

# MODELLING THE EVOLUTION OF HOUSEHOLDS' DEFAULTS\*

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## ABSTRACT

The implementation of stress tests requires, *inter alia*, having available instruments to project losses in credit portfolios, in particular under different macroeconomic scenarios. This article presents empirical regularities between measures of credit risk in banks' portfolios and macro-economic variables. Two econometric models are estimated, respectively for the mortgage segments (loans to households for housing purpose) and loans for consumption and other purposes.

## 1. INTRODUCTION

Over the last few decades, several episodes of intense credit risk materialisation in developed countries were underlying widespread banking crises. These were, in most cases, due to a combination of high leverage and the occurrence of significantly unfavourable shocks in economic activity. In this regard, Pesola (2005, 2007) undertakes a thorough exploration of the role of macroeconomic factors in explaining loan losses in Nordic and a few other developed countries which experienced banking crises. In fact, credit markets, and capital markets at large, are characterised by uncertainty and informational problems that may lead to higher than desired risk-taking during the ascending phase of the credit cycle.

A detailed theoretical discussion on credit market frictions, which can explain why credit risk materialization may deviate substantially from expectations at origination, is outside of the scope of this work. However, a few can be mentioned such as: (i) myopia; (ii) changes in investors' sentiment leading to cycles where there is increasing demand for non-monetary assets (including real assets) followed by sharp reversals towards monetary assets – Kindleberger (1978); (iii) herd behavior – Banerjee (1992); (iv) short-termism in incentives to management; (v) lack of institutional memory (the credit cycle is sufficiently long to imply the rotation of people in the underwriting process – Berger and Udell (2004)); (vi) through-the-cycle shifts in adverse selection and moral hazard effects (e.g., at the time a bank tries to increase interest rates to compensate for ex-post signs of increasing credit risk it may induce safer projects not to be financed, while providing incentives for borrowers to switch from safe to riskier projects – Stiglitz and Weiss (1981, 1983)).

Having said that, models based on simple econometric relationships able to simulate developments in defaults in banks' loan portfolios under different macroeconomic scenarios are crucial in the design of stress tests – Gambera (2000), Andersen *et al.* (2008), Hoggart *et al.* (2005). In turn, the latter are an instrument to assess the adequacy of banks' capital to withstand severe but plausible shocks, exactly those that would qualify as adequate for stress tests.

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In this work, we present models aimed at simulating defaults in the household sector, with a breakdown for loans to households for housing purposes (mortgages) and loans for purposes other than housing (consumption and other purposes). Past empirical approaches to credit risk have been dedicated mostly to the non-financial corporations' sector. One of the reasons for this is the fact that micro-level information for non-financial corporations is more readily available with sufficient depth in the time-series domain, from proprietary databases or based on public information concerning the bond market.<sup>1</sup> Another reason relates to the fact that most banking crises that erupted up to the 1990's were associated to problems in the corporate sector, while losses in the portfolio of loans to the household sector were not material enough in the aggregate. However, the very high rise in leverage of the household sector during the 2000's changed this profile dramatically, so that increased attention started to be dedicated to the determinants of risk of default in the household sector, both in the cross section and in the time series domain – Rinaldi and Sanchis-Arellano (2006); for the Portuguese case see Farinha and Lacerda (2010).

Further, direct default rates (the empirical *ex-post* counterpart of probabilities of default) are more easily available for firms and can be disaggregated by relevant characteristics of firms (such as size and economic sector of activity) with different sensitivities to macroeconomic factors. In Portugal, in the absence of time series of defaults in loans to households at the micro level (or aggregate indicators based on actual defaults) covering at least one business cycle, the estimation of a relationship between defaults and cyclical factors has to make recourse to alternative aggregate indicators we can confidently use as a proxy for default rates. Firstly, stock measures of non-performing loans (or other measure of problem loans) are not adequate, as they reflect the past accumulation of loans fallen due. As such, they retain a long memory of past default episodes and strong persistence. On its turn, both the loan loss provisions (impairments in IAS/IFRS concept) charge and write-off rates are appealing at first sight. However, they are influenced by changes in banks' provisions and write off policies and in accounting standards, so that time series are prone to spurious lumpiness. Another possibility, which we will follow in this paper, is to take the flow in problem loans as a percentage of the stock of gross loans (further ahead we will define more precisely this variable). This indicator can be interpreted as the default rate in each of the two segments of loans to households – Marcucci and Quagliariello (2008), as long as cure rate curves remain proportional to default seasoning in the sample period.

