recovery Rates and Implied Default Probability Estimations: Evidence from the Argentinean Crisis, December 2001.

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**Abstract**

This paper applies the model presented by J. Merrick Jr. (2001) to estimate both the default recovery rates and the implied default probabilities of the Argentinean Sovereign Bonds during the crisis which took place in December 2001. Between October 19th and December 24th 2001, the average bond price level reflected a downward trend, falling from USD 56.8 to USD 26.5 for each USD 100 face value. Similarly, default recovery rates descended from USD 38.7 to USD 20.8 whereas the base default probability registered an increase from 19.4% to 45.5%. Thus, bond price volatility could be explained in terms of these two embedded determinants. According to the model, bond prices were overvalued by USD 3.92 on average, which amounts to 12.9%; even when it is generally assumed that the default was foreseen by the market in December 2001. In accordance with private estimations of the Argentinean debt haircut which set it at 70% and the recovery rate estimated by the model which amounts to USD 21.7, Argentina would have overcome its default with a country risk premium of around 1960 basic points. Such a high country risk spread after debt restructuring would fully justify a deep haircut over the face value, the temporal term structure and interest rate coupons.

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## 1 Introduction

Over the last thirty years, the theory of pricing credit risk has been put forward in order to measure corporate debt. Even if similar approaches should be applied for the calculation of sovereign risk, it becomes essential to point out the differences between risky corporate debt and risky sovereign debt as well as their consequences in valuing assets. For instance, emerging country sovereign bonds are issued in countries such as the United States of America and the United Kingdom, under completely different legal jurisdiction and capacity of enforcement if compared with corporate bonds. Emerging countries are more stable than corporations, they are fewer in number, they have longer-term economic planning, they do not default as frequently as corporations do and they do not typically disappear. Consequently, there is considerably less empirical evidence of default on sovereign debt than on corporate debt.[1]

Thus, the approaches applied by portfolio managers in Argentina in 2001 were grounded on the analysis of domestic and foreign data generated by earlier international crises, such as those of Mexico (1995), Russia (1998) and Brazil (1999). One of the approaches consisted in the analysis of the time series in relation to indicators such as peaks, trends and the volatility of domestic and foreign sovereign bond price levels. An alternative approach based on a sensitivity analysis considers the bond market price in order to calculate the implied default probability for different possible recovery rates and spreads. This method entails forming conjectures about the value of recovery and size of spread by resorting to evidence provided by earlier crises.[2]

The disadvantage of this approach is that its outcomes result from different bond temporal term structures; and hence from different bond durations when compared to those of the analysed bonds. Consequently, the information provided is misleading. Moreover, the approach does not include information concerning recently issued bonds nor the particular macroeconomic conditions of the country subject to analysis. Therefore, these methods neglect highly relevant information which is later incorporated into the analysis ad-hoc.

[1] For a survey of the literature concerning this topic, see Altman Edward, Andrea Resti and Andrea Sironi (2004), Default Recovery Rate in Credit Risk Modeling: A Review of the Literature and Empirical Evidence. Economic Notes by Banca dei Monte dei Paschi di Siena. Volume 33.

[2] For an example of this approach, see Federico Sturzenegger (2000), "Defaults Episodes in 90's: Factbook, Tool-kit and Preliminary Lessons", prepared for the World Bank, which presents an example of this exercise (page 14).

As regards the theoretical background, most of the models focus on default risk adopting static assumptions, treating default recovery rates either as a constant parameter or as a stochastic variable independent of the probability of default. The connection between default recovery rates and implied default rates has traditionally been disregarded by credit risk models. Accordingly, the problem faced by analysts in 2001 was how to settle default recovery rates and the implied default probability of their portfolios, only on the grounds of their bond prices. Now, if the bond price is a function of two unknown determinants, how could analysts calculate both of them simultaneously and consistently?

Knowledge of both bond price determinants— the default recovery rate and the implied default probability— enables the analyst to anticipate the value of their position in case of default and assume a long or short position according to the benchmark, among other strategic decisions. As a result, the motivation of this research was based on the lack of methodology applied by Argentinean portfolio managers in valuing their stressed portfolios of Sovereign Bonds in the period previous to the economic collapse.

In order to avoid these disadvantages, we have applied a model, originally presented by Merrick (2001), to estimate the default recovery rates and the implied default probabilities in Argentinean Sovereign Bond prices.

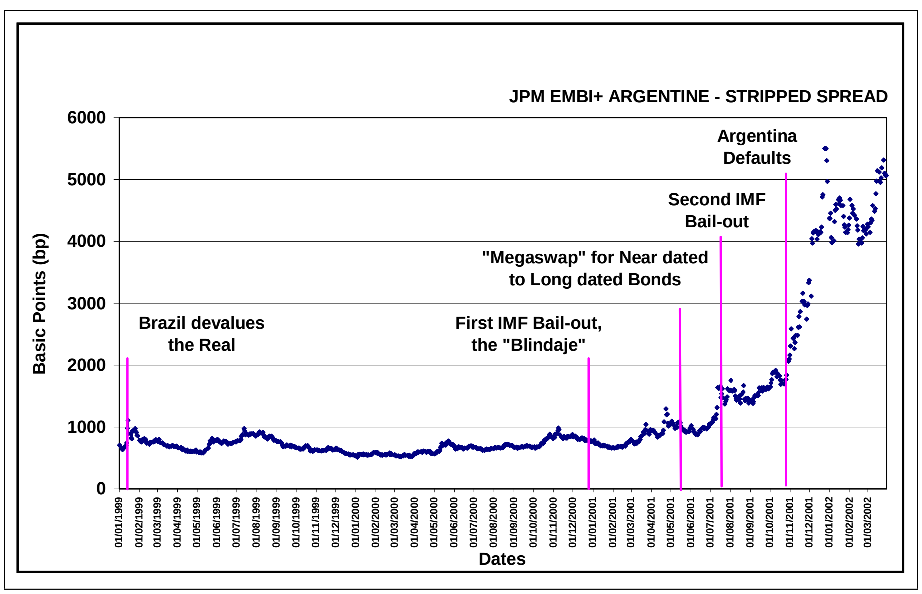
## 1.1 Brief Summary of Events Preceding the Crisis

Before presenting the model, it is worth looking at the most important events which caused the Argentinean crisis in December 2001. In August 1998, Russia defaulted on their public debt depriving Argentina of access to the international capital market. Five months later, Brazil devalued their currency causing Argentina's competitiveness in foreign markets to deteriorate. The economy sank into recession with twin deficits— a trade balance gap and a fiscal budget gap— which foreigners were less and less willing to finance. Argentinean economy needed to regain competitiveness and since the exchange rate could not be permitted to fall, prices and wages had to drop. In December 1999, after the general election, Mr. De la Rúa was elected to office but the new political structure was too weak to face the strong political change necessary to overcome the crisis.

