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# Collectible Pricing and Collector Utility: The Role of Production Commitments

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**Abstract**

This paper investigates the effect of production commitments on consumers of collectable goods. Using data on prices for *Magic: The Gathering* trading cards, we estimate that the reprinting of certain card varieties caused a 34% decrease in the relative price of reprinted cards. We interpret this estimate with a model of a forward-looking consumer that views collectibles as both a source of enjoyment and a store of wealth. Using a mapping between structural parameters of the model and difference-in-differences regression parameters, we compute lifetime discounted utility decreased by as much as 14% for collectors holding mainly reprinted cards.

**JEL Codes**: D4, L1, L2

**Keywords**: production commitments; secondary markets; collectibles; demand estimation

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Collectibility is an important part of a trading card game. We also feel that gameplay is important, and when the two conflict, we choose gameplay over collectibility.

*Peter Adkison* (Founder & CEO of Wizards of the Coast from 1990-2001), Excerpt from *Scrye* magazine (March, 1996)

# 1 Introduction

Collectable goods are a common investment choice across the wealth distribution. This asset class accounts for 3 to 5 percent of all private wealth, and survey evidence[1] suggests that collectibles are most popular among low-income individuals.[2] While collectibles markets are well-studied by economists (Stoller, 1984; Stone & Warren, 1999; Dimson & Spaenjers, 2011; Dimson, Rousseau, & Spaenjers, 2015; Lovo & Spaenjers, 2018; Pénasse, Renneboog, & Scheinkman, 2021), the focus is typically limited to luxury goods trading in relatively illiquid secondary markets.

In this paper, we study the market for an accessible and actively-traded collectible: the market for *Magic: The Gathering* (*MTG*) trading cards. We apply economic theory and econometric methods to demonstrate the adverse effects collectible goods producers inflict on collectors through production commitments. We argue that the vulnerability of collectors to the future actions of collectible producers is particularly important in markets with low-income consumers, and that the actions of producers cause significant changes in collector lifetime discounted utility through the secondary market price of collectibles.

We estimate price and welfare effects resulting from an unexpected and controversial production decision made by the original producer of *Magic the Gathering*, Wizards of the Coast (WotC). In 1995, in a purported measure to maintain the competitive integrity of the *MTG* card game, WotC surprised consumers by reprinting 166 original rare cards from its expansion sets.[3] This abrupt change in policy from WotC led to criticism from early adopters and secondary-market dealers whose card holdings decreased in value. In 1996, WotC addressed consumer's concerns by defining an explicit reprint policy that included both a list of cards it would *never* reprint—known as the Reserved List—and a set of explicit forward-looking criteria it would use to update the Reserved List.

We quantify short-term price effects from these policy changes using hand-collected prices from the trade magazine *Scrye*. Produced by WotC from from 1994 to 2009, *Scrye* summarized secondary-market prices.

[1] For a detailed overview on collectable goods markets, see this 2020 report by Credit Suisse Research Institute. This 2022 survey in *Magnify Money* reports those with income less than $35,000 invest nearly 8% of their income on collectibles, while those in higher income brackets invest between 4 and 7%.

[2] The term "collectable" is an adjective used to describe objects that may be collected, while "collectible" is a noun for such an object. Note that, for example, "prices of collectable goods" should also be written as "collectibles prices," as the prices are not the collectable object.

[3] We use the term "1995 Reprinting" to refer to this specific reprinting episode, "1995 Reprinting Set" when referring to the set of reprinted cards themselves, and, when there is no confusion, "reprinting" to refer to either a reprinting decision or a reprinted card.

Figure 1 displays the interior of a typical *Scrye* publication.

MAGIC: THE GATHERING BETA CARD LIST

| Col | Type | Rar | HIGH | MEDIAN | LOW | CARD NAME |
|---|---|---|---|---|---|---|
| U | Su | U | $ 3.30 | $ 3.00↑ | $ 3.00 | Glasses of Urza |
| U | Ins | R | $30.00 | $25.00↑ | $19.00 | Gloom |
| U | EAr | U | $ 3.50 | $ 3.00↑ | $ 2.80 | Goblin Balloon Brigade |
| B | ED | U | $ 3.00 | $ 2.00↑ | $ 1.50 | Goblin King |
| W | EW | R | $ 8.80 | $ 8.50↑ | $ 5.50 | Granite Gargoyle |
| A | C | R | $ 8.60 | $ 6.80↑ | $ 6.00 | Gray Ogre |
| W | Sor | R | $13.00 | $11.00↑ | $ 7.00 | Green Ward |
| G | ECr | R | $12.50 | $10.50↑ | $ 7.30 | Grizzly Bears |
| B | E | R | $10.25 | $ 9.50↑ | $ 7.60 | Guardian Angel |
| B/R | DL | R | $11.00 | $ 9.50↑ | $ 7.40 | Healing Salve |
| W | Sor | R | $11.50 | $ 9.00↑ | $ 5.90 | Helm of Chatzuk |
| A | M | U | $ 3.30 | $ 3.00↑ | $ 2.80 | Hill Giant |
| B/G | DL | R | $10.50 | $ 9.30↑ | $ 6.10 | Holy Armor |
| W | Su | C | $ 0.70 | $ 0.50 | $ 0.30 | Holy Strength |
| G | Ins | U | $10.00 | $ 8.00↑ | $ 7.00 | Howl from Beyond |
| G | Su | R | $11.50 | $ 8.00 | $ 6.00 | Howling Mine |
| B | Su | U | $ 4.10 | $ 3.50↑ | $ 3.00 | Hurloon Minotaur |
| A | M | R | $50.00 | $40.00↑ | $27.00 | Hurricane |
| A | C | U | $ 5.00 | $ 3.00 | $ 3.00 | Hypnotic Specter |
| W | ECr | U | $ 2.50 | $ 2.00 | $ 2.00 | Ice Storm |
| W | Ins | R | $27.50 | $19.00↑ | $14.75 | Icy Manipulator |
| W | ECr | R | $12.00 | $10.00↑ | $ 7.80 | Illusionary Mask |
| U | Int | C | $ 0.90 | $ 0.60↑ | $ 0.30 | Instill Energy |
| W | ECr | U | $ 2.50 | $ 2.00↑ | $ 2.00 | Invisibility |
| B | Su | U | $ 3.60 | $ 3.00 | $ 3.00 | Iron Star |
| U | Sor | R | $11.75 | $10.00↑ | $ 8.30 | Ironclaw Orcs |
| R | ECr | U | $ 3.00 | $ 2.00↑ | $ 2.00 | Ironroot Treefolk |
| G | Ins | U | $ 8.40 | $ 5.80↑ | $ 3.20 | Island Sanctuary |
| W | E | U | $ 3.00 | $ 3.00↑ | $ 2.30 | Island Blue |
| A | M | U | $ 3.00 | $ 3.00↑ | $ 2.50 | Island Golden |
| G | Sor | U | $ 3.50 | $ 3.00 | $ 2.50 | Island Red |
| A | M | R | $33.50 | $19.00↑ | $16.25 | Ivory Cup |
| R | Int | R | $ 8.80 | $ 6.50↑ | $ 4.60 | Jade Monolith |
| W | E | C | $ 0.80 | $ 0.60↑ | $ 0.40 | Jade Statue |
| W | E | C | $ 0.70 | $ 0.50↑ | $ 0.40 | Jayemdae Tome |
| W | E | C | $ 0.70 | $ 0.50↑ | $ 0.40 | Juggernaut |
| W | E | C | $ 0.70 | $ 0.50↑ | $ 0.40 | Jump |

| Col | Type | Rar | HIGH | MEDIAN | LOW | CARD NAME |
|---|---|---|---|---|---|---|
| A | M | U | $ 3.30 | $ 3.00↑ | $ 2.00 | Psionic Blast |
| B | E | U | $ 3.00 | $ 3.00 | $ 2.90 | Psychic Venom |
| R | Su | U | $ 2.50 | $ 2.00↑ | $ 1.80 | Purelace |
| R | Su | R | $11.25 | $10.00↑ | $ 7.10 | Raging River |
| R | Su | R | $11.75 | $11.00↑ | $ 7.30 | Raise Dead |
| R | Su | C | $ 0.90 | $ 0.50 | $ 0.30 | Red Elemental Blast |
| W | E | U | $ 2.00 | $ 2.00↑ | $ 1.80 | Red Ward |
| G | Su | C | $ 0.70 | $ 0.50↑ | $ 0.30 | Regeneration |
| W | Ins | C | $ 0.50 | $ 0.50↑ | $ 0.30 | Regrowth |
| W | Ins | C | $ 0.70 | $ 0.50↑ | $ 0.30 | Resurrection |
| A | M | R | $10.00 | $ 9.00↑ | $ 6.50 | Reverse Damage |
| R | Su | C | $ 0.90 | $ 0.60↑ | $ 0.30 | Righteousness |
| W | ECr | C | $ 0.50 | $ 0.50↑ | $ 0.30 | Roc of Kher Ridges |
| W | ECr | C | $ 0.90 | $ 0.60↑ | $ 0.30 | Rock Hydra |
| B | Ins | C | $ 0.50 | $ 0.50 | $ 0.30 | Rod of Ruin |
| A | C | R | $10.00 | $10.00↑ | $ 6.30 | Royal Assassin |
| R | Su | C | $ 0.90 | $ 0.60↑ | $ 0.30 | Sacrifice |
| G | Sor | U | $ 3.00 | $ 3.00↑ | $ 2.50 | Samite Healer |
| B | Su | U | $ 5.00 | $ 4.30↑ | $ 3.40 | Savannah |
| G | Sor | U | $ 8.50 | $ 5.50↑ | $ 3.50 | Savannah Lions |
| A | M | U | $22.00 | $20.00↑ | $11.25 | Scathe Zombies |
| A | P | R | $25.00 | $18.00↑ | $10.50 | Scavenging Ghoul |
| G | ECr | U | $ 3.00 | $ 2.00 | $ 1.90 | Scrubland |
| U | ECr | C | $ 4.00 | $ 1.50↑ | $ 1.50 | Scryb Sprites |
| A | P | U | $ 3.00 | $ 2.50↑ | $ 2.30 | Sea Serpent |
| R | Su | C | $ 1.30 | $ 0.60↑ | $ 0.40 | Sedge Troll |
| G | Su | C | $ 1.00 | $ 0.40 | $ 0.30 | Sengir Vampire |
| W | E | R | $ 9.50 | $ 9.00↑ | $ 6.00 | Serra Angel |
| U | L | C | $ 0.30 | $ 0.10↓ | $ 0.10 | Shanodin Dryads |
| U | L | C | $ 0.30 | $ 0.10↓ | $ 0.10 | Shatter |
| U | L | C | $ 0.30 | $ 0.10↓ | $ 0.10 | Shivan Dragon |
| A | P | U | $ 2.90 | $ 2.50↑ | $ 2.10 | Simulacrum |
| A | P | R | $ 8.80 | $ 6.00↑ | $ 5.50 | Sinkhole |
| A | M | U | $11.25 | $ 7.00↑ | $ 4.40 | Siren's Call |
| A | M | R | $ 9.50 | $ 9.00↑ | $ 6.60 | Sleight of Mind |
| A | AC | U | $ 3.60 | $ 3.00 | $ 3.00 | Smoke |
| U | Ins | C | $ 0.50 | $ 0.40 | $ 0.30 | Sol Ring |

| Col | Type | Rar | HIGH |
|---|---|---|---|
| U | Ins | C | [illegible] |
| U | EL | C | [illegible] |
| W | Int | R | [illegible] |
| R | E | R | [illegible] |
| B | Sor | C | [illegible] |
| R | Ins | C | [illegible] |
| W | ECr | U | [illegible] |
| G | ECr | C | [illegible] |
| G | Sor | C | [illegible] |
| W | Sor | U | [illegible] |
| W | Ins | R | [illegible] |
| W | Ins | R | [illegible] |
| R | Su | R | [illegible] |
| R | Su | R | [illegible] |
| A | M | U | [illegible] |
| B | Su | R | [illegible] |
| B | Int | U | [illegible] |
| W | Su | C | [illegible] |
| G/W | DL | R | $11.00 |
| W | Su | R | $10.00 |
| B | Su | C | $ 0.70 |
| B | Su | U | $ 1.00 |
| B/W | DL | R | $11.00 |
| G | Su | C | $ 0.50 |
| U | Su | C | $ 0.90 |
| R | Su | R | $15.00 |
| B | Su | U | $ 7.30 |
| W | Su | U | $ 9.50 |
| G | Su | C | $ 0.50 |
| R | Ins | C | $ 0.90 |
| R | Su | R | $25.00 |
| B | Ins | U | $ 3.00 |
| B | Sor | C | $ 4.50 |
| U | Ins | U | $ 3.00 |
| U | Int | R | $10.50 |
| R | E | R | $10.00 |
| A | M | U | $ 5.30 |

Figure 1: **Scrye Magazine Interior (1995).** This figure shows part of a scanned image of the interior of *Scrye* #3 published in 1995. The excerpt from this specific magazine shows card names for LEB as of the time of publication. "HIGH," "MEDIAN," and "LOW" columns correspond to the upper, median, and lower quartile of secondary market prices for the listed card.

We use price data from *Scrye* issues published from 1995 Q3 to 1997 Q1 to create a quarterly panel data set for more than 389 unique *MTG* cards.[4] Difference-in-differences and event study analyses show large and meaningful effects on price for both the 1995 Reprinting and Reserved List policy changes. In the 8 quarters after the 1995 Reprinting and Reserved List, we find a 38% decrease in the price of reprinted expansion-set cards relative to the price of non-reprinted expansion-set cards.[5] Event study estimates indicate secondary-market prices decreased approximately 23% between the 1995 Reprinting and Reserved List announcement date and an additional 25% following the announcement of the Reserved List. We interpret the 39.53% relative price decrease in the final quarter of our sample, 1997 Q1, as a new steady-state price incorporating WotC's explicit commitments to limit future card supply. While these events illustrate short-run price effects, for investment purposes, long-term returns may be more relevant. We find that between 1996 Q1 and June of 2023, cards in the 1995 Reprinting Set experienced a 3.1% annualized price appreciation, while cards on

[4] We later quantify long-term price effects using prices collected in June of 2023 from MTGStocks, an online price aggregator. MTGStocks collects transaction and listing data from eBay and TCGPlayer through a webscraping tool.

[5] That is, a 0.41 unit decrease in log-price.

the Reserved List experienced a 6.6% annualized price appreciation. In June of 2023, median prices for cards in the 1995 Reprinting Set and Reserved List were $47 and $244, respectively.

Supply decisions that increase the stock of cards are beneficial for gameplay purposes but detrimental for investment purposes. To quantify consumer welfare changes caused by the firm's commitment to limit production, we use a dynamic model of secondary-market demand for collectible goods. Each period, a representative collector adjusts her portfolio of collectibles to maximize lifetime discounted utility subject to a budget constraint. The portfolio mimics the dual nature of collectibles as both a source of utility and an investment vehicle: the agent gains contemporaneous utility from her portfolio of collectibles and uses the portfolio of collectibles to transfer wealth to the next period. Solving the dynamic model yields recursive inverse demand curves for each collectible in the portfolio. The price of any given collectible is decreasing in the stock of cards, increasing in future price, and increasing in its idiosyncratic gameplay value. Assuming the pre-1995 Reprint and post-Reserved List time periods correspond to two different steady states allows us to use difference-in-differences estimates to identify structural parameters necessary for welfare calculations.

