



BANQUE CENTRALE DU LUXEMBOURG

# Measuring Banking Output and Productivity: A User Cost Approach to Luxembourg Data

Paolo Guarda and Abdelaziz Rouabah<sup>\*</sup>  
Banque centrale du Luxembourg

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Abstract: The definition of banking output has long been controversial. This paper adopts an empirical approach that makes it possible to endogenously classify financial products as inputs or outputs in the production process depending on the sign of their user cost. The resulting classification is then used to construct Tornqvist indices of output and productivity for Luxembourg's banking sector. The decline in TFP growth at the peak of the cycle in 2001 was followed by signs of recovery in 2002.

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<sup>\*</sup>Views expressed in this paper are those of the authors and do not necessarily reflect those of the Banque centrale du Luxembourg. The authors are grateful to Roland Nockels for sharing his extensive knowledge and experience with banking statistics. email: [paolo.guarda@bcl.lu](mailto:paolo.guarda@bcl.lu)

## 1. Introduction

The contribution of banking services to economic growth in the euro area is likely to increase with the impulse towards greater financial integration provided by European monetary union and, more importantly, by the Financial Services Action Plan to complete the single market in financial services. In this context, it is important to assess developments in the banking sector through appropriate measures of output, prices, and productivity.

However, the measurement of banking output has long been a controversial issue (see Triplett, 1990, Fixler and Zieschang, 1991 or Berger and Humphrey, 1992). The conceptual and empirical difficulties common in other service industries are exacerbated by the lack of agreement on the definition of banking output. In large part, the problem is due to the two different types of bank revenues: net interest (the difference between interest collected on loans and interest payments made to deposits) and explicit service charges. Net interest flows typically dwarf revenue from explicit service charges, but the latter are largely insufficient to cover non-interest costs of operation (i.e. wages, rents, equipment, etc.). This means that some of the services provided by banks are paid for by interest income rather than explicit service charges.

Fixler and Zieschang (1991) attribute the controversial nature of the discussion on measuring banking output to long-held differences in how interest is viewed. Some prefer to view interest as a *transfer payment* from borrowers to lenders (depositors) for foregone consumption. On this view, the intermediary services provided by banks are not productive. In fact, some national accounts implementations exclude interest flows from value added since they will be contaminated by “pure interest” reflecting intermediation. As a result, most banking output is excluded from measured GDP. On the other view, interest is considered a *payment for services* provided to the community (payments services and money creation), to the depositor (recordkeeping, safekeeping, and interest payments on deposits) or to the borrower (funding, credit rating). On this view, it is easier to accept that banks use net interest income partly to pay for services that are not explicitly charged to customers.

However, once one recognises that banks purchase funds from depositors not just with interest payments but also with bartered depositor services, one can no longer automatically classify liabilities as inputs and assets as outputs. Interest payments required by liabilities (i.e. deposits) may be offset by explicit service charges paid by depositors, who may also face minimum deposit requirements or limits to the number

of checks written per month. On the other hand, interest flows generated by assets (i.e. loans) may be offset by the cost of attendant services (credit checks, withdrawals).

Hancock (1985, 1986) developed a theory of production for the financial firm in which the input or output status of individual financial products can be determined empirically. This approach is based on the user cost of money as developed by Donovan (1978) and Barnett (1980). The user cost of each *asset* is calculated as the difference between the banks' opportunity cost of capital and its holding revenue. The user cost of each *liability* is calculated as the difference between its holding cost and the bank's opportunity cost of money. When a positive user cost is attached to an asset (because its holding revenue rate is insufficient to cover the opportunity cost of capital) this will contribute to the financial firm's costs and the asset is therefore classified as an input. When the opposite is true, the asset adds to the firms' revenue and is therefore classified as an output. The same is true of liabilities, which can also be classified endogenously as either inputs or outputs depending on the sign of the associated user cost. For example, a deposit whose holding cost (interest due plus the cost of services not explicitly charged) falls short of the opportunity cost of money will add to revenue and thus be classified as an output.