In this paper, we opt for estimating a single multivariate equation, rather than a VAR model, the latter being particularly popular in the literature because it takes care of all possible interactions between variables. However, the integration of the output of VAR models into a full blown stress test infrastructure, including a macro-economic model is not as straightforward. It should be noted that non-linearities have been identified in the empirical literature as a relevant feature of credit risk models. As a matter of fact, the sensitiveness of credit risk variables to macro-economic variables are often time-variant through-the-cycle. In particular, they show up to be more responsive to macro-economic factors in recessionary periods than in non-recessionary periods – see Marcucci and Quagliariello (2009), Laevan and Majnoni (2003), Gasha and Morales (2004), Misina and Tessier (2008).<sup>2</sup>

Finally, it should be highlighted that this paper does not address issues about banks' provisioning policies or the respective procyclicality. Those issues would have to be tackled within a broader framework where provisions/impairments are directly used as the variable of interest, in conjunction with the cyclical evolution of income gross of provisions – see Bikker and Metzmakers (2005), Luc and Majnoni (2003), Bikker and Hu (2005).

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<sup>1</sup> In this regard, see Pederzoli and Torriceli (2005), Bonfim (2009), Simons and Rowles (2009), Allen and Saunders (2004), Sorge and Virolainen (2006), Gambera (2000), Andersen *et al.* (2008) and Jakubík (2006).

<sup>2</sup> It must be said also that when models estimate default rates (or ratios which are to proxy it) directly without any non-linear transformation, the model can predict values that lay outside the admissible range for the variable. In particular, predicted values can fall below zero. A way to obviate that would be to use a logistic transformation, which transform a variable with support minus infinity to plus infinity into the [0,1] range.

The note is organized as follows. In Section 2 we describe the main features of the data that will be estimated. In Sections 3 and 4 we present the econometric models underlying the estimation. Section 5 presents out-of-sample forecasts of the models, using Banco de Portugal’s latest macroeconomic projections. Section 6 concludes.

