Regulating Competing Payment Networks

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March 4, 2024

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Abstract

Payment markets are two-sided. Networks like Visa and Mastercard charge merchant fees to fund consumer rewards. I study how regulation, private entry, and public entry in this market affect prices, distribution, and welfare in equilibrium. I model two-sided multi-homing, retail price-setting, and network competition. I estimate the model by matching data on consumers' card holdings, merchant acceptance, network pricing, and the effects of debit reward reductions. The estimated model matches external evidence on networks' costs, merchants' margins, and the effects of AmEx's 2016–2019 cuts in merchant fees. Using the estimated model, I compare the effects of capping credit card merchant fees, increasing entry of private credit card networks, and introducing a low-fee public option like FedNow. Capping credit card merchant fees is progressive and increases annual welfare by reducing rewards, retail prices, and credit card use. However, because consumer adoption is ten times more price-sensitive than merchant acceptance, competition from private networks like Discover or Buy Now Pay Later services like Affirm raises rewards without lowering fees, lowering welfare. A public option struggles to gain consumer adoption without rewards, limiting welfare gains.

*Wang: Kellogg School of Management. Email: lulu.wang@kellogg.northwestern.edu. This is a revised version of my job market paper. I am extremely grateful to my advisors, Amit Seru, Darrell Duffie, Ali Yurukoglu, and Claudia Robles-Garcia. I thank Lanier Benkard, Liran Einav, Matthew Gentzkow, Joseph Hall, Ben Hebert, Gregor Matvos, my discussants Alex Shcherbakov and Devesh Raval, and seminar audiences at Stanford, MIT Sloan, USC Marshall, Princeton, Columbia, NYU Stern, Duke Fuqua, Chicago Booth, Yale SOM, Wharton, Imperial College London, Kellogg, and Harvard Business School for helpful comments. Juliane Begenau, Lanier Benkard, Matteo Benetton, Greg Buchak, Jacob Conway, José Ignacio Cuesta, Liran Einav, Wesley Hartmann, Arvind Krishnamurthy, Hanno Lustig, Max Miller, Peter Reiss, Jean-Charles Rochet, Nishant Vats I acknowledge support from the National Science Foundation Graduate Research Fellowship under Grant Number 1656518. Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

Section I Introduction

Payment markets are hard to regulate because they are two-sided. Merchants in the U.S. pay $120 billion per year in fees to accept cards, but consumers receive around $50 billion per year in rewards (Agarwal et al., 2015; Nilson, 2020b). The theoretical literature shows that two-sidedness can reverse many of our usual intuitions about the desirability of regulation and competition. Capping merchant fees at marginal cost can deprive networks of the revenue to fund socially desirable rewards (Rochet and Tirole, 2003). When consumers are reward-sensitive, but merchants are fee-insensitive, competition can lead to higher fees and lower welfare (Edelman and Wright, 2015). In the absence of empirical evidence on the subject, European and Australian regulators cap merchant fees, whereas U.S. regulators encourage entry (Read et al., 2020; Federal Reserve, 2022). Despite the diversity in regulatory strategies, little is known about their relative merits.

I quantify how merchant fee caps and network competition affect prices and welfare in U.S. consumer-to-business payments. The central contribution is a quantitative model of how payment networks compete in merchant fees and consumer rewards. Data on bank payment volumes, consumer card holdings, and merchant card acceptance data provide reduced-form evidence that consumer adoption is reward-sensitive, whereas merchant acceptance is fee-insensitive. I estimate a model of consumer adoption and merchant acceptance, retail pricing, and network competition. With the estimated model, I simulate how regulation and competition affect prices, distribution, and welfare.

I estimate large distributional and total welfare gains from changing how the U.S. regulates merchant fees, whereas encouraging competition through entry can be harmful. Two regulatory changes — capping credit card merchant fees at 1% and repealing the Durbin Amendment's caps on debit card merchant fees — are progressive and raise total annual welfare by $29 and $7 billion, respectively. In contrast, private entry reduces welfare by $4 billion, and a low-fee government entrant like FedNow creates only small benefits of $2 billion.

The key to explaining the effects of these policies is that reducing credit card use is both progressive and welfare-increasing. Capping credit card merchant fees and repealing Durbin both reduce credit card use. In contrast, more competition encourages credit card networks to raise rewards without large fee cuts, which increases credit card use. Moreover, new low-fee public sector entrants do not offer competitive rewards, which limits consumer adoption and welfare gains.

The central friction behind my price and welfare results is price coherence. Even though cash discounts and card surcharges are legal, merchants in the U.S. typically charge consumers the same price for different payment methods (Stavins, 2018).[1] Price coherence incentivizes networks to charge high merchant fees to fund consumer rewards. In doing so, networks' consumers benefit from the full increase in rewards but only bear part of the cost of higher retail prices (Levitin, 2005). This is both regressive and wasteful. When merchants pass on merchant fees into higher retail prices, lower-income cash and debit card users fund credit card users' rewards (Felt et al., 2020).[2] In equilibrium, too many consumers use credit cards because they do not internalize the effect of their credit card use on retail prices (Edelman and Wright, 2015). Even if consumers collectively prefer a world of low retail prices and credit card use, they individually prefer to use credit cards to earn rewards. Price coherence means that policies that reduce credit card use are both progressive and welfare-enhancing.

To motivate the importance of two-sided competition in payments, I document three reduced-form facts to illustrate how consumer adoption is reward-sensitive, but merchant acceptance should be fee-insensitive. Thus, networks face incentives to charge high merchant fees to fund generous consumer rewards. First, I use a bank-level panel of payment volumes to show that the 25 basis point reduction in debit rewards after the 2010 Durbin Amendment caused debit card spending to decline by 30%. Second, I use the positive correlation between consumers' payment and shopping behavior in the Diaries of Consumer Payment Choice to show that card acceptance increases sales by around 30% for the average merchant. Third, I use Homescan data and find that not all consumers carry cards from multiple networks. Merchants risk large declines in sales when they decline consumers' preferred payment methods. Networks thus compete primarily for consumers, not merchants.

To quantify the equilibrium implications of these reduced-form facts, I develop a structural model in which payment networks compete in merchant fees and consumer rewards. I model three kinds of players: consumers, merchants, and payment networks. Consumers choose up to two cards to put in their wallets and where to shop.[3] Consumers prefer cards that pay high rewards and that are widely accepted. They buy more from merchants that set low prices and accept the consumers' cards. Merchants choose the subset of payment methods to accept and pass on merchant fees into higher retail prices for all consumers. In deciding whether to accept a card, merchants trade off the

[1] I explore surcharging both theoretically and empirically in Appendix C.

[2] While the cross-subsidies that I identify resemble those transfers from naifs to sophisticates in Gabaix and Laibson (2006) or Agarwal et al. (2022), the policy implications are different. Whereas disclosure helps in models of shrouding, no information intervention would help cash and debit users in my model.

[3] Even though consumers in the model have no incentive to carry cards from multiple networks, many consumers in the data carry credit cards from multiple networks. In Appendix D, I derive a dynamic micro-foundation that rationalizes consumers' card holdings in a manner consistent with the model.

incremental benefits from higher sales against the incremental cost of merchant fees. Multiproduct networks compete by adjusting rewards and fees to balance consumer adoption with merchant acceptance.

I go beyond existing theoretical work by combining consumer multi-homing, merchant heterogeneity, and merchant competition. Edelman and Wright (2015) show that platform competition hurts consumers but assume that consumers carry only one card at a time (single-home). This locks consumers into cards before they arrive at the store and prevents merchants from steering consumers between cards by declining high-fee cards. In such models, competition necessarily raises merchant fees (Armstrong, 2006) and lowers welfare. Rochet and Tirole (2011) compare profit-maximizing and socially optimal interchange fees but assume homogenous merchants. This lets monopoly networks charge the highest possible merchant fee consistent with card acceptance. In models of homogenous merchants, network competition then necessarily lowers merchant fees (Guthrie and Wright, 2007; Anderson et al., 2018; Gentzkow et al., 2022). Rochet and Tirole (2003); Teh et al. (2022) are flexible models of platform competition that capture consumer multi-homing and merchant heterogeneity but ignore merchant competition. Their models, therefore, understate networks' incentives to charge merchant fees to fund rewards (Wright, 2012) and ignore how merchant fees redistribute consumption among consumers. By combining consumer multi-homing, merchant heterogeneity, and merchant competition, my model is flexible enough to examine how competition affects welfare in payments empirically.

I estimate the model by matching the reduced-form facts and aggregate data on merchant fees, rewards, and market shares. The estimation recovers how consumer adoption responds to rewards and merchant acceptance responds to fees. The strong negative effect of the Durbin Amendment on debit card spending pins down consumers' high reward sensitivity. The high equilibrium level of merchant fees pins down merchants' low fee sensitivity. Merchants must be fee-insensitive to rationalize why networks levy such large taxes on merchants to subsidize consumers.

My estimated reward and fee sensitivities suggest that consumers are ten times more sensitive to rewards than merchants are sensitive to fees. A one-basis-point (1-bp) increase in Visa credit rewards increases Visa credit's market share among consumers by 3%. In contrast, a 1-bp increase in merchant fees for Visa credit cards causes only a 0.3% decline in the share of merchants that accept Visa credit. This large difference in price sensitivities is consistent with many out-of-sample moments, including the effects of American Express's fee cuts on merchant acceptance, the effect of Durbin on credit card volumes, accounting data on costs, and merchant margins.

In my main counterfactual, I cap Visa and Mastercard credit card merchant fees to 1%. Fee caps are common globally and approximate the effects of other important regulatory changes such as mandating dual routing or repealing anti-steering provisions (Zenger, 2011; Durbin, 2023). Such a policy would reduce credit card use, be progressive, and increase welfare. Lower merchant fees pass through to a 69 bp decline in credit card rewards. Reduced credit card use creates a progressive transfer by lowering retail prices by 61 bps. The decline in retail prices benefits cash and debit card users, who tend to have lower incomes. Lower credit card use ultimately increases annual consumer and total welfare by $39 billion and $29 billion, respectively. For context, the CARD Act was a major piece of credit card legislation that was estimated to have increased consumer welfare by around $12 billion/year (Agarwal et al., 2015). Thus, the gains from regulating networks are at least as large as the gains from regulating issuers.

Welfare rises because consumers dislike the non-price characteristics of credit cards, a phenomenon I call "credit aversion." I infer this from revealed preference: many debit card consumers have access to a credit card but choose not to pay with it.[4] Credit aversion means too many consumers use credit cards. The marginal consumer who uses credit instead of debit bears credit aversion to earn rewards. But while credit aversion is a social cost, the rewards are merely transfers funded by higher retail prices. Caps on credit card merchant fees raise total welfare by reducing credit card rewards, credit card use, and credit aversion.

The same logic justifying caps on credit card merchant fees suggests that the Durbin Amendment's caps on debit card merchant fees were regressive and reduced total welfare by $7 billion/year. By cutting debit merchant fees, the policy eliminated debit rewards, increased credit card use, and reduced welfare.

In contrast to the large gains from improved price regulation, more credit card network entry is regressive and welfare-reducing. Consumers are reward-sensitive, whereas merchants are fee-insensitive. Therefore, more competition among credit card networks generates higher rewards without pushing down merchant fees. This then exacerbates the excessive use of credit cards. For example, if Discover became as large as American Express, total welfare falls by $4 billion even before accounting for fixed entry costs. The two-sidedness of payments reverses the usual one-sided intuition that competition brings down prices and increases welfare in concentrated markets.

While the above counterfactual studies the entry of a private network, my model also predicts that a low-cost, government-run payment network, like FedNow, would

[4] Appendix E presents evidence on credit aversion. It could reflect fears of overspending, higher adoption costs, or costs to avoid shrouded interest payments (Gabaix and Laibson, 2006).

only create $2 billion of benefits. These gains are smaller than the gains from repealing the Durbin Amendment. In response to entry, incumbent credit card networks raise merchant fees to fund more rewards. In equilibrium, FedNow steals market share mostly from debit cards, with muted effects on aggregate retail prices and welfare.

More broadly, my paper suggests that platform competition under price coherence can be harmful. For example, search engines like Google charge merchants high advertising prices while investing in consumer benefits. As in payments, competition can lead platforms to invest more in benefits and to fund these investments with even higher advertising prices. I show how variation on one side of the market can help identify demand on both sides, enabling an empirical study of platform competition.

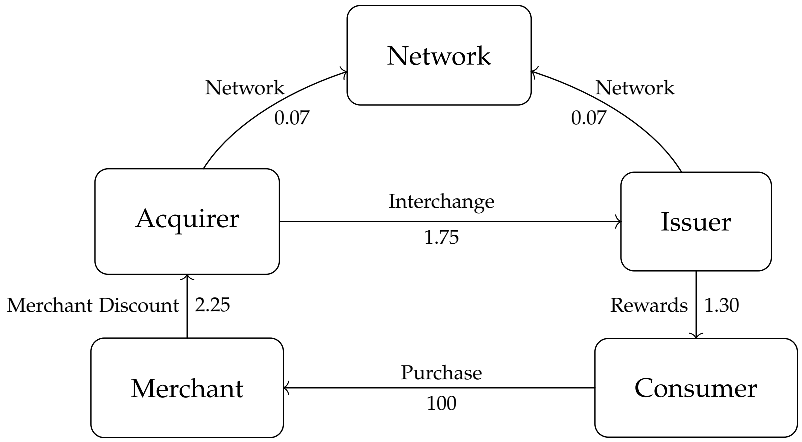
I.A Related Literature

My paper primarily contributes to the industrial organization literature on two-sided markets by estimating a quantitative model of platform competition with variation from natural experiments (Rysman, 2004; Lee, 2013). New theoretical work emphasizes that the effects of platform competition depend crucially on whether consumers single or multi-home (Anderson et al., 2018; Bakos and Halaburda, 2020; Gentzkow et al., 2022). By modeling a mix of single and multi-homing consumers, I provide a more realistic model of platforms' pricing incentives compared to the existing empirical literature (Rosaia, 2020; Song, 2021; Sullivan, 2022).

The closest related empirical work is Huynh, Nicholls and Shcherbakov (2022), who also estimate a structural two-sided model of consumer and merchant card adoption. I build on their work by modeling merchant and network competition. Merchant competition lets me capture how credit card rewards inflate retail prices, redistribute consumption, and ultimately hurt consumers. Network competition lets me endogenize merchant fees and consumer rewards, enabling an assessment of how price controls and competition affect prices and total welfare.

I also contribute to a growing literature on the industrial organization of financial markets. Important examples include models of imperfect competition in deposit banking (Egan et al., 2017; Honka et al., 2017), mortgages (Allen et al., 2014; Buchak et al., 2020; Benetton, 2021; Robles-Garcia, 2022), credit cards (Nelson, 2020; Cuesta and Sepulveda, 2021), and insurance (Cohen and Einav, 2007; Koijen and Yogo, 2015). My contribution is to take a structural approach to a two-sided market of payments.

Figure 1: Illustration of payment flows in a payment network.



Notes: Prices are meant to capture typical fees paid. The merchant discount fee comes from Nilson (2020b). The average network fee comes from example rate sheets from acquirers and from dividing the non-foreign exchange fees from Visa's 10k by the total payment volumes (Visa, 2020; Helcim, 2021). I split the network fees evenly between the two sides as in (Federal Reserve, 2010). The interchange is derived from Visa's interchange schedule for a Visa Signature card at a large retailer (Visa, 2019). The rewards are from Agarwal et al. (2018), with a fraud adjustment from Nilson (2020a).

Section II Institutional Details and Data

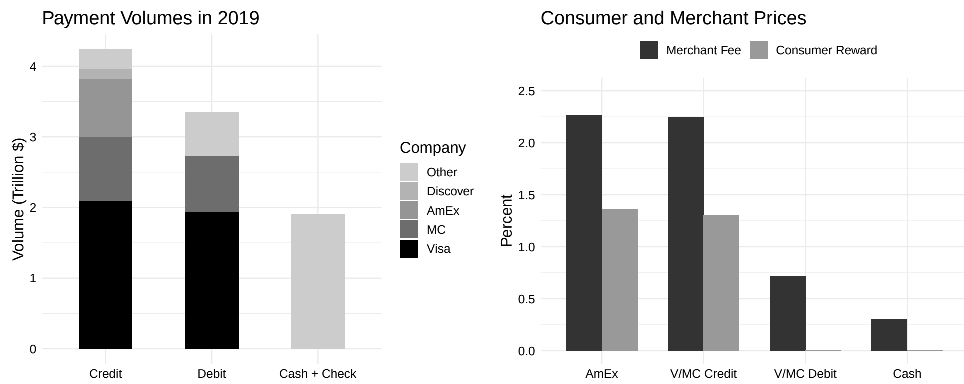
II.A Network Pricing: Merchant Fees and Consumer Rewards

Payment markets are two-sided. With every card swipe, the merchant pays a fee, and the consumer may receive a reward. Payment networks compete with each other by adjusting these fees and rewards. While AmEx sets merchant fees and consumer rewards directly, "open-loop" networks like Visa and MC influence merchant and consumer prices by adjusting the *interchange fee* and *network fee*.

Visa and MC connect four types of players: merchants, merchants' banks (acquirers), consumers' banks (issuers), and consumers (Benson et al., 2017). Figure 1 illustrates the typical flow of money between these players. When a consumer uses her credit card to buy $100 of product at a large retailer, the merchant pays a $2.25 merchant discount fee to her acquiring bank to process the transaction. The acquirer can be a bank like Wells Fargo or a fintech player like Square. The acquirer will use some of that fee to cover its costs but must also send $1.75 to the issuing bank (e.g., Chase) in the form of interchange. The issuer and the acquirer collectively then pay around $0.14 in network fees to Visa. While some of the $1.75 covers the issuer's costs, a large part is returned to the consumer as a reward. On average, for a credit card, the rebate is $1.30.

Regulatory shocks are the best evidence for how interchange strongly affects merchant fees and rewards while having limited effects on borrowing. When the E.U. and Australia mandated interchange fee reductions, merchant fees declined roughly one-for-one (Gans, 2007; Valverde et al., 2016; European Commission, 2020). Appendix Figure

Figure 2: Aggregate payment volumes, merchant fees, and consumer rewards



Notes: The left chart shows payment volumes measured in trillions from Nilson (2020c,d). Visa and MC own credit and debit cards, whereas AmEx primarily offers credit and charge cards. Discover is much smaller than the other three networks. The right chart shows merchant fees from Nilson (2020b) and V/MC rewards from Agarwal et al. (2018). I calculate AmEx's reward from its 2019 10-K. Debit cards no longer offer rewards checking in the wake of Durbin (Hayashi, 2012). The cost of cash is from Felt et al. (2020)

H.1 shows that after credit card interchange was capped in Australia, rewards fell, annual fees on rewards credit cards rose, whereas annual fees on non-reward credit cards and interest rates were left unchanged.

II.B Data

I combine bank-level and aggregate data from a payments trade journal, the Nilson Report, with consumer-level data from the Nielsen Homescan panel and the Federal Reserve's Diaries and Surveys of Consumer Payment Choice. These data let me estimate consumer and merchant demand for payments.

Aggregate Prices and Shares: I use aggregate shares and prices derived from the Nilson Report and the portfolio-level data on rewards from Agarwal et al. (2018). Figure 2 documents payment volumes, merchant fees, and rewards. Visa, Mastercard (MC), and American Express (AmEx) process 85% of all card payments. All three major credit card networks charge similar merchant fees of around 2.25%, whereas the debit networks charge around 0.72% due to the Durbin Amendment. I use these aggregate prices and shares to estimate consumer preferences, the network cost parameters, and merchants' fee sensitivity.

