Network Externalities in the Market for Electronic Check Payments

Joanna Stavins

Senior Economist, Federal Reserve Bank of Boston. *Jeff Fuhrer, Richard Kopcke, and Christina Wang provided helpful comments. Radoslav Raykov supplied excellent research assistance, and Marie Willard helped with obtaining the data.*

Network externalities exist when the value of a good or service to a potential consumer increases with the number of other consumers using the same product. For example, my e-mail becomes more valuable to me the more people have access to e-mail. Similarly, if a payment technology involves a direct exchange between firms and thus requires a common standard, a firm is more likely to adopt the technology the more it is adopted by other firms in its market. Network externalities could arise from a need to communicate directly with other consumers or firms, as in the case of e-mail, but could also exist when firms share a certain technological standard or when information about the technology spreads faster within a network than outside it.

For a service characterized by network externalities, adoption and use can be below the socially optimal level, because consumers or firms do not take into account the positive effect of their own use on others' use. A firm may decide not to adopt a technology because its private net benefits from adoption are negative, even though net social benefits may be positive.

This article tests whether network externalities exist in electronic check services provided by the Federal Reserve. Electronic check products have been relatively slow to spread—the recent decline in the number of paper checks (Gerdes and Walton 2002) has been attributed to growth in other forms of electronic payments, such as credit or debit cards, and not to a switch to electronic check services. There could be at least two reasons for the low rate of growth: Financial institutions (or their customers) do not find electronic check products sufficiently attractive, and network externalities slow down the rate of adoption of these services. In the first

Table 1
Main Electronic Check Services Offered by the Federal Reserve

MICR Information	As the check passes through a sorter, the MICR line data are captured and stored in an electronic data file, which is then transferred electronically, but legal presentment is said to have occurred when the physical items are delivered to the paying institution or its designated processor.
MICR Presentment	The paying bank may decide to debit the amount on the check based on the electronic presentment. In this case, legal presentment is said to have occurred when the MICR file arrives at the paying bank. The depositing bank is automatically debited for the amount of this electronic file that same day. The debiting occurs whether or not the paper checks were successfully delivered to the customer or its designated presentment point that day.
MICR Presentment Plus	The MICR line data are captured and delivered, and the delivery of the electronic file constitutes legal presentment. This service adds a return service, where checks are held at the Reserve Bank awaiting information about return items (usually because of insufficient funds) from the paying bank. The Reserve Bank sends returned checks to the collecting bank and forwards the remaining checks to the paying bank.
Truncation	The MICR line data are captured and delivered, and the delivery of the electronic file constitutes legal presentment, but the paper checks are stopped at the Reserve Bank. The checks or their images (digital or microfilm) are stored at the Reserve Bank.
Image	Digital images of checks are captured and archived by the Reserve Bank. Images can then be delivered to the depository institution, or the institution can view and download selected images. MICR data are not directly entered, but are used to identify checks.

case, there is no need for any policy intervention, and the services should be priced based on their market conditions. But in the second case, there may be a reason to provide additional incentives to depository institutions, perhaps by changing prices or by other means, such as bundling electronic check payments with other types of services. Because electronic check services are primarily used in banks' back-office operations and less often in direct payment exchanges among financial institutions, potential network effects are more likely to arise from the spread of information than from any coordination needs.

Following Gowrisankaran and Stavins (forthcoming), we apply two tests for the presence of network externalities: clustering and market concentration. The first test is based on the idea that a bank is more likely to adopt a network-type technology the more other institutions in its market adopt it. If network externalities exist in the market for electronic check payments, adoption can be expected to show "clusters," where depository institutions in some markets have much higher adoption rates than those located in other markets, controlling for bank and market characteristics. A cluster can get started because of the presence of such characteristics, but then it grows at a disproportionally high rate. This method can test for the presence of local network externalities only. To the extent that depository institutions exchange payments primarily with other institutions located in their area, network externalities result in clusters of adopters. This method will not, however, capture network effects on the national level.

The second test relies on the idea that a firm located in a concentrated market internalizes the externality and thus is more likely to adopt a technology characterized by network externalities than a competitive firm is. A competitive firm may decide not to adopt a given technology because it does not take the effects of its own adoption on others into account. However, a monopolist internalizes the externalities and therefore makes a socially optimal adoption decision. Extending this argument, the higher the market concentration, the more likely a firm is to adopt a technology characterized by network externalities, as the smaller is the effect of its decision on other firms in the market. That may explain why banks in Europe, where market structure is much more concentrated than in the U.S., have adopted electronic payments at a much higher rate than U.S. banks have. We therefore expect that if network externalities exist, a bank located in a more concentrated market is more likely to adopt electronic check products than a bank located in a market with lower market concentration. Banks located in more remote markets, which tend to have a higher market concentration, face higher costs of paper check transport, raising their incentives to substitute paper with electronics.