As a consequence, peso quotation edged downwards, tax revenues faltered and Argentina's debts in US dollars became harder to repay. In spite of this, Argentina refused to fold and kept raising the stakes. At the beginning of 2001, Argentina requested a USD 15 billion loan from the IMF, which was known as 'blindaje' or 'armour'. In order to buy some time, in June 2001, the country completed the notorious 'megaswap' in which near-dated securities were exchanged for longer-dated securities, higher-yielding bonds. In August 2001, Argentina received a second $8 billion bail-out. Finally, political turmoil and lack of further assistance from multilateral institutions drove Argentina into default in December 2001 (see Graph1).

This paper is divided in three sections. Section II describes the Model and the Data, Section III analyses the estimations and results and Section IV presents the conclusions. Finally, the Appendix produces a detailed presentation of the estimated results and other complementary data.

Graph 1: Argentinean Sovereign-Debt Spread.
Relevant Pre-Default Events.




## 2 The Model

This section presents the pricing framework for $N$-period sovereign bonds, which is made up of four elements.

The first element is the Bond Structure, which is made up of the coupons and the principal, showing the amount of the coupon paid in the period $t$ as $C_t$ and the amount of the principal paid on due date in the period $N$ as $F_N$.

The second component is the default recovery rate which is represented with letter $R$. In this analysis, $R$ is the amount paid to the bondholder immediately after default has been announced.[3]

The third element is the adjusted risk-neutral payment probability distribution. Denote the adjusted probability of default during the specific date $(t-1)$ to date $t$ period as $p_t$.Moreover, we will define $P_t$ as the joint probability of no default between the moment when the bond is issued and the moment $t$ , when the payment of the coupon is made. Thus, the Risk-Free Adjusted Payment Probability is indicated by means of $p_t$ and defined as: [4]

$$p_t = P_t + P_{t-1}$$

The fourth and last element is the risk-free present value discounted factor for a time t cash flow, denoted $f_t$. The discount rate used is the risk-free rate, since the risk is captured by the third term, as it is shown in equation (1) below.

Having described the four elements, we are in a better position to state equation (1) which enables us to value a bond through the expected present value of cash flows. As it has already been suggested by Jonkhart (1979), Fons (1987) and Hurley and Jonson (1996), we state that the present value of a bond is the sum of its expected cash flows (coupons, principal and the recovery rate), multiplied or adjusted by their probability. As in Leland and Toft (1996) and Merrick (2001), the probability distribution used here is interpreted as the implied risk-neutral distribution. Henceforward, we are implicitly referring to *risk-neutral* probabilities.

$$V_0 = \sum_{t=1}^{N} \{P_t.f_t.C_t\} + \{P_N.f_N.F_N\} + \sum_{t=1}^{N} \{p_t.f_t.R\} \tag{1}$$

It should be noted that expressing the pricing equation in these terms implies that the asset risk becomes captured by the implied default probability and its complement— the probability of receiving the promised

[3]The recovery rate can also be defined as the expected present value of cash flows, which have been or are to be reprogrammed. For a detailed presentation, see: Recovery Rates: The Search of Meaning. High Yield. Merrill Lynch. March 2000.

[4]Alternatively, the probability of receiving a promised date t coupon payment,$P_t$ , can be expressed as: $P_t = 1 - \sum_{s=1}^{t} p_s$.

payment, and by the default recovery rates whereas cash flows –coupons and principal– remain discounted at the risk-free rate. Otherwise, the asset risk is generally enclosed in the discount rate.

Let us now outline the model a little further. Before stating the joint probability of no default, $P_t$, we define the risk-neutral default probability rate, noted as $\delta_t$. Previous researches, such as Fons (1987) and Bhanot (1998), consider a constant $\delta_t$. Our proposal, as much as Merrick (2001), understands $\delta_t$ as an increasing linear function with respect to time, $t$, as it is shown in equation (2):

$$\delta_t = \alpha + \beta . [t] \tag{2}$$

The purpose of this function is to capture the default probability temporal term structure throughout time in a parsimonious way. This formalisation registers the fact that in a critical period, the probability of default is greater as the deadline of the coupons and the amortisation become closer in time.[5]

Thus, the joint probability of no default, $P_t$, can be defined as:

$$\begin{aligned} P_t &= (1 - \delta_t) \\ P_t &= (1 - (\alpha + \beta . [t])) \end{aligned} \tag{3}$$

In which parameters $\alpha$ and $\beta$ are restricted so that $P_t$ is always less than or equal to one or greater or equal to zero. Consequently, equation (4) explicitly states the three unknown elements, $R$, $\alpha$ and $\beta$ incorporated in the model:

$$\begin{aligned} V_0 = & \sum_{t=1}^{N} \left\{ (1 - (\alpha + \beta . [t]))^t . f_t . C_t \right\} + \\ & \left\{ \left( 1 - (\alpha + \beta . [N])^N \right) . f_N . F_N \right\} + \\ & \sum_{t=1}^{N} \left\{ \left[ (1 - (\alpha + \beta . [t-1]))^{t-1} - (1 - (\alpha + \beta . [t]))^t \right] . f_t . R \right\} \end{aligned} \tag{4}$$

Having established the equations, it is possible to present the model that allows for a consistent estimation of the three unknown variables,

[5] Otherwise, during crisis long-term default probabilities might be lower than the short-term conditional on the sovereign's ability to avoid the case to fall into default. This effect is not captured by this assumption. See Andrezky, J. R. (2004) which assumes a Gumbel distribution to capture the shape the temporal term structure.

which will, in turn, enable us to know the default recovery rate and the default probability temporal term structure. In order to do this, we define equation (5) as the sum square of residuals (SSR) and equation (6) as the sum of residuals equalised to zero.

$$SSR_0 = \sum_{i=1}^{l} \left( V_{i,0} - \overset{\wedge}{V}_{i,0} \right)^2 \tag{5}$$

where $V_{i,0}$ denote the bond price (market price) and $\overset{\wedge}{V}_{i,0}$ denote the estimated bond price

$$\sum_{i=1}^{l} \left( V_{i,0} - \overset{\wedge}{V}_{i,0} \right) = 0 \tag{6}$$

The model has three unknown variables and is formalised through the statement of five equations; i.e., $i = 1, ....5$.

For the model to be consistent, it is assumed that the bonds have a cross-default clause— which is a realistic assumption in the case of Argentina. This assumption implies that there is a representative default recovery rate for the economy as a whole.

We employ a Solver that minimises square residuals— equation (5) — on condition that the sum of errors is equalised to zero— equation (6). The Solver applies the Generalised Gradients Method to estimate the unknown elements. [6]

We have selected the five most representative bonds of the economy –i.e., the bonds which have been most actively traded in the short, medium, and long term. From these five bonds we obtain the default recovery rate and the default probability temporal term structure, which are the most representative determinants of the economy for a given market price structure at each moment in time. Subsequently, this exercise is repeated for each day of the analysed period.

The Appendix includes an example that shows the estimated results based on the market price structure of October 1st 2001. The data and results concerning the fourth quarter 2001 are shown in a Table.