Issuer Payment Volumes: I construct an annual panel of issuer payment volumes from the Nilson Report. I use this panel to study the effects of the Durbin Amendment on payment volumes. My main difference-in-difference analysis focuses on a subset of 36 issuers, 16 of them above $10 billion in assets and 20 below. My sample excludes issuers that made large acquisitions exceeding 50% of equity or large credit card portfolio

Table 1: Summary statistics for different consumer types in the payment diary sample.

	Cash	Debit, Low Credit Share	Debit, High Credit Share	Credit
Share	0.25	0.20	0.21	0.34
Owns credit card	0.68	0.61	1.00	1.00
Owns rewards credit card	0.45	0.32	0.76	0.85
Owns bank account	0.87	1.00	1.00	0.99
Credit utilization	0.22	0.32	0.26	0.10
Household income (000's)	61.25	67.48	86.05	112.88
Debit share	0.29	0.73	0.55	0.14
Credit share	0.17	0.01	0.26	0.66
Card acceptance	0.96	0.98	0.98	0.97
Credit score > 650	0.66	0.60	0.81	0.96

Notes: Consumers are split into four groups: those who prefer to use cash as their main non-bill payment instrument, those who prefer debit but have a below-median utilization of credit cards (relative to all debit card users), those who prefer debit but have an above-median utilization of credit cards, and those who prefer credit cards. The share variable reports the share of the sample in each column. Card acceptance is the expenditure share in each group at merchants that accept cards. All other variables report averages across consumers for each group. Credit share and debit share are shares of transactions on credit cards and debit cards, respectively.

acquisitions. Appendix Table G.1 reports the main summary statistics for this sample.

Consumer Payment Surveys: I combine the Atlanta Federal Reserve's Diary of Consumer Payment Choice (DCPC) and Survey of Consumer Payment Choice (SCPC) to build a transaction-level dataset on consumers' payment choices over three-day windows. I use the data from the 2015–2020 waves of both surveys. To study credit versus debit acceptance, I also use data from the 2008–2014 waves of the SCPC. These data help me estimate merchants' benefits from payment acceptance. Table 1 shows summary statistics on consumers' payment preferences. Debit is the most popular payment instrument, followed by credit and cash. Most consumers in the sample are banked and have access to credit cards. Most spending is at merchants that accept cards.

Homescan: The Nielsen Homescan panel tracks the payment decisions of around $90,000$ households at large consumer packaged goods stores. I use this to build measures of consumers' first and second choices over payment methods, which feeds into estimating substitution patterns. Appendix Table G.2 reports the main summary statistics at the household-year level. Appendix Table G.3 shows that Homescan slightly overrepresents cash and debit transactions while underrepresenting American Express.

Section III Reduced-Form Facts

The reduced-form facts show that consumers are reward-sensitive, but merchants should be fee-insensitive. Networks, therefore, face strong incentives to charge high merchant fees to fund generous consumer rewards. Any model of merchant fees must then capture how networks compete in a two-sided manner.

III.A Consumer Substitution Between Credit and Debit

The Durbin Amendment reduced debit interchange rates, led issuers to cut debit rewards, and led to a large reallocation of spending from debit to credit. Consumer choice between debit and credit is thus sensitive to rewards.

The Durbin Amendment was part of the 2010 Dodd-Frank Act. It reduced debit interchange fees at large banks and credit unions with more than \$10 billion in assets by around half (Mukharlyamov and Sarin, 2022). Credit interchange was unaffected. By reducing issuers' income from debit card spending, this law led large issuers to end debit rewards (Hayashi, 2012; Schneider and Borra, 2015). In contrast, small issuers kept paying rewards (Orem, 2016).

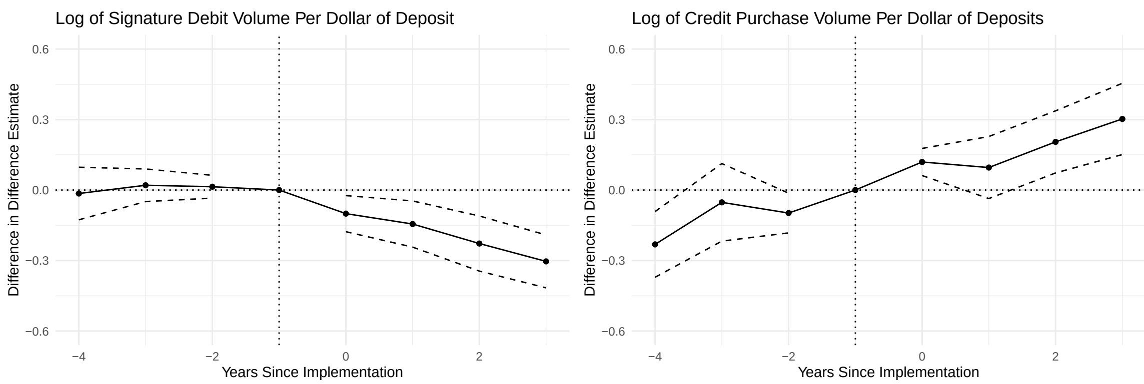
I use a difference-in-differences approach that compares payment volumes at large and small issuers to estimate the effect of changes in rewards on payment volumes. I define large issuers as those with between \$10 and \$200 billion in assets and small issuers as those with between \$2.5 and \$10 billion in assets. By focusing on this range of asset values, I exclude systemically important issuers like Chase that were subject to other new regulations. Although I use a similar research design as Kay et al. (2018); Mukharlyamov and Sarin (2022), I focus on payment volumes, not fee income. This yields a causal estimate of how rewards affect payment volumes. I estimate:

$$y_{it} = \sum_{k=-3}^{3} \beta_k I\left\{t = k\right\} \times \text{Treated}_i + \delta_i + \delta_t + \epsilon_{it} \tag{1}$$

where y_{it} is the logarithm of signature debit or credit card payment volumes per dollar of deposits at issuer i. Treated_i refers to whether issuer i had more than \$10 billion in assets in 2010, and δ_i and δ_t represent issuer and year fixed effects, respectively. By comparing large and small issuers, I can difference out the effects of the Durbin routing requirements, the CARD Act, and potential changes in merchant acceptance on debit and credit card use. I define $t = 0$ as 2011.

The regressions suggest that consumers are sensitive to rewards. Using the Wayback machine, I confirm Hayashi (2009)'s estimates that the average pre-Durbin debit rewards

Figure 3: The effect of the Durbin Amendment on debit, credit card volumes.



Notes: Data are from the Nilson Report. The vertical line marks the year before the policy announcement. The policy started in Q3 2011 and went into full effect in year 2012, which is at $t = 1$. Standard errors are clustered at the issuer level.

program paid consumers around 25 bps of transaction value. Reduced rewards led to a 30% decline in signature debit volumes and 30% increase in credit card volumes. Figure 3 and Appendix Table G.4 show the estimation results. Volume largely shifted between cards, as I estimate overall card spending fell by a more modest 10%. [5]

III.B Merchant Benefits from Card Acceptance

The average merchant's sales increase around 30% from accepting cards. These large benefits relative to the level of fees suggest that merchant acceptance should be insensitive to higher card acceptance fees.

I exploit variation in consumer payment preferences to identify how much merchants' sales increase from card acceptance. I assume that variation in payment preferences among consumers is orthogonal to consumers' baseline preferences over merchants, conditional on observables. If card acceptance increases sales, card consumers should spend more at merchants who accept cards when compared to cash consumers.

I use a logistic regression to measure the correlation between payment and shopping preferences across consumers. Index consumers by i and transactions by t. Let y_{it} be the indicator for whether the transaction t occurred at a store that accepts cards. Let X_i be the indicator of whether the consumer prefers cards. Let δ_{it} be a vector of fixed effects

[5] The increase in credit card volumes suggests the decline in debit card volumes does not reflect large issuers shrinking after Durbin. In the Appendix, I include additional results and robustness checks. Table G.4 shows the regression estimates and validates that my estimated decline in interchange is consistent with the effect of Durbin, given that credit interchange was not affected and made up around one-third of total interchange revenue. Figure H.2 shows that deposit growth did not trend differently in the two groups. Figure H.3 shows that the pre-policy debit versus credit mix at the treatment and control issuers were similar. Figure H.4 shows that the estimates are robust to varying the minimum and maximum asset cutoffs.

Table 2: Card consumers spend more at merchants that accept cards

	No Controls	Transaction Controls	Consumer Controls	Both
Prefer Card	0.34***	0.31***	0.36***	0.28**
	(0.08)	(0.09)	(0.08)	(0.09)
N	28987	28987	28987	28987
State, year FE	X	X	X	X
Transaction controls		X		X
Consumer controls			X	X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Data are from the DCPC. Standard errors are clustered at the consumer level. Transaction controls refer to fixed effects for the ticket size and merchant type (e.g., restaurant or retail). Consumer controls refer to fixed effects for the consumer's income, education, credit score, and age.

such as the consumer's characteristics (e.g., income, education, credit score, and age) and transaction characteristics (e.g., ticket size, merchant type). I estimate:

$$y_{it} \sim \phi X_i + \delta_{it} + \epsilon_{it}. \tag{2}$$

Because most merchants accept cards, the coefficient ϕ can be interpreted as the average increase in sales experienced by the merchants who accept cards.

My preferred model includes transaction and consumer controls and suggests that the average consumer who prefers cards is around 30% more likely to shop at a store that accepts cards than a consumer who prefers cash. This average number is consistent with experimental evidence from shocks to merchant adoption. An important advantage of my approach relative to those that use quasi-random shocks to merchant adoption is that it provides an estimate of the average effect of card acceptance on sales.[6] Given the ubiquity of card acceptance in the U.S., the marginal store that adopts cards in response to a shock is unrepresentative. Table 2 shows the results with different controls. The stability of the results suggests there is little unobserved variation driving the result.[7]

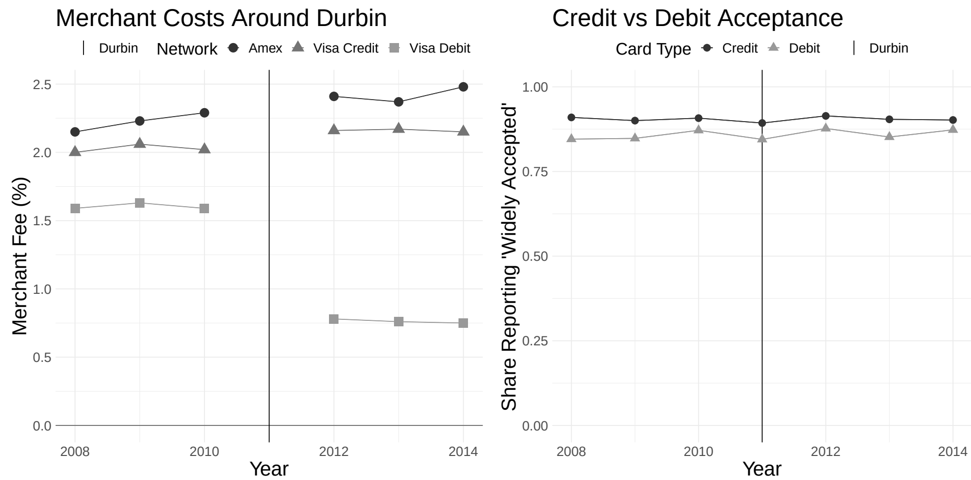
III.C Merchant Substitution Between Networks

Accepting debit cards does not substitute for accepting credit cards; accepting one credit card network is only an imperfect substitute for accepting other networks. Despite

[6]Studies that use merchant shocks in other countries and the adoption of BNPL in the U.S. find that accepting consumers' preferred payment methods can raise sales from those consumers by 10%–40% (Higgins, 2022; Berg et al., 2022; Di Maggio et al., 2022).

[7]Appendix Table G.5 shows that this effect does not vary much across debit versus credit card users, those who hold one or multiple cards, or high- or low-income respondents. Thus, I do not model consumer heterogeneity in interaction benefits, as in Ambrus and Argenziano (2009).

Figure 4: Card fees and acceptance around Durbin.



Notes: The left panel shows the change in merchant costs around the Durbin Amendment, whereas the right panel shows perceptions of credit and debit card acceptance around this time. Merchant costs come from the Nilson Report. Consumer ratings of credit and debit acceptance come from the SCPC and count the proportion of consumers in each year who rate credit and debit cards as either “usually accepted” or “almost always accepted.”

many networks, merchants may still accept high-fee networks to avoid losing sales.

I use a large change in the relative costs of debit and credit acceptance to show that merchants do not substitute between the two. Two goods are close substitutes if changes in their relative prices induce large changes in relative quantities. However, Figure 4 shows that merchants did not reduce credit card acceptance debit card merchant fees fell after Durbin. The lack of response is not the result of bundling between credit and debit cards.[8] Instead, it likely reflects that consumers who use both debit and credit cards use them for different purposes.[9]

Turning to credit cards, the extent to which consumers single-home (i.e., carry cards from one network) versus multi-home (i.e., carry cards from multiple networks) shapes the extent to which merchants can substitute between credit card networks. When every Visa consumer carries an MC and vice-versa, networks are perfect substitutes. Accepting either network serves the same consumers, and only the lowest-fee network is accepted.

[8] A 2003 settlement ended Visa’s and MC’s rules tying debit and credit acceptance (Constantine, 2012). Bundling counterfactually predicts that Visa’s credit card fees should be much higher than Amex’s. The Durbin Amendment in the U.S. means the price of debit card acceptance is below the market equilibrium price. If Visa debit and credit were bundled, Visa should raise credit card fees to extract some of the surplus from cheap debit card acceptance.

[9] The idea that consumers use debit and credit differently is why debit cards and credit cards have been treated as distinct markets in antitrust cases (Jones, 2001). Debit may not substitute for credit when consumers use the credit card for its credit function. Experimental evidence also suggests that point-of-sale incentives for debit card use do not decrease credit card use, suggesting that consumers do not substitute between credit and debit at the point of sale (Conrath, 2014)

Table 3: Conditional probabilities of each secondary card given the consumer's primary card.

	Secondary Card				
Primary Card	Cash	Debit	Visa	MC	AmEx
Debit	0.22		0.45	0.26	0.07
Visa	0.16	0.38		0.29	0.17
MC	0.13	0.29	0.45		0.13
AmEx	0.09	0.20	0.49	0.22	
Primary Card Share	0.26	0.44	0.18	0.08	0.04

Notes: Data are from Homescan. Visa, MC, and AmEx refer to their credit cards, whereas Debit refers to all debit cards. The bottom row shows the share of each column payment method among primary payment methods. The other rows show the conditional probability of the column payment method being the secondary card, conditional on the primary card being the row payment method. If a consumer only uses one type of card, the secondary "card" is defined as cash.

But if all consumers single-home, as in Edelman and Wright (2015), merchants who decline high-fee cards lose substantial sales. Merchants' fee sensitivity is not a reduced-form object and instead depends on the share of single versus multi-homing consumers.

I use the Homescan shopping data to study how consumers allocate their card spending across networks. Here, I define a network as Visa credit, MC credit, AmEx credit, or any debit card. In Appendix Table G.6, I find that consumers put around 95% of their card spending on two networks.[10] Given this fact, I characterize household-years by their primary and secondary cards, in which their primary card is the most-used network, and the secondary card is the second-most used network. If the consumer only uses one network, the secondary card is defined as cash.

Around 50% of primary credit card consumers use cards from multiple credit card networks. Table 3 shows the conditional probabilities of each secondary card given the primary card and overall shares for the different payment methods among primary cards.[11] The row for Visa shows that among consumers whose primary payment method is a Visa credit card, around 50 percent multi-home across credit card networks. I find somewhat larger shares for primary MC and AmEx users. Because the market features a mix of single-homing and multi-homing consumers, merchants have only a limited ability to substitute between credit card networks.

[10]A household that spends on five different Visa cards is treated as exclusively using Visa. The primary network typically covers around 80% of the card spending.

[11]The table excludes consumers with a high proportion of cash transactions who I characterize as primary cash users. I define the cutoff to match the share of consumers who prefer cash as their main non-bill payment instrument from the SCPC.

III.D Summarizing the Reduced-Form Facts

The large change in debit volumes in response to the Durbin Amendment suggests that consumers are willing to switch to networks with high rewards (Fact 1). Moreover, merchants' large sales benefits from card acceptance and the presence of consumers with cards from only one network suggest that merchants who reject cards from high-fee networks risk large declines in sales (Facts 2 and 3). These facts suggest that consumers are reward-sensitive, and merchants should be fee-insensitive. I now quantify the implications of these facts for network competition in a model.

Section IV Model

I develop a two-sided model of payment network competition with a mix of single and multi-homing consumers. Heterogeneous merchants accept cards to increase sales, and competition can cause networks to raise merchant fees to fund rewards. The model maps reduced-form facts into estimates of consumer and merchant preferences. Once I estimate the parameters, solving the game under different conditions lets me calculate the equilibrium price and welfare effects of competition and regulation.

IV.A Structure of the Game

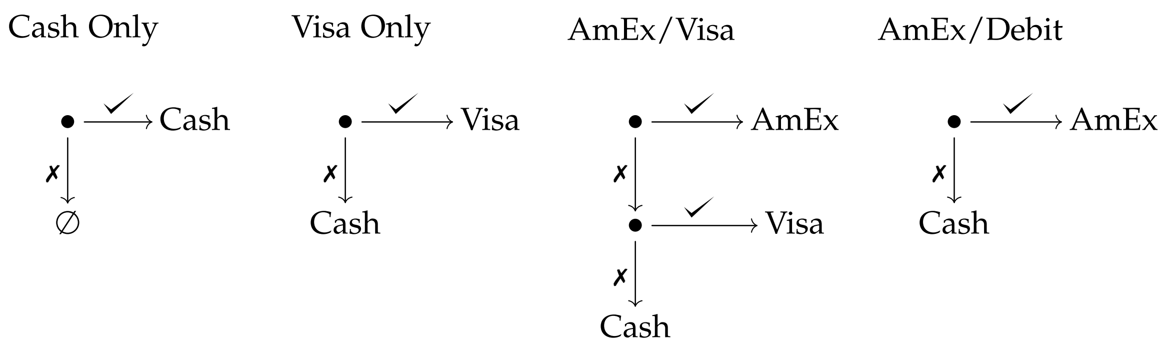
I model competition between card networks as a static game with three stages and three kinds of players: networks, consumers, and merchants.[12] I solve for a subgame perfect equilibrium of this game.

In the first stage, profit-maximizing networks set per-transaction fees for merchants and promised utility levels for consumers. In the second stage, consumers and merchants make adoption and pricing decisions.[13] Consumers choose up to two cards to put in their wallets. Merchants set retail prices and choose which cards to accept. In the third stage, consumers decide how much to consume from each merchant and pay with the cards in their wallets. Consumers vary in their preferences over payment methods. Merchants vary in how much their sales increase from card acceptance. The model makes several simplifying assumptions that I discuss in Section IV.F.

[12] Because I do not model issuers or acquirers, the Visa network should be viewed as the combination of Visa, the corporation, the issuers of Visa cards (e.g., Chase), and the acquirers who help merchants accept Visa (e.g., Square).

[13] Because merchants are infinitesimal, no one merchant's acceptance decision influences consumer adoption. In a richer model in which some firms are large, they could bargain with the networks because by joining a network, a firm can get more consumers to join the network as well. My model omits the effects of these deals on competition between retailers.

Figure 5: Illustration of how consumers choose payment methods at the point of sale.



