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# Interaction effect between product and process innovation: the case of Tunisian banks


## Abstract

The authors examine the impact of the relationship between two types of financial innovation and bank performance. The research attempts to test hypotheses that are not yet validated by previous studies focusing on the financial services industry, thus, giving the study an exploratory look. The authors try, specifically, to determine the interaction effect of both types of financial innovation on bank performance and, then, try to enrich innovation theory with new hypotheses on product and process innovation. The results show that Tunisian banks have begun, probably, to see the importance or the need for the simultaneous adoption of two types of financial innovation since 1995 to improve their poor performance. The authors also find that the interaction effect of product and process innovation reduces profitability. However, efficiency is achieved in terms of market share and value. The authors conclude that financial innovation is a value creation instrument for Tunisian banks.


**Keywords:** financial innovation, product innovation, process innovation, performance, efficiency, banks.
**JEL Classification:** C33, C36, G21, G28, O31, O33.

## Introduction

In general, innovation is one of the most raised issues in social sciences. Indeed, in an environment with high turbulence, a successful innovation may equip a company with a competitive advantage and, thus, a superior performance. Interest in financial innovation has become increasingly important with the recent development in the banking business, where it became essential that banking institutions should try to increase their arsenal of innovation. This can only be achieved through constantly innovating products and processes (Porter, 2004), despite the fact that financial innovation is often accused during international crises (Betz, 2016)[1].

This study focuses on the dynamics of financial innovation and its implication on the efficiency of Tunisian banks. Indeed, after the 2011 revolution and the political instability that followed, the Tunisian economy has experienced unprecedented difficulties in 2011, a situation that had a negative impact on the financial strength of the Tunisian banking system.

Specifically, our interest focuses on determining the real impact of financial innovation on Tunisian banks' performance, given their environmental and organizational characteristics. To this end, we examine, on the one hand, the individual impact of each type of innovation and, on the other hand, the impact of the interactive relationship between the two types of financial innovation and banking performance.

Indeed, it is admitted in the literature that innovation of products and processes mutually interact leading to a greater banking efficiency. In this study, our main objective, therefore, is to provide a better understanding of the relationship between financial innovation and banking performance.

To validate the impact of the interactive relationship between the two types of financial innovation on banking performance, we will test hypotheses that are not yet validated by previous studies examining financial services, thus, giving this study an exploratory outlook. Ultimately, our contribution pertains to enriching innovation theory with a new look into financial innovation of products and processes.

## 1. The previous literature

**1.1. Typology of financial innovation.** As accepted by most researchers, there are two main categories of financial innovation, namely, innovation of products and innovation of processes (Dan Awrey, 2013).

- Product innovation refers to an extension of the range of financial assets or services offered by financial institutions. It can be either at the margin, as part of a strategy of differentiation, or a breach with existing products.
- Process innovation refers to introducing new technologies related to the process of production or distribution. This is, basically, the introduction of IT and telematics in the management of payment systems.

Batiz-Lazo and Wood (2002) stipulate that product innovation focuses on the market and is, primarily, customer-driven, otherwise, introduced to meet external needs of a user or a market. However, process innovation has an internal focus, seeking


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[1] It proposes the use of ICT technologies in international banking, increased frequency and intensity of the international financial crises. At the end of the twentieth century, we began to witness, globally, very destabilizing capital flows, especially during the 1997 Asian financial crisis, the 2007 Global financial crisis and the 2010 Euro crisis.

to develop new skills and competencies and is, mainly, efficiency-driven.

Likewise, Batiz-Lazo and Woldesenbent (2006) suggest that a distinction between product and process innovation is important, insofar, as the adoption of each type needs different organizational skills. Indeed, first, product innovation needs banks to focus on customer needs, and to change behavior, and to create new ways to access banking markets. Moreover, process innovation needs banks to implement the New Technologies of Information and Communication to improve efficiency in marketing the product and ensuring a better service quality (Damanpour and Gopalakrishnan, 2001).

**1.2. Synchronizing the adoption of product and process innovations.** There is a wide agreement that product and process innovations affect each other and they need to be adopted together. Walker (2004) suggests that, on the one hand, one leads the other and, therefore, may be adopted in succession and, on the other hand, they complement each other and may be adopted simultaneously. The author added that organizations adopting both product and process innovation are most likely to achieve high levels of performance. In this context, Damanpour et al. (1989), studying the relationship between product and process innovation over time and their impact on firm performance, found that both types of innovation interact with each other to positively affect firm performance that changes over time depending on the dominant type of innovation (product or process). Ettlie (1995) found that developing activities, including product and process innovation, have a positive impact on firm performance. Thus, both types of innovation are necessary to maintain or improve performance.

The results of Damanpour and Gopalakrishnan (2001) confirm the need to synchronize the adoption of product and process innovation and their positive effect on banking efficiency, suggesting that to improve bank performance, introducing new products needs simultaneous introduction new processes. Buzzachi et al. (1995) also argue that introduction of new products needs the simultaneous introduction of new processes, particularly in the service industries.

