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Panayiotis P. Athanasoglou  
Evangelia A. Georgiou  
Christos C. Staikouras

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BANK OF GREECE  
Economic Research Department – Special Studies Division  
21, E. Venizelos Avenue  
GR-102 50 Athens  
Tel: +30210-320 3610  
Fax: +30210-320 2432

[www.bankofgreece.gr](http://www.bankofgreece.gr)

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# ASSESSING OUTPUT AND PRODUCTIVITY GROWTH IN THE BANKING INDUSTRY

Panayiotis P. Athanasoglou  
Bank of Greece

Evangelia A. Georgiou  
Bank of Greece

Christos C. Staikouras  
Athens University of Economics and Business

## ABSTRACT

This paper assesses the evolution of output and productivity in the Greek banking industry for the period 1990-2006. Three main categories of bank output were estimated based on modern theoretical approaches, while for the aggregation and estimation of output and inputs and the estimation of productivity (partial and total factor) we relied on the index number method (Tornqvist index). Additionally, we considered the effect of labor quality on banks' productivity and using a growth accounting framework we examined the contribution of total factor productivity (TFP) to bank output growth. The results show that bank output and labor productivity increased considerably during the period under examination, outpacing the respective GDP growth and labor productivity of the Greek economy. Capital productivity and TFP of the Greek banking industry have also improved remarkably mainly since 1999, as a result of the structural changes that took place within the industry, capital investments (mainly in IT equipment) as well as improvement in the quality of human capital.

*Keywords:* Bank output; user-cost approach; total factor productivity; Tornqvist index; growth accounting; labor quality

*JEL classification:* D24, G21, J24, O47

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## Correspondence:

Panayiotis P. Athanasoglou  
Economic Research Department  
Bank of Greece, 21 E. Venizelos Ave.,  
102 50, Athens, Greece  
Tel.: +30210-320 2449  
Email: [panathasoglou@bankofgreece.gr](mailto:panathasoglou@bankofgreece.gr)



## 1. Introduction

The financial sector plays a crucial role in the effective allocation of resources, in economic growth and in job creation. In advanced economies, this sector has shown relatively high rates of growth during the last decades. In the European Union (EU), the financial sector represented in 2006 about 5.6% of GDP and 3.4% of employment, while this contribution is expected to increase further.

Over the last twenty years, the financial sector and especially the banking industry have undergone important institutional and operational changes both in the EU and in Greece. These adjustments came as a result of a number of factors such as the liberalization of financial markets, rapid technological progress in the areas of telecommunications and information technology (IT) as well as the increasing integration of European money and capital markets, which was significantly promoted by the introduction of the euro.<sup>1</sup> As a result, competition was enhanced and the operation and structure of the financial sector changed radically.<sup>2</sup>

Greek banks responded to these new conditions by undertaking mergers and acquisitions, mainly in the second half of the 1990s and early 2000s, with a view to acquiring a size that would afford them economies of scale and scope (see Athanasoglou and Brissimis, 2004). Also, in the same period, many state-controlled banks were privatized, while at the beginning of the 2000s a number of new small-sized banks entered the market. Additionally, Greek banks took advantage of modern technology in order to offer innovative products and improve the quality and range of services for enterprises and households. These services include electronic (remote) banking, which reduces the importance of branch networks for customer service and has become more and more popular in the last few years. Finally, large-sized Greek banks expanded their activities abroad, mainly in countries of Southeastern Europe and Turkey, through the acquisition of existing local banks so as to exploit synergies stemming from the development and modernization of the existing network.

The reliable, exact and unbiased estimation of basic aggregates such as bank output, inputs and productivity is essential for the evaluation of the performance of the Greek banking system. In general, output measurement in the service sector

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<sup>1</sup> See European Central Bank (ECB, 2007a).

<sup>2</sup> See ECB (2002).

presents significant problems both conceptually and empirically (Melvin, 1995). In the case of the banking industry in particular, these problems are even more intense because of the multiple and inter-dependent nature of production,<sup>3</sup> as a result, measuring bank output and productivity has been widely discussed in the international literature (Triplett, 1991, Casu *et al.*, 2004).

In Greece, the National Statistical Service (NSSG) publishes data on the output of financial intermediaries, which, however, include, apart from banks, other financial institutions.<sup>4</sup> Additionally, these data are subject to frequent revisions and methodological changes that make them hard to compare over time.

In the Greek literature, bank output measurement usually serves productivity or efficiency measurement. In many studies, bank output is proxied by total revenues or total assets, while labor and capital inputs are proxied by number of employees and total non-labor cost respectively (Athanasoglou and Brissimis, 2004 and Athanasoglou *et al.*, 2008). These data are available from the balance sheets of banks; however, they do not accurately reflect neither bank output due to its multiple and interdependent nature mentioned above nor bank inputs as they ignore their quality aspect. Additionally, existing studies which apply more elaborate methods for measuring Greek bank output and productivity (Rezitis, 2006 and Tsionas *et al.*, 2003) often use a small sample of banks or cover a relatively short period.

Against this background, the contribution of the present study to the relevant literature could be summarized as follows:

- I. The study measures and evaluates the evolution of output, inputs and productivity in the Greek banking sector for a relatively long period of seventeen years (1990-2006).
- II. The study follows, for the first time to the best of our knowledge, a more detailed and specialized method for measuring bank output which is based on modern theoretical approaches and is analyzed in Section 3. Our measurement method distinguishes three categories of services offered by banks: financial intermediation, payment services and “other” services. This

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<sup>3</sup> The provision of one service might require the provision of several other services that cannot be priced separately.

<sup>4</sup> These institutions include the central bank, insurance companies, pension funds, stock exchanges, brokerage companies and fund transfer companies.

enables us to recognize the special characteristics of the productive structure of banks and reduces the potential for biased estimations due to the use of inconsistent aggregate output measures.

III. Apart from partial factor productivity (of labor and capital), the study also estimates Total Factor Productivity (TFP) which is considered a wider measure of productivity as it takes into account the specific combination of inputs used in the production process.

IV. Finally, the study also examines, for the first time, the effect of labor quality on productivity measurement of Greek banks, as well as the contribution of inputs' and TFP growth to output growth.

According to our results, bank output and productivity are clearly differentiated between periods 1990-1998 and 1999-2006, with the latter period exhibiting a remarkable improvement. Total output increased significantly (6.6%) between 1990 and 2006, while financial intermediation remained the main source of income for banks. Inputs showed a moderate increase overall, which was relatively stronger in the case of capital, reflecting the gradually increasing capital intensity of the banking industry during this period. Partial and total factor productivity recovered remarkably from 1999 onwards. This fact is obviously connected with structural adjustments in the industry, productive investments in capital (mainly technological equipment) as well as an improvement in the quality of human capital.

The paper is structured as follows: Section 2 provides a brief overview of the literature regarding bank output measurement and presents relevant results for output and productivity in the banking industry at an international level. The way the output of the Greek banking industry is measured in this paper is described in detail in Section 3. Section 4 analyses the concept of productivity, the several methods of estimating total factor productivity, the estimation of productivity for Greek banks as well as the effect of labor quality on this estimation. Section 5 reports the results of this study on Greek banks. Finally, Section 6 presents some conclusions.

## **2. Literature overview**

### **2.1. Measuring the output of banks**

Measuring the output of banks is the starting point of the empirical research on productivity measurement, as well as the estimation of cost and economies of scale and the study of the efficiency of banks. However, there is no consensus among researchers regarding the definition of bank output (Triplett, 1991 and Berger and Humphrey, 1992). This fact is connected with the intangible, multiple and interdependent nature of the services that banks provide to their customers. In particular, banks provide a wide range of services which are often difficult to separate and price independently, while other services are provided without any explicit charge.

In the literature, there are three alternative approaches to measuring bank output, based on the classical microeconomic theory:

- a) the production approach;
- b) the intermediation approach; and
- c) the user-cost approach.

The production approach, which was initially developed by Benston (1965) and Bell and Murphy (1968), supports the view that banks “produce” several categories of loans and deposits, using labor and capital as inputs. According to Benston et al. (1982), “output should be measured in terms of what banks do that cause operating expenses to be incurred”. However, critics of this approach claim that the cost criterion does not serve to distinguish financial inputs from financial outputs. Also, this approach does not apply consistently either volume terms (number of accounts or transactions) or value terms. The data most commonly used are expressed in value terms, as they are more readily available (Freixas X. and Rochet J.C., 1997).

The intermediation approach (Sealy and Lindley, 1997, Murray and White, 1983, Favero and Papi, 1995) emphasizes the intermediating role of banks, i.e. the fact that they collect deposits and buy capital, which they convert into loans and other assets. The value of loans is used to measure output, while deposits along with labor and capital comprise the inputs.



The matter of whether deposits should be considered as output (production approach) or input (intermediation approach) is of particular relevance and is the basic difference between these two approaches. Deposits can qualify as output insofar as they are connected with the provision of a number of not directly charged services such as of liquidity, safe-keeping and payment services (free cheque books, ATM use etc.) which customers receive in return for their deposits. On the other hand, deposits can qualify as input, as the funds that banks collect through deposits are used for the “production” of loans and other bank assets.

Finally, the user-cost approach addresses the issue empirically, relying on the user cost of money<sup>5</sup> in order to determine whether a bank asset or liability is an input or an output. This approach was elaborated by Hancock (1985), who developed a production theory for financial firms, whose inputs and outputs are determined empirically. For a bank asset, the user cost of money is defined as the difference between a benchmark rate (representing the opportunity cost of the bank) and the interest rate (rate of return) associated with holding this asset (Guarda and Rouabah, 2007). For a bank liability, the user cost of money is defined as the difference between the interest rate associated with this liability and the benchmark rate. In both cases, if the user cost of money is positive (negative), then the asset or liability in question is considered as an input (output). It should be noted that a positive user cost of money suggests that this asset or liability contributes to the bank’s operating expenses, and conversely a negative user cost of money means that it increases the bank’s revenues.

## **2.2. Empirical results for bank output and productivity**

Fixler and Zieschang (1992) and Fixler (1993) applied the user cost of money approach in order to measure the output of US commercial banks. More specifically, Fixler (1993) argued that every monetary unit of bank products (e.g. deposits, loans) corresponds to a bundle of financial services, whose classification as an input or an output is determined endogenously, depending on the user cost of money as analyzed above. Output measurement is based on modern index number theory, in particular

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<sup>5</sup> The concept of the user cost of money was initially developed by Donovan (1978) and Barnett (1980).

the Tornqvist index.<sup>6</sup> The empirical results showed that during 1985-1988 the output of large-sized US commercial banks recorded a considerable increase.

Guarda and Rouabah (2007) follow a similar empirical approach, classifying bank products as inputs or outputs according to the sign of the respective user cost. This classification is used for the calculation of output, input and TFP indices of the Tornqvist-type for 176 banks of Luxembourg for the period 1994-2006. Their estimations show that output increased at a much higher rate than that of inputs, which resulted in a commensurate improvement of TFP. In particular, TFP increased by 4% during the period under examination, while there was a clear differentiation according to the size of banks, with the larger ones tending to be more productive.

