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Was there a credit crunch during the 2007-2009 financial crisis? Empirical analysis and evidence from a vector error correction model

Abstract

This paper presents an econometric estimation of the production sector's demand for bank loans and provides empirical evidence to support the theory that, in Italy, over the course of the 2007-09 economic and financial crisis, there has not been a credit crunch. An error correction model (ECM) is used – estimated for the pre-crisis period (1998.Q2-2007.Q2) and applied both with the one and two step procedure – which considers lending as a function of the added value of the private sector, of the gross operating margin to nominal added value ratio (a proxy for self-financing) and of the real interest rate applied to loans. To test the robustness of the results obtained in the first specification of the model, the author removes the assumption of weak exogeneity of the independent variables of the single equation model and constructs a multivariate multiequation model (VECM). All the adopted approaches provide similar results: the demand for credit increases as real added value increases and decreases as the cost of lending and self-financing increase. The dynamic out-of-sample forecast of the model, relating to the first two-year period of economic and financial crisis (2007.Q3-2009.Q2), shows that the actual loan stock remained well above the "theoretical" level forecasted on the basis of the functional relationships estimated before the crisis. This delta is interpreted as the outcome of a rightward shift of the credit supply curve, rather than a leftward shift as would have happened in a credit crunch scenario.

Keywords: credit crunch, Italian banks, bank lending, production sector, loan demand, error correction model, cointegration.
JEL Classification: C32, C51, E44.

Introduction

Economic literature and past experience show that credit and finance play a decisive role in economic growth. The occurrence of an epoch-making financial crisis and of one of the most severe recessions in economic history has therefore led to questions, throughout the world, as to the risk that the generalized process of bank deleveraging and the rapid deterioration of the income conditions of households and enterprise could generate a credit crunch with consequent negative repercussions on production activity.

The objective of this paper is to explore bank lending trends to non-financial corporations and verify if there are actually grounds to sustain that there has been a credit crunch in Italy during the 2007-09 financial crisis. It contributes to the debate on three fronts: (1) it describes and evaluates credit dynamics using different methods; (2) it estimates a loan demand model for the historic period before the financial crisis; (3) it uses said model and offers proof that would seem to counter the hypothesis of a credit crunch.

The paper is organized as follows. Section 1 provides the economic meaning of credit crunch on the basis of the approach commonly used in literature. Section 2 describes credit and production activity during the crisis and provides first descriptive tools to be able to evaluate the presence, or otherwise, of a credit crunch in Italy, correlating credit trends with those of industrial production and GDP. Section 3 econometrically estimates a demand for loans function and uses it to compare the amount of actual loans with that forecasted on the basis of the model estimated in the pre-crisis period. The final section summarises the main conclusions.

1. Credit crunch: definition and analysis tools

In order to verify the existence, if any, of a credit crunch, we first have to establish the economic meaning of this term. The definition of credit crunch most commonly used in literature is that of Bernanke and Lown (1991, p. 207): "a significant leftward shift in the supply of bank loans, holding constant both the real interest rate and the quality of potential borrowers".

According to this definition, a credit crunch represents a decline in the supply of credit (leftward shift of the curve) of an excessive and anomalous magnitude with respect to the trend of the business cycle; the focal point, therefore, entails valuing the decline in the supply of credit against the performance of the economy, taking for granted the fact that the bank lending tends to normally and physiologically slow down or decline during a period of recession[1].

This definition suggests two analysis approaches:

♦ a more description approach is expanded in section 2, which entails comparing the credit trend with those of the main indicators of the business cycle (industrial production and GDP);

♦ a more analytical approach is illustrated in section 3, which is based on the construction of an eco-

[1] For more details on the interpretation and the causes of the credit crunch, see Clair and Tucker (1993).

nometric model, which explains credit trends as a function of its determinants and which emphasizes the short- and long-run statistical relation between credit variables and the macroeconomic scenario.

2. Credit and production activity during the crisis

Loans to the production sector have shown a marked slowdown in 2008-2009: the annualized quarterly change was about -2.1% in August 2009. In the same period, the industrial production index (a possible proxy of the firm's credit demand for new investment in industry) collapsed to all intents and purposes, further deteriorating as of September 2008: the annual change of the seasonally-adjusted series fell from +3.2% in July 2007 to -24.9% of March 2009, only partially recovering in the following months. Therefore, the slowdown in credit was actually fairly modest if compared to industrial production dynamics (Figure 1): loans continued to rise y-o-y, also in the presence of a downsizing of investment projects by companies[1, 2].
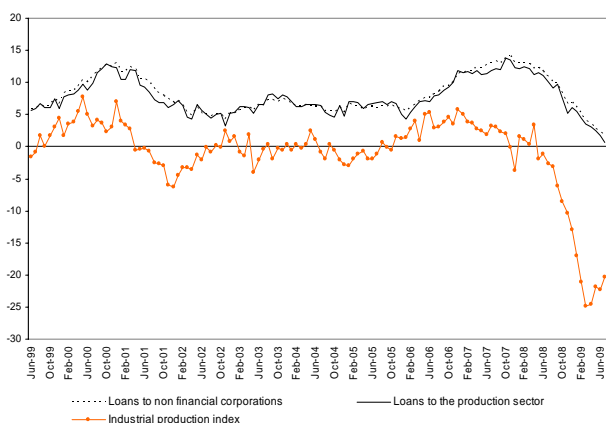
Source: Author's computations on Bank of Italy and Istat data.

Fig. 1. Credit and industrial production: annual growth rates (% change; seasonally-adjusted data)

A similar conclusion is reached if the long-run trend is removed from outstanding loans and the industrial production index (Figure 2)[3].
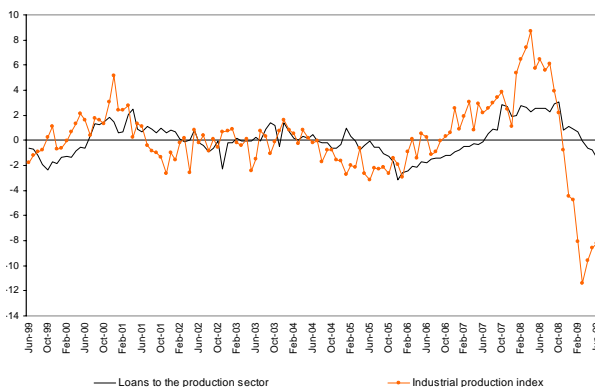
Source: Author's computations on Bank of Italy and Istat data.

Fig. 2. Credit and industrial production: the cyclical component (percentage gap with respect to the long-run trend)

To what extent can it be claimed that the collapse of industrial production led to the slowdown in lending? Granger's causality test (Granger, 1969) shows that, by using the cyclical components of the two time series analyzed in the last decade, this claim could be upheld: the results obtained say, in fact, that the production index causes bank loans and not the contrary (Table 1)[4].

