

# LEGO - THE TOY OF SMART INVESTORS

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## Abstract

We study a new alternative investment asset - LEGO sets. LEGO is an iconic toy with diminishing over time supply and a high collectable value. A huge secondary market for LEGO sets with tens of thousands of transactions per day has developed since the turn of the century. We find that LEGO investments outperform large stocks, bonds, gold and other alternative investments, yielding the average return of at least 11% (8% in real terms) in the sample period 1987-2015. Small and huge sets, as well as seasonal, architectural and movie-based sets, deliver higher returns. LEGO returns are not exposed to market, value, momentum and volatility risk factors, but have an almost unit exposure to the size factor. A positive multifactor alpha of 4-5%, a Sharpe ratio of 0.4, a positive return skewness and a low exposure to standard risk factors make the LEGO toy an attractive alternative investment with a good diversification potential.

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## 1. INTRODUCTION

Increasing globalization and interconnections between various asset markets leave fewer opportunities for diversification. As a result, investors turn to alternative non-financial assets to reduce their risks and increase potential returns. According to a Barclays (2012) survey, the average high-net-worth individual holds about 10 percent of her wealth invested in collectible assets such as artworks, antiques, jewelry, fine wines, rare automobiles and other luxuries partially in order to diversify their portfolios and hedge their financial investments. Investment funds which deal with collectible wines, artworks, precious metals and stones improve the accessibility of such assets to retail investors.<sup>1</sup> The ‘traditional’ alternative investments, which have been popular for decades, have been widely studied in the literature.<sup>2</sup> In this paper, we study a relatively new alternative asset, which has not received any attention in the academic finance literature - LEGO sets. Although it may seem odd to invest in a toy, a huge secondary market for LEGO sets with tens of thousands of investors developed in the 2000s (Maciorovsky, 2015). The popularity of LEGO investments is partially driven by the fact that this alternative asset does not belong to the luxury segment and is therefore affordable to any retail investor.

LEGO Group (LEGO thereafter), a Danish company, which was established in Billund in 1932 as a small wooden toy producer, is nowadays the largest toy producer in the world. Fortune magazine named LEGO "the toy of the century" in 2000. According to a massive survey of more than three thousand adults in 2010, LEGO was named the most popular toy of all times (Robertson and Breen, 2013). Together with Coca-Cola and Disney, LEGO occupies a top position in the Young&Rubicam rating of the most popular world brands. The LEGO factory in Billund produces 2.2 million bricks every hour, and the number of LEGO bricks produced each year is five times as high as the current world population (Robertson and Breen, 2013). Every child in every country knows and plays LEGO.

Apparently, LEGO is not just a kids' toy. Thousands of adults around the world collect LEGO sets. LEGO bricks are used to build large-scale objects and real art masterpieces (e.g. the world famous exhibition "The Art of the Brick" by Nathan Sawaya). Even a full-scale house was built of 3.2 million LEGO bricks by a British television presenter and journalist James May.

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<sup>1</sup> For example, the IQ Physical Diamond Trust, the Diamond Circle Capital Fund and the diamond fund by Swiss Asset Advisors are several recent examples (Romano, 2011; Popper, 2012).

<sup>2</sup> E.g. works of art (Baumol, 1986; Goetzmann, 1993; Mei and Moses, 2002; Renneboog and Spaenjers, 2011 and 2013; Dimson and Spaenjers, 2014), precious metals and stones (Renneboog and Spaenjers, 2012; Auer and Schuhmacher, 2013; Low et al., 2016), collectible automobiles (Martin, 2016), postage stamps (Dimson and Spaenjers, 2011 and 2014), collectible violins (Graddy and Margolis, 2011; Dimson and Spaenjers, 2014), fine wines (Masset and Weisskopf, 2010; Kourtis et al., 2012; Dimson et al., 2015). More details are reported in section 2.

LEGO sets and rare minifigures also serve as alternative investments. There is a huge secondary market for new and used sets (e.g. eBay), where tens of thousands of sets are traded in the world every day (Maciorovsky, 2015). The returns on some retired sets reached outrageous numbers (up to 600% per annum), which received a lot of attention from financial press. For example, an article in the Telegraph reported a 12% average return on LEGO sets since the turn of the Millennium compared to 4.1% on FTSE 100 and 9.6% on gold (the Telegraph, 24 December 2015). The article also named five most expensive sets with the current values above £1,500 and five most profitable sets with returns above 1,000% over 8-10 years since their release dates.<sup>3</sup>

This paper studies historical returns on a wide sample of 2,322 LEGO sets from all most popular themes to obtain a complete picture of the attractiveness of this market to investors. We find, that different sets perform unequally with average returns ranging from -50% to 600% per annum. The cross-sectional distribution of set average returns has the mean of 18.5%, the standard deviation of 35% and the skewness of +9. Small and huge sets are more profitable than medium-sized sets. Small sets often contain unique parts or minifigures, whereas large sets are usually popular among adult collectors<sup>4</sup>. Different LEGO themes are not equally attractive. In general, seasonal, architectural and movie-based themes deliver higher returns. LEGO returns tend to be higher towards the end of the sample period, when LEGO secondary market became deeper with the development of different LEGO trading platforms.

The LEGO price index, that we construct from a hedonic regression coefficients, has the average return of 11% per annum (8% in real terms) over 1987-2015<sup>5</sup>. Discounted purchases of LEGO sets on the primary market make the returns even higher.<sup>6</sup> Thus, LEGO investments outperform large stocks, bonds, gold and other ‘hobby investments’. The LEGO returns are not significantly exposed to market, value, momentum and volatility risk factors. We only identify a unit exposure to the Fama-French size factor, suggesting that LEGO investments perform similarly to small stocks. The positive multifactor alpha of 4-5%, the Sharpe ratio of 0.4, the positive return skewness and the low exposure to standard risk factors make the LEGO toy an attractive alternative investment with a good diversification potential. Moreover, since sales of LEGO were constantly

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<sup>3</sup> The five most expensive sets (secondary market value as of December 2015 in parentheses) are Ultimate Collector’s Millennium Falcon (£2,712), Café Corner (£2,096), Taj Mahal (£1,848), Death Star II (£1,524) and Imperial Star Destroyer (£1,467). The five most profitable sets (total return in parentheses) are Café Corner (2,230% over 8 years), Market Street (1,064% over 8 years), Holiday Train (1,048% over 9 years), Rescue from the Merpeople (1,018% over 10 years) and The Batboat: Hunt for Killer Croc (1,011% over 9 years).

<sup>4</sup> Thanks to a LEGO hobbyist Gaurav Thakur for pointing this out.

<sup>5</sup> LEGO prices continue to rise at the pace of 6.2% per annum in 2016-2018 (based on a sub-sample of 320 sets).

<sup>6</sup> Because in this paper we calculate returns relative to the official primary market prices, we significantly underestimate returns, actually received by LEGO investors. All LEGO re-sellers are unanimous in the view that it is important to search for bargains. ‘The goal is to buy retail and on discount’, says Jeff Maciorowski to Wealthsimple (“How to invest in Legos and make a bazillion dollars” by Bill Bradley, Wealthsimple, September 14, 2016).

increasing in the 90s and 2000s despite the global financial crises, when other toy companies experienced difficulties, we can expect ‘safe-haven’ properties from LEGO investments. Indeed, the LEGO market delivered positive average returns in the crisis years 2002 and 2008, when the CRSP index plunged.

The main reason for such high LEGO returns on the secondary market is diminishing over time supply. In this respect, LEGO can be compared to fine wines<sup>7</sup>. Once a bottle of wine is opened, the supply of this particular kind of wine falls. Once a LEGO box is opened, the supply of this particular set falls. Over time, old LEGO sets become more and more rare, collectors hunt for them, and their prices inevitably rise.

The high return on LEGO secondary market is also attributed to underpricing of collectable sets on the primary market. We explore the evolution of secondary market prices during the first six years after sets are released by the company and find the following tendency. The secondary market prices are generally lower than the official prices while the sets are still being offered in stores, and they tend to jump up after two-three years of the release when the sets disappear from the primary market. The prices continue to rise gradually thereafter.

The rest of the paper is organized as follows. Section 2 explains why LEGO is so special compared to other toys. Section 3 reviews academic studies of alternative ‘hobby investments’. In section 4, we present a brief history of LEGO group and describe how the LEGO toy transformed over time and became an investment in addition to being just a toy. Section 5 lays out a simple illustrative model of LEGO price behavior over time. Sections 6 and 7 describe the data, the data sources and the descriptive statistics. In section 8, we build LEGO price indices and analyze their characteristics and risk exposure. In section 9, we explore the dynamics of LEGO returns in the first several years after set release. Section 10 is devoted to related transaction costs. Section 11 concludes.

## 2. WHY LEGO?

What makes the LEGO toy a so special investment asset with high expected returns besides just being the “toy of the century”? Why shall we expect high returns in the future? There are several features, which make LEGO bricks different from other toys and create an investment potential.