In our model, producers destroy collector welfare by increasing the stock of cards. More specifically, inverse demand for a specific card is a function of the per-player stock of collectible cards. Per-player card holdings—the ratio of the stock of cards divided by the number of consumers—represent the collectible producer's reprinting policy. For example, if the number of players is growing, but the stock is fixed, this ratio is less than one; alternatively, if the number of players grows and the stock increases at the same rate, this ratio is equal to one. Our structural model allows us to use difference-in-differences estimates to identify changes in this ratio. Intuitively, variations in price caused by the reprinting policy identify the change in consumer's perceptions regarding the rate of change of the stock, up to a time-discount calibration (i.e. inflation rate of collectibles). Our estimates imply a rate of inflation for reprinted cards of nearly 1%. Depending on the specific parametrization of preferences for an incumbent collector, lifetime discounted utility decreased between 3 and 14%, due to inflation of reprinted cards decreasing stored wealth.

**Related Literature.** Our paper relates to several strands of literature. Most narrowly, it speaks to investment performance of collectibles and alternative investment assets in general. The financial returns of collectibles has been studied in Dimson & Spaenjers (2011), Goetzmann et al. (2011), Renneboog & Spaenjers (2013), Dimson et al. (2015), Goetzmann (1993), Spaenjers et al. (2015), and Dobrynskaya & Kishilova (2022) among others. However, despite the size of both primary and secondary markets, the relative novelty of collectible card games (CCGs) and the resulting lack of historical data has left this investment area relatively unstudied, with a very notable exception being Hughes (2022) (which is discussed later in this section). We contribute to the investment performance of collectibles by quantifying short and long-term returns and the determinants thereof.

This paper also contributes to the economics literature estimating structural demand for durable goods. Esteban & Shum (2007) estimate a dynamic structural model of automobile demand and supply to study the effects of durability and secondary markets on firm behavior. Chen, Esteban, & Shum (2013) calibrates a structural model in a similar setting to estimate the effect of secondary markets on the profits of durable goods manufacturers. Gillingham, Iskhakov, Munk-Nielsen, Rust, & Schjerning (2022) estimate a dynamic general-equilibrium model of automobile markets focusing, as we do, on stationary supply flow equilibria. Hodgson (2022) builds a structural model to estimate the equilibrium effect of private jet buyback schemes, in which a manufacturer accepts trade-in jets to increase demand for new units. The increase in demand for new private jets is driven by a decrease in the transaction costs of upgrading, which is also estimated in the model. Hodgson (2022) establishes substitution away from new jets caused by increased supply in secondary markets make buyback schemes a dominant strategy for only a subset of jet manufacturers.

Our structural model and its application differ from the above-mentioned studies in several important ways. First, because *MTG* gameplay requires a deck of roughly 60 not-necessarily-unique cards, we model a consumer that decides how much of each card to purchase instead of which card to purchase, hence making a continuous choice of simultaneous good consumption and not a discrete choice among mutually exclusive product options. Second, our setting includes an de facto monopolist, as *MTG* was not only the sole producer of *MTG* but also the only producer of a CCGs during our sample period, so strategic behavior between firms is of little consequence. In contrast, the above-mentioned papers estimate equilibrium models that include firm decision-making and imperfectly competitive market conditions. The simplicity of our setting allows us to estimate structural parameters using linear regression difference-in-differences estimates and with price variation alone.

Our approach is in the spirit of several recent studies, such as those by Kuminoff & Pope (2014) and Banzhaf (2021), that discuss conditions for interpreting ordinary least squares and difference-in-differences estimates in light of model primitives, consumer welfare, and causality. Specifically, Kuminoff & Pope (2014) extend a well-known economic model of housing markets to derive that translating capitalization effects into welfare measures with estimates of a first-differences regression of price requires unrealistic assumptions regarding sorting in a differentiated products market.

Cabral & Dillender (2020) estimate a difference-in-differences specification and an instrumental variables specification to compute the impact of workers' compensation on the decisions of workers, program cost, and ultimately welfare increases to workers. Building on the methodology of Chetty (2006) and Kroft & Notowidigdo (2016) that relates public benefit expenditure to economic welfare, Cabral & Dillender (2020) derive a formula for the welfare change due to a change in workers compensation benefits. The authors calibrate the formula with employment duration elasticises estimated from reduced-form models and present welfare change estimates for a variety of risk aversion parameter calibrations.

We also contribute to the literature focusing on the supply of collectibles. The supply of collectibles is related to studies on asset float including key works Hong et al. (2006), Pénasse et al. (2021). Similar in spirit, we demonstrate how both an exogenous increase and a subsequent limit to the stock of cards affects prices on the secondary market. Hughes (2022) studies prices of *MTG* cards from 2019 and identifies price variation driven by rarity (relative quantity) and not scarcity (absolute quantity). In our study, we identify structural determinants of price variation using an exogenous change to supply. Moreover, the demand problem of the structural model is written from the perspective of a representative agent, implying rarity and scarcity are the same for the collector in our model.

Finally, this study contributes to the understanding of a more general problem faced by firms, in which production decisions (such as quantity, quality, or differentiation) influence the utility from consumption of goods already purchased. In this case, a firm has an incentive to make production decisions with respect to both incumbent and new customer preferences and may maximize profit at a choice different than what would otherwise be optimal for either group. "Two-sided" markets and platforms (Rochet & Tirole, 2003; Rysman, 2009) fall into this category, where a firm strategically maximizes profit considering the interdependence of their consumers.

This paper begins by first discussing the background of *Magic: The Gathering* as the world's first trading card game and solidifying the timeline of events leading up to Wizards of the Coast's commitment to reprint certain cards in Section 2. We explain data collection and estimation of the 1995 Reprinting effect on secondary market prices in Section 3. Section 4 presents a dynamic model of lifetime collectibles consumption along with the associated estimates of structural parameters and lifetime utility loss from collectibles supply inflation. Section 5 presents estimates of long-term price effects, and Section 6 concludes.

## 2 Background and Timeline

We briefly describe the early history of *MTG* with an emphasis on how early production decisions customers contributed to the 1995 Reprinting and the Reserved List. Before Hasbro bought *MTG* for $325m in 1999, *MTG*'s origins were similar to many startups. Richard Garfield created *MTG* in 1993 as a portable version of the popular table-top role-playing game, *Dungeons and Dragons*. Unlike other successful CCGs that came later, initial demand for *MTG* did not rely on any pre-existing intellectual property or customer base.[6] As a result, WotC offered a limited release of 295 cards with a print run of 1,100 each at the tabletop gaming convention, Geneva Convention, in August 1993. Following a successful initial release, late 1993 and early 1994 were high-growth periods for *MTG*. Table I displays production information for the first twelve sets produced by WoTC.[7]

[6] The CCG associated with *Pokémon* resulted from a popular video game series and television series. The CCG *Yu-Gi-Oh* resulted from a popular television series.

[7] Print run data is harder to collect than *MTG* price data, which is presented in the following section. Former CEO of WOTC, Peter Adkison has confirmed the print runs of some sets indicated in the table, whereas many other print run values have been approximated through efforts of the community and disclosures from retailers and vendors. Some formal works like Edwards (2008) have published the most "confident" estimations of early *MTG* set print runs along with approximate print runs of newer sets based on the reverse-engineering of the individual rare card print sheets from specific sets. Nevertheless, the print numbers shown in Table I are fairly accurate and are not varying with time.

| Set Name | Set Type | Unique Cards | Rares | Non-Rares | Rare Print Run | EXP Set Rare Reprints | New Cards | Release Date |
|---|---|---|---|---|---|---|---|---|
| Alpha | CORE | 295 | 116 | 179 | 1,100 | – | 295 | 08/1993 |
| Beta | CORE | 302 | 117 | 185 | 3,200 | – | 2 | 10/1993 |
| Unlimited | CORE | 302 | 117 | 185 | 18,500 | – | 0 | 12/1993 |
| Arabian Nights | EXP | 78 | 33 | 45 | 20,500 | – | 77 | 12/1993 |
| Antiquities | EXP | 85 | 30 | 55 | 31,000 | – | 85 | 03/1994 |
| Revised Edition | CORE | 306 | 121 | 185 | 289,000 | 13 | 0 | 04/1994 |
| Legends | EXP | 310 | 121 | 189 | 19,500 | – | 310 | 06/1994 |
| The Dark | EXP | 119 | 78 | 41 | 128,000 | – | 119 | 08/1994 |
| Fallen Empires | EXP | 102 | 36 | 66 | 744,000 | – | 102 | 11/1994 |
| Fourth Edition | CORE | 368 | 121 | 247 | 353,500 | 122 | 0 | 04/1995 |
| Ice Age | EXP | 383 | 121 | 262 | 202,000 | – | 339 | 06/1995 |
| Chronicles | – | 116 | 46 | 70 | 516,500 | 116 | 0 | 07/1995 |

Table I: **Set Breakdowns.** This table displays print run information on all the early *MTG* trading card set releases.

WotC defines cards as common, uncommon, or rare based on relative within-set print runs. Table I, and our empirical analysis, focuses exclusively on rare cards as these cards were most likely held for investment purposes.

Table I clarifies why sets are classified into core sets and expansion sets. Core sets are produced annually and increase the stock of pre-existing cards. The sets *Beta* and *Unlimited* increased the stock of cards in *Alpha* from 1,100 in August 1993 to 22,800 in December of 1994. For investment purposes, WotC made it possible to easily identify vintage by varying font and borders across sets; however, within the game, vintage does not play any role. Expansion sets introduce new cards to the game but do not (in general) increase the stock of pre-existing cards. In December of 1993 and March of 1994, *MTG* released *Arabian Nights* and *Antiquities* with print runs of 20,500 and 31,000, respectively. As Table I indicates, WotC had never before produced any of the cards in these two sets.

In April of 1994, WOTC released the core set *Revised Edition* with a rare print run of 289,000. Importantly, WoTC omitted 13 cards included in previous core sets it deemed problematic for gameplay. In their place, WotC reprinted 11 rare cards from *Arabian Nights* and 2 rare cards *Antiquities*.[8] Ostensibly, WotC made the decision to promote gameplay; however, the firm also signalled it would do so by reprinting cards from expansion sets, albeit it in a limited manner.

By 1995, the limited stock and high prices of cards from the early expansion sets had created financial barriers for late adopters. In April of 1995, WotC released an its annual core set, *Fourth Edition* with a rare print run of 353,500. This core set omitted 51 cards from previous core sets and added 122 rare cards from expansion sets *Legends* and *The Dark*. At the time, this policy change implied any cards in expansion sets could be reprinted. In July 1995, WotC released an additional core set *Chronicles* with a rare print run of 516,500. This set contained 116 rare cards from multiple expansion sets. For cards in *Arabian*

[8] 26 common and uncommon cards from these sets were reprinted for a total of 39.

*Nights*, the print run in *Chronicles* represented a more than 16-fold increase in the stock. The production decisions behind *Fourth Edition* and *Chronicles* signalled to players WotC's commitment to favor gameplay over collectibility.

The release of *Chronicles* is a high-water mark in the tension between gameplay and collectibility inherent in CCGs. Responding to accumulated frustration from players and secondary-market sellers alike, WotC announced a formal reprinting policy on its website in March 1996 stating it would

1. No longer reprint cards in any current expansion set

2. Introduce a Reserved List of cards from core and expansion sets it would no longer reprint

3. Introduce forward-looking criteria for adding cards to the Reserved List

The Reserved List is seen as a compromise between players, retailers, and WotC. More importantly, by releasing the statement on its website, WotC created a formal, legally enforceable commitment mechanism.[9] The remainder of the paper examines price effects from the WotC reprinting decisions and calculates the welare effects of the Reserved List to existing players.

Figure 2 diplays a timeline of events related to *MTG*'s early operation. The releases of *4ED* and *CHR* are marked in red, representing the first change in firm policy regarding the reprinting of expansion set cards. The formal definition and announcement of reprinting policy was made in March 1996 with the implementation of the Reserved List, RL, in blue.

# 3 Estimating the Effect of Commitment on Price

## 3.1 Magic the Gathering Price Data

We use a quarterly panel of prices from *Scrye* magazine issues covering 1994 Q3 to 1997 Q1. *Scrye* reports the median, upper quartile, and lower quartile of prices. *Scrye* surveys retailers, distributors and other stakeholders who sell *MTG* cards. The 1995 Reprinting created new vintages of some, but not all, of the cards in expansion sets. *Scrye* contains prices for both originals and new vintage printings. Because we are interested in the effect of reprinting on the price of original printings, our sample includes prices for original printings and does not include prices for new vintage printings. For collectors, there is no uncertainty about the vintage of a card as all original printings have a black border and all reprints have a white border, see Figure 7.

We limit our sample to rare cards from the expansion sets *Antiquities* and *Legends*. We limit the sample to rare cards as these are most likely purchased for investment purposes and most significantly affected by the 1995 Reprinting. We limit the sample to cards in *Antiquities* and *Legends* to more easily interpret the regression coefficient. First, unlike *The Dark*, these two expansion sets had small print runs, see Table I.

[9] Although not an explicit contract between producer and consumer, the commitment mechanism is an example of the legal doctrine of *promissory estoppel*.

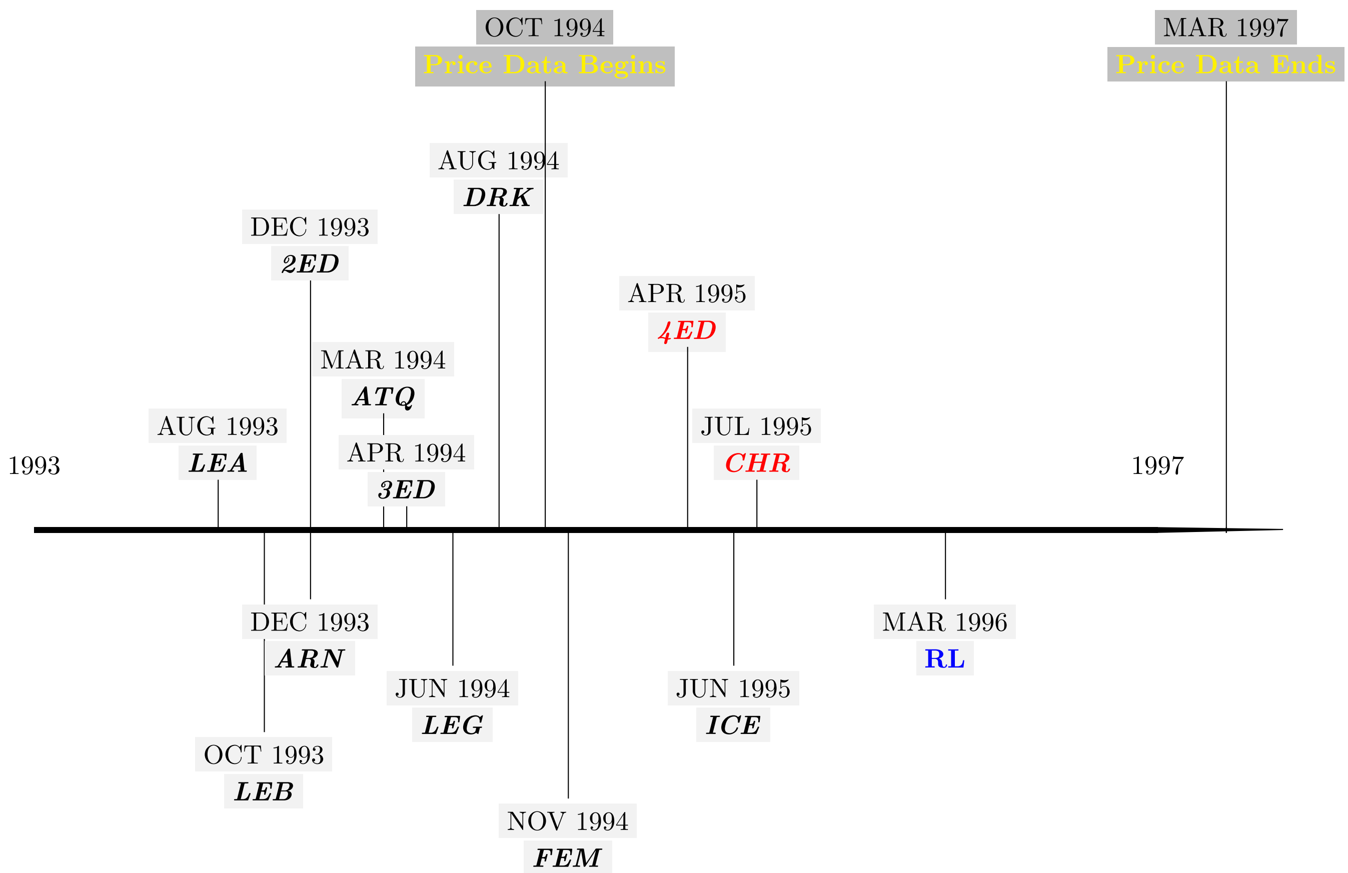


Figure 2: **Set Release Timeline.** This figure displays a timeline of every *MTG* set release from 1993 to 1996. The releases of *4ED* and *CHR*, marked in red, indicate the first widespread reprints of expansion set cards. The implementation of the Reserved List, RL, is indicated in blue.