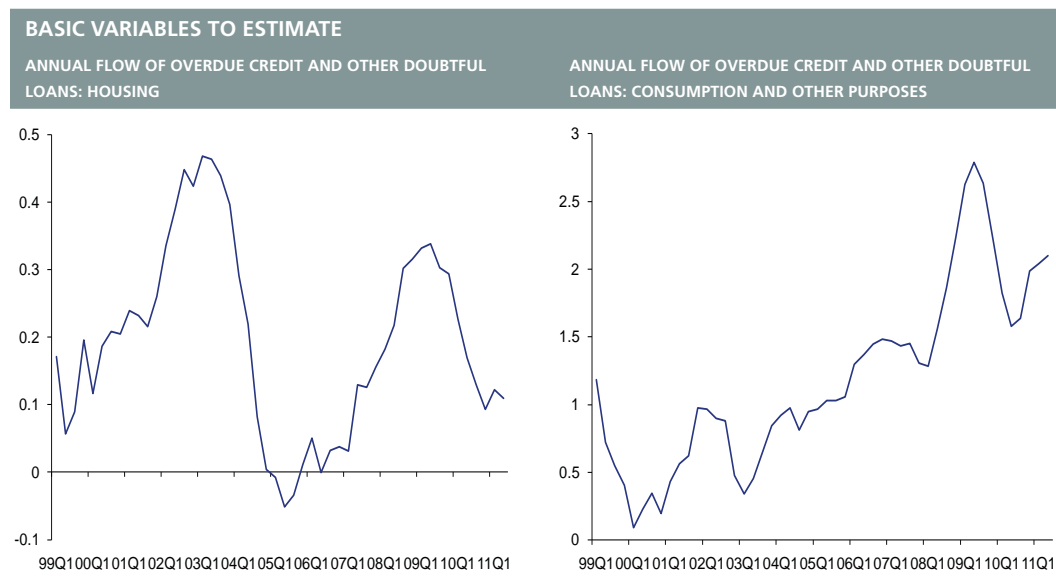
## 2. THE DATA

In order to estimate losses in the banks’ household credit portfolios we would ideally start by computing probabilities of default (PD) based on individual data on household loans and subsequently apply a standard loss-given default (LGD) to those PDs. This would mimic the methodology used at Banco de Portugal to calculate credit losses in non-financial corporations.<sup>3</sup> Unfortunately, sufficiently long-term series are not currently available for these data.<sup>4</sup>

In this paper we present a new methodology to estimate defaults in the banks’ loan portfolios of households based on aggregate macroeconomic data. Importantly, the procedure also allows predicting defaults under changing macroeconomic conditions.

The procedure is rooted in the time-series of the annual flow of overdue credit and other doubtful loans – the latter defined as those loans which fulfil the criteria underlying article 4 of Notice 3/95 of Banco de Portugal – as a percentage of loans, adjusted for securitisation. The series are calculated by adjusting the change in the outstanding amount of overdue credit and other doubtful loans for write-offs/downs from assets, reclassifications and, starting December 2005, sales outside the banking system of overdue credit and other doubtful loans not written off/down from assets, reported on a quarterly basis in accordance with Banco de Portugal Instruction 2/2007. Values are also adjusted regarding the sale of a loan portfolio by *BPN to Parvalorem*. The time-series are available since 1999Q1. We separate loans for housing purposes from loans for consumption and other purposes (Chart 1). Banco de Portugal publishes these series on a regular basis in the *Financial Stability Report*.

Chart 1



Source: Banco de Portugal.

3 See Banco de Portugal’s *Occasional Paper 1/2007 “Financial Sector Assessment Programme Portugal: Banking System Stress Testing Exercise”* for a description of the methodology.  
 4 Banco de Portugal is currently starting a project aimed at filling this gap, which will imply requesting the relevant micro databases from banks.

It should be underlined that these flows do not correspond strictly to a measure of PDs, given that they also include recoveries from previously defaulted loans. Nonetheless, we would expect the evolution of these series to be a reasonable benchmark to project the evolution of PDs.<sup>5</sup>

Chart 1 reveals some interesting features of the data, which are worth highlighting. First, while the annual flow of new overdue credit and other doubtful loans for housing purposes is a stationary variable, the annual flow for consumption and other purposes is clearly non-stationary in the sample period under analysis. Second, in 2011, while the annual flow of new overdue credit and other doubtful loans for housing purposes stood at relatively low levels, the flow for consumption and other purposes increased to very high levels, albeit below the maxima achieved during 2009. Third, these annual flows may on occasion be negative (for example, in case loan recoveries more than compensate new overdue loans). This actually happened in 2005 in the case of housing loans.

The different nature of the two flows of overdue credit implies that we need a different econometric model for each case. The model predicting credit losses in housing loans is presented in the following section. The model for consumption and other purposes is presented in Section 4.

### 3. MODELLING THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: HOUSING

As mentioned above, the annual flow of overdue housing credit and other doubtful housing loans (as a percentage of loans, adjusted for securitisation) is a stationary variable in the sample. Due to data constraints the estimation period spans only from 1999Q1 until 2011Q2. This is a relatively short sample, but has the upside of ensuring that the estimation occurs under the same monetary regime.

The general empirical model is the following

$$Flow\ of\ overdue\ credit_t^{housing} = f\left(M6, spread^{housing}, \Delta^4GDP, \Delta^4U, dummy_{crisis}\right)_{t-j}$$

Where  $M6$  corresponds to the 6-month money market interest rate,  $spread^{housing}$  is the spread between the interest rate on housing loans and the 6-month money market rate,  $\Delta^4GDP$  is the year-on-year rate of change of GDP,  $\Delta^4U$  is the year-on-year change in the unemployment rate and  $dummy_{crisis}$  is a *dummy* variable starting in 2009, which captures the financial crisis period after the failure of Lehman Brothers. These data come from Monetary Statistics and from the latest summer edition of Banco de Portugal's *Economic Bulletin*.