Morttinen (2002) tried to contribute to the issue of measuring the output of banks, mainly based on the user cost of money approach, as she took into consideration the opportunity cost of deposits and loans. She used data from banks' financial statements and payment transactions and calculated Tornqvist-type indices for the output and labor productivity of six European countries (Finland, Sweden, United Kingdom, Germany, France and Italy) as well the TFP of Finland for a period of 11 to 20 years (1980-2000) depending on the data available for each country. The results showed that the productivity (labor and TFP) of Finnish banks increased mainly because of the drastic reduction of the number of employees, while the output increase was rather subdued. By contrast, for the remaining countries, there was a significant improvement in labor productivity, especially after mid-90's, which is however attributed almost solely to an increase in output.

Another strand of the literature, after defining inputs and outputs, estimates distance functions by using the "Data Envelopment Analysis (DEA)" method and constructs a Malmquist index<sup>7</sup> for TFP measurement. Among this group of studies, the following can be briefly mentioned:

Berg et al. (1992) estimated the output (production approach) and TFP of Norwegian banks for the period 1980-1989. Their results showed that TFP decreased in the years before the liberalization of the market and increased rapidly afterwards.

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<sup>6</sup> See Section 4.2.2 for the definition and use of this index.

<sup>7</sup> Malmquist productivity index measures productivity differences between two productive units and two time periods based on the estimation of distance functions and its change can be decomposed into two separate elements: technical change and efficiency change (Färe *et al.*, 1994)

Wheelock and Wilson (1999) measured output (intermediation approach) and productivity of US banks for the years 1984-1993. They found that TFP decreased during that period, due to bank's deteriorated efficiency and failure to exploit economies of scale and technological advances.

With particular regard to Greece, Rezitis (2006) followed the intermediation approach for output measurement and studied TFP of six banks for the period 1982-1997. His results showed that TFP increased by 2.4% on average during that period, while the TFP rise was substantially higher for the years after market liberalization. Similarly, the results of Tsionas et al. (2003) showed that the TFP growth (3.8%) of Greek banks during the period 1993-1998 is mainly connected with the technological improvement in large-sized banks.

Asimakopoulos et al. (2008) studied the evolution of Greek bank efficiency<sup>8</sup> for the period 1994-2006 and found that it improved gradually from 1999 onwards, a fact which is attributed, to a great extent, to the better management of production factors by banks.

### **3. Measuring the output of Greek banks**

In this study, following Morttinen (2002), the services offered by banks are classified in three categories:

- a) financial intermediation services;
- b) payment services; and
- c) "other" services.

Output indices (in constant prices) are computed for each of these categories, which are then aggregated to construct a total bank output index. The construction of a separate output index for each category of services recognizes the multiple nature of the services provided by banks and aims at avoiding biased estimations stemming from inconsistent aggregate output measures (Kim, 1986).

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<sup>8</sup> To this end, they specified as outputs the various revenue-generating elements and as inputs the various cost elements from the profit and loss account of banks, following the approach of Drake *et al.* (2006).

For the measurement of each output category, elements of the approaches mentioned earlier are combined. For financial intermediation, we apply the user cost of money approach to classify loans and deposits (demand and time) as an input or an output and then we estimate their value added on the basis of their opportunity cost. For payment services, we take into account the relevant bank fees, which are considered a priori as an output,<sup>9</sup> as well as free payment services offered by banks through demand deposits measured on the basis of their opportunity cost. This treatment of bank payment services is thought to provide a more accurate picture of the productive structure of banks (Humphrey, 1991). Alternatively, payment services are measured by the number of the relevant transactions (see Appendix), which is consistent with the production approach.

“Other” services consist of securities income and fees other than those corresponding to payment services. These two elements are considered a priori as outputs, given that they appear in profit and loss accounts of banks and are not associated with any asset or liability.<sup>10</sup>

### **3.1. Financial intermediation services**

These services concern acquiring funds from surplus units (savers) by issuing liabilities and using these funds for granting loans to deficit units (borrowers). Through their intermediation, banks offer important advantages to both sides, e.g. by reducing transaction costs and limiting information asymmetry in financial markets, thus contributing to economic welfare. It should be noted that due to technological advances and the development of innovative financial products, the intermediating activity of banks has decreased over the last decades at an international level<sup>11</sup> and has been partially substituted by the activity of other financial institutions such as pension funds and insurance companies as well as by fund-raising through capital markets.<sup>12</sup>

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<sup>9</sup> This treatment of bank fees and securities income is in accordance with the profit and loss account approach followed by Drake *et al.* (2006) and Asimakopoulou *et al.* (2008). See also Guarda and Rouabah (2007) and Fixler and Zieschang (1992).

<sup>10</sup> See the previous footnote.

<sup>11</sup> See ECB (2000) and Davis and Tuori (2000).

<sup>12</sup> See Bank of Greece, October 2003, p.p. 89-100.

In more detail, according to the definition of section 2.1, the user cost of money for loans ( $u_{\delta,t}$ ) is given by the relationship:

$$u_{\delta,t} = \varepsilon_{\alpha,t} - \varepsilon_{\delta,t} , \quad (1)$$

where  $\varepsilon_{\alpha,t}$  : benchmark rate (12-month Euribor)<sup>13</sup> ; and  
 $\varepsilon_{\delta,t}$  : lending rate.

As mentioned earlier, if  $u_{\delta,t} < 0$ , then loans, being assets, are classified as outputs and in the opposite case ( $u_{\delta,t} > 0$ ) they are classified as inputs.

Similarly, the user cost of money for demand deposits ( $u_{\kappa\tau,t}$ ) and time deposits ( $u_{\kappa\pi,t}$ ) is given by the relationships:

$$u_{\kappa\tau,t} = \varepsilon_{\kappa\tau,t} - \varepsilon_{\alpha,t} , \quad (2)$$

$$u_{\kappa\pi,t} = \varepsilon_{\kappa\pi,t} - \varepsilon_{\alpha,t} , \quad (3)$$

where  $\varepsilon_{\kappa\tau,t}$  : demand deposit rate; and  
 $\varepsilon_{\kappa\pi,t}$  : time deposit rate.

If  $u_{\kappa\tau,t}, u_{\kappa\pi,t} < 0$ , then deposits, being liabilities, are classified as an output, while in the opposite case ( $u_{\kappa\tau,t}, u_{\kappa\pi,t} > 0$ ) they are classified as inputs.

According to our estimations, loans and demand deposits are classified as outputs throughout the period 1990-2006, as are time deposits for most (82%) of the years under examination.<sup>14</sup> The classification of deposits as an output is more consistent with the production approach and would be incompatible with the intermediation approach.

In order to estimate the output of financial intermediation, the above-mentioned user-cost relationships should be written as:

$$u_{\delta,t} = \begin{cases} \varepsilon_{\alpha,t} - \varepsilon_{\delta,t} & \text{if } u_{\delta,t} > 0 \\ \varepsilon_{\delta,t} - \varepsilon_{\alpha,t} & \text{if } u_{\delta,t} < 0 \end{cases} , \quad (1')$$

<sup>13</sup> Guarda and Rouabah (2007) and Fixler and Zieschang (1992) used, alternatively, more than one benchmark rates; without, however, reaching significantly different results.

<sup>14</sup> More specifically, and according to the analysis of the user cost of money in section 2.1, loans and demand deposits contributed to the increase of bank revenues all the years under examination and time deposits in 14 out of 17 years. For the other three years (1990, 2003 και 2004), the user cost of money shows that these deposits contributed to an increase in the operational cost of banks.

$$u_{\kappa\tau,t} = \begin{cases} \mathcal{E}_{\kappa\tau,t} - \mathcal{E}_{\alpha,t} & \text{if } u_{\kappa\tau,t} > 0 \\ \mathcal{E}_{\alpha,t} - \mathcal{E}_{\kappa\tau,t} & \text{if } u_{\kappa\tau,t} < 0 \end{cases}, \quad (2')$$

$$u_{\kappa\pi,t} = \begin{cases} \mathcal{E}_{\kappa\pi,t} - \mathcal{E}_{\alpha,t} & \text{if } u_{\kappa\pi,t} > 0 \\ \mathcal{E}_{\alpha,t} - \mathcal{E}_{\kappa\pi,t} & \text{if } u_{\kappa\pi,t} < 0 \end{cases}, \quad (3')$$

In this study the output of financial intermediation consists conceptually of two components: a) bank credit and b) consumption smoothing provided through deposits, as analysed in the next paragraphs.

Bank credit to enterprises and households is the most important source of income for banks. Loans yield a relatively higher return as they are less liquid than other assets and involve higher default risk. Given that the relevant aspect here is the value added of bank intermediation, we measure output of this category as the difference between the lending rate and the benchmark rate.

Bank deposits (demand and time) have several advantages over alternative investments. For one, they protect depositors against fluctuations in their wealth, as the principal is guaranteed (almost risk-free), offering a typically rather low return. In addition, demand deposits feature a higher degree of liquidity as funds are redeemable on request. Consequently, banks earn the opportunity cost that the depositor is ready to incur in order to enjoy these advantages.

In view of the previous analysis, the value of the output of financial intermediation services is measured as follows:

$$\Pi_1 = u_{\delta,t} \delta + u_{\kappa\pi,t} \kappa_\pi + u_{\kappa\tau,t} \kappa_\tau, \quad (4)$$

where<sup>15</sup>  $\Pi_1$ : value of output (in constant prices) of financial intermediation services

$\delta$ : loans to enterprises and households

$\kappa_\pi$ : time deposits

$\kappa_\tau$ : demand deposits

However, given the last term of (4) can be written as:

$$u_{\kappa\tau,t} \kappa_\tau = (\mathcal{E}_{\alpha,t} - \mathcal{E}_{\kappa\pi,t}) \kappa_\tau + (\mathcal{E}_{\kappa\pi,t} - \mathcal{E}_{\kappa\tau,t}) \kappa_\tau, \quad (5)$$

the relationship (4) would become:

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<sup>15</sup> For more details on the statistical data used and their sources see the Appendix.

$$\Pi_1 = u_{\delta,t} \delta + u_{\kappa\pi,t} (\kappa_\pi + \kappa_\tau) + (\varepsilon_{\kappa\pi,t} - \varepsilon_{\kappa\tau,t}) \kappa_\tau , \quad (6)$$

However, the term  $(\varepsilon_{\kappa\pi,t} - \varepsilon_{\kappa\tau,t})\kappa_\tau$  will be excluded from (6) since it also concerns payment services and will be included only in this category in order to avoid double calculation, as will be analyzed in the next section. Therefore,  $\Pi_1$  is expressed as:

$$\Pi_1 = u_{\delta,t} \delta + u_{\kappa\pi,t} (\kappa_\pi + \kappa_\tau) , \quad (7)$$

In order to deflate  $\Pi_1$  we used the following price index:

$$T_t = \text{CPI}_t [(\varepsilon_\delta - \varepsilon_{\kappa\pi})_t / (\varepsilon_\delta - \varepsilon_{\kappa\pi})_0] , \quad (8)$$

which captures both the general level of prices and the interest rate margin.<sup>16,17</sup>

### 3.2. Payment services

Payment services are one of the basic functions of banks in modern advanced economies. Market liberalization and growing financial integration in the EU have increased significantly the volume of bank payment transactions both at a national and at an international level.

Payment services include customer account management and ensuring that all relevant procedures will be concluded, i.e. the bank guarantees that the transaction amount will be paid to the beneficiary.<sup>18</sup>

In Greece, the use of cash in daily transactions remains important, mainly as regards payments of low value. However, the use of cashless instruments (credit transfers, credit cards, direct debits) has been increasing in the last few years, which is attributed to their intense promotion by banks as well as to their operational characteristics such as user-friendliness and short time of execution.<sup>19</sup>

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<sup>16</sup> I.e. the difference between the lending rate and the time deposit rate.