Limiting our sample these two sets allows the 1995 Reprinting to have a homogeneous treatment effect in terms of the relative increase in the relative quantity of cards produced. Second, unlike *Arabian Nights*, these two sets did not contain any cards reprinted in core sets prior to the 1995 Reprinting. Excluding *Arabian Nights* allows us to interpret the treatment effect as the effect of the 1995 Reprinting on original card prices for rare cards in expansions sets with similarly small print runs and no cards having ever been reprinted before.

Table II displays summary statistics for the price of *MTG* trading cards in our sample. The statistics are tabulated by whether the card variety $i$ is among those reprinted and by whether the quarter $q$ is before or after the 1995 Reprinting in the second quarter of 1995.

| Full Sample: $1994Q3 \leq q \leq 1997Q1$ | | | | | |
|---|---|---|---|---|---|
| $Reprint_i$ | Min | Mean | Median | Max | SD |
| 1 | 3.93 | 11.90 | 10.52 | 30.42 | 4.99 |
| 0 | 5.37 | 14.95 | 13.50 | 74.83 | 8.22 |
| Pre-Period: $1994Q3 \leq q \leq 1995Q1$ | | | | | |
| $Reprint_i$ | Min | Mean | Median | Max | SD |
| 1 | 5.57 | 9.50 | 8.43 | 23.67 | 3.80 |
| 0 | 5.37 | 8.58 | 7.77 | 24.42 | 2.36 |
| Post-Period: $1995Q2 \leq q \leq 1997Q4$ | | | | | |
| $Reprint_i$ | Min | Mean | Median | Max | SD |
| 1 | 3.93 | 12.80 | 11.50 | 30.42 | 5.08 |
| 0 | 8.77 | 17.32 | 14.50 | 74.83 | 8.36 |

Table II: **Price Summary Statistics.** This table displays summary statistics for the the equally-weighted *MTG* trading card price, computed as the equally-weighted average of the median, upper quartile, and lower quartile price reported in *Scrye*.

## 3.2 Empirical Methodology

We estimate price effects using the following regression model, where the unit $i$ indexes varieties of original rare *MTG* cards and the period $q$ indexes quarterly observations from 1994Q3 to 1997Q1:[10]

$$\ln p_{iq} = \theta_R Reprint_i \times Post_q + \theta_i + \theta_q + \varepsilon_{iq} \tag{3.1}$$

where $p_{iq}$ is the price of card $i$ in quarter-year $q$.[11] Treatment in this difference-in-differences specification is assigned with the indicator variable $Reprint_i$ which takes a value of 1 if card $i$ is reprinted in either *Fourth Edition* or *Chronicles*. If card $i$ is not reprinted, then $Reprint_i = 0$. Note that by not reprinting card $i$, WotC effectively puts card $i$ on the Reserved List.

The variable $Post_q$ indicates whether $q \geq 1995Q2$, which is the the release date of *Fourth Edition* and signified WotC's change in policy towards reprinting. Because WotC would formalize and announce their reprinting policy with the introduction of the *Reserved List* in 1996, we also estimate a specification with two post-treatment indicators included: one for observations between 1995Q2 and 1995Q4, and another for observations 1996Q1 and after. Finally, $\theta_i$ is a card variety-specific fixed effect, $\theta_q$ is a time-period specific

[10]We index time in the dataset with $q$ because we index time with the variable $t$ in the economic model in Section 4, and $q$ and $t$ emphatically do not necessarily represent the same unit of time.

[11]We use the log of the equally-weighted average of lower quartile, median, and upper quartile price for the dependent variable. Measurement error in the dependent variable does not generate measurement error in difference-in-differences estimates (Card & Krueger, 2000). Point estimates and results are nearly identical when using the log of the median price; see Table VIII in Appendix C.

| Dependent Variable: $\ln p_{iq}$ | (1) | (2) |
|---|---|---|
| $Reprint_i \times Post_q$ | $-0.41^{***}$ | |
| | (0.06) | |
| $Reprint_i \times \mathbf{1}\{1995Q2 \leq q \leq 1995Q4\}$ | | $-0.23^{**}$ |
| | | (0.07) |
| $Reprint_i \times \mathbf{1}\{q \geq 1996Q1\}$ | | $-0.48^{***}$ |
| | | (0.04) |
| Num. obs. | 1372 | 1372 |
| $R^2$ | 0.91 | 0.92 |

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table III: **Effect of Reprint on Price.** Regression results for the difference-in-differences model in Equation 3.1. The dependent variable is equally-weighted log-price, computed as the equally-weighted average of median, upper, and lower quartiles. All standard errors are two-way clustered at the card and quarter levels. All estimates include year-quarter and card fixed-effects.

fixed effect, and $\varepsilon_{iq}$ is an idiosyncratic error term.

The parameter $\theta_R$ is our parameter of interest and quantifies the difference in log-price between reprinted and non-reprinted cards after the 1995 Reprinting. For now, we refrain from making either causal or structural interpretations regarding the set of estimated parameters $\Theta \equiv \{\theta_R, \theta_i, \theta_q, \varepsilon_{iq}\}_{i,q}$. In Section 4, we establish an economic interpretation of these parameters by solving a model of collectibles demand. Specifically, we derive a mapping from $\Theta$ to structural parameters representing intertemporal preferences for collectibles and a firm's commitment to future supply levels. Figure 8 in Appendix C displays a scatter plot of prices vs. time for both reprinted and non-reprinted cards, and we also present estimates of an event study in Figure 3—these result both support the parallel trends identifying assumption for difference-in-differences estimation.

## 3.3 Results

Column (1) of Table III displays estimation results for the difference-in-differences specification in Equation 3.1. We interpret the 1995 Reprinting price effect using the conversion $100 \cdot \left[\exp\left(\hat{\theta}_R\right) - 1\right] = -33.64\%$. We also estimate separate price effects for each reprinting event in Column (2) of Table III. Price decreases of reprinted cards relative to non-reprinted cards in the last three quarters of 1995 were (using the same conversion) $-20.55\%$. After adoption of the Reserved List in 1996 Q1, reprinted cards decreased an additional 18%, which is 38.12% less than prices before 1995 Q2.

We explore dynamic effects using event study. Figure 3 displays coefficient estimates and standard errors for the quarterly relative prices between reprinted and non-reprinted cards. Results include card fixed effects, quarter-year fixed effects, and two-way standard errors clustered at the card and quarter levels. This event

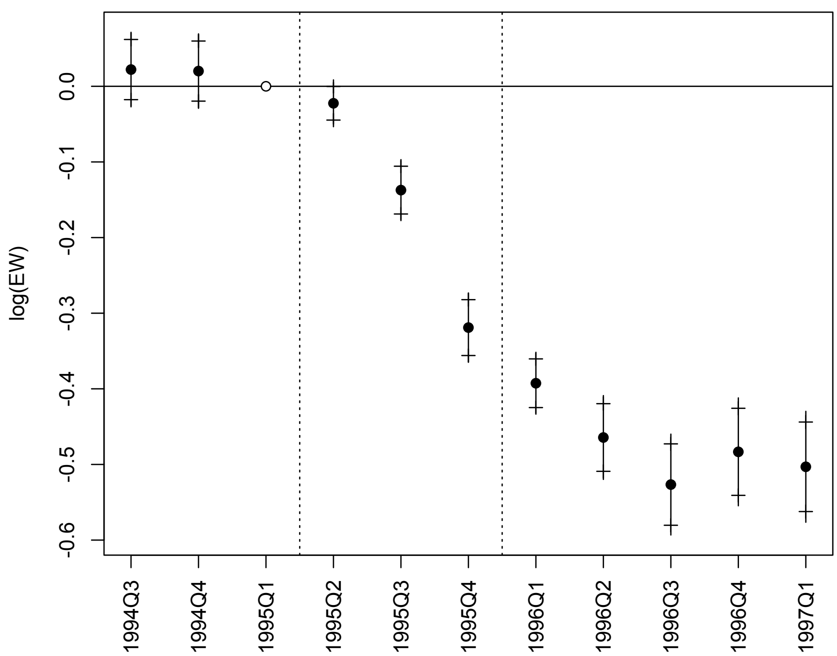


Figure 3: **Event Study.** This figure plots coefficient estimates of an event study of log-prices. The difference in price in the quarter immediately preceeding *4ED*'s release, 1995Q1, is normalized to 0. The leftmost vertical dashed line designates the release of *4ED*, and the other designates introduction of the RL. Endpoints of the solid vertical lines correspond to sup-t 95% confidence intervals, Freyaldenhoven et al. (2021). Horizontal bars correspond to pointwise 95% confidence intervals. All standard errors are two-way clustered at the card and quarter levels.

study indicates no statistical difference between the prices of reprinted and non-reprinted cards before 1995 Q1 and suggests an assumption of parallel trends in prices following the 1995 Reprinting Set is valid. In 1997 Q1, nearly two years post-implementation of the reprinting policy, reprinted card prices stabilized at nearly 40% less than non-reprinted card prices. Additional price estimates are presented in Appendix C, Table VIII, including estimates of the effect on other surveyed price statistics collected by *Scrye*.

# 4 A Model of Demand for Collectibles

In this section, we develop and solve a model to derive a structural interpretation of the difference-in-differences parameter estimates of Equation 3.1. Specifically, we are interested in measuring 1) what the relative price decline of reprinted cards, $\hat{\theta}_R$, indicates about consumer beliefs regarding future supply decisions and (2) how much consumer lifetime utility changed after the Reserved List. In developing of the model, we impose several assumptions (particularly on consumer preferences) that facilitate the derivation of a linear equation for steady-state log-price.

The basis of our dynamic model is that collectable goods provide both a flow of utility and a store of wealth. In each period, the consumer is limited by a budget constraint. Total consumption plus collectible expenditures must be less than or equal to (exogeneous) income in the current period plus the value of the collectibles held in the previous period and sold at current period prices.

Formally, index collectibles by $i \in \{1, \ldots, I\}$, and let $q_{it}$ be the quantity of collectible $i$ held by the consumer in period $t$. The consumer obtains contemporaneous utility $u_t(\mathbf{q}_t)$ from the vector of collectible holdings $\mathbf{q}_t \in \mathbf{R}_+^I$. In the case of MTG, this is utility from not only playing the game but also any enjoyment or appreciation from owning the cards. For now, we assume only that $u_t$ is twice-continuously differentiable with positive and decreasing partial derivatives. We impose further assumptions on preferences to derive closed-form expressions for steady-state prices. Consumption of a non-collectable good in period $t$ is denoted $c_t$. We assume consumption is numeraire in this economy, and collectible prices are described by $p_{it}$ for $i \in 1, \ldots, I$.

The consumer's indirect value function in period $t$ is

$$V_t(\mathbf{q}_{t-1}) = \max_{\mathbf{q}_t \in \mathbf{R}_+^I} \alpha \cdot u_t(\mathbf{q}_t) + (1-\alpha) \cdot \ln c_t + \beta E_t [V_{t+1}(\mathbf{q}_t)] \tag{4.1}$$

$$\text{s.t. } c_t + \mathbf{p}_t' \mathbf{q}_t \leq y_t + \mathbf{p}_t' \mathbf{q}_{t-1} \tag{4.2}$$

where $\alpha \in (0, 1)$ is a utility weight on collectible consumption, and $\beta \in (0, 1)$ is the time discount factor. While we do not formally define a stochastic variable or state transition, we include the expectation operator $E_t[\cdot]$ to account for uncertainty in future market conditions. Specifically, the consumer may not have perfect foresight regarding future prices (or the determinants of future prices) but makes decisions in the current period based on expectation of future prices conditional on the state in period $t$ (hence the subscript on the operator).

In Appendix D, we derive the following dynamic pricing relationship from first-order conditions and envelope conditions of the consumer's problem:

$$\frac{p_{it}}{c_t} = \frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta E_t\left[\frac{p_{it+1}}{c_{t+1}}\right], \tag{4.3}$$

where $u_{it}\left(\mathbf{q}_t\right) \equiv \frac{\partial u_t}{\partial q_{it}}\left(\mathbf{q}_t\right)$. We interpret Equation 4.3 as the consumer's recursive inverse demand curve for collectible $i$. The pricing dynamics are simple and intuitive: per unit of consumption $c_t$, the price of collectible $i$ in period $t$ is a weighted sum of scaled marginal utility of collectible $i$ plus the discounted expected price of collectible $i$ in the next period.

We assume that the consumer is representative. This means we can also interpret Equation 4.3 as the market-level inverse demand curve for collectible $i$ in period $t$. Formally, because we are considering a market of representative consumers, market-level inverse demand is simply scaled representative consumer inverse demand. Without loss of generality, we assume this scaling factor is captured by the level of consumption, $c_t$.

The representative consumer assumption is rather strong, but it facilitates analysis in two ways. First, the vector of collectibles consumption $\mathbf{q}_t$ has elements $q_{it}$ representing the holdings of collectible $i$ in period $t$ *per consumer*. In other words, $\mathbf{q}_t$ is the average consumption of collectible $i$ in period $t$. Accordingly, we derive steady-state pricing using consumer beliefs about per-consumer collectible holdings. Second, as a practical matter, we do not observe consumer-specific or even card variety $i$-specific quantities or market shares, so any empirical analysis performed would aggregate over consumer differences incorporated into the model.

## 4.1 Steady-State Pricing

Here, we derive closed-form solutions for the inverse demand curve across steady states. Steady states vary by how per-consumer collectible consumption $\mathbf{q}_t$ evolves from period $t$ to $t+1$. *Within* a steady state, we assume that income and preferences are time invariant. This in turn means non-collectible consumption is also constant, and variations in prices of collectibles across varieties $i$ and periods $t$ depends only on the sequence of future per-consumer collectible holdings $\mathbf{q}_{t+k}, k \geq 0$.

Formally, consider a steady state in which $y_t \equiv y$ and $u_{it}(\cdot) \equiv u_i(\cdot)$, and $c_t \equiv c$. Inverse demand expands to

$$\frac{p_{it}}{c} = \frac{\alpha}{1-\alpha} \cdot u_i\left(\mathbf{q}_t\right) + \beta E_t\left[\frac{\alpha}{1-\alpha} \cdot u_i\left(\mathbf{q}_{t+1}\right) + \beta E_{t+1}\left[\frac{\alpha}{1-\alpha} \cdot u_i\left(\mathbf{q}_{t+2}\right) + \beta E_{t+2}\left[\frac{p_{it+3}}{c}\right]\right]\right]. \tag{4.4}$$

Thus, contemporaneous collectibles price $p_{it}$ depends on current and (expected value of the) future stream of per-consumer availability of the collectibles. The expectation operator $E_t[\cdot]$ is included here as uncertainty may still be present in the evolution of $\mathbf{q}_t$ through supply-side conditions. In the following proposition, we specify supply-side conditions. This eliminates the need for an expectation operator and facilitates derivation of closed-form (non-recursive) inverse demand functions.