Notes: A ✗ marks what happens when the payment method is not accepted. For example, the AmEx/Visa consumer first tries to spend on her AmEx. Only if it is not accepted does she try her Visa. If neither is accepted, she pays with cash. The AmEx/Debit consumer does not spend on her debit card because it is not the same type as her primary card. All merchants accept cash in equilibrium, so the cash-only consumer can always pay with cash. In this diagram, Visa refers to Visa credit cards.

IV.B Stage 3: Consumer Shopping and Payment

In the third stage, consumers make consumption and payment decisions.

IV.B.1 Payment Behavior at the Point of Sale

At the point of sale, consumer payment behavior is mechanical and reflects the order of the cards in their wallet.[14] Consumers first try to use their primary card. If it's not accepted, they use their secondary card if it shares the same card type as their primary card. If that is also not accepted, they pay with cash. Consumers only use the secondary card if it shares the same type as the primary card to match the evidence that merchants do not treat credit and debit card acceptance as substitutes (Section III.C). I model payment behavior mechanically because "top-of-wallet" effects are strong (Section III.C). Thus, rewards primarily influence card usage at the adoption stage.

Formally, define the set of all inside payment methods (i.e., cards) as $\mathcal{J}_1 = \{1, \ldots, J\}$, and the set of all payment methods as $\mathcal{J} = \{0\} \cup \mathcal{J}_1$, where 0 refers to cash. Each payment method has a type $\chi^j \in \{0, D, C\}$ for cash, debit, and credit.

Each consumer has a wallet w with zero, one, or two cards that have already been chosen in the second stage of the game. A wallet $w = (w_1, w_2)$ has primary and secondary payment methods, w_1 and w_2. Let $\mathcal{W}$ denote the set of all possible wallets. I define an indicator $I^w_{M,j}$ for whether a consumer with wallet w pays with j when the

[14] Consumer payment choices only reflect the order of cards in their wallet and not the merchant's identity. This is largely true, even for store cards. For example, when the AmEx-Costco exclusivity agreement ended, it was revealed that 70% of the spending on the Costco AmEx card was not at Costco (Sidel, 2015). I abstract away from how store cards may influence competition between retailers.

merchant accepts the cards $M \subset \mathcal{J}_1$. Mathematically it is:

$$I^w_{M,j} = \{w_1 = j \in M\} \vee \{w_2 = j \in M, w_1 \notin M, \chi^{w_1} = \chi^{w_2}\} \tag{3}$$

I simultaneously model cash consumers, single-homers, and multi-homers. Figure 5 shows how different types of consumers pay. A cash-only consumer's primary payment method is cash, $w_1 = 0$. A single-homing Visa consumer has $w_1 =$ Visa but $w_2 =$ Cash. An AmEx/Visa multi-homing consumer has $w_1 =$ AmEx, $w_2 =$ Visa. The AmEx/Debit consumer pays with AmEx or cash, skipping over the debit card. This occurs because AmEx and debit are different types χ.[15]

IV.B.2 Consumption Decisions Over Merchants

Consumers value both card acceptance and low prices. Card acceptance raises sales by γ percent from card consumers, where $\gamma \sim G$ varies across merchants. A low γ firm may be a small business with loyal customers for whom the payment method is unimportant. A high γ firm may be an e-commerce firm that benefits from significantly higher sales if the checkout process is convenient.[16] When heterogeneous merchants accept cards to increase sales, platform competition can increase merchant fees and lower welfare (Guthrie and Wright, 2007; Wright, 2012).

I use a constant-elasticity of substitution (CES) demand curve to capture both preferences. Suppose that all other merchants charge prices $p^*(\gamma)$ and accept payment methods $M^*(\gamma) \subset \mathcal{J}_1$. Suppose a given merchant of type γ sets a price p and accepts payment methods $M \subset \mathcal{J}_1$. Then a consumer with wallet $w = (w_1, w_2)$ and income y^w buys q^w, where:

$$\begin{aligned} q^w(\gamma, p, M, y^w, P^w) &= (1 + \gamma v^w_M)\, p^{-\sigma} \frac{y^w}{(P^w)^{1-\sigma}} \\ (P^w)^{1-\sigma} &= \int \left(1 + \gamma v^w_{M^*(\gamma)}\right) p^*(\gamma)^{1-\sigma}\ \mathrm{d}G(\gamma) \\ v^w_M &= I^w_{M,w_1} + I^w_{M,w_2} \end{aligned} \tag{4}$$

The variable $v^w_M = 1$ provided the consumer pays with either her primary or secondary card and is zero if she pays with cash. Consumers who multi-home across credit card

[15]I model AmEx/Debit consumers even though they don't use Debit because they help me identify consumer preferences for AmEx versus debit at the consumer adoption stage of the model.

[16]I model one dimension of heterogeneity because variation in payment acceptance is typically vertical: some merchants in the U.S. are cash-only, others accept Visa and Mastercard, and others accept all three. This contrasts with the case of food delivery studied in Sullivan (2022).

networks buy the same amount if either of their cards is accepted.[17] The price index P^w summarizes the influence of other merchants' actions. Rewards are lump-sum and do not affect relative consumption choices across merchants.[18] In Appendix A.1, I micro-found this demand function as the solution to a consumer problem with CES utility in which payment acceptance increases product quality through convenience, and rewards increase income.

In equilibrium, consumers optimally buy $q^{w*}(\gamma)$ from each merchant type γ, given all merchants' equilibrium pricing p^* and adoption M^* decisions:

$$q^w\left(\gamma, p^*\left(\gamma\right), M^*\left(\gamma\right), y^w, P^w\right) = q^{w*}\left(\gamma\right) \tag{5}$$

IV.C Stage 2: Pricing, Acceptance, and Adoption

Merchants maximize profits by choosing prices and payment acceptance.

IV.C.1 Merchant Pricing

Conditional on the payment acceptance decision M, merchants optimally pass the average transaction fee uniformly on to all consumers. Collapse the wallet-specific price indices from the consumer problem to $P = \left(P^w\right)_{w\in\mathcal{W}}$. Let the merchant fee for payment method j equal τ_j of sales. The cost of cash is $\tau_0 \geq 0$, which covers costs like cash deposit fees.[19] The fee incurred by a customer with wallet w depends on what the merchant accepts M, and equals $\tau_M^w = \sum_{j\in\mathcal{J}} I_{M,j}^w \tau_j$. Let the share of consumers with wallet w be $\tilde{\mu}^w$ and collapse the vector of shares as $\tilde{\mu}$. These shares represent the share of dollars in the economy in a wallet of type w. Normalize the firm's marginal costs to 1. Appendix A.2 shows that the optimal price is:

$$\hat{p}\left(\gamma, M, P, \tau, \tilde{\mu}\right) = \frac{\sigma}{\sigma - 1} \times \frac{1}{1 - \hat{\tau}}, \hat{\tau} = \frac{\sum_{w\in\mathcal{W}} q^w \tilde{\mu}^w \tau_M^w}{\sum_{w\in\mathcal{W}} q^w \tilde{\mu}^w} \tag{6}$$

Prices are the standard CES markup of $\frac{\sigma}{\sigma-1}$ multiplied by the effective marginal cost that incorporates total merchant fees divided by total pre-fee revenue. In equilibrium,

[17] A model with three cards gives similar results; Bertrand competition with two or three competitors results in the same equilibrium price.

[18] The lump-sum assumption means higher fees matched with higher rewards decrease merchant acceptance. This idea matches how AmEx cuts merchant fees when Visa and MC are forced to cut interchange due to regulation (AmEx, 2007). An alternative model in which rewards affect spending across merchants would make rewards competition even more intense.

[19] I ignore potential social costs of cash through increased crime, money laundering, or tax evasion (Rogoff, 2017). Incorporating these costs changes the policy recommendation to repeal caps on debit card merchant fees in lieu of capping credit card merchant fees.

merchants set optimal prices given other merchants' pricing and adoption strategies:

$$\hat{p}\left(\gamma, M^*\left(\gamma\right), P, \tau, \tilde{\mu}\right) = p^*\left(\gamma\right) \tag{7}$$

IV.C.2 Merchant Acceptance

Merchants choose the optimal subset of payments to accept. The threat of dropping Visa while accepting MC and AmEx disciplines Visa's merchant fee and is crucial for matching the merchant fee sensitivity with realistic gross margins. Let $\widehat{\Pi}\left(\gamma, M, P, \tau, \tilde{\mu}\right)$ be the profit function from accepting a particular subset of payments $M \subset \mathcal{J}_1$, accounting for the optimal price. In Appendix A.3, I prove that $\widehat{\Pi}$ is approximately proportional to a linear function of γ, which I call quasiprofits $\overline{\Pi}$. Merchants maximize $\overline{\Pi}$:

$$\widehat{M}\left(\gamma, P, \tau, \tilde{\mu}\right) = \underset{M \subset \mathcal{J}_1}{\operatorname{argmax}} -a_M + b_M \gamma \tag{8}$$

$$a_M = \sum_{w \in \mathcal{W}} \mu^w \tau_M^w,\ b_M = \frac{1}{\sigma} \sum_{w \in \mathcal{W}} \mu^w v_M^w \left(1 - \sigma \tau_M^w\right) \tag{9}$$

where the insulated shares μ^w are the shares of demand for a cash-only merchant from consumers with wallet w. Intuitively, the intercept a_M captures the loss from paying fees, whereas b_M captures the profits from higher sales.[20]. The merchant problem captures the theoretical insight that multi-homing consumers reduce merchants' incentives to accept high-fee cards (Appendix A.4). Models of single-homing consumers like Edelman and Wright (2015) therefore understate merchant fee sensitivity. The relationship between consumers' card holdings and merchant acceptance means that merchant fee sensitivity is not a primitive parameter but instead depends on consumer behavior.

In equilibrium, merchants adopt optimal bundles holding fixed the optimal adoption and pricing behavior of other merchants:

$$\widehat{M}\left(\gamma, P, \tau, \tilde{\mu}\right) = M^*\left(\gamma\right) \tag{10}$$

IV.C.3 Consumer Adoption

Consumers choose both a primary and secondary payment method.

Primary Payment Method: This is the one with the highest payment utility from

[20]Crucially, adding a more expensive card (e.g., AmEx) incurs fees from all consumers who use that card but increases sales only from the consumers who do not already carry other cards (e.g., Visa). In the *Ohio v. AmEx* case, the DoJ referred to the second category of consumers as "insistent".

adoption.[21] Log payment utility V_i^j for method $j \in \mathcal{J}$ is:

$$\log V_i^j = \underbrace{\log U^j}_{\text{CES}} + \underbrace{\Xi^j}_{\text{Unobs Char}} + \frac{1}{\alpha}\left(\underbrace{\eta_i^j}_{\text{T1EV}} + \underbrace{\beta_i X^j}_{\text{R.C.}}\right) \tag{11}$$
$$\beta_i \sim N\left(0, \Sigma\right)$$

The CES utility, U^j, represents the maximized utility attained from solving the consumption problem over merchants for a consumer who single-homes on j. It allows me to measure consumer welfare in terms of consumption instead of relative to a fixed outside option. Although rewards depend on both cards in the consumer's wallet, I slightly abuse notation and write the reward for a consumer who single-homes on card j as $f^{(j,0)} \equiv f^j$. I model rewards as an increase in income to $1 + f^j$.[22] Standard results on CES give that the consumer's optimized utility is:

$$\log U^j \approx f^j - \log P^j \tag{12}$$

where $P^j \equiv P^{(j,0)}$ is the CES price index associated with a customer who only carries j, defined in Equation 4. The CES price index captures the value of acceptance by capitalizing the benefits γ into an equivalent increase in real income.

The utility from the CES system increases for a payment method that earns a large reward, decreases if the overall level of retail prices is high (which increases P^j), and increases for a payment method that is widely accepted (which decreases P^j). CES utility means that a 1% increase in retail prices cancels out a 1% increase in rewards.

The other parameters are more standard. The variables Ξ^j represent unobserved characteristics that rationalize market shares. I normalize the unobserved characteristic of cash as $\Xi^0 = 0$. The parameter α measures consumers' reward sensitivity.[23] If α is large, a small increase in rewards f^j leads to a large increase in j's market share. The shocks η_i^j represent unobserved reasons different consumers might choose one payment method over another. The characteristics X^j are indicators for whether a payment method is a card or cash and whether it extends credit. The random coefficients are distributed $\beta_i \sim N\left(0, \Sigma\right)$ for some covariance matrix Σ. This unobserved heterogeneity

[21]The Visa product can be thought of as the best card among Visa issuers for this consumer.

[22]In reality, rewards may incorporate other perks. To the extent issuers create gains from trade (e.g., cheaper plane tickets), those gains can be realized at every level of merchant fees and thus do not matter for the counterfactuals.

[23]Consumers in the model have the same reward sensitivity α. Variation in α_i would likely exacerbate the regressive nature of credit card rewards since high-income consumers likely have a higher sensitivity.

captures rich substitution patterns between payment methods of similar characteristics.

Secondary Payment Method: The payment method with the second-highest utility becomes the secondary payment method in the wallet. Therefore, I treat data on secondary cards as second-choice data for estimating substitution patterns (Berry et al., 2004). I define *insulated* market shares for the wallet $w = (w_1, w_2)$ as:

$$\mu^w = P\left(\left(V_i^{w_1} = \max_{j\in\mathcal{J}} V_i^j\right) \cap \left(V_i^{w_2} = \max_{j\in\mathcal{J}\setminus\{l\}} V_i^j\right)\right) \tag{13}$$

Insulated versus Consumer Market Shares: Consumer market shares $\tilde{\mu}$ are reverse-engineered so that each merchant's decision on which cards to accept depends only on the insulated shares μ, and not on the price index P^w or the rewards f^w. Actual market shares $\tilde{\mu}$ are thus derived from the insulated shares as:

$$\tilde{\mu}^w = \frac{1}{C}\frac{\mu^w\left(P^w\right)^{1-\sigma}}{1+f^w}, C \equiv \sum_{w\in\mathcal{W}} \frac{\mu^w\left(P^w\right)^{1-\sigma}}{1+f^w} \tag{14}$$

where f^w is the total rewards paid to a consumer with wallet w.

Whereas the consumer market share $\tilde{\mu}^w$ is the share of consumers who carry a wallet, the insulated market share μ^w captures the share of a cash-only merchant's demand coming from consumers with a given wallet. The two shares differ because I model merchant competition. While the market shares $\tilde{\mu}$ are required for computing network profits, the insulated shares μ are required for merchants' acceptance choices. In practice, because α is much larger than 1, the modification of market shares in Equation 14 has only a small effect on estimates of how rewards affect card use.

IV.D Stage 1: Network Competition

In the first stage of the game, multiproduct payment networks maximize profits, anticipating consumer and merchant actions.

IV.D.1 Profits

Network profits equal transaction fees charged to merchants minus costs and the rewards paid to consumers. Let $\tilde{d}_j^w$ equal the total dollar amount that consumers with wallet w spend on card j. This is:

$$\tilde{d}_j^w = \frac{\mu^w}{C}\int I^w_{M^*(\gamma),j}\left(1+\gamma v^w_{M^*(\gamma)}\right) p^*\left(\gamma\right)^{1-\sigma}\ \mathrm{d}G\left(\gamma\right) \tag{15}$$

where the indicator $I^w_{M,j}$, defined in Equation 3, detects if payment method j is used. Total profits from the merchant side of the market for card j are:

$$T_j = \left(\tau_j - c_j\right) \sum_{w \in \mathcal{W}} \tilde{d}^w_j \tag{16}$$

where c_j is the cost of processing \$1 on method j. The total cost of rewards is:

$$S_j = \sum_{w \in \mathcal{W}} \tilde{\mu}^w f^w_j = \underbrace{\frac{1}{C} \times \frac{\mu^{(j,0)} \left(P^{(j,0)}\right)^{1-\sigma}}{1+f^j}}_{\text{Market Share of single-homers}} \times \underbrace{f^j}_{\text{single-homing Rewards}} \times \underbrace{\frac{\sum_{w' \in \mathcal{W}} \tilde{d}^w_j}{\tilde{d}^{(j,0)}_j}}_{\text{multi-homing}} \tag{17}$$

where f^w_j is the reward paid to a consumer with wallet w for her use of j. The rewards f^w_j for the consumers who multi-home scale up the single-homing rewards f^j under the assumption that equilibrium rewards are proportional to the amount of spending. For a network n that owns cards $\mathcal{O}_n \subset \mathcal{J}_1$, it earns profits:

$$\Psi_n = \sum_{j \in \mathcal{O}_n} \left(T_j - S_j\right) \tag{18}$$

There remains a fixed point between the normalizing constant C and the rewards f^w paid to each type of agent. This fixed point exists because rewards increase incomes, which changes spending volumes and rewards for multi-homing consumers. I circumvent this by approximating C in Equations 15 and 17 with $\tilde{C}$

$$\tilde{C} = \sum_{w=(w_1,w_2) \in \mathcal{W}} \frac{\mu^w \left(P^w\right)^{1-\sigma}}{1+f^{w_1}}$$

This approximation replaces the multi-homing rewards in the denominator with the single-homing rewards of the primary card. Visa thus ignores the effect of paying more rewards on the dollar spending of secondary Visa cardholders.

IV.D.2 Conduct and Equilibrium Determinacy

Networks maximize profits by adjusting promised CES utility levels for consumers U^j and transaction fees for merchants τ_j, holding fixed utility levels and transaction fees from other networks. Platform models generally have multiple equilibria because consumer adoption depends on merchant acceptance. Weyl (2010) argues that guaranteeing utility is a reduced-form way of capturing penetration pricing by which networks subsidize consumer adoption when merchant acceptance is low.[24] By paying more in rewards if acceptance is low, consumers have a dominant strategy in deciding what to adopt, which pins down a unique equilibrium in the subgame.

When each network chooses utility levels and transaction fees, it maximizes expected profits while assuming small trembles in the choice variables. I make this assumption because network profits are not differentiable with respect to merchant fees.[25] Each network $n = 1, \ldots, N$ sets promised utility levels U^{j*} and transaction fees τ_j^* for the cards that they own $\mathcal{O}_n$ such that:

$$\left(U^{j*}, \tau_j^*\right)_{j \in \mathcal{O}_n} = \underset{\left(U^j, \tau_j\right)_{j \in \mathcal{O}_n}}{\text{argmax}} \; \mathbb{E}\left[\Psi_n\left(\tilde{U}^j, \tilde{\tau}_j, \tilde{U}^{-j}, \tilde{\tau}_{-j}\right)\right] \tag{19}$$

$$\tilde{U}^j \sim N\left(U^j, \sigma^2\right), \tilde{\tau}_j \sim N\left(\tau_j, \sigma^2\right) \text{ iid}$$

where σ^2 is a small variance that I set to 10^{-10}, and U^{-j}, τ_{-j} capture all the CES utilities and fees set by the other networks. I model cash as a network that sets fees to the cost of cash $\tau_j = c_0$ and sets a utility level U^0 equal to $1/P^0$ to not pay any rewards.

IV.E Equilibrium

Equilibrium is characterized by fees τ^*, CES utility U^*, insulated shares μ, merchant prices $p^*(\gamma)$, merchant adoption strategies $M^*(\gamma)$, and consumer consumption $q^{w*}(\gamma)$ such that consumption across merchants is optimal (5), merchants maximize profits (7 and 10), consumers choose the optimal payment methods to reflect their preferences (13), private networks maximize their profits (19), and cash charges merchants the cost of cash τ_0 while paying no rewards.

IV.F Discussion of Key Assumptions

In this section, I discuss the key assumptions and model predictions.