<sup>17</sup> See also Morttinen (2002).

<sup>18</sup> Apart from banks, money transfers are also undertaken by intermediaries, which, however, have a relatively small market share, as they cannot easily compete the modern and reliable payment systems of banks.

<sup>19</sup> During 2001-2005, the number and value of cashless payment transactions in Greece rose by an average 16,2% and 7,5% per year, respectively (ECB, 2007 b).

In this study, output from payment services includes: a) direct fees for payment services provided<sup>20</sup> and b) free payment services provided through demand deposits. These free-of-charge services are measured by the opportunity cost (implicit charges) of the deposit, which is connected with the depositor's motive for high liquidity. Opportunity cost is defined as the difference between the demand deposit interest rate and time deposit rate (liquidity margin). Consequently, payment services output is given by the relationship:

$$\Pi_2 = \pi_\alpha + (\varepsilon_{\kappa\pi,t} - \varepsilon_{\kappa\tau,t}) \kappa_\tau \quad , \quad (9)$$

where  $\Pi_2$ : value of output (in constant prices) of payment services  
 $\pi_\alpha$ : direct fees for payment services

In relationship (9),  $\pi_\alpha$  is deflated by the CPI and the component of implicit charges by a price index, similar to that of the previous output category:

$$T_t = \text{CPI}_t [(\varepsilon_{\kappa\pi} - \varepsilon_{\kappa\tau})_t / (\varepsilon_{\kappa\pi} - \varepsilon_{\kappa\tau})_0] \quad , \quad (10)$$

Alternatively, payment service output was also measured on the basis of the number of transactions on a series of payments including payments through ATMs, credit and debit cards, credit transfers, direct debits and cheques.<sup>21</sup> This output index is reported in the Appendix.

### 3.3. “Other” services

Bank non-interest income (fees, income from securities<sup>22</sup> and capital gains) has show in the last few years a considerable upward trend in many European countries.<sup>23</sup> The conditions of intense competition that have prevailed in the Greek banking market in combination with the low levels of interest rates and volatility in financial

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<sup>20</sup> Direct fees refer to services such as the deposit or transfer of money to a third party's account, issuing bank cheques, remittances, direct debits for bill payments, withdraw of money from the ATM of another bank, etc.

<sup>21</sup> These data come from the “Blue Book, payment and securities settlement systems in the EU” of the ECB.

<sup>22</sup> This income includes dividends from shares and other variable income securities, coupons from fixed return securities, participations in associated companies, etc.

<sup>23</sup> Indicatively, it is mentioned that according to ECB (2000) data, the share of non-interest income to total operating income of banks in the EU reached 41% in 1998 from 32% in 1995.



markets internationally, have given banks the opportunity to offer new investment services such as underwriting, consultancy, asset management, insurance products etc.

It should be noted that in this study we take into account income from fees and securities (that make up the bulk of banks' non-interest income), while capital gains from portfolio management are not included as they are considered rather incidental.

The output of “other” services can be expressed as follows:

$$\Pi_3 = (\pi_\sigma - \pi_\alpha) + \tau \quad , \quad (11)$$

where  $\Pi_3$  : value (in constant prices) of “other” services output

$\pi_\sigma$  : total fees

$\tau$  : securities income

The value of this output category was deflated by the CPI.

### 3.4. Total output

Total bank output is the weighted sum of the three output categories using the Tornqvist index.<sup>24</sup> This index has been widely used in the literature for measuring total output and input in the banking industry, aggregating the separate categories of outputs and inputs.<sup>25</sup> The Tornqvist index for total output of banks between two consecutive periods t and t+1 is as follows:

$$\ln (\Pi_{t+1} / \Pi_t) = \frac{1}{2} \sum_{i=1}^3 (\omega_{i,t+1} + \omega_{it}) \ln (\Pi_{i,t+1} / \Pi_{it}) \quad , \quad (12)$$

where  $\Pi_t$ : total bank output

$\Pi_{i,t}$  : value (in constant prices) of i category of output

$\omega_{it}$  : weight of i category of output

The yearly weights of the three output categories represent the percentage share of each output category in the value of total bank output and are presented in detail in the Appendix.

<sup>24</sup> For more details on the definition and use of this index see section 4.2.2.

<sup>25</sup> See Fixler (1993), Morttinen (2002) and Guarda and Rouabah (2007).

## 4. Concept and measurement of productivity

### 4.1. Partial and total factor productivity

Productivity measurement has received a lot of attention from economists and policy makers because of its information content regarding the productive efficiency of an economy (or a sector) as well as the determinants of economic growth.

Productivity measures the quantity of total bank output per unit of inputs used in production. A productive unit (country, industry or firm) is considered more productive than another one if it produces either a given quantity of output with less inputs or a higher output quantity with given inputs. When the contribution of each input to the output is examined separately, then we refer to partial productivity, such as labor or capital productivity. However, partial productivity may be an inaccurate measure of the true contribution of a single input, as other factors may also interact (such as changes in input proportions, qualitative improvements and technological or organizational advances incorporated in the production process). For example, an increase in the labor productivity of an economy or an industry may partially reflect the substitution of labor by capital.

In order to overcome the weaknesses of partial productivity, we estimate TFP, which is defined as the ratio of total output to total inputs<sup>26</sup> used in production, i.e.:

$$TFP_t = \Pi_t / I_t \quad , \quad (13)$$

where  $I_t$ : index of total inputs in time  $t$ .

The concept of TFP was initially developed by Tinbergen (1942) and Stigler (1947), while Solow (1957) created a reference framework for the main empirical approaches to TFP measurement. Within this framework, TFP is a residual (Solow residual), i.e. that part of the change in output that cannot be explained by the change in inputs and is usually attributed to innovation and technological and organizational improvements.<sup>27</sup>

In the literature, there are several views on what TFP expresses:  
a) One view is that TFP refers to technological progress associated with a shift in the

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<sup>26</sup> Most productivity studies concentrate on labor and capital, and many researchers recognize that it is not possible to take into account all the production factors that influence output. For this reason they prefer the term “multifactor” rather than “total” factor productivity.

<sup>27</sup> For more details see section 4.2.1.

production function (Barro, 1999). Production technology is defined as all the known to date ways of converting inputs into outputs (Griliches, 1987), whether physical, such as changes in the type and quality of inputs (new capital or intermediate goods), or non-physical (scientific progress, new managerial and organizational techniques, general experience etc.) which is associated with TFP improvement. b) A second view focuses on efficiency improvement. A firm or an industry may increase its TFP, even without any technological improvement, if it uses inputs more efficiently and operate more closely to the technically optimum combination of inputs and outputs (Balk, 2001). c) A third view emphasizes the exploitation of economies of scale by changing the scale of the firm's or the industry's operation (Balk, 2001, Jorgenson and Griliches, 1967). However, if a firm or an industry produces more than one output and/or uses more than one input, TFP change may reflect changes in the composition of the output and/or the input mix.

## 4.2. Methods of TFP measurement

### 4.2.1. Solow growth accounting method

This method (Solow, 1957) considers TFP change as the part of output (Q) change that is not explained by the change in capital (K) and labor (L) inputs. Essentially, TFP is associated with technology (t) which determines output production and is given by the relationship:

$$Q = F(K, L; t) \quad , \quad (14)$$

Production function (14) is subject to the following assumptions:

- 1) technological progress is neutral;
- 2) markets are perfectly competitive;
- 3) production function is characterized by constant scale economies; and
- 4) producers are efficient, as they maximize their profits.

The first hypothesis implies that technological progress is separable, thus relationship (14) can be written as follows:

$$Q = A(t) F(K, L) \quad , \quad (15)$$

The second hypothesis suggests that the price of labor ( $w_L$ ) and the price of capital ( $w_K$ ) equal their marginal product:

$$w_L = \partial Q / \partial L = A(t) \partial F / \partial L , \quad (16)$$

$$w_K = \partial Q / \partial K = A(t) \partial F / \partial K , \quad (17)$$

If we define labor elasticity of output as:  $\alpha_L = w_L L/Q$ , and capital elasticity of output as:  $\alpha_K = w_K K/Q$ , then from the third hypothesis we deduct that  $\alpha_L + \alpha_K = 1$  and  $w_L L + w_K K = Q$ . Consequently, according to (15), the output growth rate<sup>28</sup> ( $\hat{Q}$ ) can be defined as :

$$\hat{Q} = \hat{A} + \alpha_K \hat{K} + \alpha_L \hat{L} , \quad (18)$$

or solving for  $\hat{A}$ , and given that  $\hat{A} = \hat{TFP}$ , then:

$$\hat{TFP} = \hat{Q} - (\alpha_K \hat{K} + \alpha_L \hat{L}) , \quad (19)$$

From relationship (19) it can be seen that the growth rate of TFP ( $\hat{TFP}$ ) is a residual (Solow residual), being the part of output growth that cannot be explained by the growth rate of inputs K and L.

Estimating (19) presupposes knowing labor and capital elasticities of output ( $\alpha_L$  and  $\alpha_K$  respectively), which are usually not available. However, if we assume that production function is of a Cobb-Douglas type, then parameters  $\alpha_L$  and  $\alpha_K$  equal the income shares of labor ( $\alpha$ ) and capital ( $1-\alpha$ ), for which, as it is known, there are statistical data. Consequently, TFP can take the following form:

$$\hat{TFP} = \hat{Q} - \alpha \hat{L} - (1-\alpha) \hat{K} , \quad (20)$$

Based on (20) we can express the relationship between the growth rates of TFP,  $P_L$  (labor productivity) and R (capital deepening, K/L), as follows:

$$\hat{TFP} = \hat{P}_L - (1-\alpha) \hat{R} , \quad (21)$$

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<sup>28</sup> The sign ^ above a variable indicates that the respective growth rate is considered.

From (21) it is obvious that  $T\hat{F}P$  is determined by  $\hat{P}_L$ , while the influence of  $\hat{R}$  is proportional.

From (20) it can also be deduced that  $T\hat{F}P$  equals the weighted sum of the growth rates of labor productivity ( $\hat{P}_L$ ) and capital productivity ( $\hat{P}_K$ ), or:

$$T\hat{F}P = \alpha \hat{P}_L + (1-\alpha) \hat{P}_K \quad , \quad (22)$$

Finally, if we assume that in the long-run the relationship  $K/Q$  is constant, then (22) can be written as follows:

$$T\hat{F}P = \alpha \hat{P}_L \quad , \quad (23)$$

Consequently,  $\hat{P}_L > T\hat{F}P$  should be valid in the long run.

#### 4.2.2. Index number method

This method is an extension of Solow's growth accounting method and considers a case where more than one inputs are used to produce more than one outputs (services). In this context, for  $n$  outputs and  $m$  inputs, (19) can be written as follows:

$$T\hat{F}P = \sum_{i=1}^n \beta_i \hat{\Pi}_i - \sum_{j=1}^m \alpha_j \hat{I}_j \quad , \quad (24)$$

where  $\beta_i = p_i \Pi_i / p \Pi$  and  $i = 1, \dots, n$  the number of outputs

$p_i$  = the price of output  $\Pi_i$

$\alpha_j = w_j I_j / w I$  and  $j=1, \dots, m$ , the number of inputs

$w_j = A(t) \partial F / \partial I_j$

Based on (24), in order to aggregate  $n$  output categories and  $m$  input categories from period  $t$  to  $t+1$ , we use as weights the income shares ( $\beta_i$ ) of output and the cost shares ( $\alpha_j$ ) of inputs respectively.