Firstly, the *adult audience* due to the long history of the brand and compatibility of all sets ever produced by the company. “A lot of the buyers are people who are in their 30s and 40s, and they are looking for something that is nostalgic from when they were a kid”, says Nate Tobik, a LEGO re-

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<sup>7</sup> Other similarities between fine wines and LEGO are their consumption values and relatively cheap initial prices. Such alternative investments have an embedded option of being consumed in case of financial losses.

seller, in an interview with Marketplace.<sup>8</sup> He says, that part of what drives demand on the secondary market is the sheer enthusiasm as well as the financial means of adult fans of LEGO (known as AFOL). Because LEGO is rather expensive for a toy and is not always affordable by parents, we observe a high demand for sets released decades ago by adults regaining their childhood, says a LEGO retail shop manager Adrian Burke.<sup>9</sup> Adult collectors often buy sets in a particular theme (like Pirates or Star Wars), and the compatibility of old and newly released sets is important. The LEGO group recognizes this, and most big and expensive sets are marketed towards adult collectors. “Adult fans of LEGO are also an important audience for the company”, says Julia Goldin, the LEGO marketing director, in an interview with CNBC.<sup>10</sup>

Secondly, the *diminishing over time supply* on the secondary market. LEGO Group has a policy to continuously release new sets and generally not to repeat older sets in production. As Julia Goldin says to CNBC, “children are always looking for novelty”. The company releases new sets to attract children and make high profits. However, if a collector wishes to buy a retired set, she can only do this on the secondary market. The supply there is limited by the number of sealed sets in resellers' hands. Once sets are bought and opened, they leave the secondary market, and the total supply falls. Therefore, over time, it becomes more and more difficult to buy older sets, collectors have to hunt for them, and their prices increase. LEGO investments are generally considered very long-term. Rare (limited-edition) sets tend to pay off sooner, but for common sets, you need to wait years before they become rare on the secondary market to realize a positive return. In this respect, LEGO investments are similar to other consumable alternative investments like art or fine wines.

Thirdly, *underpricing of collectible sets on the primary market*. The high collectible value of LEGO sets is not reflected in the primary market prices because of the company's policy of marginal cost pricing, i.e. the price of a set depends on the amount of plastic used to produce it. However, as a LEGO hobbyist pointed out in a private conversation, many sets which have any of the following features:

- 1) rare parts or minifigures,
- 2) licensed sets,
- 3) large sets with >1,000 pieces,
- 4) sets with low price per piece ratio,
- 5) sets with short production runs,
- 6) limited edition sets,
- 7) small sets and polybags,
- 8) seasonal sets,
- 9) sets, which were only sold at promotional events,
- 10) unique sets

have high collectible value despite their moderate original prices. A good example is a minifigure of Mr. Gold, which is a desire of many collectors and is offered on the secondary market for about

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<sup>8</sup> “Bang for your brick: behind Lego’s thriving secondary market”, by Justin Ho, Marketplace, March 04, 2019.

<sup>9</sup> “Is Lego still a good investment in 2019?” by Adrian Burke, Quora, January 26, 2019.

<sup>10</sup> “How marketing built Lego into the world’s favourite toy brand”, by Lucy Handley, CNBC, April 27, 2018.

\$2,000 nowadays despite its original price of \$2.99 in 2013. We often observe a price jump on the secondary market once a set is retired and disappears from the primary market (see section 9 for details). Therefore, a part of the LEGO long-run return is due to the mispricing on the primary market. The bad news is that this mispricing is difficult to recognize before a set is retired.

### **3. OVERVIEW OF OTHER ALTERNATIVE INVESTMENTS**

Collectible assets (so-called ‘emotional assets’ or ‘investments of passion’) form an important part of portfolios of high-net-worth investors around the globe.

The most popular and traditional ‘emotional asset’ which received a lot of attention in the academic literature is art. Returns in the art market have been widely studied for several decades already. Early studies of the art market (e.g. Baumol, 1986; Goetzmann, 1993; Pesando, 1993) analyze art performance in 17<sup>th</sup>-20<sup>th</sup> centuries and obtain controversial results. Whereas Goetzmann’s art index significantly outperformed both stocks and bonds during 1900-1986, Pesando (1993) found that modern prints under-performed both stocks and bonds during 1977-1992. However, these studies use rather limited samples of paintings or short sample periods. Mei and Moses (2002) study a large sample of repeat sales of about 5,000 painting during 1875-1999 and come to an intermediate conclusion that art outperforms fixed-income securities but underperforms stocks in the US earning a real return of about 5% per annum. However, art returns were higher and closer to equity returns in the second half of the 20<sup>th</sup> century. Art is also found to have lower volatility and correlation with other assets, making it attractive for portfolio diversification.

Renneboog and Spaenjers (2013) use a new data set of over one million transactions of paintings and construct a hedonic art price index for 1957-2007. They estimate the average real return to art of 4% per annum, which is comparable to corporate bond returns. The risk-return profile of art, measured by the Sharpe ratio, is inferior to that of financial assets, but superior to that of physical assets, such as gold, commodities and real estate.

A number of papers identify lagged equity market returns, real income and income inequality as the main determinants of art returns, highlighting the importance of luxury consumption demand for art (Goetzmann et al., 2011; Renneboog and Spaenjers, 2013; Dimson and Spaenjers, 2014). Art returns have particularly been high in fast-growing emerging economics, such as China, Russia and the Middle East, where significant growth in income inequality and the personal wealth of a small fraction of the population has been observed in the recent years (Renneboog and Spaenjers, 2011).

Another group of popular alternative assets includes precious metals and stones. Renneboog and Spaenjers (2012) build a hedonic price index for gems and find that white and coloured

diamonds outperformed the stock market earning a real return of 6.4% and 2.9% per annum, respectively, in 1999-2010. The average returns on other precious stones (sapphires, rubies and emeralds) were in between. Gem returns covary positively with stock returns underlying the importance of wealth-induced demand. Auer and Schuhmacher (2013) confirm the superior performance of diamonds compared to the stock market in 2002-2012. However, they point to the low correlation of diamond returns with financial asset returns and highlight a diversification potential.

Precious metals like gold and silver also tend to be attractive (Renneboog and Spaenjers, 2012; Low et al., 2016). Moreover, precious metals, as well as 1 carat flawless colourless diamonds, exhibit 'safe-haven' hedging properties in highly volatile periods (Baur and Lycey, 2010; Low et al., 2016).

Collectible automobiles also exhibit superior returns compared to traditional equity, bond and gold investments in 2007-2016 (Martin, 2016). The author finds that this alternative asset class offers higher risk-adjusted returns and presents potential portfolio diversification benefits.

Dimson and Spaenjers (2011) analyze the returns to British collectible postage stamps using Stanley Gibbons catalogue prices for 1900-2008. They estimate the average long-term real (nominal) return of 2.9% (7%) per annum, which is between bond and equity returns. The stamp return volatility is comparable to that of equities, the market correlation is positive, although the systematic risk measured by beta is rather low. Dimson and Spaenjers (2014) update this stamp return index to 2012 using Stanley Gibbons' GB 30 Rarities Index and find a slightly lower average annualized real return (2.8% per annum in GBP).

Returns on collectible musical instruments are studied by Graddy and Margolis (2011). The authors collect prices of old Italian and French violins, about half of which were made by Stradivari, and estimate the average real return of 3.5% per annum during 1850-2008, which is lower than in the stock and bond markets. However, the violin returns were stable over time with a slightly negative correlation with bond and stock returns.

Dimson and Spaenjers (2014) use the data from Graddy and Margolis (2011 and 2013) and estimate the average annualized real (nominal) return on violins of 2.5% (6.5%) in 1900-2012, which is very similar to the long-run performance of collectible stamps and art. The authors conclude that collectibles like art, stamps and violins outperform bonds and bills, although underperform equities in this century-long time period.

Dimson et al. (2015) study the long-term investment performance of fine wines. Wine collections of high-net-worth individuals, on average, represent about 2% of their wealth (Mitchell, 2012). Previous studies, which analyze short samples of 15 years or less, find rather low net returns

on wine investments, although adding wine to an investment portfolio improves its risk-return profile (Masset and Weisskopf, 2010; Kourtis et al., 2012; Lucey and Devine, 2015). Dimson et al. (2015) estimate the average long-term real return on collectible wine investments (net of storage and insurance costs) of 4.1% in 1900-2012, which exceeds bonds, art and stamps, although underperforms equities and precious metals. Returns on wine and equities are significantly positively correlated due to wealth-induced demand.

One more type of collectable studied in the finance literature is Baedeker guidebooks issued between 1828 and 1945 (Erdős and Ormos, 2012). These guidebooks are traded on eBay, where there are approximately 100 online auctions run in parallel, 24 hours a day. The authors collect and analyze eBay auction prices for 2005-2009, which range from \$1 to \$14,000. Because the studied period is very short and includes the crisis years, the average return to the guidebooks was negative with a slightly lower volatility, compared to stock market returns. The guidebook returns exhibited a correlation of 45.57% with the stock market. The estimated Jensen alphas were significantly negative in multifactor models suggesting underperformance in comparison with equities.