Fixler and Zieschang (1992a) and Fixler (1993) applied the user cost of money approach to calculate an index of commercial banking output and prices. Using the exact index number results of Caves, Christensen and Diewert (1982), they constructed a Tornqvist index with superlative properties and showed that it was robust to alternative measures of the opportunity cost of money (i.e. the interest rate on 90-day Treasury Bills, 1-year and 2-year Treasury Notes). Fixler and Zieschang (1992a) used a distance function approach to estimate the opportunity cost of money econometrically and confirmed that results are robust to use of several additional measures of the opportunity cost (i.e. banks' rate of return on assets). Fixler and Zieschang (1992b) allow for quality change by extending the index of banking output to incorporate additional information. Fixler and Zieschang (1999) further explored the impact of quality adjustment on measures of productivity in the banking sector.

These methods were first applied to quarterly data on banks in Luxembourg by Dimaria (2001). The present paper extends that analysis in several different directions. First, this paper uses a larger set of banks and covers the period 1994Q1 to 2002Q4. Second, it uses a slightly different breakdown of financial products than that in Dimaria (2001), treating commission income as a financial product (included among directly charged services) and treating commissions paid as an input *ex ante*.

Third, the user costs constructed for the different financial products take account of provisions and changes to provisions established for individual balance sheet items. Finally, once financial products are classified as outputs or inputs, they are aggregated into a Tornqvist output index and a Tornqvist input index.

Section 2 outlines the methods used in more detail. Section 3 describes the data and discusses some trend behaviour. Section 4 presents the resulting Tornqvist indices of output and prices in the banking sector and compares them to national accounts series. The final section presents some conclusions.

## 2. Methods

The user cost for the  $l$ th asset is calculated as the difference between the banks' opportunity cost of capital and its holding revenue rate for that class of assets:

$$(1) \quad u_{ai}^t = \rho - h_{ai}^t$$

where the user cost  $u_{ai}^t$  may vary depending on the period  $t$  as well as the assets class  $i$ . The opportunity cost of money is denoted  $\rho$  and the holding revenue rate for asset  $i$  in period  $t$  is denoted  $h_{ai}^t$ . In theory, the holding revenue on an asset class accounts for both capital gains and provisions for loan losses on the given asset.

The user cost of liability  $i$  is calculated as the difference between the banks' holding cost rate and its opportunity cost of capital.

$$(2) \quad u_{li}^t = h_{li}^t - \rho$$

where again the user cost  $u_{li}^t$  may vary across periods  $t$  and across liability classes  $i$ . The holding cost rate for liability  $i$  in period  $t$  is denoted  $h_{li}^t$  and includes not only interest payments net of explicit service charges but also the product of  $\rho$  and the reserve requirements on the given class of liabilities<sup>1</sup>.

Obviously, for equations (1) and (2) to be operational, we need some measure of  $\rho$ , the opportunity cost of money. Although Fixler and Zieschang (1991, 1992a) found that several alternative risk-free rates can be used without substantially changing the results, we follow Fixler and Zieschang (1992a) in estimating this rate econometrically. This introduces more flexibility, allowing  $\rho$  to vary across banks, reflecting the

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<sup>1</sup> Following Fixler and Zieschang (1992), we drop discounting terms to simplify the analysis.

heterogenous nature of the sample in Luxembourg. In practice, Fixler and Zieschang assume that the opportunity cost of money is a constant fraction of the total rate of return on assets (which varies across banks and across periods). This fraction is estimated by specifying an output distance function conditional on the level of deposits. Adopting a translog functional form, the parameters of this function are recovered from an estimated system of share equations<sup>2</sup>. The system is estimated by iterated seemingly unrelated regression, imposing the cross-equation restrictions required for the distance function to be homogenous in prices. The user cost of money parameter is recovered from the estimated value of the intercept in the distance function. Multiplying this fraction by the total rate of return on assets observed in each bank produces a bank-specific series for  $\rho$ .