Table 1. Credit and industrial production: pairwise granger causality tests

Sample period: 06.1999 - 07.2009 (monthly data)		
Null hypothesis	F-statistic	Probability
Industrial production does not Grange cause loans to the production sector	8.911	0.000
Loans to the production sector do not Grange cause industrial production	1.291	0.279
Lags 2: The test consider the variables' cyclical components, obtained removing the long period components (computed using the Hodrick-Prescott filter)		

Source: Author's computations on Bank of Italy and Istat data.

This substantiates the conclusion that lending slowed down during the crisis due to the very high and more than proportional fall in the firm's loans demand for new investments.

However, the analysis conducted above has three critical aspects. Firstly, it was conducted on a relatively limited historic time period: as a longer homogeneous time series for loans was not available, only the last decade was considered; this does not enable us to verify what happened in past recessions (such as for example that of 1992-93).

Furthermore, note that industrial production, unlike loans, is expressed in real terms and, as it does not include services, regarding a sector that represents less than 30% of added value.

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[1] The comparison between the trend of the industrial production index and loan dynamics has a limitation stemming from the fact that we are comparing a nominal aggregate (loans) to an index expressed instead in real terms (industrial production). However, our calculations show that even if loans are deflated with the price index (consumer and production), the same conclusions are reached: the slowdown in loans (in real terms) over the past one and a half years has been decidedly more contained that the collapse of the production index.

[2] The significant fall in the demand for loans by enterprises to fund new investment projects is confirmed by the results of a recent survey on bank lending (Bank Lending Survey) conducted by the Bank of Italy and the European Central Bank.

[3] The long-run trend was calculated by applying the Hodrick-Prescott filter. Again, results are similar even if loans are considered in real terms (deflated with the consumer or production price index).

[4] This result is obtained by considering both loans in nominal and real terms (deflated with the consumer price index).

Lastly – passing to the third critical aspect – only the demand for loans to fund new investment projects has been considered, ignoring for example the fact that the demand for loans may also increase to cover new liquidity requirements that have occurred due to a sudden fall in self-financing.

To circumvent the latter problem, all of the possible determinants of the demand for loans must be considered: the econometric model developed in section 3 seeks to offer a solution to this aspect.

With regard, on the other hand, to the first two critical aspects, a first improvement of the analysis was made by observing credit dynamics with relation to the trend of nominal GDP, both recently and with regard to Italian recessions in past decades. As a uniform time series for loans for the period prior to 1998 is not available, a recent research conducted by the International Monetary Fund (IMF) was used, which explores the topic of credit crunch, using data for Italy from 1970 onwards (IMF World Economic Outlook, April 2008)[1].

Following Bernanke and Lown's definition, the IMF has defined a bank credit squeeze "as a slowdown in the growth rate of the bank credit-to-GDP ratio sharper than that experienced during a normal business cycle downturn" and a bank credit crunch as "a severe bank credit squeeze driven by a significant decline in the banking system's supply of credit" (IMF World Economic Outlook, April 2008, pp. 10-11). Its empirical study shows that, on the basis of the historic evidence considered, in Italy we should talk about a credit squeeze/crunch in the presence of an annual rate of change of the bank credit-to-GDP ratio of between 0.6% and 1%[2].

Calculated on the total amount of loans to the production sector, the annual rate of change of the bank credit-to-GDP ratio fell in 2008 and in the first half of 2009 (Figure 3), but it has still remained decidedly positive (from +9.1% in the first quarter of 2008 to +3.8% in the second quarter of 2009), showing a value that is considerably higher than -0.6% threshold indicated by the IMF[3].
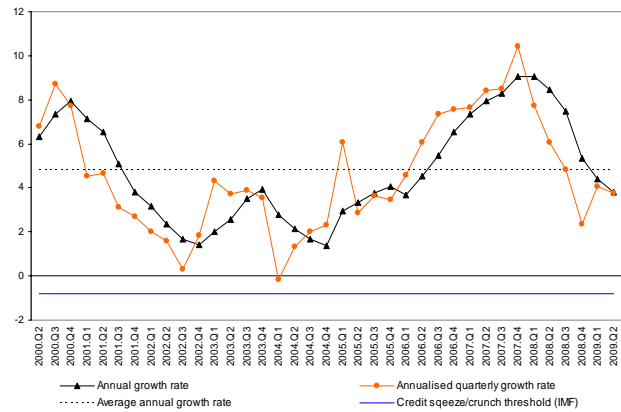
Source: Author's computations on Bank of Italy and Istat data.

Fig. 3. Dynamics of the bank credit-to-GDP ratio of the production sector (% change; quarterly data 2.2000-2.2009)

The analysis of the bank credit-to-GDP ratio would appear to indicate better credit (per unit of GDP) dynamics for the 2007-2009 period with respect to the trend shown in previous downturns experienced from 1970 onwards, and enable us to reject the hypothesis of both credit crunch and credit squeeze[4].

3. Bank lending and credit demand: an econometric analysis

The comparison between trend of loans and industrial production dynamics would almost appear to point to an excess of credit supply with respect to the demand for loans by companies to fund new investment. This gap could however be explained by the increase in the demand for bank loans to cover the lack of resources that companies are able to draw upon through self-financing. On the other hand, lending dynamics have certainly also been influenced by other factors, the role of which can be understood and measured using an econometric analysis.

In line with a research approach that returned to popularity in the early 90's, we therefore construct and estimate an equation able to summarize the relationships that link credit demand with its main determinants[5].

This analysis, conducted on the basis of a quarterly database covering the period between the second quarter of 1998 and the second quarter of 2009, breaks down into two stages:

♦ In the first stage (Section 3.1) we estimate a loans demand equation in the pre-crisis period (up until 2007.Q2) in order to verify what were the relationships that linked credit to the va-

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[1] The time period analyzed for Italy in this IMF study is that between the first quarter of 1970 and the second quarter of 2007. Therefore, it does not take the lending trend in the last two years into account.
[2] In its study, the IMF establishes this threshold by identifying the episodes of credit squeeze/crunch in all of those quarters in which the rate of growth of the bank credit-to-GDP index was in the lowest decile of the distribution. Said episodes occurred in Italy between the fourth quarter of 1993 and the second quarter of 1996.
[3] The bank credit-to-GDP ratio is calculated as the ratio between the seasonally adjusted good loans (net of the non-performing loans) and the four periods mobile sum of nominal GDP.