**1.3. Reciprocal causality between financial innovation and banking performance.** By studying the impact of Internet banking on the performance of US community banks, De Young et al. (2007) raise the issue that adoption of Internet is not completely exogenous to all indicators of banking performance. The authors attempted to solve this endogeneity problem by making use of instrumental variables. An example of this is the existing two-way causality between profitability and financial innovation. Increase in cost[2] does not necessarily generate low profits because innovative banks make more revenue from non-interest income, which allows them to cover additional expenditure through the received commissions (De Young et al., 2007; Sullivan, 2000). Thus, on the one hand, financial innovation can improve bank profitability (Roberts and Amit, 2003). In turn, it allows banks to provide the funds necessary for the adoption of financial innovation[3] and, thus, maintain their competitive positions (Furst et al., 2002). Moreover, De Young et al. (2007) found that banks with higher non-interest expenses do adopt Internet banking. They argue that this is to reduce inefficiency by developing distribution channels at lower costs. Similarly, the results show that non-interest expenses increase with Internet adoption because of the related costs.

## 2. Methodology

In what follows, we present our sample and data. Then, a measurement of our variable will be provided. To this end, we summarize, first, all the formulated hypotheses in order to have an overall view of the various proposed relationships. Second, we present the objectives of this study.

**2.1. The research question.** We can summarize the effort of financial innovation found in a large research question, namely:

What is the consequence of the interaction of forms of financial innovation, if it exists, on the effectiveness of Tunisian banks?

**2.2. The research hypotheses:**

**I. Hypotheses on the relationship between product - process innovation.**

*H1: Introduction of product innovation is done simultaneously with process innovation.*
*H2: Product and process innovation interact with each other.*

**II. Hypotheses on the impact of the interaction between product and process innovation on banking efficiency.**

*H3: The interaction between the two types of innovation leads to a high level of banking efficiency.*
*H 3.1: The interaction between the two types of innovation leads to a high level of bank profitability.*
*H 3.2: The interaction between the two types of innovation leads to a high level of market share.*
*H 3.3: The interaction between the two types of innovation leads to a high level of market value.*
*H 3.4: The interaction between the two types of innovation leads to a low level of bad debts.*

**2.3. Objectives and expected contributions.** In this study, although certain aspects of our problems have

[2] Mainly because of the expenses related to process innovation.

[3] To our knowledge, this has been demonstrated by the authors, only for process innovation (internet and web banking).

been previously treated separately, others are examined for the first time. Thus, studying the Tunisian context enables us to, first, test some hypotheses not yet validated by previous studies, and, second, to determine the nature of the interaction between the two types of financial innovation and the impact of this relationship, if any, on bank performance. This last part gives our study a fairly exploratory outlook.

## 3. Sample and data

**3.1. Sample.** The recent deregulation of the Tunisian banking industry, under the scope of financial liberalization initiated since 1986-1987, has led to increased competition and motivated banks to use new technologies in their production and distribution processes and diversify their range of offered products and services in order to gain a competitive advantage (Mabrouk and Mamoghli, 2010).

**3.2. Data.** We examine a sample of 10 retail banks, and data that cover the 1985 to 2010 period. Observations retained differ depending on the measurement used. We have a panel data of 260 observations. Also, two questionnaires were administered. The first was addressed to banking experts and the second to banking managers affiliated with the banks in the sample.

## 4. List of financial innovations

The targeted innovations include 17 classic and unconventional intermediation product innovations, and 8 process innovations.

Table 1. List of product and process innovations

| Product innovations | Process innovations |
|---|---|
| Loans | Electronic payment services |
| Lease credit | Magnetic strip card (debit) |
| Express credit | Magnetic strip card (debit and ATM card) |
| Auto loan | Magnetic strip card (ATM and credit card) |
| Flexible interest rate mortgage | Automatic cash dispenser |
| Line of credit (up to 3 times the sum in savings) | Automatic teller machine |
| Child savings plan loan | Electronic payment terminal |
| Investments | Risk assessment system |
| Certificates of deposit[1] | |
| Foreign currency deposits | |
| Investment account | |
| Bond open-ended investment company | |
| Currency exchange | |
| Transfer of funds | |
| Forward cover | |
| Telematic products | |
| Telephone banking (voice server) | |
| Fax banking | |
| SMS banking | |
| Net banking (account access and consultation of operations on the account) | |
| Magnetic strip card (business card with special privileges) | |

Note: This is a short or long-term negotiable security issued by the bank for a specific term. The subscriber may re-sell the bond at any time on the secondary market.

**4.1. Estimation technique**: testing our assumptions is made in two steps. First, two successive surveys were conducted, one with banking experts and the other with the Tunisian banks of our sample. The second component of our methodology uses panel techniques.

Before we move to the obtained results, we prefer to start with some descriptive statistics to highlight the dynamics of financial innovation in the Tunisian banking industry.

## 5. Descriptive statistics

Product and process innovations affect each other and are adopted either successively or jointly (Batiz-Lazo and Woldesenbet, 2006; Walker, 2004). Indeed, on the one hand, one can lead to the other and, therefore, they may occur in succession. This is almost a lag pattern. On the other hand, one completes the other and can, they thus, occur simultaneously. In this case, this is a synchronous pattern.

Our aim is to test an innovation adoption model in the Tunisian banking context. To this end, we, first, describe correlations[4] between product and process innovation across the three sub-periods[5]. In the following, we present number of innovations as a measure of adoption degree[6].