Note that the system of share equations is estimated separately for each quarter in the sample. This allows for changing technology and the shifting composition of the sample of banks. Future work will test the assumption of fixed cross-term coefficients implicit in calculating Tornqvist productivity indices. The quarter-specific estimates of the technology also make it possible to decompose total factor productivity growth of individual banks into the separate effects of technical progress, changing efficiency and variable returns to scale.

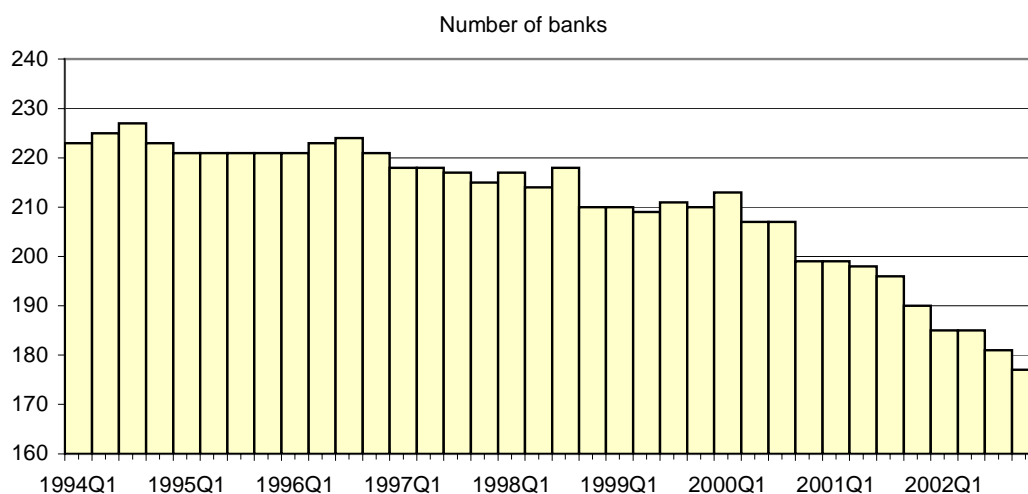
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<sup>2</sup> The output distance function is conditional on deposits so that the share equations relate asset receipts to total asset income. An “unconditional” distance function would relate shares of (positive) asset income and (negative) deposit payments to *net* asset income. This would be problematic as net asset income shares would not be bounded between zero and one.

### 3. Data

The dataset includes observations on an average of 210 banks per quarter over the period covering 1994Q1 to 2002Q4. The exact number of banks per period varies as some banks enter, leave or merge each quarter. The following bar chart presents the evolution of the number of banks over the sample<sup>3</sup>.

