CAES Working Paper Series

Investments of Listed Military Firms Worldwide

Nicolas de Menis and Junmin Wan

Fukuoka University, Japan

WP-2023-010

Center for Advanced Economic Study
Fukuoka University
(CAES)

8-19-1 Nanakuma, Jonan-ku, Fukuoka,
JAPAN 814-0180
+81-92-871-6631

Investments of Listed Military Firms Worldwide[1]

Nicolas de Menis and Junmin Wan[2]

Graduate School of Economics, Fukuoka University

December 27, 2023

[1] This research was partially supported by a JSPS KAKENHI grant (#22K01589). The second author gratefully acknowledges the support of this fund.

[2] Any remaining errors here are the authors' responsibility. Correspondence: Junmin Wan, Nanakuma 8-19-1, Jonan Ward, Fukuoka City, Fukuoka 8140180, Japan; (e-mail) Wan: wan@fukuoka-u.ac.jp; (tel) +81-92-871-6631(ext.4208); (fax) +81-92-864-2904.

Highlights

1. Using panel data on 49 listed military firms active between 1991–2022, we find a significantly negative relationship between their share of arms sales and their profit rates.

2. From our estimates of Tobin's average q and marginal q based on military firms receiving governmental subsidies, we find that the q values are significantly higher than 1.

3. Panel regression results show that Tobin's marginal q, but not Tobin's average q, has a significant positive impact on investment. This implies that investment follows the final goods market evaluation, as opposed to the capital market.

4. Arms exports promote military investments indirectly by raising sales. Therefore, governmental subsidies on military firms, which increase their exports, could induce an oversupply of arms globally and domestically.

Abstract

The military race is an example of Nash's (1951) non-cooperative games, although Aumann (1961) argues that a cooperative equilibrium could be obtained. The current equilibrium induces arms overdemand and oversupply at the national and global levels. Arms serve as a demerit good globally; however, a Pigouvian tax (1920) cannot be used due to the lack of a world government. Ironically, governments compete to subsidize their military firms. These policies could limit the efficiency of state-owned enterprises. Governments privatize military supply with subsidies to overcome budget constraints. For 49 listed companies among the top 100 military firms in the world between 1991 and 2022, we find that there is a significantly negative relationship between the ratio of military sales to total sales and the profit ratio, implying low efficiency for subsidized firms. With government subsidy, Tobin's average q and marginal q are estimated based on Tobin's q theory. Panel regression results show that marginal q has a significant positive impact on the firms' investments. Arms exports could promote military investments indirectly by raising sales and revenues, shifting the equilibrium from an optimal level.

JEL Classification：H20; H56; L13; G10; E22; C72

Keywords: Military firm, replacement investment, fixed investment, Tobin's average q, Tobin's marginal q

1 Introduction

The military race is an example of Nash's (1951) non-cooperative games, although Aumann (1961) argues that a cooperative equilibrium could be obtained. The current equilibrium induces arms overdemand and oversupply at the national and global levels. Arms serve as a demerit good globally; however, a Pigouvian tax (1920) cannot be used due to the lack of a world government. As shown in Figure 1, there are clear correlations among exports, the number of deaths in state conflicts, and the stock price of military firms. The global optimal demand and supply of arms should be strictly zero, but the demand and supply of arms have shown instead a continuously increasing trend; this could be viewed as the biggest tragedy in human society.

According to Hummel (1990) and Hummel and Lavoie (1994), national defense is one of the archetypal examples of a public good, being vital for collective security and national well-being due to its non-excludable and non-rivalrous nature. In contrast to private goods, national defense cannot be privatized and lacks inherent profit incentives. However, as publicly listed defense suppliers experience unprecedented success, exploration of the complexities surrounding military goods becomes intriguing. While domestically deemed as merit goods, they globally exhibit negative externalities, leading to their classification as demerit goods.

The defense industry, characterized by its production of military goods, stands as a peculiar case within the realm of economic theory. Often regarded as a public good, national defense defies privatization and the conventional pursuit of profits. However, paradoxically, publicly listed suppliers in this sector boast stock with unprecedented high prices. Elveren and Hsu (2015) found that arms-exporting governments' profit rates increased, while those of non-arms-exporting countries decreased. Pamp and Thurner (2018) concluded that exports lead to lower military expenditure. As increasing research and development (R&D) can be considered as a sunk cost, arms-producing countries have incentives to produce more arms than necessary for their own national defense to reach economies of scale and to export the oversupply to other countries. This dichotomy warrants closer examination of military goods as both merit goods domestically and demerit goods globally, the latter exemplified by negative externalities arising from perceived threats posed by neighboring nations.

1.1 Privatization of military firms and government subsidies

In the post-Cold War era, Sköns (1994) found that the defense base industry (DBI) has shifted toward internalization and exports, and from predominantly government-owned entities to privatized entities, especially in the Western world. This is due to both budget constraints and low efficiency of state-owned companies. This shift sparks controversy, with critics decrying excessive profits and supporters arguing for reduced taxpayer burden. This issue divides stakeholders and academia, with studies from Wang and Miguel (2012) in the United States and Neels (2014) in Germany highlighting excessive profits among US military contractors.