We found that the correlation between adoption of product innovation, during the first period, and the process innovation, during the second period, is smaller in absolute value than correlation of the opposite phenomenon (-0.2712 against -0.4811). Similarly, correlation between adoption of product innovation, during the 2nd period, and process innovation, during the 3rd period, is lower in absolute value than correlation of the opposite phenomenon (0.073 against -0.6721). Moreover, correlation between adoption of process innovation (2nd period) and product innovation (3rd period) is 0.6721 ($p < 0.05$). This may indicate that a priori banks follow a lag pattern in the adoption of process-product innovation.

Then, Spearman test[7] is used to better shed light on which of the two types of innovation occurs first.

[4]For example, compare the correlation between the level of adoption of products (period 1) – degree of adoption of processes (period 2) the correlation between the degree of adoption of processes (period 1) - degree of adoption of products (period 2).

[5]1987-1994, 1995-2002 and 2003-2010.

[6]Both measures reflecting the degree of adoption of innovation led to the same results.

[7] The Spearman test is a variable ranking test. It tests whether two variables are independent. These can be coded, for example, from highest to lowest, from best to worst or from first to last. Spearman rho takes values between -1 and 1. In our context, a value of 1 would indicate that both types of innovation occurring within the rank of the mentioned lag. However, a value of -1 means that it is the opposite phenomenon which occurs with a lag. A rho = 0 means independence of both types of innovation.

Table 2. Correlation matrix

| Variables | Mean | Std. dev | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| Inv. produit Période 1 | 1.5 | 0.9718 | 1.00 | | | | | |
| Inv. produit Période 2 | 4.9 | 2.6853 | -0.5322 | 1.00 | | | | |
| Inv. produit Période 3 | 6.2 | 2.0976 | -0.2180 | -0.5681* | 1.00 | | | |
| Inv. processus Période 1 | 1.8 | 1.1352 | -0.5189 | -0.4811 | 0.4386 | 1.00 | | |
| Inv. processus Période 2 | 3.2 | 1.6865 | -0.2712 | 0.8390*** | -0.6721** | -0.5571* | 1.00 | |
| Inv. processus Période 3 | 4.2 | 1.8135 | -0.3783 | 0.0730 | 0.8007*** | -0.0863 | -0.1962 | 1.00 |

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 3. Spearman rho test between degrees of adoption of product and process innovation

| Product innovation | Process innovation | | |
|---|---|---|---|
| | Period 1 1987-1994 | Period 2 1995–2002 | Period 3 2003-2010 |
| Period 1 1987-1994 | -0.4768 (0.1396) | -0.2487 (0.4884) | -0.4361 (0.2077) |
| Period 2 1995-2002 | -0.5434* (0.0910) | 0.9400*** (0.0011) | 0.2445 (0.4959) |
| Period 3 2003-2010 | 0.3701 (0.2925) | -0.6507* (0.0702) | 0.8902*** (0.0029) |

For each case, *rho* and *p-value* are displayed.
Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

As we mentioned above, there is an agreement that product and process innovation need to be adopted together. Therefore, we sought to determine this adoption model on the banks of our sample. Otherwise, we would like to determine whether both types of innovation occur successively, or one complements the other or both are adopted simultaneously. For this, we used the Spearman rho test.

The test indicates that correlation between adoption of process innovation (at a time) and product innovation (during another period) rule out the possibility of a lag pattern, i.e., there is a delay between the adoption of each type of innovation. This fits a synchronous pattern.

Moreover, probably, Tunisian banks have begun to see the importance or the need for the simultaneous adoption of two types of financial innovation since 1995 to improve their poor performance.

## 6. The empirical study

**6.1. Model [I] specification.** The model below is constructed to test hypotheses H1 and H2. It captures the interactive relationship between the two types of financial innovation and its impact on bank performance.

The [I] system:

$$\begin{cases} IVPD_{i,t} = \lambda_{i1} IVPC_{i,t} + \gamma'_{i1} PRF_{i,t} + \theta_{i1} Z_{i,t1} + \\ + \eta_1 Y_{t1} + C_{i1} + v_{i,t1}, \end{cases} \quad (1)$$

$$\begin{cases} IVPC_{i,t} = \lambda_{i2} IVPD_{i,t} + \gamma'_{i2} PRF_{i,t} + \theta_{i2} Z_{i,t1} + \eta_2 Y_{t1} + \\ + C_{i2} + v_{i,t2}. \end{cases} \quad (2)$$

$$PRF_{i,t} = \lambda_{i3} IVPD_{i,t} \times IVPC_{i,t} + \lambda_{i4} IVPD_{i,t} + \lambda_{i5} IVPC_{i,t} + \\ + \theta'_{i3} Z_{i,t2} + \eta_3 Y_{t2} + C_{i3} + v_{i,t3}. \quad (3)$$

In the first equation of the [I] system, we regress product innovation on process innovation, performance and the variables representing the environmental and organizational context of banks. In the second equation, we regress process innovation on product innovation, performance and the variables representing the environmental and organizational context of banks. In the third equation, we regress bank performance on the relationship between the two types of financial innovation, product innovation, process innovation and on a set of control variables, including variables representing banks' characteristics, banking industry and the macroeconomic conditions.