For each depository institution, we define its market as the MSA or non-MSA county where the institu-

Table 2
Fraction of Depository Institutions that Used Each Federal Reserve Electronic Check Product, by Asset Size and Type of Institution
First quarter 2001

	MICR Information	MICR Presentment	MICR Presentment Plus	Image	Truncation	Number of Institutions[a]
	Percent Using Product					
Commercial Banks						
<$100 million	4.5	23.9	6.3	4.5	0.8	5,169
$100 m to $1 b	4.7	19.4	1.3	4.0	0.3	3,566
>$1 billion	7.1	11.0	1.6	9.9	0.2	547
Credit Unions						
<$100 million	0.0	0.1	0.1	0.4	0.3	9,342
$100 m to $1 b	0.3	2.2	1.1	7.1	4.1	879
>$1 billion	0.0	2.1	2.1	10.4	0.0	48
Thrifts (all sizes)	0.0	0.0	0.0	0.0	0.0	1,060
All						
<$100 million	1.6	8.3	2.3	1.8	0.5	14,971
$100 m to $1b	3.4	14.4	1.1	4.2	1.0	4,947
>$1 billion	5.6	8.8	1.4	8.5	0.1	693

[a] Number of institutions with distinct entity numbers and valid values for bank assets.

tion is located.[1] Using the first test, we find weak evidence that network externalities exist in MICR Presentment, Truncation, and Image. However, the results were not robust to the estimation methods used. In particular, instrumental variable estimation did not confirm the initial results. Moreover, the second test did not show any evidence of network externalities for these services. Therefore, we do not find evidence for network externalities in electronic check services.

Section I discusses previous literature on network externalities, with a focus on the effect of market concentration on adoption. Section II describes the data used in this article and shows some summary statistics. Section III presents our model, while the results are discussed in Section IV. Section V concludes.

I. Previous Literature

Although theoretical literature on network externalities is plentiful, empirical literature is scarce, because of lack of suitable data. For some goods, only time series data exist. Network externalities are typically present in technology-intensive industries, where costs and prices decline over time. Although usage of these products grows over time, without controlling for cross-sectional variation it is difficult to distinguish the effect of network externalities from an increase in demand due to lower prices. In studies that apply cross-sectional data, it is hard to distinguish clustering of tastes and preferences from network effects.

A few previous papers studied the effect of market concentration on technology adoption. Hannan and McDowell (1984a) and (1984b) found that banks operating in more concentrated markets had a higher probability of Automated Teller Machine (ATM) adoption, whether adoption was measured as the speed of diffusion or as the proportion of banks that adopted the technology. Saloner and Shepard (1995) found that adoption of ATMs was faster in states with a higher market concentration, supporting the idea that banks located in those markets internalized network externalities to a greater extent than banks in more competitive markets. Genesove (1999) estimated the effect of competition on the speed of technological adoption in the U.S. newspaper industry. He found that a duopolist adopted the technology three years later than a monopolist did.

Previous studies have shown that some types of electronic payments can be characterized by network

[1] Although larger institutions cross county or even state borders, the majority of check transactions continue to be local. Using counties as relevant markets did not change our results. As mentioned above, we test for the presence of local, and not national, network externalities.

Table 3
Average Quarterly Volumes of Electronic Check Products, by Asset Size and Type of Institution
First quarter 2001

	MICR Information	MICR Presentment	MICR Presentment Plus	Image	Truncation
	Thousand of Items				
Commercial Banks					
<$100 million	162.68	101.54	61.11	145.38	105.70
$100 m to $1 b	408.07	294.87	221.49	211.47	314.40
>$1 billion	3008.30	1264.82	387.07	412.68	582.29
Credit Unions					
<$100 million	131.18	77.46	40.24	78.85	208.10
$100 m to $1 b	21.49	604.23	384.42	420.06	582.30
>$1 billion	0.00	0.00	0.09	779.50	0.00
Thrifts (all sizes)	0.00	0.00	0.00	0.00	0.00
All					
<$100 million	162.28	101.44	60.26	136.84	150.22
$100 m to $1 b	401.21	303.14	251.11	274.25	515.32
>$1 billion	3008.30	1264.82	348.37	438.88	582.29
	Total Quarterly Volume in Sample, Millions of Units				
All Institutions	220.58	415.73	37.90	117.34	35.68

would prompt others to do the same. That might be especially relevant in the case of truncation and image, services that are more likely to be reflected in end users' preferences.

Besides testing whether banks located in more concentrated markets are more likely to adopt electronic check payments, we also test whether the relationship between adoption and concentration is nonlinear. For example, a monopolist may be more likely to adopt than a bank located in any other type of market, but the relationship between adoption and concentration may no longer hold in other types of market structure. In that case, there would be no difference between an oligopolist and a bank located in a nearly perfectly competitive market.

externalities (Weinberg 1997, Roberds 1998, Gowrisankaran and Stavins (forthcoming)). Gowrisankaran and Stavins found evidence of network externalities in the market for the automated clearinghouse (ACH) product. They found that ACH adopters clustered in certain areas and that banks in more concentrated markets were more likely to have adopted ACH. Using the Herfindahl-Hirschman Index of market concentration (HHI), they found that the higher the market concentration, the more likely are banks to adopt ACH, controlling for bank and market characteristics.