[6] In this paper, we have used the Solver included in Microsoft Office Package.

## 2.1 Description of the Data

For the period subject to analysis – October 2001- December 2001— we have considered 5 Global Bonds, denominated Eurobonds, at a fixed rate, with semestrial coupons and amortisation at finish. These characteristics are specified below:

Table 1: Sample of US-Dollar denominated Eurobonds

| Name | Issue Date | Maturity Date | Coupons |
|---|---|---|---|
| Arg. 03 | 20-Dec-1993 | 20-Dec-2003 | 8.375 |
| Arg. 06 | 09-Oct-1996 | 09-Oct-2006 | 11.000 |
| Arg. 10 | 15-Mar-2000 | 15-Mar-2010 | 11.375 |
| Arg. 17 | 30-Jan-1997 | 30-Oct-2017 | 11.375 |
| Arg. 27 | 19-Sep-1997 | 19-Sep-2027 | 9.758 |

These bonds are not guaranteed. They have a cross-default clause and they were issued under the jurisdiction of English Courts in London. This analysis was carried out considering the daily prices supplied by the Secretary of Finances of the National Ministry of Economy from the Argentine Republic.

Figure 1 shows the average daily prices for the bonds which have been described as representative of the economy for the period we are analysing. Figure 2, in turn, specifies the same series considering each of the bonds individually.

Figure 1 : Average Bond Prices

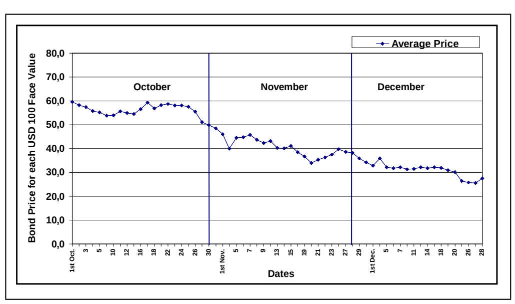
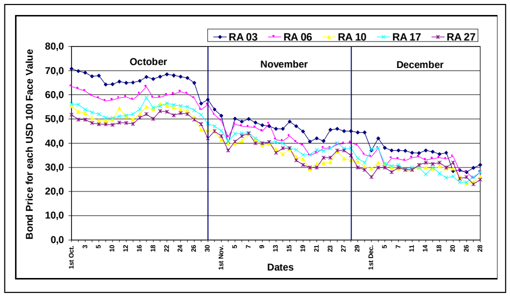



Figure 2 : Individual Bond Prices

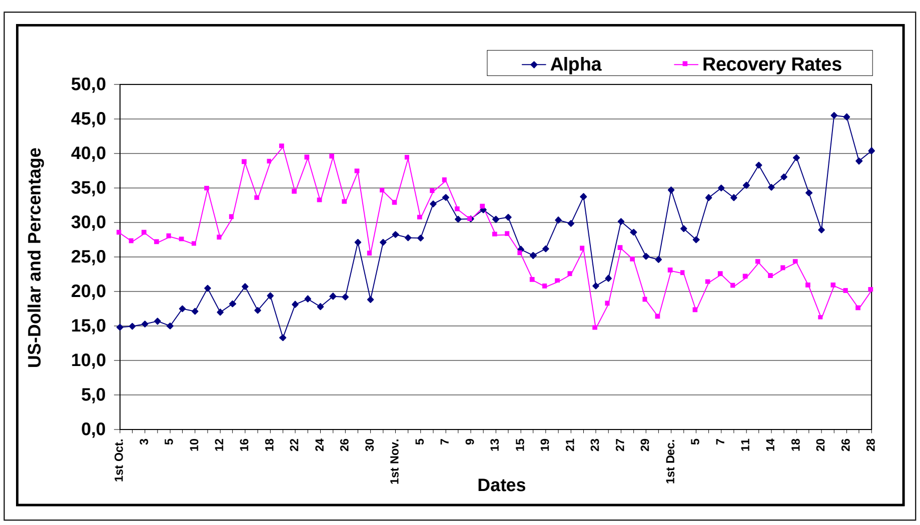



## 3 Description of Estimations

This section deals with the model estimations concerning the aforementioned Eurobonds for the case of the Argentinean domestic crisis. We will focus on the fourth quarter in 2001.

Figure 2 presents default recovery rates and base default probabilities both implied in market prices. It is worth noticing that the *Base* Default Probability is defined in the model by means of parameter Alfa ($\alpha$). The estimations regarding parameter Beta ($\beta$), which we employ to calculate the default probability temporal term structure, shows an increasing linear trend with respect to time. However, we will not analyse the estimations of the Betas.[7]

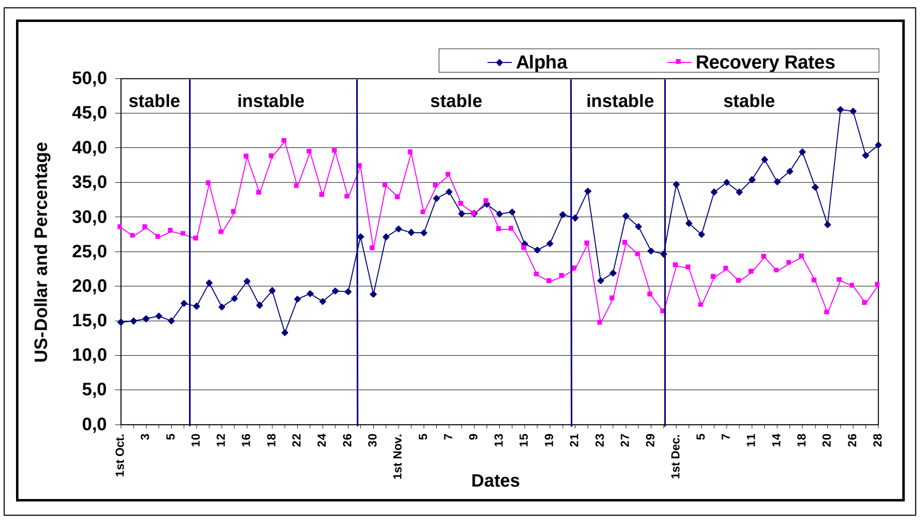
Figure 2: Estimated Default Recovery Rates and Base Default Probabilities.




[7]For a detailed presentation, see Andritzky, J. R. (2004).

This Figure (see also Figure 3) shows that in the period extending from October 1st to October 11th, both curves are stable, whereas from October 12th to November 6th, the curves are unstable, and produce a 'saw'-like shape. The same sequence is repeated in the sub-periods extending from November 7th to December 5th, and from December 5th to December 28th. As regards the stability of the last sub-period, it should be pointed out that the exception is the estimation correspondent with December 20th.

Figure 3: Default Recovery Rates and Base Default Probabilities classified by the stability of results.