Output and input volume indices widely used in the literature are of the Fisher or the Tornqvist type. These output indices are defined respectively by the following formulas:

$$\ln Q_F = \frac{1}{2} (\ln Q_L + \ln Q_P) \quad , \quad (25)$$

$$\ln Q_T = \frac{1}{2} \sum (\beta_{i,t+1} + \beta_{i,t}) \ln (\Pi_{i,t+1} / \Pi_{i,t}) \quad , \quad (26)$$

where  $Q_F$ ,  $Q_L$ ,  $Q_P$  and  $Q_T$  are the output indices of the Fisher, Laspeyers, Paasche and Tornqvist type respectively.

Tornqvist and Fisher output indices feature some desirable properties i.e. they are: 1) symmetric, 2) chained, 3) exact and 4) superlative.

- The Tornqvist index is a *symmetric* one, as it gives equal importance to periods  $t$  and  $t+1$ . Generally, it is argued (Hill, 1993) that symmetric indices (as the Tornqvist and Fisher indices): first, are quite close to one another and second, are preferable to other non-symmetric indices (such as Laspeyers and Paasche).
- *Chained* indices (for each period  $(t+1)$ , the previous period  $(t)$  is used as a base) have the advantage that they minimize the substitution bias<sup>29</sup> which is usually present in fixed-weight indices, such as the Laspeyers index. In general, chained indices are preferable for comparisons of long time periods, as they measure year-on-year changes. Additionally, as chained indices measure as a rule relatively small changes, they can approximate adequately the theoretically optimum indices.
- An index is described as *exact* when it is derived from a certain function of aggregation. Diewert (1976) showed that the Tornqvist index is exact when the underlying function is homogeneous translog<sup>30</sup> and the usual assumptions for producers' behavior also hold. As a result this index has an important advantage, given that this functional form is a special case of a wider group of functions. In a similar way, it can be proved that the Fisher index is exact for the quadratic function.
- *Superlative* is an index that is exact and additionally the underlying function is "flexible", i.e. the underlying function is a second order approximation of a linear homogeneous function. Tornqvist and Fisher indices are superlative, given that their underlying functions are flexible (Diewert, 1976).

The Tornqvist index provides an aggregation formula for individual output and input categories to total output and total input respectively, under the presupposition

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<sup>29</sup> The substitution bias is particularly intense in fixed-weight indices, as it reflects the overestimation of the contribution of outputs and inputs whose relative prices have decreased and their underestimation in case their relative prices have increased.

<sup>30</sup> The reverse also holds, i.e. that the translog function is exact for the Tornqvist index.

that there is perfect competition in the industry, constant returns of scale, neutral by Hicks technological progress and separability of outputs and inputs. However, Caves *et al.* (1982) proved that the Tornqvist index is also suitable (superlative) under more general conditions such as non-homogeneous functions and variable economies of scale and, as a result, it provides a consistent aggregator of outputs and inputs for a wider range of productive structures.

Among two or more output or input indices, the choice of the most suitable one is usually based on two sets of criteria: a) the economic ones and b) the statistic ones.

- The *economic criteria* refer to the production function (from which the index is derived from) and the optimization goals of the producers. More specifically, the Tornqvist index, which, as mentioned earlier, comes from the translog function, is based on the assumption that producers face a given price and maximize their profit or minimize their cost. However, in the case of Tornqvist index, it is not required for the production function to be separable between outputs and inputs, as it is the case with Fisher index.

- According to the *statistical (axiomatic) criteria*, it has been proven that Fisher index satisfies more criteria compared to Tornqvist.<sup>31</sup> However, between these two indices, Tornqvist is usually preferred because : (i) it approaches Fisher quite well, (ii) translog production and cost functions have been widely used in the literature and (iii) as already mentioned, the Tornqvist index can come from a wider set of functions.<sup>32</sup>

#### 4.2.3. Distance function method

This method takes into account the percentage use of the production factors, by using distance functions of output and inputs. TFP changes are decomposed in movements towards the optimum production frontier and to shifts of the optimum production frontier. Output distance function measures the relative distance between produced output per unit of input and the respective point of the production frontier. For example, an estimation of the distance of output 0.7 means that the actual output is 70% of the output that could be produced given these inputs.

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<sup>31</sup> See Coelli *et al.* (2005) and Diewert and Lawrence (1999).

<sup>32</sup> Indicatively, in the productivity literature, the Tornqvist index was used by Star (1974), Star and Hall (1976) and Diewert and Lawrence (1999).

#### 4.2.4. *Econometric method*

This method is based on the estimation of the parameters of a production (or cost, profit etc.) function, where technological change is usually represented by TFP. The econometric method has certain advantages, such as flexibility of the production function, estimation of other parameters apart from TFP, hypothesis testing etc. (Hulten, 2000).

### **4.3. Measuring partial and total factor productivity of Greek banks**

Partial (labor and capital) productivity of banks as well as TFP are measured by using the index number method and, in particular, the Tornqvist index. As mentioned earlier, the three individual categories of bank output were aggregated by using the Tornqvist index to construct an index for total output. In a similar way, separate input indices were aggregated to obtain a total input index, which was then used to measure TFP.<sup>33</sup>

Labor productivity measures the quantity of bank output per unit of labor. Labor is proxied by the number of employees and alternatively, in order to capture labor quality aspects, by wages (in constant prices).<sup>34</sup>

Capital productivity measures the quantity of bank output per unit of capital used. Capital comprises two individual categories of fixed assets: a) real estate (i.e. buildings and land) and b) other fixed assets (mostly information technology equipment), which are represented by their net book value, as it is shown in the balance sheets of banks.<sup>35</sup> The value of real estate was deflated by the index of prices of dwellings; the value of other fixed assets was deflated by the producer price index.<sup>36</sup>

As mentioned earlier, TFP is calculated as the ratio of bank output to the corresponding index of total inputs. Between two consecutive periods  $t+1$  and  $t$ , TFP change is given by the following relationship:

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<sup>33</sup>See Guarda and Rouabah (2007) and Morttinen (2002) for TFP measurement using a Tornqvist index.

<sup>34</sup>For more details on labor quality see the next section.

<sup>35</sup>In addition, we tried to measure capital stock of the banking sector based on data provided by NSSG. However, we do not present the relevant estimates, since they (mainly the “other fixed capital” data) probably contain measurement errors.

<sup>36</sup>For more details on the sources of statistical data see the Appendix.



$$\ln(\text{TFP}_{t+1} / \text{TFP}_t) = \frac{1}{2} \sum_{i=1}^n (\beta_{i,t+1} + \beta_{i,t}) \ln (\Pi_{i,t+1} / \Pi_{it}) - \frac{1}{2} \sum_{j=1}^m (\alpha_{j,t+1} + \alpha_{jt}) \ln (I_{j,t+1} / I_{jt}), \quad (27)$$

The weights of labor and capital for the construction of a Tornqvist index of total inputs were calculated on the basis of the percentage share of each input, i.e. labor cost (wages) and non-labor cost (depreciation and general operating expenses), to the banks' total operating expenses.

#### *4.3.1. The influence of labor quality on productivity measurement*

Human resources of an economy can be classified according to qualitative characteristics such as educational and skills level, age and gender. The evolution of these characteristics changes over time depending on the conditions in labor market, which, in turn, depend on the process of economic growth and the extent of specialization in the economy. As a consequence, the contribution of human resources (human capital) to labor productivity also changes. However, the measurement of labor input which is usually based on the number of employees or the number of hours worked ignores these changes in human capital, i.e. changes in labor quality, and leads to underestimating the contribution of labor in the output.

The important influence of labor quality on productivity measurement has been widely recognized in the literature, especially after Jorgenson and Griliches' finding (1967) that possible improvements in the quality of the inputs that are not taken into account result in the overestimation of productivity growth.<sup>37</sup> Estimating labor quality is based on the assumption that the aforementioned characteristics reflect differences in productivity and wages.<sup>38</sup> This assumption is based on a model of competitive labor markets, where wages are equal to the marginal product of labor. However, in actual labor markets various factors such as discriminations and collective bargaining may often refute this assumption. In the absence of more direct measures, wages are considered in this study as the best available measure of labor quality (Schwerdt and Turunen, 2006).

<sup>37</sup> See also Brandolini and Cipollone (2001).

<sup>38</sup> See Card (1999) and Katz and Murphy (1992) who document empirically the relationship between these characteristics and the wages and productivity.

The influence of labor quality on productivity becomes even more relevant for this study, which examines the productivity of banks over a rather long time period, during which the banking sector underwent major institutional and operational changes that radically altered its functioning and structure. Taking all these into account and especially the latter observation, measurement of labor by using wages reflects directly (at least to some extent) the characteristics of human capital mentioned earlier.

The growth rate of labor quality is defined as the difference between the respective rates of quality-adjusted and non-adjusted labor:

$$\hat{L}_Q = \hat{L}_W - \hat{L} \quad , \quad (28)$$

where<sup>39</sup>  $\hat{L}_Q$  : labor quality

$\hat{L}_W$  : quality-adjusted labor (wages)

$\hat{L}$  : non-adjusted labor (number of employees).

Finally,  $\hat{L}_Q$  can be expressed in terms of non-adjusted labor productivity ( $\hat{P}_L$ ) and quality-adjusted labor productivity ( $\hat{P}_W$ ), as follows:

$$\hat{L}_Q = \hat{P}_L - \hat{P}_W \quad , \quad (29)$$

Based on (29), equation (22) can be written as:

$$TFP = \alpha \hat{L}_Q + \alpha \hat{P}_W + (1-\alpha) \hat{P}_K \quad , \quad (30)$$

Therefore from (30) it is clear that besides partial productivity of L (quality-adjusted) and K, labor quality also affects TFP.

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<sup>39</sup> See footnote 27.

## 5. Empirical results for Greek banks

### 5.1. Bank output

Table 1 shows the average annual growth rates of total bank output as well as of the three individual categories of output for the period 1990-2006 and the respective growth rate of GDP of the Greek economy. Additionally, these growth rates were calculated for two sub-periods 1990-1998 and 1999-2005, reflecting the fact that the latter sub-period is associated, as already mentioned, to a large extent with many important developments in the Greek banking system such as numerous mergers and acquisitions, privatizations of banks under state control, preparations for and entry of Greece into the EMU and expansion of bank activities abroad and specifically in the countries of the Southeastern Europe.