This paper applies similar methods to test whether network externalities exist in several types of electronic check payments services. While ACH is a payment system, electronic check services are still mainly used for banks' internal purposes. Therefore, financial institutions do not need to coordinate their electronic check technology, and adoption by one bank does not require that others follow suit. However, there are reasons why banks' adoption of electronic check services might be clustered. Network externalities may arise from the spread of information about a given technology, and not just from the need for compatible standards. To the extent that electronic check services are utilized by end users, one might expect that adoption by some banks in a geographic area

II. Data

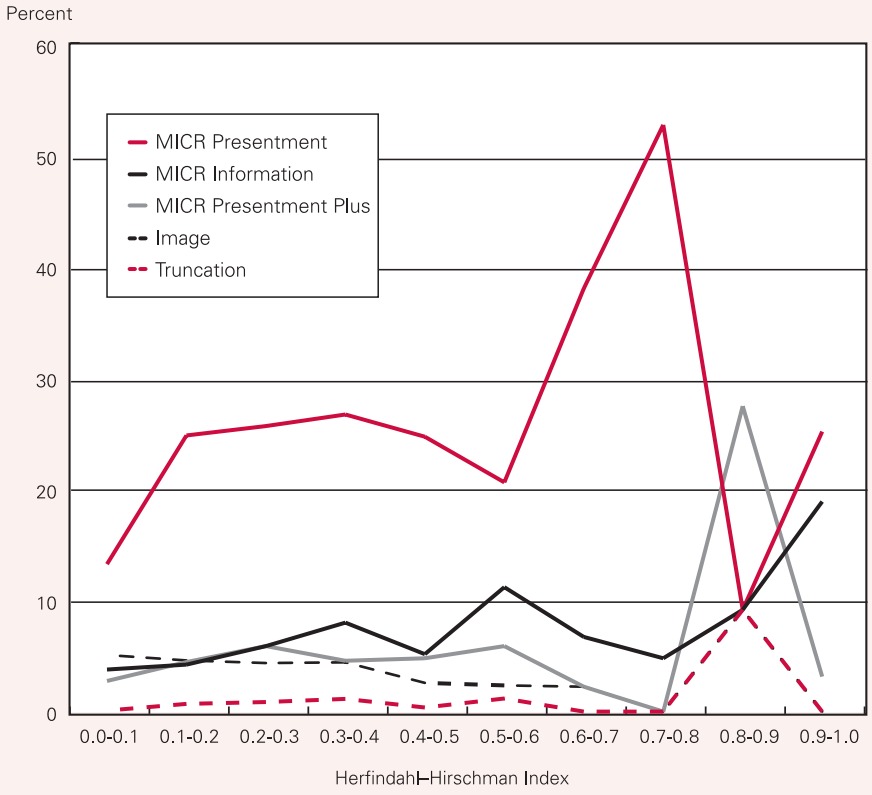
Our data were compiled from multiple sources. The data on individual depository institutions' use of electronic check services are from the Financial Services Information System (FSIS) data collected by the Federal Reserve. These data record monthly purchases of electronic check products by individual depository institutions in the United States. We use the data for the last three quarters of 2000 and all four quarters of 2001. Although the FSIS data have been collected since 1996, product codes were not unified across Reserve Banks until April 2000, and, therefore, the earlier data could not be pooled across Districts. Electronic check services were categorized as follows: MICR Information, MICR Presentment, MICR Presentment Plus, Truncation, and Image. A description of each service is provided in Table 1.

For each institution in the FSIS data set, we have the American Banking Association (ABA) number that allows us to link these data with other publicly available banking data. We obtained data on commercial banks' quarterly deposits, assets, and loans from the quarterly Reports of Condition and Income filed with the Federal Financial Institutions Examination Council (Call Reports). Credit union data were obtained from

Figure 1

Commercial Banks' Adoption of Electronic Check Services, by Market Concentration

Percent Using Each Service in the First Quarter of 2001



the Statement of Financial Condition filed with the National Credit Union Administration. Because some credit unions file their reports quarterly, while others file semiannually, we used quarterly data when available and interpolated the data linearly for the credit unions that filed semiannually. Thrift data came from the quarterly Thrift Financial Report filed with the Office of Thrift Supervision.

The Call Report data on assets and deposits are reported by RSSD (Research, Statistics, Supervision, and Discount) number. Banks with a given RSSD number may use one or more ABA numbers. Thus, we aggregated the Federal Reserve electronic check volumes up to the RSSD level. A small fraction of the ABA numbers from the FSIS data were not in the Call Reports database, nor in the credit union database, nor in the thrift database. However, we were able to match over 80 percent of our sample.