**Proposition 4.1** *Assume that income, preferences, and consumption are time invariant: $y_t \equiv y$, $u_{it}(\cdot) \equiv u_i(\cdot)$, and $c_t \equiv c$. Collectible price $p_{it} \equiv p_i$ in the steady-state is given by the following:*

1. *Let collectible holdings per consumer be time-invariant: $\boldsymbol{q}_t \equiv \boldsymbol{q}$. Then, steady-state inverse demand is*

$$p_i(\boldsymbol{q}) = \frac{\alpha \cdot c}{(1-\alpha)(1-\beta)} \cdot u_i(\boldsymbol{q}) \ . \tag{4.5}$$

2. *Let collectible holdings per consumer scale by a constant factor $\rho \in (0, \infty)$: $\boldsymbol{q}_{t+1} \equiv \rho \boldsymbol{q}_t$. Furthermore, assume collectibles preferences $u_t(\cdot) \equiv u$ are homogenous of degree $\Gamma_t \equiv \Gamma \leq 1$. Then,*

$$p_i(\boldsymbol{q}; \rho) = p_i(\rho \boldsymbol{q}) = \frac{\alpha \cdot c}{(1-\alpha)(1-\beta\rho^{\Gamma-1})} \cdot u_i(\boldsymbol{q}) \ . \tag{4.6}$$

3. *Let collectible holdings per consumer scale by* differentiated *rates: $q_{it+1} = \rho_i q_t$ for $\rho_i \in (0, \infty)$. Assume that collectibles utility functions $u_t$ have the Cobb-Douglass form*

$$u_t(\boldsymbol{q}_t) = \prod_{i=1}^{I} q_{it}^{\Gamma_{it}} \tag{4.7}$$

*where parameters $\Gamma_{it}$ measure the elasticity of collectibles utility with respect to holdings, and $\sum_{i=1}^{I} \Gamma_{it} \equiv \Gamma_t \leq 1$. Then, in a steady state where $\Gamma_{it} \equiv \Gamma_i$,*

$$p_i(\boldsymbol{q}; \boldsymbol{\rho}) = p_i(\boldsymbol{\rho} \odot \boldsymbol{q}) = \frac{\alpha \cdot c}{(1-\alpha)\left(1 - \beta\rho_i^{\Gamma_i - 1}\prod_{j \neq i}\rho_j^{\Gamma_j}\right)} \cdot u_i(\boldsymbol{q}) \ , \tag{4.8}$$

*where $\odot$ denotes element-wise vector or matrix multiplication.*

Proof*: See Appendix D.*

Each item in Proposition 4.1 represents a progressively more restrictive assumption on the collectibles utility function $u_t$. The closed-form steady-state inverse demand function assuming average collectible holdings are constant is given by Equation 4.5. The price of collectible $i$, in the steady-state with a constant per-consumer holdings, follows the law of demand with price decreasing in $q_i$. Price is proportional to marginal utility; the proportionality constant depends on the consumer's preferences for collectibles relative to consumption, $\alpha$, and the time-discount factor $\beta$. The price of collectibles relative to consumption is increasing in $\beta$. A myopic consumer with $\beta = 0$ would purchase collectibles to maximize contemporaneous utility, and spend the remainder of income on consumption. A consumer with $\beta > 0$, however, will consume less and collect more, in order to increase wealth in future periods. As $\beta$ approaches 1, the benefit to the consumer of transferring income from the current period to the following period grows larger.

The second item of Proposition 4.1 assumes preferences for collectable goods are homogeneous of degree $\Gamma \leq 1$ and steady-state per-player collectible holdings grow by a factor of proportionality given by $\rho \equiv \frac{q_{it+1}}{q_{it}}$ for all $i, t$ in the steady state where the parameter $\rho \in (0, \infty)$. These assumption allows us to derive the *parameterized* steady-state inverse demand curve, $p_i(\mathbf{q}; \rho)$. Equation 4.6 introduces an important structural determinant of collectibles prices, $\rho$. This parameter determines the per-period change in (steady-state) per-player card holdings or card stock. Because income and consumer preferences are held constant in the steady-state (including consumers entering the market), changes in collectible holdings per consumer are necessarily driven by the rate at which the collectibles are supplied by the producer. This allows us to interpret this parameter as the *flow* of collectible supply within the steady-state. The stock is *depreciating* if $\rho < 1$, or *appreciating* if $\rho > 1$.

Price is given by Equation 4.6. The parameter, $\Gamma$, captures the rate of diminishing returns to increasing collectible holdings. Assuming $\Gamma - 1 \leq 0$, $p_i(\mathbf{q}; \rho)$ is decreasing in both flow, $\rho$, and levels, $q_i$. As $\rho$ increases, collectible holdings *per consumer* increase, the relative scarcity of collectibles decreases, and steady-state price decreases. The proof of Proposition 4.1 requires the utility function be homogeneous of degree less than 1. This assumption facilitates derivation of a closed-form expression for steady-state inverse demand $p_i(\mathbf{q}; \rho)$ with minimal added preference parameters. Inverse demand defined in Equation 4.5 is equal to Equation 4.6 when $\rho = 1$: that is, $p_i(\mathbf{q}; 1) = p_i(\mathbf{q})$, as $\rho = 1$ implies constant per-player holdings.

The final item of Proposition 4.1 allows card-specific flow values, $\rho_i$. To allow for this generality and maintain a closed-form solution, we restrict preferences to the Cobb-Douglas form. Equation 4.8 can can be rewritten as

$$p_i\left(\mathbf{q}; \boldsymbol{\rho}\right) = \frac{\alpha \cdot c}{(1-\alpha)\left(1 - \beta \cdot \frac{\Psi}{\rho_i}\right)} \cdot u_i\left(\mathbf{q}\right) \tag{4.9}$$

where $\Psi_t \equiv \prod_{j=1}^{I} \rho_j^{\Gamma_{jt}}$. The Cobb-Douglass form of $u_t$ also allows us to write $\Psi_t = \frac{u_t(\boldsymbol{\rho} \odot \mathbf{q}_t)}{u_t(\mathbf{q}_t)}$, implying the parameter $\Psi_t$ measures the rate of change of the flow of utility from collectibles in the steady state.

Equation 4.9 indicates whether the steady-state price for collectible $i$ will be above or below the steady-state price when $\rho_i \equiv 1$. Specifically, the ratio $\frac{\Psi}{\rho_i}$ determines if there is a price premium for collectible $i$ for a given marginal utility. If $\rho_i < \Psi$, then price $p_i$ is larger than it would be under a steady-state with constant per-player holdings. While this inverse demand function assumes a specific functional form for preferences and is less general than previous pricing equations, Equation 4.8 nests the other specifications just as 4.6 nests 4.5 with regards to $\boldsymbol{\rho}$.

Applying the Cobb-Douglass functional form of $u_{it}$, the log-price equation is

$$\ln p_i = \ln c + \ln\left(\frac{\alpha}{1-\alpha}\right) - \ln\left(1 - \beta\frac{\Psi}{\rho_i}\right) + \ln\Gamma_i - \ln q_i + \sum_{j=1}^{I}\Gamma_j \ln q_j \tag{4.10}$$

Indexing variables by steady state $s$

$$\ln p_{is} = \ln c_s + \ln\left(\frac{\alpha}{1-\alpha}\right) - \ln\left(1 - \beta\frac{\Psi_s}{\rho_{is}}\right) + \ln\Gamma_{is} - \ln q_{is} + \sum_{j=1}^{I_s}\Gamma_{js} \ln q_{js} \tag{4.11}$$

This equation describes prices *across* steady-states. We use Equation 4.11 and difference-in-differences estimates to identify parameters assuming changes over time correspond to changes in steady-state outcomes.

## 4.2 Application to Magic the Gathering's Reserved List and Reprints

We apply this model to *Magic the Gathering*. Let $i = \{1, \dots, I\}$ correspond to specific cards, where $q_{is}$ is the quantity of card $i$ held by the representative magic player in steady state $s$. The steady-state log-pricing equation is

$$\ln p_{is} = \ln c_s + \ln\left(\frac{\alpha}{1-\alpha}\right) - \ln\left(1 - \beta\Psi_s\rho_{is}^{-1}\right) + \ln\Gamma_{is} - \ln q_{is} + \sum_{j=1}^{I_s}\Gamma_{js} \ln q_{js} \tag{4.12}$$

where the supply of cards per-consumer evolves as $q_{it+1} = \rho_i q_{it}$ within a steady-state $s$, and $\Psi_s = \prod_{j=1}^{I_s}\rho_{js}^{\Gamma_{js}}$.

We aim to model the effect of the 1995 Reprinting and Reserved List as detailed in Section 2.[12] We model the 1995 Reprinting and Reserved List policies as creating two classes of original rare *MTG* cards from expansion sets: cards not subject to reprinting with an implied non-increasing $q_{it}$ over time, and those cards subject to reprint with an unrestricted $q_{it}$ over time.

Before the policy change, we assume all card prices are determined by the steady-state inverse demand function $p_{is}(\mathbf{q}_s; \boldsymbol{\rho}_s)$, where $\boldsymbol{\rho}_s$ is an $I \times 1$ vector with each element equal to $\rho_s \in (0, \infty)$. We interpret $\rho_s$ as the initial flow of rare *MTG* cards, which is identical across cards. Before the 1995 Reprinting and for cards in expansion sets, we assume $\rho_s \leq 1$. This implies any change in a particular card's holding $q_i$ would necessarily come from either destruction of the card stock over time or growth in the player base.

We generate the 1995 Reprinting in the following way. Let $R$ be the set of original rare cards $i$ that are reprinted in 1995. Beginning in steady state $s^*$, cards $i \in R$ are reprinted. This changes the flow parameter of those cards from $\rho_s$ to $\rho_s\rho_R$. Define

$$\rho_{is} = \rho_s \cdot \rho_R^{\mathbf{1}\{i\in R\}\times\mathbf{1}\{s\geq s^*\}} \tag{4.13}$$

[12]We computed that the price effect of this policy change regarding the supply of collectable playing cards was a relative decline in reprinted card prices of about 33% (see Section 3, Table III).

where $\rho_s$ is the flow of non-reprinted cards. Using the above definition and 4.12, the new steady-state log-price is

$$\ln p_{is} = \ln c_s + \ln\left(\frac{\alpha}{1-\alpha}\right) + \ln \Gamma_{is} - \ln(q_{is}) + \sum_{j=1}^{I} \Gamma_{js} \ln(q_{js})$$
$$- \ln\left(1 - \beta\Psi_s\rho_s^{-1} \cdot \rho_R^{-\mathbf{1}\{i\in R\}\times\mathbf{1}\{s\geq s^*\}}\right). \tag{4.14}$$

A first-order Taylor series approximation of $\ln\left(1 - \beta\Psi_s\rho_s^{-1} \cdot (x)^{-\mathbf{1}\{i\in R_s\}\times\mathbf{1}\{s\geq s^*\}}\right)$ centered at $x = \rho_R = 1$ yields

$$\ln p_{is} \approx \ln c_s + \ln\left(\frac{\alpha}{1-\alpha}\right) + \ln\Gamma_{is} - \ln q_{is} + \sum_{j=1}^{I}\Gamma_{js}\ln q_{js} \tag{4.15}$$
$$+ \frac{\beta\Psi_s\rho_s^{-1}}{1-\beta\Psi_s\rho_s^{-1}} \cdot (1-\rho_R)\cdot\mathbf{1}\{i\in R_s\}\times\mathbf{1}\{s\geq s^*\} + \ln\left(1-\beta\Psi_s\rho_s^{-1}\right). \tag{4.16}$$

Note that $\Psi_s = (\rho_s\rho_R)^{\Gamma_{Rs}}\rho_s^{\Gamma_s-\Gamma_{Rs}} = \rho_s^{\Gamma_s}\rho_R^{\Gamma_{Rs}}$, $\Gamma_s = \sum_{j=1}^{I}\Gamma_{js}$, and $\Gamma_{Rs} = \sum_{j\in R_s}\Gamma_{js}$. Note that these terms are useful to define, as the ratio $\Gamma_{Rs}/\Gamma_s$ is the share of the consumer's collectibles budget spent on reprinted cards. For example, extreme consumer preferences such that $\Gamma_{Rs} = 0$ would imply no reprinted cards were purchased by the consumer.

Collecting terms and applying the same notation as the difference-in-differences specification in Equation 3.1, the steady-state log-linear equation for price is

$$\ln p_{is} = \theta_{Rs}\mathbf{1}\{i\in R_s\}\times\mathbf{1}\{s\geq s^*\} + \theta_s + \theta_i + \varepsilon_{is} \tag{4.17}$$

where

$$\theta_{Rs} = \frac{\beta\rho_s^{\Gamma_s-1}\rho_R^{\Gamma_{Rs}}}{1-\beta\rho_s^{\Gamma_s-1}\rho_R^{\Gamma_{Rs}}}\cdot(1-\rho_R) \tag{4.18}$$

$$\theta_s = \ln c_s + \sum_{j=1}^{I}\Gamma_{js}\ln q_{js} + \ln\left(1-\beta\rho_s^{\Gamma_s-1}\rho_R^{\Gamma_{Rs}}\right) \tag{4.19}$$

$$\theta_i + \varepsilon_{is} = \ln\Gamma_{is} - \ln q_{is} + \ln\left(\frac{\alpha}{1-\alpha}\right). \tag{4.20}$$

Equation 4.17 shows steady-state log prices can be written as the sum of a difference-in-differences term, card fixed effects, steady-state fixed effects, and an additional term. If we assume the observed price $p_{iq}$ in *Scrye* for card $i$ in quarter $q$ correspond to steady-state prices, we can estimate the left-hand side values in 4.18, 4.19, and 4.20 using linear regression.[13]

[13] Allowing $\theta_{Rs}$ to vary over steady-state $s$ is accordingly identical to a two-way fixed-effects event study. Estimates for this specification are in Figure 3 in Section 3 and Table VIII in Appendix C.

## 4.3 Structural Interpretation of Identification and Parameter Estimates

Equation 4.17 and the following Equations 4.18, 4.19, and 4.20 offer interpretations of the results from the price effects estimated in Section 3 with Equation 3.1. First, note that time-unit fixed effects $\theta_q$ from the difference-in-differences specification are equivalently steady-state specific factors effecting the secondary market for collectibles, $\theta_s$. Our model shows that the steady-state $s$ has price-level determined by combination of the *level* of consumption, $c_s$, the *level* of collectibles utility (given Cobb-Douglass form), and a term capturing time-related preferences.

The reduced-form price-effect parameter $\theta_R$ in Equation 3.1, and more specifically the event study coefficients presented in Figure 3, correspond to the parameter $\theta_{Rs}$ in Equation 4.18. The effect on price that we estimate is thus a function of the time discount factor, $\beta$, the rate of diminishing marginal utility with respect to card holdings, $\Gamma_s$, preferences for collecting reprinted cards, $\Gamma_{Rs}$, and the card supply flow parameters $\rho_s$ and $\rho_{Rs}$. Under the assumption that preferences are constant *across* steady states as well as *within* steady-states, the estimate $\hat{\theta}_R$ is then representative of the flow parameters $\rho_s$ and $\rho_{Rs}$ determining relative increases in the supply of reprinted cards compared to non-reprinted cards.

Because we do not observe card-specific demands or market shares, we cannot separately identify any of the parameters comprising $\theta_R$. This is because identification of preferences for cards would require observing variation in both the price of a card and the quantity demanded of the card. However, because print runs are constant and this secondary market has effectively inelastic supply within steady-states, variation in quantity demanded is not observable.