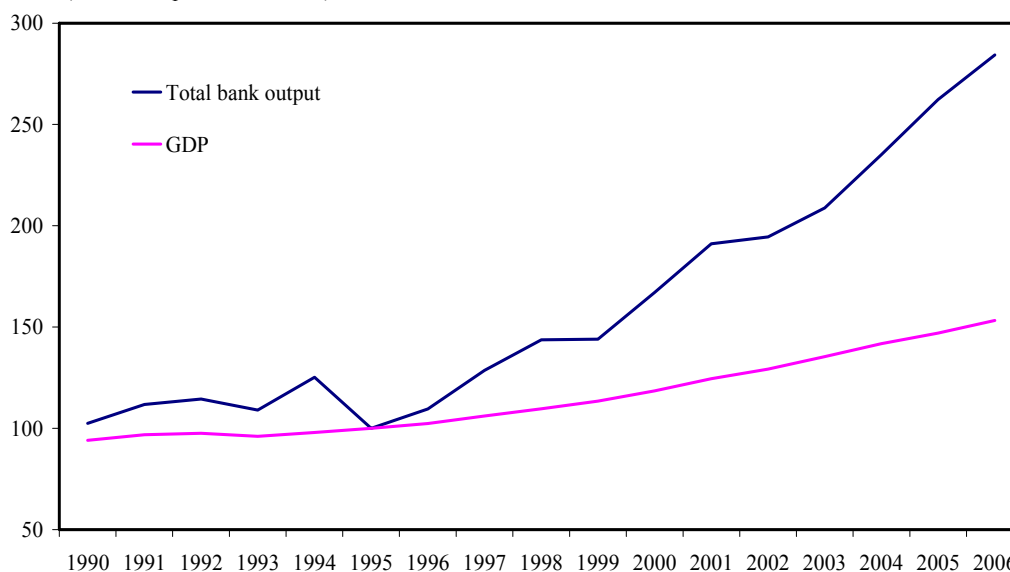
**Table 1 - Bank output and GDP of the Greek economy**  
(in constant prices)

Output	Yearly average growth rate		
	1990-2006	1990-1998	1999-2006
<b>Total bank output</b>	6.6	4.3	8.9
- Financial intermediation	7.6	4.9	10.5
- Payment services	3.9	2.5	5.3
- "Other" services	2.1	0.9	3.4
<b>GDP</b>	3.1	1.9	4.3

Total bank output increased by 6.6% annually, almost tripling between 2006 and 1990 (see Table 1 and Figure 1) and outperforming GDP growth. More specifically, it was more than double the growth rate of GDP both in the whole period under examination<sup>40</sup> (6.6% against 3.1%) as well as in each of the two sub-periods (1999-2006: 8.9% against 4.3%, 1990-1998: 4.3% against 1.9%).

<sup>40</sup> The percentage share of financial intermediaries in GDP increased from 3.5% in 1990 to 6.0% in 2004 (NSSG data for the Gross Value Added of the sectors of the Greek economy), indicating that the value added of these institutions increased faster than GDP.

**Figure 1 - Total bank output and GDP of the Greek economy**  
(in constant prices; 1995=100)

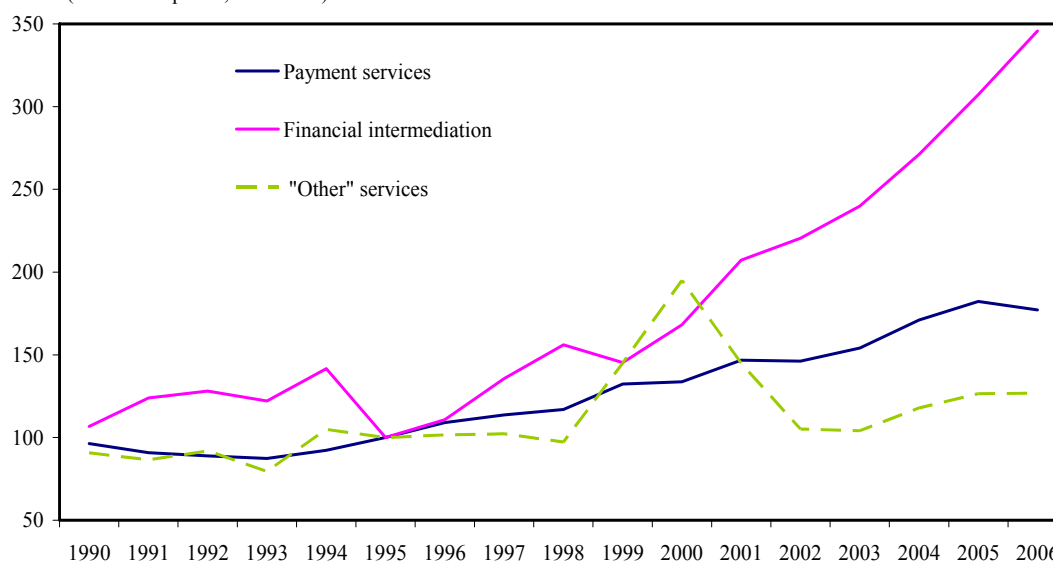


As far as the individual categories of bank output are concerned, financial intermediation is the most important one, with a share in the total value of output of 73% on average during the period 1990-2006 (see Figure 10.A), followed by payment services (19%) and “other” services (8%).<sup>41</sup> The share of financial intermediation remains relatively stable throughout the period under examination with only small deviations from the average. Consequently, over the last two decades, the output of this category remained robust in Greece. However, it should be noted that, in relative terms, bank intermediation may have declined due to the considerable expansion of capital markets during this period.<sup>42</sup>

<sup>41</sup> The yearly weights for each output category are presented in Figure 10A of the Appendix.

<sup>42</sup> See footnotes 11 and 12.

**Figure 2 - Bank output categories**  
(in constant prices; 1995=100)



*Financial intermediation* output rose by 7.6% yearly and, thus, at the end of the period under review it was three times higher than in 1990 (see Figure 2). This rise was particularly strong from 1999 onwards, as, apart from the above mentioned developments, Greece's entry into EMU resulted in a significant fall in interest rates and high credit growth, which, in turn, contributed to the considerable growth of this category of services. Financial intermediation grew at a higher pace than that of total bank output during both the whole period 1990-2006 and the two sub-periods (see Table 1).

The output of *payment services* showed an upward trend with an annual growth rate of 3.9%. As already mentioned, the provision of these services has developed significantly since the second half of the '90s (see Figure 2) due to technological advances in payment systems. The widespread use of ATMs and credit cards and, more recently, the gradual expansion of electronic banking resulted in a significant rise mainly of the volume<sup>43</sup> and, to a lesser extent, the value of payment transactions.<sup>44</sup> The growth rate of this category of services reached 5.3% in the second sub-period than 2.5% in the first one. These rates were considerably lower than those of total output for the whole period under review (1990-2006: 3.9% against 6.6%, 1999-2006 : 5.3% against 8.9%, 1990-1998: 2.5% against 4.3%).

<sup>43</sup> For the evolution of payment services in volume terms (number of transactions) see the Appendix.

<sup>44</sup> See also footnote 18.

“*Other*” services output showed a rather moderate annual increase of 2.1% (see Table 1). However, there was an exceptional two-year period (1999-2000) when this category of output rose remarkably (see Figure 2), due to the development of investment banking as a result of the favourable conditions in the stock market. The growth rate of this output category falls significantly behind the respective rate of total output for the whole period 1990-2006.

As pointed out earlier, the second sub-period (1999-2006) is characterized by a considerable acceleration of the growth rate of the three individual categories as well as total bank output. This finding was tested on the basis of the statistical significance of the difference between the averages of the two sub-periods. According to this test, the average level of the individual categories and total bank output of 1999-2006, is statistically significantly higher than those of the previous sub-period (especially as far as payment services are concerned).

## **5.2. Bank inputs**

Before going on to further analysis, it should be noted that the composition of bank inputs changed drastically during the period under review. In particular, on the basis of the share of each input category in total bank operating expenses, labor represented 78% in 1990 but this share had fallen to 61% by 2006. On the other hand, the respective share of capital increased from 22% to 39%.<sup>45</sup> Thus, during 1990-2006, the production of Greek banking industry became gradually more capital-intensive, although it remains a labor-intensive one.

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<sup>45</sup> The weights of inputs are presented in Figure 10B of the Appendix.

**Table 2 - Bank inputs and labor quality**  
(in constant prices)

Inputs	Yearly average growth rate		
	1990-2006	1990-1998	1999-2006
<b>Total inputs</b>			
- quality-adjusted	3.1	2.3	3.9
- non-adjusted	2.0	2.1	2.0
<b>Labor</b>			
- quality-adjusted	2.9	2.4	3.4
- non-adjusted	1.2	2.0	0.4
- <i>labor quality</i>	1.7	0.4	3.0
<b>Capital</b>	3.7	2.5	4.8
- Real estate capital	2.2	-2.5	7.1
- Other fixed assets	4.0	3.8	4.2

Apart from the number of employees, labor input was measured by wages which reflect, as already mentioned, improvements in the quality of this input.<sup>46</sup> More specifically, quality-adjusted labor grew during 1990-2006 at a yearly rate of 2.9%. This pace accelerated between the two sub-periods under examination from 2.4% to 3.4% (see Table 2 and Figure 3.A). However, non-adjusted labor (i.e. the number of employees) recorded a considerably lower growth rate (1.2%) for the whole period reviewed. More specifically, even though the number of employees increased by 2% during 1990-1998, it remained almost stable (0.4%) thereafter.

According to the analysis that preceded in Section 4.3.1, Greek bank labor quality increased significantly by 1.7% year-on-year in 1990-2006 (see Table 2 and Figure 3.A), suggesting that during these years there was a rising participation in the banking industry of employees with a higher educational level, greater specialization and more professional experience.<sup>47</sup> This increase in labor quality took place almost exclusively in the sub-period 1999-2006 (3.0%), while during the former period it recorded a much lower growth rate (0.4%).

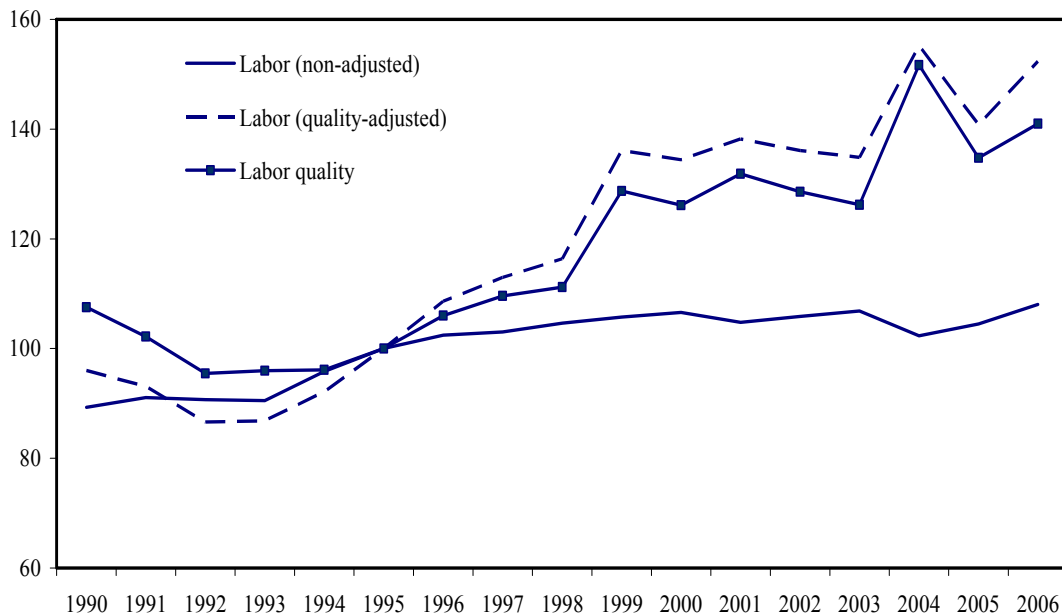
<sup>46</sup> For more details on labor quality measurement see section 4.3.1.