Our final data set includes observations on 21,547 distinct depository institutions, as identified by Federal Reserve entity numbers. The majority of these institutions did not use the Federal Reserve's electronic check services. The data set is on the market level, where a market is defined as an MSA or a non-MSA county where the bank's branch is located. If a bank has more than one branch in a county, all branches are treated as one, and their deposits summed. Deposits, assets, and loans, which are available only on the bank (not market) level, are distributed among branches using the bank's fraction of deposits in a given market as weights.

Tables 2 and 3 show, respectively, the fractions of depository institutions that used Federal Reserve electronic check services and the average quarterly volumes, by size and type of institution for the first quarter of 2001.

To calculate our measure of market concentration in each market—the Herfindahl-Hirschman Index (HHI)[2]—we needed branch-level deposits. As Call Reports do not break down deposits by individual branches, we used the Federal Deposit Insurance Corporation (FDIC) annual Summary of Deposits data. Because the branch-level Summary of Deposits data are collected once a year, each market's HHI is the same throughout each year. The HHI data were merged with the Call Report data. Over 94 percent of the sample matched correctly.

Figure 1 and Table 4 show commercial banks' adoption of each product for different ranges of HHI. It is not apparent that the usage of any of the products increases monotonically with market concentration.

[2] HHI for market J is calculated as follows:

$$HHI_J = \sum_{j \in J} S_j^2 = \sum_{j \in J} \left(\frac{DEPOSITS_j}{DEPOSITS_J} \right)^2$$

Table 4
Fraction of Commercial Banks that Used Each Federal Reserve Electronic Check Product, by Market Concentration
First quarter 2001

Market Concentration (HHI Range)	MICR Information	MICR Presentment	MICR Presentment Plus	Image	Truncation	Number of Institutions[a]
	Percent Using Product					
0.0–0.1	3.8	13.2	2.7	5.1	0.1	2,157
0.1–0.2	4.2	24.7	4.4	4.6	0.7	3,480
0.2–0.3	5.8	25.5	5.8	4.3	0.9	1,522
0.3–0.4	7.9	26.5	4.5	4.4	1.1	705
0.4–0.5	5.1	24.5	4.8	2.6	0.4	273
0.5–0.6	11.1	20.5	5.8	2.3	1.2	171
0.6–0.7	6.7	37.8	2.2	2.2	0.0	45
0.7–0.8	4.8	52.4	0.0	0.0	0.0	21
0.8–0.9	9.1	9.1	27.3	9.1	9.1	11
0.9–1.0	18.8	25.0	3.1	0.0	0.0	32

[a] Number of institutions with distinct entity numbers and valid values for HHI.

For three products (MICR Presentment Plus, Image, and Truncation), usage is highest in the 0.8–0.9 range of HHI, but then drops again for banks located in markets where concentration is the highest. The result is puzzling. Later in this paper, we show the results of robustness tests to see whether omitting the few institutions located in very highly concentrated markets changes our results.

Population for each county (our measure of market size) is from the 2000 Census. Nonfarm payroll employment by state, year, and quarter is from the Bureau of Labor Statistics. Using zip codes, we calculated the distance from each institution's headquarters to the nearest Federal Reserve check processing location.[3]

Electronic check services are priced locally by each Federal Reserve District, and, in some cases, branch offices within the same district charge different prices. We used the actual prices charged by each Federal Reserve Bank for each type of service. Most Reserve Banks charged a fixed fee to cover the cost of each transaction (regardless of the number of checks) and a variable fee for each check. Prices varied substantially across Districts. For instance, in 2000, the fee for MICR Information varied from a $2 fixed fee plus $0.0013 per item at Philadelphia to a $15 fixed fee plus $0.0060 per item at Kansas City and San Francisco. Although some Districts changed their electronic check prices between 2000 and 2001, most prices remained constant. Out of 340 different product prices that existed in 2000, only 80 changed the following year. In contrast, 317 out of 447 changed in April 2000. Several products were also dropped at the time, explaining the difference in the number of different services offered.

III. Model

We estimate a logit equation of each bank's adoption of a given electronic check product on the fraction of other institutions in the same market that adopted the same product and on the level of market concentration in the bank's market. We control for several bank and market characteristics. Based on a Federal Reserve survey of consumers, Mantel and McHugh (2001) found that consumers in large markets were more likely to use debit cards than consumers living in small markets. Whether the difference arises from the demand side or the supply side, banks located in larger markets can be expected to adopt some forms of electronic payments before small-market institutions do, even controlling for bank size and market structure. In the case of electronic check services, individuals' preferences may not directly influence depository institutions' choice of technology, but they may influence corporations' preferences, which in turn may

[3] We used mapblast.com to get each Reserve Bank's location. We obtained distances for each zip code based on the latitude and longitude of a given point using the MABLE/Geocorr Geographic Correspondence Engine provided by the Office of Social and Economic Data Analysis at the University of Missouri <http://oseda.missouri.edu:80/plue/geocorr/>. In cases where zip codes were missing, we used the U.S. postal web site, www.usps.com, to find the closest zip code.