Card-specific fixed effects $\theta_i$ and error term $\varepsilon_{iq}$ represent unobserved card and steady-state specific preferences. The card-specific fixed effect $\theta_i$ measures time-invariant preference for card $i$. We show estimates for this parameter in Table IX in the Appendix. We note here that the estimates of $\theta_i$ reflect highest preference for the so-called *Power Nine* cards, the most powerful *MTG* cards in terms of game-play, with the well known *Black Lotus* having the largest estimate.

Equation 4.20 also yields a structural interpretation of the idiosyncratic error term $\varepsilon_{it}$ in the DID specification, hence elucidating the identification assumption for $\theta_R$. Specifically, the identification assumption is that time-varying card-specific characteristics, specifically $\Gamma_{is}$ and $q_{is}$, are uncorrelated *across steady states* with the implemented set of reprints, $R_s$. In other words, $\theta_R$ is identified under the exclusion restriction that a card being reprinted does not change the contemporaneous utility associated with owning the card, only the consumer's perception of the future value of the card.

In the Table IV, we present estimates of the structural parameter $\rho_R$ taking the difference-in-differences parameter $\hat{\theta}_R = -0.503(\pm 0.030)$ as given and varying calibrations of $\beta$, $\rho_s$, $\Gamma_s$, and $\Gamma_{Rs}$.[14] In all of these estimates, we set $\rho_s$, which is the supply flow rate of change of non-reprinted cards, to $\rho_s \equiv 1$. This yields two benefits: first, the value of $\Gamma_s$ does not affect $\hat{\rho}_R$ when $\rho_s = 1$; second, the interpretation of $\rho_R$ when

[14] We choose this specific value of $\hat{\theta}_R$ because it is the estimate of the terminal period of data in our sample, 1997 Q1, when prices have stabilized post after the Reserved List announcement. (See Figure 3 in Section 3.)

| | | $\Gamma_R$ | | | |
|---|---|---|---|---|---|
| | | 0.1 | 0.3 | 0.5 | 0.7 |
| $\beta$ | 0.95 | 1.0252 | 1.0229 | 1.0210 | 1.0194 |
| | 0.98 | 1.0098 | 1.0089 | 1.0082 | 1.0076 |
| | 0.99 | 1.0048 | 1.0044 | 1.0041 | 1.0038 |
| | 0.995 | 1.0024 | 1.0022 | 1.0020 | 1.0019 |

Table IV: **Estimates of** $\hat{\rho}_R$. This table displays the estimate of structural parameter $\rho_R$ given difference-in-differences estimate $\hat{\theta}_R = -0.503$ and the specified calibrations of $\beta$ and $\Gamma_R$. We use Equation 4.18 to solve for $\hat{\rho}_R$, assuming $\Gamma_t = \rho_s \equiv 1$.

$\rho_s = 1$ is that $\rho_R$ is the supply flow of reprinted cards, which is more understandable.

Even after normalizing $\rho_s = 1$, computing $\hat{\rho}_R$ from $\hat{\theta}_R$ and an associated standard error is not straightforward. Equation 4.18 defines an implicit relationship between $\rho_R$ and $\theta_R$, which we denote with the function $\theta\left(\rho_R\right)$. However, 4.18 cannot be inverted analytically to solve for $\rho_R$ as a function of $\theta_R$, such that $\rho_R(\theta) = \theta^{-1}\left(\rho_R\right)$. Accordingly, we numerically invert this function and use the difference-in-differences estimator $\hat{\theta}_R$ to obtain the numerical solution, denoted $\hat{\rho}_R = \rho_R(\hat{\theta}_R)$.

Standard errors are then computed using the standard error of $\hat{\theta}_R$, denoted $s_{\hat{\theta}_R}$, and the delta method. Derivatives of $\rho_R(\cdot)$ are also obtained numerically, where the standard error of $\hat{\rho}_R$ is then $s_{\hat{\rho}_R} = s_{\hat{\theta}_R} \cdot \rho_R'\left(\hat{\theta}_R\right)$, where $\rho_R'(\cdot)$ is the numerical derivative of the numerical inverse of Equation 4.18.

Implementation of this model requires several conditions on the market characteristics defined by the model's parameters. In particular, if $\rho_R^{-1} < \Psi\beta$, then price $p_{it}$ of non-reprinted cards would diverge to infinity. This is because for relatively large values of $\beta$ and $\rho_R$, utility from the relative growth in the price of non-reprinted cards outpaces the rate at which time is discounted and lifetime discounted utility does not ultimately converge. We discuss this logic in detail and present valid parameterizations in Appendix D. Empirical estimates and associated structural values presented in Table IV are well within valid parametric regions.

Table V displays the ratio of the lifetime discounted utilities for a consumer in steady-states with and without reprinting implemented for a subset of cards. Specifically,

$$\frac{V\left(\mathbf{q}_s; \boldsymbol{\rho} = \hat{\boldsymbol{\rho}}\right)}{V\left(\mathbf{q}_s; \boldsymbol{\rho} = \mathbf{1}\right)}, \tag{4.21}$$

where $\hat{\boldsymbol{\rho}} = [\{\hat{\rho}_R\}_{i\in R}, \{\mathbf{1}\}_{i\notin R}]$. In other words, this ratio is the *reprint-discounting factor* of lifetime discounted utility in a steady-state where per-consumer supply of reprinted cards changes $q_{it+1} = \rho_R \cdot q_{it}$ and the per-consumer supply of non-reprinted cards is constant.

In Appendix D we derive the following approximation for the counterfactual proportion increase in lifetime

| | | $\Gamma_R$ | | | |
|---|---|---|---|---|---|
| | | 0.1 | 0.3 | 0.5 | 0.7 |
| $\beta$ | 0.95 | 0.9697 | 0.9221 | 0.8874 | 0.8619 |
| | 0.98 | 0.9694 | 0.9213 | 0.8862 | 0.8605 |
| | 0.99 | 0.9693 | 0.921 | 0.8858 | 0.8601 |
| | 0.995 | 0.9692 | 0.9209 | 0.8856 | 0.8598 |

Table V: **Estimates of** $\frac{V(\mathbf{q}_s;\boldsymbol{\rho}=\hat{\boldsymbol{\rho}})}{V(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1})}$. This table displays the estimate of the reprint discount factor $\frac{V(\mathbf{q}_s;\boldsymbol{\rho}=\hat{\boldsymbol{\rho}})}{V(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1})}$, given difference-in-differences estimate $\hat{\theta}_R = -0.503$ and the specified calibrations of $\beta$ and $\Gamma_R$. We use Equation 4.18 to solve for $\hat{\rho}_R$, assuming $\Gamma_t = \rho_s \equiv 1$.

discounted utility from a card flow of $\hat{\boldsymbol{\rho}}$ instead of a constant card flow $\boldsymbol{\rho} = 1$:

$$\frac{V\left(\mathbf{q}_s;\boldsymbol{\rho}=\hat{\boldsymbol{\rho}}\right)}{V\left(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1}\right)} \approx 1 + \frac{\Gamma_{R_s}}{\Gamma_s}\cdot\left(1-\beta\cdot\hat{\rho}_R^{\Gamma_{R_s}}\right)\cdot\left\{\left[\hat{\rho}_R\cdot\left(\hat{\rho}_R-\beta\right)\right]^{-1}-\left(1-\beta\right)^{-1}\right\} \tag{4.22}$$

This ratio simplifies to 1 when $\hat{\rho}_R = 1$.[15] Standard errors are computed with the delta method for error propagation by taking the numerical derivative of

$$\frac{V\left(\mathbf{q}_s;\boldsymbol{\rho}=\tilde{\boldsymbol{\rho}}\left(\hat{\theta}_R\right)\right)}{V\left(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1}\right)}$$

with respect to $\hat{\theta}_R$ and multiplying by $s_{\hat{\theta}_R}$.

Figure 4 graphs the functions $\tilde{\rho}(\hat{\theta}_R)$ (left panel) and $\frac{V\left(\mathbf{q}_s;\boldsymbol{\rho}=\tilde{\boldsymbol{\rho}}(\hat{\theta}_R)\right)}{V(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1})} \equiv \frac{\hat{V}}{V}$ (right panel). We calibrate $\Gamma_R \in \{0.1, 0.3, 0.5, 0.7\}$, $\beta = 0.98$, and $\Gamma_t = \rho_s \equiv 1$ to generate these figures, and use the estimated standard errors to plot 95% confidence intervals.

# 5 Additional Results on Long-Run Performance

The previous sections document and interpret price changes in the two years following the 1995 Reprinting. Although performance over this period is important, investors may also invest in collectibles for longer horizons. In this section, we present additional results on the long-run relative performance of reprinted and non-reprinted Reserved List cards from 1995 Q2 to June 2023. Prices from June 2023 are obtained from MTGStocks. Similar to the results above, we use only original printings from the sets *Antiquities* and *Legends*.

To compare the investment performance of *MTG* cards to other collectibles and asset classes, we calculate annualized returns. Unfortunately, we do not observe prices from 1997 Q1 to June 2023 and cannot calculate quarterly returns using a panel of quarterly or annual price data. Instead, we estimate the effect of the

[15] We additionally make the calibration that $\Gamma_s = 1$ to compute values in Table V. Recall this was not necessary to compute $\hat{\rho}_R$ given the calibration $\rho_s = 1$, but it is necessary to compute the reprint-discounting factor.

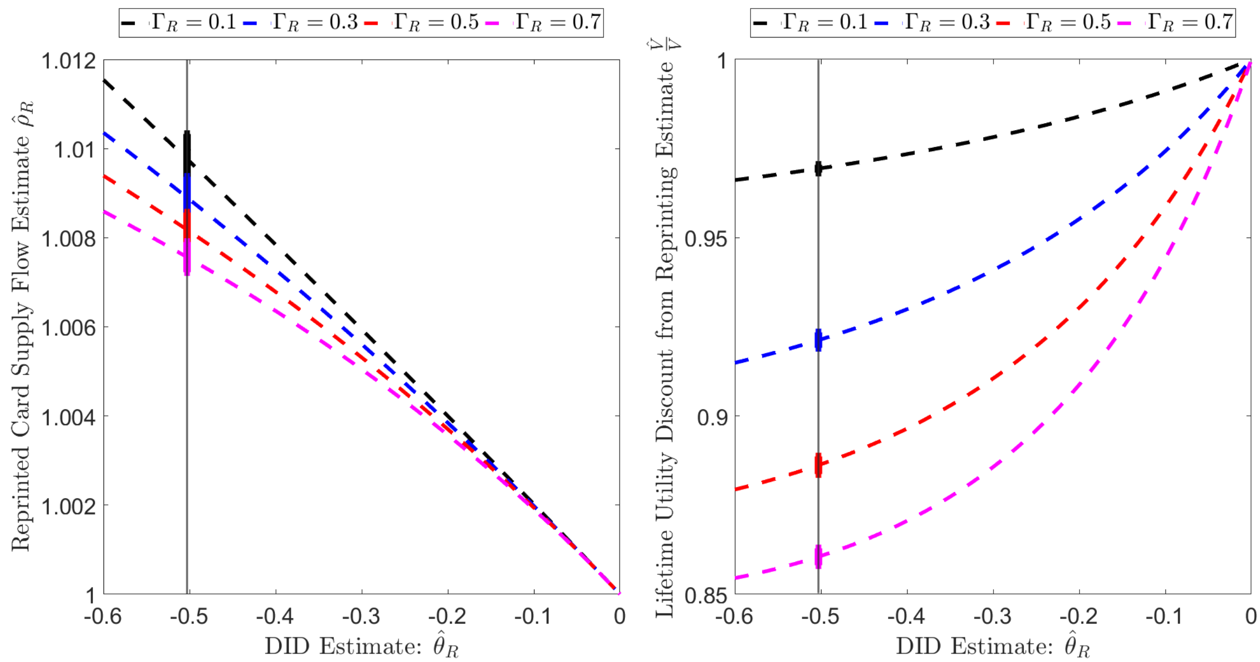


Figure 4: **Estimates and Confidence Intervals.** The left panel of this figure displays the function $\tilde{\rho}(\hat{\theta}_R)$ for $\Gamma_R \in \{0.1, 0.3, 0.5, 0.7\}$, $\beta = 0.98$, and $\Gamma_t = \rho_s \equiv 1$. The right panel shows $\frac{V(\mathbf{q}_s;\boldsymbol{\rho}=\tilde{\boldsymbol{\rho}}(\hat{\theta}_R))}{V(\mathbf{q}_s;\boldsymbol{\rho}=\mathbf{1})}$ for the same calibration. A 95% confidence interval for $\hat{\rho}_R$ and $\frac{\hat{V}}{V}$ are graphed at steady-state DID estimate $\hat{\theta}_R = -0.503$.

reprinting policy on long-run returns using a cross-section of annualized returns. We calculate returns using prices just before the 1995 Reprinting (1995 Q2) ending in June 2023 and just after the Reserved List (1997 Q1) and ending in June 2023. For card $i$, we calculate the annualized return from 1995 Q2 to June 2023 as $r_{i,1995Q2} = \left(\frac{P_{i,June2023}}{P_{i,1995Q2}}\right)^{1/28} - 1$ where $P_{it}$ is the equally-weighted price of card $i$ in time period $t$. Annualized returns from 1997 Q1 to June 2023 are calculated as $r_{i,1997Q1} = \left(\frac{P_{i,June2023}}{P_{i,1997Q1}}\right)^{1/26} - 1$. To estimate the effects of the reprinting policy on returns, we estimate the following cross-sectional regression for $j \in \{1995\text{ Q2}, 1997\text{ Q1}\}$

$$r_{i,j} = \alpha_{0,j} + \alpha_{1,j} \times Reprinting_i + \eta_{i,j} \tag{5.1}$$

In 5.1, $Reprinting_i = 1$ if card $i$ is in the 1995 Reprinting set and $Reprinting_i = 0$ if card $i$ is not in the 1995 Reprinting set, and $\eta_{i,j}$ is a zero-mean random variable independent of $Reprinting_i$. The coefficient $\alpha_{0,j}$ is the expected annualized return for $MTG$ cards in expansion sets not affected by the 1995 Reprinting and $\alpha_{1,j}$ is the difference between the expected annualized returns of reprinted and non-reprinted cards. A negative $\alpha_{1,j}$ indicates the long-run return of reprinted cards was less than the long-run return of non-reprinted cards.

Results for 5.1 are presented in Table VI. Column 1 uses $r_{i,1995Q2}$ as the dependent variable. Column 2 uses the real annualized return from 1995 Q2 to June 2023 as the dependent variable by deflating $P_{June2023}$ to April 1995 dollars using the CPI. Column 3 uses $r_{i,1997Q1}$ as the dependent variable. The intercept estimate

Table VI: Investment Performance as of June 2023

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| (Intercept) | $0.060^{***}$ | $0.036^{***}$ | $0.059^{***}$ |
| | (0.004) | (0.004) | (0.004) |
| Reprinting | $-0.038^{***}$ | $-0.037^{***}$ | $-0.025^{***}$ |
| | (0.006) | (0.006) | (0.006) |
| $R^2$ | 0.185 | 0.185 | 0.097 |
| N | 157 | 157 | 157 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

in column 1 indicates investors who purchased cards not affected by the 1995 Reprinting in 1995 Q2 would have realized annualized returns of 6 percent from the time of purchase to June 2023; in contrast, investors who purchased cards affected by the 1995 Reprinting in 1995 Q2 would have realized annualized returns of only 2.2 percent from the time of purchase to June 2023. The estimated real returns in column 2 for non-reprinted cards are 3.6 percent per year. For comparison, Dimson et al. (2015) report real annualized returns of 4.1 percent for art over the period 1900 to 2012.