With:

$$
\begin{aligned}
&IVPD_{i,t} = \left(NINV_{i,t1}\right)\\
&IVPC_{i,t} = \left(NINV_{i,t2}\right)\\
&Z_{i,t1} = (DIV_{i,t}, PUB_{i,t}, ETR_{i,t}, T_{i,t}, RF_{i,t})_{(1,5)}\\
&\theta_{i1} = (\theta_{1,i1}, \theta_{2,i1}, \theta_{3,i1}, \theta_{4,i1}, \theta_{5,i1})_{(1,5)}\\
&\theta_{i2} = (\theta_{1,i2}, \theta_{2,i2}, \theta_{3,i2}, \theta_{4,i2}, \theta_{5,i2})_{(1,5)}\\
&Y_{t1} = (IHHD_t)_{(1,1)}\\
&PRF_{i,t} = (ROA_{i,t}, ROE_{i,t}, PMC_{i,t}, PMD_{i,t}, RCRD_{i,t}, MTB_{i,t})\\
&Z_{i,t2} = (DEP_{i,t}, CRD_{i,t})_{(1,2)}\\
&\theta_{i3} = (\theta_{1i3}, \theta_{2,i3})_{(1,2)}\\
&Y_{t2} = (IHHA_t, TFL_t, SBC_t)_{(1,3)}\\
&\eta_3 = (\eta_{1,3}, \eta_{2,3}, \eta_{3,3})_{(1,3)}
\end{aligned}
\qquad (4)
$$

$v_{i,t1}$, $v_{i,t2}$, $v_{i,t3}$ $v_{i,t4}$ sont les termes d'erreurs. $c_{i1}$, $c_{i2}$, $c_{i3}$ et $c_{i4}$ sont les effets inobservables.

In order to determine the interaction effect, we included the impact of each product and process innovation in the third equation. The aim is to neutralize their direct effects on performance, because, otherwise, their interaction term does not reflect the interaction effect, but it will also include their respective direct effects. Indeed, in general, models with interaction effects should also include the direct effects of the interaction of variables separately in terms, even if the direct effects are no longer significant once all are included in the same equation (Jaccard et al., 2003; Jaccard and Wan, 1996).

**6.2. The control function approach.** These estimators are also obtained in two steps. Consider, for example, equation (1) of the [I] system. The first instrumental step consists in regressing the endogenous variables $PRF_{i,t}$ and $IVPC_{i,t}$, respectively, on the exogenous variables in equation (1) and instruments present, respectively, in equation (2) and equation (3), then, extract the two fitted values of error terms. Then, second, we regress $IVPD_{i,t}$ on the exogenous variables ($Zi,t_1$ ,$Yt_1$) of equation (1), $IVPC_{i,t}$, $PRF_{i,t}$ and both fitted values of error terms. This will control the endogeneity of the endogenous variables $IVPC_{i,t}$ and $PRF_{i,t}$ in the original equation (1). However, for the endogenous variables $IVPC_{i,t}$ in equation (1) and $IVPD_{i,t}$ in equation (2), this is an extreme case where equations (1) and (2) include exactly the same exogenous variables. This involves looking for instruments outside the [I] system.

**Choice of instruments:**

consider equation (1) of the [I] system:

$$IVPD_{i,t} = \lambda_{i1}\, IVPC_{i,t} + \gamma'_{i1}\ PRF_{i,t} + \theta'_{i1}.Z_{i,t1} + \eta_1.Y_{t1} + c_{i1} + v_{i,t1.}$$

To ensure a valid instrumentation of $IVPC_{i,t}$, the control function approach technique assumes a certain correlation (at a level of significance not greater than 5%) between the instruments $Z_j$ and $IVPC_{i,t}$ to ensure consistency. We also assume that the instruments satisfy the condition: cov ($Z_j$ , $v_{i,t1}$) = 0, $j$ = 1,…, $k$. Instrumentation of $IVPC_{i,t}$ is the same as that of $IVPD_{i,t}$ in equation (2).

We propose to instrument $IVPC_{i,t}$ and $IVPD_{i,t}$ by their respective lags ($t$ -1) and ($t$ -2). Indeed, Roberts and Amit (2003) suggest that innovative activity of a bank is a function of its history in financial innovation. The results show that these two lagged variables have a significant impact on Tunisian banks' adoption of financial innovation, $IVPD_{i,t}$ and $IVPC_{i,t}$ (at the 1% and 5% levels). Thus, during this first stage of estimation, we obtain a dynamic panel. In addition, the choice of the lag date is a bit tricky, because $IVPC_{i,t}$ and $IVPD_{i,t}$ each represents the number of process and product innovations, respectively, introduced over the past five years[8].

**Tests of validity of instruments:**

the Sargan and Hansen over-identification tests are used to check the validity of the instruments. Moreover, we opted for the two instrumental variables $IVPC_{i,t}$ and $IVPD_{i,t}$ so that equations (1) and (2) are identified as required by the GMM method[9].

**6.3. Description of the measures.** *NINV* represents the number of product or process innovations adopted by the bank in the past five years. In other words, innovation is a time variable reflecting a cumulative five-year process. We believe that this period is long enough to show some variability in the adoption of innovation in product and process, and to observe their impact on bank performance. Bank performance in terms of efficiency is opera-

[8] The generalized method of moments GMM takes into account the endogeneity problems, issued also from the possibility of simultaneity between the endogenous variable and its instruments.

[9] We also checked for the absence of multicollinearity in this first estimation step.

tionalized through measures of profitability, market value, market share and risk. Performance indicators, mainly derived from De Young et al. (2007), Mohieldin and Nasr (2007), Iannotta et al. (2007), Dow (2007), Furst et al. (2002), are measured in terms of variation in performance between year *t* and (*t* -5).