The changes evidenced in the behaviour of curves are primarily due to the fact that in stable portions, the square residuals of these estimations are low (one digit) whereas in unstable portions, square residuals range from 15 to 30 (see the table of results in the Appendix). The estimations show that in the cases in which residuals are close to zero, the Solver has found a combination of prices which exactly reproduces the market curve (see the example for October 1st in the Appendix). As it has already been said, moderate changes in the estimated parameters reproduce the behaviour of market prices.

In the second place, the portions in which the Solver makes estimations with bigger square residuals coincide with the portions in which bond prices experience a change in the trendline (or are more volatile).

For the cases in which square residuals are bigger, the Solver returns as a result the value of the parameters subject to significant errors, so that we obtain a result that belongs to an interval of broader values, which explains why the series registers more unstable behaviour. This might be solved by using a Solver of a higher resolution which could always find an alternative combination of prices reproducing with greater precision the market curve and parameters. This is an attempt to obtain more accurate results for all possible market price structures.

The information provided by the model enables the individualisation of the parameters ruling over market prices. But in order to improve the quality of the information supplied and as a result of the preceding analysis, we have plotted the series considering the moving average in the last two periods (days) to obtain a more stable series which can average out the statistic errors produced by the Solver used (See Figure 4a). Alternatively, the same series is presented with a moving average of 4 periods, getting closer to the last moving week (See Figure 4b).

Figure 4: Default Recovery Rate and Base Default Probability with Trendline

Figure 4a: Two moving average

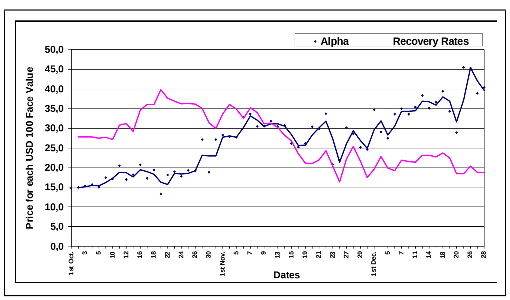
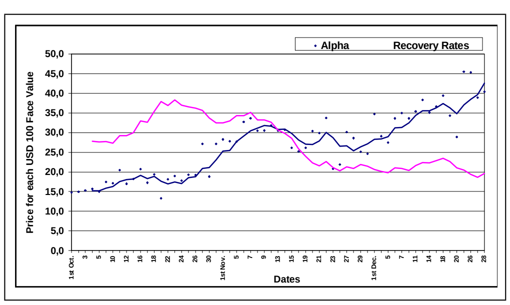



Figure 4b: Four moving average




As it has already been mentioned and in keeping with the preceding figures, it has been shown that the period October 1st - October 11th registers that both curves are stable and that the default recovery rate registers a downward trend whereas the Default Probability reveals an upward trend, both being coherent with a drop in bond prices. It must be observed that both determinants show a moderate gradient which corresponds to the trend intensity registered by market prices. Subsequently, the opposite phenomenon is registered in the first half of the second sub-period. Thus, we can conclude that the Model presented is capable of assessing slight oscillations in market prices. In such cases, the Solver can find a structure of prices which minimises square residuals to zero (or a number very close to zero).

However, when market prices experience a change in the trendline the estimated parameters are less precise and the square residuals become bigger. In this manner, short periods (less than a week), register a positive correlation between default recovery rates and implied default probabilities.

To sum up, it should be expected that:

- The increase in prices was accompanied by an increase in default recovery rates and a fall of implied default probabilities.
- The reduction in prices was accompanied by a drop in default recovery rates and an increase in implied default probabilities.

This relationship is accomplished if we take a longer period so that statistic errors can be compensated for. Considering the period extending from October 19th to December 21st, along which bond prices registered a downward trend, it is possible to observe that default recovery rates start at USD 40.9 for each USD 100 face value and reach USD 20.8 whereas base default probability ($\alpha$) starts at 13.3% and reaches 45.5% (See Figure 6 and the Table in the Appendix).

In brief, the results obtained show that for long periods (e.g. a two-month period), the model produces results which are consistent in time and coherent with the economic theory. These results are likely to be optimised by the use of a higher resolution Solver which operates in the limit to equalise statistic errors – particularly, square residuals— to zero.

Figure 6: Default Recovery Rate and Base Default Probability with Trendline

Figure 6a: Logarithmic Trendline

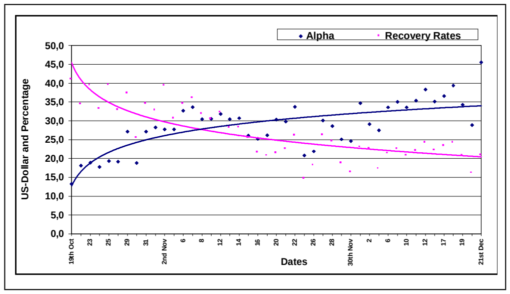
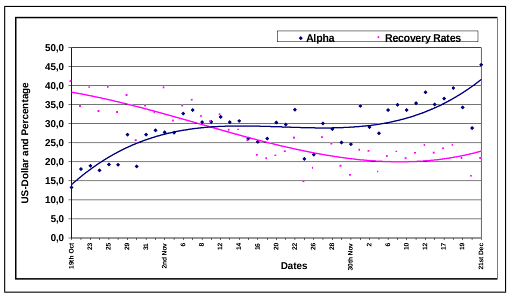



Figure 6b: 3rd Order Polynomial Trendline




## 3.1 Interpretation of Results

Market information produced between December 10th and December 28th, before and after default was officially announced, is presented in the following Table:

Table 2: Estimated Parameters:
Before and after Default (December 24th)

| Date | RA 03 | RA 06 | RA 10 | RA 17 | RA 27 | Average Price | Recovery Rate |
|---|---|---|---|---|---|---|---|
| 10 Dec | 36.8 | 32.8 | 29.0 | 29.0 | 29.0 | 31.32 | 20.73 |
| 11 Dec | 36.0 | 34.0 | 29.0 | 30.0 | 29.0 | 31.60 | 22.04 |
| 12 Dec | 35.9 | 34.4 | 30.1 | 30.0 | 31.0 | 32.28 | 24.16 |
| 14 Dec | 37.0 | 33.1 | 30.0 | 27.1 | 32.0 | 31.84 | 22.15 |
| 17 Dec | 37.0 | 33.6 | 29.4 | 30.0 | 31.5 | 32.20 | 23.30 |
| 18 Dec | 35.5 | 34.0 | 30.5 | 27.5 | 32.0 | 31.90 | 24.21 |
| 19 Dec | 36.1 | 33.4 | 29.5 | 25.8 | 30.0 | 30.96 | 20.77 |
| 20 Dec | 28.5 | 34.5 | 29.5 | 26.3 | 32.0 | 30.16 | 16.08 |
| 21 Dec | 28.9 | 28.5 | 26.0 | 23.9 | 25.3 | 26.52 | 20.79 |
| 26 Dec | 28.0 | 28.0 | 23.3 | 23.9 | 26.0 | 25.84 | 20.01 |
| 27 Dec | 29.8 | 25.5 | 24.0 | 26.0 | 23.0 | 25.66 | 17.50 |
| 28 Dec | 31.0 | 28.0 | 26.0 | 28.0 | 25.0 | 27.60 | 20.15 |