The final specification, estimated using a standard general to specific reduction procedure, is presented in table 1. The in-sample estimates are presented in chart 2. The fit of the model is quite good, in particular when taking into account that no autoregressive term has been added to the equation. The signs of the coefficients are all as expected. Indeed, the annual flow of overdue housing credit and other doubtful housing loans increases with interest rates (both the money market rate and the interest rate spread) and is broadly countercyclical. Furthermore, since the beginning of the crisis, the flow of overdue loans stood above what would be expected on the basis of the above determinants, as reflected in the positive sign of the dummy variable (and its significance). This may be due inter alia to the tightening of financing conditions during this period. Finally, the coefficients are stable throughout the sample (the results from a recursive analysis are available upon request).

<sup>5</sup> In order to test this hypothesis we compared the level and dynamics of the annual flow of overdue credit and other doubtful loans for non-financial corporations with the measure of PDs typically computed by Banco de Portugal using the Portuguese credit register. The results, available upon request, suggest that the evolution of the annual flow of overdue credit and other doubtful loans tracks the evolution of PDs quite closely (albeit at a different level, due to the cure rate).

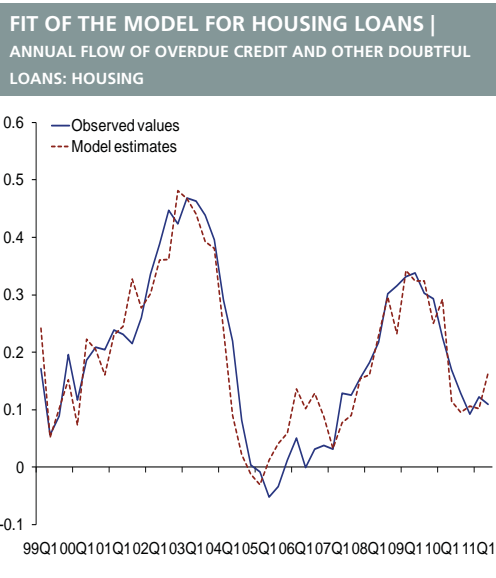
Table 1

MODELLING THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: HOUSING	
Variables	Coefficient
Constant	-0.903*** (-0.09)
$M6_t$	0.196*** (0.017)
$spread_t^{housing}$	0.103*** (0.020)
$spread_{t-2}^{housing}$	0.099*** (0.020)
$spread_{t-4}^{housing}$	0.085*** (0.017)
$\Delta^4 GDP_t$	-0.032*** (0.009)
$\Delta^4 GDP_{t-1}$	-0.034*** (0.009)
$\Delta^4 U_{t-1}$	0.062*** (0.018)
$\Delta^4 U_{t-4}$	0.103*** (0.015)
$dummy_{crisis}$	0.265*** (0.036)
Number of jobs	50
$R^2$	0.864

Source: Authors' calculations.

**Notas:**  $M6$  is the 6-month money market interest rate;  $spread^{housing}$  is the spread between the interest rate on housing loans and the 6-month money market rate;  $\Delta^4 GDP$  is the year-on-year GDP rate of change;  $\Delta^4 U$  is the year-on-year change in the unemployment rate and  $dummy_{crisis}$  is a dummy variable starting in 2009Q1. \*\*\*, \*\* and \* indicate significance at the 1%, 5% and 10% level, respectively.

Chart 2



Source: Authors' calculations.

#### 4. MODELLING THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: CONSUMPTION AND OTHER PURPOSES

The annual flow of overdue credit and other doubtful loans for consumption and other purposes is a non-stationary variable in the sample period (1999Q1-2011Q2). We will thus model this variable in an Error-Correction Mechanism (ECM) framework.

In the sample period there is a long run relation between the annual flow of overdue credit and other doubtful loans for consumption and other purposes, the unemployment rate and the interest rate on loans for consumption and other purposes. This is attested for example with Johansen cointegration tests (see table 2, which displays the tests corrected for small sample bias).