The literature review examined a variety of independent variables. We selected a limited number of variables, because our main focus is to test the hypotheses on the relationship between the two types of financial innovation and the impact of the latter on banking efficiency.

In this study, measures of independent variables of financial innovation are tricky because its adoption is a cumulative process over five years, which leads to a simultaneity hypothesis[10]. Thus, like Herrera and Minetti (2007), we take the average of the values of the independent variables between years (*t* -5) and (*t* -1), against the values of the independent variables proceeding each period, i.e., in (*t* -5)[11].

Several authors, such as Dow (2007), assume a reverse causality between the determinants of adoption of financial innovation and these latter. To circumvent any potential simultaneity bias, Furst et al. (2002) ensured that the independent variables, measuring bank characteristics, precede adoption of Internet banking.

Table 4. Summary of the variables

| Variable | Definition |
|---|---|
| Financial innovation (total count of innovative acts during the previous five years) | |
| FIRST (product) | The number of innovations adopted during the previous five years for which the bank was the first mover in product innovation. |
| FIRST (process) | The number of innovations adopted during the previous five years for which the bank was the first mover in process innovation. |
| IMIT (product) | The number of innovations adopted during the previous five years for which the bank was the imitator in product innovation. |
| IMIT (process) | The number of innovations adopted during the previous five years for which the bank was the imitator in process innovation. |
| Performance (Δ between t and (t-5)) | |
| Δ ROA<br>Δ ROE | Δ (net profit / total bank assets).<br>Δ(net profit / Equity). |
| Δ MSC | Δ (credit granted by the bank / total credit granted by all banks). |
| Δ PMC | Δ (bank loans / total loans). |
| Δ PMD | Δ (bank deposits / total deposits). |
| Δ CRDR | Δ (delinquent loans / total loans). |
| Δ MTB | Δ (market value / book value of the shares). |
| Control variables of financial innovation (average between (t-5) and (t-1)) | |
| IHHD | The average of Hirshman-Herfindhal index of concentration of bank deposits. |
| DIV | The average of D = (1-\|2x-1\|) where x = non-interest income / net operating revenue. |
| PUB | The average percentage of public share ownership. |
| FRG | The average percentage of foreign share ownership. |
| SIZE | The logarithm for the average of the total assets of the bank. |
| FR | The average of net profit. |
| Control variables of performance (average between (t -6) et (t -1))<br>SBC balance of payment | |
| TFL the average of inflation rate, measured by the average of consumer goods | |

Several authors like De Young et al. (2007), Herrera and Minetti (2007) have examined the effect of competition. Size is used by all the studies on the adoption of innovation in the banking industry (Dow, 2007; De Young et al., 2007; Furst et al., 2002). We measured competition by the logarithm of the average of the total assets of the bank in order to diminish the problem of scale. Diversification was used in the banking industry by several authors (Baele et al., 2007; Leaven and Levine, 2007; Stiroh, 2006), where the D measure takes into account diversity of income[12]. We use percentages of public and foreign participation in the capital of the bank as measures of ownership structure. Net income reflects the ability of the bank to finance these investments and take risks (Fuentelsaz et al., 2003). It provides, as well, banks with funds necessary for the adoption of financial innovation (Furst et al., 2002). Financial resources, FR, are measured by net profit. They provide, as well, banks with funds necessary for the adoption of financial innovation, essentially, process innovation because of the high investment they demand (Furst et al., 2002).

## 6. Impact of the interaction between product and process innovation on bank performance

In what follows, we test the hypothesis that the two types of financial innovation interact with each other and whose interaction leads to high levels of banking efficiency. The latter is operationalized in terms of profitability, market value, market share

[10] Indeed, the choice of the year, belonging to the interval [t -4 ; t], the value of the independent variable may coincide with the year of the adoption of certain innovation.

[11] We believe that such values are restrictive in order to circumvent the endogeneity problem. This is achieved by failing to take into account the kind of different values obtained during each period of five years and may, certainly, influence the cumulative process of financial innovation.

[12] The *D* measure takes into account income diversity. It takes values between 0 and 1 and it increases when the degree of diversification of the bank increases.

and risk. The numbers of product and process innovations are adopted as measures.

The aim is to determine the interaction effect of both types of financial innovation on Tunisian banking efficiency. We would like to show that if, for a high level of product (process) innovation, adoption of process (product) innovation leads to an improvement in banking efficiency. In other words, a positive value of the interaction effect term means that the greater is the adoption of product innovation (more positive), the greater is the effect of the adoption of process innovation on bank performance. Similarly, the greater is the adoption of process innovation, the larger (more positive) is the effect of the adoption of product innovation on bank performance[13].

We found a strong positive relationship between adoption of product and process innovation, with a significant correlation coefficient of 0.23 at the 5% level. The results also show that product and process innovations are positively correlated, and this in all estimations, suggesting thereby that, for Tunisian banks, the introduction of new products leads to an increase in new processes and vice versa. We found that the separate impacts of each type of innovation on performance (in equation 3) are not significant[14], except on the risk indicator. Their direct impact on this performance indicator is significant because their interaction effect is not.