The exponential increase in global military spending from 2001 to 2022 raises concerns. Despite representing nearly 50% of all public expenditure, the defense industry presents a “two-sided front”. While providing security and enhancing business well-being domestically, it remains a burden on taxpayers with at least two negative externalities. Connolly (1970) discusses the negative externalities originating from a non-ally country increasing their armament production, whereas Hikotani et al. (2022) argues that even an ally’s military and arms can have negative externalities, using the example of the US presence in Okinawa.

The global classification of military goods as demerit goods introduces a dichotomy in government policy. Traditionally, demerit goods are subjected to increased taxation to curb their consumption and mitigate harm to citizens. Paradoxically, governments may actively subsidize the investments of military firms, as their exports may, according to Muñoz et al. (2023), promote labor productivity as well as gross domestic product (GDP) growth, whereas more arms on the market could ultimately create or escalate conflicts globally. In another study, Pamp and Thurner (2018) found that arms exporting leads to reduced military expenditure in the case of democracies. Subsidies, often criticized for impeding efficiency, are justified by governments as a crucial tool to address market failures in public goods and maintain a competitive edge in the global arms race.

1.2 Analysis of military firms' investment behavior

Issues arise when discussing arms industries economics. The defense industry itself is difficult to define. For example, Hartley et al. (1997) examined the defense industry supply chains of the United Kingdom and found that a single UK company had about 200 direct suppliers. Moreover, many of those were supplied by other companies, some of which did not even know that they were producing toward a military good. The DBI is partially (as for most companies in this study) founded by governments, and many of the contracts involved are shadowy at best and top-secret at worst. Government grants, loans, and contracts make collecting accurate data to compare with other industries much more difficult.

While public goods traditionally lead to market failure, necessitating government intervention, the DBI has undergone a transformative journey since the end of the Cold War. Governments have actively pursued the privatization of military suppliers, a complex undertaking with outcomes whose social desirability is challenging to ascertain. Public goods often lead to market failure, and companies producing public goods act in a regulated market, obtaining subsidies to survive or even thrive. Indeed, according to Bernini et al. (2017), subsidized firms experience slower productivity growth compared to their non-subsidized counterparts, thereby imposing a burden on taxpayers. However, governments often justify these subsidies to rectify market failure in public goods, even if the optimal domestic supply does not align with the socially desirable supply on a global scale, potentially leading to oversupply of demerit goods.

Navigating governmental budget constraints and the inefficiencies of state-owned enterprises, DBI firms have been introduced onto the market, and they obtain subsidies to overcome inherent challenges. Without these subsidies, DBI firms would struggle to survive. Nevertheless, major DBI firms, subsidized by the government, have become attractive investments for private entities. This necessitates a comprehensive analysis of the behavior of these firms, from perspectives of domestic and global public goods and within the framework of market discipline.

1.3 Contributions of this research

The importance of this study is two-fold. This is the first research combining data from various arms-producing leading countries. All past research has focused on a single company or a single country (or, at best, a regional cluster of countries). Many of these studies were influenced by specific beliefs and tend to be biased. The US DBI is, without doubt, the most researched. Moreover, it accounts for almost 40% of the world's military spending (Dyvik, 2023) and encompasses 49 of the top 100 defense companies. This paper uses all publicly available micro-data of listed defense industries, without excluding any country or company.

Second, although some researchers have found it difficult to determine Tobin's marginal q, Ogawa (2003) succeeded in deriving an accurate method. Applying Tobin's q theory, a renowned efficiency measure, to corporate and military firms for the first time, we scrutinize investment behaviors through the lenses of both public goods considerations and investment efficiency. The usefulness of this method, and especially of marginal q, has been proven multiple times in recent years by authors such as Gugler and Yurtoglu (2003) and Bjuggren and Wiberg (2008). As more than half of the top 100 DBI entities are now privately listed, we employ Tobin's q market theory to analyze trends in the DBI and its investments.

1.4 Organization of the paper

Section 2 introduces the research questions and hypotheses. Section 3 details the data sources and derives the average q, marginal q, and depreciation and investment rates, as well as the investment equations. Section 4 summarizes the empirical results. Section 5 presents our conclusions and some of the issues left for future research.

2 Research questions and hypotheses

2.1 Increasing defense spending

According to the Stockholm International Peace Research Institute (SIPRI, 2023), worldwide military expenditure reached an all-time high of $2,239.9 billion US dollars in 2022, accounting for 2.3% of the world's GDP or 5% of total government spending. After a steep decline between 1985 and 1995, this spending has remained fairly constant, fluctuating between

2.1% and 2.6%. While the relationship between military spending and economic growth has been studied extensively since the 1970s, a consensus on their connection has proven elusive.