These data show that the market adjusted bond prices ranging from USD 30.02 for each USD 100 face value to USD 26.5 on December 21st after the resignation of the Minister of Economy and the President, instead of producing the adjustment on December 26th after default was officially announced. Thus, we understand that Argentina really defaulted on December 21st.[8]

As regards the default recovery rates evidenced between December 10th and December 28th, these estimations make for a good approximation to the market value as they present quite small square residuals, except for those registered on December 20th. It should be obseved that estimations recorded on December 20th registered square residuals of three digits. Consequently, in order to obtain a better approximation to this value, we will take the average value of default recovery rates in the pre-default period— i.e. between December 10th and December 19th . This average value amounts to USD 22.48.[9]

| **Period: 10 – 20 / 12 / 2001** | | |
|---|---|---|
| **Data** | **Interval** | **Average** |
| Average Price | USD 30.2 - USD 32.3 | USD 31.5 |
| Recovery Rate (1) | USD 20.7 - USD 24.2 | USD 22.5 |

To sum up, the results before and after market adjustment were as follows:

| **Period: 21 – 28 / 12 / 2001** | | |
|---|---|---|
| **Data** | **Interval** | **Average** |
| Average Price (2) | USD 25.8 - USD 27.6 | USD 26.4 |
| Recovery Rate | USD 20.8 - USD 17.5 | USD 19.6 |

Market average prices registered as of December 21st— the date the market considers Argentina defaulted— are considered as the default recovery rates validated by the market. As a result, this paper compares

[8] Brief chronicle of the events leading to the crisis: On December 20th, the Minister of Economy, Dr. Domingo F. Cavallo, and the President, Dr. Fernando De La Rúa, submit their resignation. On December 21st, the president of the Senate, Dr. Ramón Puerta, takes over provisionally for a 48-hour period. On December 23rd, Dr. Adolfo Rodríguez Saa is appointed as President. On December 24th, he announces the country's insolvency before the National Congress.

[9] Given that the market price on December 20th registers USD 30.2, less than the prices registered between December 10th and December 19th (USD 31.0 - USD 32.3), the Default Recovery Rate implicit in that price should be marginally smaller but in no case close to USD 16.08.

market prices registered on December 21st and the default recovery rate evidenced on December 20th. In other words, if the economic system unexpectedly defaults in a period $t$, the market price in the period $t+1$ should be equal to the recovery rate implicit in the last market price. Thus, we have that:

| Data | Interval | Average |
|---|---|---|
| The difference: (2) – (1) | USD 5.1 - USD 3.4 | USD 3.9 |

It follows that bonds were overvalued at USD 3.9 on average (in a range of USD 5.1 and USD 3.4); that is, by 12.9%. We interpret that it would have been correct to adopt a short position and buy when the market evidenced the model estimations; that is when the assets were quoted at average values of USD 22.5 (in a range of USD 20.7 and USD 24.2)[10] as it happened as of May 2002.

However, for a proper interpretation of the data, it is crucial to situate the model in the market conditions registered at the time. With this respect, two elements should be highlighted. Firstly: the Stage 1 of the debt swap started on October 30th; the public debt held by domestic investors was forcibly swapped in this stage, replacing the bonds which accrued an annual 10.4% interest on average with bonds quoted at a 6% annual interest rate. This explains why Argentinean Bonds were qualified as *Selective Default (SD)*[11]. Secondly: the interest rate spread between the peso and the dollar was widened in the second semester of 2001 (See Figure A1). This implies that if the expectation of devaluation became real, the government would significantly reduce its capacity of repayment, and, as a result, Sovereign Bonds would lose even more value.

These two reasons explain why the market assumed a scenario of default with a probability close to one and a relation debt- GDP which reduced the capacity of the State to face its obligations even further. This information is included in the market price of Argentinean bonds. Considering the aforesaid reasons, it should be assumed that the market had foreseen the scenario of default and that market prices before December 20th were the recovery rates of Sovereign Bonds.

[10] These values are correspondent with the Recovery Rates previous to the market adjustment.

[11] In these days, the Risk Country Premium went from 1200 basic points to 1600 basic points.

These two reasons explain why it should understood that the market had assumed a scenario of default with a probability close to the unity and a debt-to-GDP ratio reducing the capacity of the government to face its obligations even further. Considering the aforesaid reasons, it should be assumed that the market had foreseen the scenario of default and that market prices before December 20th were already the recovery rates of sovereign bonds. In other words, as it can be seen in equation (1), before December 20th bond prices were as follows:

$$V_0 = \sum_{t=1}^{N} \{p_t.f_t.R\}$$

where $p_t$ is equal to the unity.

Nevertheless, as of December 20th there is a break in the price series, going from USD 30.2 to USD 26.5, i.e., an 11.7% reduction. Another relevant element is that after default, the prices kept decreasing until they stabilised at USD 20 in March 2002.

Alternatively, if the market was arbitrated assuming a default probability equal to the unity, the continuous reduction in default recovery rates could be explained by the significant deterioration registered in the macroeconomic variables attributed to governability or management factors. In this respect we assume that, at the beginning, investors were not expecting such a long period to start the restructuring debt process. Thus, investors considered that USD 26.4 was the equivalent of the present value of an asset payable in the short term.

Finally, following the chronology of events, Argentina stopped servicing its USD 80,000 millions of sovereign bonds— domestic and international— on December 24th 2001. Later, Argentina dismantled the 'Convertibility System' devaluing the local currency (see Table A1 and Figure A2). It was the biggest sovereign default in history. Indeed, the 152 varieties of bonds eligible for the exchange amounted to just 55% of its total debt last year. After a three-year period of restructuring, creditors accepted the Argentinean offer taking a 70% loss, twice the average haircut in recent sovereign defaults. Only two days after the negotiation process had ended, the Minister of Economy, Roberto Lavagna, announced that the provisional take-up was 76%. Even if after the swap the Argentinean debt amounts to more than $120 billion pesos, the government will still have to face a public debt of approximately 80% of the GDP.[12]

[12] During its economic crisis the federal government shouldered the debts of the provincial governments and stuffed the country banks and pension funds with bonds, called BODENs, which were then forcibly converted to pesos.