**Figure 1: Number of Banks in Luxembourg**

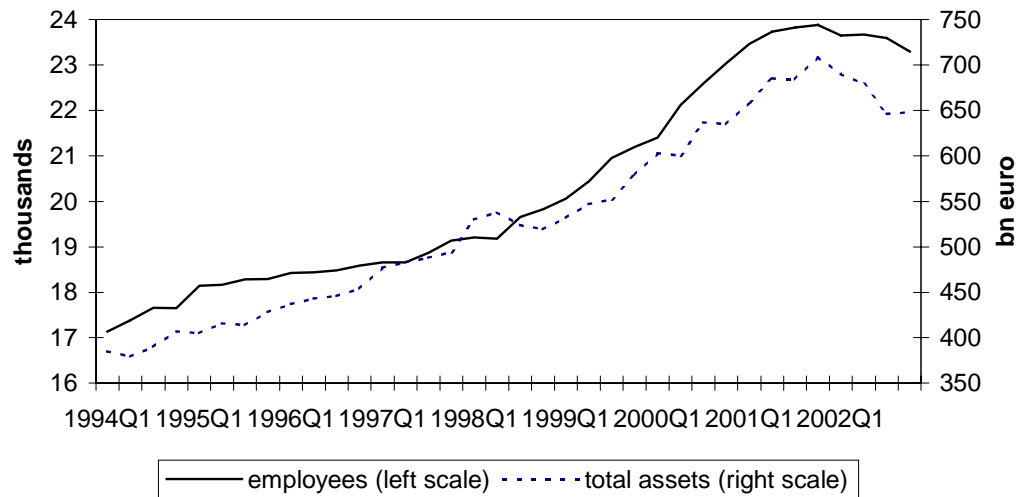


The decline in the number of banks reflects the move towards consolidation in the European banking sector, as mergers between parent banks in Germany, France, Belgium or other EU countries lead to mergers in their Luxembourg subsidiaries. In fact, the Luxembourg financial sector has continued to grow both in terms of total assets and in terms of employment, despite the decline in the number of banking firms. This is confirmed by the following figure plotting the evolution of total assets and employees summed over all banks for different quarters in the sample. Both employment and total assets grew strongly until the slowdown beginning 2001Q4.

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<sup>3</sup> This is actually a subsample as banks with zero employees have already been filtered out.

**Figure 2: Employment and total assets in Luxembourg's banks**



Following Fixler and Zieschang (1992a), we aggregate assets and liabilities drawn from the balance sheet into different product classes, with each class potentially either an input or an output. The definition of the different classes depends in part on the available detail regarding the corresponding holding revenues or costs for the given asset or liability under consideration. The following is our version of Table 6.1 in Fixler and Zieschang (1992a):

**Table 1: Financial Product Aggregation**

| <i>Aggregate financial product</i>       | <i>BCL code</i> | <i>Description</i>               |
|--|-----------------|----------------------------------|
| <i>Loans &amp; leases:</i>               |                 |                                  |
| Y123                                     | B1-04_000       | Loans to customers               |
| Y4                                       | B1-03_000       | Loans to banks                   |
|  | B1-05_000       | Leases                           |
| <i>Securities:</i>                       |                 |                                  |
| Y5                                       | B1_02_000       | Government securities            |
| Y6                                       | B1_06_000       | Fixed income securities          |
| Y7                                       | B1_07_000       | Shares                           |
|  | B1_08_000       | Participations                   |
|  | B1_09_000       | other variable income securities |
| <i>Directly charged services:</i>        |                 |                                  |
| Y8                                       | P4_01_600       | Gains on foreign exchange trades |
|  | P4_01_700       | Gains from financial instruments |
|  | P4_01_800       | Commissions charged              |
|  | P4_01_900       | Other interest income            |
|  | P4_06_000       | Gains from financial operations  |
|  | P4_07_000       | Other non-interest income        |
| <i>Deposits &amp; other liabilities:</i> |                 |                                  |
| Y9                                       | b2_01_000       | Loans to banks                   |
|  | b2_02_000       | Loans to clients                 |
|  | b2_03_000       | Securities issued                |

These seven financial product classes will be classified as inputs or outputs depending on the sign on the associated user cost.

We follow Fixler and Zieschang (1992a) in identifying three additional inputs on an *a priori* basis: labour (x1), capital (x2, including both tangible and intangible assets) and purchased materials and services (x3, including non-wage administrative costs and commissions paid). The cost of these inputs were measured respectively by wages, depreciation allowances and the financial services subindex of the Harmonised Index of Consumer Prices (HICP).

## 4. Results

The first result to be presented is the classification of financial products into inputs and outputs. As noted earlier, this classification will vary across time and even across banks at a given point in time. The table below reports for each year<sup>4</sup> the proportion of observations for which the user cost of the financial product in the column took a positive sign (i.e. the proportion of observations for which the financial product was an input in production). Directly charged services (Y8) is not reported as this is always an output.