However, since the Cold War ended, the picture has become somewhat clearer. Abu-Bader and Abu-Qarn (2003) used multivariate cointegration and variance decomposition to show that military spending negatively affects a country's economic growth. Yakovlev (2007) used an augmented Solow growth model to show that higher military and net arms exports lead to lower economic growth, while it is less detrimental if the country is a net arms exporter. Batchelor (2007) found that cuts in military expenditure could improve economic performance. Wijeweera and Webb (2011) used a panel co-integration method to demonstrate that 1% of military spending only increases the real GDP by 0.04%. Farzanegan (2014) found that increasing shocks in the military budget lead to statistically significant income growth. Korkmaz (2015) found that military spending has a negative effect on economic growth and increases unemployment.

2.2 Investments of the listed DBIs

While it is undeniable that military R&D has made its way into civilian space (e.g., the Internet and the Global Positioning System [GPS]), it is not clear whether these technologies would have been created, and at what cost, in the absence of military R&D. As shown by Stalenheim et al. (2010), many countries spend a considerable share of their GDP on their military, and particularly on military R&D. In 2022, the US Department of Defense received $95 billion dollars (from a total budget of $773 billion, or > 12%). In most cases, the DBI is supported directly by governments, receiving subsidies from the start to the completion of a project and with a minimum order contract once the product reaches maturity.

Buck et al. (1993) argued that defense R&D is controversial, as it tends to supersede valuable civil R&D expenditure and drain the civil economy of qualified labor, scientists, and engineers. He gives us the example of the United Kingdom, where a 10% cut in UK defense equipment expenditure would reportedly reduce employment levels by 6%.

Another example is the Lockheed Martin F-35 combat aircraft. In 1993, Lockheed bid successfully for the project. Later, it was joined by Northrop Grumman and the UK-based BAE Systems. The project was ultimately delayed for more than a decade, and its cost more than doubled from $200 billion to > $406 billion, paid by the taxpayers.

Mowery (2010) found that non-mission-oriented public R&D investments barely exceeded 5% in the United States. As academic research on defense R&D is scarce due to the difficulty in obtaining accurate data about the inputs and outputs of the DBI R&D process (Setter and Tishler, 2006), here we employ the *q* method of Wan and Qiu (2023) to analyze the investments of military firms as shown in Figure 2.

2.3 Depreciation of the listed DBIs

Depreciation is a fundamental consideration for governmental and corporate entitles in the context of investment planning. In the realm of corporate investments, Jorgenson's (1963) neoclassical approach places significant emphasis on capital accumulation as a primary driver of economic growth. Conversely, Keynes (1930, 1936) and Keynesian economics advocate for government interventions to stimulate demand, offering an alternative perspective to the classical belief in natural market equilibrium. Both approaches converge on the goal of achieving the most efficient allocation of resources and capital investments, particularly in terms of technology and human capital, for sustained economic development.

The focus of this study is on domestic private entities listed in the stock market. Despite their private ownership, these entities contribute to both public and private sectors by producing goods for national defense and export. Moreover, they benefit from government subsidies that support their operations. However, it is crucial to consider the argument by Heijdra et al. (1996) that lump-sum taxes, like the subsidies provided here, can inadvertently lower the marginal cost of public funds. This phenomenon raises the long-term total cost of public funds, as short-term prioritization may distort the economic landscape over time.

The economic depreciation hypothesis of Wan (2019, 2023) plays a crucial role in predicting the dynamics of replacement investment. According to this hypothesis, a higher expected profit rate acts as a catalyst for replacement investments. Corporations anticipating robust profits in the future are inclined to invest strategically to maintain competitiveness over the long term. Conversely, companies with lower profit rates may find themselves constrained, lacking the financial resources required for investments in new infrastructure, machinery, or R&D. The uncertainty surrounding the timing and potential returns on such investments further compounds the challenges faced by companies with lower profit margins.

This economic depreciation hypothesis underscores the critical relationship between profit expectations and investment decisions, shedding light on the complexities inherent in capital planning for businesses. One issue we encountered is that accounting and reporting methods vary considerably among countries. As an example, we had to adapt the Chinese balance sheet, which does not directly report any depreciation or amortization, as indicated by Qiu and Wan (2019), compared with the United States.

When assessing marginal q, a consensus exists regarding the significance of profit and interest rates. However, there is divergence of opinion concerning the depreciation rate. Wan and Qiu (2022) characterized the total value of fixed assets (TVFA) as a theoretical value derived from economic depreciation theory by Wan (2019, 2023). Their study explored the effects of the depreciation expense as an accounting item (DEAI) system. Wan and Qiu (2022) showed that DEAI is equivalent to the permanent inventory method (PIM) under some conditions. In line with the theoretical findings and newly developed empirical methods, in the next part, we introduce our hypotheses using both Tobin's average q and marginal q.

2.4 Hypotheses

The investment literature is primarily shaped by two prominent theories: the neoclassical theory proposed by Jorgenson (1963) and Tobin's q theory outlined in Tobin (1969) and Von Furstenberg et al. (1977). Hayashi (1982) closely examined Tobin's conjecture, positing that investment is intricately linked to marginal q and is tantamount to the optimal calculation of capital accumulation by firms, accounting for adjustment costs. We consider two possibilities based on the empirical specifications of the investment function presented by Abel (1980), Abel and Blanchard (1986), Chirinko (1993), Ogawa et al. (1994), Chirinko and Schaller (2001), Ogawa and Kitasaka (2019), and Wan (2019, 2023).