The results for $\alpha_{1,j}$ in columns 1 and 2 of Table VI may result from the large difference in price changes between 1995 Q2 and 1997 Q1 as indicated in Figure 3. To net out the effect of price movements from this period on long-run performance estimates, we calculate nominal annualized returns from from 1997 Q1 to June 2023. Results from estimating Equation 5.1 using these annualized returns are presented in column 3 and indicate a long-run performance for non-reprinted cards, 5.9 percent, comparable to results in column 1 of Table 5.1. Still, we find reprinted cards under perform relative to non-reprinted cards, -2.5 percent per year, even after excluding the 1995 Reprinting period. This result and the results in Table III provide evidence the Reserved List affected prices not only in the short run but also in the long run.

# 6 Concluding Remarks

In summary, our study delves into the intricate balance between the gameplay benefits and investment drawbacks associated with supply decisions in collectible markets, and by extension, markets for durable goods. Our analysis is underpinned by a dynamic model that illuminates the nuanced interplay between consumer welfare, production limitations, and the dual role of collectibles as sources of utility and investment vehicles. By employing a representative agent framework, we discern how decisions impacting the stock of cards reverberate through consumer portfolios. Our model sheds light on the factors influencing card prices, where the stock of cards, future price expectations, and gameplay value collectively shape market dynamics.

We use a difference-in-differences reduced-form approach to isolate structural parameters crucial for welfare evaluation. Specifically, our findings pinpoint the adverse effects on consumer welfare stemming from increased card stocks, as captured by the relationship between inverse demand and the per-player card holdings. Our structural model allows us to gauge changes in consumer perceptions regarding stock fluctuations caused by reprinting (or reproduction) policies. Notably, our estimates suggest an approximate 1% inflation rate for reprinted cards leads to a decline in lifetime discounted utility for incumbent collectors by an estimated range of 3% to 14%. This decrease in utility is primarily attributed to the erosion of stored wealth resulting from the inflationary impact on reprinted cards.

Ultimately, our research underscores the trade-offs between supply decisions, consumer welfare, and the multifaceted nature of durable goods within secondary markets. In our setting, as the dynamics between user benefits and investment repercussions continue to evolve, our findings provide valuable insights into the complex landscape of durable goods economies, offering an understanding of the impacts of supply decisions on consumer well-being.

In October 1999, WotC modified its statement so that it would never add additional cards to the Reserved List.[16] Presently, the Reserved List is still a point of contention within the *MTG* community. Many players view the Reserved List as a relic of a time where the future of *MTG* was largely uncertain. Given how times of changed, there's an argument to be made that the RL no longer serves its intended purpose by making key game pieces inaccessible to most players regardless of how long they've played the game. On the other hand, the Reserved List still can be thought of as symbolic statement about WotC's reprint conservatism and a promise to stakeholders in the game to do their best to respect the value of their individual collections. Even within WotC, lead designer for MTG, Mark Rosewater, has gone on the record on his personal website, Blogatog, echoing the player sentiment of the Reserved List:

> "We know the majority of players would like it to be gone. That's been true for many years. That sadly doesn't make any of the other obstacles go away." (July 15, 2022)

[16]For information on the Reserved List's history, see articles from MTG Goldfish, and TCGPlayer. For WOTC's current reprint policy, see their official website.

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# A Supplemental Figures

## A.1 Scrye Magazine Example


Figure 5: Scrye Magazine (February, 1995)

## A.2 Example of Original Versus Reprint


Figure 6: **Left**: LEG *Nicol Bolas*, **Right**: CHR *Nicol Bolas*

### A.3 Example of Functional Reprint


Figure 7: **Left**: LEA *Llanowar Elves*, **Right**: ICE *Fyndhorn Elves*

## B Glossary of Terms & Abbreviations

While we abbreviate several details throughout our paper, we utilize this appendix to formally document any and relevant abbreviations used throughout our paper along with idiosyncratic terminologies that might be commonplace in the community of Magic: The Gathering players and investors, but less so to researchers. Table VII provides formal documentation of such terms and abbreviations.

Table VII: Glossary of Terms

| Term | Applicable Abbreviation | Definition |
|---|---|---|
| **Industry Terms & Abbreviations** | | |
| Magic: The Gathering | *MTG* | The trading card game, Magic: The Gathering |
| Wizards of the Coast | WOTC | The parent company who designs and produces *MTG* cards |
| Dungeons and Dragons | D&D | A tabletop role-playing game that was the inspiration for *MTG* |
| **Set Specific Terms & Abbreviations** | | |
| Core Set | CORE | The base set of cards for tournament play |
| Expansion Set | EXP | Sets that expanded the card pool for tournament play that are not core sets |
| Limited Edition Alpha | LEA | The first set of *MTG* cards |
| Limited Edition Beta | LEB | A higher-print run rerelease of LEA |
| Unlimited Edition | 2ED | A white-bordered reprint of LEA and LEB |
| Arabian Nights | ARN | The first *MTG* expansion set |
| Antiquities | ATQ | The second *MTG* expansion set |
| Revised Edition | 3ED | A slightly censored re-release of 2ED |
| Legends | LEG | The third *MTG* expansion set and largest expansion set in our sample |
| The Dark | DRK | The fourth *MTG* expansion set |
| Fallen Empires | FEM | The fifth overall *MTG* expansion and final expansion set in our sample |
| Fourth Edition | 4ED | The core set for the year of 1995 and largest core set in our sample |
| Chronicles | CHR | A reprint-only set of expansion set cards from ARN, ATQ, LEG, and DRK |
| **Other Idiosyncratic Terms & Abbreviations** | | |
| Reserved List | RL | WOTC's reprint policy for *MTG* cards implemented after the release of CHR |
| Reprint | – | The printing of a previous card, but in a new set |
| Functional Reprint | – | A reprint that is identical to a given card in all dimension save its name |

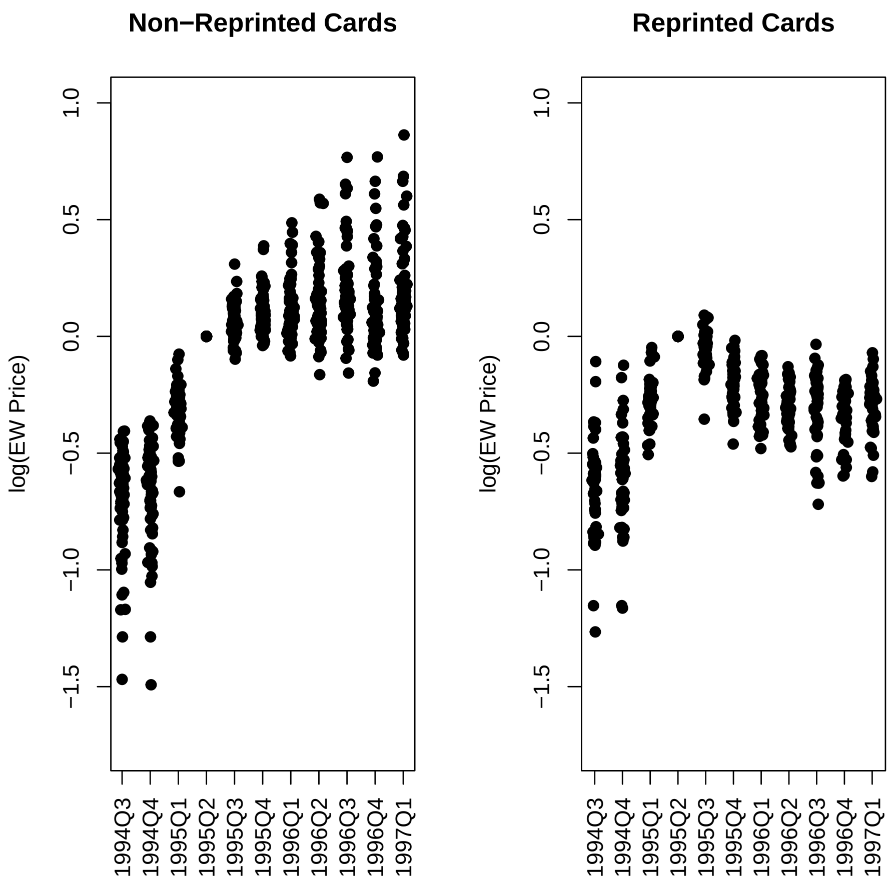


Figure 8: **Scatter Plots by Treatment.** This figure displays scatter plots of logged and equally-weighted *Scrye* price data, where the plot on the left are cards such that $Reprint_i = 0$, and $Reprint_i = 1$ on the right.

# C Data Appendix

Figure 8 shows scatter plots of de-meaned price data. The left panel is the non-treated set of cards with $Reprint_i = 0$, and the right panel is the set of treated cards with $Reprint_i = 1$.

Our data set on *MTG* card prices offer other measures of price variation based off information gathered by *Scrye*. Table VIII shows $\theta_{Rq}$. The quarter immediately preceding reprinting policy change, 1995Q1, has the normalization $\theta_R = 0$. Coefficient estimates and standard errors from Column EW of Table VIII are plotted in Figure 3.

| | Lower | Median | Upper | Upper/Lower | EW |
|---|---|---|---|---|---|
| 1994:Q3 | 0.011 | 0.003 | $0.046^{*}$ | $0.047^{*}$ | 0.022 |
| | (0.021) | (0.021) | (0.021) | (0.025) | (0.020) |
| 1994:Q4 | 0.027 | 0.006 | 0.030 | −0.014 | 0.020 |
| | (0.022) | (0.021) | (0.020) | (0.027) | (0.020) |
| 1995:Q2 | $-0.056^{***}$ | −0.014 | −0.004 | $0.066^{***}$ | $-0.022^{*}$ |
| | (0.012) | (0.013) | (0.011) | (0.009) | (0.011) |
| 1995:Q3 | $-0.179^{***}$ | $-0.150^{***}$ | $-0.097^{***}$ | $0.114^{***}$ | $-0.137^{***}$ |
| | (0.017) | (0.016) | (0.018) | (0.018) | (0.016) |
| 1995:Q4 | $-0.423^{***}$ | $-0.312^{***}$ | $-0.252^{***}$ | $0.241^{***}$ | $-0.319^{***}$ |
| | (0.018) | (0.019) | (0.019) | (0.013) | (0.019) |
| 1996:Q1 | $-0.587^{***}$ | $-0.398^{***}$ | $-0.246^{***}$ | $0.518^{***}$ | $-0.393^{***}$ |
| | (0.019) | (0.017) | (0.018) | (0.019) | (0.016) |
| 1996:Q2 | $-0.706^{***}$ | $-0.480^{***}$ | $-0.310^{***}$ | $0.685^{***}$ | $-0.464^{***}$ |
| | (0.025) | (0.026) | (0.021) | (0.037) | (0.023) |
| 1996:Q3 | $-0.721^{***}$ | $-0.516^{***}$ | $-0.396^{***}$ | $0.451^{***}$ | $-0.527^{***}$ |
| | (0.031) | (0.029) | (0.026) | (0.027) | (0.027) |
| 1996:Q4 | $-0.654^{***}$ | $-0.480^{***}$ | $-0.377^{***}$ | $0.428^{***}$ | $-0.483^{***}$ |
| | (0.035) | (0.031) | (0.027) | (0.033) | (0.029) |
| 1997:Q1 | $-0.658^{***}$ | $-0.492^{***}$ | $-0.400^{***}$ | $0.355^{***}$ | $-0.503^{***}$ |
| | (0.037) | (0.031) | (0.027) | (0.030) | (0.030) |
| $N$ | 1372 | 1372 | 1372 | 1372 | 1372 |
| $R^2$ | 0.897 | 0.892 | 0.911 | 0.611 | 0.921 |
| Card FE | 125 | 125 | 125 | 125 | 125 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table VIII: **Reprint Price Effects:** This table displays regression results for the difference-in-differences model in Equation 3.1. The leftmost three columns present estimates with the dependent variables of log of the lower quartile, median, and upper quartile of the price distribution. The fourth column uses the ratio of the upper quartile and lower quartile as the dependent variable. The rightmost column uses an "equally weighted" price that consists of the weighted average of median, upper, and lower quartiles. All standard errors are one-way clustered at the card level. All models include year-quarter and card fixed effects.

# D Model Appendix

In this section, we display the model for collectable goods. Time is in discrete periods, and we assume the consumer lives infinitely long, discounting each future period by a factor $\beta \in (0, 1)$. In each period $t$, the consumer simultaneously chooses a vector of collectible holdings $\mathbf{q}_t \in \mathbf{R}^I_+$ and consumption $c_t \geq 0$ in order to maximize their discounted (expected) lifetime utility.

In the contemporaneous period $t$, the consumer gains utility $\alpha \cdot u_t(\mathbf{q}_t)$ by holding collectibles and utility $(1-\alpha) \cdot \ln c_t$ from consumption, where $\alpha \in (0, 1)$ scales relative preference between collectibles and consumption and $u_t$ is increasing and concave in its arguments: $u_{it} > 0$, $u_{iit} < 0$. The consumer has exogenously determined income $y_t \geq 0$ in each period which is divided between consumption and new card purchases.

Let consumption $c_t$ be numeraire with price 1, and let collectibles have prices in the vector $\mathbf{p}_t \in \mathbf{R}_+^I$. The consumer carries only their collection of cards in the previous period, $\mathbf{q}_{t-1}$, as a state into the current period. The indirect value function is

$$V_t\left(\mathbf{q}_{t-1}\right) = \max_{\mathbf{q}_t \in \mathbf{R}_+^I} \alpha \cdot u_t\left(\mathbf{q}_t\right) + (1-\alpha) \cdot \ln c_t + \beta E_t\left[V_{t+1}\left(\mathbf{q}_t\right)\right] \tag{D.1}$$

$$\text{s.t. } c_t + \mathbf{p}_t' \mathbf{q}_t \leq y_t + \mathbf{p}_t' \mathbf{q}_{t-1} \tag{D.2}$$

where $E_t[\cdot]$ loosely allows for uncertain conditions in future periods, such as the flow of $y_t$ or the supply of collectibles.