**Table 2: Classification of different financial products**

|       | Y123<br>Loans to<br>customers | Y4<br>Loans to<br>banks | Y5<br>Govt.<br>Securities | Y6<br>Fixed income<br>Securities | Y7<br>Variable income<br>securities | Y9<br>Deposits |
|-------|-------------------------------|-------------------------|---------------------------|----------------------------------|-------------------------------------|----------------|
| 1994  | 0.20                          | 0.24                    | 0.84                      | 0.31                             | 0.66                                | 0.80           |
| 1995  | 0.24                          | 0.23                    | 0.85                      | 0.19                             | 0.68                                | 0.77           |
| 1996  | 0.27                          | 0.29                    | 0.89                      | 0.15                             | 0.68                                | 0.68           |
| 1997  | 0.31                          | 0.33                    | 0.90                      | 0.24                             | 0.66                                | 0.60           |
| 1998  | 0.30                          | 0.40                    | 0.91                      | 0.24                             | 0.65                                | 0.58           |
| 1999  | 0.31                          | 0.38                    | 0.85                      | 0.30                             | 0.68                                | 0.57           |
| 2000  | 0.33                          | 0.31                    | 0.85                      | 0.29                             | 0.69                                | 0.61           |
| 2001  | 0.27                          | 0.34                    | 0.89                      | 0.29                             | 0.72                                | 0.56           |
| 2002  | 0.29                          | 0.41                    | 0.88                      | 0.29                             | 0.70                                | 0.45           |
|       |                               |                         |                           |                                  |                                     |                |
| Mean  | 0.28                          | 0.32                    | 0.87                      | 0.25                             | 0.68                                | 0.63           |
| Stdev | 0.05                          | 0.07                    | 0.03                      | 0.07                             | 0.06                                | 0.12           |

Most of these proportions are relatively stable across years. As could be expected, loans to customers (Y123) and loans to banks (Y4) are generally classified as outputs. Government securities (Y5) are consistently classified as inputs as are variable income securities (Y7). Perhaps surprisingly, fixed income securities (Y6) are often classified as outputs. More naturally, considering the discussion in the introduction, the classification of deposits is the most volatile (it is the only financial product for which the user cost switches sign for a majority of banks in one of the years considered).

The last two rows of the table report statistics describing the entire sample. The mean proportion of banks with a positive user cost (input classification) is reported across all available observations. The standard deviation of the proportion is calculated across the 36 quarters in the sample.

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<sup>4</sup> Of course, results are also available for each quarter within a given year.

It should be emphasised that the sign on the user cost of different financial products is only estimated approximately. The difference between an estimate of  $-0.01$  and  $+0.01$  may not be statistically significant, so these results should only be taken as a guide to classification.

However, the given classification can be used to construct Tornqvist indices for output and prices. Caves, Christensen and Diewert (1985) showed that this type of index, which does not require knowledge of the underlying technological parameters, is *exact* when the underlying functional form is translog. Since the translogarithmic functional form provides an approximation to any arbitrary functional form, the Tornqvist index is also *superlative*. The Tornqvist quantity index for comparing periods  $s$  and  $t$  can be written in its logarithmic form:

$$(3) \quad \ln Q_{st} = \sum_{i=1}^N \left( \frac{\omega_{is} + \omega_{it}}{2} \right) (\ln q_{it} - \ln q_{is})$$

where  $\omega_{it}$  indicates the share of product  $i$  in the value of total output in period  $t$ . This formula can also be used to construct an input index. Similarly, the Tornqvist price index can be written in its logarithmic form:

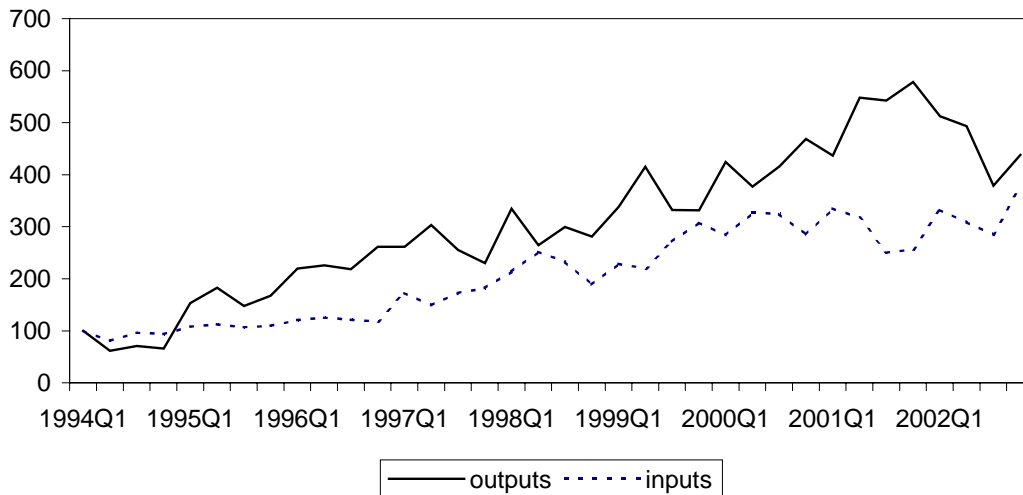
$$(4) \quad \ln P_{st} = \sum_{i=1}^N \left( \frac{\omega_{is} + \omega_{it}}{2} \right) (\ln p_{it} - \ln p_{is})$$