Hypothesis 1: Public goods makers cannot make profits and therefore cannot survive on the market as publicly listed firms. Are military firms advantaged on the market compared to their peers?

H_0: Military firms' profits are or are not positively correlated with their share of arms sales over total sales.

H_1: Military firms' profits are negatively correlated with their share of arms sales over total sales.

Hypothesis 2: Public goods makers' Tobin's *q* should be lower than 1. The DBI's investments and R&D are funded by government subsidies, increasing their Tobin's *q* so that they can invest and survive in the private stock market.

H_0: Military firms' Tobin's *q* is ≤ 1.

H_1: Military firms' Tobin's *q* is > 1.

Hypothesis 3: Public goods suppliers or state-owned enterprises and firms with public subsidies could have little incentive to reach profit maximization, so we predict:

H_0: Military firms' investment is not determined by Tobin's *q*.

H_1: Military firms' investment is determined by Tobin's *q*.

3 Data and methods

3.1 Panel data on 49 listed military firms

We obtained 647 annual observations for 49 listed military firms from 1991 to 2022. The selection of the panel data followed three simple rules:

- The company should have been among the top 100 arms producers at least once in the last 5 years (2018–2022) according to the SIPRI rankings. We also used the Defense News' rankings to enlarge our sample size.
- Arms sales as a percentage of the company's total sales should have been > 50% at least once in the last 5 years.
- The company should be publicly owned and publish annual reports available to the public.

We manually retrieved all of the data from three sources. First, we checked the official websites and downloaded the relevant annual reports. Second, we searched for additional data on the military firms' registered stock exchanges (such as https://www.sec.gov/ in the United States). Finally, we looked for additional data on websites gathering financial information for major companies (e.g., https://www.annualreports.com/). We manually calculated each average annual stock price from daily quotes when available, or weekly or monthly quotes when daily information was not available.

Based on the above criteria, we obtained information on 46 firms. No firms from Russia, China, or Japan were included, as no information could be obtained. Notably, these three countries have large military industries, so as exceptional cases, we chose to add the top-listed military firm from each of these three countries. Ultimately, we included 49 firms in our final analysis.

Our sample covers 12 countries (and the three exceptional cases), as follows (ordered by sample size): the United States (24 firms), the United Kingdom (6), South Korea (3), France (2), Germany (2), India (2), Israel (2), Australia (1), Finland (1), Italy (1), Turkey (1), Sweden (1), Russia (1), China (1), and Japan (1).

The 49 firms in our sample, by order of total military sales in 2022 (or earlier if not mentioned in 2022), are as follows: Lockheed Martin Corp. (United States), Raytheon Technologies (United States), Northrop Grumman Corp. (United States), Boeing (United States), General Dynamics Corp. (United States), BAE Systems (United Kingdom), AVIC (China), L3Harris Technologies (United States), Leonardo (Italy), Thales (France), HII (United States), Leidos (United States), Booz Allen Hamilton (United States), Dassault Aviation Group (France), Elbit Systems (Israel), CACI International (United States), SAIC (United States), Rheinmetall (Germany), Ultra Electronics (U.K.), KBR (United States), Israel Aerospace Industries (Israel), Saab (Sweden), Perspecta (United States), Babcock International Group (United Kingdom), Hindustan Aeronautics (India), Mitsubishi Heavy Industries (Japan), Hanwha Aerospace (South Korea), Trans Digm Group (United States), ManTech International Corp (United States), ASELSAN (Turkey), Bharat Electronics (India), LIG Nex1 (South Korea), BWX Technologies (United States), Hensoldt (Germany), Vectrus (United States), QinetiQ (United Kingdom), Korea Aerospace Industries (South Korea), Parsons Corp. (United States), Curtiss-Wright Corp. (United States), Austal (Australia), Mercury Systems (United States), Cobham (United Kingdom), Aerojet Rocketdyne (United States), Maxar Technologies (United States), AAR Corp. (United States), Kratos Defense and Security Solutions (United States), Patria (Finland), Chemring (United Kingdom), and the UNAC (Russia).

3.2 Sample characteristics

The 49 firms account for nearly 70% of the arms sales of the SIPRI top 100 military firms. All of the data were input manually for the firms' annual financial reports. Our calculated q-values could include some outliers, defined as values deviating from the mean by more than three standard deviations; these outliers were retained for the sake of clarity and representativeness. One of the novel aspects of this study is the large number of firms and countries of origin included in the analyses. Therefore, we decided against excluding potential outliers.