Table 5
Distribution of Banks by Asset Size and Average Number of Markets per Bank
First quarter 2001

	Number of Banks	Percent	Average Number of Markets per Bank
<$100 million	14,971	72.64	1.2
$100–200 million	2,503	12.14	2.2
$200–300 million	1,033	5.01	3.4
$300–400 million	512	2.48	4.0
$400–500 million	310	1.50	5.3
$500–600 million	194	0.94	5.0
$600–700 million	166	0.81	5.7
$700–800 million	96	0.47	6.7
$800–900 million	74	0.36	8.2
$900–1,000 million	59	0.29	10.9
>$1 billion	693	3.36	102.7
Total	20,611	100.00	

Note: Author's calculations. Includes commercial banks, thrifts, and credit unions.

affect what banks decide to offer. We test this hypothesis by including market size in the estimation. Using the Federal Reserve Survey of Retail Fees and Services of Depository Institutions, Hannan (2001) found differences between multistate and single state institutions in their ATM services. We test whether there is a difference between these two types of institutions in their adoption of electronic payment services.

We use assets as a measure of bank size. To capture the effect of bank size on the adoption of electronic check services, we create size categories. Bank assets are used in regressions in one of three ways: as a continuous variable; as three size categories (under $100 million, between $100 million and $1 billion, and above $1 billion); or as 11 size categories increasing in steps of $100 million. The vast majority of institutions are in the smallest size category. However, the larger the bank, the more branches and the more markets it operates in. Table 5 shows, for the first quarter of 2001, the distribution of banks by size and the average number of markets (MSAs or counties) in which each size category operated.

We estimate the following equation using logit estimation:

$$\begin{aligned} ADOPTION = {} & \alpha_0 + \alpha_i + \alpha_t + \alpha_1\, OTHERS + \alpha_2\, HHI + \\ & \alpha_3\, MKTSIZE + \alpha_4\, MULTI + \\ & \alpha_5\, MKTSHARE + \alpha_6\, ASSETS + \\ & \alpha_7\, DISTANCE + \alpha_8\, PRICE + \\ & \alpha_9\, CU + \varepsilon, \end{aligned} \quad (1)$$

where ADOPTION is a dummy variable equal to 1 if the bank adopts a given service, α_i are dummy variables for each Federal Reserve district or branch office, α_t are dummy variables for each quarter, OTHERS is the fraction of other banks in the market that have adopted the service, HHI is the Herfindahl-Hirschman Index of market concentration for each market, MKTSIZE is each market's population weighted by the bank's share of deposits in that market, MULTI is a dummy variable equal to 1 if the institution has branches in more than one state, MKTSHARE is the bank's share of deposits in the market, ASSETS is bank assets, entered as 11 size categories in the chosen specification, DISTANCE is the distance from the bank to the nearest Federal Reserve office, PRICE is the unit price charged by the nearest Federal Reserve office for that product at the time, and CU is a dummy variable indicating whether the institution is a commercial bank or a credit union.

Network externalities may affect the rate of adoption or, once the service is adopted, the magnitude of use. We test for the presence of network externalities both ways, by regressing the same set of variables as above on the volume of transactions for each service purchased by each bank in each quarter. Our volume regressions use fixed effects for each depository institution, to control for any bank-specific factors that may affect usage:

$$\begin{aligned} VOLUME = {} & \beta_0 + \beta_i + \beta_t + \beta_1\, OTHERS + \beta_2\, HHI + \\ & \beta_3\, MKTSIZE + \beta_4\, MULTI + \\ & \beta_5\, MKTSHARE + \beta_6\, DEPOSITS + \\ & \beta_7\, ASSETS + \beta_8\, DISTANCE + \\ & \beta_9\, PRICE + \nu, \end{aligned} \quad (2)$$

where β_i denotes bank-level fixed effects.

The expected sign on HHI is ambiguous, as HHI serves as a proxy for two different effects. If network externalities are present, we expect both adoption rates and volume to increase with HHI. On the other hand, banks in more concentrated markets may have more market power, which in turn would induce them to adopt electronic check services in expectation of higher profits. Thus, markets with higher concentration can have higher rates of adoption because of the

Table 6A
Adoption Regressions, by Electronic Check Product
Dependent Variables: 1 If Bank Adopted Service, 0 If Not

