EFFECTS OF ATMs AND ELECTRONIC PAYMENTS ON BANKING COSTS: THE SPANISH CASE BANKING

Santiago Carbó Valverde
David B. Humphrey
Rafael López del Paso

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Effects of ATMs and Electronic Payments on Banking Costs: The Spanish Case

Santiago Carbo Valverde*
University of Granada and Funcas
Granada, Spain

David B. Humphrey
Department of Finance
Florida State University
Tallahassee, Florida, USA

Rafael Lopez del Paso
University of Granada and Funcas
Granada, Spain
April, 2003

Abstract

The effect on bank cost from changing service delivery methods and payment mix are estimated using an output characteristics cost function. Over 1992-2000, the combined shift to ATMs from branch offices and to electronic payments from paper-based instruments is estimated to have saved 5 billion Euros in Spain. Unit operating cost at an average bank fell by 45%, or 7.2% a year. As these trends continue, further savings can be realized. These results are robust to using composite, translog, or fourier cost functional forms.
(85 words)

* Corresponding author: Santiago Carbó Valverde. Departamento de Teoría e Historia Económica, Facultad de CCEE y Empresariales. Universidad de Granada, Campus de Cartuja s/n. 18071- Granada (Spain); Tel: +34 958243717; Fax: +34 958 244046, e-mail: scarbo@ugr.es.

1. Introduction.

The effects on cost from technical change in banking are investigated using two specific indicators of this change—newer service delivery methods and the adoption of electronic payments. ATMs are a lower cost way to deliver cash services to depositors than are branch offices while electronic payments are cheaper to process than are their paper-based alternatives. Using a statistical model based on banking physical output characteristics that relates operating cost to service delivery and payment levels and mix, we determine how these changes have affected costs at Spanish savings and commercial banks over 1992-2000. We also show that these changes, if continued, may reduce future banking costs.

The usual approach for identifying cost savings from technical change in banking has been to specify a time-specific indicator variable or, less often, tie technical change to the use of certain inputs (e.g., less labor and more capital) (Pastor, 1995; Maudos, 1996). Our approach is quite different. Instead of relying on a time dummy or presuming that technical advances are embodied in or augment the use of certain inputs, we relate operating expenses to five characteristics of banking service output that reflect known differences in cost. As the service mix shifts to these lower cost characteristics, unit operating expenses should fall and reflect the savings associated with the spread of new technology within the industry. By specifying the five output characteristics associated with technical change we are able to not only provide an overall estimate of the cost savings from scale effects and new technology, but to also show more clearly how the various components have changed.

In what follows, Section 2 shows how service delivery methods and use of different payment instruments have changed over the past decade in Spain and six other European countries. Independent evidence that these changes can generate cost savings is also noted. Our cost model is specified in Section 3. Although we rely on a composite cost function for our analysis (Pulley and Braunstein, 1992; Pulley and Humphrey, 1993), we demonstrate the robustness of our results by also reporting cost savings estimates from more commonly used translog and Fourier cost models.

Section 4 presents and discusses our estimates of the effect of new technology on banking costs for both savings and commercial banks. We find that the average bank has apparently saved 45% in unit (or average) operating cost between 1992 and 2000, or about 5 billion Euros for the banking system as a whole. As larger institutions have progressed further in shifting from branch offices to ATMs for dispensing cash and also process higher volumes of lower cost electronic payments, these institutions have benefited the most from the associated reduction in unit operating expenses. However, this does not prevent smaller institutions that have a higher ratio of ATMs to branch offices and/or who have depositors who use more electronic payments from benefiting as well. Our main results are summarized in Section 5, which concludes the paper.

2. Changes in Service Delivery and Payment Mix.

All European countries deliver banking services using ATMs as well as branch offices and provide electronic as well as paper-based payment methods. While the mix of these delivery and payment methods often differ markedly among countries, all have consistently expanded the supply of ATMs relative to branches and have increased the share of non-cash transactions which are electronic. For the services they deliver, ATMs are considerably cheaper than branches and an electronic payment only costs about one-third to one-half as much as a paper-based transaction (Flatraaker and Robinson,1995; Wells,1996; Humphrey, Kim, and Vale, 2001)[1].Thus it is not surprising to find that the shift to ATMs and electronic payments appear to be associated with significant reductions in operating cost as a percent of bank asset value during the 1990s.

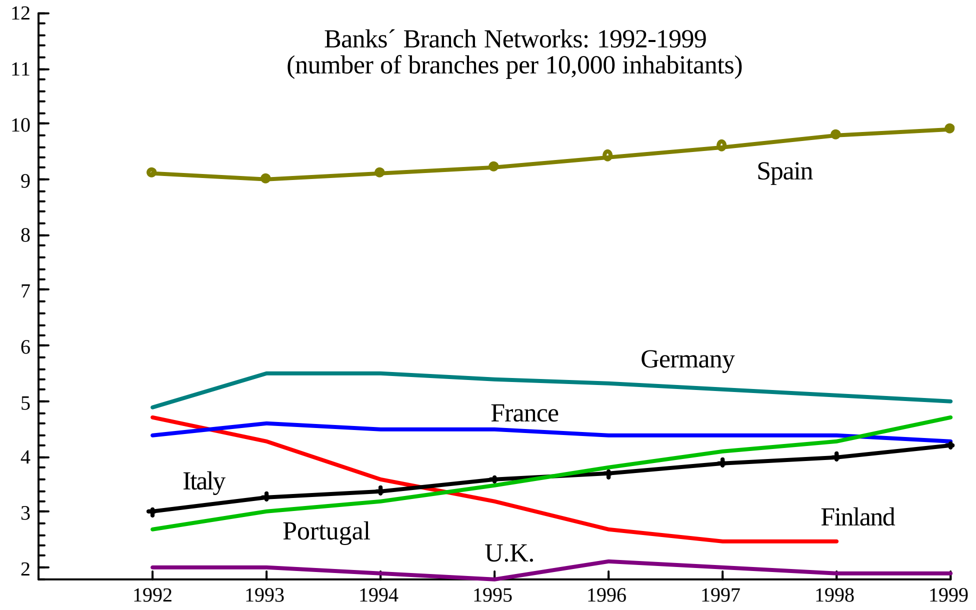
[1] This is largely due to the fact that electronic payments experience greater scale economies than paper-based transactions (since the fixed cost component is much more important the variable one). In adition, advances in computer and telecommunications technology have lowered the absolute cost of processing electronic payments at all scales of operation.

Although ATMs can not provide all the services available at a branch office, they are a superior (lower cost and more convenient) substitute for depositors withdrawing cash, transferring funds between accounts, and making a balance inquiry. These services are basic banking functions much in demand by depositors. Similarly, electronic payments are not always a perfect substitute for paper-based check or paper giro payments (or even certain cash transactions), but they are a superior (lower cost and often more convenient) substitute when used for most point-of-sale transactions, recurring bill payments, employee disbursements, and large value business transfers.

The rapid expansion of ATMs in Europe during the last half of the 1980s suggests that, for the range of services provided, ATMs have replaced the traditional banking office for a large and growing segment of depositors. Indirect evidence of this shift can be seen in Figure 1 which shows how the number of branch offices per 10,000 inhabitants in seven European countries either grew slowly or fell.[2] Slow growth is seen for Spain, Italy and Portugal. No growth occurs in the U.K. while a decline is apparent for Germany, France, and especially Finland. As Figure 1 demonstrates, the number of branch offices used to deliver banking services can differ considerably across countries. Spain is seen to provide 9 to 10 offices per 10,000 inhabitants while the other six countries provide half or less of this number. In the latter part of the 1990s, the U.K. and Finland provided only 2 to 3 offices per 10,000 inhabitants while Germany, France, Italy, and Portugal provided 4 to 5.

[2] The number of banking offices for Portugal and Finland are only available for commercial banks. The latest data avaliable for Finland is 1998.

Figure 1:



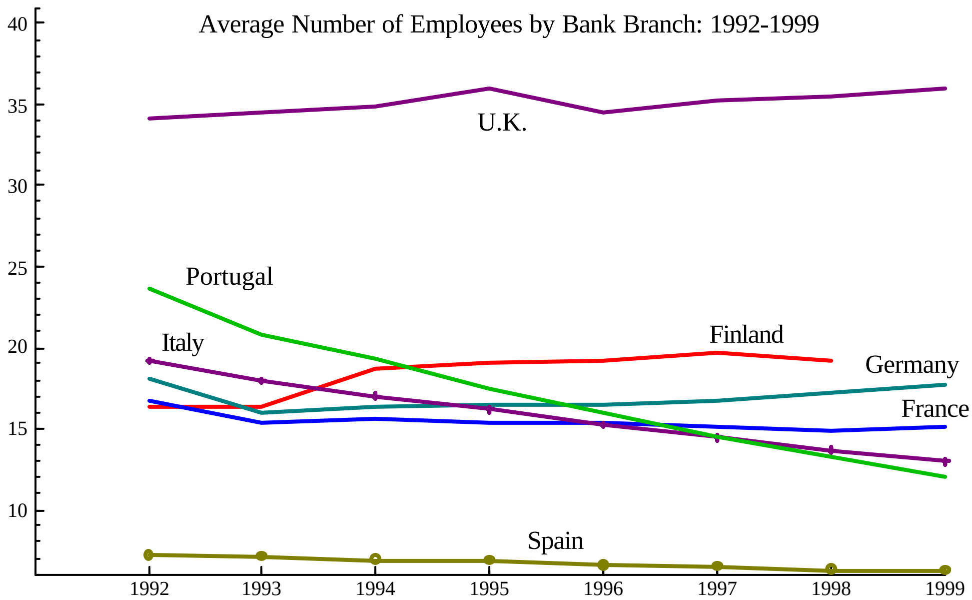
Source: Blue Book (ECB) and Bank Profitability (OECD)

Importantly, differences in the ratio of banking offices to population primarily reflect differences in the average size of banking offices across countries. For Spain, an additional influence has been deregulation in 1989 that permitted savings banks to branch outside of their home region. In the short-run, this increased bank competition for market share and more offices were opened to obtain a foothold in new markets (Humphrey and Carbo, 2000).