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[4] Another interesting study on credit dynamics in recession periods is that of Bassanetti et al. (2009), published by the Bank of Italy. Their results do not appear to significantly contrast with those obtained in this paper.
[5] See in particular Sorensen, Ibanez and Rossi (2009), Gambacorta and Rossi (2007), Casolaro, Eramo and Gambacorta (2006), Calza, Manrique and Sousa (2006) and Calza, Gartner and Sousa (2003).

riables of the scenario under normal conditions, namely before the structural break, caused by the financial crisis, occurred;

♦ In the second stage (Section 3.2) we used the relationships estimated above for the pre-crisis period and we make an out-of-sample dynamic forecast for the 2007-2009 period (2007.Q3-2009.Q2), in order to compare the amount of actual credit with the amount that the model would have predicted on the basis of the evolution of the economic scenario.

3.1. A loan demand model in the pre-crisis period. The basic model used is the error correction model (ECM), which links – in the short and long run – loans to the production sector with the cost of lending and with some indicators on production levels and on the self-financing capacity of the private sector (added value and gross operating margin).

This model was applied using three different approaches:

♦ The two-step procedure ECM by Engle and Granger (1987), in which first the long-run equation and then the short-run relations are estimated;

♦ The one-step procedure ECM, in which short and long-run equations are estimated simultaneously;

♦ The vector error correction model (VECM), with a multivariate analysis characterized by a system with several simultaneous equations.

In the first two equations, we use the basic assumption of weak exogeneity of the independent variables used in the loans equation, considering the credit trend as the only endogenous variable. The VECM represents an alternative model, which enables us to eliminate the assumption of weak exogeneity of the lending determinants and to consider all of the variables analyzed as endogenous.

The variables used are defined as follows:

♦ *IMP* are loans to the production sector (both medium-large and small non-financial firms) resident in Italy, net of gross non-performing loans (end-of-quarter outstandings, seasonally-adjusted data);

♦ *VAK* is the added value of the private sector expressed in real terms (at constant prices, seasonally-adjusted data);

♦ *VAN* is the added value of the private sector expressed in nominal terms (at current prices, seasonally-adjusted data);

♦ *MOL* is the gross operating margin (*VAN – Total labor cost*);

♦ *TIMP* is the average real interest rate on loans to medium-large non-financial firms (calculated on outstanding loans; end-of-quarter data)[1, 2, 3].

The source of the bank variables is the Bank of Italy, while Istat is the source of those relating to gross operating margin and added value.

The first objective of the analysis is to estimate a credit demand function of the following type: $IMP = f(VAK, MOL/VAN, TIMP)$.

The demand for loans, according to economic theory, falls as the interest rate applied to the same rises: from the estimations, we would expect a minus sign for the coefficient associated to the variable *TIMP*.

In the credit demand equation that we wish to consider, *VAK* represents the scale variable[4]. Added value is a production indicator: as *VAK* rises, it will be fair to expect a higher demand for bank loans (we expect a coefficient with a plus sign).

On the other hand, the gross operating margin represents gross operating profit before amortization and depreciation and corresponds to what remains of added value after having deducted labor costs; so it incorporates the level of self-financing generated before any extraordinary charges or income, financial charges and taxes. *MOL* is very important for the operating management analysis: it is not influenced by any accounting policies regarding amortizations, depreciations or allowances and shows a company's self-financing capacity. If other factors are equal, an increase of *MOL/VAN* increases a company's self-financing capacity and should lead to a lower demand for bank lending: we, therefore, expect the coefficient for this variable to have a minus sign.

A descriptive analysis, over the whole period considered, shows that there is a strong positive correlation between *IMP* and the added value of the private sector (correlation of 97% with the nominal added value and of 84% if the latter is expressed in real terms). The annual trends of these variables appear to be very closely linked over the past decade: the main stages of upturn (in 2000 and 2006) or downturn (in 2001-2002 and 2008-2009) of credit dynamics occurred at the same time as a higher or lower growth in added value (Figure 4).

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[1] The added value of the private sector was calculated by subtracting the "non market" portion provided by Istat from total added value.
[2] The real interest rate was calculated by deflating the nominal interest rate with the annual growth rate of the added value deflator of the private sector.
[3] In the calculation of the average real interest rate, loans to smaller firms have not been considered as not available in the data provided by Bank of Italy.
[4] In the credit demand function in question, the added value expressed in nominal terms already appears as the denominator of the *MOL/VAN* ratio. To avoid problems of collinearity between regressors, we therefore decided to use the added value expressed in real terms as the scale variable of firm's activity.
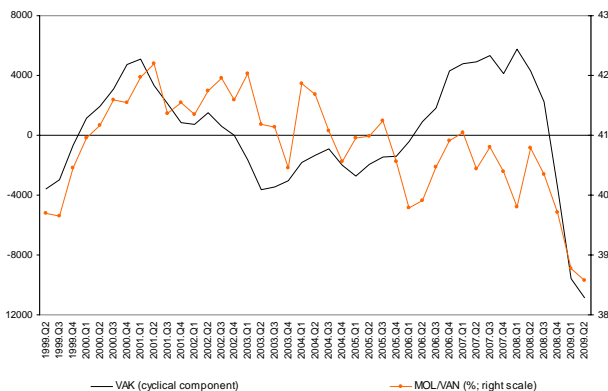
Source: Author's computations on Bank of Italy and Istat data.

Fig. 4. Loans and added value of the private sector: annual growth rates (quarterly data; % change)

During the 2007-2009 crisis *VAK* has changed from an annual growth rate of 1.9% in the third quarter of 2007 (+5% for *VAN*) to an average annual fall of 6.3% in the first six months of 2009 (-3.2% in nominal terms).

The figures also show a negative correlation (-34%) between *IMP* and *MOL/VAN*. In the past decade, the gross operating margin as a percentage of *VAN* has recorded a highly irregular trend, not always correlated to the real cycle of added value: the trend of these two variables however, has been perfectly correlated in the last period (Figure 5)[1].

Source: Author's computations on Istat data.

Fig. 5. Added value and gross operating margin (quarterly data)

From the second half of 2008, the economic recession actually caused both a collapse of real added value and a considerable drop in the gross operating margin as a percentage of nominal added value (from 40.8% in the second quarter of 2008 to 38.6% in the second quarter of 2009). In the second quarter of 2009, *MOL* has shown a y-o-y fall of 8.6%; the fall in *VAN* (-3.4%) has been less marked (see Figure 6).
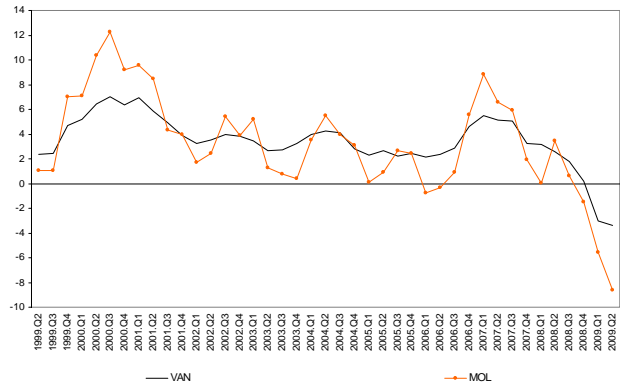
Source: Author's computations on Istat data.