As mentioned above, we proposed to instrument the endogenous variables $IVPC_{i,t}$ and $IVPD_{i,t}$ by their respective lags. The choice of lags ($t$ -1) and ($t$ -2) for the endogenous variables $IVPC_{i,t}$ in equation (1) and $IVPD_{i,t}$ in equation (2), decreased the number of observations to 180 observations[15]. Indeed, Roberts and Amit (2003) suggest that an innovative activity of a bank is a function of its history in financial innovation. The results show that these two lagged variables have a significant impact on the adoption of financial innovation, $IVPD_{i,t}$ and $IVPC_{i,t}$ (at the 1% and 5% levels) by Tunisian banks. Thus, during this first stage of estimation, we obtain a dynamic panel. Moreover, the choice of the lag date is a bit tricky because $IVPC_{i,t}$ and $IVPD_{i,t}$ each represents the number of process and product innovations, respectively, introduced over the past five years[16].

The probability of the Sargan test on the validity of the instruments $IVPC_{i,t}$ and $IVPD_{i,t}$, is, respectively, 0.937 and 0.957. Furthermore, the Hansen over-identification test[17] shows probabilities of 0.877 and 0.953. Thus, referring to both the Sargan and Hansen tests, we cannot reject hypothesis H0 on the validity of instruments.

**6.1. Profitability.** The results reported in Table 5 show that profitability, in terms of ROA and ROE, significantly stimulates (at the 1% level) the adoption of the two types of financial innovation. However, their interaction leads to a significant decrease in profitability at the 10% level. Moreover, we found similar results on the return on assets before tax ratio. Probably, the high cost required to investment in introducing process innovation explains this decrease in profitability.

**6.2. Market share.** The results in Table 6 below indicate that a high market share motivates the bank to significantly engage in a process innovation at the 10% level. In return, interaction between product and process innovation provides the bank with a competitive advantage and a significant market share at the 5% level. In other words, for a high level of adoption of process innovation (product), the adoption of product innovation (process) leads to increased market share. This result is true for both credit and deposits market share.

*Market value:* The results in Table 7 indicate that high interaction between product and process innovation positively and significantly (at the 5% level) affects market value. Market of innovative banks is high because adoption of the two types of financial innovation is perceived by the market as a determinant of efficiency and technological progress.

*Risk:* We found that high levels of bad loans discouraged the adoption of product innovation[18] (at the 1% level) and also encouraged the adoption of process innovation[19] (at the 1% level). Moreover, the direct effect of each type of innovation on credit risk is significant, where the adoption of product innovation increased the volume of bad debts (at the 5% level) while developing a risk assessment system helps to reduce credit risk (at the 5% level).

Table 7 shows that the interaction between the two types of financial innovation has no effect on credit risk ratio. We believe that the positive effect of product innovation is offset by the negative effect of process innovation. This suggests that the development of a risk assessment system by Tunisian banks will bring fruits, helping them to better overcome the problems of adverse selection and moral hazard arising from information asymmetries.

[13] This interpretation of the interaction term between two continuous variables is provided by Jaccard et al. (2003).
[14] The direct effects of the variables used in the interaction terms are, generally, no longer significant once included with their interaction effect in the same equation (Jaccard et al., 2003).
[15] This enables us to keep a good degree of freedom.
[16] The generalized method of moments GMM takes into account the endogeneity problems, issued also from the possibility of simultaneity between the endogenous variable and its instruments.
[17] The Hansen test is robust to heteroscedasticity.
[18] A classic intermediation activity.
[19] This is the risk assessment system, supposed to improve the banks' credit quality.

Table 5. Estimation by the control function approach of the interaction effect of the two financial innovation on profitability

| Independent variables | Product innovation | Process innovation | ROA | Product innovation | Process innovation | ROE |
|---|---|---|---|---|---|---|
| Constant | 10.1616 (1.19) | 32.1422 (0.70) | | 42.3857 (1.55) | 3.3214 (0.14) | |
| NINV (Inv. Product) | | 0.0149*** (2.75) | | | 0.41101*** (3.58) | |
| NINV (Inv. Process) | 0.0494** (2.18) | | | 0.3398** (1.98) | | |
| Performance | 0.0636*** (4.94) | 0.1137*** (6.63) | | 15.4966*** (3.47) | 12.4955*** (2.72) | |
| IHHD | -0.0103*** (-4.82) | -0.0103*** (-2.79) | | -0.0373*** (-2.69) | -0.0069*** (-2.85) | |
| DIV | -2.3726** (-2.51) | -1.2909 (-0.31) | | -6.75641** (-2.39) | -2.4025 (-1.18) | |
| PUB | -0.4001* (-1.12) | 3.1069 (0.32) | | -1.1935** (-1.99) | -0.4433 (-0.78) | |
| ETR | 0.3407* (1.94) | 6.0217 (0.31) | | 2.02773* (1.77) | 2.3057* (1.74) | |
| T | 0.3103 (0.92) | 0.6079* (1.89) | | -0.83042 (-1.11) | 0.92594** (2.53) | |
| RF | 0.1316* (1.94) | 0.4818* (1.91) | | 0.54053* (1.78) | 0.81028* (1.92) | |
| Pseudo $R^2$ | 0.1091 | 0.0993 | | 0.1121 | 0.0974 | |
| Log pseudolikelihood | -323.2004 | -308.4298 | | -310.4502 | -311.4035 | |
| Constante | | | -9.3723* (-1.92) | | | -0.0572 (-1.52) |
| Interaction[20] | | | -0.0479* (-1.83) | | | -0.00595* (-1.79) |
| NINV (Inv. Product) | | | 2.2762 (1.05) | | | 0.01139 (1.45) |
| NINV (Inv. Process) | | | -4.1286 (-1.30) | | | -0.0129 (-1.41) |
| IHHA | | | -0.0598*** (-2.86) | | | 0.0005*** (2.99) |
| DEP | | | -27.9961* (-1.75) | | | -0.1227 (-1.12) |
| CRD | | | -6.8664 (-0.53) | | | -0.0919 (-1.09) |
| TFL | | | -157.5684 (-1.62) | | | -0.7532 (-1.18) |
| SBC | | | -0.0547* (-1.84) | | | -0.0547** (-1.99) |
| Adjusted $R^2$ | | | 0.1371 | | | 0.1228 |