A useful way to illustrate the average size of a banking office is to compare the average number of employees per office across countries as shown in Figure 2. In 1999, there were only around 6 workers per banking office in Spain, which is less than half the 12 to 13 workers per office in Portugal and Italy and about a third as many workers in France (15), Germany (18), or Finland (19). The U.K. has around 36 workers per office, which is almost twice as large as the next highest country (Finland). Thus the fact that Spain has the largest number of offices per 10,000 inhabitants in Figure 1, and the U.K. has the lowest number, is due to the small average size of offices in Spain and the large average size in the U.K.

This distinction is important since in cross-country comparisons a high ratio of banking offices to population has often been interpreted as ”over branching” or possible ”inefficiency” when in fact it just reflects a considered decision to have many smaller-sized offices as opposed to a few larger-sized offices. Differences in branch office density within countries are influenced by differences in population density, local public transportation infrastructure, and the level of automobile ownership. For Spain, these differences have likely contributed to a preference for small and specialized local shops along with smaller branch offices. Thus the time trend in the number of banking offices per 10,000 inhabitants in Figure 1–slow growth or reduction–is more important than the level of the ratio itself.

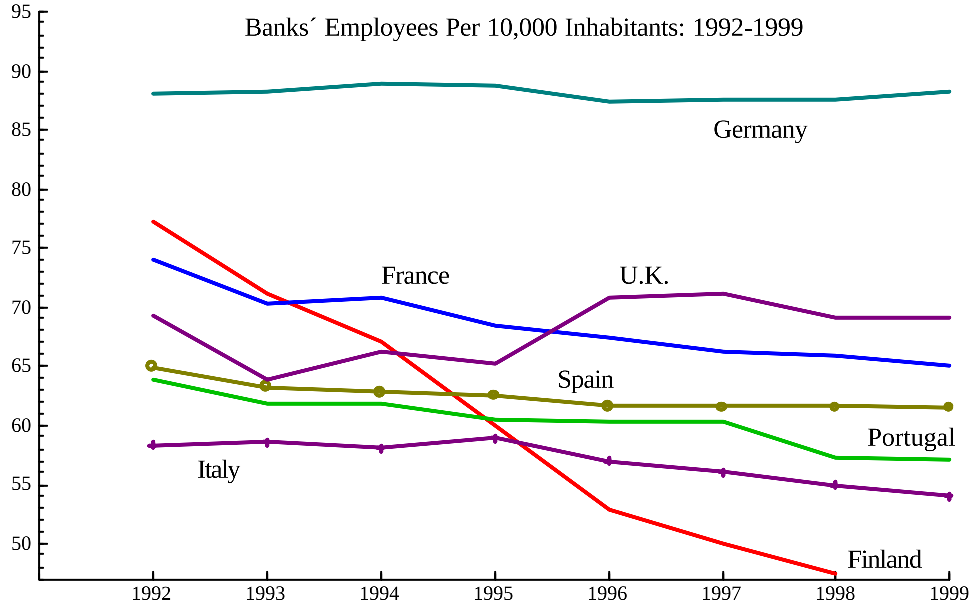
Figure 2:



Source: Bank Profitability (OECD)

Putting the information in Figures 1 and 2 together gives the number of bank employees per 10,000 inhabitants in Figure 3. The time trend of this measure illustrates the combined effects of how ATMs have reduced the need for tellers in banking offices to supply cash withdrawal, account transfer, and balance inquiry services as well as a reduced need for back office employees to process payments and maintain accounts as electronic payments expand and account maintenance activities become more computerized. All countries except Germany and the U.K. appear to have reduced their need for bank workers during the 1990s relative to the population being served. The reductions in Figure 3 over 1992-1999 were 5% for Spain, 12% for France, with a dramatic 39% fall for Finland. Germany and the U.K. had little change over the period while the changes for Italy and Portugal were slightly greater than the 5% experienced for Spain.

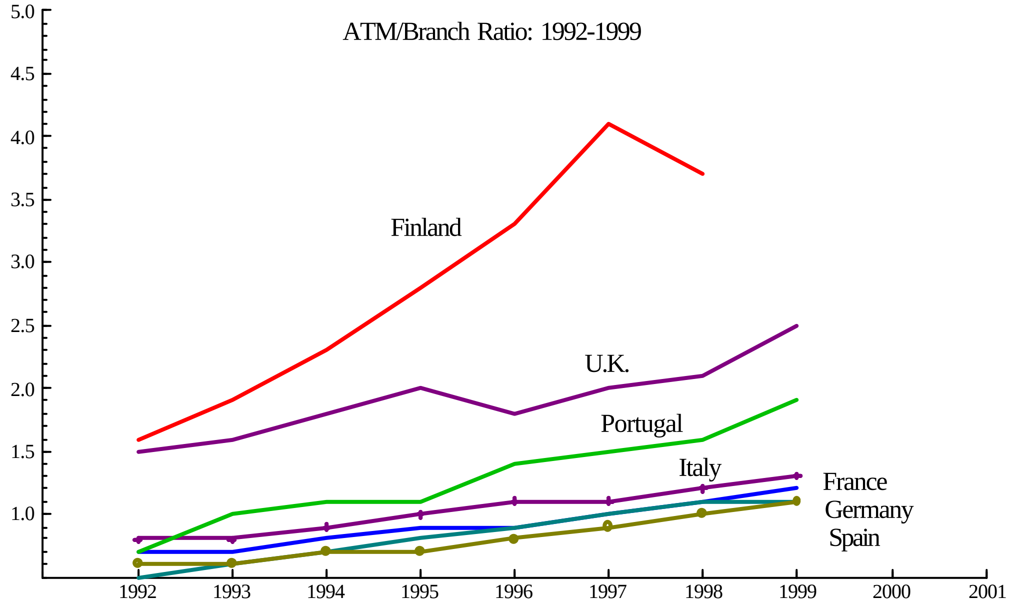
Figure 3:



Source: Blue Book (ECB) and Bank Profitability (OECD)

As illustrated in Figure 4, all countries have consistently expanded the supply of ATMs relative to branches. In 1992, only the U.K. and Finland had as many as 1.5 ATMs per branch office while the other countries all had less–from .5 to .8. By 1999, Finland, Germany, and Portugal more than doubled their ATM/branch ratios while the U.K., Italy, France, and Spain expanded theirs by 60% to 80%. As a result, all seven countries now have more than one ATM for each office. Indeed, Portugal has 2.0, the U.K. has 2.5, and Finland has almost 4.0.

Figure 4:

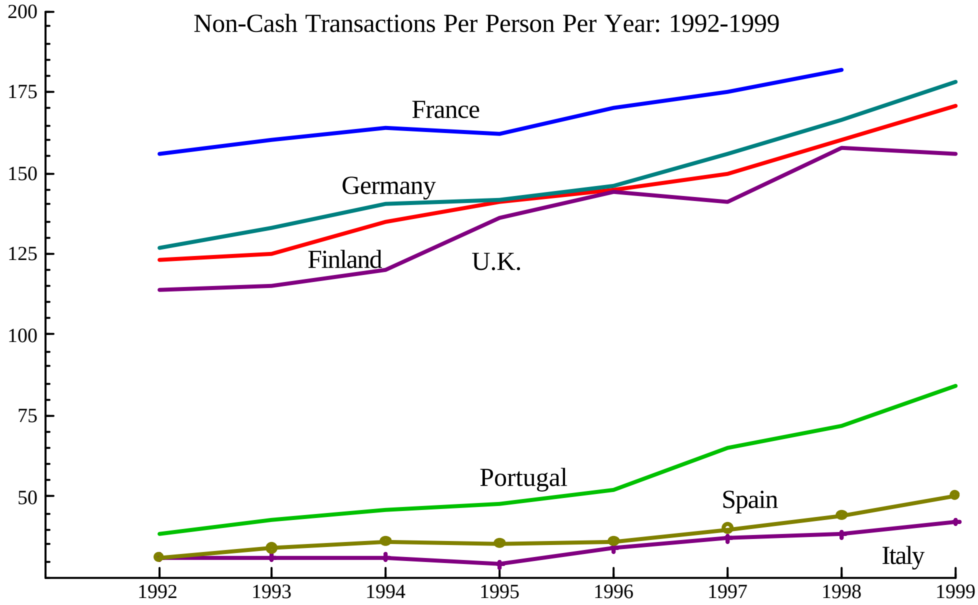


Source: Blue Book (ECB) and Bank Profitability (OECD)

Payment arrangements have also experienced considerable change during this period. As seen in Figure 5, the annual number of non-cash transactions per person has been rising in all seven European countries. This suggests that non-cash payment instruments–debit cards, credit cards, giros, automated clearing houses, checks, and wire transfers–are likely replacing cash (Carbo, Humphrey, Lopez del Paso, 2001). While the trend is upward, the levels of non-cash use across countries can be quite different. Indeed, the total number of non-cash transactions per person ranges at the lower end from 42 to 84 payments a year for Italy, Spain, and Portugal while at the higher end it is 156 to 178 annually for the U.K., Finland, Germany, and France.