Fig. 6. Gross operating margin and nominal added value: annual growth rates (quarterly data; % change)

Therefore, the economic crisis appears to have also provoked a reduction in the self-financing capacity of the private sector. This could have made the demand for bank loans by companies rise, partially compensating the lower demand caused by a fall in production activity.

3.1.1. ECM: the Engle and Granger's two-steps procedure. Following Engle and Granger's two step procedure, we initially estimated, using the Ordinary Least Squares method (OLS), the following long-run equation:

$$\ln(IMP_t) = \lambda_0 + \lambda_1(trend) + \lambda_2 TIMP_t +$$
$$+ \lambda_3 \ln(VAK_t) + \lambda_4 \ln\left(\frac{MOL_t}{VAN_t}\right) + \varepsilon_t, \quad (1)$$

where $\ln(\cdot)$ represents the variable's natural logarithm.

Equation (1) represents the long-run credit demand function. All of the variables considered in this equation are non-stationary: this justifies the use of an error correction model. The residual term $\varepsilon_t = ECM_t$, which represents the disequilibrium error in the long-run equation, is on the other hand, stationary (Table 2)[2].

Table 2. Stationarity test: Augmented Dickey-Fuller unit root test

Sample period: 1998.Q1-2007.Q2 (quarterly data)					
Null hypothesis: unit root (non-stationarity)					
Variable	Test statistic	Prob[1]	Test critical values		
			1%	5%	10%
ln (*IMP*)	-0.019	0.951	-3.627	-2.946	-2.612
TIMP	-1.991	0.289	-3.679	-2.968	-2.623
ln(*VAK*)	-0.946	0.762	-3.627	-2.946	-2.612
ln(*MOL/VAN*)	-2.243	0.195	-3.621	-2.943	-2.610
ε = *ECM*	-3.383**	0.018	-3.627	-2.946	-2.612

Source: Author's computations on Bank of Italy and Istat data.
Notes: [1] MacKinnon (1996) one-sided p-values. ** We can reject the null hypothesis at a significance level of 5%.

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[1] The cyclical component of real added value has been found using the long-run trend calculated by applying the Hodrick-Prescott's filter.

[2] The unit root tests (Augmented Dickey-Fuller test), conducted on the entire estimation period, support the non-stationarity hypothesis of ln(*IMP*), *TIMP*, ln(*VAK*) and ln(*MOL/VAN*). The non-stationarity of the real interest rate on loans is explained by its downward trend within the sample.

The variables are, therefore, cointegrated[1]. Equation (1) explains the cointegrating relationship that links, in the long run, outstanding loans to the production sector with the added value of the private sector, the gross operating margin and the loans average real interest rate[2].

In the second step of the procedure, we estimated the short-run equation, taking into account the disequilibrium error obtained in the long-run relationship at t-1 (ECM_{t-1}). The credit demand function thus becomes the following:

$$\Delta \ln(IMP_t) = \alpha + \beta_1 \Delta \ln(IMP_{t-1}) + \beta_2 \Delta(TIMP_t) +$$
$$+ \beta_3 \Delta \ln(VAK_t) + \beta_4 \Delta \ln\left(\frac{MOL_t}{VAN_t}\right) + \theta[ECM_{t-1}] + u_t, \quad (2)$$

where Δ indicates the first difference operator.

This model, therefore, enables us to explain the changes in the dependent variable as a result of the interaction of two components:

♦ The error correction component ($\theta[ECM_{t-1}]$), where θ represents the speed of adjustment of loans, namely the fraction of the disequilibrium error at time t-1 that is corrected to time t;

♦ The short-run component, identified in the first differences of $TIMP$, $\ln(VAK)$, $\ln(MOL/VAN)$ and $\ln(IMP_{t-1})$. The coefficient vector (β_1, β_2, β_3, β_4) represents the short-run impact on the lending growth rate of a change in said variables.

The estimations of the coefficients of equations (1) and (2), made by taking the pre-crisis sample period, are all statistically significant and have the expected sign (Table 3).

Table 3. Error correction model estimates

Sample period: 1998.Q2-2007.Q2 (quarterly data)				
	Equation		(1)-(2)	(3)
	Estimation procedure		Two steps (Engle and Granger procedure)	One step (single equation procedure)
	Coefficients	Regressors		
Adjustment coefficient	θ	Long-term equation	-0.548*** (0.157)	-0.492*** (0.129)
Long-run coefficients	λ_1	Trend	0.012*** (0.001)	0.012*** (0.001)
	λ_2	TIMP	-1.145*** (0.192)	-0.959*** (0.304)
	λ_3	ln(VAK)	1.858*** (0.170)	1.942*** (0.333)
	λ_4	ln(MOL/VAN)	-0.320** (0.136)	-0.375 (0.293)
	β_1	Δln(IMP$_{t-1}$)	0.482*** (0.109)	0.406*** (0.143)
Short-run coefficients	β_2	Δ(TIM$_t$)	-0.682*** (0.204)	-0.591** (0.224)
	β_3	Δln(VAK$_t$)	0.763*** (0.224)	0.707*** (0.248)
	β_4	Δln(MOL$_t$/VAN$_t$)	-0.196** (0.086)	-0.189* (0.109)

Source: Author's computations on Bank of Italy and Istat data. Notes: Estimation method: Ordinary Least Squares (OLS). Standard errors are in brackets. The symbols ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

The adjustment coefficient θ is negative and statistically significant, demonstrating the correct specification of the error correction mechanism and satisfying the stability condition: in each period, the growth rate of loans reacts in a significant way to the change in the disequilibrium error of the previous period, adjusting itself towards long-run equilibrium.

We observe a very significant long-run relationship between the demand for loans, *TIMP*, *VAK* and *MOL/VAN*. In the long run, the demand for bank lending by the production sector increases (more than proportionally) as real added value increases, while it decreases as *MOL/VAN* increases (and therefore as a company's self-financing capacity increases); the demand for loans also reacts negatively to an increase in the cost of lending[3, 4]. The sign and the statistical significance of said relationships is also confirmed by the short-run estimations (see the coefficients β_2, β_3, β_4 represented in Table 3).

The interpretation of these results would indicate that more a company produces, the higher quantity of credit it will need. On the contrary, as self-financing increases, there is a lesser need for external sources of funding: this leads to a lower demand for bank credit. Lastly, as the interest rate on loans rises, there is a lower demand for loans due to the higher cost of funding. These interpretations apply to both long and short-run relationships.

3.1.2. ECM: the one-step procedure. An alternative procedure entails estimating both the long and short run relationships at the same time in a single equation, (one step single equation procedure). Combining equations (1) and (2) we get:

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[1] The variables in question, taken separately, are all non-stationary; however, a linear combination of the same, represented by (1), is stationary. This means that the variables are cointegrated.