Overall, studies of various 'investments of passion' suggest that although they tend to yield lower returns than the traditional stock market (and incur higher transaction costs), they provide valuable opportunities for diversification and can sometimes serve as a 'safe haven' in hard times. The high demand for such assets among high-net-worth individuals suggests that subjective utility derived from owning such assets more than compensates for the lower financial returns.

#### **4. A BRIEF HISTORY OF LEGO**

This section describes a brief history of the LEGO Group as a toy producer and how the secondary market for LEGO sets developed over time.

LEGO ("Leg Godt" - "Play Well") was founded in 1932 in a small Danish town Billund by Ole Kirk Christiansen. Initially it was a small family business, which produced simple wooden toys. The company lost its factory in a fire in 1942 and re-built the factory in 1944. In 1946, the company acquired a new machine to produce plastic toys. After several years of experiments and failures, the LEGO brick was finally born and patented in 1958.

The next step was to move from single toys to the LEGO system, where all parts are compatible and there are endless opportunities for adding new objects to an initial set. This breakthrough innovation led to increasing revenues and popularity of LEGO toys. In the 1960s, the company expanded its sales to Western Europe and the USA. 1961 was marked by another important innovation - the invention of the LEGO wheel. Nowadays, with the production of about 36 million tires per year, LEGO is the largest tire manufacturer in the world.



The growing popularity of LEGO led to the creation of the first thematic park in Billund in 1968 - LEGOLAND. Nowadays, there are three LEGOLANDS in Europe and one in the US.

In the early 1970s, the sales growth slowed and the company entered a period of uncertainty. In 1979, the grandson of the founder, Kjeld Kirk Kristiansen, became the company's president, taking over from his father, Godtfred Kirk Christiansen. He started the company's reorganization. A third important step in the history of LEGO was a creation of minifigures. As of June 2013, LEGO had produced 4.4 billion minifigures, some of which are so rare that cost a fortune on the secondary market. Kjeld Kirk also worked on the creation of new LEGO themes. The "Castle" and "Space" themes together with minifigures generated high growth in the company's revenues in the 1980s (figure 1). In 1992, the company's global market share of construction toys reached 80 percent. By the mid-1990s, the LEGO group owned 45 companies on six continents.

However, this huge organization faced new challenges - video and computer games attracted children's attention more and more. The company reacted to this by a partnership with Lucasfilm and the creation of a new licensed theme "Star Wars". This was a very important milestone in the LEGO's history. The "Star Wars" LEGO sets increased sales revenues significantly and remain the most popular targets of LEGO fans, collectors and investors nowadays.

The late 1990s were also marked by a change in the company's management. The company needed a re-organization and for the first time hired an external COO Poul Plougmann. He took several steps towards the current position of LEGO in the global market. The company entered new markets, launched the production of thematic LEGO movies, video games and web-applications, developed educational and robotic sets, the Steven Spielberg MovieMaker set for children to make their own movies, launched new themes following popular movies and cartoons (e.g. Harry Potter, Superheroes, The Lord of the Rings), produced LEGO dolls for girls, created thematic clothes for children, built three new LEGOLANDS (two in Europe and one in the US) and a huge network of LEGO brand stores.

The company was growing rapidly along many dimensions and reported accounting profits, although a thorough management accounting analysis uncovered economic losses. Many of the projects turned out to be unprofitable. The company invested too much into too many new projects and was over-diversified. The number of bricks of different shapes produced each year increased from 6000 in 1997 to 14200 in 2004 (the absolute maximum). This was extremely inefficient and almost led to bankruptcy in 2003-2004.

Poul Plougmann left the company, and with Kjeld Kirk Kristiansen at the top, they followed a new strategy of concentration on its main products - LEGO sets. The company sold its four LEGOLANDS to Merlin Entertainments Group. The company also cut the number of unique bricks

by more than half. This turned out to be a successful strategy. For instance, the company's profits increased four times in 2007-2011 despite the global financial crisis and the slowdown in consumption (Robertson and Breen, 2013). New LEGO themes such as Mindstorms, Architecture and Ninjago, LEGO games and LEGO movies - all contributed to the tremendous growth in the company's revenues and popularity in the 2000s (figure 1).

Nowadays, LEGO is the number one toy producer in the world. LEGO products are sold in 130 countries. On average, the company sells 7 sets every second, whereas 36,000 LEGO elements are molded every minute in the factory in Billund (Telegraph, 2011). The number of sets produced varies per time of year and per year. In the US, the company launches on average 130 new sets per year. The production of LEGO has increased in the last decade and the company produced over 6,000 new sets in 2007-2016 worldwide (figure 2). Sets usually get retired after being in production for 1-2 years.

Whereas the company sells new sets on the primary market through its own stores and other retailers, retired sets (new and used) are actively traded on the secondary market, where the price is determined by supply and demand factors in the same way as in the stock market.<sup>11</sup> Once a set is retired, its secondary market price tends to jump up significantly. With the advent of the internet and auction sites like eBay, a huge market for retired LEGO sets developed in the 2000s. eBay is the largest marketplace for LEGO sets on the planet, where there are tens of thousands of transactions that deal with LEGO sets and pieces on any given day. Besides eBay, there are several specialized platforms for LEGO re-sellers (e.g. Brick Link, Brickpicker.com).

The main LEGO investors are LEGO fans and collectors, but with the development of the LEGO secondary market and spreading rumors of huge returns to LEGO investments in financial press (e.g. Telegraph, 2011), this alternative "investment of passion" has gained popularity among non-fan retail investors.

## 5. A PRICING MODEL

How are LEGO prices expected to change over time? We use the model of Dimson et al. (2015) to illustrate this point. The model was proposed to explain prices of collectable wines and can easily be adjusted to LEGO because the both goods are similar in terms of properties: both have consumption value and long-run investment potential due to decreasing over time supply.

Suppose, the representative investor's wealth grows at a constant rate  $z$ :  $W_t = W_0 * (1 + z)^t$ . The consumption value of a  $j$ -year-old LEGO set (that is, opening and building a set) at time  $t$  is

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<sup>11</sup> The primary market LEGO set price is usually based on the weight of a set, which depends on the amount of ABS (acrylonitrile butadiene styrene) plastic used to produce it.

$C_{i,j,t} = c_{i,j} * W_t$ , where  $i$  is the index of desirability (rarity, collectability) of a particular set. The cross-section of LEGO sets is different in terms of their desirability, so that  $c_i$  belongs to a continuum  $[c_L, c_H]$ . Ordinary sets (generally targeted at small children as mere toys) have low desirability  $c_L$ , which diminishes over time, because children like novelty. Collectible sets, which possess any of the features listed in section 2 and targeted at AFOLs, have high desirability  $c_H$  which grows with set's age and rarity.

Keeping an unopened LEGO box  $i$  generates an ownership dividend  $d_{i,j}$  (with  $d_{H,0} > d_{L,0}$ ), which grows with age  $j$ , reflecting greater rarity of old sets. To keep the model simple, we assume that the ownership dividend increases with age at a constant rate  $g$ . The equivalent monetary value of the ownership dividend depends of collectors' wealth:  $D_{i,j,t} \equiv d_{i,j} * W_t$  (similarly to the model of Goetzman and Spiegel, 1995). Then this monetary ownership dividend grows at the rate  $k \equiv (1 + g) * (1 + z) - 1$ , which is assumed to be lower than the discount rate  $r$ .

The price of a  $j$ -year-old LEGO set  $i$  at time  $t$  is the maximum of the value of immediate consumption and the present value of all future ownership dividends:

$$P_{i,j,t} = \max \left( C_{i,j,t}, \frac{D_{i,j+1,t+1}}{r-k} \right) \quad (1)$$

Figure 3 illustrates a resulting price dynamics starting at  $t=j=0$  for three ad-hoc examples of LEGO sets: an ordinary set with diminishing over time consumption value (panel A), a collectible set with increasing consumption value (panel B) and a collectible movie-related set with a future jump in consumption value due to a release of a new series, e.g. Star Wars (panel C). In panel A, the price decreases initially due to a falling consumption value (and sufficient supply on the market) until the present value of ownership dividends exceeds the consumption value. After this point, the price grows at a constant rate  $k$  due to ever increasing rarity and higher collectors' wealth. In panel B, the price grows immediately after a set release because collectible sets tend to be sold out on the primary market quickly (or may even be unavailable on the primary market, e.g. limited edition of promotional sets). In panel C, we observe a jump in the price in the future which is associated with a release of a related movie series. Since the set is retired and in limited supply on the secondary market, the demand pressure for movie-related old sets generates a great opportunity for re-sellers to earn high returns selling on the peak. If the related movie series were not released, the price dynamics would be the same as in panel B. Hence, movie-related licensed sets have an embedded option to be realized at high prices in case the new movie comes out.