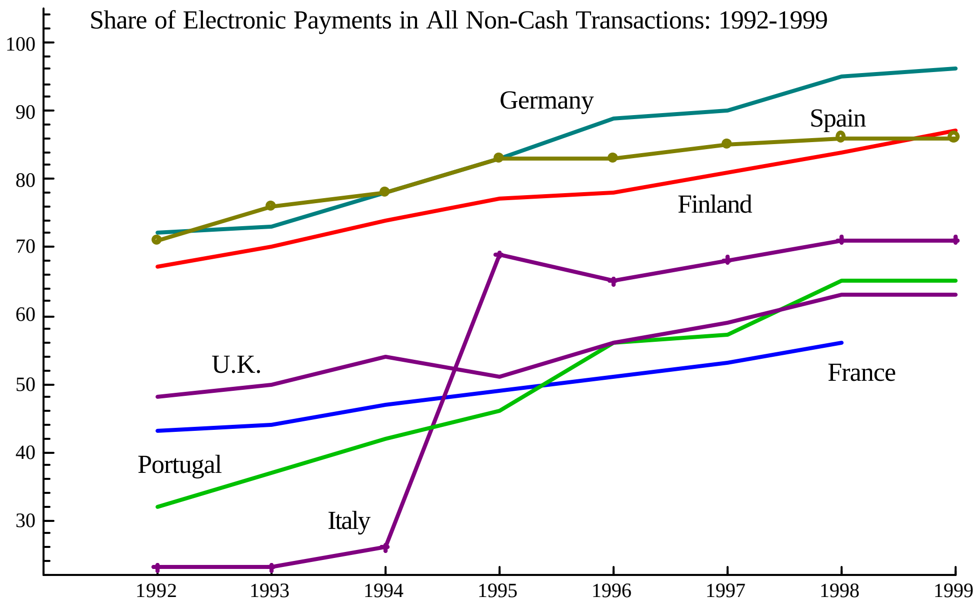
Although levels of non-cash use often differ among countries, the share of these payments that are electronic has been consistently rising during the 1990s. This is seen in Figure 6 which shows that by 1999 all seven countries had shifted over half of all their non-cash payments to electronic means. For Spain, Germany, and Finland, eighty to ninety percent of their non-cash payments are now electronic. However, since both Germany and Finland initiated over three times as many non-cash payments per person as did Spain, the absolute number of electronic payments in these two countries is also over three times larger than for Spain.

Figure 5:



Source: Blue Book (ECB) and Bank Profitability (OECD)

Figure 6:



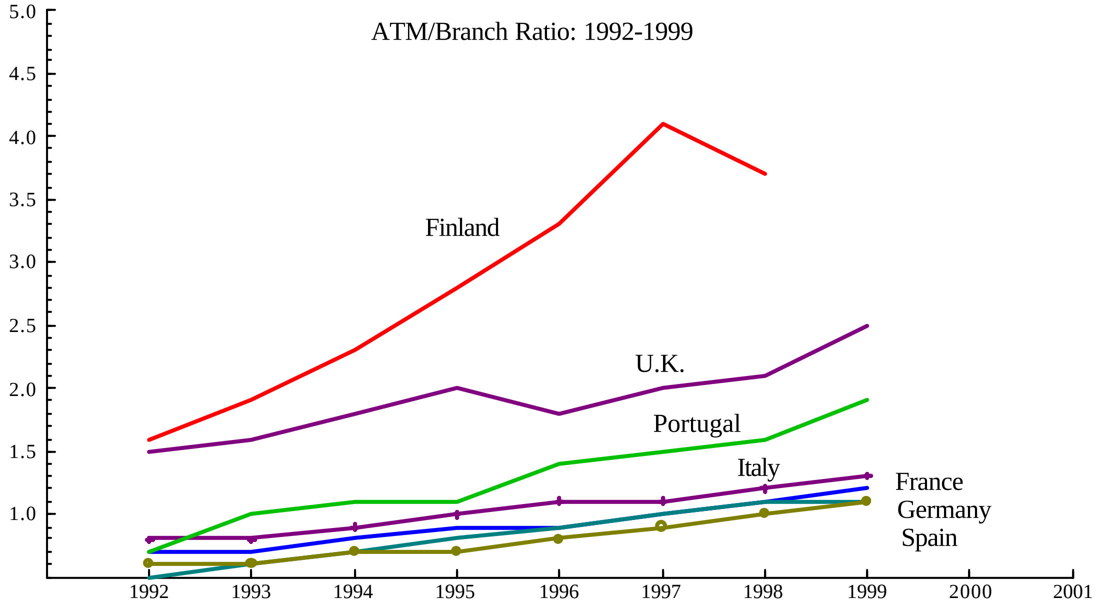
Source: Blue Book (ECB) and Bank Profitability (OECD)

Electronic debit card or giro payments for point-of-sale transactions, consumer bill payments, and employee disbursement are typically cheaper than their paper-based alternatives (a check or paper giro transaction). For these types of transactions survey information and cost estimates suggest that an electronic payment costs only one-third to one-half as much as a comparable paper-based transaction (Flatraaker and Robinson, 1995; Wells, 1996; Humphrey, Kim, and Vale, 2001). This is largely due to the fact that electronic payments experience greater scale economies than paper-based transactions (since the fixed cost component is much more important than the variable one) as well as the fact that advances in computer and telecommunications technology have lowered the absolute cost of processing electronic payments at all scales of operation.

The large expansion of ATMs relative to branch offices (Figure 4) combined with the shift to electronic payments (Figure 6) would be expected to lower bank unit operating costs. As shown in Figure 7, this seems to be the case. Operating costs as a percent of asset value fell by 17% and 19% for Italy and Germany and by 38% and 42% for the U.K. and Finland. Reductions close to 25% were experienced for Spain, France, and Portugal.[3] The rise in electronic payments and the expanded use of ATMs have likely contributed to the reduction in bank operating cost seen for these countries. Additional information on ATM use and operating cost for Spanish savings and commercial banks separately is presented in Appendix A.

[3] These results refer to all banking institutions in the countries noted. In results reported below, however, the reduction in operating cost for our sample of Spanish banks is larger than 25%. Due to missing ATM and other data, a number of small commercial banks and all cooperative banks could not be included in the statistical analysis which follows. Because of their small size, these institutions did not experience as large an absolute reduction in their operating expenses as the institutions we have information on for Spain.

Figure 7:



Source: Bank Profitability (OECD)

To summarize, the trends–if not always the level–of electronic payment and ATM use in Spain are similar to those in other European countries. In addition, operating costs as a percent of asset value has fallen in Spain and other countries during the 1990s while these two trends were underway. In what follows, we attempt to determine the effects on operating cost of the shift to electronic payments and ATM use in Spain. This requires a statistical analysis which relates savings and commercial bank operating costs to bank-specific information on ATMs, branch offices, labor and capital input prices, as well as national information on the transaction volume of different types of payment instruments[4].

3. Using Output Characteristics to Determine Cost Effects of Scale and Technical Change.

Costs in banking are primarily incurred by providing payment processing, deposit safekeeping, cash accessibility, and loan initiation and monitoring services through a geographically diversified set of general and specialized

[4] National payment data are used since bank-specific payment information are not publicly available in any country.

branch offices as well as ATMs. Instead of measuring the flow of these services directly, it has been common in academic studies to assume that this service flow is proportional to the value of the stock of bank deposits, securities, and loans in the balance sheet. Inferences on how costs may vary by size of bank are obtained by relating total operating and interest expenses across banks and over time to the value of their deposits, loans, and security holdings (or some other combination of balance sheet positions). As information does not normally exist regarding the adoption of specific technical and other cost-saving innovations in banking, the default is to assume that unknown technical change occurs linearly (or quadratically) with the passage of time and/or is somehow associated with (embodied in) the value of particular inputs.

An alternative approach, and the one used here, is to relate banking costs to measurable physical characteristics of banking output associated with service delivery and payment processing levels and mix. This achieves two goals. First, the number of bank branches and ATMs–but not necessarily their mix–is directly associated with the size of a bank and its capital and materials operating cost as is the number–but not necessarily the mix–of transactions being processed on behalf of bank customers. When mix is constant and technology is not improved, levels of these activities reflect bank size and hence scale economies. Changes in the mix of ATMs to branches or in the mix of electronic to paper-based transactions over time, along with improvements in their associated technology, represent an alternative and more specific way to identify the cost effect of technical change in banking.[5]

Service delivery is jointly produced via branches and ATMs while paper-based and electronic payment transactions are jointly processed. The service delivery and payment functions are largely separable. About the only interaction would be consumers and businesses depositing (a declining number of) checks at a branch office and perhaps, on a one-time basis, filling out documents to pay

[5] To circumvent the impossibility of separating scale effects from technical change with only time-series data, it has been common practice to use panel data so that the cross-section component identifies scale while the time-series component identifies technical change. Note that in addition to cross-section and time-series components in our panel data set, we use differences in level and mix to assist in the decomposition between scale and technical change.

recurring bills by electronic giro or applying for a debit/credit card. After establishing a giro account, bill payments occur automatically, as do all card payments, without branch or ATM intervention.