[2] This relation depends on the values of the long-run coefficients (λ_0, λ_1, λ_2, λ_3, λ_4), also called equilibrium coefficients.

[3] The values of the long-run coefficient of the credit demand equation show that if the *VAK* rises by 1% we have a rise of almost 2% in *IMP*, while if the *MOL/VAN* ratio rises by 1% we have a fall of around 0,3% in *IMP*.

[4] The value of the long-run coefficient on the interest rate indicates that a fall of 100 basis points in *TIMP* would lead to a rise of around 1% in *IMP*. The use of the interest rate on loans to medium-large non-financial firms, not considering the rate applied to smaller firms, could lead to a distortion in the estimation of the relationship between the loan demand of the production sector and the interest rate applied to loans. As the interest rate on loans to smaller firms is generally higher than that applied to medium-large size companies, this distortion could lead to an overestimation of the demand for loans; said distortion could lead to a higher "theoretical" (forecasted) value of loans. This would further substantiate the conclusions reached in section 3.2.

$$\Delta \ln(IMP_t) = \beta_1 \Delta \ln(IMP_{t-1}) + \beta_2 \Delta(TIMP_t) + \beta_3 \Delta \ln(VAK_t) + \beta_4 \Delta \ln\left(\frac{MOL_t}{VAN_t}\right) +$$

$$+ \theta \left[\ln(IMP_{t-1}) - \lambda_0 - \lambda_1(trend_{t-1}) - \lambda_2 TIMP_{t-1} - \lambda_3 \ln(VAK_{t-1}) - \lambda_4 \ln\left(\frac{MOL_{t-1}}{VAN_{t-1}}\right) \right] + u_t. \tag{3}$$

The OLS estimations of equation (3), considering the 1998-2007 sample period, provide results similar to those obtained with the two-step procedure (Table 3); the only substantial difference is that the relationship linking credit demand to firm's gross operating margin in the long run is not significant: however, the coefficient still has a minus sign. The inverse relationship between the demand for loans and the firm's self-financing component is instead significant in the short run (at a confidence level of 90%)[1].

3.1.3. VECM: analysis of a multivariate system. The underlying assumption of the ECM specification is the weak exogeneity of the independent variables in the credit demand equation. From a theoretical perspective, however, it is possible that there may be retroactive effects and simultaneity relationships between loans demand, the dynamics of added value and gross operating margin and the cost of bank lending. For example, it may be that as the credit disbursed rises, its immediate effect is a rise in added value or a rise in *MOL*; or there could be another equation which dependent variable is the interest rate on loans (loans supply function).

We, therefore, need to verify what would happen without the weak exogeneity assumption. To do this, we use a vector autoregressive model (VAR), a system of simultaneous equations where each variable is considered endogenous.

The variables considered in the system are $\ln(IMP)$, $TIMP$, $\ln(VAK)$, and $\ln(MOL/VAN)$, the same analyzed in the *ECM* specification. As suggested by the results obtained in the lag order determination tests (Table 4), we use a VAR with a lag:

$$Y_t = \mu + \sum_{i=0}^{1} \Phi Y_{t-i} + \varepsilon_t , \tag{4}$$

$$\varepsilon_t \sim VWN(0, \Sigma)$$

where

$$Y_t = [\ln(IMP), TIMP, \ln(VAK), \ln(MOL/VAN)] \cdot$$

Table 4. VAR: lag order determination tests

Endogenous variables: ln(*IMP*), *TIMP*, ln(*VAK*), e ln(*MOL/VAN*)					
Sample period: 1999.Q1-2007.Q2					
Lag	LogL	LR	FPE	AIC	SC	HQ
0	335.5149	NA	2.21e-14	-20.09181	-19.91042	-20.03078
1	505.3535	288.2110*	1.9e-18*	-29.41537	-28.50839*	-29.11020*
2	518.5723	19.22725	2.47e-18	-29.2468	-27.61425	-28.6975
3	533.8397	18.50596	2.92e-18	-29.20241	-26.84427	-28.40897
4	560.112	25.47614	2.03e-18	-29.82497*	-26.74125	-28.78739

Source: Author's computations on Bank of Italy and Istat data.
Notes: * Indicates lag order selected by the criterion. LR is the sequential modified LR test statistic (each test at 5% level). FPE is the final prediction error. AIC is the Akaike information criterion. SC is the Schwarz information criterion. HQ is the Hanna-Quinn information criterion.

The variables considered in the model are all non-stationary (Table 2). However, one or more cointegrating relationships may exist that render their linear combination stationary. Johansen's trace test indicates the existence of a cointegrating vector that links *IMP*, *TIMP*, *VAK* and *MOL/VAN* in the long run (Table 5).

Table 5. Johansen's cointegration test

Variables: ln(*IMP*), ln(*VAK*), ln(*MOL/VAN*)			
Sample period: 1999.Q1-2007.Q2			
Unrestricted cointegration rank test (Trace)			
Trend assumption: intercept and trend in cointegrating equation (Linear deterministic trend, restricted)			
Null hypothesis No. of cointegration equations (R)	Trace statistic	5% critical value	Prob.**
R = 0*	69.098	63.876	0.017
R ≤ 1	40.998	42.915	0.077
R ≤ 2	18.321	25.872	0.323
R ≤ 3	7.260	12.518	0.318

Source: Author's computations on Bank of Italy and Istat data.
Notes: Trace test indicates 1 cointegrating equation at the 0.05 level. * Denotes rejection of the hypothesis at the 0.05 level. ** MacKinnon-Haug-Michelis (1999) p-values.

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[1] In regard to the sign, the significance and the interpretation of the other coefficients, we confirm what we said describing the two-stage procedure's results.

Starting from equation (4) we, therefore, construct a four-equation VECM (vector error correction model), characterized by a cointegrating equation (long-run demand for loans) with intercept and trend and a lag in short-run relationships. The VECM estimated is as follows:

$$
\begin{bmatrix} \Delta \ln(IMP_t) \\ \Delta(TIMP_t) \\ \Delta \ln(VAK_t) \\ \Delta \ln(MOL_t / VAN_t) \end{bmatrix} = B \begin{bmatrix} \Delta \ln(IMP_{t-1}) \\ \Delta(TIMP_{t-1}) \\ \Delta \ln(VAK_{t-1}) \\ \Delta \ln(MOL_{t-1} / VAN_{t-1}) \end{bmatrix} + \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \end{bmatrix} \left[\ln(IMP_{t-1}) - \lambda_0 - \lambda_1(Trend_{t-1}) - \lambda_2 TIMP_{t-1} - \lambda_3 \ln(VAK_{t-1}) - \lambda_4 \ln\left(\frac{MOL_{t-1}}{VAN_{t-1}} \right) \right] + \begin{bmatrix} u_t^{IMP} \\ u_t^{TIMP} \\ u_t^{VAK} \\ u_t^{MOL} \end{bmatrix}, \quad (5)
$$

where B represents the matrix of short-run coefficients and vector of adjustment coefficients (θ_1, θ_2, θ_3, θ_4).