## 3.2 Debt Haircut: a wise decision

Assuming a 70% haircut over the Argentinean debt and considering the estimated recovery rate through the model of USD 21.7, Argentina could have overcome its default with a country risk premium of around 1960 basic points –assuming a 2% risk-free interest rate and preserving the currently Bond Term Structure– whereas Russia did it paying 1000 bp (see Figure A3). Thus, Argentinean restructured bonds will have a 21.6% average annual rate of return. Such a high country risk premium after debt restructuring, calls for a debt haircut consistent in the long-term. In other words, a haircut that applies not only to face value but also to the temporal term structure and the interest rate coupons should be fully justified. The Argentinean debt of 80% of GDP remains higher than the 52% debt ran by its neighbour, Brazil. But the interest burden on Argentinean debts is considerably lighter and the maturity schedule is more flexible.[13]

Regarding the aggressive haircut inflicted to creditors and the punishment they expected to impose on Argentina, it appears that capital markets have a remarkably poor memory. Evidence shows that Brazil has defaulted seven times; Venezuela nine times and Argentina five times. In the past 175 years, Argentina defaulted or restructured its debt on five occasions: 2001, 1989, 1982, 1890 and 1828. Even if investors have always returned to Argentina, it should be noticed that the country has always paid a price for their investments.

# 4 Conclusion

Along the period extending from October 18th to December 24th 2001, the average market price of the assets registered a downward trend, falling from USD 56.8 to USD 26.5. As such, the default recovery rate descended from USD 38.7 to USD 20.8 whereas the base default probability registered an increase from 19.4% to 45.5%. Notice that when sovereign bonds prices are deeply stressed, the model is particularly relevant in explaining bond price volatility by means of both implicit determinants.

Comparing these estimations with Merrick's, it appears that the default recovery rates registered in Russia, before currency devaluation and

[13] In other debt restructuring processes, creditors had to accept either a cut in the principal, a lengthening of maturity or a reduction in interest payments. Argentina has achieved all three offering a 42-year bond.

the announcement of default, were very similar to those of Argentina facing the same scenario. On average, these rates were USD 27.3 and USD 21.5, respectively. Under these circumstances, both countries registered a country risk premium which ranged from 5000 basic points to 6000 basic points.

Nevertheless, during the Russian crisis, Argentina preserved a significantly superior level of recovery, if compared with Russia or Argentina in December 2001. In the context of the Russian crisis, Argentina registered a country risk premium which ranged from 600 basic points to 750 basic points and a USD 51.2 average recovery rate. This approximately doubled the value registered by Russian and Argentinean bonds in the scenario of local crisis. Sovereign Bonds from emerging countries facing unstable macroeconomic conditions suffer a significant reduction in their recovery rate— which amounts to approximately 50%— when compared with the bonds issued in countries facing stable macroeconomic fundamentals and a stable currency value, as was the case in Argentina in August 1998.

Extending this research to test the contagion effect over Brazilian economy, it appears that almost 100% of the volatility affecting Brazilian bond prices can be explained in terms of the default recovery rate volatility, whereas the base default probability remains close to zero. Brazilian bond prices have never reached the low level registered in Argentina or Russia, in December 2001 and August 1998, respectively. In the months preceding and following Argentinean default, the average price level was never inferior to USD 85 for each USD 100 face value. It should be noticed that in the week extending from October 2nd to October 10th 2001, bond prices stood at USD 80 on average, whereas the average default recovery rate was USD 67.9 and the base default probability 1.45%.

Considering the USD 21.7 default recovery rate estimated by the model and assuming a 70% haircut, Argentina would have overcome its default with a country risk premium of 1960 basic points whereas Russia overcame default with a premium of 1000 basic points. Thus, Argentina restructured bonds will have an average annual rate of return of 21.6%. Such a high country risk premium after debt restructuring justifies a haircut which is consistent in the long-term. Thus, a significant haircut which covers a cut in the principal, a lengthening of maturity schedules and a reduction in the payment of interest should be considered as a fair renegotiating result. Looking back on Argentinean economic history, we may predict that foreign capitals will make new investments for which the country will probably have to pay a premium.

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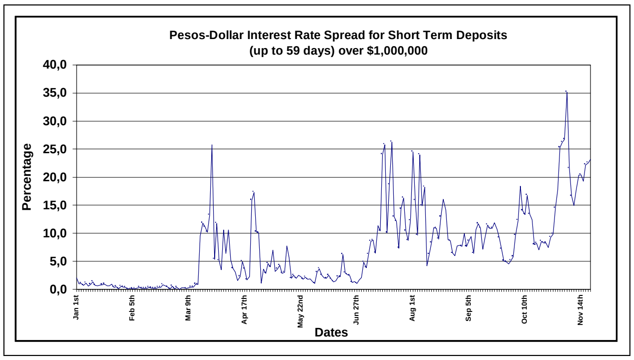
# 6 Appendix

Figure A1: Peso –Dollar Interest Rate Spread Dynamic for Short Term Deposits.

FigureA1a: Deposits over 1 million pesos




FigureA1b: Deposits under 1 million pesos

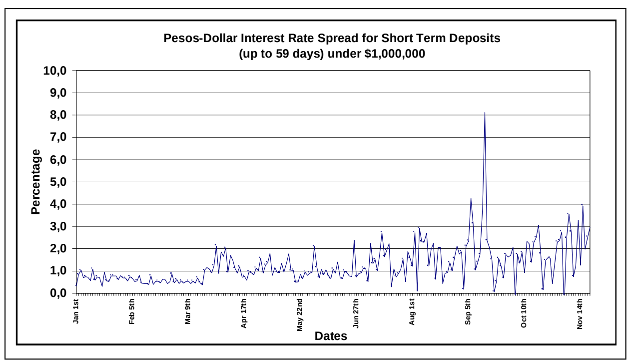



Figure A2: Exchange Rate Dynamics after the Currency Board

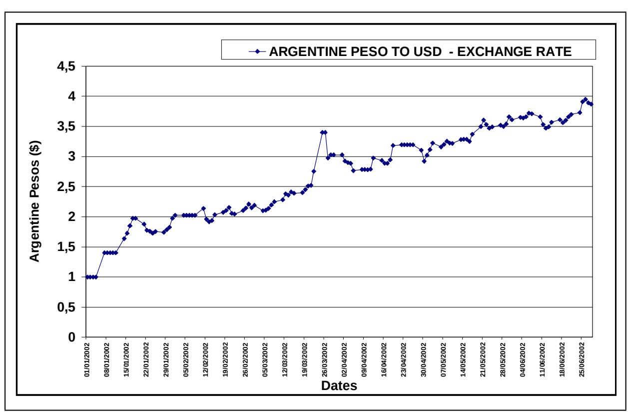



Figure A3: Argentinean and Russian Country Risk Spread.Period: January 1999 –December 2002