## 6. DATA

We collect price data for LEGO sets from the website Brickpicker.com and the book "The Ultimate Guide to Collectible LEGO Sets" (subsequently referred to as "price guide") written by the founders of Brickpicker.com Ed and Jeff Maciorowski. Brickpicker.com was launched in 2011 and, with registered members growing above 38,000 in 2014, it has become one of the premier LEGO communities on the internet. This site is the main information source on current secondary market prices for new and used LEGO sets for LEGO collectors and investors. Brickpicker.com buys LEGO price data from Terapeak Market Research, which, in turn, collects the original sales data from eBay. Brickpicker.com then aggregates data from thousands of completed eBay LEGO auctions, filtering out bad listings and removing outliers. Each set price represents an average of the 30 most recent *completed* transactions (not offer prices) on eBay, and the data are updated on a monthly basis.

Besides the secondary market price, the book and the web-site also provide the initial US primary market price set by the LEGO Group at the time of set release. All prices are in US dollars in nominal terms.

Brickpicker.com provides set prices for two categories: new and used. However, we only use the data for new sets<sup>12</sup> in order to compare them to the primary market prices and to calculate the returns.

There have been more than 10,000 LEGO sets created over the past 50 years (figure 2). The LEGO price guide which we use provides information on a sample of 2,322 sets released in 1981-2014. However, the great majority of the sets in the sample were released after 2000, and there are only 149 pre-2000, or vintage, sets covered in the book. Therefore, our price index constructed using this data is not sufficiently diversified before 2000 and should be taken with caution.<sup>13</sup> In the 21st century, however, the index has become highly diversified and provides reliable information on the price trends in the LEGO secondary market.

Our sample covers all the most popular LEGO themes, such as City, Star Wars, Harry Potter, Ninjago, Pirates, Bionicle, Architecture, Technic. In total, there are 44 themes covered in the sample.

Unfortunately, neither the price guide nor Brickpicker.com provides a complete time series of prices for each set. The price guide only provides the initial primary market price in the year when the set was released and the final secondary market price in 2015 when the book was published. Because the prices are not dated exactly and have yearly frequency, we assume that they represent

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<sup>12</sup> A new set is a complete set with contents sealed in factory plastic bags, whereas the box conditions may vary from excellent and sealed to damaged.

<sup>13</sup> Since an active secondary market for LEGO sets developed only in the 2000s, this lack of information is not crucial for our research.

end-of-year prices. We use these prices to calculate historical returns and build our yearly LEGO price indices.

Our data set also contains monthly prices for a sub-sample of 320 LEGO sets, which we hand-collected from brickpicker.com during 2016-2018. We picked several *a priori* interesting for collectors themes (Advanced models, Architecture, Discovery, Harry Potter, Hobbit, Star Wars, The Lord of Rings) and collected the secondary market prices for all sets in these themes to minimize the selection bias. These sets were released in 2000-2018, and as new sets appeared in 2016-2018, they were added to the sample. These price data cover the period from December 2015 to December 2018. We use these data to trace the secondary market price dynamics during the period when new sets are available on the primary market and several years afterwards.

## 7. DESCRIPTIVE STATISTICS

Table 1 reports average yearly nominal returns on LEGO sets released in different years. The returns are calculated using the initial primary market prices in the years of release and the final secondary market prices in 2015. Therefore, they represent the average returns during the periods of circulation of the sets up to the year 2015. For each year of release, the average return is the equal-weighted average for all sets introduced in the respective year. The table also reports cross-sectional standard deviations of average returns on sets released in each year.

A remarkable tendency is that newer sets yield higher yearly average returns than older sets. However, this can be a consequence of the growing popularity of investments in LEGO and, hence, higher returns in the recent years, rather than the age of a set itself. It is possible that older (vintage) sets yield higher returns than newer sets in a given year, but because their average returns are calculated for longer time periods, which include the 1980s and 1990s when the LEGO secondary market was not developed, we obtain lower estimates. Also, sets released in recent years exhibit higher cross-sectional dispersion of returns. For example, returns on sets released in 2013 vary from -26.73 to 227.71% per annum with the average of 16.05% and the standard deviation of 28.49%.

The returns on individual sets vary from -53.61 to 613.28% per annum with the average return of 18.5% per annum (see the bottom panel of table 1). The cross-sectional distribution of returns has a standard deviation of 35.09% and a positive skewness of 9.10. The five top performers are “Darth Revan” (Star Wars), “Elves’ Workshop” (Seasonal), “Seal’s Little Rock” (Friends), “TC-4” (Star Wars) and “Ice Skating” (Seasonal) – all were released in 2014 and earned 425-613% during one year 2014-15. The following top performer is “Iron Man & Captain America” (Super Heroes), which was released in 2012 and earned 405% per year over the three years. In total, 34 sets in our sample earned yearly average returns above 100%, 162 sets earned above 50%, 58% of sets (1,344 sets) sets

earned above 10% and 90% of sets (2,080 sets) earned positive average returns. Only 221 sets (less than 10%) are losers, which lost no more than 50% of their initial retail price.

Table 2 reports the average returns by LEGO themes. We can see huge variation here. LEGO Ideas and Seasonal sets yield the highest returns on the secondary market. Sets which follow popular movies (e.g. Super Heroes) are also attractive. The least attractive themes seem to be the ones which stopped being released before 2010. Perhaps, the company stopped producing them because of low popularity on the primary market.

Average returns by set size are reported in table 3. To assign sets to four size groups, we sort the sets by the number of pieces in decreasing order and assign first sets with 25% of total pieces to group 1, the following sets with 25% of total pieces to group 2 and so on. Therefore, each group has approximately equal number of pieces in total, albeit different number of sets. Whereas group 1 (Big) contains 96 sets with 1,928 pieces in each set, on average, group 4 (Small) contains 1,628 sets with only 113 pieces in each set, on average.

Table 3 shows that small sets yield higher returns, on average, than bigger sets, similarly to the stock market size premium. However, there is no strict monotonicity here because huge sets with the set size above 1,200 pieces tend to yield higher returns than medium sets (340-1,200 pieces). The average return to huge sets above 3,000 pieces is 18.53% per annum which is similar to the average return in the LEGO market. Therefore, we may conclude that huge and small sets are the most attractive for investment purposes.

## 8. LEGO PRICE INDICES

### 8.1 Methodology

Given the limitation of the data that, for each LEGO set, we can only observe its return between the year of release and the final year in the sample 2015 (i.e. for several years in a row), we construct the LEGO chain index as follows. We start with all LEGO sets released in 2014 and calculate their cross-sectional average return for the year 2015.<sup>14</sup> We then take all sets released in 2013 and, knowing their two-year average return up to 2015 and the LEGO market return for 2015, calculated in the previous step, we extrapolate the return for 2014 using the compound interest formula, which in general looks as follows:

$$(1 + R_t)^{2015-t} = \prod_{i=1}^{2015-t} (1 + r_{t+i}) \quad (2)$$

<sup>14</sup> We assume that sets are released at the end of the year and that the 2015 prices are also year-end prices because there is no information regarding months in this data set. This may lead to a time bias in the resulting price index, i.e. the index may be lagging behind the actual unobserved index by approximately half a year, on average.

where  $t$  is the year of release,  $R_t$  is the cross-sectional average annualized return during the period from  $t$  until 2015 of all sets released in year  $t$  calculated using the formula  $(1 + R_t)^{2015-t} = \frac{P_{2015}}{P_t}$ ,  $r_{t+1}$  is the return which we extrapolate, and  $r_{t+2}$  and so on are the returns extrapolated in the previous step(s).

We proceed to sets released in 2012 and repeat the exercise, and so on. Under the assumption that portfolios of LEGO sets released each year are sufficiently diversified and that their average returns represent the true LEGO market returns, we build the chain index for the LEGO market for 1987-2015.

As an alternative to this simple chain index, we also build a hedonic index which takes into account the varying characteristics of LEGO sets over time. We estimate the following cross-sectional hedonic regression:

$$\ln \frac{P_{iT} - P_{it}}{P_{it}} = \alpha + \sum_{m=1}^M \beta_m X_{im} + \sum_{t=1}^T \gamma_t \tau_t + \eta_{it} \quad (3)$$

where  $P_{iT}$  is the final secondary market price of set  $i$  in 2015,  $P_{it}$  is the initial retail price of set  $i$  at time  $t$  (and, hence, the dependent variable is the total return on set  $i$  during its circulation period),  $X_{im}$  are hedonic characteristics which consist of 43 dummy variables representing themes (theme “Miscellaneous” serves as the benchmark) and 3 dummy variables representing set size groups (size group 1 – the biggest sets – serves as the benchmark),  $\tau_t$  are 29 dummy variables representing release years from 1986 to 2014, and  $\eta_{it}$  is an error term.