In chart 3 the long run relationship is presented (the note to chart presents the long-run coefficients). In the long run, the annual flow of overdue and other doubtful credit to consumption and other purposes

Table 2

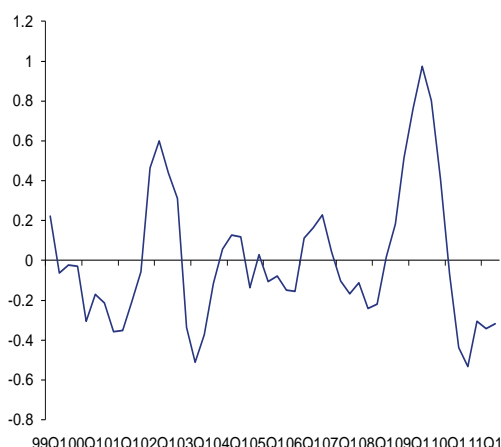
JOHANSEN COINTEGRATION TESTS: SYSTEM WITH THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS FOR CONSUMPTION AND OTHER PURPOSES, THE UNEMPLOYMENT RATE AND THE INTEREST RATE ON LOANS FOR CONSUMPTION AND OTHER PURPOSES		
Rank	Trace test [Prob.] Corrected for small sample bias	Max test [Prob.] Corrected for small sample bias
0	30.56 [0.040]**	24.25 [0.015]**
1	6.32 [0.662]	6.25 [0.588]
2	0.07 [0.040]	0.07 [0.797]

Source: Authors' calculations.

Notas: \*\*\*, \*\* and \* indicate significance at the 1%, 5% and 10% level, respectively.

Chart 3

ERROR CORRECTION MECHANISM – LONG-RUN RELATION BETWEEN THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS FOR CONSUMPTION AND OTHER PURPOSES, THE UNEMPLOYMENT RATE AND THE INTEREST RATE ON LOANS FOR CONSUMPTION AND OTHER PURPOSES | ERROR CORRECTION MECHANISM



Source: Authors' calculations.

Note: The chart depicts the following series:

$$ECM_t = Flow\ of\ overdue\ credit_t^{cons.\ and\ other\ purp.} + 4.153 - 0.305 * U_t - 0.348 * Int.\ rate_t^{cons.\ and\ other\ purp.}$$

has a positive relationship with the unemployment rate and the interest rate on loans to consumption and other purposes.

The short-run dynamics was estimated through a standard general to specific reduction procedure. The final specification turned out to be quite simple (Table 3). The change in the annual flow of overdue credit and other doubtful loans for consumption and other purposes is estimated as a function of an autoregressive term, the quarter-on-quarter change in GDP and the lagged error-correction mechanism. These variables display the expected sign. In particular, the coefficient on the ECM is estimated to be -0.27, which implies that the annual flow returns to its long-term level (as determined by the ECM) at a relatively fast pace. Overall, the model is able to broadly capture the most salient features of the explained variable throughout the sample (Chart 4).

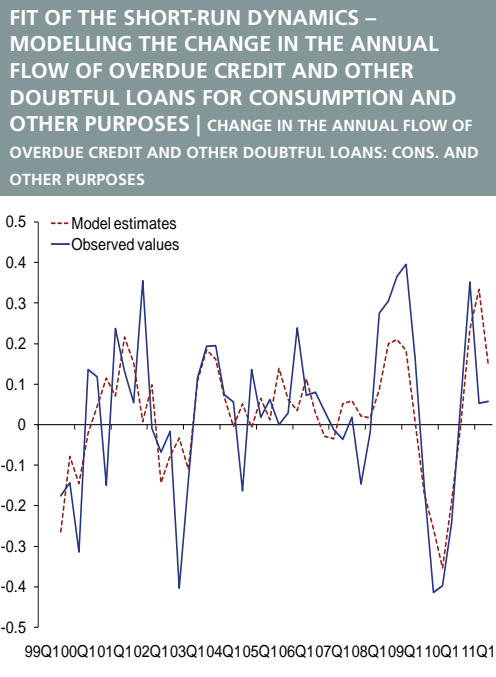
Table 3

MODELLING THE QUARTERLY CHANGE IN THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS – CONSUMPTION AND OTHER PURPOSES	
Variables	Coefficient
Constant	0.030 (0.022)
$\Delta \text{Flow of overdue credit}_{t-1}^{\text{consumption and other purposes}}$	0.551*** (0.105)
$\Delta \text{GDP}_t$	-0.047* (0.025)
$\text{ECM}_{t-1}$	-0.272*** (0.063)
Number of observations	48
R <sup>2</sup>	0.493