IV.F.1 Issuers and Acquirers

My model abstracts from issuers and acquirers; networks directly set merchant fees and consumer rewards. This is accurate for proprietary networks like AmEx or fintechs like PayPal, for whom there are no issuers or acquirers. In the case of Visa and MC, this abstraction requires that Visa, the issuers, and acquirers maximize joint profits. Joint

[24]Equivalently, networks set consumers' expectations of merchant card acceptance, fees, and rewards while holding fixed consumers' expectations for other networks' acceptance and rewards.

[25]Rochet and Tirole (2003) do not encounter this issue in their two-network model, but problems arise with more networks (Teh et al., 2022). Appendix I describes the computational details.

profit maximization holds whenever parties bargain under complete information with a complete contract space. In practice, Visa pays around one-fifth of its gross revenue in side payments to issuers and acquirers (Visa, 2020). I interpret these payments as evidence that the contract space is approximately complete. Joint profit maximization is consistent with a wide range of issuer market structures, from perfect competition to network bargaining with a monopoly issuer.

IV.F.2 Price Coherence

I assume price coherence: merchants in the model charge the same price to consumers who use different payment methods. Appendix C discusses the history, empirics, and theory of price coherence. Fewer than 5% of transactions in the U.S. feature payment-specific pricing even though discriminatory pricing is largely legal, and observed discounting and surcharging behavior does not correlate with the stringency of past state-level laws (Levitin, 2005; Stavins, 2018; CardX, 2023). When I extend my baseline model to incorporate card surcharges, I estimate the typical merchant gives up less than 20 basis points of their profits from uniform pricing. Even small reputational costs could overwhelm the benefits of surcharging.[26]

IV.F.3 Primary and Secondary Cards Reflect First and Second Choices

The model predicts that primary and secondary cards reveal first and second choices, even though consumers do not have a reason to hold multiple cards in a symmetric equilibrium. In Appendix D, I derive a dynamic micro-foundation for consumers' primary and secondary card holdings. Suppose consumers periodically get new cards, the primary and secondary cards are the two most recent cards, and the payment utilities V_i^j are the utilities from choosing card j to be a new primary card. Then, the stationary distribution of consumers' primary and secondary cards (as a Markov chain) matches the joint distribution of first and second choices. This interpretation is compatible with complementarities between credit cards with different reward categories, provided that all the networks compete in the same reward categories.[27]

IV.F.4 Pass-through of Merchant Fees into Prices

Merchants fully pass on merchant fees into higher prices because of CES demand. The literature on over-pass-through of sales taxes supports this assumption (Conlon

[26] Caddy et al. (2020) document that even though surcharging has been legal in Australia since 2003, around one-quarter of consumers report that they avoid merchants who surcharge.

[27] Although complementarities could emerge in counterfactuals in which not all merchants accept all the networks, my out-of-sample predictions on the effects of AmEx fee cut in the U.S. and the equilibrium effects of Visa/MC fee cuts in Australia suggest that these forces are not significant.

and Rao, 2020). Under CES demand, the incidence of merchant fees falls entirely on consumers, which is desirable for any long-run analysis. If merchants did not adjust prices in response to fees but could exit in response to lower profits, consumers would be hurt even more by lower variety.

IV.F.5 Identical Sales Benefits For All Consumers

The sales benefit γ depends only on the merchant, not the consumer. I make this assumption because in Appendix Table G.5, I find little variation in sales effects across consumer types. In my model, if consumers varied in γ, then high γ consumers would be more likely to multi-home. I do not find evidence for this. A common γ across consumers means I rule out the mechanism for multiple equilibria in Ambrus and Argenziano (2009), in which one network charges high fees and rewards, while the other charges low fees and rewards. Asymmetric competition does not describe competition in the U.S. empirically, as AmEx, Visa, and MC charge similar merchant fees (Figure 2).

IV.F.6 Credit Cards as a Borrowing Instrument

I do not explicitly model the borrowing features of credit cards. I do this because when Australia regulated merchant fees, there were no effects on the borrowing features of credit cards, such as interest rates or annual fees (Appendix Figure H.1). Credit drives some modeling choices and model estimates. Credit may explain why consumers do not substitute between credit and debit cards at the point of sale (Section III.C). Potential consumption smoothing benefits of credit show up in the unobserved product characteristics Ξ of credit cards. Profits from interest charges show up as lower marginal cost estimates for credit card payments (Ru and Schoar, 2020; Agarwal et al., 2022).

Section V Estimation

Estimation translates the reduced-form facts into quantitative statements about how competition affects market outcomes. The key primitives to recover are (1) consumers' preferences over the different payment options, (2) the distribution of merchants' benefits from payment acceptance, and (3) the networks' marginal cost parameters. I assume the observed transaction volume shares and prices are an equilibrium of the model with three multi-product payment networks—Visa, MC, and AmEx. Both Visa and MC own two cards (debit and credit), while AmEx only owns a credit card network.

V.A Estimation Procedure

Although many steps occur jointly, estimation is most easily understood as a five-step process. First, I estimate consumer demand by matching the difference-in-difference evidence and second-choice data. Second, I recover networks' marginal costs by inverting the networks' first-order conditions with respect to consumer rewards. Third, I infer that merchant demand must be inelastic because equilibrium markups on merchant fees are high. Fourth, merchants' profit margins and the distribution of merchants' sales benefits from card acceptance rationalize data on card acceptance, merchants' average sales benefits, and merchants' low fee sensitivity. Fifth, the observed market shares recover the unobserved characteristics. Appendix B contains the details.

V.A.1 Consumer Substitution Patterns

I first estimate how consumers substitute between payment methods of different characteristics and how consumers respond to changes in rewards. I do this without solving the full model. Instead, I exploit the fact that the insulated shares μ of the full model can also be generated by a discrete choice model in which the utility for payment method j is:

$$\begin{aligned} u_j &= \delta_j + \alpha f^j + \beta_i X^j + \eta_i^j \\ \beta_i &\sim N(0, \Sigma), \eta_i^j \sim \text{T1EV} \end{aligned} \tag{20}$$

where the new intercept δ_j absorbs the unobserved characteristics Ξ^j and the CES price indices $\log P^j$. This simplification is valid as long as merchant acceptance is held fixed. I allow the δ_j to vary across data samples but impose the same reward sensitivity α, distribution of random coefficients Σ, and observed characteristics X^j across samples. This assumption is natural because I hold these variables constant across counterfactual simulations in which I introduce new products. I then use this representation to estimate α, Σ by minimizing the distance between empirical and theoretical moments.

I recover Σ by matching the empirical probabilities of each primary and secondary card combination in the Homescan data. The distribution of random coefficients $\beta_i \sim N(0, \Sigma)$ governs substitution patterns. My key innovation is that I interpret primary and secondary cards as revealing first and second choices. I thus use data on consumer multi-homing behavior to inform my estimates of substitution patterns. The large share of credit card consumers who multi-home (50%) relative to the share of primary credit card consumers (30%) in the Homescan data identifies high substitutability between credit card networks.

I estimate the price-sensitivity coefficient α by matching the simulated effects of the Durbin Amendment with my difference-in-difference estimates. I estimate two micro-moments from the Nilson panel: the effect of the Durbin Amendment on signature debit volumes (Figure 3) and the share of signature debit card volumes of total signature debit and credit volumes (Table G.1). I impose a third aggregate moment that 20% of overall transactions by value are done by cash (Figure 2). I recover a large price-sensitivity α because a small decline in debit rewards led to a large change in debit volumes.

V.A.2 Merchant Benefits, Network Costs, and Unobserved Characteristics

I identify the network costs and merchant parameters from the networks' optimal pricing conditions. The networks' first-order conditions with respect to rewards identify networks' marginal costs. High rewards are profitable only when networks earn large profits from merchants. Therefore, marginal costs must be low relative to observed merchant fees. Because networks optimally charge merchants large markups, merchants must be fee-insensitive in equilibrium. Merchants are fee-insensitive if margins are high. The CES substitution parameter σ determines margins and is thus identified by matching the required merchant fee sensitivity. The key model assumption is that networks are optimal with respect to two prices but have only one per-transaction marginal cost. One first-order condition pins down costs, and the other pins down merchants' fee sensitivity.

The estimation exploits the insight in Rochet and Tirole (2003) that profit-maximizing platforms should tax the price-insensitive side of the market to fund adoption by the price-sensitive side. The only way to rationalize high merchant fees and generous consumer rewards is if consumers are reward-sensitive but merchants are fee-insensitive.

Given merchant margins, I recover the distribution of merchant benefits $\gamma \sim G$ using the payment surveys. I parameterize the distribution of merchant benefits G as a Gamma distribution with a mean $\overline{\gamma}$ and a standard deviation of σ_γ. A larger mean $\overline{\gamma}$ increases the gap between card and cash consumers' spending at merchants that accept cards. As the dispersion σ_γ of benefits increases, more merchants become cash-only, reducing consumer spending at merchants that accept cards. These moments correspond to the regression coefficient in Table 2 and card consumers' expenditure share at merchants that accept cards (Table 1).

I set the cost of cash $c_0 = \tau_0 = 30$ bps to match past studies (European Commission, 2015; Felt et al., 2020). The unobserved characteristics come from matching the dollar volume shares from Figure 2.

V.B Estimated Parameters

I precisely estimate that consumers are reward-sensitive, whereas merchants are fee-insensitive. The high consumer sensitivity and low merchant sensitivities generate the model prediction that competing networks raise merchant fees to fund rewards. Table

Table 4: Estimated parameters

Panel A: Consumer Parameters

Parameter	Estimate	SE
S.D. of Credit R.C.	1.9	0.0
S.D. of Card R.C.	5.1	0.1
Correlation of R.C.	-0.3	0.0
Reward sensitivity α	511.3	78.9
Visa debit $\Xi \times 100$	-4.5	0.3
Visa credit $\Xi \times 100$	-5.6	0.3
MC debit $\Xi \times 100$	-4.7	0.3
MC credit $\Xi \times 100$	-5.8	0.3
AmEx $\Xi \times 100$	-5.9	0.3

Panel B: External Estimates

Cash cost c_0 (%)	0.30	Felt et al. (2020)

Panel C: Network Parameters (bps)

Parameter	Estimate	SE
Visa debit cost	46.6	8.0
Visa credit cost	16.0	7.0
MC debit cost	53.9	4.1
MC credit cost	57.4	3.9
AmEx cost	59.0	3.6
$\Delta\tau_{MC}$	0.1	0.0
$\Delta\tau_{AmEx}$	0.0	0.0

Panel D: Merchant Parameters

Parameter	Estimate	SE
CES σ	7.0	2.1
$\overline{\gamma}$	0.3	0.1
$\log \frac{\sigma_\gamma}{\overline{\gamma}}$	-1.1	0.1

Notes: S.D. refers to the standard deviation, and R.C. refers to the random coefficients for having a credit function and not being cash. The Ξ are the unobserved characteristics. A higher merchant CES elasticity σ reduces merchant margins. The distribution of γ is a Gamma distribution, with a mean $\overline{\gamma}$ and standard deviation σ_γ.

Table 5: Estimated consumer own price and cross-price semi-elasticities.

Payment	V debit	MC debit	V credit	MC credit	AmEx
Cash	-0.3 (0.0)	-0.1 (0.0)	-0.6 (0.1)	-0.2 (0.0)	-0.2 (0.0)
V debit	$+2.5$ (0.4)	-1.0 (0.2)	-0.7 (0.1)	-0.3 (0.0)	-0.3 (0.0)
MC debit	-2.6 (0.4)	$+4.1$ (0.6)	-0.7 (0.1)	-0.3 (0.0)	-0.3 (0.0)
V credit	-0.6 (0.1)	-0.3 (0.0)	$+3.0$ (0.5)	-0.9 (0.1)	-0.8 (0.1)
MC credit	-0.6 (0.1)	-0.3 (0.0)	-2.1 (0.3)	$+4.2$ (0.7)	-0.8 (0.1)
AmEx	-0.6 (0.1)	-0.3 (0.0)	-2.1 (0.3)	-0.9 (0.1)	$+4.3$ (0.7)

Notes: Each entry shows the effect of a 1-bp change in the rewards of the column payment method on the market share of the row payment method. The change is measured as a percentage of the row payment method's market share.

4 contains all the parameter estimates. Next, I transform the random coefficients, unobserved characteristics, and reward sensitivity into the semi-elasticities in Table 5. The third column of Table 5 shows that a 1-bp shock to Visa credit rewards raises the share of Visa credit transactions by 3% with a standard error of 0.5%. The new consumers mostly come from MC credit, which declines by 2.1%. In contrast, MC debit only declines by 0.7%. The difference reflects that consumers treat debit and credit cards as worse substitutes than different networks' credit cards. Cash use only declines by 0.6%, indicating cash is an even worse substitute. Consumers are highly willing to substitute between payment methods, especially those with similar characteristics.

I estimate that merchants are fee-insensitive. Starting from an equilibrium in which three symmetric credit card networks charge the same price, a 1-bp increase in the fees to one credit card network leads to only a 0.32% decrease in the share of merchants who accept that card (S.E. 0.03%). This is roughly one-tenth of what I estimate for consumers.

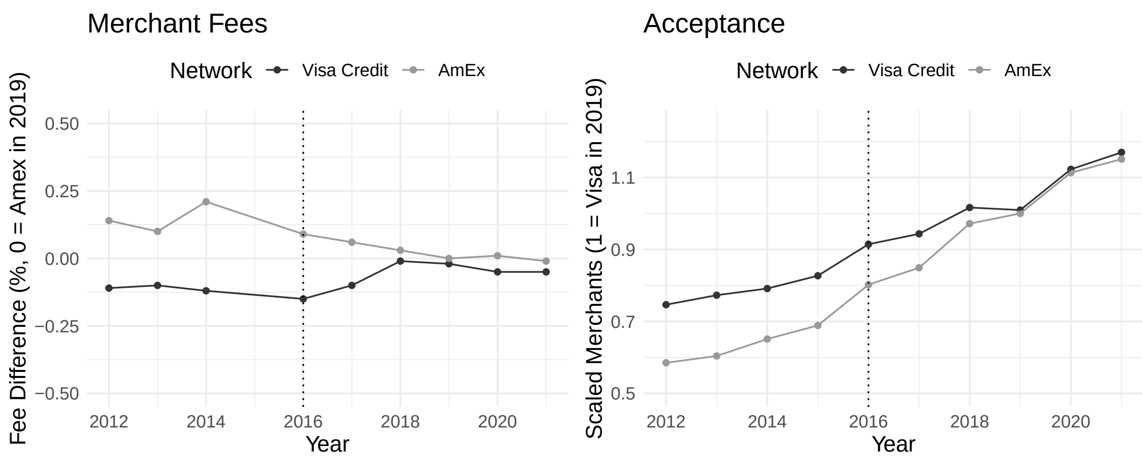
I estimate that the average consumer would prefer debit cards if credit cards did not pay rewards. The average consumer is indifferent between a Visa debit card and a Visa credit card that pays 1.1% in rewards. This preference drives my result that increases in credit card use relative to debit card use reduce welfare.

The consumer reward sensitivity is roughly five times cross-sectional estimates in Arango et al. (2015). There are two important reasons to explain this gap. First, many consumers may not choose cards with the highest rewards if there are search frictions across banks. However, consumers may still be responsive to changes in rewards at the banks in their consideration set (Honka et al., 2017). Second, my estimate captures both the direct effect of rewards and the indirect effect of banks steering customers away from debit cards following Durbin. For example, Chase stopped paying employees bonuses for signing up debit card customers after the Durbin Amendment was announced (Johnson, 2010). Capturing these indirect effects is desirable when modeling Visa's incentives to raise merchant fees to fund rewards.

V.C Goodness of Fit

The model matches several pieces of external evidence on merchant fee sensitivity, consumer substitution, merchant margins, and network costs. First, I validate my merchant fee sensitivity with AmEx's 2016–g2019 push to close the acceptance gap with Visa by cutting merchant fees (Andriotis, 2019). Figure 6 shows that during this period, AmEx cut its merchant fee by 20 bps relative to Visa, and the acceptance gap shrunk from around 9–12 points (pp) to zero. When I simulate this shock in the model, the gap shrinks by 11 pp. This test validates the importance of multi-homing consumers, as a

Figure 6: AmEx and Visa acceptance and fees



Notes: The left panel compares AmEx and Visa merchant fees over time, whereas the right panel compares acceptance locations. The acceptance locations are not weighted by sales and reflect adjustments to Visa's acceptance locations to remove ATMs and bank branches. Data is from the Nilson Report. The dotted line when AmEx started to cut fees as a part of its OptBlue program.

model of single-homing consumers would have predicted a smaller effect.

Second, I match the effect of Durbin on credit card volumes. While the estimate of α targets the percentage change in debit volumes, as an out-of-sample test, I find that the simulated and estimated effects of Durbin on credit card volumes are identical at 30 (S.E. 8) percent. This provides evidence that interpreting data on primary and secondary cards as first and second choices matches the results from exogenous price variation.

Third, the model matches macro data on markups. The retail markup in the model is estimated to rationalize equilibrium merchant fees. Yet the markup I recover of 17 percent is similar to the aggregate markups of 15–20% used in macro studies of misallocation (Edmond et al., 2022; Sraer and Thesmar, 2023).

Fourth, the network cost parameters are consistent with accounting data. I estimate marginal cost parameters for the combination of issuers, acquirers, and the network that average around 47 bps with a standard error of 5 bps. Accounting estimates of issuer costs are around 20–60 bps, acquirer costs are around 5–10 bps and network costs are around 5 bps (Lowe, 2005; Mukharlyamov and Sarin, 2022; NACHA, 2017; Visa, 2020).[28] My cost estimates validate my conduct assumption. If Visa and MC were colluding, marginal costs would need to be -19 bps to rationalize the observed fees and rewards.

[28]The close match for the merchant fee-sensitivity and network costs suggests that alternative approaches to estimating the model would have arrived at similar results. If I had microdata to estimate the merchant fee sensitivity and estimated a number consistent with the above AmEx case study, the model would have led me to recover a similar consumer reward sensitivity α.

Section VI Counterfactuals

My counterfactual results imply large distributional and total welfare gains from changing merchant fee regulations, whereas the gains from more competition are either small or negative. First, capping credit card merchant fees lowers rewards, creates a progressive transfer from higher income credit consumers to cash and debit consumers, and increases annual consumer and total welfare by $39 and $29 billion. Second, repealing the Durbin Amendment's caps on debit card merchant fees would increase welfare. Turning towards competition, I find that the entry of a privately owned credit card network is regressive and reduces welfare. Although a low-fee public option like FedNow increases welfare, the gains are small relative to repealing Durbin. In short, the Australian and European regulations worked, whereas the U.S. ones did not.

The key mechanism explaining my total welfare results is that credit card use is excessive in the current equilibrium, and policies that reduce credit card use increase welfare. I show that a revealed preference estimate of the welfare costs of excess credit card adoption quantitatively explains my results. Across counterfactuals, I cap debit card merchant fees at 0.72% unless otherwise specified. This captures existing limits on debit interchange.

VI.A Capping Credit Card Merchant Fees

In my main counterfactual, I cap Visa and MC's credit card merchant fees at 1%. I focus on this counterfactual because many governments cap Visa and MC's interchange fees, the largest component of merchant fees. The equilibrium with capped merchant fees also speaks to the welfare effects of merchants charging payment-specific prices (Zenger, 2011).

VI.A.1 Effects on Prices and Shares

Capping credit card merchant fees reduces rewards and credit card use. Table 6 shows that after Visa and MC cut their merchant fees by 125 basis points (bps), their rewards fall by 83 bps. In response, AmEx cuts merchant fees and rewards by 28 and 36 bps, respectively. Roughly two-thirds of existing credit card consumers substitute to cash and debit. The market share of debit cards and cash rise by 18 and 12 percentage points (pp), respectively.