3.3 Depreciation rate

Once a technology is researched and ready to be produced, the land, plant, and equipment fully reflect how profits are generated. However, in the case of a few military firms developing software, the company requires only an office for its operations. In those few cases, we added the intangibles as well as the amortization to accurately reflect the firms' depreciation rates. We applied the method of Wan and Qiu (2022, 2023) to define the TVFA, in which the benchmark capital stock is based on the value at each year's end:

$$\mathrm{TVFA}_{it} = \mathrm{OVFA}_{it} - \mathrm{DFA}_{it} + \mathrm{Errors}_{it} , \quad (1)$$

where:

TVFA_{it} is the total value of fixed assets of military firm *i* at time *t*;

OVFA_{it} is the original value of fixed assets of military firm *i* at time *t*;

DFA_{it} is the depreciation of fixed assets of military firm *i* at time *t*;

$Errors_{it}$ is the error term. It mainly indicates the deviation of a firm in terms of fixed asset valuation, accumulated depreciation, and provision for impairment.

TVFA encompasses land but not inventories. This distinction contrasts with the methodology employed by Qiu and Wan (2021) in their assessment of the real estate industry and the approach used by Ogawa and Kitasaka (1999) for Japanese firms. Inventories comprise both raw materials and produced goods; the former do not produce immediate value by itself, are usually paid for, and are awaiting delivery by local or overseas customers due to the tight flow of the military industry. The balance sheets show that the fixed asset ratio is almost 13.5%.

We used the DEAI method of Wan and Qiu (2022) to estimate the DBI's depreciation rates. To stabilize the data between pure arms manufacturers and software developers, we used depreciation (adding the amortization for the software developers) over total assets. Controlling for inflation using the producer price index (PPI), the estimated DEAI is calculated as follows:

$$\delta_{DEAI,it} = \frac{(AD_{it} - AD_{it-1}) \,/\, PPI_t}{TVFA_{it-1}}, \quad (2)$$

where:

$\delta_{DEAI_{it}}$ is the depreciation rate of military firm *i* at time *t*;

AD_{it} is the accumulated depreciation of military firm *i* at time *t*;

PPI_t is the PPI in the country of military firm *i* at time *t*;

$TVFA_{it-1}$ is the total fixed assets value of military firm *i* at time *t - 1*.

To estimate marginal q, we used each individual firm's depreciation and interest rates as shown in Figures 2 and 3, calculated directly from the data of their balance sheet, to accurately compute each firms' information. Figure 3 shows the average annual depreciation and interest rates of the 49 military firms.

3.4 Estimation of Tobin's average *q* and marginal *q*

Adapting the initial definition of average q of Tobin (1969), we refer to the methods of Ogawa and Kitasaka (1999) and Qiu and Wan (2021) when deriving the following formula:

$$Aq_{it} = \frac{EMV_{it} + TD_{it}}{TA_{it-1}}, \tag{3}$$

where:

Aq_{it} is the average q of military firm i at time t;

EMV_{it} is the equity market value of military firm i at time t. The precondition here is that total market value EMV_{it} is an increasing function of governmental subsidy (ξ), i.e., $\frac{\partial EMV_{it}}{\partial \xi} > 0$. Our argument is that Aq_{it} should be < 1 without governmental subsidy; these firms should then not survive in the market.

TD_{it}: total book value of liabilities of military firm i at time t;

TA_{it}: total book value of assets of military firm i at time t.

To reduce noise, we calculated the EMV by multiplying the yearly average stock price by the number of shares outstanding. We used the total assets from time $t-1$ to reduce the effect of endogeneity. The average q for each of the 10 largest listed military firms is shown in Figures 6–15.

Using the military firms' annual financial reports, we followed Hayashi (1982) and Ogawa (2003) and used the improved marginal q assessment method. We employed the simple specification of Ogawa (2003) and Wan and Qiu (2023) to derive the following equation:

$$Mq_{it} = \frac{\pi_{it}}{P_{it}^{I}} \frac{1 + r_{it}}{r_{it} + \delta_{it}}, \quad (4)$$

where:

Mq_{it} is the before- and after-tax marginal q of military firm i at time t;

π_{it} is the ratio of total profit before and after tax of military firm i at time t. The precondition here is that total profit π_{it} is an increasing function of governmental subsidy (ξ), i.e., $\frac{\partial \pi_{it}}{\partial \xi} > 0$. Our argument is that Mq_{it} should be < 1 without governmental subsidy; these firms should then not survive in the market.

P_{it}^{I}: investment of military firm i at time t;

r_{it}: average interest payments of military firm i at time t;

δ_{it}: average depreciation rate (DEAI) of military firm i at time t.

We estimated average q, before-tax marginal q and after-tax marginal q of the 49 listed companies by both firm and year as shown in Tables 1i-j. Then we calculated the median interest and depreciation rates per year of the panel sample and obtained an average DEAI of 3.03%. The median values of interest and depreciation rates for the total sample are shown in Figure 3. The marginal q (both before and after tax) for each of the 10 largest listed military firms is shown in Figures 6–15.