The estimations of equation (5) show a long-run relationship that is very similar to that obtained with the ECM (Table 6). The demand for loans increases as real added value increases and falls as the interest rate on loans rises and as self-financing increases; all of the long-run coefficients estimated are also highly statistically significant. Adjustment coefficients θ_3 and θ_4 however, are not significant: VAK and MOL/VAN do not react in a significant manner to the disequilibrium error generated in the long-run relationship of the previous period.

Table 6. Vector error correction model estimates

Sample period: 1998.Q2-2007.Q2 (quarterly data)			
Standart errors in brackets			
Cointegrating vector (long-run equation)			
ln(*IMP*) = -12.105 + 0.012***(*trend*) – 1.428***(*TIMP*) + 2.002***ln(*VAK*) – 0.455***ln(*MOL/VAN*) (0.001) (0.172) (0.157) (0.139)			
Adjustment coefficients			
Coefficients	θ_1	θ_2	θ_3	θ_4
Dependent variable	$\Delta\ln(IMP_t)$	$\Delta(TIMP_t)$	$\Delta\ln(VAK_t)$	$\Delta\ln(MOL_t/VAN_t)$
	-0.556*** (0.214)	-0.344** (0.148)	0.041 (0.147)	0.139 (0.403)

Source: author's computations on Bank of Italy and Istat data.
Notes: The symbols ***, ** and * represent statistical significance at the 1%, 5% and 10% level, respectively.

Some of the variables considered endogenous, could in reality be treated as exogenous. Weak exogeneity tests are, therefore, conducted in order to verify if it is possible to specify the model in a more parsimonious way[1]. As in Sorensen, Ibanez and Rossi (2009) and Casolaro, Eramo and Gambacorta (2006), following Johansen's procedure (1992), restrictions are introduced to the VECM specification and, verifying the statistical significance of the adjustment coefficients, weak exogeneity tests are conducted on each variable.

Table 7. VECM: weak exogeneity tests

(LR test)				
Dependent variable	$\Delta\ln(IMP_t)$	$\Delta(TIMP_t)$	$\Delta\ln(VAK_t)$	$\Delta\ln(MOL_t/VAN_t)$
Null hypothesis	$\theta_1 = 0$	$\theta_2 = 0$	$\theta_3 = 0$	$\theta_4 = 0$
Weak exogeneity of	ln(*IMP*)	*TIMP*	ln(*VAK*)	ln(*MOL/VAN*)
x^2	5.090	2.138	0.028	0.067
p-value	0.024	0.144	0.866	0.796
Joint tests				
Null hypothesis	$\theta_3 = 0$ $\theta_4 = 0$	$\theta_2 = 0$ $\theta_3 = 0$ $\theta_4 = 0$		

x^2	0.067	7.237	
p-value	0.967	0.065	

Source: Author's computations on Bank of Italy and Istat data.
Notes: Weak exogeneity is accepted, at a confidence level of 95% (90%), when the p-value is larger than 5% (10%).

These tests (Table 7) lead us to accept the hypothesis of weak exogeneity of ln(*VAK*), ln(*MOL/VAN*) and *TIMP*. This implies that the only variable that can be considered endogenous is loans, justifying and confirming the results obtained by the single-equation model (ECM): the test results permit us to rewrite equation (5) in the simpler form expressed by equation (2) or (3).

The weak exogeneity of *TIMP*, however, is the most difficult to accept from the tests, furthermore, the joint weak exogeneity test on ln(*VAK*), ln(*MOL/VAN*) and *TIMP* is rejected at a confidence level of 90%, while the joint exogeneity of ln(*VAK*) and ln(*MOL/VAN*) is accepted[2]. Therefore, even though the validity of equations (2) and (3) has been demonstrated, we verify how the results would change if only loans and the real interest rate are considered endogenous; starting from equation (5), we therefore use a more parsimonious model (reduced form VECM), characterized by a two-equation system:

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[1] When a variable is weakly exogenous, the model can be rewritten, without any loss of information, in a partial version that excludes the modelling of the same variable. Weakly exogenous variables may in any event continue to appear in long and short-run relationships.

[2] Even though the test leads to the acceptance of the null hypothesis of weak exogeneity, it shows a level of significance very close to the 10% threshold (Table 7).

$$\begin{bmatrix} \Delta\ln(IMP_t) \\ \Delta(TIMP_t) \end{bmatrix} = B \begin{bmatrix} \Delta\ln(IMP_{t-1}) \\ \Delta(VAK_t) \\ \Delta\ln(VAK_{t-1}) \\ \Delta\ln(MOL_t/VAN_t) \end{bmatrix} + \begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} \begin{bmatrix} \ln(IMP_{t-1}) - \lambda_0 - \lambda_1(Trend_{t-1}) - \lambda_2 TIMP_{t-1} - \lambda_3\ln(VAK_{t-1}) - \lambda_4\ln\left(\frac{MOL_{t-1}}{VAN_{t-1}}\right) \end{bmatrix} + \begin{bmatrix} u_t^{IMP} \\ u_t^{TIMP} \end{bmatrix}. \quad (6)$$

The estimations in equation (6) confirm the long-run relationships calculated previously (Table 8): the new cointegrating vector identified is very similar to that identified in equation (5) and to that obtained by the non-vectorial ECM (equations (2) and (3))[1]. The two adjustment coefficients are also both statistically significant. In addition, the short-run relationships are also significant or coherent with economic theory.

Table 8. Estimates of the VECM in reduced form

| (VAK and MOL/VAN exogenous)			
Sample period: 1998.Q2-2007.Q2 (quarterly data)			
Cointegration vector (long-equation)			
ln(IMP) = -10.787 + 0.013***(Trend) – 0.985***(TIMP) + 1.906***ln(VAK) – (0.001) (0.185) (0.203) - 0.299*ln(MOL/VAN) (0.172)			
	Dependent variable	$\Delta\ln(IMP_t)$	$\Delta(TIMP_t)$
Adjustment coefficients	θ_i (con i = 1.2)	-0.497*** (0.114)	-0.247*** (0.083)
	Regressors		
Short-run coefficients	$\Delta\ln(IMP_{t-1})$	0.725*** (0.119)	-0.282*** (0.071)
	$\Delta(TIMP_t)$	0.387 (0.232)	0.851*** (0.178)
	$\Delta\ln(VAK_{t-1})$	-0.354 (0.237)	-0.313* (0.183)
	$\Delta\ln(MOL_t/VAN_t)$	-0.119 (0.084)	-0.098 (0.063)

Source: Author's computations on Bank of Italy and Istat data.
Notes: Estimation methods: Seemingly Unrelated Regression (SUR). Standard errors are in brackets. The symbols ***, ** and * represent statistical significance at the 1%, 5% and 10% level, respectively.