The full Lagrangian for this problem is

$$\mathscr{L}\left(c_t, \mathbf{q}_t, \lambda_t; \mathbf{q}_{t-1}\right) = \alpha \cdot u_t\left(\mathbf{q}_t\right) + (1-\alpha) \cdot \ln c_t + \beta E_t\left[V_{t+1}\left(\mathbf{q}_t\right)\right] - \lambda_t \cdot \left[c_t - y_t + \mathbf{p}_t'\left(\mathbf{q}_t - \mathbf{q}_{t-1}\right)\right] \tag{D.3}$$

This has first order conditions

$$\frac{\partial \mathcal{L}}{\partial q_{it}}(\cdot) = \alpha \cdot u_{it}\left(\mathbf{q}_t^*\right) + \beta \cdot \frac{\partial}{\partial q_{it}} E_t\left[V_{t+1}\left(\mathbf{q}_t\right)\right] - \lambda_t p_{it} = 0 \tag{D.4}$$

$$\frac{\partial \mathcal{L}}{\partial c_t}(\cdot) = \frac{1-\alpha}{c_t^*} + \beta \cdot \frac{\partial}{\partial c_t} E_t\left[V_{t+1}\left(\mathbf{q}_t\right)\right] - \lambda_t = 0 \tag{D.5}$$

Differentiating with respect to the state variable $q_{it-1}$ yields the envelope condition

$$\frac{\partial V_t}{\partial q_{it-1}} = \lambda_t \cdot p_{it}\,. \tag{D.6}$$

Iterating forward one period and applying the linearity of differentiation we get

$$\alpha \cdot u_{it}\left(\mathbf{q}_t^*\right) + \beta \cdot E_t\left[\lambda_{t+1} \cdot p_{it+1}\right] = \lambda_t \cdot p_{it} \tag{D.7}$$

$$\frac{1-\alpha}{c_t^*} = \lambda_t \tag{D.8}$$

Replacing $\lambda_t$ and $\lambda_{t+1}$, we get

$$\alpha \cdot u_{it}\left(\mathbf{q}_t^*\right) + \beta \cdot E_t\left[\frac{1-\alpha}{c_{t+1}^*} \cdot p_{it+1}\right] = \frac{1-\alpha}{c_t^*} \cdot p_{it} \tag{D.9}$$

Finally, this gives the pricing equation

$$\frac{p_{it}}{c_t^*} = \frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_t^*\right) + \beta \cdot E_t\left[\frac{p_{it+1}}{c_{t+1}^*}\right] \tag{D.10}$$

## D.1 Proofs of Proposition 4.1

Imposing steady state conditions on Equation D.10 (and suppressing the $^*$ superscripts) yields simply

$$\frac{p_{it}}{c_t} = \frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta \cdot \frac{p_{it}}{c_t} \tag{D.11}$$

Thus, factoring out $p_{it}/c_t$ and dividing by $1-\beta$ yields

$$\frac{p_{it}}{c_t} = \frac{\alpha}{(1-\alpha)(1-\beta)} \cdot u_{it}\left(\mathbf{q}_t\right) \tag{D.12}$$

In the event $\mathbf{q}_t$ scales by a constant scalar $\rho \in (0,1)$ as in the second item of Proposition 4.1, we will use the assumed homogeneity of degree $\Gamma_t \in [0,1]$ to derive a closed form expression. Specifically, because $u_t$ is homogeneous of degree $\Gamma_t$, Euler's homoegenous function theorem indicates that $u_{it}$ must be homogeneous of degree $\Gamma_t - 1$. This means we can construct the following iterated pricing equation:

$$\frac{p_{it}}{c_t} = \frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta E_t\left[\frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_{t+1}\right) + \beta E_{t+1}\left[\frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_{t+2}\right) + \beta E_{t+2}\left[\frac{p_{it+3}}{c_{t+3}}\right]\right]\right]. \tag{D.13}$$

$$= \frac{\alpha}{1-\alpha} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta E_t\left[\frac{\alpha}{1-\alpha} \cdot \rho^{\Gamma_t - 1} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta E_{t+1}\left[\frac{\alpha}{1-\alpha} \cdot \rho^{2(\Gamma_t-1)} \cdot u_{it}\left(\mathbf{q}_t\right) + \beta E_{t+2}\left[\frac{p_{it+3}}{c_{t+3}}\right]\right]\right]. \tag{D.14}$$

Imposing constant consumption and preferences yields

$$\frac{p_i}{c} \cdot \frac{1-\alpha}{\alpha} = \sum_{t=0}^{\infty} \left(\beta \rho^{\Gamma - 1}\right)^t u_i\left(\mathbf{q}\right) \tag{D.15}$$

So,

$$\frac{p_{it}}{c_t} = \frac{\alpha}{(1-\alpha)(1-\beta\rho^{\Gamma_t - 1})} \cdot u_{it}\left(\mathbf{q}_t\right) \tag{D.16}$$

Finally, to derive Equation 4.8 in Proposition 4.1, we apply the Cobb-Douglass functional form of $u_t$,

$u_{it}(\mathbf{q}_t) = \Gamma_{it} q_{it}^{\Gamma_{it}-1} \prod_{j \neq i} q_{jt}^{\Gamma_{jt}} = \frac{\Gamma_{it}}{q_{it}} \cdot u_t(\mathbf{q}_t)$

$$u_{it}(\boldsymbol{\rho} \odot \mathbf{q}_t) = \Gamma_{it}(\rho_i q_{it})^{\Gamma_{it}-1} \prod_{j \neq i} (\rho_j q_{jt})^{\Gamma_{jt}} \tag{D.17}$$

$$= \frac{\Gamma_{it}}{\rho_i q_{it}} \cdot \prod_{j=1}^{I} (\rho_j q_{jt})^{\Gamma_{jt}} \tag{D.18}$$

$$= \frac{\Gamma_{it}}{\rho_i q_{it}} \cdot \prod_{j=1}^{I} \rho_j^{\Gamma_{jt}} \cdot \prod_{j=1}^{I} q_{jt}^{\Gamma_{jt}} \tag{D.19}$$

$$= \frac{\prod_{j=1}^{I} \rho_j^{\Gamma_{jt}}}{\rho_i} \cdot u_{it}(\mathbf{q}_t) \tag{D.20}$$

$$\equiv \frac{\Psi_t}{\rho_i} \cdot u_{it}(\mathbf{q}_t)\,. \tag{D.21}$$

Following the same algebra as the infinite series in Equation D.15, we get

$$\frac{p_{it}}{c_t} = \frac{\alpha}{(1-\alpha)\left(1 - \beta \frac{\Psi_t}{\rho_i}\right)} \cdot u_{it}\left(\mathbf{q}_t\right)\,. \tag{D.22}$$

## D.2 Assumptions for Model Consistency

As is common in settings with intertemporal choice, our setting may not admit a valid inverse demand curve, or even a valid solution to the consumer's utility maximization problem, without certain regularity conditions being established. Specifically in our case, the reduced-form inverse demand function in Equation 4.17, originally derived from Equation 4.8 in Proposition 4.1, is valid only when $1 - \beta \Psi_s \rho_{is}^{-1} > 0$. This is equivalent to

$$\frac{\rho_{is}}{\beta} > \prod_{j=1}^{I_s} \rho_{js}^{\Gamma_{js}}\,. \tag{D.23}$$

Note that if $\rho_{is} \geq \beta$, then the above is equivalent to $1 > \prod_{j=1}^{I_s} \rho_{js}^{\Gamma_{js}}$ or $0 > \sum_{j=1}^{I_s} \Gamma_{js} \ln \rho_{js}$. Equivalently,

$$0 > \sum_{j=1}^{I} \Gamma_{js} \ln \rho_{js} \tag{D.24}$$

$$0 > \frac{\sum_{j=1}^{I} \Gamma_{js} \ln \rho_{js}}{\sum_{k=1}^{I} \Gamma_{ks}} \tag{D.25}$$

$$0 > \sum_{j=1}^{I} \tilde{\Gamma}_{js} \ln \rho_{js} \tag{D.26}$$

where $\sum_{j=1}^{I} \tilde{\Gamma}_{js} = 1$. Intuitively, in the application to this condition states the *preference-weighted* average card decay $\rho_{is}$ must be less than 1. This is true if cards with higher values of $\Gamma_{it}$ tend to have lower values of $\rho_{it}$.

For example partition cards into two types, $A$ and $B$, with preference parameters $\Gamma_{As} = \sum_{j \in A} \Gamma_{js}$ and $\Gamma_s = \sum_{j=1}^{I} \Gamma_{js}$. Similarly defining $\rho_{As}$ and $\rho_{Bs}$, we have

$$\frac{\rho_{As}}{\beta} > \rho_{As}^{\Gamma_{As}} \rho_{Bs}^{\Gamma_s - \Gamma_{As}} \implies \rho_{Bs} < \beta^{-\frac{1}{\Gamma_s - \Gamma_{As}}} \cdot \rho_{As}^{\frac{1-\Gamma_{As}}{\Gamma_s - \Gamma_{As}}} \tag{D.27}$$

$$\frac{\rho_{Bs}}{\beta} > \rho_{As}^{\Gamma_{As}} \rho_{Bs}^{\Gamma_s - \Gamma_{As}} \implies \rho_{Bs} > \beta^{-\frac{1}{\Gamma_s - \Gamma_{As} - 1}} \cdot \rho_{As}^{-\frac{\Gamma_{As}}{\Gamma_s - \Gamma_{As} - 1}} \tag{D.28}$$

Accordingly, $\rho_{As} = \rho_{Bs} = \beta^{\frac{1}{1-\Gamma_s}}$ are the minimum possible values for $\rho_{is}$.

Figures 9 and 10 plot shaded regions representing valid values of $\rho_{As}$ for varying values of $\rho_{Bs}$, $\Gamma_s$, $\Gamma_{As}$, and $\beta$. Because our data on *MTG* card prices are at the quarterly level, we start with comparisons of time-discount factors of $\beta = 0.995$ and $\beta - 0.990$ in Figure 9. The left panel shows that decreasing the discount factor expands the range of valid values of $\rho_{As}$ for a given value of $\rho_{Bs}$. Intuitively, pairs $(\rho_{As}, \rho_{Bs})$ are valid as long as the values are relatively close to each other, where "relatively" depends on the size of time-discounting.

On the right panel of Figure 9, we fix $\rho_{Bs} = 1$ instead and depict valid regions of $\rho_{As}$ as a functions of $\Gamma_{As}$ for $\beta = 0.995$ and $\beta = 0.990$. Again, we see that valid values of $\rho_{As}$, when $\rho_{Bs} = 1$, also fall around 1 for all possible values of $\Gamma_{As}$. As $\Gamma_{As}$ becomes larger, the region of valid values for $\rho_{As}$ shifts from above 1 to below 1. Finally, decreasing $\beta$ from 0.995 to 0.990 simply widens the range of valid values for $\rho_{As}$.

Both panels of Figure 10 hold $\beta = 0.995$ and allow $\Gamma_s$ to change between the panels. On the left panel, decreasing $\Gamma_s$ from 1 to 0.5 removes many valid pairs of $(\rho_{As}, \rho_{Bs})$ that fall significantly below 1, while more pairs are valid above 1. Moving from the left panel to the right panel, decreasing $\Gamma_s$ from 0.5 to 0.3 while keeping $\Gamma_{As}$ constant at $\Gamma_{As} = 0.25$ has the effect of further shifting the region of valid $\rho$ pairs up the number line while simultaneously widening the cone of valid parameter pairs. Intuitively, smaller values of $\Gamma_s$ imply steeper marginal utility functions, which in turn imply larger changes in *MTG* card prices for a given size of $\rho_{As}$. Accordingly, if $\Gamma_s$ is sufficiently small, small enough values of $(\rho_{As}, \rho_{Bs})$ will imply infinite wealth for holders of *MTG* cards.

## D.3 Computing Changes in Lifetime Utility

We wish to examine how the lifetime discounted utility of a consumer changes with differences in $\rho_i$ for a given steady state. Totally differentiating $V_t$ with respect to $\rho_i$ given the rule $q_{it} = \rho_i \cdot q_{it-1}$ yields the following

$$\frac{dV_t}{d\boldsymbol{\rho}} = \sum_{i=1}^{I} \frac{\partial V_t}{\partial q_{it-1}} \cdot \frac{dq_{it-1}}{d\rho_i} \, . \tag{D.29}$$

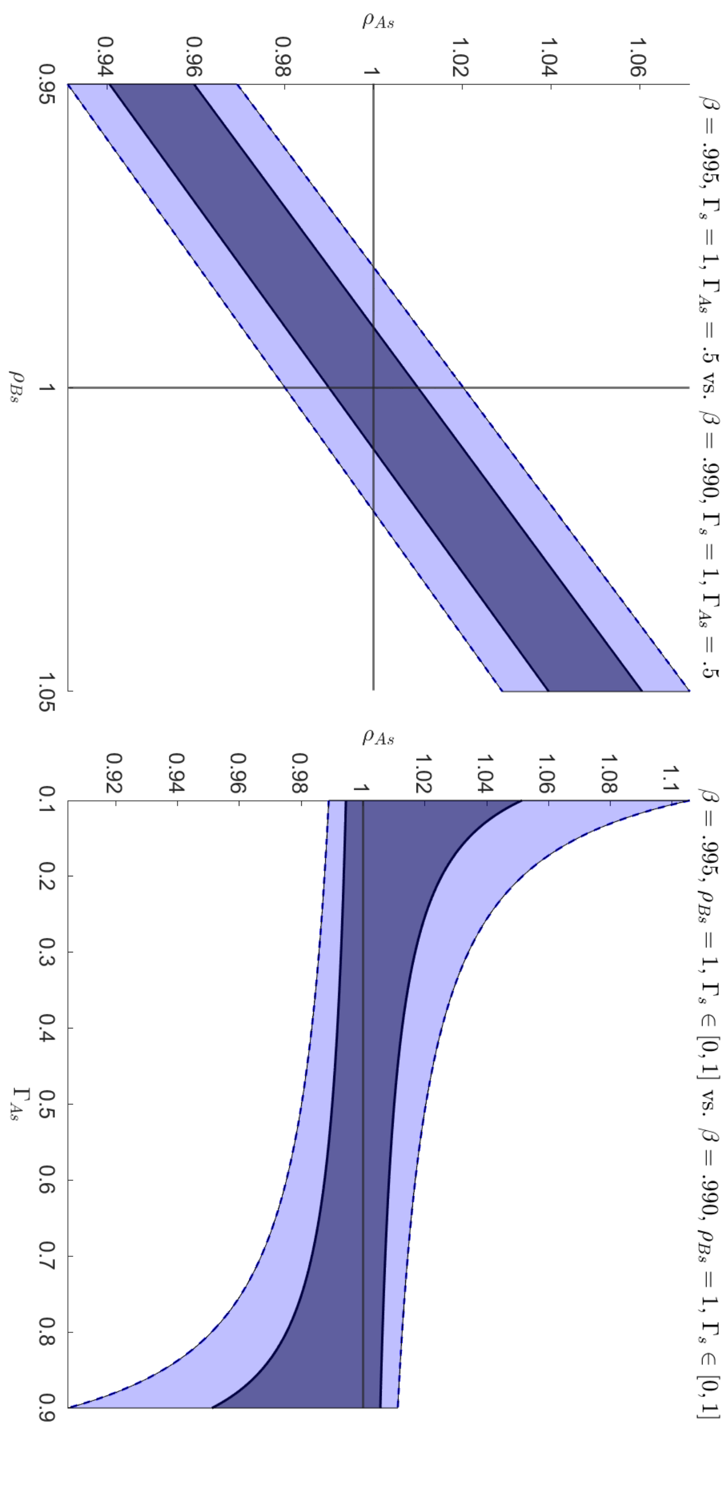


Figure 9: **Valid Parameterizations I.** This figure displays valid combinations of $\rho_{As}$ and $\rho_{Bs}$ on the top figure, and valid combinations of $\rho_{As}$ and $Gamma_{As}$ in the bottom figure. In each figure, the light-shaded region is for $\beta = 0.995$, and the dark-shaded region is for $\beta = 0.99$.