3.1. A Composite Cost Function.

Panel data on operating cost, numbers of ATMs and branch offices by bank, plus aggregate (national) data on the number of check, giro, and card payments, along with bank-specific labor and capital input prices are used in a non-linear, functionally separable, composite cost function. The purpose is to estimate the effect that increasing electronic payments and expanded ATM terminal availability may have had on the cost of banking services in Spain.[6]

The composite model approximates better the scope-type joint cost effects that are associated with altering how banking services are delivered and how payments are processed. This is because the level of banking output in a composite function is not in logs, although input prices are. By keeping output in absolutes, we specify a direct relationship between output and operating costs that is likely more accurate–for prediction purposes when one or more outputs are small–than if the log of output is related to the log of operating cost.[7] As well, by specifying the log of input prices, it is possible to impose the theoretical condition of linear homogeneity in input prices in estimation.[8]

The composite cost function (1), in its separable quadratic form, is estimated jointly with n-1 cost share equations. The Box-Cox (1964)

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[6] EFT-POS terminal availability is associated with the volume of electronic card payments–a variable we already use–and thus is not separately specified in the model.

[7] As illustrated in Pulley and Braunstein (1992), this can occur when one or more outputs is less than 5% of total output. This occurs within our sample for ATMs (as a percent of ATMs plus branches) at some banks and for checks (as a percent of check, giro, and card transactions) for some years.

[8] A similar function (CES-quadratic) was used by Röller (1990) to determine scope effects of local and long- distance telephone costs for the Bell System while Pulley and Humphrey (1993) used a composite form to assess the cost effects of separating risky loan assets from deposit liabilities into two separate "banks", funding the former with uninsured CDs and investing the latter in safe assets.

transformation is represented by a superscripted parameter in parenthesis (f) where

$$OC^{(f)} = \left(OC^{f} - 1\right)/f \text{ for } f \neq 0 \text{ and } OC^{(f)} = \ln OC \text{ for } f = 0 \text{ in:}$$

$$OC^{(f)} = f^{(f)}\left(\underline{Q}, \ln \underline{P}\right)$$

$$= \left\{ \begin{array}{l} \left[a_0 + \sum_{i=1}^{5} a_i \ln Q_i' + \tfrac{1}{2} \sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} Q_i' Q_j' \right] \bullet \exp \\ \left[\left[b_0 + \sum_{k=1}^{2} b_k \ln P_k + \tfrac{1}{2} \sum_{k=1}^{2} \sum_{m=1}^{2} b_{k,m} \ln P_k \ln P_m \right] \right] \end{array} \right\}^{(f)} \quad (1)$$

$$S_k = b_k + \sum_{m=1}^{2} b_{k,m} \ln P_k$$

where:

OC = total operating expenses, composed of labor, capital, and materials costs;

$Q'_{i,j}$ = five output characteristics composed of two service delivery alternatives– automated teller machines (ATM) and bank branches (BR)– along with three payment processing alternatives–the number of checks (CHECK), giro payments (GIRO), and debit and credit card transactions (CARD). Service delivery data are available by bank but payment transactions data are not (so data for all banks are used instead) In (1), $Q'=Q$-1;

$P_{k,m}$ k, m = two input prices referring to the average labor cost per employee and an approximation to the price of physical capital and materials represented by capital depreciation expenditures divided by the value of physical capital; and

S_k = the cost shares for the labor input (the capital/materials input share is deleted to avoid singularity).

It is expected that operating costs not directly associated with the mode of service delivery or type of payment will be represented in the intercept term.

The composite function is non-linear and is estimated iteratively. Following Pulley and Braunstein (1992), let $\underline{D} = \underline{0}$ and GM $^{f-1}$ the geometric mean of operating cost OC, then the separable quadratic form of the composite model is estimated from the "pseudo model" (2):[9]

$$D = \left[-\left(OC^{f} / GM^{f-1} \right) \right] + f^{(f)} \left(\underline{Q}, \ln \underline{P} \right) / GM^{f-1}$$

$$= \left[\ -\left\{ \left(OC^{(f)} - 1 \right) / fGM^{f-1} \right\} + \left(\left\{ \begin{matrix} \left[a_0 + \sum_{i=1}^{5} a_i Q_i' + \frac{1}{2} \sum_{i=1}^{5} \sum_{i=1}^{5} a_{ij} Q_i' Q_j' \right] \bullet \\ \exp \left[b_0 + \sum_{k=1}^{2} b_k \ln P_k + \frac{1}{2} \sum_{k=1}^{2} \sum_{m=1}^{2} b_{k,m} \ln P_k \ln P_m \right] \end{matrix} \right\}^{f} - 1 \right) / fGM^{f-1} \quad (2)$$

$$S_k = b_k + \sum_{m=1}^{2} b_{k,m} \ln P_k$$

3.2. Alternative Translog and Fourier Cost Functions.

A translog function can generate biased results, compared to the composite function, when levels of some outputs are small since outputs are specified in logs. However, this function as well as a Fourier function, are also estimated and their results contrasted with those from the composite form.

The translog cost function (3) is estimated jointly with n-1 cost share equations:

$$\ln OC = a_0 + \sum_{i=1}^{5} a_i \ln Q_i + \frac{1}{2} \sum_{i=1}^{5} \sum_{i=1}^{5} a_{ij} \ln Q_i \ln Q_j$$
$$+ \sum_{i=1}^{5} \sum_{k=1}^{2} d_{i,k} \left(\ln Q_i \ln P_k \right) + \sum_{k=1}^{2} b_k \ln P_k + \frac{1}{2} \sum_{k=1}^{2} \sum_{m=1}^{2} b_{k,m} \ln P_k \ln P_m \quad (3)$$

[9] It is generally not feasible to estimate both a_0 and b_0 intercepts. As we are more interested in output than input prices, and on the basis of fit, we set $b_0 = 0$ and retain a_0 in estimation.

$$S_k = b_k + \sum_{m=1}^{2} b_{k,m} \ln P_k + \sum_{1}^{5} d_{i,k} \ln Q_i$$

where the variables have been defined above.

The Fourier form we use adds sin and cos terms to the translog cost function. As our main concern is to allow for greater flexibility in the local identification of output effects on operating costs, the sin and cos terms are applied to the output (Q) measure. The Fourier form is a globally flexible approximation since the respective sin and cos terms are mutually orthogonal over the [0, 2π] interval. The Fourier function (4) is estimated jointly with the cost shares:

$$\begin{aligned}
\ln OC = {} & \text{Translog Cost Function} + \sum_{n=1}^{5}\left[t_n \cos\left(\ln Q_n^*\right) + w_n \cos\left(\ln Q_n^*\right)\right] \\
& \sum_{n=1}^{5}\sum_{q=1}^{5}\left[t_{nq}\cos\left(\ln Q_n^* + \ln Q_q^*\right) + w_{nq}\sin\left(\ln Q_n^* + \ln Q_q^*\right)\right] + \\
& \sum_{n=1}^{5}\left[t_{nnn}\cos\left(\ln Q_n^* + \ln Q_n^* + \ln Q_n^*\right) + w_{nnn}\sin\left(\ln Q_n^* + \ln Q_n^* + \ln Q_n^*\right)\right]
\end{aligned} \qquad (4)$$

$$S_k = b_k + \sum_{m=1}^{2} b_{k,m} \ln P_k + \sum_{1}^{5} d_{i,k} \ln Q_i$$

The new terms are $\ln Q^* = \ln Q \bullet YQ + ZQ$, $YQ = (.8 \bullet 2\pi) = (\max \ln Q - \min \ln Q)$, $ZQ = .\ 2\pi - \min \ln Q \bullet YQ$, and $\pi = 3.141593\ldots$, so that $\ln Q^*$ is essentially expressed in radians.[10]

[10] See Mitchell and Onvural (1996) and Berger and Mester (1997). Our Fourier specification follows Berger and Mester.

4. Cost effects from Changes in Service Delivery and Payment Levels and Mix.

4.1. Composite Function Results.

Predicted unit operating cost for our panel of 1,541 savings and commercial bank observations over 1992-2000 from the composite function is shown in Figure 8.[11] While the levels and mix of ATMs, branch offices, and check, giro, and card payment volumes are allowed to vary, input prices are held constant at their mean values.[12] As f in the composite form is .20, the estimated model is closer to a specification which includes the log of output as well as input prices (when $f = 0.0$) than it is to a specification with output in absolutes and prices in logs (when $f = 1.0$).[13] Even so, the estimated model is significantly different from either of these alternatives since f is significantly different from zero or one.[14]

The curve fitted to the scattergram in Figure 8 is a simple cubic spline and illustrates how unit operating cost generally varies by bank asset size over time.[15] This figure combines both scale (cross-section) and technical change (time-series) effects associated with ”front office” service delivery and ”back office” payment processing cost changes. The distinction between scale effects (moving along a unit operating cost curve for a single year) and technical change (a shift in the unit operating cost curve between years) is illustrated in Figure 9. Here separate predicted unit operating cost curves are shown for

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[11] Unit operating cost is the ratio of operating cost to asset value and is a measure of average operating cost.

[12] Our data set includes all savings banks, all but the very smallest commercial banks (which were excluded due mostly missing ATM data), and no cooperative banks (who also had missing data). Even so, the banks we use accounted for 80% of all operating cost in the Spanish banking system in 1992 and 90% in 2000. The excluded cooperative banks only account for five percentage points of the banking system’s operating costs while the excluded commercial banks account for the remaining five percentage points in 2000.