3.5 Empirical specifications

Following the steps of Ogawa et al. (1994), Ogawa and Kitasaka (2019), and Wan and Qiu (2023), we used the following reduced form of the empirical specification:

$$\frac{I_{it}}{K_{it-1}} = \varphi_0 + \varphi_1 q_{it} + \mu_i + \gamma_t + \varepsilon_{it} , \tag{5}$$

where:

I_{it} is the investment in fixed and intangible assets of military firm *i* at time *t*;

K_{it-1} is the TVFA of military firm *i* at time *t – 1*;

μ_i is a constant firm-specific factor;

φ_0 is a constant term;

φ_1 is a coefficient;

q_{it} is the average q, i.e., the before- and after-tax marginal q of military firm *i* at time *t*;

γ_t denotes time effects;

ε_{it} is random error.

Following Chirinko (1993), Ogawa et al. (1994, Ogawa and Kitasaka (2019), and Wan and Qiu (2023), we assumed a structural form of the adjustment cost model for before- and after-tax marginal q and average q:

$$\frac{I_{it}}{K_{it-1}} = \tau + \frac{1}{a}(q_{it} - 1)\frac{p^I_{it}}{p_{it}} + \mu_i + \gamma_t + \varepsilon_{it}, \quad (6)$$

where:

p^I_{it} is the price of investment goods of firm *i* at time *t*;

p_{it} is the output price (price index of arms) of firm *i* at time *t*;

a and τ are parameters of the quadratic adjustment cost function.

We then used panel estimation methods with fixed effects and robust standard errors to obtain the coefficients.

4 Empirical results

4.1 Depreciation and interest rate

Adapting the DEAI to compare different countries with various financial reporting methodologies, we found an average depreciation rate of 0.0303. The average interest rate was 0.0219, which is in accordance with Blanchard (2019) and Del Negro et al. (2019). The depreciation rate is impacted significantly by the profit rate.[3] This result is consistent with the theoretical prediction by Wan (2019, 2023), and it implies that the decision on replacement investment follows the theory of profit maximization.

[3] The detailed empirical results are available upon request.

4.2 Profit rate and share of arms sales over total sales

We calculated the average profit rate and the share of arms sales relative to total sales by firm. Figure 4 shows the before- and after-tax profit rates of the 49 listed DIB firms by year. For the two profit rates and in relation to the ratio of military sales to total sales; the two measures were significantly negatively correlated (p-value<0.01).[4] Hence, the null hypothesis of ***Hypothesis 1*** was rejected. This implies that military firms' profits are significantly and negatively correlated with their share of arms sales relative to total sales.

4.3 Tobin's average *q* and marginal *q*

We calculated the average *q*, and the before- and after-tax marginal *q*, for the 49 listed military firms. The descriptive statistics are shown in Table 2. Figure 5 shows the average investment rates versus the average *q* and marginal *q*, while Figures 6–15 show the average *q* and marginal *q* values for the top ten firms of our sample; the mean average *q* is 1.628, the mean before-tax marginal *q* is 2.063, and the after-tax marginal *q* is 1.381. The average *q* is nearly identical to the average *q* of Japanese firms in 1970–1990 cited by Ogawa and Kitasaka (1999); however, the marginal *q* after tax is higher (1.163). The average *q* is also higher than that for the United States between 1952 and 1976, as calculated by Von Furstenberg et al. (1977). Using a difference test, the null hypothesis of ***Hypothesis 2*** can be rejected. This implies that military firms' Tobin's average *q*, Tobin's before-tax marginal *q*, and Tobin's after-tax marginal *q* are all significantly > 1.

[4] The detailed empirical results are available upon request.

4.4 Investment equations using Tobin's *q* theory

The investment rates versus the average *q* and marginal *q* are shown in Figure 5. Tables 3 a, b, c show the panel regression results obtained by the reduced form of investment, as described by Equation (5), and the structured form of investment as Equation (6) that considers adjustment costs. Regardless of controlling for year dummies and the specifications, when we use Tobin's average *q* based on the capital market, the null hypothesis of ***Hypothesis 3*** is not rejected, whereas when we use Tobin's marginal *q*, the null hypothesis of ***Hypothesis 3*** is rejected and the alternative hypothesis is accepted. Hence, we conclude that investment is affected by Tobin's before–tax and after-tax marginal *q* and is not affected by Tobin's average *q*.

5 Conclusions and implications

National defense is one of the best examples of public goods. As for most public goods, national defense cannot be privatized and cannot create profits. However, it is reported in the literature that national defense relies mainly on publicly listed suppliers whose stock prices are at all-time highs, with profit rates often being higher than their non-defense peers. While military goods could be classified as merit goods domestically, it is undeniable that they have negative externalities globally, as one country perceives threats from another. Therefore, military goods are classified as demerit goods.

According to standard economic theory, as proposed by Pigou (1920), demerit goods should be taxed by governments to reduce their consumption and reduce harm to citizens, because both overdemand and oversupply can easily occur instead of social optimality. However, in actuality, governments subsidize military firms' investments to promote their activity and increase their worldwide exports, even though this policy may escalate global conflicts. This tragic circumstance could be due to the fact that this consequence has yet to be internalized by any country due to the absence of a world government.