The estimates of  $\alpha + \gamma_t$  represent the average cumulative returns from period  $t$  to 2015 after controlling for the individual set characteristics. Under the assumption that all omitted set characteristics are orthogonal to those included, these coefficients account for constant-quality price trends over the sample period. We use the estimates of  $\alpha$  and  $\gamma_t$  to construct the hedonic price index using the compound interest formula similarly as we construct the simple chain index.

The hedonic chain index is different from the simple chain index because it is free from biases which arise due to varying set characteristics over time. Moreover, the hedonic approach allows testing the significance of individual set characteristics, such as theme and size, in determining returns in the LEGO market.

## 8.2 Results

Table 4 reports our estimates of the chain and hedonic LEGO indices and figure 4 illustrates their dynamics compared to bonds and stocks.

The chain and hedonic indices are highly correlated (the correlation coefficient of 0.95) and have similar return distributions. Therefore, the varying LEGO set characteristics over time do not impose significant biases on return estimates of the simple chain index. The average return in the LEGO market is 10-11% per annum with a standard deviation of 25-28% and a positive skewness of about 0.7. The positive skewness reflects a low crash risk in the LEGO market, unlike the stock market. LEGO investments slightly underperform the CRSP index, which includes all NYSE, AMEX and NASDAQ stocks (CRSP average return is 12% during the sample period), but outperform big stocks proxied by the S&P500, long-term government bonds and Treasury bills (CRSP data).

LEGO returns correlate slightly negatively with bonds (the correlation coefficients are -0.13 and -0.16) and slightly positively with stocks (the correlation coefficients are below 0.24). The correlation with the CRSP index is higher than that with the S&P500, and therefore, the performance of LEGO investments is closer to the performance of small stocks. Interestingly, the LEGO market seems to be immune to US stock market crashes and provides some opportunities for diversification. However, we notice that the greatest plunges in the LEGO returns occurred in the years of financial crises in other countries: 1992 – the Exchange Rate Mechanism crisis in Europe, 1998 – the Asian and Russian financial crisis, 2007 – the start of the Global financial crisis. Since in all these years the stock returns in the US were positive, we obtain low market correlation estimates and, hence, low market risk.

The hedonic regression allows us to explore if and how individual set characteristics affect returns (a cross-sectional analysis). Column 1 of table 5 reports the estimates of theme and size dummy coefficients in regression (3). Apparently, there is a significant heterogeneity in returns of different themes and size groups. The most attractive for investment themes are those with positive and statistically significant dummies: Advanced models, Batman, Dino, Discovery, Harry Potter, Hero Factory, Ideas, Indiana Jones, Monster fighters, Superheroes and Seasonal sets. Noticeably, many of these themes follow popular movies. The least attractive themes are Atlantis, Factory, Prince of Persia, Racers, Space and Toy Story. These findings are in line with the descriptive statistics in table 2.

Regarding set size, we find that medium-sized sets (groups 2 and 3) yield significantly lower returns compared to the biggest (the benchmark group 1) and the smallest (group 4) sets, and the smallest sets yield the highest returns. This confirms the evidence in table 3.

In columns 2-4 of table 5, we report the estimates of alternative specifications with the number of pieces, the number of pieces<sup>2</sup> and the number of minifigures instead of the size group dummies. We confirm that bigger sets yield lower returns, on average, and that the relationship between set



size and returns is U-shaped. The greater number of minifigures, which is usually associated with greater set size, has an additional negative effect on returns.

Whereas the returns in the LEGO market are comparable to those in the stock market, they are not significantly exposed to market risks. Table 6 reports betas of LEGO chain and hedonic index returns with respect to the market, SMB (small-minus-big stocks), HML (high-minus-low book-to-market stocks), momentum (winner-minus-loser stocks) and VIX risk factors. The only significant exposure is consistently observed with respect to the SMB factor. The SMB beta estimates are all close to 1. Therefore, the returns in the LEGO market seem to be closely related to small stock returns. The hedonic index also has a significant HML beta of -0.5. Betas to other risk factors are low and statistically insignificant<sup>15</sup>.

The LEGO alpha is positive (about 4-5%), but statistically insignificant. Again, we can conclude that the LEGO market does not outperform the stock market. However, the insignificant exposure to risk factors suggests that LEGO sets provide good opportunities for portfolio diversification. LEGO investments are also more attractive compared to other alternative investments such as art, wine, stamps, automobiles, etc., which underperform the stock market significantly.

## **9. DYNAMICS OF SECONDARY MARKET PRICES AFTER SET RELEASE**

This section is based on the monthly data set for a sub-sample of 320 LEGO sets in 7 themes. Although we picked *a priori* attractive for collectors themes, they turned out to deliver moderate returns as table 2 suggests. Hence, this sample of themes may be thought of as almost random. The average return of this sample on the secondary market was 6.2% pa in 2016-2018<sup>16</sup>. We use these monthly data to trace the dynamics of secondary market prices after set releases. Table 7 reports average returns in the year of release and 6 subsequent years. Note that each column represents the average returns for a mixed group of sets released in different years (e.g. in column 1 we have sets released in 2015-2018 and we measure their returns in their years of release, respectively). The return dynamics has an interesting general pattern.

First, we observe a few cases when the first secondary market prices in the year of release (or even before the official release) are significantly higher than the primary market prices. This is the evidence of speculator activity: speculators managed to obtain sets before they appear on the primary market and benefit from extracting consumer surplus of impatient collectors who are ready to pay this premium. When sets are officially released and available on the primary market, their secondary market prices

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<sup>15</sup> The results are not sensitive to the number of lags in the Newey-West adjustment.

<sup>16</sup> This extension is also an out-of-sample test of the average LEGO returns after the LEGO Price Guide was published.

fall. On average, the secondary market prices for sealed sets are 10% lower than the primary market prices at the end of their release years (column 1 of table 7). Hence, short-term investments in LEGO sets are generally not profitable (except for specific cases of unique or limited edition sets).

In the second year after the release ( $t+1$ ), secondary market prices start rising up, probably, because some sets are retired and sold out on the primary market. However, the prices, on average, are still below the primary market prices at the end of the second year. The average cumulative return relative to the primary market price is -4% (column 2)<sup>17</sup>. The low secondary market prices, on average, can be explained by the fact that some sets are still available in stores (likely at discounted prices) even if they have already been retired.

Next, we observe a jump in the secondary market prices in 2-3 years after the release (columns 3 and 4). At the end of this period, the secondary market price is already 1,56 times as high the primary market price, on average. The secondary market yearly return during the third and fourth years after the release is 13-14%, on average. This jump in the secondary market prices can be explained by the fact that retired sets become unavailable on the primary market. Collectors have to buy them on the secondary market with limited supply and have to pay the premium. This jump is also an indirect evidence of the primary market underpricing. Therefore, three years after the release can be considered as the minimum investment horizon for a LEGO re-seller.

In the subsequent three years, the secondary market prices continue to grow, although at a slower pace (the average secondary market return is 6-8% per annum), and the average return converges to the long-run level<sup>18</sup>.

This general pattern of price dynamics is in line with our theoretical model predictions for ordinary LEGO sets. Indeed, since our sample is random, most sets are ordinary (i.e. do not possess the characteristics of collectible sets listed in section 2). However, if we look at particular collectible sets, we often observe gradually increasing secondary market prices right after the release. An illustrative example is set #10262-1 “James Bond Aston Martin DB5” with 1,290 pieces (“Advanced models” theme), which was released in 2018 at the initial retail price of \$149.99 and had the secondary market price in December 2018 of \$174.83 (16.6% return in the first year).

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<sup>17</sup> Note that this figure is calculated for a different sub-sample of 85 sets released in 2014-2017.

<sup>18</sup> Note that row 2 of table 7 reports returns relative to primary market prices, whereas row 3 reports returns relative to the secondary market prices in the previous period. Returns relative to the primary market prices are higher for sets released several years ago because they include the jump due to the primary market underpricing, which is observed in 2-3 years after set release.

## **10. A NOTE ON TRANSACTION COSTS**

The returns estimated above do not take into account transaction costs. However, similarly to other alternative investments, trading LEGO sets is associated with relatively high transaction costs.

The most popular trading platform for LEGO sets is eBay, whose prices we use. eBay charges listing and final value fees when products are listed and sold, respectively. Whereas in many cases the listing fee is absent because sellers receive a certain number of free listings per month depending on the type of account they have, the final value fee is charged each time a sale is made and accounts for 9.15% of the sale price for the ‘Toys and Hobbies’ category. After taking into account this type of transaction costs, the average return on individual LEGO sets falls from 18.5% to 14.7% per annum.

Moreover, a seller has to pay a fixed cost associated with the eBay subscription (\$20-25 per month, as of January 2018). On top of that, one should take into account semi-fixed storage costs which can vary significantly depending on the scale of the business. For example, keeping hundreds of boxes for several years requires a storage space. The storage costs are not as high as one would expect for such alternative investments as art, wine or automobiles, but they are definitely higher compared to owning financial assets.