The close match between my price results and what was observed in Australia highlights the importance of a quantitative model. When Visa and MC are forced to cut merchant fees in the counterfactual, AmEx optimally opts for a high merchant fee, high rewards strategy. In equilibrium, its merchant fees are around 100 bps higher than Visa's.

Table 6: Changes in market shares, prices, and welfare of users of incumbent payment methods across counterfactuals.

	Price Controls		Change Competition		
	Cap CC Fees	Repeal Durbin	Credit Entry	Merge MC/AmEx	FedNow Debit
Δ Merchant Fees (bps)					
Debit	0	28	0	0	0
Credit	−96	4	0	3	1
Δ Rewards (bps)					
Debit	−12	21	3	−4	0
Credit	−69	2	5	−9	3
Δ Shares (pp)					
Cash	12	−2	−2	2	−1
Debit	18	10	−2	2	−6
Credit	−30	−8	−4	−5	−1
Δ Welfare (bps)					
Cash	61	−2	−7	7	1
Debit	50	19	−3	3	1
Credit	−5	−1	−1	−3	4

Notes: Share changes are only for incumbents, so entry reduces total shares. Welfare in bps measures changes in rewards less increases in retail prices. Cap CC reduces V/MC merchant fees to 1%. Repeal Durbin raises the ceiling on debit card merchant fees to 1%. Credit entry introduces a new large network with a credit card product. FedNow debit introduces a public network that prices at-cost and has similar characteristics as debit cards.

This matches how AmEx responded to Visa/MC's interchange fee caps in Australia (Chan et al., 2012).

VI.A.2 Distributional Effects

Capping credit card fees is progressive. To calculate the redistributive effects, I focus on the consumers who do not change their payment method in the counterfactual. For these consumers, the change in welfare is purely pecuniary: it is the change in rewards less the change in the price index. Cash and debit card consumers gain 61 and 50 bps of consumption, respectively, from lower retail prices, whereas credit card users lose 5 bps due to lower rewards. Whereas Felt et al. (2020) assume that consumer payment choice does not change with rewards, my results show that high credit card merchant fees redistribute consumption even after accounting for consumers' switching behavior.

VI.A.3 Consumer Welfare Effects

To study the welfare effects of merchant fee caps, I decompose consumer welfare into three terms—retail prices, the average reward paid, and non-pecuniary utility. This step requires revealed preference. Let E_i^k be an indicator that consumer i chooses payment method k. I decompose consumer welfare as:

$$\mathbb{E}\left[\max_k \log V_i^k\right] = \underbrace{-\log P^0}_{\text{Retail Prices}} + \underbrace{\sum_k \mu^k f^k}_{\text{Rewards}} + \underbrace{\mathbb{E}\left[\sum_k E_i^k \left(-\log \frac{P^k}{P^0} + \Xi^k + \frac{1}{\alpha}\left(\eta_i^k + \beta_i X^k\right)\right)\right]}_{\text{Non-Pecuniary Utility}}$$

where $\mu^k = \sum_j \mu^{(k,j)}$ is the insulated share of instrument k. This measure weighs all consumers equally and thus understates the gains from progressive policies.

The first term captures the loss to all consumers from higher retail prices. In contrast to a standard model that normalizes the value of the outside option to zero, I set the value of the outside option to the welfare of a cash consumer. The welfare of the cash user is low if retail prices are high. The second term captures the average level of subsidies paid to consumers, weighted by the market share of each payment instrument. The third term captures the extent to which consumers choose payment methods that offer high non-pecuniary utility.

In practice, changes in non-pecuniary utility primarily reflect my estimates of how some consumers dislike the non-pecuniary aspects of using credit cards as a primary payment instrument. As shown in Table 1, around 80% of consumers who prefer to pay with debit own a credit card. By revealed preference, these consumers must be credit averse. Appendix E shows survey evidence on how credit aversion could reflect

Table 7: Decomposing counterfactual consumer and total surplus effects

	Price Controls		Change Competition		
	Cap CC Fees	Repeal Durbin	Credit Entry	MC/A Merger	FedNow Debit
Consumer Welfare ($bn)					
Retail Prices	61	−2	−7	7	1
Rewards	−51	0	9	−11	1
Non-Pecuniary Utility	29	9	−4	6	2
Consumers	39	6	−2	2	4
Total Welfare ($bn)					
Merchants	1.1	−0.4	0.3	−0.6	0.3
Networks	−11	1	−3	5	−2
Total	29	7	−4	6	2
Revealed Preference	30	10	−5	6	1

Notes: Declines in non-pecuniary utility mostly captures the losses from credit-averse consumers using credit cards. Revealed preference refers to the approximation discussed in Section VI.D.

a fear of overspending on a credit card, adoption costs, or the mental cost consumers pay in a Gabaix and Laibson (2006) model to avoid shrouded interest payments. While I cannot exactly pin down the source of this credit aversion, ignoring non-pecuniary utility would counterintuitively imply that the introduction of debit cards hurt consumers who switched from credit. When fewer consumers use credit cards, they bear less credit aversion and this non-pecuniary term increases.

Aggregate consumer welfare increases by 39 bps from the decline in credit card merchant fees, consumer rewards, and credit card use. Scaled up to the $10 trillion in consumer-to-business payments, this represents a $39 billion per year gain. Table 7 shows how the three terms contribute to consumer welfare. Lower retail prices increase welfare by $61 billion, lower rewards reduce welfare by $51 billion, but reduced credit aversion benefits consumers by $29 billion.

The pass-through of merchant fees into retail prices changes the sign of welfare calculations. Had I ignored the equilibrium effect of retail prices as in Huynh et al. (2022), a standard discrete choice analysis based on observed market shares would lead to a $22-billion decrease in consumer welfare from the regulation.

VI.A.4 Total Welfare Effects

Regulations hurt network profits, moderating the total welfare gains. To measure total welfare, I assume the profits from merchants and the networks are rebated to all consumers equally. Table 7 decomposes the total welfare effects. Merchant profits rise by a negligible amount because consumers have lower incomes from lower rewards that offset the decline in transaction fees. Total network profits fall by $11 billion, or 40% of industry profits. Profits fall because the decline in rewards increases cash use. The net result is that total welfare rises by $29 billion.

VI.B Repealing the Durbin Amendment

Although credit card merchant fee caps increase welfare, the Durbin Amendment's caps on debit card merchant fees lower welfare. I repeal the Durbin Amendment in the model by raising the cap on debit card fees to 1% from their current level at 0.72%.[29] Merchant fees for debit cards rise by 28 bps, and debit rewards rise by 21 bps. Consumers switch to debit. The market share of debit cards rises by 10 pp, and the market share of credit cards falls by 8 pp.

Repealing the Durbin Amendment creates a progressive transfer and increases consumer and total welfare. Higher rewards increase the consumption of debit card users by 19 bps, but higher merchant fees reduce the consumption of credit card and cash users by 1 and 2 bps, respectively. This transfer is progressive since debit card users tend to be lower income than credit card users. Overall, consumers gain $6 billion of consumption, largely from lower credit aversion. Total welfare rises similarly as lower merchant profits offset higher network profits.

This counterfactual shows that the current U.S. regulatory regime is worse than either laissez-faire or European-style regulations. The Durbin Amendment exacerbated the excess adoption of credit cards by capping debit merchant fees while leaving credit unconstrained. Even though regulating both debit and credit card merchant fees is beneficial (Rochet and Tirole, 2011), regulating debit without regulating credit is not.

VI.C Increasing Competition from Private Networks

Although a major part of U.S. policy towards payment markets involves increasing competition through entry, I find that this is generally regressive and welfare-reducing. Even competitive payment markets can be socially inefficient.

I simulate three changes in private competition. First, I simulate the entry of a fourth major credit card network like Discover. Second, I simulate a merger of MC and AmEx. Third, in Appendix F, I model a new Buy Now, Pay Later (BNPL) entrant like Affirm. Below, I focus my discussion on the entry of a credit card network. The effects of the merger are similar, with opposite signs, and the losses from BNPL are even larger.

[29]This generates approximately the same level of debit rewards as in the pre-Durbin data.

To introduce a new credit card network, I introduce a new product with characteristics that match AmEx. Namely, it has the same observed X^j and unobserved Ξ^j characteristics and the same marginal cost c. I then compute a new Nash Equilibrium in which the four networks compete.

Entry triggers more intense competition over rewards, generating regressive transfers. In the new equilibrium, the incumbent credit card networks raise their rewards by 5 bps, and debit card rewards rise by a smaller 3 bps. Merchant fees are approximately flat as the incentives for networks to undercut each other to attract merchants are offset by the incentives to fund more rewards. Higher rewards incentivize credit card use, increasing merchants' costs by 7 bps. Cash users, therefore, lose 7 bps of consumption, and debit users lose 3 bps.

Higher credit card use lowers consumer and total welfare. Entry in typical one-sided markets raises consumer welfare because output is below socially efficient levels (Petrin, 2002). Entry lowers markups, increasing output and welfare. But, in payment markets, credit card use is too high as consumers internalize the benefits from rewards but not the costs from high merchant fees. Competition reduces network markups, expanding output but reducing welfare. Although the net effect of higher subsidies and prices increases consumer welfare by \$2 billion, the \$4-billion cost from credit aversion results in lower consumer welfare after entry. Total welfare falls by \$4 billion as networks compete down profits.

These counterfactuals are consistent with historical experiences with network competition. A major shock to competition was the *United States v. Visa U.S.A.* Supreme Court case that struck down rules preventing Visa and MC issuers from also issuing AmEx cards. Following that court decision, Visa and MC raised interchange to incentivize issuers to stay on their networks instead of switching to AmEx (GAO, 2009). My model and historical evidence therefore suggest that more fundamental changes to how networks compete for merchants, potentially through the repeal of anti-steering provisions, are necessary for network competition to create benefits.

VI.C.1 Public Options

One argument for introducing new public options for payments, whether CBDC's (Shin, 2021; Usher et al., 2021) or faster payments like FedNow (Brainard, 2021; Federal Reserve, 2022), is that it will help bring down merchant fees for credit and debit card transactions. In contrast, I find that government entry is unlikely to substantially lower total merchant fees or increase welfare. I simulate government entry as a new debit network with the same demand and supply characteristics as MC debit. Unlike

MC, the entrant cannot pay rewards and sets merchant fees at cost. The new platform fails to significantly lower fees or raise welfare for two reasons. First, incumbent credit card networks limit the adoption of the entrant by charging 1 bps higher merchant fees to fund 3 bps more rewards. Second, the entrant steals market share primarily from debit cards, which already charge low merchant fees. On net total welfare rises by $2 billion, which is smaller than the gains from repealing the Durbin Amendment.

VI.D Revealed Preference and the Effects of Credit Constraints

The total welfare effects across the counterfactuals are close to a revealed preference estimate for the change in aggregate credit aversion. Because differences in rewards reveal the credit-aversion of the marginal credit card user, the total welfare change should be approximately the difference between credit and debit card rewards multiplied by the share of consumers who switch away from credit:

$$\Delta W \approx \left(f^{\text{Credit}} - f^{\text{Debit}}\right) \times -\Delta\tilde{\mu}^{\text{Credit}}$$

The model predicts how market shares change, but conditional on the shares, the magnitude of the welfare effects reflects revealed preference. The last row of Table 7 shows that the output of the revealed preference argument fits well.

Credit constraints do not affect my estimated welfare results so long as revealed preference applies to unconstrained consumers who switch in response to rewards. A richer model with constraints would need a larger reward sensitivity α to rationalize the Durbin evidence. Both models would give the same predictions for how market shares and welfare respond to rewards.

VI.E Summary of Counterfactual Results

An important theme from the counterfactuals is that credit card use is currently excessive, and this one fact shapes whether market structure or regulatory changes increase or decrease welfare. Either capping credit card merchant fees or repealing the Durbin Amendment makes credit cards less attractive and thus raises consumer welfare. Conversely, entry makes credit cards more attractive, decreasing welfare. Because new public options are unlikely to displace credit cards, they create only small welfare gains.

Section VII Conclusion

This paper compares the relative merits of regulating prices versus increasing competition in U.S. payment markets. There are large gains from either capping credit card merchant fees or uncapping debit card merchant fees, whereas encouraging competition between credit card networks is harmful. To study this question, I develop and estimate a two-sided model of network competition and simulate the price and welfare effects of regulation and competition. Payment markets are inefficient because of too much credit card use and not too little competition. High credit card rewards inflate retail prices for all consumers while encouraging excessive credit card use. Unlike in standard antitrust settings in which competition benefits consumers through low prices and high output, payment network competition can cause harm through high merchant fees and high output.

More broadly, my empirical approach that uses variation on one side of the market to identify both sides' preferences can be used to study the welfare effects of network competition in other two-sided markets. For example, search engines fund large investments in software with high advertising prices. To what extent does competition between such platforms inflate retail prices and encourage excess software investment? I hope to study these questions in future work.

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Online Appendices: Not for Publication

A Additional Model Details

A.1 Deriving the Consumer Demand Function for Merchants

Each consumer has symmetric CES preferences over merchants, and payment acceptance affects quality. There is a unit continuum of single-product merchants that sell varieties ω. Each merchant is characterized by a type $\gamma(\omega) \geq 0$ that determines the importance of payment availability for consumer shopping behavior at the merchant. Let the elasticity of substitution be σ. The consumer has income y^w. The consumer chooses a consumption vector $q^w(\omega)$ to maximize utility subject to a budget constraint:

$$U^w = \max_{q^w} \left(\int_0^1 \left(1 + \gamma(\omega) v^w_{M^*(\omega)}\right)^{\frac{1}{\sigma}} q^w(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{21}$$

$$\text{s.t.} \int_0^1 q^w(\omega) p^*(\omega) \, d\omega \leq y^w$$

The presence of $v^w_{M^*(\omega)}$ means that a consumer derives higher utility from consuming at a merchant that accepts a card the consumer wants to use. I assume consumers only care about *whether* they use a card from their wallet and not about which card is used.

Standard CES results imply that the quantity consumed at a merchant ω depends on the type γ, the price p, the payments accepted M, income y^w, and an aggregate price index P^w that summarizes the pricing and adoption decisions of all other merchants. The demand from a consumer with wallet w for a merchant of type γ is:

$$q^w(\gamma, p, M, y^w, P^w) = (1 + \gamma v^w_M) p^{-\sigma} \frac{y^w}{(P^w)^{1-\sigma}} \tag{22}$$

$$(P^w)^{1-\sigma} = \int \left(1 + \gamma(\omega) v^w_{M^*(\omega)}\right) p^*(\omega)^{1-\sigma} \, d\omega$$

In this demand curve, only γ, v^w_M, and p vary across merchants. The price index P^w and the income y^w are not affected by any one merchant's actions.[30]

Two merchants with the same γ will choose the same price and acceptance policy. Therefore, the merchant variety ω can be dropped from the analysis. I can describe merchant actions in terms of an equilibrium price schedule $p^*(\gamma)$ and a set valued adoption schedule $M^*(\gamma)$. This reparameterization means that the price index can now be expressed as in Equation 4, where $G(\gamma)$ is the distribution of the γ parameter across merchants.

[30] This simplifies the strategic interaction between merchants, who only need to care about other merchants' pricing and adoption decisions through the effect on the price index.

A.2 Deriving Merchant Optimal Pricing

The profit function as a function of the price is:

$$\Pi\left(p,\gamma,M,P,\tau,\tilde{\mu}\right)=\sum_{w\in\mathcal{W}}\tilde{\mu}^{w}\left[\underbrace{q^{w}p\left(1-\tau_{M}^{w}\right)}_{\text{Net Revenue}}-\underbrace{q^{w}}_{\text{Costs}}\right] \tag{23}$$

Where the fee τ_M^w for wallet $w=(w_1,w_2)$ is the fee of the payment method that is finally used. Formally, it is $\tau_M^w=\sum_{j\in\mathcal{J}}I_{j,M}^w\tau_j$, where the indicators $I_{j,M}^w$ are defined in Equation 3 and detect if payment method j is used.

The expression for profit in Equation 23 is a wallet weighted average of revenues, net of transaction fees, less production costs, which have been normalized to 1. The merchant's optimal pricing problem is:

$$\hat{p}\left(\gamma,M^{*}\left(\gamma\right),P,\tau,\tilde{\mu}\right)=\underset{p}{\operatorname{argmax}}\,\Pi\left(p,\gamma,M,P,\tau,\tilde{\mu}\right) \tag{24}$$

To solve the optimal pricing problem, note that each q^{w*} is still a CES demand curve that satisfies the property:

$$\frac{\partial q^{w}}{\partial p}=-\sigma\frac{q^{w}}{p}$$

Let the optimal price for the firm, holding fixed the pricing and adoption decisions of other merchants, be $\hat{p}$. Then the first-order condition is:

$$\sum_{w\in\mathcal{W}}\left[\frac{\partial q^{w}}{\partial p}\left(\hat{p}\left(1-\tau^{w}\right)-1\right)+q^{w}\left(1-\tau^{w}\right)\right]=0$$

Rearranging terms yields an expression for the optimal price as a function of the average transaction fee $\hat{\tau}$, which matches Equation 6.

A.3 Linearizing Merchant Profits

In this section I prove that the merchant profit function $\overline{\Pi}$ is approximately linear in γ, holding fixed the other variables.

Theorem 1. *For any γ,M,P,τ,*

$$\widehat{\Pi}-\overline{\Pi}=\left(1+\gamma\right)O\left(\left(\tau^{\max}\right)^{2}\right)$$

where

$$\overline{\Pi}\left(\gamma,M,P,\tau\right)\equiv\frac{1}{C}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left\{-a_M+b_M\gamma+\frac{1}{\sigma}\right\} \tag{25}$$

$$a_M=\sum_{w\in\mathcal{W}}\mu^w\tau^w_M$$

$$b_M=\frac{1}{\sigma}\sum_{w\in\mathcal{W}}\mu^w v^w_M\left(1-\sigma\tau^w_M\right)$$

$$\tau^{\max}=\max_j\tau_j \tag{26}$$

Proof. The profit function $\widehat{\Pi}$ is difficult to compute exactly is because as γ increases, the composition of consumers and the optimal price $\hat{p}\left(\gamma,M\right)$ changes for each γ. However, by the envelope theorem, the effect of these price changes has only second-order effects on profits. Formally, start from the optimal payment specific prices under the assumption that consumers do not switch their payment choices with respect to the prices. These are $p_j=\frac{\sigma}{\sigma-1}\frac{1}{1-\tau_j}$ for payment method j. Any prices that are within an order τ_j adjustment then deliver the same profit, up to second-order terms in τ_j.