<sup>47</sup> According to ECB estimates, labor quality in the euro area economy seems to have been improving between 1984 and 2004 at an average annual growth rate of 0.6% (see ECB, *Monthly Bulletin*, October 2005). The same analysis also shows that changes in labor quality play an increasingly important role in the growth of labor productivity, as in the beginning of the '80s it accounted only for 15% of labor productivity increase while this percentage exceeded 30% in early 2000s.

Capital input increased by 3.7% yearly, while this rate was higher in the second sub-period in comparison to the first one (4.8% against 2.5% - see Table 2 and Figure 3.B). Between the two individual categories of capital, other fixed assets recorded the higher growth rate (4%), while real estate capital increased by 2.2%. The change in real estate capital fluctuated significantly (from -2.5% the first sub-period to 7.1% the second one), which is mainly attributed to revaluations in the real estate of large banks, due to the application of the International Financial Accounting Standards since 2005. Other fixed assets value (which mainly concern IT infrastructure) increased by 3.8% during 1990-1998 and 4.2% in the second sub-period.

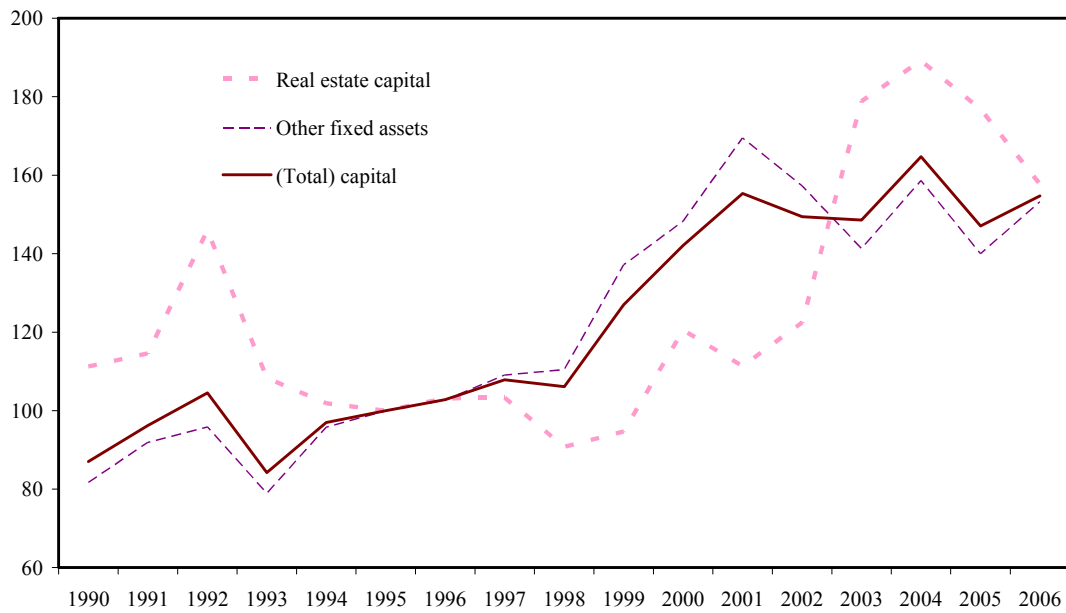
**Figure 3 - Bank inputs and labor quality**  
(in constant prices; 1995=100)

**A. Labor and labor quality**

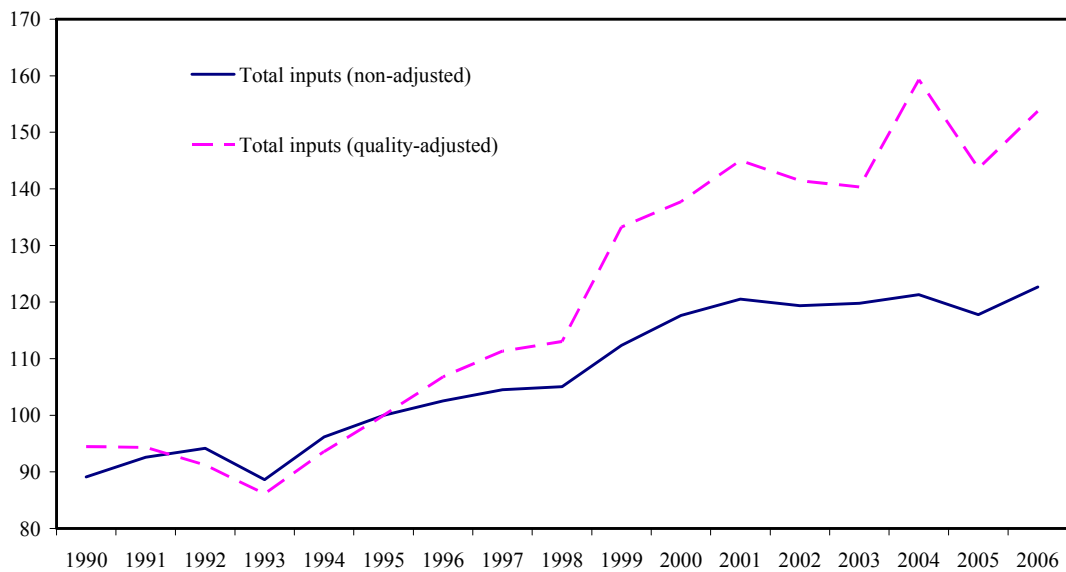




### B. Capital



### C. Total inputs



Total inputs rose in the period under examination by 3.1% (2.0%)<sup>48</sup> (see Table 2 and Figure 3.C). Between the two sub-periods reviewed, this rate came up to 3.9% (2.0%) from 2.3% (2.1%). It should be noted that the increase in inputs is much stronger if labor is adjusted for quality.

<sup>48</sup> The first figure reported refers to the growth rate with labor measured by wages, while the figures in parentheses refer to the case of labor being measured by the number of employees.

### 5.3. Bank productivity

#### 5.3.1. Labor productivity

Labor productivity (quality-adjusted) increased by 3.6% yearly during 1990-2006, accelerating from 1.8% in 1990-1998 to 5.3% in the second sub-period (see Table 3 and Figure 4). Measuring labor by the number of employees (non-adjusted labor), the corresponding average annual increase in labor productivity comes up to 5.3%, accelerating from 2.3% to 8.5%, i.e. it is considerably higher than the corresponding rates of the quality-adjusted labor productivity (see Table 3). (Non-adjusted) labor productivity of banks was higher than the respective productivity of the Greek economy for the whole period under examination (1990-2006: 5.3% against 2.2%, 1999-2006: 8.5% against 3.3%, 1990-1998: 2.3% against 1.2%). The remarkable improvement in labor productivity since 1999 is associated, as mentioned earlier, with the structural adjustment as well as the capital deepening that took place in the Greek banking industry.

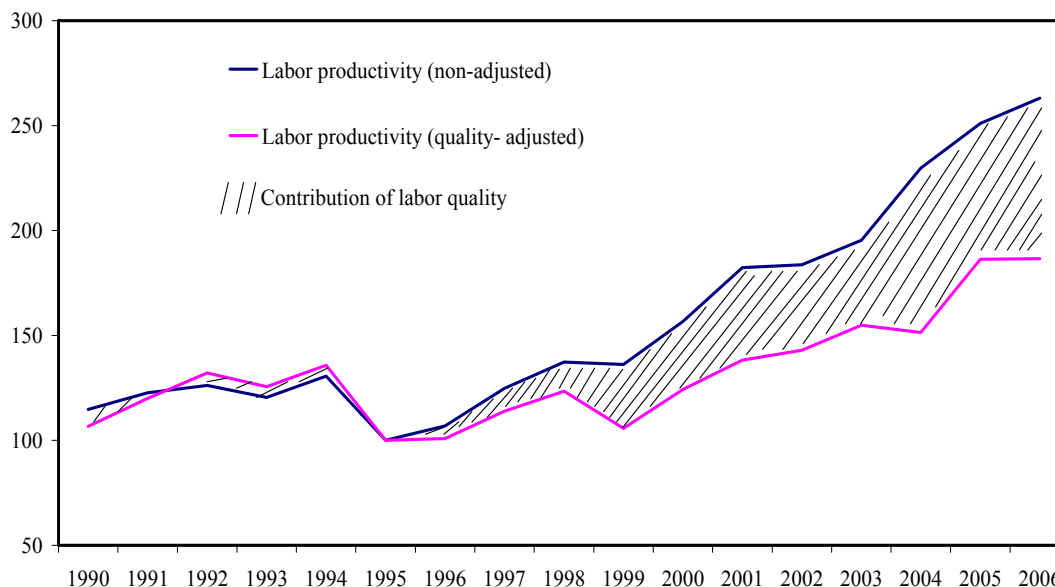
**Table 3 - Productivity of banks**

Productivity	Yearly average growth rate		
	1990-2006	1990-1998	1999-2006
<b>Labor productivity</b>			
- of banks			
- quality-adjusted	3.6	1.8	5.3
- non-adjusted	5.3	2.3	8.5
- of the Greek economy (non-adjusted)	2.2	1.2	3.3
<b>Capital productivity</b>	2.8	1.8	3.9
- real estate capital productivity	4.3	7.0	1.6
- other fixed assets productivity	2.5	0.5	4.5
<b>TFP</b>			
- quality-adjusted	3.4	2.0	4.8
- non-adjusted	4.5	2.2	6.8

Figure 4 shows growing divergence between two indices of labor productivity, since 1996 largely due to improvements in the quality of human capital not reflected in the number of employees. From (29) and Table 2 and it becomes clear that during

1990-2006 improvements in labor quality account for almost one third of the increase in (non-adjusted) labor productivity<sup>49</sup>.

**Figure 4 - Labor productivity of banks and the contribution of labor quality (1995=100)**



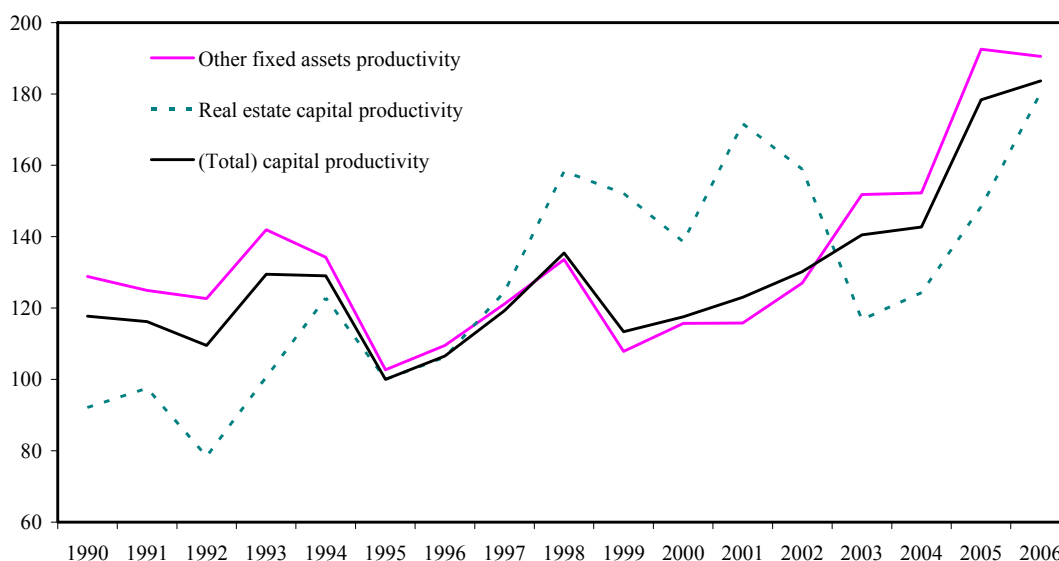
### 5.3.2. Capital productivity

Capital productivity rose during the period under examination by 2.8% yearly (see Table 3). This rate accelerated significantly from 1999 onwards to 3.9%, from 1.8% in the previous sub-period.