## **11. CONCLUSION**

This paper presents a novel analysis of financial returns in the LEGO market. LEGO is not just a toy, but also a reasonable alternative investment with average returns comparable to stock returns, low market and crash risks and a positive alpha. Indeed, a huge global secondary market for new and used LEGO sets has developed over the last 30 years.

We hand-collect unique data on the primary and secondary market prices for a sample of 2,322 LEGO sets which belong to all most popular LEGO themes. We build chain and hedonic LEGO price indices for 1987-2015, analyze their returns and exposure to the major risk factors. We estimate the average return in the LEGO market of 10-11% per annum during the studied period, which is higher than returns on most other alternative investments. Moreover, discounted purchases of LEGO sets on the primary market make LEGO investments even more profitable. However, different LEGO sets are not equally attractive. We find that small and very large sets yield higher returns than medium-sized sets. We also name the most and least attractive LEGO themes. Not surprisingly, themes which follow popular movies are more attractive, in general.

LEGO returns are not exposed to the market, momentum, HML and volatility (VIX) factors, but have an almost unit exposure to the SMB factor. Therefore, the LEGO market can be considered as an alternative to the market for small stocks in terms of risk. However, the average return to the

SMB factor is only approximately 1% per annum during the studied period, and the average return to LEGO investments is much higher. Hence, the risk-return profile of LEGO investments is attractive.

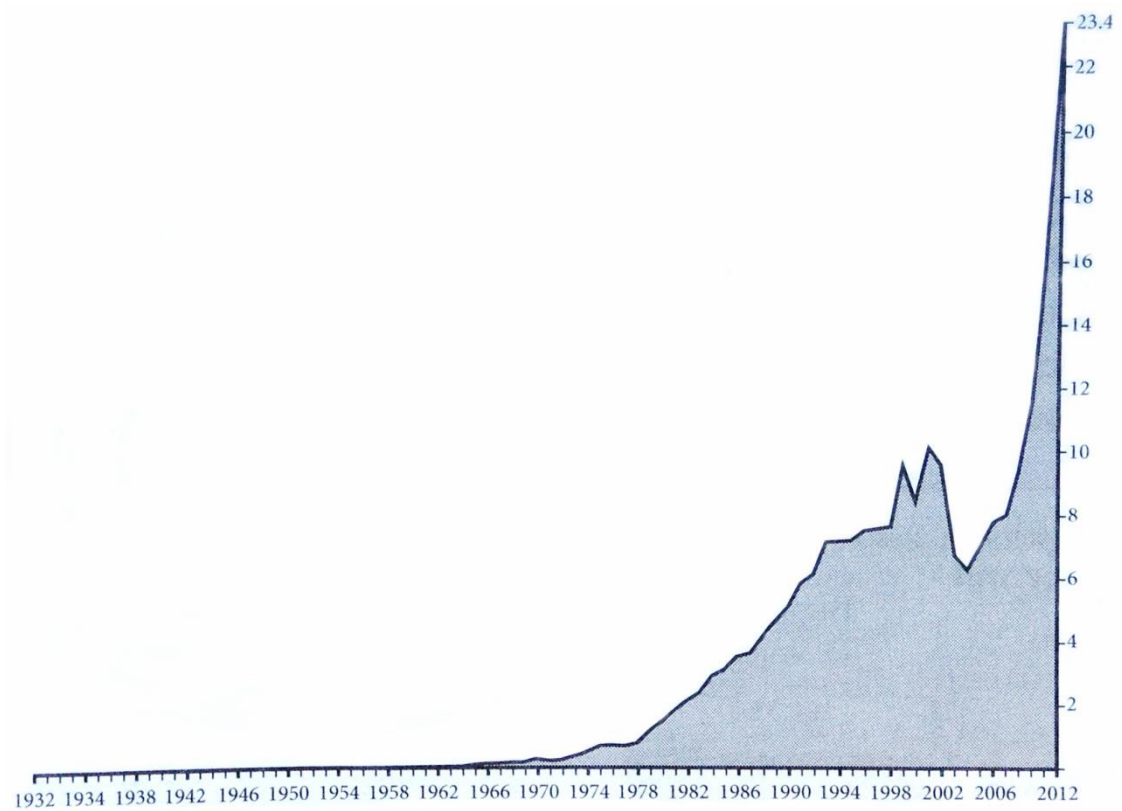
All these findings are novel in the academic finance literature since LEGO investments, to our knowledge, have not been studied before. However, these results should be taken with a caution, because the LEGO market, similarly to markets for other alternative investments, is not as liquid as the stock market and requires relatively high transaction and storage costs. The minimum investment horizon for a LEGO re-seller is longer (above 3 years). Moreover, LEGO investments require specific knowledge and interest in this product which not all investors possess. Therefore, this alternative financial investment would be most attractive primarily for LEGO fans. But there are millions of LEGO fans around the world!

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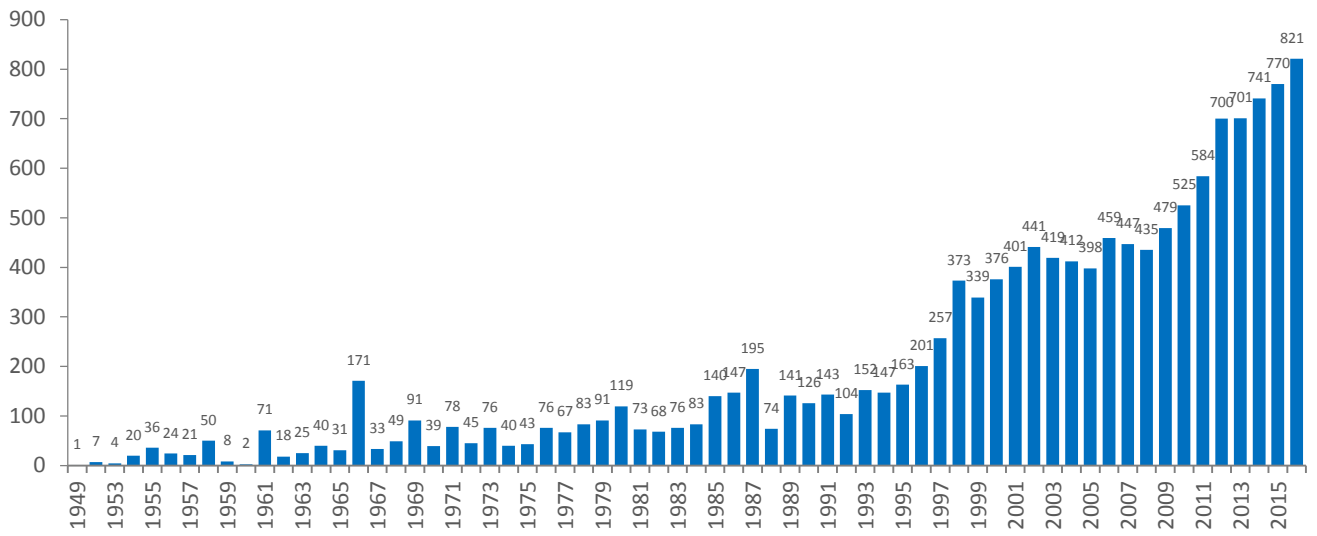
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**Figure 1. Sales of LEGO**



The figure shows the dynamics of sales of the LEGO Group in 1932-2012 in bln. Danish kroner.  
*Source: Robertson and Breen (2013)*

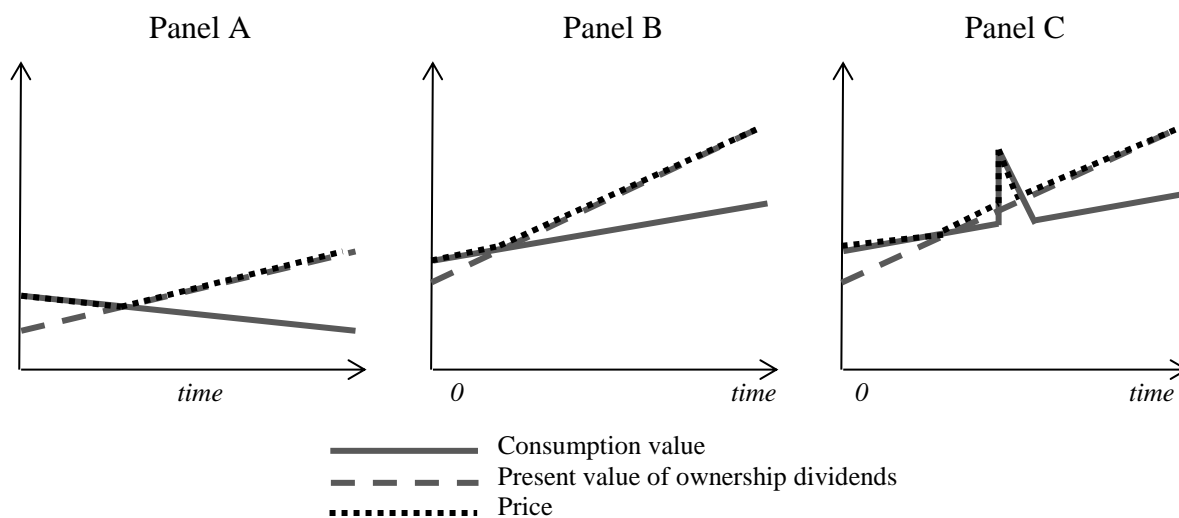
**Figure 2. Number of LEGO sets produced each year**