Source: Authors' calculations.

Notas: \*\*\*, \*\* and \* indicate significance at the 1%, 5% and 10% level, respectively.

Chart 4

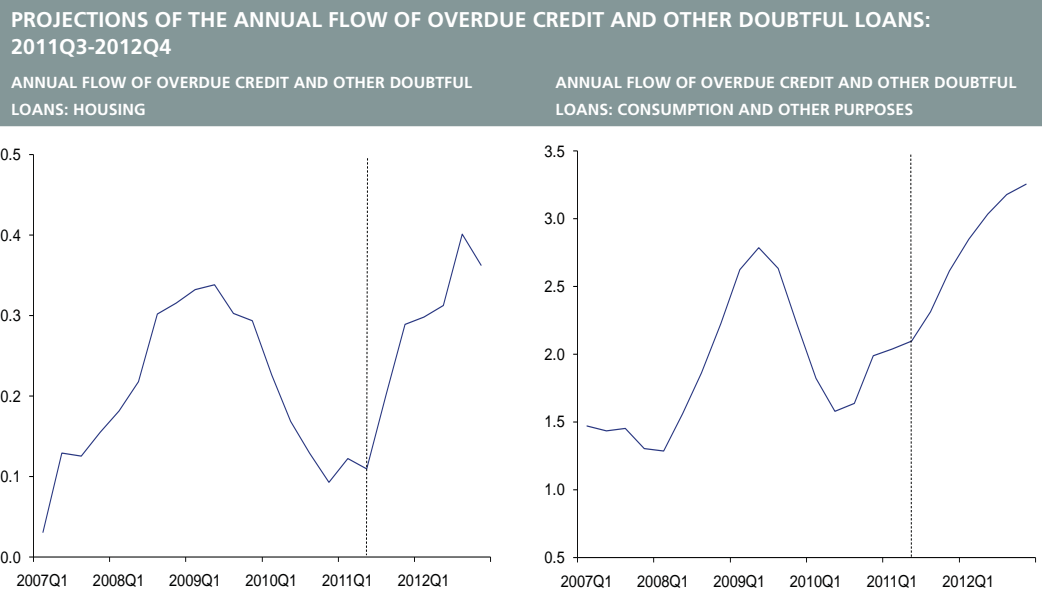


Source: Authors' calculations.

## 5. OUT-OF-SAMPLE FORECASTS

The models described in Sections 3 and 4 can be used to predict the evolution of the annual flow of overdue credit and other doubtful loans under different macroeconomic scenarios. In this section we present out-of-sample forecasts using Banco de Portugal's latest macroeconomic projections. The results, for the period 2011Q3-2012Q4, are presented in chart 5. The results show that under the stringent

Gráfico 5



Sources: INE, Banco de Portugal and authors' calculations.

macroeconomic conditions of the Portuguese economy – and despite the low money market interest rates – the flow of overdue credit and other doubtful loans in both segments should increase significantly in the next quarters, to levels above the ones observed in mid-2009.

## 6. CONCLUSIONS

This note presented two models aimed at estimating the evolution of the annual flow of overdue credit and other doubtful loans, in the two most important segments for households: housing and consumption and other purposes. The in-sample performance of the models seems acceptable and robust.

Under certain conditions – most importantly the broad constancy of the cure rate – the evolution of these flows will be a good proxy for the dynamics of PDs in each loan segment. In this sense, these models allow us to project the evolution of households' defaults under different macroeconomic scenarios.