3.2. Credit during the crisis: a comparison with the forecasts of the model. In this last part of the paper, using the coefficients estimated with the different techniques described above, we make a dynamic out of sample forecast, starting from the third quarter of 2007, the period in which the financial crisis started. Like in the estimation stage, we look first at the dynamic forecast of the ECM model and then verify how the dynamic forecast of multivariate systems (VECM) diverges from them.

The performance of the ECM in the estimation period (1998.Q2-2007.Q2) is very good: the one period ahead static forecast provides an average forecast error of only 0.4% (around 2.4 billion euro) both with the one and two step procedures (Figures 7-8).

---

[1] Overall, the following relationships emerge from the long-run loan demand equations estimated: if *VAK* rises by 1%, *IMP* rises by around 2%; if the *MOL/VAN* ratio increase by 1%, *IMP* falls by 0.3%-0.5%; a fall of 100 basis points in *TIMP* leads to an increase of around 1% in *IMP*.

This corroborates the results we obtain with the out-of-sample dynamic forecast.
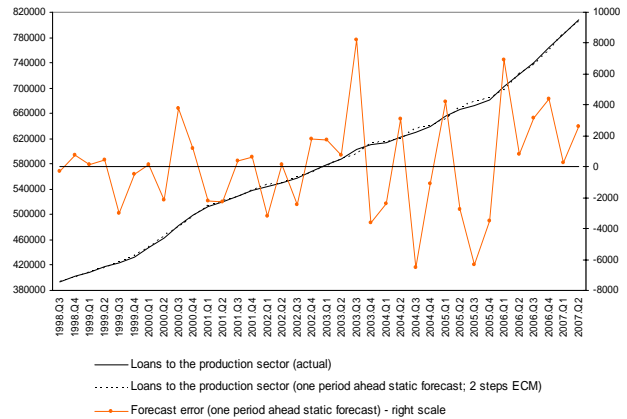
Source: Author's computations on Bank of Italy and Istat data.

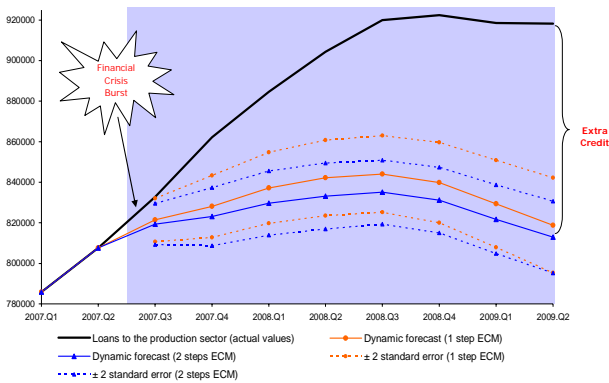**Fig. 7. The performance of the 2-step ECM in 1998-2007 (in millions euros)**
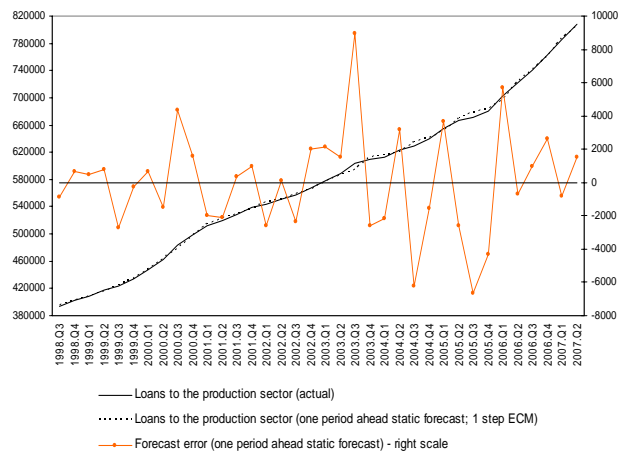
Source: Author's computations on Bank of Italy and Istat data.

Fig. 8. The performance of the 1-step ECM in 1998-2007 (in millions euros)

The results of the dynamic forecast conducted on the 2007-2009 period diverge considerably from the actual value of loans: as we can see in Figure 9, the outstanding loans figure is always higher than the ECM forecast values calculated on the basis of the functional relationships estimated before the crisis. Loans demonstrated a divergent trend with respect to their theoretical level, both with the two-steps and one-step approaches; the difference between actual loans and their forecast value – statistically significant from the third quarter of 2007 onwards – grows as the crisis intensifies. In the fourth quarter of 2008 and in the first three months of 2009, the period in which the GDP dropped the most, this sort of "extra-credit" exceeded 80 billion euros on the basis of the one-step approach and 90 billion according to the two-

step approach; in mid-2009, it was around 100 billion, an additional 12% of loans compared to that justified by the changed macroeconomic scenario[1].
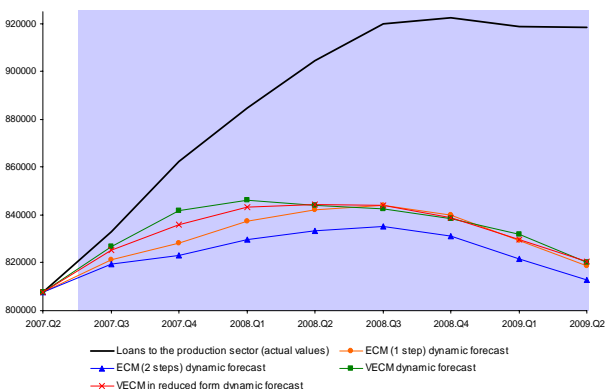

Source: Author's computations on Bank of Italy and Istat data.

Fig. 9. Bank lending during the crisis and dynamic forecast of the ECM (in millions euros)

The same forecasting method can be applied to the estimations obtained by the VECM specification, both in its complete form and in the parsimonious model (reduced form model). The dynamic forecast of multivariate systems is performed only using the equation of the model in which lending is a dependent variable, in order to verify how bank lending should have behaved during the 2007-2009 period, given the performance of the determinants of demand and on the basis of the relationships identified by the system.
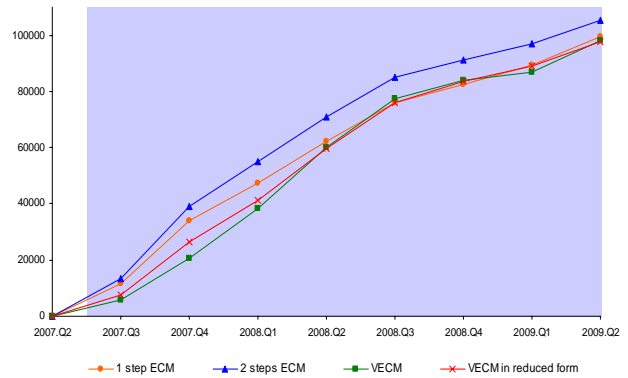
The results of the forecasting exercise conducted on the multivariate systems lead to the same conclusions reached with the ECM specifications (Figures 10-11): the positive difference between actual outstanding loans and their forecast value continues to increase during the crisis. This difference materializes – both with the VECM and in the reduced form system – at the end of 2008 and in the first half of 2009 with values of between 80 and 100 billion.