	MICR Information	MICR Presentment	MICR Presentment Plus	Truncation	Image
Fraction of Adopters	–0.86	0.86	–0.85	1.53	0.13
	(–8.5)	(12.8)	(–5.2)	(4.6)	(1.2)
HHI	0.38	–0.60	0.50	–0.49	–0.62
	(3.1)	(–5.6)	(2.9)	(–1.2)	(–5.3)
Market Size	5E-08	–2E-08	4E-09	–8E-08	1E-08
	(4.4)	(–2.1)	(0.3)	(–2.5)	(2.3)
Multistate	0.72	–0.34	0.55	–0.89	0.63
	(13.4)	(–7.4)	(6.2)	(–3.8)	(17.0)
Market Share	–0.07	0.51	–0.52	0.26	0.15
	(–0.7)	(5.5)	(–3.4)	(0.8)	(1.5)
Distance	0.004	–0.001	–0.003	–0.006	–0.002
	(22.2)	(–10.9)	(–10.9)	(–8.5)	(–12.4)
Price	1536.0	5199.9	1943.7	1577.5	5.3
	(57.2)	(86.0)	(43.6)	(26.7)	(19.0)
Size Category Dummies?	Yes	Yes	Yes	Yes	Yes
Federal Reserve Office Dummies?	Yes	Yes	Yes	Yes	Yes
Time Dummies (Quarterly)?	Yes	Yes	Yes	Yes	Yes
Type of Depository Institution Dummies?	Yes	Yes	Yes	Yes	Yes
Number of Observations	191,460	209,161	170,092	99,706	192,639
Log Likelihood	–19,112	–25,290	–11,054	–2,955	–31,258
Pseudo R^2	0.65	0.68	0.54	0.66	0.25

Note: Logit regressions. Z-statistics in parentheses.

market power effect, even if no network externalities are present. However, if the effect of market concentration on adoption rates is positive because of banks' market power, the volume of services for banks with market power will be lower than the volume in a competitive market. That is because in a noncompetitive market, prices are higher and the equilibrium volume is lower than in a competitive market, as long as demand is somewhat inelastic. In contrast, with network externalities, the equilibrium quantity conditional on adoption increases with concentration.

One could argue that market concentration is endogenous because banks adopting a new technology could attract customers away from their competitors. New customers could select a bank based on whether the bank has or has not adopted electronic check services, while existing customers could withdraw their deposits from a bank not offering electronic payments. In that case, one could argue that market concentration depends on the adoption decision. For example, Hannan and McDowell (1990) found that large banks' adoption of ATMs increased market concentration, although that was not the case for general adoption of ATMs or for adoption by small banks.

However, switching depository institutions based on the banks' adoption of electronic check services is extremely unlikely. First, most of the electronic check services cannot be observed by bank customers, whether they are individuals or corporations. Thus, customers are not typically aware of their bank's use of such products. Second, it is unlikely that a customer would be willing to undergo a costly and cumbersome transfer of funds based on his bank's use of electronic payments, unless the use of those services affected interest rates and fees. But even if adoption influenced consumer behavior, expectations of higher profits would induce banks to adopt electronic services even if network externalities did not exist. Market concentration would still be associated with a higher likelihood of adoption, although the cause of that relationship would be different. The implication on volume would be different as well: Under the market power hypothesis, banks in more concentrated markets would have lower volumes of electronic check prod-

Table 6B
Instrumental Variable Adoption Regressions, by Electronic Check Product
Dependent Variables: 1 If Bank Adopted Service, 0 If Not

	MICR Information	MICR Presentment	MICR Presentment Plus	Truncation	Image
Fraction of Adopters	–0.04	0.00	–0.01	0.50	–0.26
	(–2.7)	(0.1)	(–0.1)	(0.9)	(–1.5)
HHI	0.0019	0.0004	–0.0001	0.0065	–0.0003
	(1.0)	(0.1)	(–0.1)	(1.2)	(–0.1)
Market Size	–2E-10	–1E-11	3E-12	1E-10	–5E-10
	(–0.9)	(–0.0)	(0.0)	(0.6)	(–1.1)
Multistate	0.003	–0.001	0.001	–0.002	0.002
	(0.3)	(–0.1)	(0.1)	(–0.1)	(0.1)
Market Share	0.0005	–0.0004	0.0000	0.0023	0.0032
	(0.3)	(–0.2)	(0.0)	(0.6)	(1.1)
Distance	–0.000035	–0.000023	–0.000053	–0.000004	0.000024
	(–15.2)	(–7.5)	(–20.4)	(–2.3)	(6.8)
Price	14.0	114.0	30.9	9.0	0.1
	(63.8)	(184.5)	(98.3)	(32.3)	(6.5)
Size Category Dummies?	No	No	No	No	No
Federal Reserve Office Dummies?	No	No	No	No	No
Time Dummies (Quarterly)?	Yes	Yes	Yes	Yes	Yes
Type of Depository Institution Dummies?	No	No	No	No	No
Number of Observations	214,744	214,744	214,744	214,744	214,744
Wald Chi-square	57,242.2	104,995.4	14,465.3	11,792.5	10,433.5

Note: Fixed-effects linear probability model regressions. Z-statistics in parentheses.

ucts, controlling for bank size. Endogeneity in this case is very unlikely.