The productivity of (total) capital is mainly driven by that of other fixed assets, as this category is assigned a high weight of 80% on average. The rather limited rise in capital productivity during 1990-1998 is mainly attributed to banks' increased investment in fixed capital (mostly IT equipment) in the second half of the 1990s and in the early part of the current decade, while its acceleration since 2001 implies that these investments have paid off (see Figure 5).

<sup>49</sup> Schwerdt and Turunen (2006) reached the same result for labor productivity (of the total economy) in the euro area.

**Figure 5 - Total capital, real estate capital and other fixed assets productivity of banks (1995=100)**



Between the components of capital productivity, the productivity of other fixed assets recorded the higher improvement by 2.5% for the whole period reviewed. This growth rate accelerated to 4.5% in the second sub-period from almost zero during 1990-1998. Real estate capital productivity growth followed the reverse trend as it decelerated to 1.6% from 7.0% respectively, and stood at a cumulative 4.3% for the period as a whole.

### 5.3.3. Total Factor Productivity

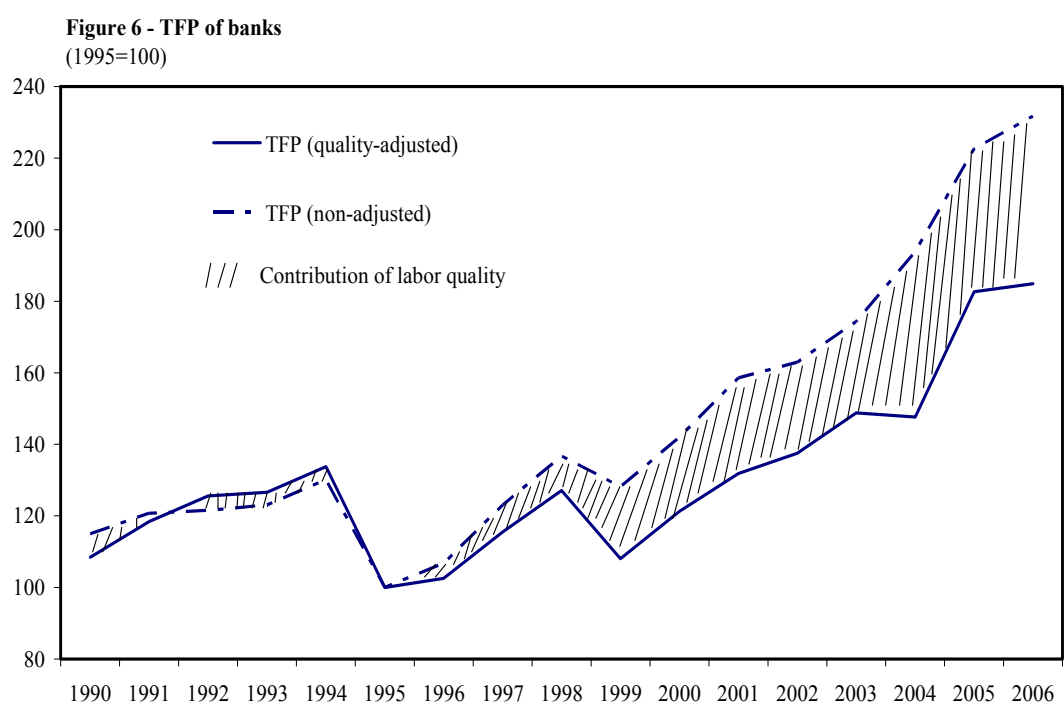
Figure 6 presents TFP of Greek banks under two alternative measures of labor i.e. by wages and by the number of employees. The examination of this Chart shows that TFP remained stagnant or increased slightly until 1999, while thereafter it recovered considerably, reflecting a significant rise in output and a modest increase in the use of bank inputs.<sup>50</sup>

During 1990-2006, bank TFP rose by 3.4% yearly (see Table 3). This rate accelerated notably in the second sub-period when it came up to 4.8% from 2.0% the

<sup>50</sup> Asimakopoulos *et al.* (2008) reached the same conclusion as they found that better management of bank resources has contributed to improving Greek bank efficiency since 1999. A similar picture arises from the results of Athanasoglou and Brissimis (2004), who found that during 1994-1997 there was scope for significant improvement in bank cost and profit efficiency. Also they found that in 2000-2002, mergers and acquisitions that took place in the Greek banking industry resulted in improving cost and mainly profit efficiency of banks that emerged from them, while labor productivity had a positive contribution.

previous one. In the case that we used the number of employees, the respective TFP growth rates are significantly higher and reached 4.5% for the whole period, 2.2% for the first sub-period and 6.8% for the second one.

Additionally, during the period under examination, labor quality seems to have had an important contribution to TFP. In particular, based on equation (30) and Tables 2 and 3, it can be deduced that improvements in labor quality accounted on average for one quarter of the increase in TFP for the period as a whole, reaching almost one third in the second sub-period from over one tenth in the first one.



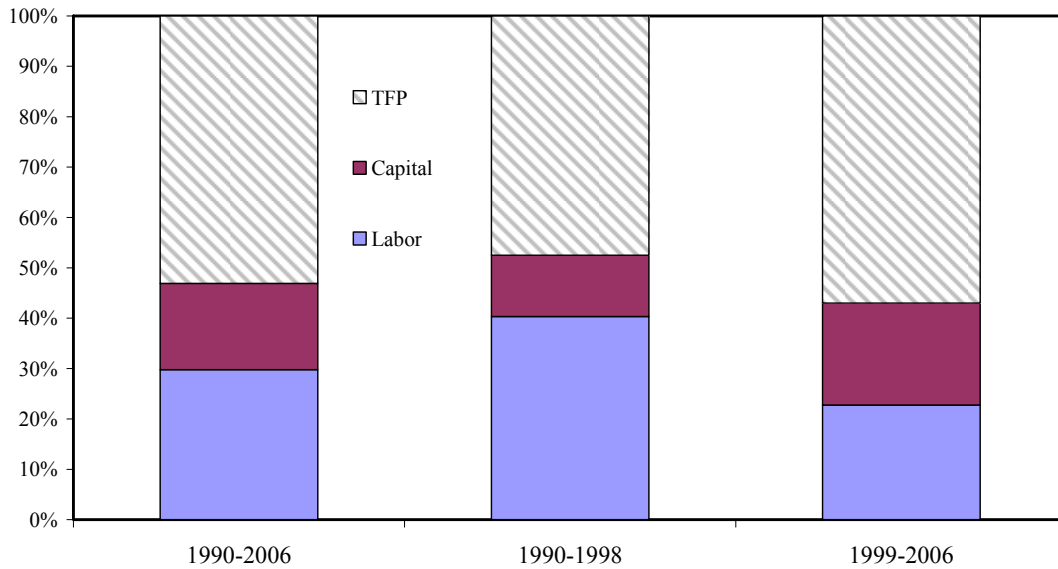
Finally, the average levels of both partial and TFP of the second sub-period are statistically significantly higher than those of the first sub-period.

#### 5.3.4. TFP contribution to bank output growth

The contribution of TFP to the increase of total output of banks during 1990-2006 was substantial.<sup>51</sup> In particular, more than one half (53%) of the total rise in bank output (6.6%) is explained by TFP improvement, 30% by labor increase (quality-adjusted) and the remaining 17% by capital growth (see Figure 7).

<sup>51</sup> The following analysis is based on a growth accounting framework as it has been presented in section 4.2.1 and the relationship (18).

**Figure 7 - Contribution to the growth of bank output**  
(Period averages; percentages %)



Between the two sub-periods examined, the contribution of TFP strengthens considerably in the second one reaching 56% from 48%, while a similar rise is recorded by the respective contribution of capital which comes up to 20% from 12%. On the other hand, the contribution of labor decreases significantly from 40% to 24%. To sum up, during 1990-2006, the fall in the contribution of labor to the increase of total bank output is outweighed by the enhanced contributions of both TFP and capital.

#### **5.4. Bank output and labor productivity in other European countries**

Table 4 presents the estimations of this study for output growth and labor productivity (based on the number of employees) of Greek banks, in juxtaposition to the respective estimations of Mortinnen (2002) for the banks of Finland, Sweden, United Kingdom and Germany during the common period 1990-1998.

**Table 4 - Output and labor productivity of banks in other European countries**

Country	Average yearly growth rate 1990-1998	
	Output	Labor productivity
Greece	4.3	2.3
Germany	6.4	5.3
United Kingdom	3.6	3.7
Finland	0.7	10.1
Sweden	1.8	2.1
Average rate of European countries	3.1	5.3

Bank output improved in all these countries; however at varying degrees, reflecting the different stages of development of the banking systems of these countries. Total bank output in Germany and United Kingdom remarkably increased during 1990-1998, in Greece and Sweden it started to grow considerably as from the mid-90s, while in Finland it recorded a relatively weaker rise. In this period, Greek bank output growth rate (4.3%) was higher than the respective average rate (3.1%) for the other four European countries.

Labor productivity also increased in all countries under review. The size of improvement in individual countries seems to depend on the extent to which structural adjustments took place in their banking systems. For example, the productivity increase in Finland is attributed to a drastic downsizing of banks' number of employees rather than to the growth of output, while in the remaining countries output growth was the driver of labor productivity and the number of employees remained stable or decreased slightly. During 1990-1998, labor productivity in the Greek banking industry increased at a lower pace (2.3%) than in the other four European countries (5.3%).

## 6. Conclusions

This study examined the evolution of output and productivity in the Greek banking industry during the period 1990-2006. To this end, individual categories of bank output and inputs were analyzed. More specifically, we estimated three main categories of output (financial intermediation, payment services and "other" services) and two inputs (labor and capital) for which we measured both partial and TFP. The

contribution of TFP to output growth was also examined, as well as the influence of labor quality on productivity.

According to the results, output and productivity growth record a significant differentiation between sub-periods 1990-1998 and 1999-2006. In the former sub-period industry performance was rather low, while subsequently there was a remarkable increase in these aggregates which can be attributed to the effects of the structural changes that took place in this industry in the second half of the '90s.

During 1990-2006 total bank output increased significantly by 6.6% annually, i.e. at a growth rate that is more than double the respective rate of GDP. In particular, we find that financial intermediation remained strong in Greece recording the highest rates of growth in comparison to payment and "other" services offered by banks. However, these two last categories of services increased considerably since 1999, due to technological advances in payment systems as well as the development of investment services respectively.

As far as bank inputs are concerned, it seems that their increase was rather moderate, even though it was relatively stronger in the case of capital. As a result, the Greek banking industry became gradually more capital-intensive during the years under review, although it remained a labor-intensive one. Apart from the number of employees, labor was measured by wages in order to capture labor quality aspects. In the latter case, labor increase, and consequently the increase of total inputs, is clearly stronger.

The improvement in bank labor productivity was more than double that of the Greek economy as a whole. In particular, both quality-adjusted and non-adjusted labor productivity indices showed a considerable rise since 1999 as a result of the structural adjustments and capital deepening in the banking industry. However, these two indices gradually diverge after mid-90s largely due to improvements in labor quality. It is estimated that these improvements account for almost one third of the increase of labor productivity.