Consequently, the products of military firms could fail in both the domestic and global markets. Traditionally, in the domestic market, public goods are not efficiently provided by the market, potentially leading to market failure requiring government intervention. The DBI has been investigated extensively, but mostly as a public goods supplier. Since the end of the Cold War era, the privatization of military suppliers has been a major goal of governments; however, it is difficult to judge if this is more socially desirable. The literature indicates that subsidized firms' productivity grows slower than that of non-subsidized firms, burdening taxpayers. The subsidies are a tool used by governments to fix market failure of public goods. However, even if the market reaches its optimal supply domestically, it does not attain a socially desirable supply on the global market by creating oversupply of those demerit goods. The subsidies are, nonetheless, justified by governments to retain their position at the top of the food chain, as the R&D of military firms would cost too much for too long before next-generation arms are actually produced and sold.

Due to government budget constraints and the low efficiency of state-owned enterprises, the DBI has been put on the market, but it obtains subsidies to overcome these issues. Without subsidies, DBI firms could not survive in the market. Furthermore, some of the major DBI firms receive funding from private investors. Consequently, it is necessary to analyze the behavior of these firms, from both domestic and global perspectives, with respect to public goods and market discipline. The former requires closer examination at the national level via normative analysis, such as that used by Nash (1951) or Aumann (1961); however, it would be difficult to obtain any empirical information. The latter could be tested empirically based on market outcomes under various government subsidies. Tobin's q theory is a well-known efficiency measure for corporate firms. Here, we applied it to military firms for the first time from the perspectives of a public good and investment efficiency.

By hand-collecting and analyzing data for 49 of the top 100 listed military firms, which account for over half of all military sales from 1991 to 2022, we found that there is a significant negative relationship between the ratio of military sales to total sales and the profit ratio. This supports the low-efficiency hypothesis for subsidized firms, given that firms with higher military sales could receive more subsidies. However, there is no consensus on this viewpoint.

Furthermore, a structural model based on Tobin's q theory with governmental subsidy was used to estimated Tobin's average q and Tobin's marginal q for every firm by year for the first time. Using panel regression analysis, we found that Tobin's marginal q, as opposed to Tobin's average q, has a significant positive relationship with investment. This implies that corporative decisions on investment follow the final goods market evaluation as opposed to the capital market. In line with these empirical results, arms exports promote military investment indirectly by raising sales and revenues. Therefore, governmental subsidies on military firms, which increase their exports, could increase the scale of the military industry domestically and globally, further shifting the equilibrium toward an oversupply of arms.

Future research should aim to obtain accurate information on governmental subsidies at the firm level, as these subsidies are a precondition of this study. Next, the employment decisions of these firms should be investigated, where human capital should be more important than physical capital. Additionally, care should be taken to avoid misallocation of resources due to the potential oversupply of arms domestically and globally. Finally, we need to theoretically and empirically analyze how much subsidy or tax should be levied on the DBI at the firm and country levels.

References

Abel, Andrew B (1980) Empirical investment functions: An integrative framework, *Carnegie Rochester Conference Series on Public Policy*, 12, 39-91.

Abel, Andrew B. and Olivier Blanchard (1986) The present value of profits and cyclical movements in investment, *Econometrica*, 54, 239-273.

Abu-Bader, Suleiman and Aamer S. Abu-Qarn (2003) Government expenditures, military spending and economic growth: causality evidence from Egypt, Israel, and Syria, *Journal of Policy Modeling*, 25 (6-7), 567-583. https://doi.org/10.1016/S0161-8938(03)00057-7

Aumann, R. J. (1961) The core of a cooperative game without side payments. *Transactions of the American Mathematical Society*, 98 (3), 539–552. https://doi.org/10.2307/1993348

Batchelor, Peter, J. Paul Dunne and David S. Saal (2000) Military spending and economic growth in South Africa, *Defence and Peace Economics*, 11 (4), 553-571. https://doi.org/10.1080/10430710008404966

Bernini, Cristina, Augusto Cerqua and Guido Pellegrini (2017) Public subsidies, TFP and efficiency: A tale of complex relationships, *Research Policy*, 46 (4), 751-767.

Bjuggren, P. O. and Wiberg, D. (2008) Industry specific effects in investment performance and valuation of firms, *Empirica*, 35, 279–291. https://doi.org/10.1007/s10663-008-9064-5

Blanchard, Olivier (2019) Public debt and low interest rates, *American Economic Review*, 109 (4), 1197-1229. DOI: 10.1257/aer.109.4.1197

Buck, David, Keith Hartley and Nick Hooper (1993) Defense research and development, crowding-out and the peace dividend, *Defense Economics*, 4 (2), 161-178. https://doi.org/10.1080/10430719308404757

Chirinko, Robert S. (1993) Business fixed investment spending: Modeling strategies, empirical results, and policy implications, *Journal of Economic Literature*, 31, 1875-1911.

Chirinko, Robert S. and Huntley Schaller (2001) Business fixed investment and “bubbles”: the Japanese Case, *American Economic Review*, 91 (3), 663-680.