IV. Results

Adoption

Table 6A shows the results of logit adoption regressions where the dependent variables are equal to 1 if a bank adopted a given electronic check product and 0 otherwise. In the cases of MICR Presentment, Truncation, and Image, the coefficients on the fraction of adopters in the bank's market were positive, although not statistically significant in the case of Image. Those results are consistent with the presence of network externalities in those markets and make sense—MICR Presentment and Truncation require more substantial investments in back-office technology than MICR Information, and banks may be more likely to be affected by their neighbors' adoption.

Coefficients on market concentration (HHI) did not confirm the above result, however. For services where the effect of the fraction of adopters was positive, the coefficient on HHI turned out to be negative. If network externalities were present, we would expect to find the opposite result—banks in more concentrated markets would have higher adoption rates.

The effect of market size was mixed. Controlling for bank size, institutions located in larger markets were more likely to adopt MICR Information or Image, but not the other payments methods. When interaction terms of market size and bank size were added, the coefficients on the fraction of adopters and on market concentration did not change.

Banks with branches in more than one state (multistate) had a higher probability of adopting MICR Information, MICR Presentment Plus, or Image, but a lower probability of adopting the other two types of electronic check services. The coefficient on the bank's market share was statistically significant in only two of the regressions. Contrary to expectations, the coefficient on distance from the nearest Federal Reserve office was negative in four out of five regressions. This result is surprising, given that electronic check services speed up the collection process and thus might appeal to banks located far away from processing centers.

Table 7A
Volume Regressions, by Electronic Check Product
Dependent Variables: Quarterly Volume for Each Bank by Product

	MICR Information	MICR Presentment	MICR Presentment Plus	Truncation	Image
Fraction of Adopters	–7147.91	1534.63	1012.15	22059.05	2327.40
	(–5.2)	(0.9)	(2.2)	(13.6)	(2.0)
HHI	–28425.40	–47374.27	–2075.92	154.44	–6446.01
	(–19.4)	(–20.5)	(–6.5)	(0.3)	(–6.2)
Market Size	2E-03	4E-03	2E-04	3E-04	2E-03
	(18.8)	(18.3)	(5.4)	(4.8)	(18.9)
Market Share	28623.41	59631.81	2293.73	1152.59	7609.60
	(22.3)	(29.5)	(8.3)	(2.2)	(8.4)
Size Category Dummies?	No	No	No	No	No
Federal Reserve Office Dummies?	No	No	No	No	No
Time Dummies (Quarterly)?	Yes	Yes	Yes	Yes	Yes
Type of Depository Institution Dummies?	No	No	No	No	No
Number of Observations	216,210	216,210	216,210	216,210	216,210
F-Statistic	101.5	129.1	12.0	28.4	45.5

Note: Fixed-effects regressions. t-statistics are given in parentheses.

Because more remotely located markets tend to have higher rates of market concentration, the effect could have been picked up by other coefficients.

To control for exogenous bank-level factors, we included dummy variables for 11 asset size categories, Federal Reserve offices, quarters, and type of depository institution (that is, commercial bank, credit union, or thrift).

The negative coefficients on the fraction of adopters of MICR Information and MICR Presentment Plus are puzzling. To validate those results, we employed instrumental variable (IV) estimation. If the fraction of adopters is correlated with the error term, the original results are biased. We use exogenous characteristics of other banks in the market as instruments. In particular, a bank's size can be expected to affect its own decision whether or not to adopt a given service. Thus, other banks' sizes will influence their adoption decisions. However, other banks' sizes will not directly affect the bank's decision whether or not to adopt, and thus will not be correlated with the error term ε. We use the average assets of all banks located in the same market as instruments. Two measures are applied: one with the bank in question included in the mean and the other with the bank omitted.

The results of the IV estimation are in Table 6B. The IV estimation produced insignificant coefficients on the fraction of adopters and on HHI. We therefore cannot find evidence for network externalities using either the clustering or the market concentration test. Because we could not use instrumental variable estimation in logit, those equations were estimated using a linear probability model.

Volume

Table 7A shows the results of regressions of each bank's quarterly volume of electronic check services. We applied fixed-effects estimation, thus controlling for any institution- or area-specific factors that may affect usage of those services. As in the previous set of regressions, quarterly time dummies were included. Coefficients on the fraction of adopters are positive for four out of the five services: the higher the fraction of other banks in the market that adopt each electronic check service, the higher the volume of that service the bank uses. As was the case in the adoption regressions above, the effect of market concentration was negative in most cases, contrary to what we would expect to see in markets characterized by network externalities. Banks with higher market share and those located in larger markets were found to have higher volumes of each type of electronic check product.