Capital productivity also accelerated since 1999, reflecting increased returns from bank investments in fixed capital the previous years, and mainly due to the enhanced contribution of the productivity of other fixed assets. On the other hand, real estate productivity followed a downward path.



TFP showed a rather small improvement until 1999, while subsequently it recorded a notable increase. Labor quality is estimated to have contributed about one quarter of TFP increase during 1990-2006. Finally, the contribution of TFP and capital to total bank output growth gradually intensified during this period, while the respective role of labor decreased accordingly.

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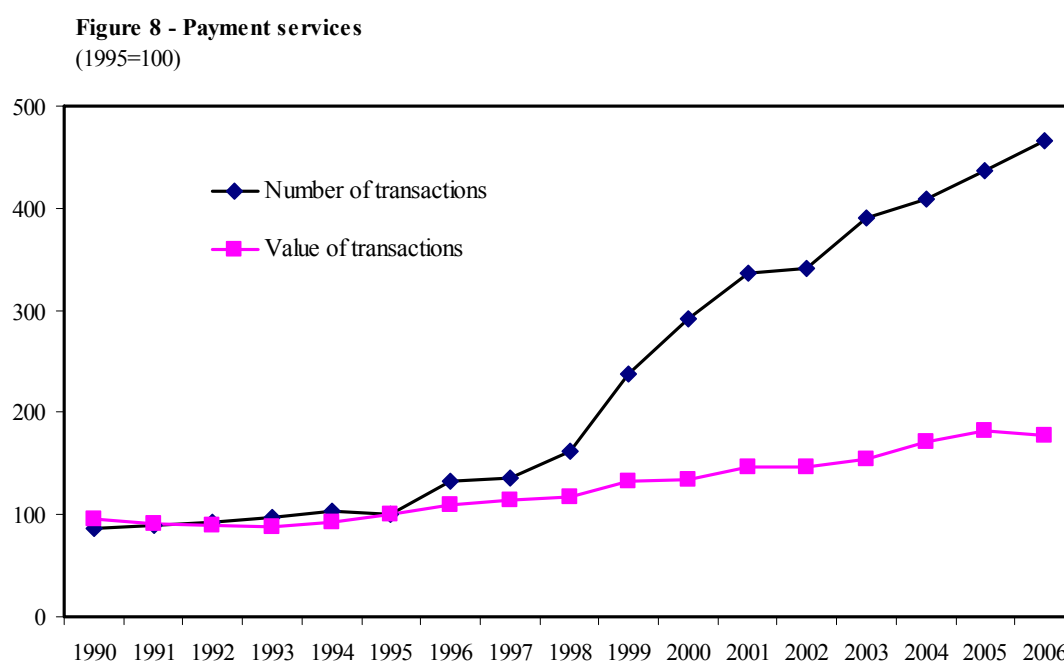
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## Appendix

### 1. Payment services output according to the number of transactions

In order to derive a more complete picture of the development of payment services during 1990-2006 as many of which are not explicitly priced, we also estimated this output category based on the number of transactions in non-cash means of payment such as cheques, credit cards, credit transfers and direct debits as well as ATM transactions<sup>52</sup> (see Chart 8).

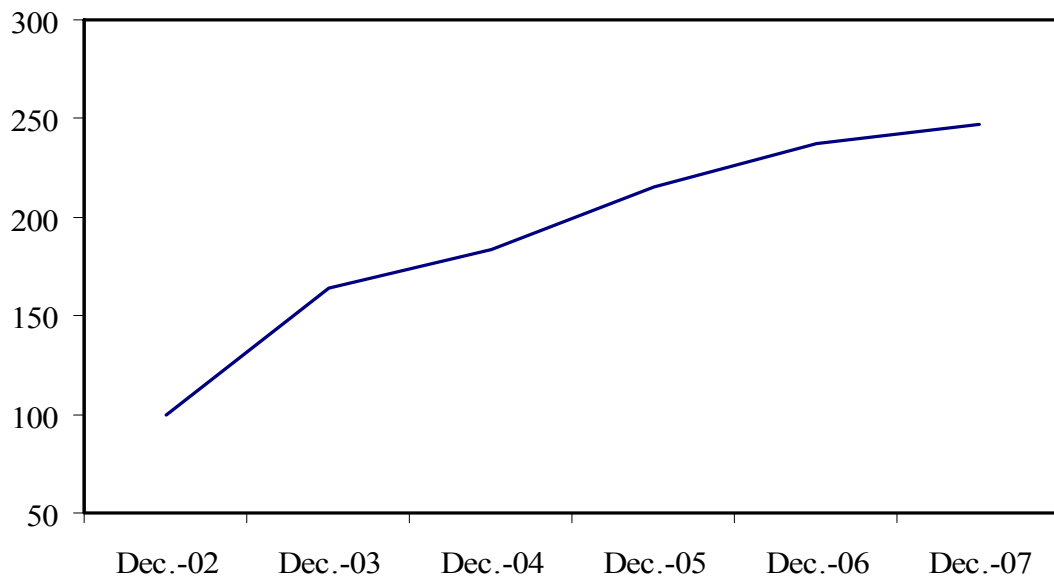


According to this alternative estimation, payment services output more than quadrupled in the period under examination. This increase which took place since the second half of the '90s is attributed to the widespread use of ATMs in daily transactions, while since 2000 the use of cashless means of payment developed significantly. The average yearly growth rate of payment services according to the volume (number) of transactions reached 11% for the period as a whole, 8% for the sub-period 1990-1998 and 14% for 1999-2006, i.e. it is remarkably higher (almost triple) in comparison to the respective rates based on the value of this output category. However, these data were not used in total output estimation as there are no such data (volume data) available for the rest two output categories.

<sup>52</sup> According to data from the Blue Book of ECB.

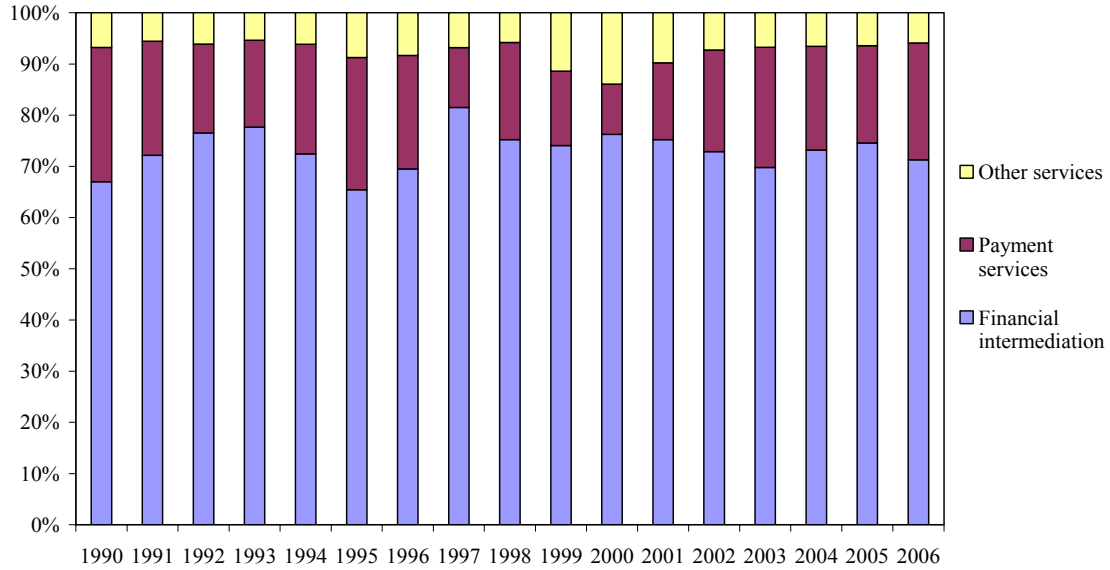
Finally, Chart 9 depicts the number of loan accounts that households and enterprises keep in Greek banks at the end of each year, according to the available data since 2002.

**Figure 9 - Number of loan accounts in Greece, 2002-2007  
(Dec. 2002=100)**

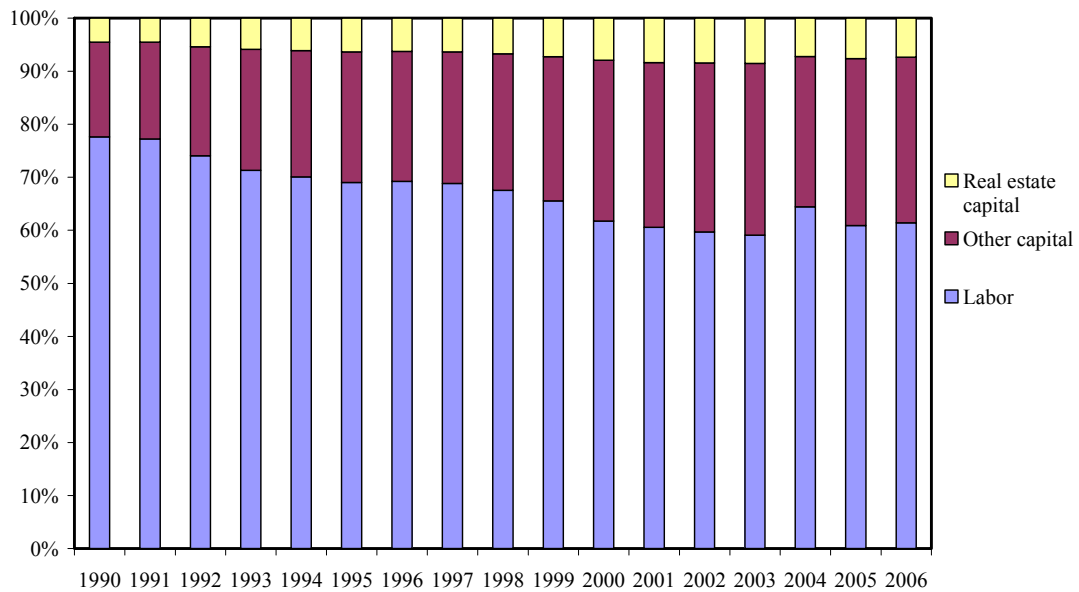


## 2. Weights of individual output and input categories

**Figure 10 - A. Weights of bank output categories**



**B. Weights of bank inputs**





### 3. Sources of statistical data

- **Interest rates** (of demand deposits and time (1 year) deposits, business loans up to 1 year and 12-month Euribor): Bank of Greece.
- **Loans, Deposits** (stocks of private sector loans and demand and time deposits): Bank of Greece.
- **Total fees, income from securities** : Banks' income statements.
- **Fees from payment services** : they were estimated as a percentage of total fees according to ECB data in the report EU Banks' Income Structure (April 2000) for the years 1993-1998 and estimations of the authors for the rest of the years.
- **Fixed assets (net book value), total wages, depreciations, general expenses and number of employees**: Banks' balance sheets.
- **Consumer Price Index, producer price index (wholesale price index), GDP and number of employed in the Greek economy**: National Statistical Service of Greece (NSSG).
- **Index of the prices of dwellings**: Bank of Greece.
- **Number of transactions for payment services**: ECB, Blue Book, estimations of the authors for the years 1990-1993.
- **Number of loan accounts**: Bank of Greece.



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