[13] The estimated parameters of the composite function underlying this figure are presented in Appendix B.

[14] For more on these two alternative specifications which depend on the value of f, see Pulley and Braunstein (1992) or Pulley and Humphrey (1993).

[15] Bank size on the X-axis is indicated by the natural log of asset value. Taking the log improves comparability among the numerous smaller and less numerous very large banks.

1992, 1996, and 2000. Scale economies exist since unit cost falls as (the log of) asset size increases on the X-axis. As well, the operating cost curves shift down over time showing that unit operating expenses are falling as technical change progresses with the substitution of ATMs for branch offices, the replacement of checks (and cash) with giro and card electronic payments, and technological improvements associated with all five of these output characteristics.

Figure 8:

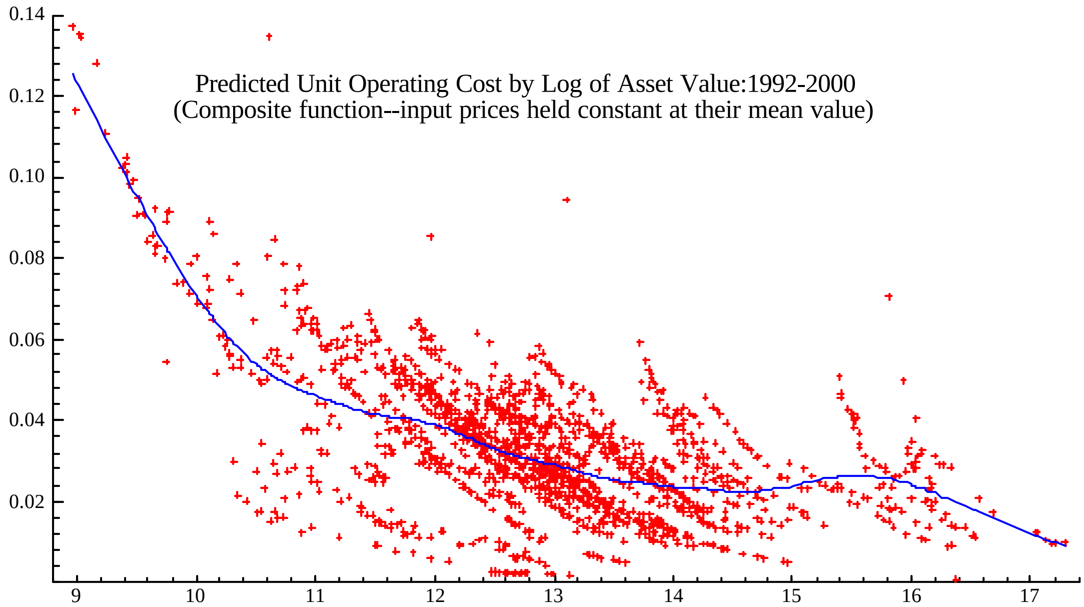
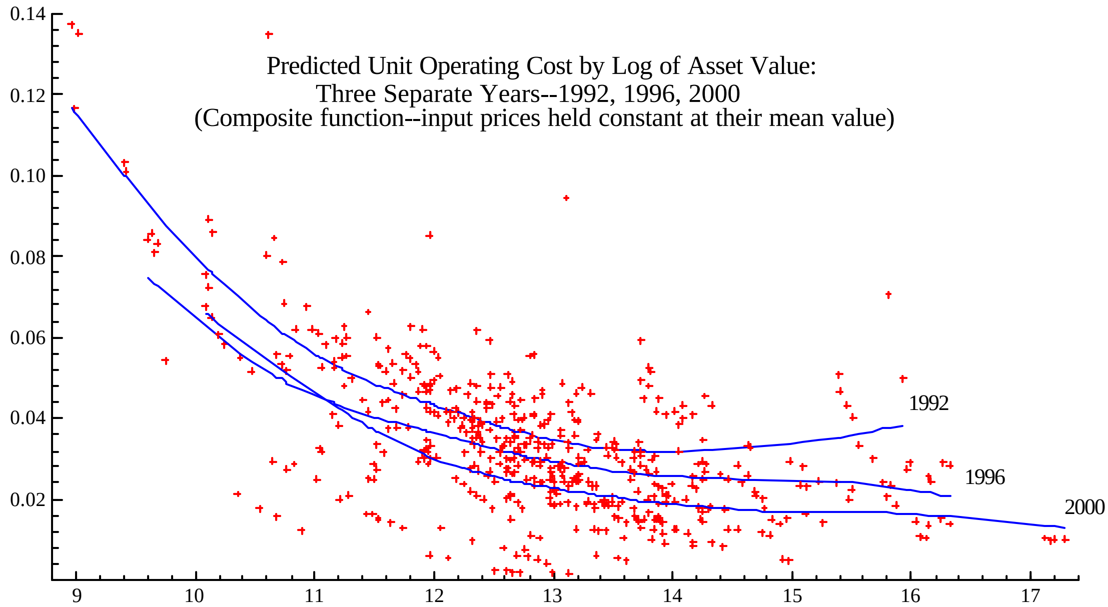


Figure 9:



In 1992, 1996, and 2000, the predicted unit operating cost for an average bank was, respectively, .044, .032, and .024.[16] This ratio fell by -25% between 1992 and 1996 and by -45% between 1992 and 2000.[17] Looking at all banks together, rather than at an average bank, unit operating cost is expressed as the sum of operating expense across all banks divided by the sum of asset values.[18] This aggregate ratio is .029, .024, and .019, respectively, for 1992, 1996, and 2000.[19] For the Spanish banking system as a whole, unit operating cost has fallen by -19% over 1992-1996 and by -35% over 1992-2000. In sum, for the average bank or for the banking system as a whole, operating cost is seen to have been significantly reduced during the 1990s in Spain.

Since total bank operating cost in 1992 was 14.1 billion Euros, this suggests that operating expenses would have been 5 billion Euros (.35 times 14.1 billion) higher in 2000 than they were if there were no scale or technical change effects to reduce operating costs from their ratio to assets in 1992.[20] Put differently, unit operating cost at an average bank fell by 7.2% a year associated with changes in service delivery and payment volume levels and mix.

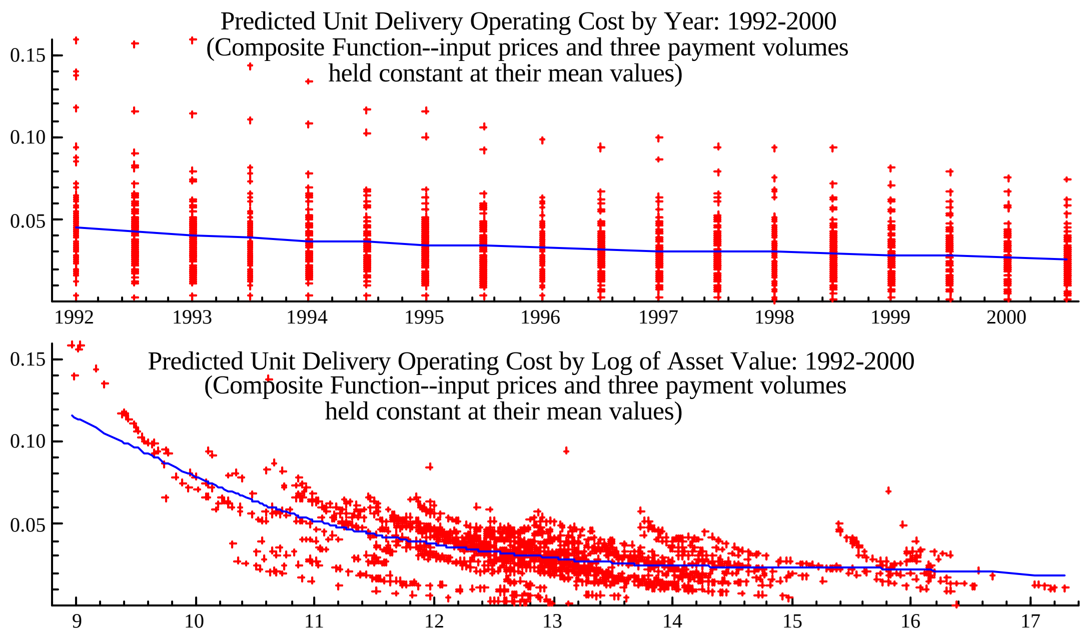
4.2. Service Delivery Costs: ATMs and Branch offices.