where  $\omega_{it}$  now indicates the share of product  $i$  in the value of total output/input in period  $t$ . Total factor productivity (TFP) can be measured directly by the Tornqvist TFP index defined, in its logarithmic form as the ratio of the Tornqvist output index and the Tornqvist input index.

$$(5) \quad \ln TFP_{st} = \ln (T\_output_{st}) - \ln (T\_input_{st})$$

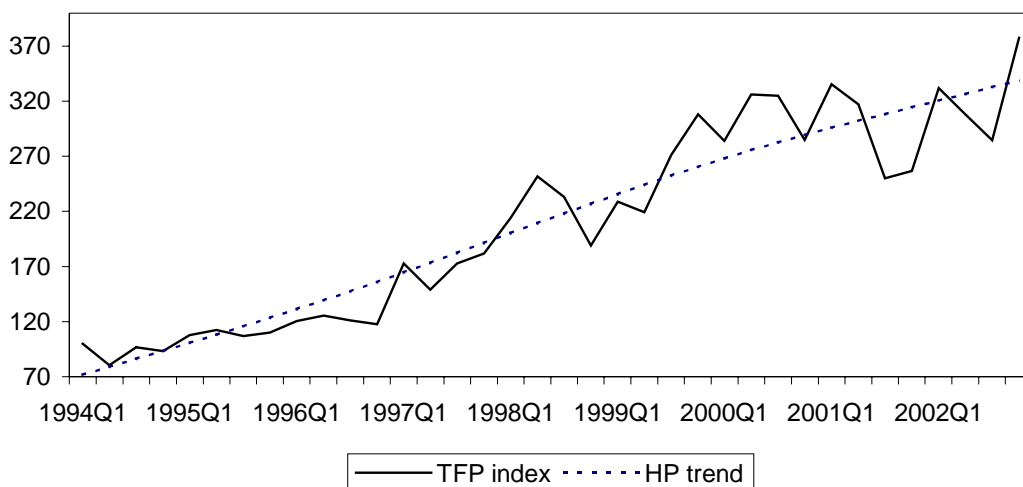
These indices were calculated for each quarter in the data set, aggregating inputs and outputs across banks as classified by the sign of the user cost. The chain-linked indices for nominal output and inputs appear in the following figure (the value of both indices in the initial quarter was arbitrarily set to 100). Note that the Tornqvist input index is not only based on growth in labour (x1), tangible and intangible assets (x2), and purchased materials and services (x3) but also takes account of growth in government securities (y5), variable income securities (y7) and deposits (y9) where these financial products are classified as inputs in production.

**Figure 4: Tornqvist output and input indices for Luxembourg's banks**



Note that the output index increases much more than the input index, suggesting significant gains in TFP until the end of the sample. Following the slowdown in 2001Q4, there is a drop in the output index and the two series seem to converge. Figure 4 plots a chain-linked index of TFP obtained from the logarithm of the ratio of the Tornqvist output and input indices as well as its trend as extracted by the Hodrick-Prescott filter ( $\lambda=1600$ ). Note that quarter-to-quarter TFP developments are very volatile, with a mean of 3.6% growth and a standard deviation of 27%. This implies a

**Figure 3: Tornqvist TFP index for Luxembourg's banks**



year-on-year growth rate for TFP of 19% on average. Over the most recent observations, TFP growth was negative over 2001Q2-2002Q2 but has been accelerating since 2002Q3.