Source: Author's computations on Bank of Italy and Istat data.

Fig. 10. Bank lending during the crisis and dynamic forecasts of the models: a comparison between ECM and VECM (in millions euros)

Source: Author's computations on Bank of Italy and Istat data.

Fig. 11. Credit during the crisis: the difference between actual values and forecast values (in millions euros)

So what does this "extra-credit" represent and why was it developed? A possible theoretical explanation can be obtained by using a supply and demand model of bank loans ($L = IMP$), represented on a Cartesian plan (Figure 12) as a function of the real interest rate ($i = TIMP$). Starting from a hypothetical market equilibrium P^*, in place before the crisis, we see what could have happened in the 2007-2009 financial crisis period. The collapse of production and the reduction of investment programmes provoked a fall in the credit demand: the result was a leftward shift of the demand curve[2]. Maintaining the pre-crisis relationships and the initial supply curve constant, the theoretical equilibrium P_1 identifies the quantity of credit L_1 coherent with the new level of added value and the *MOL* shown during the crisis: L_1 therefore represent the outstanding loans forecasted by the model[3].
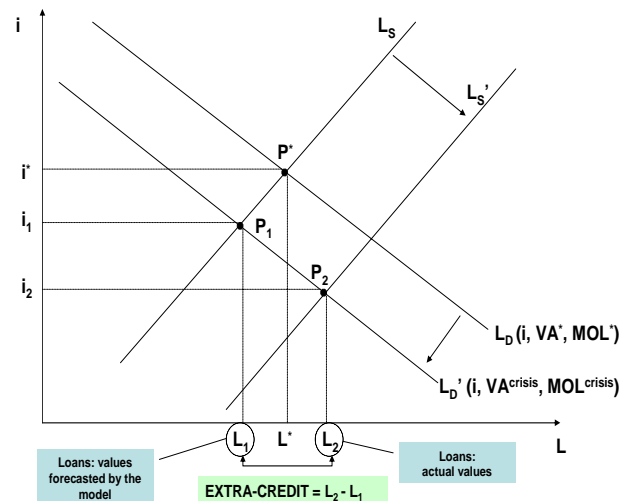

Fig. 12. "Extra-credit": a theoretical explanation

The outstanding loans observed were nevertheless higher than L_1: this difference was formed due to a change in pre-crisis relationships and by virtue of a rightward shift of the supply curve, in line with the

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[1] This result cannot be compared to that obtained by the IMF study contained in the October 2009 Global Financial Stability Report (Onado, 2009), where credit demand also includes that of the public sector, which in 2009 was almost double that of the private sector.

[2] This should have more than offset the positive effect on demand resulting from the simultaneous fall in self-financing.

[3] This explanation also considers the monetary effects caused by inflation.

lower level of interest rates. Equilibrium P_2 represents actual market equilibrium and L_2 are the outstanding loans actually recorded during the crisis.

The concept of "extra-credit" can therefore be identified as the difference between L_2 and L_1 and is explained by a rightward shift of the supply curve; instead, if there had been a credit crunch, we would have expected to see a significant leftward shift of the credit supply curve, as indicated in the Bernanke and Lown definition[1].

Conclusions

The empirical evidence presented in this paper supports the theory according to which, in Italy, over the course of the 2007-09 economic and financial crisis, despite a considerable slowdown in bank lending, there has not been a credit crunch.

The paper moves from an analysis of credit trends, first demonstrating how the dynamics of loans to non-financial corporations were much more positive than those recorded for important economic variables such as industrial production. In the period between September 2008 and August 2009, the average annual growth rate of loans (seasonally-adjusted) was 4.5% compared to a corresponding average fall in industrial output of 16.8%. This aspect is particularly important in the light of the causality link between the two variables, which, conducted on a time series appropriately cleaned of trends, and using Granger's casuality test, demonstrated that bank lending is determined (caused) by industrial production and not vice versa.

Given that industrial production represents a minor part of economic activity, the paper then focused on credit related to the output produced as a whole. From the analyses, it appears that over the course of 2008 and in the first six months of 2009, the bank credit-to-GDP ratio (credit per unit of GDP) slowed down but never fell; furthermore, the annual trend was far higher than that experienced in previous downturns identified by the International Monetary Fund, which in a recent report identified the threshold for the change in the bank credit-to-GDP ratio beyond which we can speak of credit squeeze/crunch as between -0.6 and -1%.

In this paper, in order to take the whole series of determinants of credit demand into account, an erro correction econometric model (ECM) was constructed –

estimated in the pre-crisis period (1998.Q2-2007.Q2) and applied using both the one-step and two-step procedure – which considers loans as a function of the added value of the private sector, of the gross operating margin to nominal added value ratio (a proxy for self-financing) and of the real interest rate on loans. To test the robustness of the results obtained, we then removed the assumption of weak exogeneity of the independent variables of the single-equation model and constructed a multivariate multi-equation system (VECM).

All of the different approaches and methods used provide similar results: as expected, credit demand increases as the real added value increases and falls as the cost of lending and self-financing increase. Weak exogeneity tests would also appear to indicate that the only variable that can certainly be considered endogenous in the multivariate system is loans, confirming the results obtained with the single-equation non-vectorial model (ECM).

The dynamic out-of-sample forecast of the model, relating to the first two-year period of economic and financial crisis (2007.Q3-2009.Q2), shows that the actual loan stock was far higher than the "theoretical" level forecasted on the basis of the functional relationships estimated before the crisis. This delta, a sort of "extra-credit", estimated to be over 80 billion euros (10-13% of loans) at the end of the first half of 2009, can be interpreted as the result of a rightward shift of the credit supply curve and not a leftward one as should have happened in the case of a credit crunch.

If other factors are considered stable, and given the difficult economic scenario, the higher propensity to grant credit could be the result of the increased awareness of the banking industry of all of those aspects – beyond traditional ones – that tend to reinforce medium/long-run relationships with customers (higher consideration of firm's income prospects, personal and long-lasting relationships with entrepreneurs etc.).

These conclusions have been drawn from macroeconomic data. It would be interesting to conduct further exploration, conducting some disaggregation, to test any asymmetries in the results from a territorial, sector-related or dimensional perspective. A further development could be to extend the research to the main countries of the euro area.

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[1] See section 1.

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