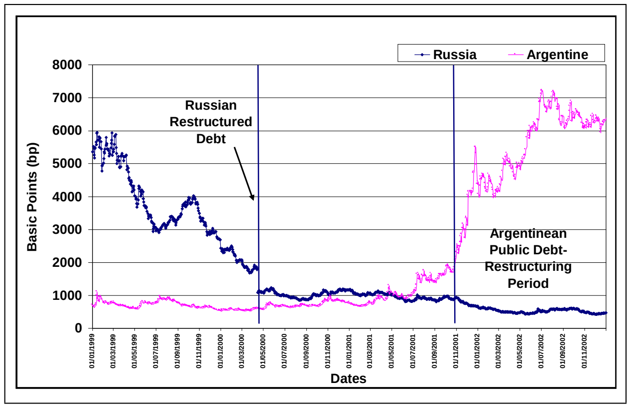



Table A1: International Evidence about Changes in the Exchange Rate Regime

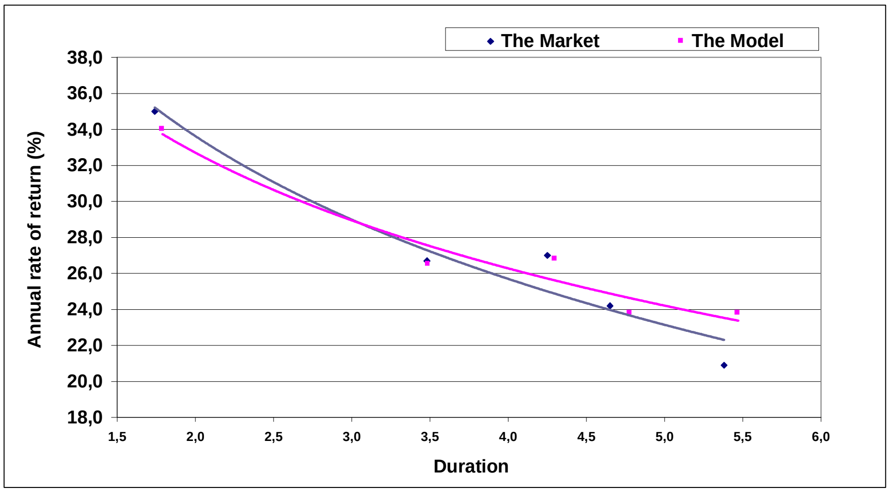
| | Russia '98 | Argentine '01 | Argentine '89 |
|---|---|---|---|
| **Exchange Rate before Devaluation** | 6.29 | 1.00 | 25.00 |
| **Devaluation** | | | |
| Date | Aug-1998 | Dec-2001 | Feb-1989 |
| Exchange Rate a Month After | 16.06 | 2.15 | 40.48 |
| *Variation (%)* | *155,3* | *115.0* | *61.9* |
| Exchange Rate a Year After | 17.00 | 3.37 | 3.69 |
| *Variation (%)* | 293.5 | 237.0 | 14.671,6 |
| Exchange Rate Two Years After | 27.77 | 2.95 | 9.42 |
| *Variation (%)* | *72.9* | *195.0* | *23.180,5* |

Solver Results Sample: The data and the results produced by the Solver for a specific day are presented in the tables. This exercise was repeated for each day in the quarter analysed.

Tables and Figure Sample for October 1st 2001.

| **The Data** | | | |
|---|---|---|---|
| **BOND DESCRIPTION** | **Market** | | |
| | **Duration** | **Yield** | **Price** |
| Global Bond Arg. 03 | 1.74 | 35.0% | 70.75 |
| Global Bond Arg. 06 | 3.48 | 26.7% | 63.5 |
| Global Bond Arg. 10 | 4.25 | 27.0% | 55.25 |
| Global Bond Arg. 17 | 4.65 | 24.2% | 56.25 |
| Global Bond Arg. 27 | 5.38 | 20.9% | 51.75 |

| The Results | | | | | | |
|---|---|---|---|---|---|---|
| BOND | Model | | | Parameters | | |
| DESCRIPTION | Duration | Yield | Price | Alpha | Beta | Recovery |
| Global Bond Arg. 03 | 1.79 | 34.0% | 70.6 | 0.15 | 0.00 | 28.45 |
| Global Bond Arg. 06 | 3.49 | 26.5% | 63.7 | | | |
| Global Bond Arg. 10 | 4.30 | 26.8% | 54.1 | 1.92 | Minimised Equation (5 | |
| Global Bond Arg. 17 | 4.78 | 23.8% | 56.8 | 0.00 | Equation (6) Equalised | |
| Global Bond Arg. 27 | 5.47 | 23.8% | 52.3 | | to zero | |




The blue logarithmic curve represents the market curve whereas the pink line represents the curve which results from the estimations produced by the model. In the figure, it is possible to visualise the degree of adjustment the model proposes in the cases of small statistic errors, which are less than 2 as this case shows. A Solver of a higher resolution would enable a level of adjustment for all price combinations.

Table A2: Data and Results: The bigger Square Residuals which could still be optimised are emphasised in bold type.