Service delivery costs represent those operating expenses associated with in-stalled ATMs and branch offices, holding input prices and check, giro, and card payment volumes constant at their mean values. These predicted delivery expenses for each bank are divided by the number ATMs and offices each bank has. The resulting predicted unit service delivery expenses are seen

[16] This represents the ratio of operating cost to asset value for each bank, averaged across all banks (a simple average).
[17] Percent changes were computed before ratios were rounded off.
[18] Unit operating and delivery costs were estimated separately for savings and commercial banks. These results are briefly noted in Appendix A.
[19] The aggregate ratio is lower because it gives a larger weight to larger banks that typically have lower unit operating cost (as seen in Figures 7 and 8).
[20] The 14.1 billion euro figure is the sum of operating cost for all banks in Spain in 1992 (Pta. 2,340.830 billion divided by the Peseta/euro exchange rate of Pta. 166.386 = 1 euro). The OECD data base gives total operating cost in Spain for 1992 as 17.2 billion euros. Using this figure, the implied savings would be larger at 6 billion euros.

to fall both over time (top of Figure 10) and by size of institution (bottom of Figure 10). For the average bank, predicted unit delivery expenses fell by 41% between 1992 and 2000. More detailed computations for ATMs and branch offices separately (not shown), indicate that almost all of the reduction in unit delivery expenses over 1992-2000 were due to reductions in average ATM costs, since average branch expenses were relatively stable over the period. And, although average branch expenses tend to fall at larger banks that have more offices, average ATM expenses fall more rapidly. Thus most of the cost reduction shown in Figure 10 is due to using more ATMs relative to branches as well as scale and technical changes associated with their use. Over an eight year period, the number of ATMs more than doubled, rising from 19,700 in 1992 to 41,900 in 1999. In contrast, the number of branch offices rose by only 10%, expanding from 35,400 in 1992 to 39,000 in 1999.

Figure 10:



The extent to which unit delivery costs fall as the ratio of ATMs to branch offices rises is shown in Figure 11. Delivery expenses fall as the ATM/branch ratio rises from zero (no ATMs, only branch offices) to an average of 2 ATMs per branch office. In 1992, the average ATM/branch ratio across all banks was .6. By 1999, it rose to 1.1. Since costs seem to fall up to the point where this ratio approaches 2.0 in Figure 11, there seems to be additional scope for further operating cost reductions with a higher ratio of ATMs to branch offices in the future.

The derivative of operating cost with respect to ATMs and branch offices in the estimated composite function can be expressed in percentage terms, like a ”cost elasticity” measure. For ATMs, this cost elasticity is .16. With 41,900 ATMs in 1999, a 10% increase could raise operating cost by 1.6%. The cost elasticity for branch offices is .87 and, with 39,000 offices in 1999, a 10% reduction may reduce operating cost by -8.7%. It is of course unlikely that it would take only 10% (419) more ATMs to replace 10% (390) of existing offices to keep the level of banking services to depositors ”constant”. But if this percent tradeoff was one-to-one, then the net savings in operating expense from a 10% rise in ATMs and a 10% reduction in offices would be 7.1% (i.e., 8.7% - 1.6%). If it took 20% (838) more ATMs to tradeoff with 10% fewer branches, the net savings would be 5.5%, and so on, up to the point where the net savings would apparently be .7% if it took 50% more ATMs to provide the same service delivery level to depositors as 10% fewer offices. At this latter point, the overall ATM/branch ratio would be 1.8, which is still less than the 2.0 shown in Figure 11 where cost savings seem to stop. The actual ATM-branch tradeoff that keeps service delivery levels constant is, of course, unknown but a tradeoff of 50% (or less) additional ATMs for 10% fewer branches may still provide some expense reduction according to our cost function results.[21]

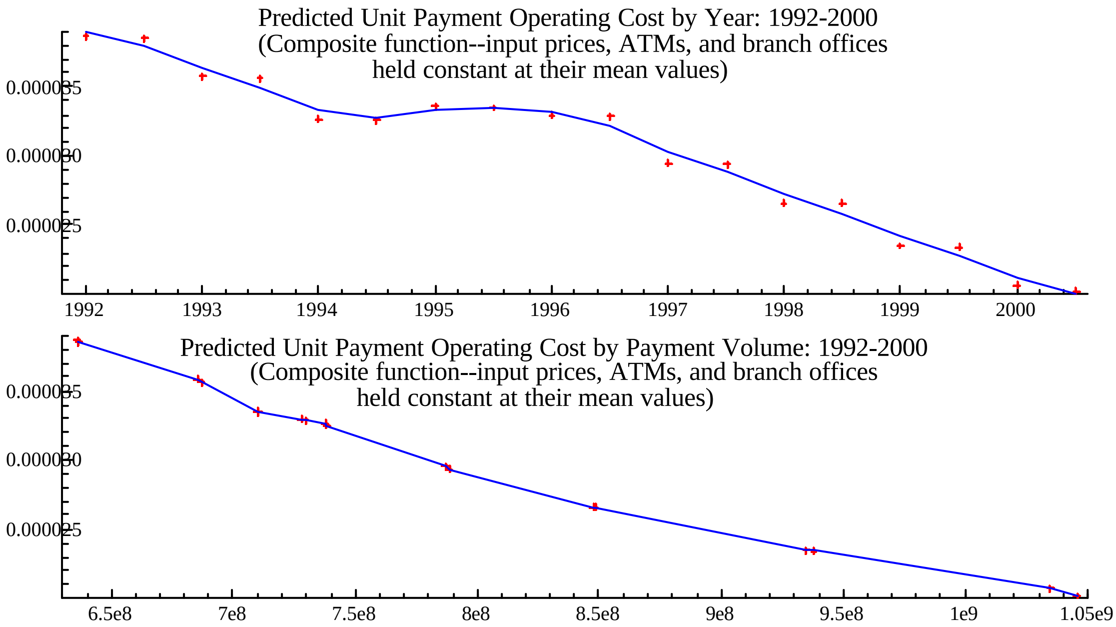
4.3. Processing Costs: Check, Giro, and Card Transactions.

Payment processing costs represent operating expenses associated with the level and composition of check, giro, and card transactions, holding input prices, ATMs, and branch offices constant at their mean values. These predicted payment costs are divided by the total number check, giro, and card transactions made each year.[22] For the average bank, unit payment costs are seen to fall both over time (top of Figure 12) and by total payment volume

[21] As derivatives are more accurate for determining effects from small changes, as opposed to the relatively large ones we illustrate here, this conclusion is tentative.
[22] Recall that payment volume information is only available by year and for the total of all banks in Spain. Bank-specific payment data are not reported and are considered confidential.

(bottom of Figure 12). Predicted unit payment cost fell by 47% between 1992 and 2000 (which is more than the reduction in delivery expenses).[23]

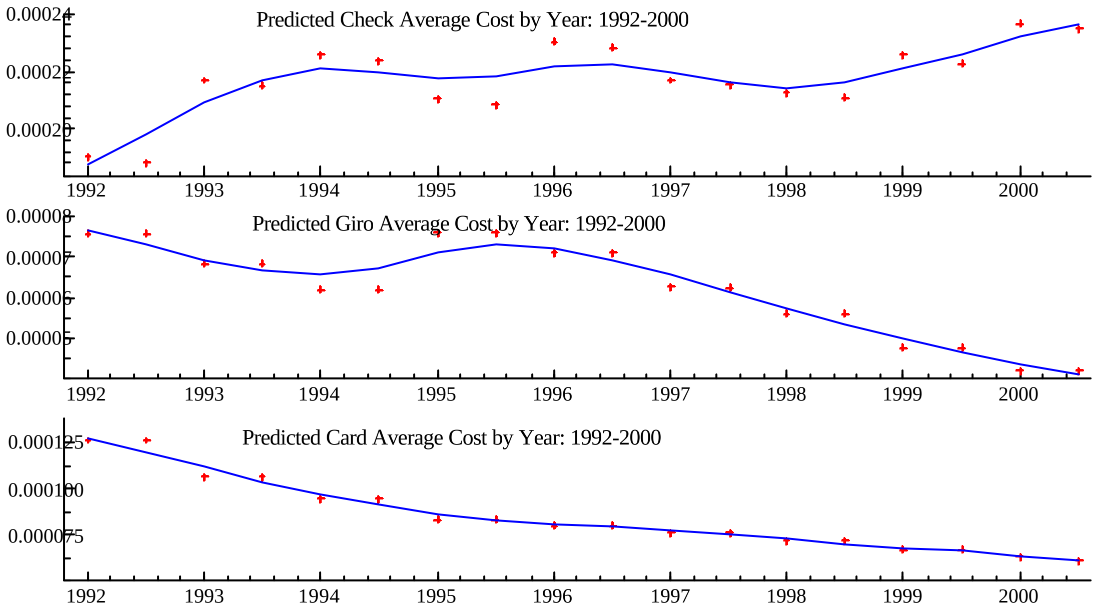
Figure 12:



As shown in Figure 13, not all payment costs are falling. Indeed, the reduction in unit payment expense seen in Figure 12 is composed of rising check average costs and falling giro and card average costs over time. Giro and card payments expanded by 85% and 78%, respectively, over 1992-2000 while checks fell by 18%. As a result, the share of checks in all non-cash payment transactions fell from .19 in 1992 to only .10 in 2000. Giro transactions accounted for a .56 share in 2000 while cards were .34. Scale economies in the processing of electronic giro and debit card payments help explain the reduction in the average per transaction payment expenses in Figure 12 while the scale benefit works in reverse (to offset some of this benefit) as the number of checks processed falls.

[23] As reported above, predicted unit operating cost for an average bank fell by -45% between 1992 and 2000 while unit deli very cost fell by -41%.