The results are consistent with the market power explanation for adoption rather than with network externalities. We find that the volume of electronic check

Table 7B
Instrumental Variable Volume Regressions, by Electronic Check Product
Dependent Variables: Quarterly Volume for Each Bank by Product

	MICR Information	MICR Presentment	MICR Presentment Plus	Truncation	Image
Fraction of Adopters	–264,294.3	–251,577.4	–73,878.0	216,643.4	–388,605.6
	(–20.5)	(–12.8)	(–5.7)	(1.0)	(–4.7)
HHI	–17,516.8	–27,109.1	–2,318.5	2,141.0	–6,234.2
	(–10.4)	(–9.3)	(–6.8)	(0.9)	(–4.8)
Market Size	1E-03	3E-03	9E-05	3E-04	1E-03
	(9.6)	(11.8)	(2.7)	(4.3)	(5.7)
Market Share	30,228.0	60,531.6	2,462.9	2,364.2	10,972.2
	(21.7)	(28.2)	(8.3)	(1.6)	(8.2)
Size Category Dummies?	No	No	No	No	No
Federal Reserve Office Dummies?	No	No	No	No	No
Time Dummies (Quarterly)?	Yes	Yes	Yes	Yes	Yes
Type of Depository Institution Dummies?	No	No	No	No	No
Number of Observations	215,893	215,893	215,893	215,893	215,893
Wald Chi-square	4801.4	7215.9	2963.5	1205.6	1525.9

Note: Fixed-effects regressions. t-statistics are given in parentheses.

services decreases with HHI, consistent with the idea that any positive effects of HHI on adoption are caused by market power, and not by network externalities.

As in the case of adoption regressions above, we applied instrumental variable estimation, where the average assets of other banks was used as an instrument for the fraction of adopters in the bank's market. Those results are in Table 7B. We could not find any evidence for network externalities with the instrumental variable method. The coefficients on the fraction of adopters became negative or statistically insignificant. The negative coefficient estimates on HHI are consistent with banks' market power, but not with network externalities. We therefore confirm that there is no evidence for network externalities in electronic check services.

Robustness Tests

We performed several robustness tests of the above results. Figure 1 shows that as market concentration increases, the rates of adoption of electronic check services either stay fairly constant or increase up to an HHI of 0.8. For the highly concentrated markets—with HHI above 0.8—adoption rates change substantially. We looked more closely at the institutions located in these markets. As can be expected, they are predominantly small banks located in small, non-MSA counties (see Table 8). Markets where the HHI ranged from 0.9 to 1.0 had an average population of 3,270.

Despite these differences, omitting institutions located in the most concentrated markets did not alter either the adoption or the volume regressions. While the coefficients changed slightly, none of the results changed substantially.

Because banks could adopt a technology in response to other institutions' past adoption, we estimated (1) and (2) using other banks' lagged adoption. The results remained qualitatively the same as when concurrent adoption was used in the regressions. In another specification, we altered the market definition and used counties instead of the mix of MSAs and non-MSA counties. Other specifications included omitting HHI to test whether that omission affects the estimated coefficients on the fraction of adopters, and including various ways to control for bank size, such as assets and deposits squared. Again, all of the results remained qualitatively the same.

V. Conclusion

We used data on individual banks' use of Federal Reserve electronic check services to test whether network externalities exist in those markets. We applied

two tests for the presence of network externalities developed by Gowrisankaran and Stavins (2002): a clustering test and a market concentration test. If network externalities exist, depository institutions are more likely to adopt a given payments technology the more other banks in their market adopt it, resulting in clusters of banks using that service, either because of the spread of information or because end users in some areas are more likely to use such services than end users elsewhere.

Table 8
Market Population, Assets, and Deposits by HHI

HHI Range	Population	Assets	Deposits
		Thousands of Dollars	
0.0–0.1	6,694,797	181,035	128,699
0.1–0.2	1,010,288	94,893	66,251
0.2–0.3	122,022	79,090	61,423
0.3–0.4	136,361	60,541	47,332
0.4–0.5	385,605	120,980	88,837
0.5–0.6	38,680	48,193	39,689
0.6–0.7	10,885	48,280	40,192
0.7–0.8	51,281	58,429	47,746
0.8–0.9	10,511	49,497	41,721
0.9–1.0	3,270	26,451	22,600

For some types of electronic check services, we found that the larger the fraction of banks in a market adopting a service, the more likely it is that another bank in that market will adopt it, and the higher will be the volume that the bank processes, indicating that network externalities may be present. However, those coefficient estimates become insignificant when instrumental variable estimation is used, indicating that the fraction of other adopters may be correlated with the error term in the initial model.

The second test relies on the notion that in the presence of network externalities, a bank in a more concentrated market is more likely to internalize the externality and adopt the technology than a bank located in a more competitive market. We included the Herfindahl-Hirshman Index of market concentration to test for the presence of network externalities in electronic check payments. The results did not confirm the network effects found in the first test, and thus we cannot find any evidence for network externalities in electronic check services.

As a result of network externalities, a service may be underutilized relative to the socially optimal level. Because we do not find any evidence that network externalities exist, our results do not support a view that electronic check services are underutilized relative to their socially optimal levels.

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