It therefore suffices to find a pricing schedule $p\left(\gamma,M\right)$ that is within order τ of p_j that generates the above expression for quasiprofits. A natural candidate is $\overline{p}=\frac{\sigma}{\sigma-1}$, i.e. the price that ignores merchant fees. In general, profits are

$$\Pi\left(p\right)=\sum_w\tilde{\mu}^w\frac{y^w}{\left(P^w\right)^{1-\sigma}}\times\left(1+\gamma v^w_M\right)p^{-\sigma}\times\left(p\left(1-\tau^w_M\right)-1\right)$$

Plugging in $p=\overline{p}$ and the definition of market shares $\tilde{\mu}^w$ from 14 yields

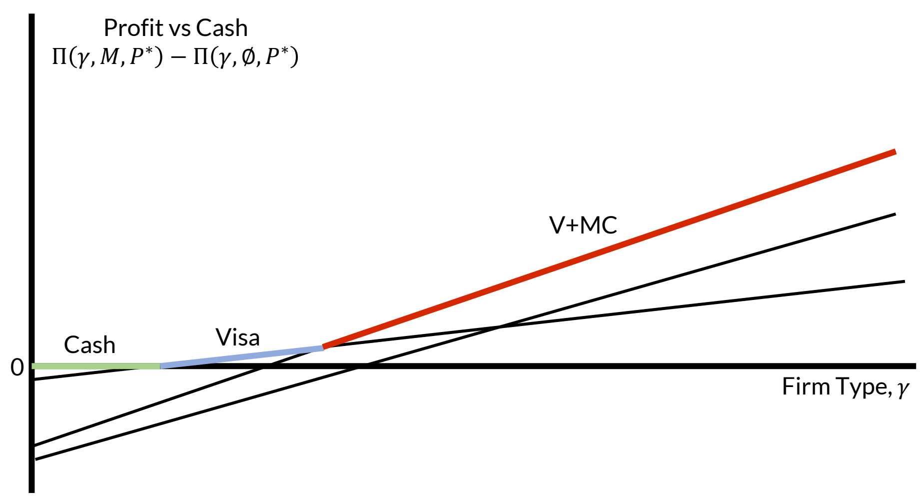
$$\begin{aligned}\Pi\left(\overline{p}\right)&=\frac{1}{C}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}\sum_w\mu^w\left(1+\gamma v^w_M\right)\left(\frac{1}{\sigma-1}-\frac{\sigma}{\sigma-1}\tau^w_M\right)\\&=\frac{1}{C}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\sum_w\mu^w\left(1+\gamma v^w_M\right)\left(1-\sigma\tau^w_M\right)\frac{1}{\sigma}\\&=\frac{1}{C}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(-\underbrace{\sum_w\mu^w\tau^w_M}_{a_M}+\gamma\times\underbrace{\frac{1}{\sigma}\sum_w\mu^w v^w_M\left(1-\sigma\tau^w_M\right)}_{b_M}+\frac{1}{\sigma}\right)\end{aligned}$$

□

The σ^{-1} in b_M term captures that profits are decreasing in merchants' demand elasticity, and the $\sigma\tau_M^w$ is the loss from double marginalization between the payment network and merchant.

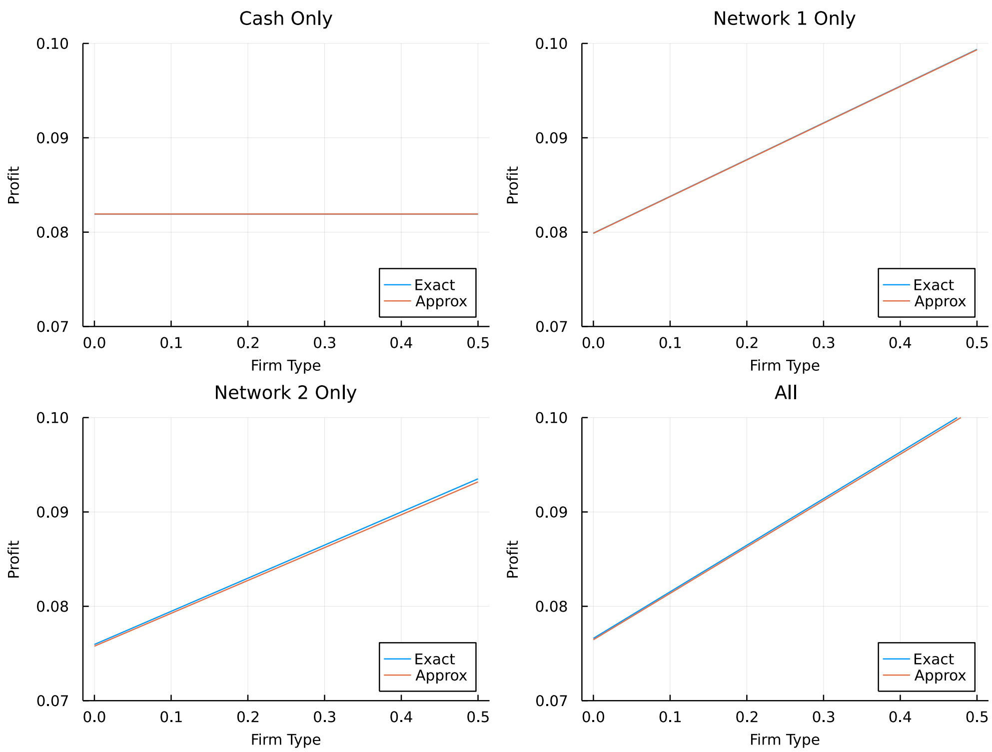
Figure A.1 shows an example of computing an equilibrium when Visa charges merchants low fees but has a low market share among consumers, MC charges high fees and has a high market share, and cash is free. At $\gamma = 0$, because cards cost more than cash, all the quasiprofit functions for bundles M that include cards are less than the quasiprofit for cash. Therefore, merchants with low benefit parameters γ choose to only accept cash. However, because Visa's fee is lower, its y-intercept is closer to zero and its quasiprofit function crosses zero first. The crossing point marks the start of a region of merchants who only accept Visa. When the quasiprofit function for the combination of Visa plus MC exceeds the quasiprofit function for Visa, all merchants of that type or higher will then accept both.

Figure A.1: Illustration of how to compute the merchant adoption subgame.



A natural question is whether the quasiprofit functions are a good approximation of true profits. Figure A.2 compares exact and approximate profits in a case with two networks with symmetric market shares, differentiated only by the two networks charge different fees. The fit is very close for all values of the merchant type γ.

Figure A.2: Numerical example of how quasiprofit functions approximate true profit functions for a case of two networks with symmetric consumer parameters but who set merchant fees of $\tau_1 = 0.02$ and $\tau_2 = 0.04$



A.4 Comparison of Merchant Acceptance with Rochet and Tirole (2003)

The linearity of quasiprofits also reveals how the extent to which consumers hold one card or two shapes merchants' willingness to substitute between accepting different cards, as in (Rochet and Tirole, 2003).

Consider a simplified economy in which consumers pay with cash and two cards, Visa (v) and American Express (a). Visa and American Express charge merchant fees of $0 < \tau_v < \tau_a$. Let the insulated shares be μ. Then the merchant adoption equilibrium will feature three regions:

1. Merchants of types $\gamma \in \left[0, \frac{\sigma\tau_v}{1-\sigma\tau_v}\right]$ accept only cash

2. Merchants of type $\gamma \in \left[\frac{\sigma\tau_v}{1-\sigma\tau_v}, \frac{\mu^{a,v}(\tau_a-\tau_v)+\mu^{a,0}\tau_a}{-\sigma\mu^{a,v}(\tau_a-\tau_v)+\mu^{a,0}(1-\sigma\tau_a)}\right]$ accept Visa only, where $\mu^{a,v}$ is the insulated share of consumers who primarily use American Express but who also have a Visa, and $\mu^{a,0}$ is the insulated share of consumers who only have an American Express and do not have a Visa.

3. Merchants of type $\gamma > \frac{\mu^{a,v}(\tau_a-\tau_v)+\mu^{a,0}\tau_a}{-\sigma\mu^{a,v}(\tau_a-\tau_v)+\mu^{a,0}(1-\sigma\tau_a)}$ accept both

When many American Express holders carry Visa, then $\mu^{a,v}$ is large and fewer merchants will accept American Express if Visa charges a low fee. Merchants become unwilling to accept American Express because doing so would force the merchant to raise higher prices, lowering demand, while getting few incremental sales. When fewer merchants accept American Express, Visa is better off and so Visa has strong incentives to compete for merchants if most American Express consumers hold Visa cards. In contrast, if no American Express users carry a Visa, then $\mu^{a,v}$ is zero and the lowest type merchant who accepts American Express is $\frac{\sigma\tau_a}{1-\sigma\tau_a}$. In this case, the set of merchants that accepts American Express no longer depends on the fees that Visa charges. This would dramatically weaken Visa's incentives to compete for merchants.

B Estimation Details

B.1 Consumer Substitution

I first discuss how I use the Homescan data. Let cash be the outside option, and order the choice set in Homescan as debit, Visa credit, MC credit, and AmEx. For each possible wallet (j, k) let s_{jk} be the estimated probability that a Homescan consumer is a primary j user and a secondary k user. Stack the share of primary cash consumers $s_0 = \sum_k s_{0k}$, as well as the shares of each primary and secondary card combination $s_{jk}, j \neq 0$ as s. I use the simplified representation in Equation 20 to calculate model implied probabilities. Since there is no price variation in Homescan I normalize $f^j \equiv 0$. The probability of a given combination of primary and secondary cards equals

$$\hat{s}_{jk}(\Sigma, \delta) = \int \frac{\exp\left(\delta_j + \beta_i X^j\right)}{\sum_l \exp\left(\delta_l + \beta_i X^j\right)} \times \frac{\exp\left(\delta_k + \beta_i X^j\right)}{\sum_{l \neq j} \exp\left(\delta_l + \beta_i X^j\right)} \, \mathrm{d}H(\beta_i) \tag{27}$$

where H is the joint distribution of β_i (Berry et al., 2004). I compute this with Monte Carlo integration. Stack the model implied shares as $\hat{s}$.

Next, I describe how I use the Nilson data. I order the choice set of payment methods as cash, signature debit, and credit cards to match the data provided.[31] Let the mean utilities in this model be $\tilde{\delta}$ to distinguish from the mean utilities used in the Homescan data. Let $\Delta f = 25$ bps, which is the change in debit rewards as a result of Durbin. The model implied moments are

$$\hat{m}(\Sigma, \alpha, \phi) = \begin{pmatrix} \log \int \frac{\exp\left(\tilde{\delta}_1 - \alpha \Delta f + \beta_i X^1\right)}{\sum_k \exp\left(\tilde{\delta}_k - \alpha \Delta f I\{k=1\} + \beta_i X^k\right)} - \log \int \frac{\exp\left(\tilde{\delta}_1 + \beta_i X^1\right)}{\sum_k \exp\left(\tilde{\delta}_k + \beta_i X^k\right)} \\ \int \frac{\exp\left(\tilde{\delta}_1 + \beta_i X^1\right)}{\sum_k \exp\left(\tilde{\delta}_k + \beta_i X^k\right)} \times \left(\int \frac{\exp\left(\tilde{\delta}_1 + \beta_i X^1\right)}{\sum_k \exp\left(\tilde{\delta}_k + \beta_i X^k\right)} + \int \frac{\exp\left(\tilde{\delta}_2 + \beta_i X^2\right)}{\sum_k \exp\left(\tilde{\delta}_k + \beta_i X^k\right)} \right)^{-1} \\ \int \frac{1}{\sum_k \exp\left(\tilde{\delta}_k + \beta_i X^k\right)} \end{pmatrix}$$

where all integrals are against the distribution H of random coefficients β_i.

I estimate the consumer substitution parameters with GMM with the optimal weight matrix. I estimate the covariance matrices of the micro-moments in s, m with the Bayesian bootstrap. I assume that the aggregate cash moment is independent of the other moments and is observed with only a small 1 bps standard error. Denote the estimated covariances as $\hat{S}_1, \hat{S}_2$ respectively. Since the empirical moments are from dif-

[31] The crucial assumption is that the customers of these small regional banks consider only cash, their bank's debit card, and their bank's credit cards in their choice set. If borrowers substitute across banks, I over-estimate substitution. Yet in Figure H.2 I do not observe asset substitution across banks.

ferent datasets, the optimal weight matrix W is block diagonal with $\hat{S}_1^{-1}$ and $\hat{S}_2^{-1}$. Stack the model moments as $\hat{g}(\Sigma, \alpha, \delta, \phi) = \begin{pmatrix} \hat{s}(\Sigma, \delta) & \hat{m}(\Sigma, \alpha, \tilde{\delta}) \end{pmatrix}^T$ and the data moments as $g = \begin{pmatrix} s & m \end{pmatrix}^T$. Stack the parameters as $\theta_1 = \begin{pmatrix} \Sigma & \alpha & \delta & \tilde{\delta} \end{pmatrix}^T$. I estimate θ_1 by solving

$$\hat{\theta}_1 = \underset{\theta_1}{\operatorname{argmin}} \left(\hat{g}(\theta_1) - g\right)^T W \left(\hat{g}(\theta_1) - g\right)$$

I use the estimates $\hat{\alpha}, \hat{\Sigma}$ in the next step, but the mean utility levels $\delta, \tilde{\delta}$ are nuisance parameters.

B.2 Merchant Benefits and Network Costs

Let the first data moment ϕ_1 be the expenditure share of card consumers at card stores from the payment surveys (97%). Let the second data moment ϕ_2 be the logistic regression coefficient of how consumers' card preference relates to whether a transaction is done at a card merchant (Table 2). Stack these data moments as ϕ.

To calculate the analogous model moments, define expenditure at all merchants with types $\gamma \geq \gamma'$ for a consumer with wallet w as $e^w\left(\gamma'\right)$. This is an integral of expenditure at each type of merchant:

$$e^w\left(\gamma'\right) = \int_{\gamma > \gamma'} q^{w*}(\gamma)\, p^*(\gamma)\ \mathrm{d}G(\gamma)$$

Let $\mathcal{M} = \{w \in \mathcal{W} : w_1 \in \{\text{Visa Credit}, \text{MC Credit}, \text{AmEx}\}\}$ be the set of wallets that are primary credit card consumers. Let $\mathcal{C} = \{w \in \mathcal{W} : w_1 = \text{Cash}\}$ be the set of wallets of primary cash users. Let γ^* be the lowest merchant type that accepts all credit cards.[32] The two model moments are

$$\begin{aligned} \hat{\phi}_1 &= \frac{\sum_{w \in \mathcal{M}} e^w(\gamma^*)}{\sum_{w \in \mathcal{M}} e^w(0)} \\ \hat{\phi}_2 &= \ell(\hat{\phi}_1) - \ell\left(\frac{\sum_{w \in \mathcal{C}} e^w(\gamma^*)}{\sum_{w \in \mathcal{C}} e^w(0)}\right) \\ \ell(p) &= \log \frac{p}{1-p} \end{aligned}$$

The first moment is the expenditure share of credit card consumers at card stores. The second moment is the difference in the logits of two expenditure shares: the shares of credit and cash consumers' spending at card stores. Stack these two model mo-

[32] I treat credit card acceptance as the sign of accepting all cards because some merchants in the model accept debit but not credit.

ments as $\hat{\phi}$.

I make an assumption on fees. First, I assume that the aggregate fees are observed with error because my model cannot rationalize three credit card networks of different sizes charging identical fees. Instead of matching the surveyed fees in Figure 2, I instead assume that MC credit charges a fee $\tau_{\text{Visa Credit}} + \Delta\tau_{\text{MC}}$ and that AmEx charges a fee $\tau_{\text{Visa Credit}} + \Delta\tau_{\text{MC}} + \Delta\tau_{\text{AmEx}}$, where $\Delta\tau_{\text{MC}}$ and $\Delta\tau_{\text{AmEx}}$ are fee adjustment parameters to be estimated. In practice, these parameters are less than a tenth of a basis point, and thus I match the observed equilibrium of nearly symmetric fees.

I can then jointly estimate the parameters by finding the 15 parameters to match 2 moment conditions $\hat{\phi} = \phi$, 8 first-order conditions, and 5 share constraints. The 15 parameters are the average $\overline{\gamma}$ and standard deviation σ_γ of merchant benefits, the 5 marginal cost parameters c for each card, the 5 utility intercepts Ξ for each card, the two fee adjustments $\Delta\tau_{\text{MC}}, \Delta\tau_{\text{AmEx}}$, and the CES substitution parameter σ.

- The 8 first-order conditions are the 3 first-order conditions of each credit card network with respect to its merchant fee and the 5 first-order conditions of each card with respect to the promised utility U^j to the consumer. Debit card fees are not at a first-order condition due to the Durbin Amendment.

- The 5 share constraints require that at the profit maximizing promised utility for each card, the resulting aggregate shares $\tilde{\mu}$ from Equation 14 match the data. Visa, MC, and AmEx's credit card volumes are scaled up to cover the entirety of credit card volumes, and Visa and MC's debit volumes are scaled to cover the entirety of debit card volumes. A consumer in my model represents one dollar of expenditure. Here I use true market shares rather than insulated shares because the wedge between the two depends on the CES price index, which can change across parameter specifications.

I solve the moment conditions and the first-order conditions jointly because the distribution of merchant types affects the networks' first-order conditions.

I calculate the standard errors through the delta method. Denote all the parameters to be estimated in this step as θ_2. Stack all the first-order conditions and moment conditions into a function F. The estimate $\hat{\theta}_2$ solves the equation:

$$F\left(\hat{\theta}_2, \hat{\theta}_1, \hat{\phi}\right) = 0$$

The implicit function theorem gives a representation of $\hat{\theta}_2$ as $\hat{\theta}_2\left(\hat{\theta}_1, \hat{\phi}\right)$ with a known Jacobian. I calculate the covariance matrix of $\left(\hat{\theta}_1, \hat{\phi}\right)$ by using the Bayesian bootstrap for the distribution of $\hat{\phi}$ and the GMM formula for $\hat{\theta}_1$. The delta method converts the covariance matrix and the Jacobian into a full covariance matrix for $\hat{\theta}_2$.

C Price Coherence

Although merchants in the U.S. can charge discriminatory prices for different payment methods, most choose not to. It can be rational to do so even while assuming small menu costs.

C.1 A Brief History of Price Coherence in the US

While cash discounts have long been legal in the U.S., merchants' ability to apply card surcharges has only gradually increased over time.[33] The Cash Discount Act of 1981 guarantees merchants' right to offer discounts for cash (Chakravorti and Shah, 2001; Levitin, 2005; Prager et al., 2009). The Durbin Amendment in 2010 also gave merchants the right to offer discounts for debit cards (Schuh et al., 2011; Briglevics and Shy, 2014).

The first major change to allow for credit card surcharging was the 2013 settlement between Visa, Mastercard and the DOJ, which removed no-surcharge rules at the network level. This settlement meant that merchants in the 40 states without state-level no-surcharge rules could now freely charge higher prices for credit card transactions (Blakeley and Fagan, 2015). Visa's allowed multi-state merchants who operated in states with no-surcharge rules to surcharge in states that allowed them (Visa, 2013). Although the settlement technically only applied to Visa and Mastercard, American Express and Discover relaxed their no-surcharge rules at this time to allow merchants to surcharge American Express and Discover credit cards at the same level as the Visa and Mastercard (Merchant, 2016).

In the wake of the 2013 settlement, the last remaining barrier to card surcharging in the US were state-level prohibitions in 10 states: California, Colorado, Connecticut, Florida, Kansas, Massachusetts, Maine, New York, Oklahoma, and Texas (Visa, 2013; Merchant, 2016). Yet over the subsequent years, many of these states also dropped their requirements against surcharging. As of 2023, only Massachusetts and Connecticut have bans against surcharging (CardX, 2023), although the disclosure requirements in New York and Maine render card surcharging impractical.[34]

[33]Under complete information, discounts and surcharges are identical. But if the existence of discounts or surcharges is shrouded, then cash discounts are a kind of giveaway whereas surcharges are an add-on price (Bourguignon et al., 2019).