| Date | RA 03 | RA 06 | RA 10 | RA 17 | RA 27 | Average Prices | Alpha | Recovery Rates | (SSR) |
|---|---|---|---|---|---|---|---|---|---|
| **1st Oct.** | 70,8 | 63,5 | 55,3 | 56,3 | 51,8 | 59,5 | 14,82 | 28,45 | 1,92 |
| **2** | 69,8 | 62,5 | 53,0 | 56,0 | 49,8 | 58,2 | 14,95 | 27,21 | 1,83 |
| **3** | 69,1 | 61,6 | 52,5 | 54,0 | 49,8 | 57,4 | 15,28 | 28,45 | 1,95 |
| **4** | 67,6 | 59,6 | 50,3 | 52,7 | 48,4 | 55,7 | 15,68 | 27,07 | 0,38 |
| **5** | 67,9 | 58,6 | 49,3 | 52,1 | 47,8 | 55,1 | 15,00 | 27,92 | 0,95 |
| **9** | 64,3 | 57,5 | 49,3 | 50,5 | 47,8 | 53,9 | 17,50 | 27,47 | 2,34 |
| **10** | 64,4 | 57,9 | 49,6 | 50,4 | 47,6 | 54,0 | 17,12 | 26,80 | 3,69 |
| **11** | 65,5 | 58,7 | 54,3 | 51,1 | 48,5 | 55,6 | 20,46 | 34,79 | **33,78** |
| **12** | 64,9 | 59,1 | 51,0 | 51,5 | 48,4 | 55,0 | 16,99 | 27,71 | 5,04 |
| **15** | 65,0 | 58,0 | 49,9 | 52,0 | 48,0 | 54,6 | 18,21 | 30,68 | 2,86 |
| **16** | 65,7 | 60,4 | 52,0 | 54,1 | 50,5 | 56,5 | 20,70 | 38,65 | **15,48** |
| **17** | 67,4 | 63,3 | 55,0 | 58,8 | 52,0 | 59,3 | 17,25 | 33,42 | 7,90 |
| **18** | 66,5 | 58,8 | 54,1 | 54,6 | 50,1 | 56,8 | 19,37 | 38,71 | **19,09** |
| **19** | 67,5 | 59,0 | 56,2 | 55,3 | 53,3 | 58,3 | 13,28 | 40,94 | **20,40** |
| **22** | 68,5 | 59,9 | 55,5 | 56,5 | 53,0 | 58,7 | 18,12 | 34,38 | 7,39 |
| **23** | 68,0 | 60,3 | 54,8 | 55,8 | 51,5 | 58,1 | 18,93 | 39,35 | **15,65** |
| **24** | 67,5 | 61,3 | 53,8 | 55,5 | 52,5 | 58,1 | 17,79 | 33,09 | 1,42 |
| **25** | 67,0 | 60,5 | 53,4 | 55,0 | 52,0 | 57,6 | 19,31 | 39,48 | **11,03** |
| **26** | 64,9 | 58,5 | 50,6 | 53,6 | 49,8 | 55,5 | 19,20 | 32,85 | 0,97 |
| **29** | 56,4 | 53,8 | 45,5 | 51,8 | 47,9 | 51,1 | 27,14 | 37,29 | 6,71 |
| **30** | 58,0 | 56,0 | 45,3 | 48,0 | 42,0 | 49,9 | 18,84 | 25,42 | **25,91** |
| **31st Oct.** | 54,0 | 51,8 | 44,9 | 47,0 | 45,0 | 48,5 | 27,12 | 34,50 | 8,47 |
| **1st Nov.** | 51,4 | 49,4 | 41,4 | 45,1 | 43,0 | 46,1 | 28,27 | 32,77 | 7,79 |
| **2** | 40,0 | 42,5 | 39,8 | 40,8 | 37,0 | 40,0 | 27,77 | 39,27 | **15,18** |
| **5** | 50,2 | 47,8 | 39,8 | 43,9 | 40,7 | 44,5 | 27,72 | 30,59 | 8,56 |
| **6** | 49,0 | 47,0 | 41,0 | 44,0 | 43,0 | 44,8 | 32,68 | 34,48 | 3,49 |
| **7** | 50,0 | 46,8 | 43,8 | 44,3 | 44,0 | 45,8 | 33,64 | 36,03 | 5,38 |
| **8** | 48,5 | 46,5 | 41,3 | 42,0 | 40,0 | 43,7 | 30,47 | 31,83 | **12,69** |
| **9** | 47,5 | 45,0 | 39,0 | 40,0 | 40,0 | 42,3 | 30,51 | 30,42 | 9,23 |
| **12** | 47,0 | 48,0 | 39,8 | 40,5 | 40,5 | 43,2 | 31,84 | 32,21 | **27,06** |
| **13** | 46,0 | 41,4 | 37,4 | 40,5 | 36,0 | 40,3 | 30,44 | 28,17 | 6,82 |
| **14** | 46,0 | 41,0 | 35,5 | 40,0 | 38,0 | 40,1 | 30,73 | 28,22 | 0,35 |
| **15** | 49,0 | 43,0 | 37,5 | 38,0 | 38,0 | 41,1 | 26,11 | 25,45 | 6,76 |
| **16** | 47,0 | 40,5 | 34,4 | 37,3 | 33,0 | 38,4 | 25,22 | 21,59 | 5,65 |
| **19** | 44,8 | 39,0 | 33,4 | 35,3 | 31,0 | 36,7 | 26,16 | 20,66 | **10,63** |
| **20** | 40,6 | 35,0 | 29,3 | 35,3 | 30,0 | 34,0 | 30,35 | 21,43 | 6,38 |
| **21** | 42,0 | 36,0 | 31,4 | 37,3 | 30,0 | 35,3 | 29,86 | 22,46 | **15,08** |
| **22** | 41,0 | 38,0 | 31,9 | 36,8 | 34,0 | 36,3 | 33,74 | 26,11 | 2,81 |
| **23** | 45,5 | 38,0 | 32,1 | 37,8 | 34,0 | 37,5 | 20,81 | 14,63 | **40,56** |
| **26** | 46,0 | 39,4 | 36,5 | 40,1 | 37,0 | 39,8 | 21,89 | 18,16 | **56,97** |
| **27** | 45,0 | 39,8 | 33,6 | 37,8 | 37,0 | 38,6 | 30,13 | 26,21 | 1,33 |
| **28** | 45,0 | 40,2 | 32,9 | 38,0 | 35,0 | 38,2 | 28,60 | 24,55 | 2,70 |
| **29** | 44,5 | 39,0 | 32,4 | 33,8 | 30,0 | 35,9 | 25,10 | 18,71 | **12,84** |
| **30th Nov.** | 44,5 | 35,3 | 30,3 | 32,0 | 29,0 | 34,2 | 24,64 | 16,28 | 3,94 |
| **1st Dec.** | 37,0 | 34,4 | 29,5 | 37,3 | 26,0 | 32,8 | 34,7 | 22,94 | **50,24** |
| **4** | 42,0 | 38,0 | 32,0 | 37,9 | 30,0 | 36,0 | 29,1 | 22,60 | **21,92** |
| **5** | 38,1 | 30,4 | 31,3 | 31,6 | 30,0 | 32,3 | 27,5 | 17,20 | **33,65** |
| **6** | 37,0 | 33,8 | 30,0 | 30,5 | 28,0 | 31,9 | 33,6 | 21,28 | **12,15** |
| **7** | 37,0 | 33,5 | 29,5 | 31,0 | 30,0 | 32,2 | 35,0 | 22,45 | 3,52 |
| **10** | 36,8 | 32,8 | 29,0 | 29,0 | 29,0 | 31,3 | 33,6 | 20,73 | 8,21 |
| **11** | 36,0 | 34,0 | 29,0 | 30,0 | 29,0 | 31,6 | 35,4 | 22,04 | 8,98 |
| **12** | 35,9 | 34,4 | 30,1 | 30,0 | 31,0 | 32,3 | 38,3 | 24,16 | **10,34** |
| **14** | 37,0 | 33,1 | 30,0 | 27,1 | 32,0 | 31,8 | 35,1 | 22,15 | **28,60** |
| **17** | 36,5 | 33,6 | 29,4 | 30,0 | 31,5 | 32,2 | 36,6 | 23,30 | 6,98 |
| **18** | 35,5 | 34,0 | 30,5 | 27,5 | 32,0 | 31,9 | 39,4 | 24,21 | **28,80** |
| **19** | 36,1 | 33,4 | 29,5 | 25,8 | 30,0 | 31,0 | 34,3 | 20,77 | **35,52** |
| **20** | 28,5 | 34,5 | 29,5 | 26,3 | 32,0 | 30,2 | 28,9 | 16,08 | **161,81** |
| **21st Dec.** | 28,9 | 28,5 | 26,0 | 23,9 | 25,3 | 26,5 | 45,5 | 20,79 | **17,10** |
| **26** | 28,0 | 28,0 | 23,3 | 23,9 | 26,0 | 25,8 | 45,3 | 20,01 | 9,41 |
| **27** | 29,8 | 25,5 | 24,0 | 26,0 | 23,0 | 25,7 | 38,9 | 17,50 | 5,37 |
| **28th Dec.** | 31,0 | 28,0 | 26,0 | 28,0 | 25,0 | 27,6 | 40,4 | 20,15 | 5,11 |

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