The figure shows the dynamics of LEGO production (number of new sets released) in 1949-2015.  
*Source: brickset.com*

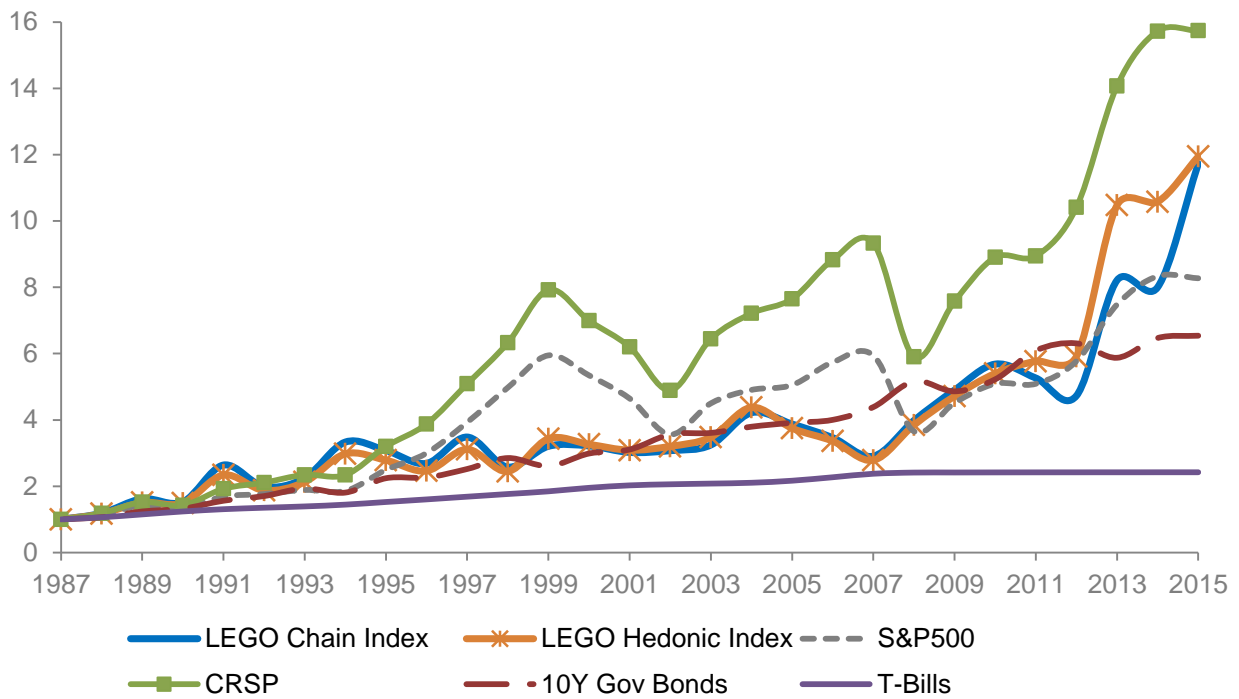


**Figure 3. An illustrative model of LEGO price dynamics**



The figure plots price patterns for three examples of LEGO sets: an ordinary set with diminishing consumption value (panel A), a collectible set with increasing consumption value (panel B) and a collectible movie-related set with a jump in consumption value due to a new movie series release (panel C). The patterns are implied by the model in section 5.

**Figure 4. Returns to LEGO indices**



The figure plots the LEGO chain and hedonic indices as well as indices of stocks and government bonds in the USA.

**Table 1. Average returns by year of release**

<b>Year of release</b>	<b>Number of sets</b>	<b>Average return (% pa)</b>	<b>Cross-sectional SD of returns (%)</b>
2014	297	46.51	81.71
2013	261	16.05	28.49
2012	278	24.04	31.18
2011	215	18.12	16.76
2010	171	13.44	10.92
2009	160	13.96	8.58
2008	133	14.72	8.45
2007	104	14.75	8.97
2006	101	12.53	7.97
2005	94	10.04	6.31
2004	74	8.66	4.98
2003	73	9.99	5.22
2002	75	9.77	4.32
2001	84	8.91	4.85
2000	53	7.37	4.98
1999	20	7.18	4.05
1998	14	8.86	2.65
1997	10	6.49	2.57
1996	13	7.64	2.21
1995	10	6.60	1.90
1994	9	5.73	2.23
1993	14	6.65	3.35
1992	12	7.72	1.81
1991	4	6.10	2.00
1990	6	8.28	1.50
1989	12	7.44	2.25
1988	7	8.55	1.79
1987	3	9.11	1.00
1986	4	5.55	5.37
1984	8	7.60	1.78
1981	3	6.51	2.49
<b>Total</b>	<b>2,322</b>		
<b>Min</b>		<b>-53.61</b>	
<b>Average</b>		<b>18.50</b>	
<b>Max</b>		<b>613.28</b>	
<b>SD</b>		<b>35.09</b>	
<b>Skewness</b>		<b>9.10</b>	

The table reports average returns for LEGO sets released in a given year. For each LEGO set, we first calculate its geometric average return per annum for the period of its circulation (i.e. between the year of release and the final year in the sample 2015). We then take the average and the standard deviation of these returns across all sets released in a given year. The bottom panel reports the descriptive statistics of the distribution of individual sets' average returns for the total sample of 2,322 LEGO sets.

**Table 2. Average returns by LEGO theme**

<b>Theme</b>	<b>Number of sets</b>	<b>Average return (% pa)</b>	<b>Cross-sectional SD (%)</b>	<b>Period</b>
Ideas	8	64.11	83.20	2010-2014
Seasonal	61	58.07	95.00	2006-2014
Super Heroes	46	51.14	78.91	2011-2014
Minecraft	9	45.50	36.19	2013-2014
Friends	82	38.17	65.71	2012-2014
Monster fighters	13	36.01	33.16	2012-2012
Dino	7	34.76	12.38	2012-2012
Hero factory	83	29.76	21.60	2010-2014
Batman	33	27.62	21.92	2006-2014
Legends of Chima	75	24.82	30.59	2013-2014
Miscellaneous	28	24.72	27.71	2010-2014
Pirates of Caribbean	14	20.54	16.83	2011-2011
Indiana Jones	16	19.83	7.18	2008-2009
Creator	123	19.74	27.64	2001-2014
Ninjago	91	19.49	20.20	2011-2014
Disney princess	7	17.99	20.97	2014-2014
Power miners	16	17.84	6.98	2009-2010
Star Wars	341	17.29	46.68	1999-2014
Advanced models	34	16.99	12.71	2000-2014
City	238	16.63	23.95	2005-2014
Harry Potter	52	16.33	8.10	2001-2011
Lone Ranger	8	16.23	27.57	2013-2013
The Lego movie	23	16.08	25.77	2014-2014
Architecture	25	15.89	48.26	2008-2014
Spongebob Squarepants	14	15.43	6.37	2006-2012
Agents	19	15.22	9.93	2008-2014
Cars	22	14.64	12.39	2011-2012
Discovery	6	14.41	6.72	2003-2003
Lord of the Rings	32	12.71	23.08	2012-2014
Technic	124	12.05	11.87	1994-2014
Trains	28	11.67	6.76	2001-2013
Bionicle	243	10.90	6.10	2001-2010
Spider-man	8	10.31	8.65	2003-2004
Castle	189	9.19	8.52	1981-2014
Pirates	62	8.74	4.63	1989-2013
Model team	1	8.51	n/a	1996-1996
Racers	11	8.50	12.87	2002-2010
Toy story	15	6.52	9.90	2010-2010
Atlantis	21	6.08	7.66	2010-2011
Space	62	6.04	11.67	2001-2013
Teenage mutant ninja turtle	18	4.64	17.40	2013-2014
Factory	7	2.69	8.23	2005-2008
Prince of Persia	6	0.90	7.74	2010-2010
The Simpsons	1	-3.52	n/a	2014-2014

The table reports average returns for 44 LEGO themes sorted in descending order. For each LEGO set, we first calculate its geometric average return per annum for the period of its circulation (i.e. between the year of release and the final year in the sample 2015). We then take the average and the standard deviation of these returns across all sets which belong to a given theme. The last column reports the period when sets in a given theme were released.

**Table 3. Average returns by set size**

<b>Group</b>	<b>Average set size (# of pieces)</b>	<b>Range of set sizes</b>	<b>Number of sets</b>	<b>Average return (% pa)</b>	<b>Cross-sectional SD (%)</b>
1 - Big	1,928	1,204-5,922	96	12.07	12.15
2	862	660-1,197	215	6.88	13.26
3	466	340-659	383	10.08	18.66
4 - Small	113	1-339	1628	22.44	39.93

The table reports average returns and cross-sectional standard deviations of LEGO set groups formed by size. All sets are sorted by the number of pieces and allocated to four size groups so that each group has approximately equal *total* number of pieces. Columns 2-4 report the group size characteristics.