[34]In New York and Maine, retailers must disclose the dollars and cents value of the credit card price and the cash price in order to surcharge. This would entail posting twice the number of prices. In New York, this requirement is explicitly described as making sure consumers "should not have to do math to figure out whether they are paying the surcharge" (Westchester, 2019)

C.2 Price Coherence in the Data

In this section I show that fewer than 5% of transactions in the Diaries of Consumer Payment Choice (DCPC) are at a merchant with either card surcharges or cash discounts. This fact explains why I assume price coherence throughout my paper. I focus on transactions on cash, checks, debit cards, and credit cards. I exclude bank account payments through ACH because it is not covered in the aggregate payments volumes from Nilson (2020c). I group cash and check as "cash", and then separate debit and credit. I exclude government or financial transactions to capture the idea of retail purchases.

I compute three metrics: the share of cash or check transactions that earn a discount, the share of credit card transactions that pay a surcharge, and the share of credit card transaction that are steered to other payment instruments.[35] These are not mutually exclusive categories because a consumer who originally intended to use a credit card may get steered to cash and earn a discount. However, I use them because they are transparent, and the sum of these proportions is an upper bound to the share of transactions with discriminatory prices. I also split the sample by transactions with ticket sizes of more than $100 and those with less. The transactions above $100 comprise around half of the total value of transactions in the DCPC.

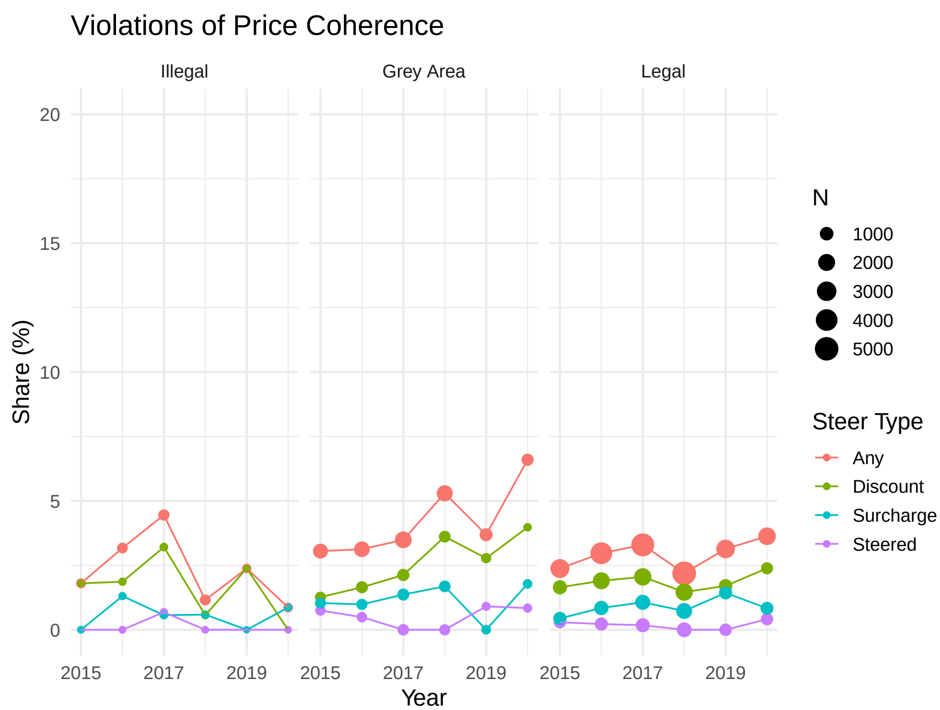
I show the computed shares in the table below. At most 3.1% of transactions overall earn a discount or a surcharge. While discounts are more common for large transaction sizes (potentially because stores offer a discount for a check), the share of cash discounts only rises from 1.8 to 7.7 percent.

Violation of Price Coherence	All Transactions	$>$ \$100	$\leq$ \$100
Cash Discounts (%)	1.9	7.7	1.8
Card Surcharge (%)	0.9	1.1	0.9
Steered (%)	0.2	0.2	0.2
Sum	3.1	9.1	2.9

One potential reason surcharging is rare is because it was not always legal. This does not explain why there are so few cash discounts. In addition, I can also show that the rates of cash discounts and card surcharges across states do not vary with legality. I group states into three categories: "Legal" states that never had state level prohibitions on surcharging, "Illegal" states that still had bans as of 2020, and "Grey Area" states that used to have state level no surcharge rules but repealed them at some point in

[35] In the DCPC, respondents state their preferred payment method P. Whenever they use a different payment method D, they are asked "why did you use D for this transaction?" Two of the potential answers are "I received a discount for using D," and "I would have paid a surcharge if I used P."

2013 – 2020. I show time series of various measures of violations of price coherence below. Overall, rates are low and uncorrelated with the legal regime. Although rates of surcharging picked up in 2020 in California (one of the "grey area" states), data in 2020 is hard to interpret due to the dramatic decline in transactions from the pandemic.



C.3 Private Incentives to Surcharge

This section outlines the theoretical argument for how small menu costs can support price coherence as an equilibrium outcome. First, I show that merchants are unable to use surcharges to steer consumers between cash and card. Second, by the model assumption that consumers do not substitute between credit and debit at the point of sale, the inability to steer card consumers to cash rules out all kinds of steering between different payment types (e.g., credit vs debit). Third, given this inability to steer, merchants' losses from uniform prices are second order in any type-symmetric equilibrium in which cards of the same type (e.g., Visa/MC/AmEx credit cards) all charge the same merchant fee. Intuitively, price-coherence results in merchants charging card-consumers a price that is slightly too low, and charging cash-consumers a price that is slightly too high. By the envelope theorem, neither price deviation has a first-order effect on profits.

I focus on the type-symmetric case because it is a good approximation of the US market structure (See Figure 2). In the estimated equilibrium, these losses from charging uniform prices are less than 16 *basis points* in profits. Thus, even small menu costs, such as upsetting customers (Caddy et al., 2020), can explain why merchants choose not to surcharge.

The previous results concern type-symmetric equilibria. In principle, merchants may find it attractive to surcharge high fee networks more than others. While a full analysis of this case is beyond the scope of the paper, I discuss some reasons why even this ability may not be enough to motivate merchants to charge different fees.

C.3.1 No Steering

To show that merchants cannot steer consumers between card and cash, I first prove the case when there's a monopoly network. With that result, it immediately follows that in any type-symmetric equilibrium, then merchants are also unable to steer consumers between payment types. Another way of stating the result is that card use is always ex-post efficient in the model, and so passing on merchant fees does not steer consumers between types.

I first extend the baseline model to allow consumers to make a choice of how to pay at the point of sale and to allow merchants to charge payment specific prices. I now model the consumption decision in two nests. Consumers choose effective consumption levels of each variety $q(\omega)$, but now effective consumption is a linear aggregate of card $c(\omega)$ and cash consumption $a(\omega)$. Merchants are also allowed to charge different prices for card versus cash, such that card consumers pay a price that is $1+s(\omega)$ higher. Consumers solve

$$U = \max_{c,a} \left(\int_0^1 q(\omega)^{\frac{\sigma-1}{\sigma}} \, \mathrm{d}\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{28}$$

$$\text{s.t. } q(\omega) = \left(1 + \gamma(\omega) v^w_{M(\omega)}\right)^{\frac{1}{\sigma-1}} c(\omega) + a(\omega) \tag{29}$$

$$y \geq \int_0^1 \left(c(\omega)(1+s(\omega)) + a(\omega)\right) p(\omega) \, \mathrm{d}\omega \tag{30}$$

The linear aggregation corresponds to the idea that card goods are higher quality and perfect substitutes with cash goods. The model assumes that the convenience benefit of using a card is the same on every shopping trip. This assumption is crucial for the result that surcharging is not effective. Note that the original model corresponds to the case of

$$(c(\omega), a(\omega)) = \begin{cases} (0, q^w(\omega)) & v^w_{M(\omega)} = 0 \\ (q^w(\omega), 0) & v^w_{M(\omega)} = 1 \end{cases}$$

Lemma 1. *At a merchant of type γ that accepts cards, a card consumer will use cash only if*

$s > (1+\gamma)^{\frac{1}{\sigma-1}} - 1$

Proof. Suppress the variety ω. The FOC for the Lagrangian with respect to more card spending c and cash spending a for a card consumer at a merchant who accepts cards is

$$\frac{\partial \mathcal{L}}{\partial c} = I^{\frac{1}{\sigma-1}} \times q^{-\frac{1}{\sigma}} \times (1+\gamma)^{\frac{1}{\sigma-1}} - \lambda (1+s)\, p$$
$$\frac{\partial \mathcal{L}}{\partial a} = I^{\frac{1}{\sigma-1}} \times q^{-\frac{1}{\sigma}} - \lambda p$$

where $I = \int_0^1 q(\omega)^{\frac{\sigma-1}{\sigma}} \, \mathrm{d}\omega$ Both card spending and cash spending are at an interior solution provided that

$$(1+\gamma)^{\frac{1}{\sigma-1}} = 1+s$$

Because the aggregator for q is linear, for any $s > (1+\gamma)^{\frac{1}{\sigma-1}} - 1$, card spending $c = 0$. For any lower surcharge, cash spending $a = 0$. □

Theorem 2. *In a market with a monopoly credit card network that charges a merchant fee of* τ*, no merchant that accepts the credit card in the baseline model can steer consumers by setting* $s = \tau$

Proof. By the expressions for quasiprofits from 1, we have that the lowest type that accepts credit cards in the baseline model satisfies $\gamma^* = \frac{\sigma\tau}{1-\sigma\tau}$. For general $\gamma > 0, \sigma > 1$ we have the inequality that

$$(1+\gamma)^{\frac{1}{\sigma-1}} \geq 1 + \frac{\gamma}{\gamma+1}\frac{1}{\sigma-1}$$

Thus by Lemma 1 the required surcharge exceeds

$$s^* \geq 1 + \frac{\gamma^*}{\gamma^*+1}\frac{1}{\sigma-1} - 1 = \tau\frac{\sigma}{\sigma-1} > \tau$$

□

The result may be surprising because intuitively it should be possible to use a surcharge to get a credit card user to switch to a debit card. I have ruled that out by the assumption that consumers only use cards that share the same type as their primary card. I have done this to conform with empirical evidence and antitrust thinking on the topic (Jones, 2001). Empirically, debit card incentives do not steer credit card consumers (Conrath, 2014).

C.3.2 Magnitude of Losses from Uniform Pricing

When card surcharges do not change the method of payment, then uniform pricing results in only second-order losses. This section quantifies the losses from uniform pricing. Suppose merchants can charge wallet-specific prices p^w. Stack these prices into a vector. Then after dropping the CES price indices and income from the normalization, we get that total profits $\widehat{\Pi}$ are proportional to

$$\widehat{\Pi} \propto \sum_{w \in \mathcal{W}} \mu^w \pi^w$$
$$\pi^w = (1 + \gamma v_M^w)(p^w)^{-\sigma}(p^w(1 - \tau^w) - 1)$$

Let p^* denote the vector of optimal prices, and $\hat{p}$ denote the vector of uniform prices. I use a second order Taylor expansion of $\log \widehat{\Pi}$ with respect to $\log p$ to derive the losses from uniform pricing:

Theorem 3. *The percentage loss from charging the optimal uniform price instead of optimal payment method specific prices is:*

$$\log \widehat{\Pi}(p^*) - \log \widehat{\Pi}(\hat{p}) = \sum_w \frac{\mu^w (1 + \gamma v_M^w)}{\sum_l \mu^l (1 + \gamma v_M^l)} \times \frac{\sigma(\sigma - 1)}{2} (\tau^w - \hat{\tau})^2 + O\left(\tau^3\right)$$

Proof. First, a first order Taylor expansion gives that

$$\log \widehat{\Pi}(p^*) - \log \widehat{\Pi}(\hat{p}) \approx \sum_w \frac{\mu^w (1 + \gamma v_M^w) \pi^w}{\sum_l \mu^l (1 + \gamma v_M^l) \pi^l} \times (\log \pi^w(p^*) - \log \pi^w(\hat{p}))$$

which merely says that the percentage loss in total profits is the weighted sum of the percentage loss in profits from consumers of each different wallet. By Equation 6 the optimal payment specific price is $p^{w*} = \frac{\sigma}{\sigma - 1}(1 - \tau^w)^{-1}$. After dropping all terms of order τ and higher we have that $\pi^w \approx \pi^l$. It then remains to show that

$$\log \pi^w(p^{w*}) - \log \pi^w(\hat{p}) \approx \frac{\sigma(\sigma - 1)}{2} (\tau^w - \hat{\tau})^2$$

to second order. By the envelope theorem, $\log \pi^w(p^*) - \log \pi^w(\hat{p}) = 0$ to first order. We then compute a second order expansion in $\log p$. Express log profit in terms of the log price

$$\log \pi^w = -\sigma \log p^w + \log(\exp(\log p)(1 - \tau^w) - 1)$$

Differentiate twice to obtain

$$\begin{aligned}
\frac{\partial^2 \log \pi^w}{\partial (\log p)^2} &= \frac{\partial}{\partial \log p} \frac{\exp(\log p)(1-\tau^w)}{\exp(\log p)(1-\tau^w)-1} \\
&= \frac{\partial}{\partial \log p}\left(1 - \frac{1}{\exp(\log p)(1-\tau^w)-1}\right) \\
&= \frac{\exp(\log p)(1-\tau^w)}{(\exp(\log p)(1-\tau^w)-1)^2}
\end{aligned}$$

By plugging in the optimal price, we get

$$\begin{aligned}
\exp(\log p^{w*})(1-\tau^w) &= \frac{\sigma}{\sigma-1} \\
\implies \frac{\exp(\log p)(1-\tau^w)}{(\exp(\log p)(1-\tau^w)-1)^2} &= \sigma(\sigma-1) \\
\log p^{w*} - \log \hat{p}^w &= \tau^w - \hat{\tau}
\end{aligned}$$

Substituting terms into the second order Taylor expansion then yields the desired result.

□

Thus, high fees do not make uniform prices costly. Rather, it is dispersion in fees among the accepted cards that makes uniform prices costly. Thus, increasing the number of competitors has no effect on the incentives to surcharge if all networks end up charging symmetric fees regardless. With my estimated value of σ =7, the losses from uniform pricing are on the order of 16 *basis points* of profit.

C.3.3 Gains from Charging One Credit Card Versus Another

The above results focus on why surcharges on card versus cash are ineffective, but in practice merchants also fight for the right to differentially surcharge cards, e.g., surcharge AmEx higher than Visa or MC (Conrath, 2014). One challenge, however, is that the benefits of steering are linear in the difference in fees between the (historically) high fee network (e.g., AmEx) and the low fee network (e.g., Visa). However, the costs of steering are fixed (e.g., the amount of time to tell a consumer, the counter space for a sign). If there are any fixed costs of charging discriminatory prices, in a neighborhood of any type symmetric equilibrium, no merchants would surcharge. This means that the networks' first order conditions would still be satisfied at the original type-symmetric equilibrium even if merchants are allowed to differentially surcharge. While it may be possible for networks to deviate with a non-local fee cut, I leave that analysis for future work.

D Micro-Foundation for First and Second Choices

This note outlines a micro-foundation by which consumers' secondary cards can be used to identify hypothetical second choices for primary card. I assume consumers have wallets with two cards: a primary card and a secondary card. The consumer usually uses the primary card and with some small probability uses the secondary card. Periodically, consumers re-assess their primary card and choose primary cards of different brands with some probabilities. If the brand of the primary card changes, the consumer then downgrades the existing primary card to secondary status, and the new card becomes the primary card.

The conditional distribution of the secondary card conditional on the brand of the primary card will then have the same distribution as second choices for primary cards conditional on the primary card. In other words, the fact that Visa cards are often found in wallets of primary AmEx users will mean that Visa is a close substitute for AmEx.

D.1 Environment and Proof

Let time be discrete $t = 1, 2, \ldots$. For consumer i at time t, suppose that the utility from choosing a card $j \in \{1, \ldots, J\} \equiv \mathcal{J}$ is

$$u_{ijt} = \delta_{ij} + \epsilon_{ijt}$$

Suppose her wallet at time t contains two cards, $w_t = (p_t, s_t)$, where $p_t \in J$ is the primary card and s_t is the secondary card. Then at time $t+1$, the consumer draws new utilities and chooses a new primary card $p_{t+1} \in J$ that yields the highest utility. If $p_{t+1} = p_t$, then the wallet does not change and $w_{t+1} = w_t$. Otherwise, the new primary card changes, and then the old primary card becomes the new secondary card $s_{t+1} = p_t$. Hence, $w_{t+1} = (p_{t+1}, s_{t+1})$.

Theorem 4. *The joint stationary distribution of w_t is the same as the joint distribution of first and second choices, that is*

$$P\left(\left(u_{ijt} = \max_{l \in \mathcal{J}} u_{ikt}\right) \cap \left(u_{ikt} = \max_{l \in \mathcal{J} \setminus \{j\}} u_{ilt}\right)\right) = P\left(p = j, s = k\right)$$

Proof. Suppress i for clarity. The probability of choosing j is

$$q\left(j\right) = \frac{\exp\left(\delta_j\right)}{\sum_{l \in \mathcal{J}} \exp\left(\delta_l\right)}$$

The joint distribution of first and second choices comes from a standard result on logit choice probabilities:

$$P\left(\left(u_{jt} = \max_{l\in\mathcal{J}} u_{ikt}\right) \cap \left(u_{kt} = \max_{l\in\mathcal{J}\setminus\{j\}} u_{lt}\right)\right) = q\left(j\right) \times \frac{q\left(k\right)}{\sum_{l\neq j} q\left(l\right)}$$

Next we calculate the joint stationary distribution of the wallets w_t. Denote this stationary distribution with P. Fix the wallet $w_{t+1} = (p_{t+1}, s_{t+1})$ at time $t+1$. For this to have occurred, there are two possibilities for the wallet at time t. In the first case, the wallet did not change and $w_{t+1} = w_t$. This happens with probability $q\left(p_{t+1}\right) P\left(w_{t+1}\right)$. In the second case, a new primary card was chosen at time $t+1$ such that the primary card is p_{t+1} and the secondary card was s_{t+1}. This happens with probability

$$\begin{aligned} q\left(p_{t+1}\right) \sum_{k=1}^{J} P\left(w_t = \left(s_{t+1}, k\right)\right) &= q\left(p_{t+1}\right) q\left(s_{t+1}\right) \sum_{w_{t-1}} P\left(w_{t-1}\right) \\ &= q\left(p_{t+1}\right) q\left(s_{t+1}\right) \end{aligned}$$

We can then drop time subscripts, and the stationary distribution P must then be determined by:

$$\begin{aligned} P\left(w\right) &= q\left(p\right) P\left(w\right) + q\left(p\right) q\left(s\right) \\ P\left(w\right) &= \frac{q\left(p\right) q\left(s\right)}{1 - q\left(p\right)} \\ &= q\left(p\right) \times \frac{q\left(s\right)}{\sum_{l\neq p} q\left(l\right)} \end{aligned}$$

Which is the same as Equation D.1.

□

D.2 Discussion

This works because an IIA assumption holds conditional on i. For a given i, if a particular card p is the primary card, then the probability a different card is the second choice is determined by just dividing the probabilities.

The assumption that the primary card changes only if the new primary card is a different brand helps to map the thought experiment to my empirical work. In my empirical work, the secondary card counts any card brand with any amount of positive spending. Therefore, if a Visa/Mastercard multi-homer decides to add a new Visa card to her wallet, provided that she puts some positive spending on Mastercard, I will count her secondary card as Mastercard. Adding a new card does not change primary/secondary status if the new card has the same brand as the old primary card.

The model is consistent with different cards being complements for each other because they have different rewards categories, provided that the different networks have similar coverage of the rewards categories. For example, the trigger for getting a new card may be a desire to get a credit card in a new rewards category. But provided that the choice probabilities for each network do not depend on the rewards category, the above micro-foundation shows that primary and secondary cards can still reveal hypothetical first and second choices.