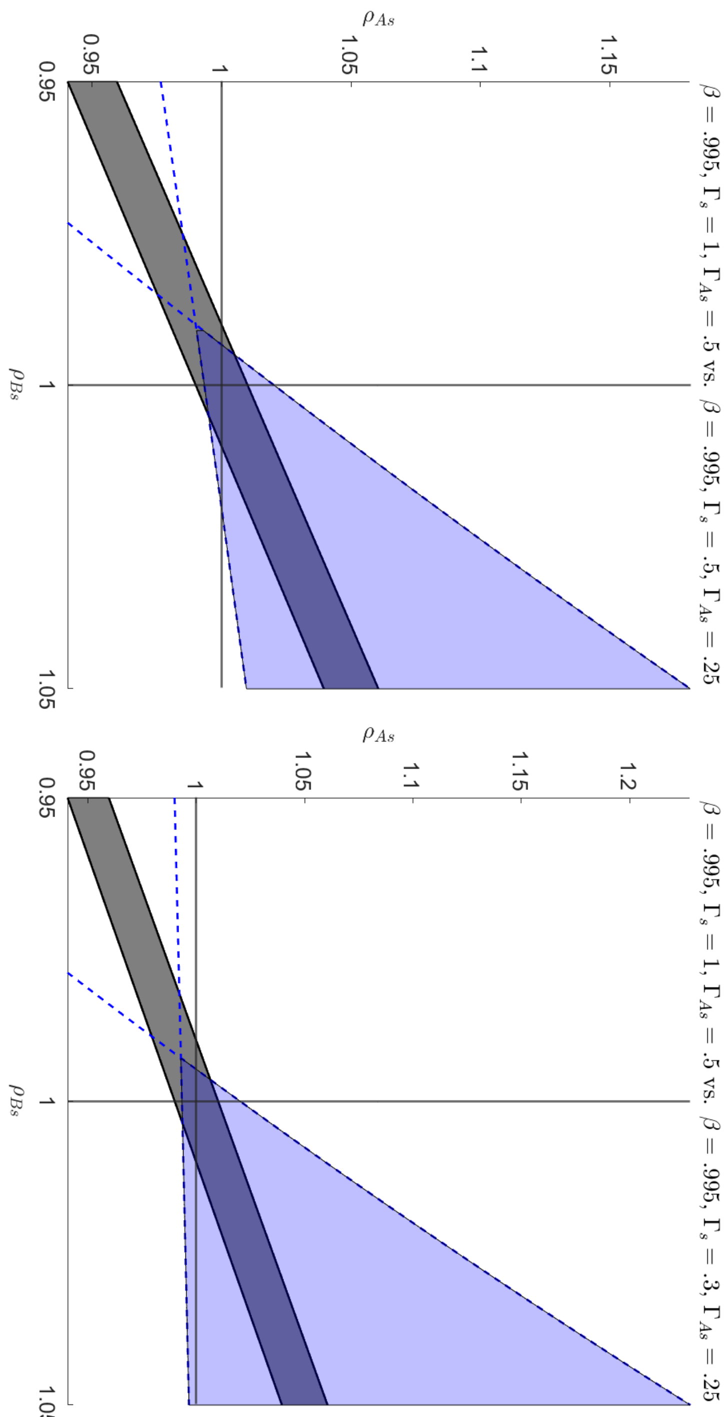


Figure 10: **Valid Parameterizations II.** This figure displays valid combinations of $\rho_{As}$ and $\rho_{Bs}$ on the top and bottom figures. In each figure, the dark-shaded region (with the gray) is valid parameterizations with $\beta = 0.995$, $\Gamma_s = 1$, and $\Gamma_{As} = 0.50$ (the same as the top panel of Figure 9). In the top figure, the light-shaded region (with the blue) is valid paramerizations with $\beta = 0.995$, $\Gamma_s = 0.50$, and $\Gamma_{As} = 0.25$. In the bottom figure, the light-shaded region is valid paramerizations with $\beta = 0.995$, $\Gamma_s = 0.30$, and $\Gamma_{As} = 0.25$.

We know from the objective function above that

$$\frac{\partial V_t}{\partial q_{it-1}} = \lambda_t \cdot p_{it} = \frac{1-\alpha}{c_t} \cdot p_{it} = \frac{\alpha}{1-\beta \cdot \Psi \cdot \rho_i^{-1}} \cdot u_{it}\left(\mathbf{q}_t^*\right) \tag{D.30}$$

$$\frac{dq_{it-1}}{d\rho_i} = \frac{d}{d\rho_i}\rho_i^{-1} \cdot q_{it} = -\rho_i^{-2} \cdot q_{it} \tag{D.31}$$

Combining and applying $u_{it}\left(\mathbf{q}_t^*\right) \cdot q_{it}^* = \Gamma_{it} \cdot u_t\left(\mathbf{q}_t^*\right)$ we get

$$\frac{dV_t}{d\boldsymbol{\rho}} = -u_t\left(\mathbf{q}_t^*\right) \cdot \sum_{i=1}^{I} \frac{\alpha}{\rho_i\left(\rho_i - \beta \cdot \Psi\right)} \cdot \Gamma_{it} < 0 \tag{D.32}$$

Note that $u_t\left(\boldsymbol{\rho} \odot \mathbf{q}_t^*\right) = \Psi \cdot u_t\left(\mathbf{q}_t^*\right)$ where $\Psi = \prod_{i=1}^{I} \rho_i^{\Gamma_{it}}$. The above formula describes the change in lifetime discounted payoff given $\mathbf{q}_{t+1} = \boldsymbol{\rho} \odot \mathbf{q}_t$. Note that $V_t$ is decreasing in $\boldsymbol{\rho}$: this is because $u_t(\cdot)$ is positive, and $\rho > \beta \cdot \Psi$ for valid calibrations of parameters (see previous section for more details).

Next, note that if $\boldsymbol{\rho} = \mathbf{1}$, then the above simplifies to

$$\frac{dV_t}{d\boldsymbol{\rho}}(\boldsymbol{\rho} = \mathbf{1}) = -u_t\left(\mathbf{q}_t^*\right) \cdot \sum_{i=1}^{I} \frac{\alpha}{1-\beta} \cdot \Gamma_{it} = -\frac{\alpha}{1-\beta} \cdot \Gamma_t \cdot u_t(\mathbf{q}_t^*) \tag{D.33}$$

The first-order approximation for $V_t\left(\boldsymbol{\rho}\right)$ around $\boldsymbol{\rho} = 1$ using the *total* derivative is

$$V_t\left(\boldsymbol{\rho}\right) \approx V_t\left(\boldsymbol{\rho} = 1\right) + \frac{dV_t}{d\boldsymbol{\rho}}\left(\boldsymbol{\rho}\right), \tag{D.34}$$

so our proportion change in lifetime discounted utility, and the ultimate object of interest, is

$$\frac{V_t(\boldsymbol{\rho})}{V_t(\boldsymbol{\rho} = \mathbf{1})} \approx \frac{V_t(\boldsymbol{\rho} = \mathbf{1}) + \frac{dV_t}{d\boldsymbol{\rho}}(\boldsymbol{\rho})}{V_t(\boldsymbol{\rho} = \mathbf{1})} \tag{D.35}$$

Because the total derivative at a point $\boldsymbol{\rho} = 1$ is also the best linear approximation of $V_t(\cdot)$ at this point, we have

$$V_t(\boldsymbol{\rho} = 1) \approx -\frac{\alpha}{1-\beta} \cdot \Gamma_t \cdot u_t(\mathbf{q}_t^*). \tag{D.36}$$

Finally, we have

$$V_t\left(\boldsymbol{\rho}\right) \approx V_t\left(\boldsymbol{\rho} = 1\right) + \frac{dV_t}{d\boldsymbol{\rho}}(\boldsymbol{\rho}) \tag{D.37}$$

$$= -\frac{\alpha}{1-\beta} \cdot \Gamma_t \cdot u_t(\mathbf{q}_t^*) - u_t\left(\mathbf{q}_t^*\right) \cdot \sum_{i=1}^{I} \frac{\alpha}{\rho_i\left(\rho_i - \beta \cdot A\right)} \cdot \Gamma_{it} \tag{D.38}$$

which is the first order Taylor series approximation of $V_t(\boldsymbol{\rho})$ around $\boldsymbol{\rho} = \mathbf{1}$. Simplifying,

$$V_t(\boldsymbol{\rho}) \approx -\alpha \cdot u_t(\mathbf{q}_t^*) \cdot \left[\frac{\Gamma_t}{1-\beta} + \sum_{i=1}^{I} \frac{1}{\rho_i(\rho_i - \beta \cdot A)} \cdot \Gamma_{it}\right] \tag{D.39}$$

$$= -\frac{\alpha}{1-\beta} \cdot u_t(\mathbf{q}_t^*) \cdot \left[\sum_{i=1}^{I} \frac{\rho_i \cdot (\rho_i - \beta \cdot A) + 1 - \beta}{\rho_i \cdot (\rho_i - \beta)}\right] \tag{D.40}$$

$$= -\frac{\alpha}{1-\beta} \cdot u_t(\mathbf{q}_t^*) \cdot \sum_{i=1}^{I} \Gamma_{it} \left[\frac{\rho_i - \beta \cdot A}{\rho_i - \beta} + \frac{1-\beta}{\rho_i \cdot (\rho_i - \beta)}\right] \tag{D.41}$$

This means the proportion increase in lifetime discounted utility is

$$\frac{V_t(\boldsymbol{\rho})}{V_t(\boldsymbol{\rho}=1)} = \frac{-\frac{\alpha}{1-\beta} \cdot u_t(\mathbf{q}_t^*) \cdot \sum_{i=1}^{I} \Gamma_{it} \left[\frac{\rho_i - \beta \cdot A}{\rho_i - \beta} + \frac{1-\beta}{\rho_i \cdot (\rho_i - \beta)}\right]}{-\frac{\alpha}{1-\beta} \cdot \Gamma_t \cdot u_t(\mathbf{q}_t^*)} \tag{D.42}$$

$$= \sum_{i=1}^{I} \frac{\Gamma_{it}}{\Gamma_t} \left[\frac{\rho_i - \beta \cdot A}{\rho_i - \beta} + \frac{1-\beta}{\rho_i \cdot (\rho_i - \beta)}\right] \tag{D.43}$$

In the case there is just two card types, one with $\rho_R \neq 1$ and $\rho = 1$ otherwise, we have

$$\frac{V_t(\boldsymbol{\rho})}{V_t(\boldsymbol{\rho}=1)} = \frac{\Gamma_{Rt}}{\Gamma_t} \left[\frac{\rho_R - \beta \cdot \rho_R^{\Gamma_{Rt}}}{\rho_R - \beta} + \frac{1-\beta}{\rho_R \cdot (\rho_R - \beta)}\right] + \frac{\Gamma_t - \Gamma_{Rt}}{\Gamma_t} \left[\frac{1 - \beta \cdot \rho_R^{\Gamma_{Lt}}}{1-\beta} + 1\right] \tag{D.44}$$

$$= 1 + \frac{\Gamma_{Rt}}{\Gamma_t} \left[\frac{\rho_R - \beta \cdot \rho_R^{\Gamma_{Rt}}}{\rho_R - \beta} + \frac{1-\beta}{\rho_R \cdot (\rho_R - \beta)} - \frac{1 - \beta \rho_R^{\Gamma_{Rt}}}{1-\beta} - 1\right] \tag{D.45}$$

$$= 1 + \frac{\Gamma_{Rt}}{\Gamma_t} \cdot \left(1 - \beta \cdot \rho_R^{\Gamma_{Rt}}\right) \cdot \left\{[\rho_R \cdot (\rho_R - \beta)]^{-1} - (1-\beta)^{-1}\right\} \tag{D.46}$$

This means that consumer utility is increasing at a given $\rho$ relative to 1 if

$$\frac{1}{\rho_R(\rho_R - \beta)} > \frac{1}{1-\beta} \tag{D.47}$$

Note that if $\rho_{Rt} = 1$, we get equivalence, and the rate of change is 1.

The above inequality simplifies to

$$-\rho_R^2 + \rho_R \cdot \beta + 1 - \beta > 0 \tag{D.48}$$

$$\tag{D.49}$$

The solutions are

$$\rho_R = \frac{-\beta \pm \sqrt{\beta^2 - 4 \cdot (-1) \cdot (1-\beta)}}{-2} = 1 \text{ or } \beta - 1 \tag{D.50}$$

There is a unique positive solution at $\rho_R = 1$. Note also this fraction's function has a vertical asymptote at $\rho_R = \beta$, where $V_t(\rho)/V_t(\rho = 1)$ approaches infinity.

Conclusion:

$$\frac{V_t(\boldsymbol{\rho_R})}{V_t(\boldsymbol{\rho_R}=1)}\begin{cases} >1 & \text{if } \rho_R \in (\beta,1) \\ =1 & \text{if } \rho_R = 1 \\ <1 & \text{if } \rho_R > 1 \end{cases} \tag{D.51}$$

# E Card-Specific $\theta$ Estimates

We note that our structural $\theta$ estimates tend to confirm widely-understood beliefs that the *MTG* player community has held with regards to the "most powerful cards" in the game. In fact, to this day, the most nine powerful cards in the game (collectively referred to as the *Power Nine*) consist of: Black Lotus, Mox Ruby, Mox Jet, Mox Sapphire, Mox Emerald, Mox Pearl, Time Walk, Timetwister, and Ancestral Recall. We note from our above table that the first seven cards with the highest individual $\theta$ estimates align with the consensus Power Nine. The other two Power Nine cards, Timetwister, and Ancestral Recall occupy the tenth and eleventh highest $\theta$ positions, however. Furthermore, the general consensus is that the Black Lotus is the most powerful card for gameplay purposes in *MTG* (still widely considered as true through the present day). This is further confirmed via our $\theta$ estimate for Black Lotus, which occupies the top spot in magnitude.

Table IX: Card-Specific $\theta$ Estimates

| **Card** | **Reprinted in 4ED/CHR?** | **Reserved List?** | $\theta$ **Estimate** |
|---|---|---|---|
| Black Lotus | 0 | 1 | 0.029 |
| Mox Ruby | 0 | 1 | 0.018 |
| Mox Jet | 0 | 1 | 0.017 |
| Mox Sapphire | 0 | 1 | 0.017 |
| Mox Emerald | 0 | 1 | 0.017 |
| Mox Pearl | 0 | 1 | 0.017 |
| Time Walk | 0 | 1 | 0.015 |
| Gauntlet of Might | 0 | 1 | 0.013 |
| Forcefield | 0 | 1 | 0.012 |
| Timetwister | 0 | 1 | 0.012 |
| Ancestral Recall | 0 | 1 | 0.011 |
| Chaos Orb | 0 | 1 | 0.010 |
| Cyclopean Tomb | 0 | 1 | 0.009 |
| Time Vault | 0 | 1 | 0.008 |
| Word of Command | 0 | 1 | 0.008 |
| Two-Headed Giant of Foriys | 0 | 1 | 0.008 |
| Lich | 0 | 1 | 0.008 |
| Ali from Cairo | 0 | 1 | 0.007 |
| Guardian Beast | 0 | 1 | 0.007 |
| Raging River | 0 | 1 | 0.007 |
| Illusionary Mask | 0 | 1 | 0.006 |
| Mirror Universe | 0 | 1 | 0.006 |
| Blaze of Glory | 0 | 1 | 0.006 |
| Juzám Djinn | 0 | 1 | 0.006 |
| Natural Selection | 0 | 1 | 0.005 |
| Shivan Dragon | 0 | 0 | 0.005 |
| Diamond Valley | 0 | 1 | 0.005 |
| Singing Tree | 0 | 0 | 0.004 |
| Royal Assassin | 0 | 0 | 0.004 |
| Old Man of the Sea | 0 | 1 | 0.004 |
| Jihad | 0 | 1 | 0.004 |
| Vesuvan Doppelganger | 0 | 1 | 0.004 |
| All Hallow's Eve | 0 | 1 | 0.004 |
| Argivian Archaeologist | 0 | 1 | 0.004 |
| Nicol Bolas | 1 | 0 | 0.004 |
| Candelabra of Tawnos | 0 | 1 | 0.004 |
| Fork | 0 | 1 | 0.004 |
| Vaevictis Asmadi | 1 | 0 | 0.004 |
| Palladia-Mors | 1 | 0 | 0.004 |
| Ring of Ma'rûf | 0 | 0 | 0.004 |
| Nightmare | 0 | 0 | 0.004 |
| Island of Wak-Wak | 0 | 1 | 0.004 |
| Chromium | 1 | 0 | 0.004 |
| Arcades Sabboth | 1 | 0 | 0.004 |
| Force of Nature | 0 | 0 | 0.004 |
| The Abyss | 0 | 1 | 0.004 |
| The Wretched | 1 | 0 | 0.004 |
| Sword of the Ages | 0 | 1 | 0.003 |
| Drop of Honey | 0 | 1 | 0.003 |
| Dakkon Blackblade | 1 | 0 | 0.003 |