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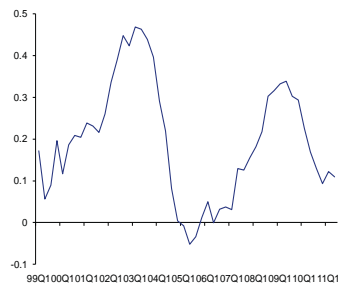
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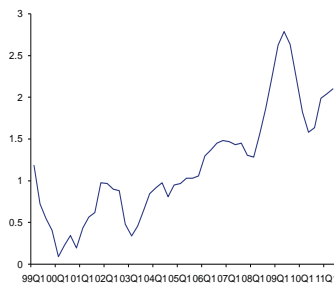
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## ANNEX: THE DATA

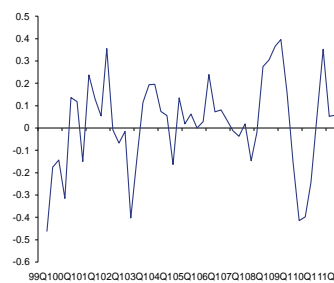
**ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: HOUSING**



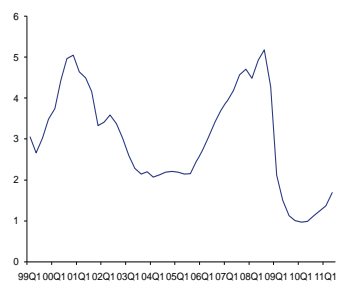
**ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: CONSUMPTION AND OTHER PURPOSES**



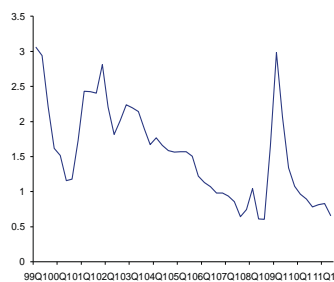
**CHANGE IN THE ANNUAL FLOW OF OVERDUE CREDIT AND OTHER DOUBTFUL LOANS: CONSUMPTION AND OTHER PURPOSES**



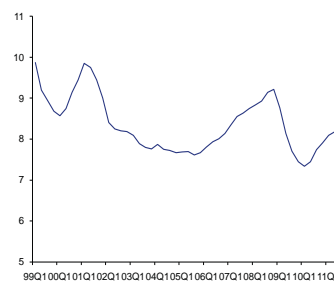
**6-MONTH MONEY MARKET INTEREST RATE**



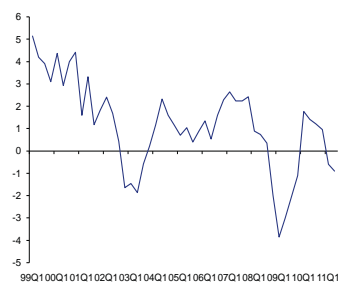
**INTEREST RATE SPREAD (VIS-À-VIS 6-MONTH MONEY MARKET RATE): PRIVATE INDIVIDUALS FOR HOUSE PURCHASE**



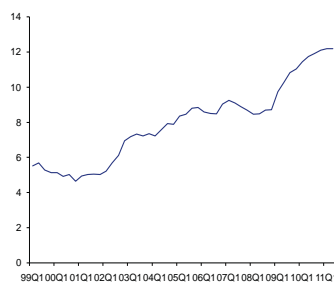
**INTEREST RATE: PRIVATE INDIVIDUALS FOR CONSUMER CREDIT AND OTHER PURPOSES**



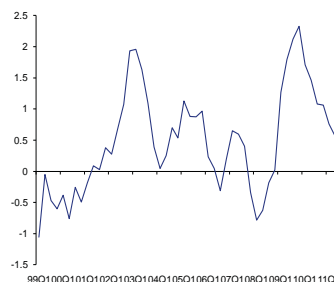
**YEAR-ON-YEAR RATE OF CHANGE OF GDP**



**UNEMPLOYMENT RATE (NEW METHODOLOGY)**



**YEAR-ON-YEAR CHANGE IN THE UNEMPLOYMENT RATE**



Sources: INE and Banco de Portugal.