Table 6. Estimation by the control function approach of the interaction effect of the two types of financial innovation on market share (total sample)

| Independent variables | Product innovation | Process innovation | PMC | Product innovation | Process innovation | PMD |
|---|---|---|---|---|---|---|
| Constant | 29.33002 (1.11) | -9.06784 (-0.43) | | 34.34785 (0.95) | 25.90524 (0.71) | |
| NINV (Inv. Product) | | 0.55726*** (3.22) | | | 0.4893*** (2.73) | |
| NINV (Inv. Process) | 0.48913** (2.57) | | | 0.47928** (2.24) | | |
| Performance | 4.0929* (1.82) | 2.1136* (1.70) | | 7.3079* (1.75) | 4.5060 (1.22) | |
| IHHD | -0.0206*** (-2.74) | -0.0093*** (-2.87) | | -0.0219*** (-2.73) | -0.0014*** (-2.92) | |
| DIV | -1.5324*** (-3.17) | -2.03068 (-1.01) | | -1.8735** (-2.09) | -0.9173 (-0.24) | |

[20] Product innovation * process innovation.

Table 6 (cont.). Estimation by the control function approach of the interaction effect of the two types of financial innovations on market share (total sample)

| Independent variables | Product innovation | Process innovation | PMC | Product innovation | Process innovation | PMD |
|---|---|---|---|---|---|---|
| PUB | -1.4106* (-1.95) | -0.4121 (-0.92) | | -1.4773* (-1.88) | -0.0076 (-0.15) | |
| ETR | 0.5386** (1.99) | 0.2985* (1.93) | | 0.6555* (1.84) | 0.7801** (2.84) | |
| T | -0.2631 (-1.22) | 0.4055* (1.98) | | -0.4203 (-1.24) | 0.99092* (1.73) | |
| RF | 0.30155* (1.83) | 0.57234* (1.96) | | 0.30325* (1.88) | 0.16417* (1.91) | |
| Pseudo $R^2$ | 0.1131 | 0.1053 | | 0.1147 | 0.1084 | |
| Log pseudolikelihood | -234.2004 | -255.4231 | | -239.5731 | -275.0392 | |
| Constant | | | -0.0027 (-0.86) | | | 0.0021 (1.02) |
| Interaction | | | 0.0002** (2.02) | | | 0.0003** (2.27) |
| NINV (Inv. Product) | | | 0.0054 (1.29) | | | 0.0005 (1.52) |
| NINV (Inv. Process) | | | 0.0033 (1.34) | | | 0.0007 (1.29) |
| IHHA | | | 0.00001*** (3.47) | | | 9.19e-06*** (2.99) |
| DEP | | | -0.06687*** (-3.36) | | | 0.0307*** (2.82) |
| CRD | | | 0.13194*** (5.33) | | | -0.0089 (-0.59) |
| TFL | | | 0.0743 (0.36) | | | 0.0315 (0.24) |
| SBC | | | 0.00002 (0.88) | | | 0.00001 (-1.28) |
| Adjusted $R^2$ | | | 0.2033 | | | 0.1834 |

Table 7. Estimation by the control function approach of the interaction effect of the two types of financial innovation on market value and credit risk (total sample)

| Independent variables | Product innovation | Process innovation | MTB | Product innovation | Process innovation | RCRD |
|---|---|---|---|---|---|---|
| Constant | -9.8032 (-1.00) | 15.1987 (0.33) | | 79.4817*** (2.95) | -89.8862*** (-3.27) | |
| NINV (Inv. Product) | | 0.0357*** (2.68) | | | 1.1359*** (5.34) | |
| NINV (Inv. Process) | 0.0527** (2.48) | | | 0.57625** (2.02) | | |
| Performance | -0.0996 (-0.68) | 0.1672 (1.37) | | -31.5812*** (-3.57) | 37.8495*** (4.05) | |
| IHHD | -0.0022*** (-3.18) | -0.0106*** (-3.00) | | -0.0656*** (-4.57) | -0.0761*** (-4.23) | |
| DIV | -2.3559*** (-2.70) | -2.7321 (-0.67) | | -6.7004** (-2.50) | -8.4787 (-1.01) | |
| PUB | -0.9506** (-2.52) | 5.8172 (0.60) | | -2.2312* (-1.84) | 2.40841 (1.27) | |
| ETR | 1.0354* (1.82) | 12.3395* (1.90) | | 2.39714* (1.89) | 2.90856* (1.95) | |
| T | -0.4005 (-1.19) | 1.2192* (1.77) | | 0.27173 (1.22) | 0.41278** (2.03) | |
| RF | 0.0936* (1.91) | 0.2378* (1.89) | | 0.21858* (1.87) | 0.27907* (1.94) | |
| Pseudo $R^2$ | 0.1079 | 0.0917 | | 0.1005 | 0.1084 | |
| Log pseudolikelihood | -323.6239 | -307.6081 | | -294.0923 | -245.2971 | |
| Constant | | | 4.7404*** (4.43) | | | 0.0193 (0.97) |
| Interaction | | | 0.0564** (1.99) | | | 0.0016 (1.11) |