Figure 13:



The derivative of operating cost with respect to check volume in the estimated composite cost function, expressed as a cost elasticity, is .46. Thus a 10% reduction in the 99.4 million checks cleared in 2000 (10 million) would be associated with a 4.6% reduction in operating cost. Since one less check transaction will likely show up as one more giro or card payment (but probably not a new cash payment), 10 million fewer checks would expand giro plus card payments by around 10 million. The exact expansion of giro or card payments is unknown since no information exists on what check payments in Spain are used for–a point-of-sale transaction (a card substitute) or bill payments, employee disbursements, or business transactions (all giro substitutes).[24]

For illustration, it is assumed that a 10 million reduction in check payments (which corresponds to the actual reduction in checks over the past four years) is evenly divided between new giro and card transactions. Since

[24] Historical information is little help here since, between 1992 and 2000, check payments fell by 20 million while giro transactions rose by 270 million and card payments expanded by 156 million. As the rise in giro plus card payments was more than 20 times the decline in check transactions, something more than one-to-one substitution is at work here. The much larger rise in giro and card payments is due to the substitution of card payments for cash (Carbo, Humphrey, and Lopez del Paso, 2001) as well as higher incomes (which generate more transactions) in addition to the replacement of check payments.

there were 586 million giro payments in 2000, a rise of 5 million represents a .85% increase. As the estimated giro cost elasticity is .28, this implies that operating cost would rise by .24% and offset some of the cost savings from the reduction in checks. An additional offset, but this time in the opposite direction, would be associated with a 5 million rise in card volume. The estimated cost elasticity for cards is -.39.[25] A 5 million rise in card volume over the 355 million experienced in 2000 represents a 1.4% rise and this implies that operating cost could fall by .54%. Combining the -4.6% fall in operating cost from 10 million fewer checks with the .24% rise in costs from 5 million more giro payments and the -.54% reduction in cost from 5 million more card transactions suggests that a shift from checks to giro and card payments could lower operating cost by 4.9%(or 4.1% if the 10 million fewer checks showed up only as new giro payments). While one can argue with the specifics of this example, the main point–clearly illustrated in Figures 12 and 13–is that there seems to be further opportunities to reduce bank operating expenses with a continued shift away from check transactions to lower cost electronic payments.

4.4. Translog and Fourier Function Results.

The operating cost results using the easier to estimate translog model (3) are almost identical to those presented above for the composite cost function. Indeed, Figures 8 and 9 for the composite form–showing predicted unit operating cost over 1992-2000 by bank asset size and for three years separately–are so close to those using the translog results that it is very difficult to tell them apart. Consequently, they are not shown here. As a result, the predicted change in unit operating cost for the average bank between 1992 and 2000 for both models are quite close. These were -45% for the composite form and -43% with the translog. Similarly, changes in unit delivery and payment

[25] The card cost elasticity is negative since the cost reductions associated with expanded card use have (during the 1990s) more than offset the expected rise in operating cost as more card transactions were processed. All of the cost elasticities for the five output characteristics from the composite model combine scale and technical change effects but only for cards does the latter more than offset the former, giving a negative elasticity.

expenses over 1992-2000 were -41% and -47%, respectively, using the composite but -40% and -44% using the translog.[26]

The Fourier cost model (4) adds sin and cos terms for the five out-put characteristics to the standard translog form. The purpose is to capture more than just the quadratic nonlinearity which would be captured with the translog specification. Since bank-specific data are available for ATM and branch offices in our panel data set, so that for these two output characteristics we have both cross section and time-series variation, the Fourier form may improve the fit compared to the translog form. However, no country has publicly available bank-specific data on the volumes of check, giro, and card transactions.[27] Thus our payment data have no cross-section variation, only time-series variation at the national level. As payment volumes experience low variance over time, it turns out that the quadratic specification in the translog portion of the Fourier form is sufficient to locally identify all of the nonlinearity in these data. For this reason, all the parameters specified in the full Fourier model in (4) could not be estimated and the cos and sin terms in the final estimated model only refer to two (ATMs and branches) rather than the full five output characteristics.[28]

The main differences in our results for the Fourier form, compared to the composite, are for the smallest and largest banks, not for the average bank. The simplest way to see this is to compare Figure 14, which illustrates predicted unit operating cost for 1992, 1996, and 2000 using the Fourier form, with Figure 9, which shows the same three cost curves for the composite function. While the middle segments of these two figures which reflect the average bank are largely congruent, the large operating cost scale economies for the smallest banks shown for the composite (or translog) form are considerably smaller

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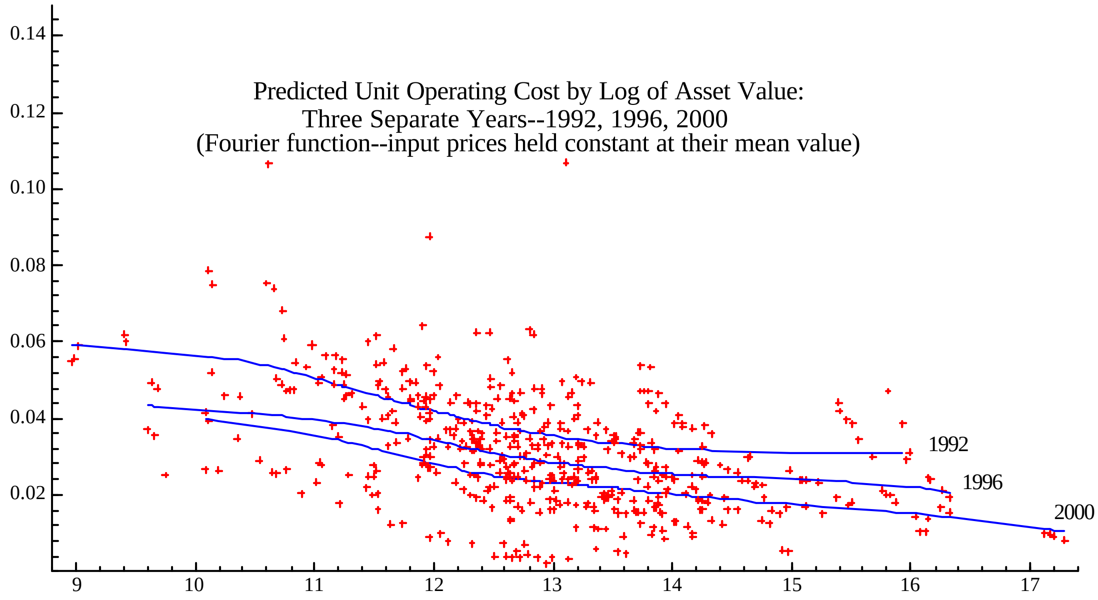
[26] The strong correspondence between the translog and composite results is not unexpected since f in the composite form is .20, indicating that this estimated model is closer to a specification which includes the log of output as well as input prices (as would be the case if f=0.0).

[27] Only Norway has collected payment volume data by bank over time but even here it is only publicly available for all commercial banks or all savings banks together, not by individual institution (see Humphrey, Kim, and Vale, 2001).

[28] As the sin and cos terms for three output characteristics (check, giro, and card transactions) could not be estimated, all of the single and double summations shown in (4) are over two output characteristics (ATMs and branches), not five.

when the Fourier form is used. As well, the slight scale diseconomies evident for the largest banks in 1992 with the composite (or translog) form are shown as constant unit cost with the Fourier form in that year. Even so, these differences have little effect on the predicted changes in unit operating cost between 1992 and 2000. With the composite form, unit operating cost fell by -45% over this period while unit delivery and payment costs fell, respectively, by -41% and -47%. The same three figures are -42%, -38% and -47% with the Fourier model.

Figure 14:



5. Summary and Conclusions.

Two common trends among banking systems in developed countries have had a large impact on operating cost, and hence on service level and price, to users. One trend has been the expansion of lower cost and more convenient ATMs, relative to branch offices, to deliver cash, account transfer, and balance inquiry services to depositors. A second trend has been the ongoing replacement of paper-based payment instruments (checks and paper giro payments) with lower cost electronic alternatives (debit cards and electronic giro payments). Indeed, these five banking output characteristics related to service delivery and payment (and deposit account) processing make up the bulk of bank operating costs.[29]

The effect on cost from these five activities incorporate both scale influences and technical change. A statistical model based on these output characteristics relates operating cost to service delivery and payment levels and mix to determine how changes in these characteristics have affected operating costs at Spanish savings and commercial banks over 1992-2000. We find that the average Spanish bank has apparently saved 45% in unit (or average) operating cost between 1992 and 2000, or about 6 billion Euros for the banking system as a whole. As larger institutions have progressed further in shifting from branch offices to ATMs for dispensing cash and also process higher volumes of lower cost electronic payments, these institutions have benefited the most from the associated reduction in unit operating expenses.

Both service delivery and payment activities experienced similar reductions in unit operating cost over 1992-2000. The overall reduction (noted above) was -45% while that for service delivery was -41% with -47% for payments. In determining the average effect on operating cost from changes in service delivery methods and the level and mix of payment volumes, it does not matter much whether a composite, translog, or Fourier cost model is used, although for very small and very large banks there are some differences.

With respect to the future, it appears that if ATMs were expanded further (relative to branch offices) additional operating cost could be saved. At present, the ATM/branch ratio is 1.1 but costs seem to continue to fall for institutions with ratios up to around 2.0. It is also evident that additional operating expense could be saved with a continued reduction in check and paper giro use since electronic payments generally only cost one-third to one-half as much as its paper-based non-cash alternative.

[29] While it is true that banks al so provide loan origination and monitoring services, asset liquidity management with security holdings, and trust and safekeeping services, these are performed at branch offices and the labor input component is small relative to that associated with deposit service delivery and payment activities.