**Table 4. LEGO returns**

	<b>Chain index returns</b>	<b>Hedonic index returns</b>	<b>CRSP returns</b>
1987	-0.33	-0.31	0.02
1988	0.19	0.17	0.18
1989	0.37	0.29	0.29
1990	-0.06	-0.01	-0.06
1991	0.73	0.57	0.35
1992	-0.25	-0.20	0.10
1993	0.13	0.13	0.11
1994	0.48	0.40	-0.00
1995	-0.08	-0.06	0.37
1996	-0.13	-0.12	0.21
1997	0.29	0.26	0.31
1998	-0.26	-0.21	0.24
1999	0.24	0.40	0.25
2000	0.00	-0.05	-0.12
2001	-0.06	-0.05	-0.11
2002	0.02	0.04	-0.21
2003	0.06	0.09	0.32
2004	0.30	0.26	0.12
2005	-0.08	-0.14	0.06
2006	-0.11	-0.10	0.15
2007	-0.16	-0.17	0.06
2008	0.37	0.38	-0.37
2009	0.23	0.23	0.28
2010	0.16	0.15	0.17
2011	-0.07	0.07	0.00
2012	-0.10	0.03	0.16
2013	0.74	0.77	0.35
2014	-0.03	0.01	0.12
2015	0.47	0.13	0.00
<b>Average return</b>	<b>0.11</b>	<b>0.10</b>	<b>0.12</b>
<b>Standard deviation</b>	<b>0.28</b>	<b>0.25</b>	<b>0.18</b>
<b>Skewness</b>	<b>0.69</b>	<b>0.75</b>	<b>-0.73</b>
<b>Corr. with S&amp;P500</b>	<b>0.13</b>	<b>0.16</b>	<b>0.99</b>
<b>Corr. with CRSP</b>	<b>0.20</b>	<b>0.24</b>	<b>1.00</b>
<b>Corr. with bonds</b>	<b>-0.13</b>	<b>-0.16</b>	<b>-0.15</b>
<b>Corr. of LEGO indices</b>	<b>0.95</b>		

The table reports LEGO simple chain and hedonic index returns as well as the historical returns on CRSP equity index for comparison. The bottom panel reports the descriptive statistics of these indices and correlations with other indices.

**Table 5. Hedonic regression coefficients for theme and size dummies**

	(1)	(2)	(3)	(4)
Advanced models	0.3434***	0.5729***	0.5451***	0.4591***
Agents	-0.0480	-0.1395	-0.0469	0.0163
Architecture	-0.0817	-0.1337	-0.0526	-0.1338
Atlantis	-0.3709***	-0.4067***	-0.3644***	-0.3300**
Batman	0.4484***	0.4101***	0.4741***	0.5098***
Bionicle	-0.0981	-0.1045	-0.0926	-0.0884
Cars	-0.0692	-0.1042	-0.0575	-0.1078
Castle	-0.1130	-0.1385	-0.0972	0.0087
City	0.0090	-0.0386	0.0110	0.0624
Creator	-0.0059	-0.0457	0.0117	-0.0393
Dino	0.4316**	0.3944*	0.4596**	0.4790**
Discovery	0.6124***	0.5117**	0.6241***	0.5718***
Disney princess	-0.0936	-0.1044	-0.0656	-0.0696
Factory	-0.6098***	-0.6234***	-0.4765**	-0.5447***
Friends	0.1585	0.1307	0.1548	0.1585
Harry Potter	0.4008***	0.3783***	0.4366***	0.5439***
Hero factory	0.2018**	0.1996*	0.1982*	0.1749*
Ideas	0.4905***	0.3718*	0.4488**	0.4334**
India Jones	0.3452**	0.2699*	0.3557**	0.4714***
Legends of Chima	0.0210	-0.0162	0.0133	0.0347
Lone Ranger	0.1025	0.0305	0.0855	0.1754
Lord of the Rings	-0.0746	-0.1219	-0.0533	0.0433
Minecraft	0.3219*	0.1757	0.2730	0.2040
Model team	0.1056	0.3530	0.5332	0.3574
Monster fighters	0.4023**	0.3731**	0.4292***	0.4783***
Ninjago	0.0343	-0.0011	0.0288	0.0692
Pirates	-0.0482	-0.0813	-0.0316	0.0938
Pirates of Caribbean	0.1845	0.1200	0.1727	0.2569*
Power miners	0.1891	0.1645	0.2153	0.2725*
Prince of Persia	-0.6044***	-0.6383***	-0.5821***	-0.4850**
Racers	-0.3956**	-0.3419*	-0.2308	-0.3152*
Seasonal	0.3750***	0.3706***	0.3833***	0.3864***
Space	-0.3169***	-0.3749***	-0.3140***	-0.2575**
Spider-man	0.1293	0.1115	0.1683	0.3179
Spongebob Squarepants	0.0772	0.0334	0.1008	0.1543
Star Wars	0.0454	0.0211	0.0727	0.1289
Super Heroes	0.4408***	0.4034***	0.4252***	0.5052***
Technic	-0.1055	-0.1259	-0.0301	-0.1163
Teenage mutant ninja turtle	-0.0738	-0.1691	-0.1033	-0.0268
The Lego movie	0.0349	-0.0681	0.0072	0.0568
The Simpsons	-0.2677	0.1183	0.0972	0.0830
Toy story	-0.3516**	-0.3887**	-0.3472**	-0.2756*
Trains	0.1911	0.1634	0.2316*	0.2602**
Size group 2	-0.2438***			
Size group 3	-0.2214***			
Size group 4	0.0536			
Number of pieces		-0.0002***	-0.0005***	-0.0003***
Number of pieces <sup>2</sup>			1.33e-07***	9.98e-08***
Number of minifigures				-0.0397***
Constant	2.3694***	2.4124***	2.4357***	2.4980***
R-squared	0.4695	0.4472	0.4698	0.4828
Observations	2,303	2,303	2,303	2,302
29 Time dummies	yes	yes	yes	yes

The table reports estimates of hedonic regression theme and size dummy coefficients (column 1) and estimates of alternative specifications with number of pieces and minifigures instead of the size dummies (columns 2-4). The stars denote the statistical significance: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Table 6. Exposure of LEGO returns to risk factors**

	Chain index			Hedonic index		
alpha	0.0424 [0.8213]	0.0426 [0.6879]	0.0487 [0.7335]	0.0358 [0.7479]	0.0394 [0.7330]	0.0471 [0.8841]
Rm	0.3581 [1.0069]	0.2441 [0.6886]	0.2149 [0.5234]	0.3835 [1.0977]	0.2577 [0.7364]	0.2212 [0.5723]
SMB		1.1000 [2.6623]	1.0749 [2.1889]		1.0967 [3.2954]	1.0654 [2.6490]
HML		-0.4667 [-1.2741]	-0.4859 [-1.2320]		-0.4894 [-2.0049]	-0.5133 [-1.8234]
MOM		0.1934 [0.9216]	0.1808 [0.8338]		0.1671 [1.0401]	0.1513 [0.9524]
VIX			-0.0321 [-0.1327]			-0.0400 [-0.1808]
R <sup>2</sup>	0.0510	0.2555	0.2560	0.0724	0.3280	0.3289

The table reports time-series regression estimates of annual LEGO returns on traded risk factor returns (betas) and alphas. The corresponding t-statistics are reported in brackets. The t-statistics are calculated using Newey-West standard errors with 1 lag. Sample period: 1987-2015.



**Table 7. Dynamics of secondary market prices after set release**

	T=t (year of release)	T=t+1	T=t+2	T=t+3	T=t+4	T=t+5	T=t+6
Cumulative return ( $P_T/P_0-1$ )	<b>-0.10</b>	<b>-0.04</b>	<b>0.11</b>	<b>0.56</b>	<b>0.89</b>	<b>1.21</b>	<b>1.42</b>
(per annum)	(-0.10)	(-0.02)	(0.04)	(0.12)	(0.14)	(0.14)	(0.13)
Return ( $P_T/P_{T-1}-1$ )		0.03	0.13	0.14	0.08	0.06	0.06
Release years	2015-2018	2014-2017	2013-2016	2012-2015	2011-2014	2010-2013	2009-2012
Number of sets	89	85	92	65	75	79	76

The table reports average secondary market returns in the first 6 years after sets are released. The cumulative return is calculated by dividing the secondary market price at the end of the respective period ( $P_T$ ) by the initial primary market price ( $P_0$ ). The average annualized returns are in the parentheses. Returns in a given year are calculated by dividing the secondary market price in December of the given year ( $P_T$ ) by the secondary market price in December of the previous year ( $P_{T-1}$ ). Samples of sets in columns differ by years of release. Sample period for prices: December 2015 – December 2018.