Table 7 (cont.). Estimation by the control function approach of the interaction effect of the two types of financial innovation on market value and credit risk (total sample)

| Independent variables | Product innovation | Process innovation | MTB | Product innovation | Process innovation | RCRD |
|---|---|---|---|---|---|---|
| NINV (Inv. Product) | | | 0.6917 (1.29) | | | 0.0159** (1.98) |
| NINV (Inv. Process) | | | 1.5225 (1.18) | | | -0.0272** (-2.38) |
| IHHA | | | -0.0075* (-1.75) | | | 0.0004** (2.40) |
| DEP | | | -8.5691*** (-2.96) | | | -0.07962 (-0.55) |
| CRD | | | 5.4763** (2.03) | | | -0.00251 (-0.02) |
| TFL | | | -25.7556 (-1.06) | | | 0.44002 (0.31) |
| SBC | | | -0.0042 (-0.95) | | | 0.0039** (2.31) |
| Adjusted $R^2$ | | | 0.2704 | | | 0.2554 |

## 7. The results

**7.1. The relationship between the two types of financial innovation.** The results of the descriptive statistics rather converge towards the simultaneous adoption of the two types of financial innovation during the 1995 to 2010 period, which points to synchronous adoption pattern. H.1 hypothesis is not confirmed because it is only validated during the 1995-2010 period. Moreover, the results confirm the hypothesis H.2: product and process innovation interact with one another.

**7.2. Impact of the interaction of the two types of innovation on banking efficiency.** We found that the interaction of the two types of financial innovation adopted by Tunisian banks improves their efficiency only in market share and market value, thus, confirming only H3.2 and H3.3. However, the interaction effect of product and process innovation reduces profitability (at the 10% level). We conclude that this is, probably, explained by the fact that incomes of Tunisian banks are unable to cover the higher costs of investing in new technologies. Specifically, interaction between the two types of financial innovation has no significant impact on credit risk. Thus, hypothesis H3 is not, ultimately, confirmed.

**7.3. Robustness of the results.** The results allowed us to identify the influential determinants of financial innovation. This is explained by the choice of relevant internal and external factors of banks which show the specificities of the Tunisian banking industry. More specifically, determinants of financial innovation have kept the same sign and, at least, the same significance in equations (1) and (2) of the proposed model. Moreover, dividing the study period into two periods to consider accounting changes the banks' financial statements[21] consolidate the robustness of the results. However, we note that the effect of financial innovation on bank performance during first period [1991, 1997] is very small or insignificant. It becomes significant at the 5% and 1% levels during the second period [1998, 2010]. This can be explained by the fact that maturation of financial innovation was gradually reached in 1998. In other words, with a perspective of openness to financial services, Tunisian banks looking for a better performance, began to better understand how to achieve this objective, from that date. Thus, they seem to better control the introduction of new technologies in managing their production and distribution systems and leveraging more knowledge in their main intermediation activity[22] and in the market.

**7.4. Contributions.** In addition to bringing some light to understanding the relationship between innovation and performance, this study used a joint empirical modeling of variables defining environmental and organizational context, financial innovation and bank performance.

Furthermore, under this empirical modeling, if some aspects of our problem have already been previously treated separately, others are examined for the first time. Thus, studying the Tunisian case, we tried, first, to confirm or refute some previous results and, second, to test hypotheses not yet validated by previous studies, which gives this study on the interaction of the two types of financial innovation and its impact on bank performance a fairly exploratory outlook.

## Conclusion

We examined the interaction between the two types of financial innovation and its impact on banking efficiency. We found that this interaction led to a significant decrease in profitability at the 10% level and provides the bank with a significant market share. Moreover, high interaction of product and process

[21] The new standard is applied to financial statements of fiscal years beginning on 1 January 1997. Thus, the first fiscal year starts from December 31, 1997.

[22] Through better job quality which is reflected by a slowdown in the volume of non-performing loans.

innovation positively and significantly (at the 5% level) affects market value where the market perceives financial innovation as a determining factor of efficiency and technological progress. However, the interaction between the two types of financial innovation has no effect on credit risk ratio. From these results, we can conclude that Tunisian banks have not yet managed to achieve any efficiency targets, through the joint adoption of product and process innovation. This efficiency is achieved only in terms of market share and value. Thus, financial innovation is a value creation instrument for Tunisian banks. Still, the development of a risk assessment system seems essential to start bringing some benefits. Thus, we recommend that Tunisian banks improve, on the one hand, their profitability by optimizing the proposed telematics products to stimulate online banking. On the other hand, attempt to optimize the risk assessment system. Once the Tunisian banking system exceeds enough the revolution fallout, it would be interesting to pursue and explore again the dynamics of financial innovation.

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