The following table compares yearly growth in the Tornqvist output index to yearly growth of nominal production in Luxembourg's financial intermediation sector (NACE 65) as published by Statec, the national statistical office.

**Table 3: Comparison with National Accounts Data**

| Year | Growth in Tornqvist output index | Growth in nominal production |
|------|----------------------------------|------------------------------|
| 1994 | -0.30%                           | 0.34%                        |
| 1995 | 1.16%                            | 0.08%                        |
| 1996 | 0.46%                            | 0.23%                        |
| 1997 | -0.43%                           | 0.14%                        |
| 1998 | 0.18%                            | 0.13%                        |
| 1999 | -0.28%                           | 0.30%                        |
| 2000 | 0.53%                            | 0.25%                        |
| 2001 | 0.37%                            | 0.02%                        |
| 2002 | -0.48%                           | -0.02%                       |
| Mean | 0.13%                            | 0.16%                        |

The linear correlation coefficient is weak and negative although not statistically different from zero. The Spearman rank-order correlation coefficient (which is more appropriate with only nine observations) is positive but also finds no statistically significant correlation. This could be attributed to a variety of factors. First, the two measures have different coverage. In addition to commercial banks, NACE 65 includes the central bank as well as other monetary and financial intermediaries. In Luxembourg this means the enormous mutual fund industry, which is one of the largest in the world. Second, differences in the two nominal measures may reflect the different price concepts used. By relying on the user cost principle, the Tornqvist index of nominal output may be more fully capturing reductions in output prices reflecting rapid technological change, whereas the national accounts measure relies on a limited number of price series that can be directly observed. Third, the Tornqvist index is more flexible, allowing an individual balance sheet item to be counted either as an input or as an output for a given bank or a given quarter, depending on the sign of the net revenue flow it generates. The national accounts measure instead is based on the same accounting rules for all firms and all periods, regardless of market developments. Fourth, the Tornqvist output index is based solely on data from the banking sector

whereas the national accounts series is the result of a “balancing” exercise which reconciles data from different sources covering all sectors of the economy.

Compared to the national accounts series, the Tornqvist output indicator has the important advantage that it is available at a quarterly frequency. This is important both for monitoring current developments and in developing forecasting models. Such an indicator is particularly useful in Luxembourg, where banking represents about 25% of total value added in the economy. Note also that the two measures presented are *gross* output measures, while the banking sector’s contribution to GDP is determined by value added. The latter concept is based on separability of production with respect to inputs other than physical capital and labour. It is possible to test this separability assumption using the estimated distance function parameters. This could shed some light on the sources of growth in the financial sector.

## **5. Conclusions and Directions for Further Research**

This paper implemented the user cost approach to classify banks’ balance sheet items as financial inputs or outputs in the intermediation process. This classification was then used to construct Tornqvist indices of output, inputs and TFP for the Luxembourg banking sector. Results suggest that strong growth in this sector over the last nine years reflects substantial TFP gains. TFP growth slowed at the peak of the business cycle in 2000 and recovered in 2002 as banks adjusted to the new environment.

The TFP measure derived only provides an appropriate measure of technological progress under several restrictive assumptions. First, firms are assumed to be technically and allocatively efficient, otherwise changes in TFP may actually reflect variations in the average level of efficiency in production. The translogarithmic distance function estimated here using a system of share equations can be used to calculate the level of efficiency of individual firms in given quarters following the approach in Berger and Humphrey (1992). Thus stochastic frontier methods can be applied to evaluate changes in average efficiency from one quarter to another. Second, if the assumption of constant returns to scale is violated, the TFP measure may be contaminated by scale effects as firms change the volume of production. Therefore the estimated parameters of the distance function should be used to test the hypothesis of constant returns to scale and to correct the TFP measure for scale effects where present. Finally, the estimated parameters of the distance function can be used to quantify technical progress as the shifts in average technology as represented in the distance function.

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