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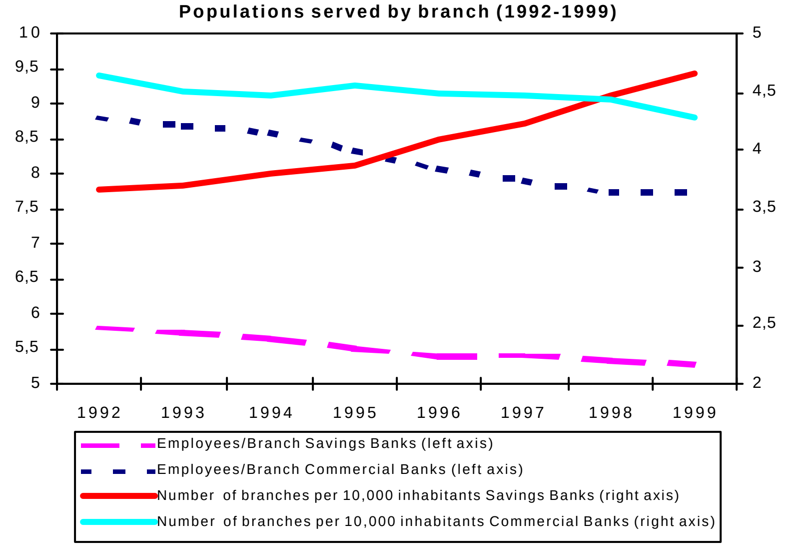
Appendix A: Information on Savings and Commercial Banks.

The replacement of branch offices with ATMs for Spanish savings and commercial banks together is described in Section 2. This appendix shows how Spanish savings banks have at times differed from commercial banks in this replacement process. As seen in Figure A1, savings banks expanded the number of their branches per 10,000 inhabitants over 1992-1999 while there was a small reduction for commercial banks. Even so, the average number of employees per branch office fell slightly for both savings and commercial banks over this period. Savings banks have somewhat fewer employees per office (5.3 workers in 1999) than do commercial banks (7.7 workers). The growth in savings bank offices per 10,000 inhabitants is attributed to the removal of branching restrictions in 1989 which had prevented them from branching outside of their traditional region, a power which commercial banks already had. By 1999, the number of offices per 10,000 inhabitants were very similar between savings and commercial banks, although the average size of an office was somewhat smaller (as measured by number of employees) for savings banks.

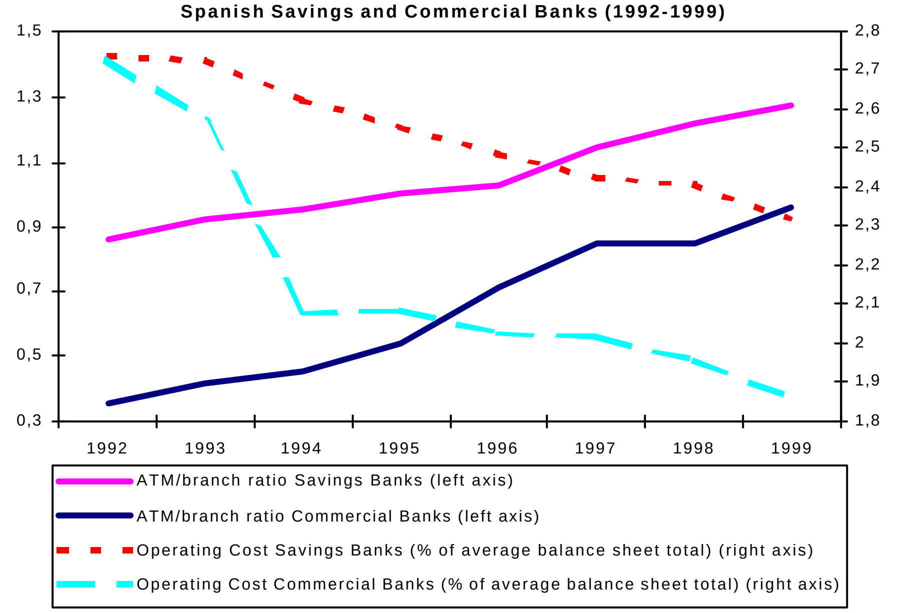
Figure A 1: Average Number of employees by branch and Populations served by branch (1992-1999)



Source: AEB, CECA and INE

Figures 4, 6, and 7 in the text show that for Spanish savings and commercial banks, the rise in the ATM/branch ratio and expanded electronic payments occurred at the same time that there was a marked reduction in the ratio of operating cost to asset value. While the operating cost/asset ratio may be affected by other influences in addition to these two trends, Figure A2 illustrates a similar relationship for savings and commercial banks separately. Between 1992-1999, the number of ATMs per office at savings banks rose from .8 to 1.3. This added an additional ATM for each of two branch offices in existence. For commercial banks, the rise was from.4 to 1.0, which added 1.2 additional ATMs for each of two existing offices. In both cases, the rise in the ATM/branch ratio occurred while the share of operating cost to asset value fell.[30] Commercial banks experienced a larger reduction since the share of operating cost fell from around .027 of asset value down to around .019. For savings banks, the reduction was from around .027 down to .023. In both cases, this represents a large and significant reduction inoperating cost.

Figure A 2: Substitution of ATMs for Branches and Operating Cost in Spanish Savings and Commercial Banks (1992-1999)



Source: AEB, CECA and INE

[30] Bank-specific information on electronic (or any) payments are not publicly available for savings or commercial banks. However, Figure 6 in the text showed that the share of all non-cash payments in Spain rose during this period.

The most important factor explaining the greater relative use of ATMs to branch offices at savings banks likely was the larger investment in technology following the deregulation of branching restrictions in 1989 and the high level of cooperation to make ATMs compatible through the Spanish Confederation of Savings Banks (CECA). In contrast, one reason for the larger reduction of operating costs at commercial banks is that they reduced the absolute number of branch offices they had while savings banks expanded theirs.

Table A1: Costs for Commercial and Savings Banks

	1992	1996	2000
Unit Operating Cost:			
Commercial Banks	.047	.035	.024
Savings Banks	.037	.028	.022
Unit Delivery Cost:			
Commercial Banks	.050	.037	.028
Savings Banks	.035	.028	.024

Using the composite function, estimates of unit operating and delivery expenses were undertaken separately for commercial and savings banks. These are shown in Table A1.[31] As seen, unit operating expenses for the average savings bank appear to be less than those for the average commercial bank.[32] However, because this difference narrows over time, the reduction in unit operating expense for commercial banks over 1992-2000 is larger (-49%) than that for savings banks (41%). A similar situation exists for unit delivery expenses where the average savings bank experiences lower delivery costs but the average commercial bank had a larger reduction (-44%) than did savings banks (-31%) over the period. The higher average ATM/branch ratio for savings banks seems to explain their lower unit cost compared to commercial banks. In any event, the reduction in unit costs for both types of institutions were quite large and point to the benefits obtained from changes in service delivery

[31] In determining unit operating cost, input prices were held constant at their mean value in each bank's sample. For unit delivery cost, input prices and the three payment volumes were kept at their mean values. Separate determination of unit payment expenses is not possible as payment transaction data are not available for savings and commercial banks separately.

[32] The operating cost to total asset ratio for the average savings or commercial bank is a simple average (where each bank has the same weight). The same ratio is shown in Figure A2 but is a weighted average, where the weights are effectively the size of the bank. Thus, although the operating cost to asset ratio fell in both cases, the magnitude of the percent reductions differ.

methods and payment technology. The similarity of these costs between savings and commercial banks in 2000 suggest that competition between these institutions has increased over 1992-2000.

Appendix B: Parameter Estimates for the Composite Cost Function.

Number of observations = 1541

Log likelihood = 1552.14

Standard Errors computed fromheteroscedastic-consistent matrix (Robust-White)

Parameter	Estimate	t-statistic	P-value
ϕPHI	.202328	8.92303	[.000]
α_0 A0	-18716.2	-.399177	[.690]
α_1 A1	.281204E-	3.416044	[.677]
α_2 A2	-.299445E-	-.335690	[.737]
α_3 A3	.592566E-	.374518	[.708]
α_4 A4	-9.19995	-.323759	[.746]
α_5 A5	61.3300	2.48845	[.013]
α_{11} A11	-.245264E-11	-.464970	[.642]
α_{22} A22	.469004E-13	-13.47814	[.634]
α_{33} A33	-.511713E-14	-.010180	[.992]
α_{44} A44	.021483	23.85152	[.000]
α_{55} A55	.042371	8.23871	[.000]
α_{12} A12	.539854E-12	.457658	[.647]
α_{13} A13	-.716467E-12	-.445548	[.656]
α_{14} A14	.353708E-06	.840684	[.401]
α_{15} A15	-.495466E-06	-1.38610	[.166]
α_{23} A23	-.105496E-12	-.253784	[.800]
α_{24} A24	.148884E-07	.448586	[.654]
α_{25} A25	-.385897E-07	-1.22558	[.220]
α_{34} A34	-.236912E-07	-.358464	[.720]
α_{35} A35	-.269126E-07	-.473414	[.636]
α_{45} A45	-.056755	-5.15559	[.000]
β_1 B1	.488917	71.6883	[.000]
β_{11} B11	.041537	17.1063	[.000]

Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Std. error of regression = .383213

Sum of squared residuals = 226.299

LM het. test = 1541.00 [.000]

Durbin-Watson = 1.95306

Share Equation:

Mean of dep. var. = .600130

Std. error of regression = .059252

Sum of squared residuals = 5.41006

R-squared = .055606

LM het. test = 11.4947 [.001]

Durbin-Watson = 1.63261

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