E Survey Evidence on Consumer View of Credit Cards

Survey evidence from the SCPC and external marketing surveys suggests a sizeable fraction of consumers dislike the non-price characteristics of credit cards as a payment instrument, so that credit card use is crucially supported by the high levels of rewards.

Table E.1: Survey data on why consumers choose their preferred payment instrument

	Cash	Debit, Low Credit Share	Debit, High Credit Share	Credit
Budget control	0.15	0.09	0.09	0.04
Convenience	0.31	0.40	0.41	0.28
Rewards	0.00	0.02	0.03	0.28

Notes: Consumers are split into four groups: those who prefer to use cash as their main non-bill payment instrument, those who prefer debit but have a below median utilization of credit cards (relative to all debit card users), those who prefer debit but have an above median utilization of credit cards, and those who prefer credit cards. Each variable is equal to 1 if the consumer reports the feature as the "most important characteristic" of the preferred payment instrument in making purchases. All averages and shares are calculated with individual level sampling weights.

Fear of overspending is a significant concern for many consumers. Table E.1 summarizes data from the DCPC on the reasons consumers choose their primary payment method. Around 15% and 9% of primary cash and debit card users say they pay with cash or debit because it helps them control their budget, compared to 4% of credit card users who report the same response. This is consistent with marketing surveys that show around a quarter of consumers report feeling "impulsive," "anxious," or "overwhelmed" when using a credit card, twice the rates from debit card use (Issa, 2017).

There is also some evidence that some consumers find debit cards simpler to use. Table E.1 shows that debit card consumers are around 10 percentage points more likely than credit card consumers to choose their primary payment method based on convenience. Given that debit and credit cards have similar physical forms, the convenience here potentially refers to any concerns about making sure to make on-time payments, or the simple fact that debit cards come already bundled with checking accounts. An important strand of the household finance literature emphasizes that banks make large profits off of unsophisticated consumers by charging hidden fees (Gabaix and Laibson, 2006; Agarwal et al., 2022). If some consumers are sophisticated behavioral agents, they will anticipate these fees, find credit cards less convenient to use, and avoid credit cards.

Some consumers may also be debt averse. Around 37% of consumers who do not have a credit card say they "prefer not to carry any debt" as the reason they do not have a card, whereas only 26% say they do not qualify for a credit card (Boehm, 2018). Behavioral marketing research finds that some consumers prefer to time payments with consumption so that the pain of payment occurs before enjoying the purchase (Prelec and Loewenstein, 1998).

The fact that 28% of credit card consumers say that the most important reason they pay with credit cards is for the rewards suggests that these consumers would not use credit cards without the rewards. This suggests that even many credit card consumers dislike the non-price characteristics of credit cards as a payment instrument.

F Buy Now, Pay Later

In this counterfactual, I show that the entry of a new payment network that shares characteristics with credit cards and emerging fintech payment apps increases merchant fees and consumer rewards and decreases consumer and total welfare. This highlights how the lessons of the model can be used to study new technological entrants.

Some of the fastest growing payment networks are Buy Now, Pay Later (BNPL) companies like Affirm or Klarna that charge merchants around 5-6% merchant fees to fund interest free loans to finance consumer purchases. On the consumer side, these new companies substitute most directly with credit cards (Garg et al., 2022). Merchants accept BNPL despite the high fees because it lets merchants sell more, even if the merchant already accepts credit cards and the consumer owns a credit card (Di Maggio et al., 2022; Berg et al., 2022; Bian et al., 2023).

I model the new app much as I model Discover in the main text, but give it a new payment type $\chi^j = A$. This means that a merchant who only accepts credit cards—but not the app—loses some sales from app users who own credit cards. Given these characteristics and costs, I can solve for the new equilibrium after the app enters.

The assumption that the entrant is a new payment type is consistent with studies of e-commerce that consumers who prefer alternative payment methods are unwilling to substitute to cards when their preferred method is not available (Berg et al., 2022). The assumption can also be justified by the way new platforms are combining commerce and other financial services with payments into "superapps." Not accepting the app would reduce demand from consumers who use the app even if those consumers own credit and debit cards.[36]

The main difference between such an entrant and a traditional credit card network is that merchants are even more fee-insensitive. While consumers can substitute to traditional credit cards, merchants cannot serve app consumers by accepting credit cards. The entrant charges merchant fees of 2.3% and pays rewards of 1.6%. These are 0.4% and 0.3% higher than American Express' baseline fees and rewards, respectively. The effect of the entrant's high merchant fees and consumer rewards are amplified by incumbent credit card networks' competitive response. They also raise their fees by 8 bps to fund 14 bps more rewards.

The larger increases in fees and rewards then amplify the distributional and total

[36]For example, in their 2021 financial results "buy now pay later" platform, Klarna argues that "the Klarna app is now the single largest driver of [gross merchandise volume] across the Klarna ecosystem, fueling growth for Klarna and its retail partners through consumer acquisition and referrals... our app is becoming a central place in our consumers' financial lives."

welfare effects relative to a new credit card network. Cash and debit card users now lose 16 and 9 bps of consumption, respectively. Annual consumer and total welfare fall by $7 and $10 billion, respectively.

G Additional Tables

Table G.1: Summary statistics of Nilson Report panel

	N	Mean	P25	P50	P75
Assets	285	28337.32	4001.97	8593.27	28846.41
Credit	266	1544.07	401.00	627.23	1628.75
Debit	266	5547.77	1241.00	2526.00	5940.25
Signature Debit	259	3307.77	810.00	1348.00	2913.00
Sig Debit Ratio	242	0.65	0.58	0.67	0.77
Treated	285	0.44	0.00	0.00	1.00

Notes: Treated refers to whether the financial institution had more than $10 billion in assets in 2010. Assets are measured in millions. Credit, Debit, Signature Debit all refer to measures of card volumes in millions.

Table G.2: Summary statistics of the Homescan sample

	N	Mean	P25	Median	P75
Years per Household	92107	3.06	1.00	2.00	5.00
Transactions	92107	500.49	134.00	306.00	669.00
Average Tx Size	92107	56.62	35.41	49.56	69.43

Table G.3: Comparing Homescan payment shares to aggregate shares

Payment Method	Homescan	Nilson
AmEx	0.04	0.10
Cash	0.24	0.20
Debit	0.37	0.33
MC	0.11	0.11
Visa	0.24	0.26

Notes: Homescan payment shares are calculated by summing all the dollars spent on each payment method and dividing by the total spending.

Table G.4: Event study estimates for the effect of the Durbin Amendment on signature credit, debit card, and total volume

	Interchange	Signature Debit	Credit	All Cards
Treat, t=-4	-0.049	-0.015	-0.231**	-0.157**
	(0.092)	(0.057)	(0.071)	(0.054)
Treat, t=-3	0.080	0.020	-0.052	-0.041
	(0.090)	(0.035)	(0.084)	(0.033)
Treat, t=-2	-0.082	0.014	-0.098*	-0.030
	(0.075)	(0.025)	(0.043)	(0.024)
Treat, t=0	-0.013	-0.100*	0.119***	-0.029
	(0.063)	(0.039)	(0.029)	(0.034)
Treat, t=1	-0.473***	-0.145**	0.096	-0.033
	(0.113)	(0.050)	(0.067)	(0.036)
Treat, t=2	-0.400**	-0.228***	0.205**	-0.056
	(0.126)	(0.060)	(0.067)	(0.043)
Treat, t=3	-0.395**	-0.304***	0.303***	-0.104*
	(0.118)	(0.057)	(0.077)	(0.047)
N	270	259	266	242
Bank FE	X	X	X	X
Year FE	X	X	X	X
Cluster N	36	36	36	36

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table G.5: Subgroup analysis for the effect of card preference on the likelihood the consumer shops at a store that accepts card

	Credit vs Debit	Singlehome	Singlehome CC	Income Group
Prefer Credit	0.24*			
	(0.11)			
Prefer Debit	0.32**			
	(0.10)			
Singlehome X Prefer Card		0.11	0.06	
		(0.13)	(0.09)	
Prefer Card		0.27**	0.26**	0.41**
		(0.09)	(0.09)	(0.13)
High Income X Prefer Card				-0.22
				(0.17)
N	28987	28987	28987	28987
State, year FE	X	X	X	X
Transaction controls	X	X	X	X
Consumer controls	X	X	X	X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

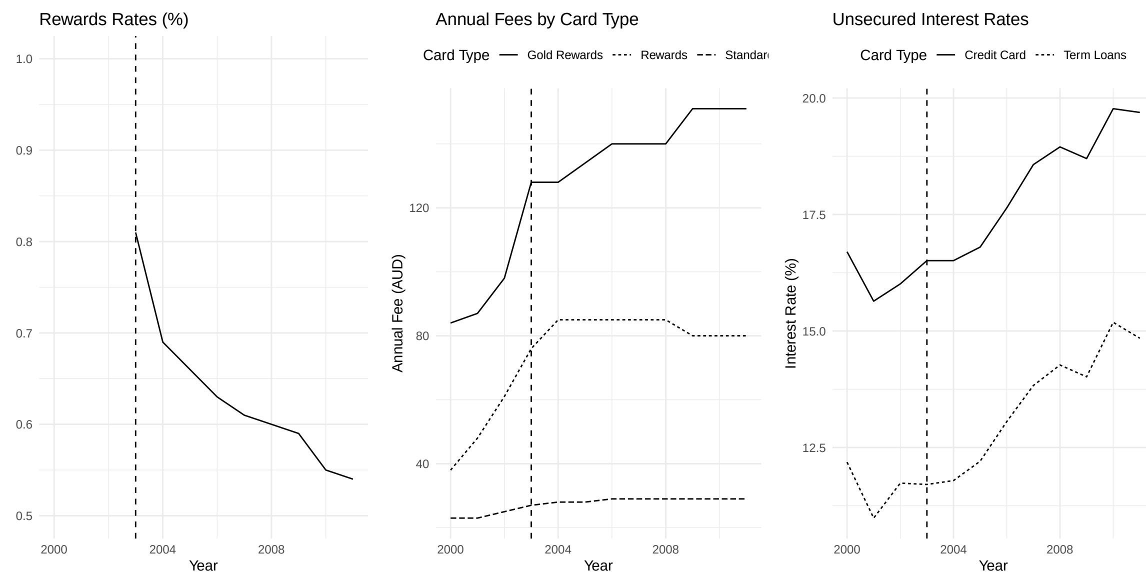
Notes: Standard errors are clustered at the consumer level. Transaction Char. FE refers to FE's for the ticket size, the merchant type (e.g., restaurant or retail). Consumer Char. FE refers to FE's for the consumer's income, education, credit score, and age

Table G.6: The average share of total card spending on consumers' top two cards split by the primary card of each consumer

Primary Card	Primary Share	Secondary Share	Top Two Total
AmEx	0.76	0.18	0.95
Visa	0.81	0.15	0.97
MC	0.77	0.18	0.95
Debit	0.86	0.11	0.97

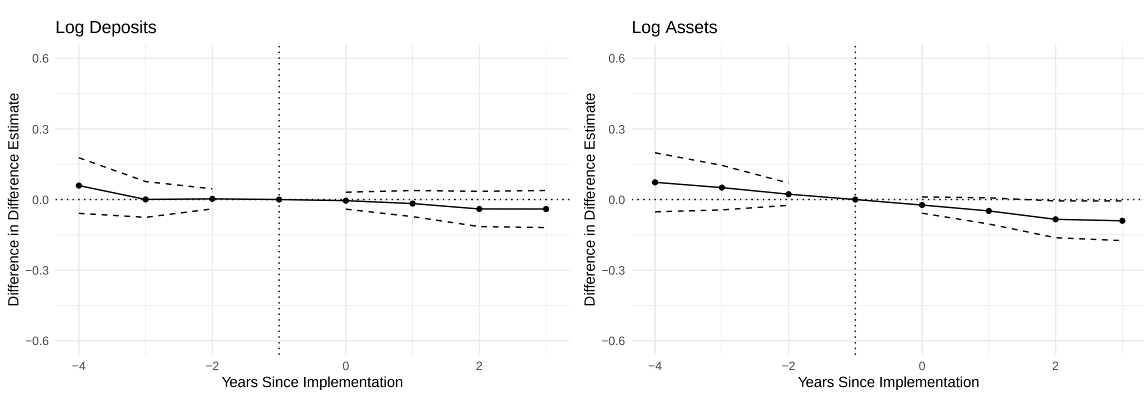
H Additional Figures

Figure H.1: Key changes in the Australian credit card market after interchange regulation



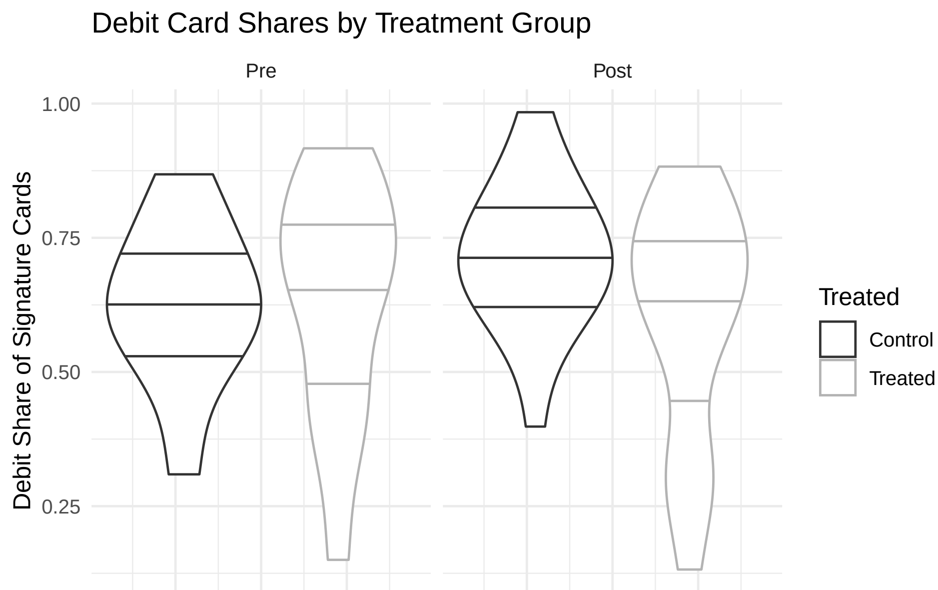
Notes: The vertical line marks the 2003, the start of interchange regulation in Australia. 'Gold' refers to the highest tier of rewards credit cards, whereas 'Rewards' refers to the basic tier of rewards credit cards. 'Basic' refers to credit cards without rewards. Data on rewards comes from Chan et al. (2012). The data on annual fees comes from annual reports on "Banking Fees in Australia". Interest rate data is from the F05 interest rate publication from the Reserve Bank of Australia.

Figure H.2: The effect of the Durbin Amendment on deposits and assets



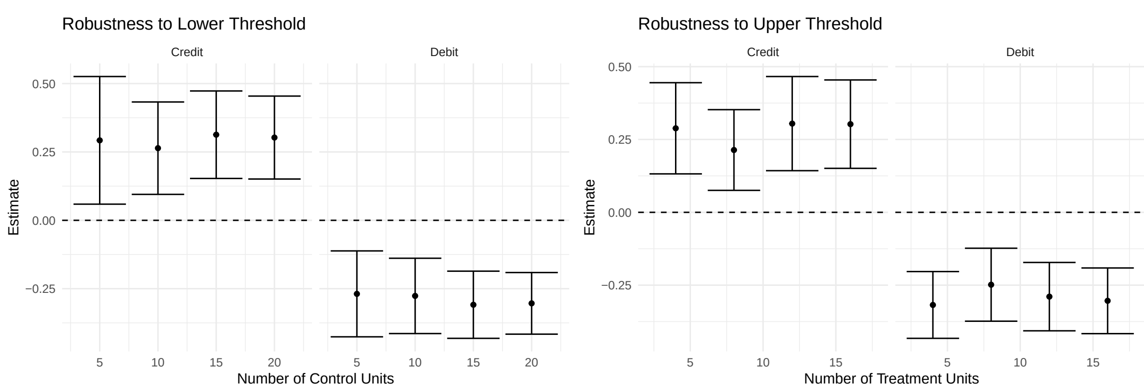
Notes: The vertical line marks 2010, the year before the policy began to be implemented.

Figure H.3: Comparing debit versus credit shares at treatment and control banks



Notes: For each bank, I calculate the average share of signature debit card transactions as a share of signature debit and credit card volume in the pre-Durbin period and the post-Durbin period. Each panel shows a violin plot illustrating the distribution of debit shares for the control (<$10 billion in assets in 2010) and treatment banks (>$10 billion) in the pre and post periods. The dashed lines show the 25th, 50th, and 75th percentiles of each distribution. The distributions exhibit substantial overlap.

Figure H.4: Testing robustness of estimate to varying asset size cutoffs



Notes: I re-run the difference-in-difference regressions for credit and debit card volumes while changing the size of the control group (left graph) or the treatment group (right graphs). I change the size by moving the minimum asset requirement up towards $10 billion (for the control group) or by moving the maximum asset size down towards $10 billion (for the treatment group) until the treatment or control group is of the desired size. I find the estimates do not substantially change as the control and treatment groups change.

I Differentiating Expectations of Non-differentiable Functions

Suppose $f : \mathbb{R}^N \to \mathbb{R}$ is continuous but non-differentiable. Then by a standard convolution theorem

$$\begin{aligned} h : \mathbb{R}^N &\to \mathbb{R} \\ \mu &\mapsto \mathbb{E}\left[f\left(X\right)\right], X \sim N\left(\mu, \sigma^2 I\right) \end{aligned}$$

is differentiable. This note explains how to efficiently compute an approximation to the partial derivatives of h. This is non-trivial because the standard Monte Carlo approximation of h as $\hat{h} = N^{-1}\sum_{i=1}^{N} f\left(X_i\right)$ where $X_i \sim N\left(\mu, \sigma^2 I\right)$ does not generate a differentiable function in μ.

The key trick is to use the fact that convolution and differentiation commute. Let $g\left(x\right) = \mathbb{E}\left[f\left(X_1, \ldots, X_N\right) | X_1 = x\right]$. Then by the law of iterated expectations, we get the one-dimensional integral:

$$\begin{aligned} \mathbb{E}\left[f\left(X\right)\right] &= \mathbb{E}\left[g\left(X_1\right)\right] \\ &= \frac{1}{\sqrt{2\pi\sigma^2}} \int_{\mathbb{R}} g\left(z\right) \exp\left(-\frac{1}{2\sigma^2}\left(z - \mu_1\right)^2\right) \mathrm{d}z \end{aligned} \tag{31}$$

where μ_1 is the first term in μ. Interchanging differentiation and integration yields

$$\frac{\partial}{\partial \mu_1}\mathbb{E}\left[f\left(X\right)\right] = \frac{1}{\sqrt{2\pi\sigma^2}} \int_{\mathbb{R}} g\left(z\right) \frac{z - \mu_1}{\sigma^2} \exp\left(-\frac{1}{2\sigma^2}\left(z - \mu_1\right)^2\right) \tag{32}$$

Equations 31 and 32 provide integral expressions for the expectation and the derivative of the expectation. To approximate these expectations, one can simulate g with standard Monte Carlo techniques as $\hat{g}$. While $\hat{g}$ will not be differentiable, by the convolution theorem expressions 31 and 32 will both be differentiable even if g is replaced by $\hat{g}$. The remaining integral can then be calculated efficiently by Gauss-Hermite quadrature.