Connolly, Michael (1970) Public goods, externalities and international relations, *Journal of Political Economy*, 78 (2), 279-290. https://doi.org/10.1086/259627

Del Negro, Marco, Domenico Giannone, Marc P. Giannoni and Andrea Tambalotti (2019) Global trends in interest rates, *Journal of International Economics*, 118, 248-262. https://doi.org/10.1016/j.jinteco.2019.01.010

Dyvik, Einar (2023) Countries with the highest military spending 2022, Nov. 30. https://www.statista.com/statistics/262742/countries-with-the-highest-military-spending/

Elveren, Adem Y. and Sara Hsu (2015) Military expenditures and profit rates: Evidence from OECD countries, *Metroeconomica*, 67 (3), 551-577. https://doi.org/10.1111/meca.12111

Farzanegan, Mohammad Reza (2014) Military spending and economic growth: The case of Iran, *Defence and Peace Economics*, 25 (3), 247-269. https://doi.org/10.1080/10242694.2012.723160

Gugler, Klaus and Burcin B. Yurtoglu (2003) Average *q*, marginal *q*, and the relation between ownership and performance, *Economics Letters*, 78 (3), 379-384. https://doi.org/10.1016/S0165-1765(02)00261-6

Hartley et al. (1995) *Handbook of Defense Economics*, Vol. 1, Chapter 14, 399-430. https://EconPapers.repec.org/RePEc:eee:hdefec:1

Hayashi, Fumio (1982) Tobin's marginal *q* and average *q*: A neoclassical interpretation, *Econometrica*, 50 (1), 213-224.

Heijdra, Arrow Ben J. and Frederick van der Ploeg (1996) Keynesian multipliers and the cost of public funds under Monopolistic competition, *The Economic Journal*, 106 (438), 1284–1296. https://doi.org/10.2307/2235521

Hikotani, Takako, Yusaku Horiuchi and Atsushi Tago (2022) Revisiting negative externalities of US military bases: the case of Okinawa, *International Relations of the Asia-Pacific*, 23, 325-349. https://doi.org/10.1093/irap/lcac002

Hummel, Jeffrey R. and Don Lavoie (1994) National defense and the public-goods problem, *Journal des Economistes et des Etudes Humaines*, 5, 1-26. DOI: 10.1515/jeeh-1994-2-306 Republished as a chapter in *Anarchy and the Law: The Political Economy of Choice*, edited Edward P. Stringham in 2007, 353-377, ISBN 9781315082349.

Hummel, Jeffrey R. (1990) National goods versus public goods: Defense, disarmament, and free riders. *The Review of Austrian Economics,* 4, 88-122. https://doi.org/10.1007/BF02426365

Jorgenson, Dale W. (1963) Capital theory and investment behavior, *The American Economic Review*, 53, 247-259.

Keynes, J. M. (1930). Economic possibilities for our grandchildren, In: *Essays in Persuasion. Palgrave Macmillan, London*, 2010. https://doi.org/10.1007/978-1-349-59072-8_25

Keynes, J. M. (1936) The general theory of employment, In: *Interest and Money, Palgrave Macmillan, London.*

Korkmaz, Suna (2015) The effect of military spending on economic growth and unemployment in Mediterranean countries, *International Journal of Economics and Financial Issues*, 5 (1), 273-280.

Mowery, David C. (2010) Handbook of the Economics of Innovation, Vol. 2, Chapter 29, 1219-1256. https://doi.org/10.1016/S0169-7218(10)02013-7

Muñoz, Francisco José Callado, Jana Hromcová, Ricardo Laborda Herrero and Natalia Utrero González (2023) An empirical analysis of arms exports and economic growth spillovers: The case of the United States, *Defense and Peace Economics*, 34 (7), 893-913. https://doi.org/10.1080/10242694.2022.2087324

Nash, J. (1951) Non-cooperative games, *Annals of Mathematics*, *54* (2), 286-295.
https://doi.org/10.2307/1969529

Neels, Tom (1994) Excessive profits of German defense contractors.
https://core.ac.uk/download/pdf/36736138.pdf

Ogawa, Kazuo, Shin-ichi Kitasaka, Toshio Watanabe, Tatsuya Maruyama, Hiroshi Yamaoka and Yasuharu Iwata (1994) Asset market and business fluctuations in Japan, *The Economic Analysis*, Economic Research Institute, Economic Planning Agency, No. 138, 17-97.

Ogawa, Kazuo (2003) Financial distress and corporate investment: The Japanese case in the 90s, *ISER Discussion Paper* No. 584, Osaka University. Included in Fumio Hayashi ed., *Malfunctioning of Financial Systems*, (Empirical Analysis and Design of Economic Systems, Vol. 2, in Japanese), Chap. 2, pp. 35-63, Keiso Shobo Publishing Co. Ltd., 2007.
https://www.iser.osaka-u.ac.jp/library/dp/2003/DP0584.pdf

Ogawa, Kazuo and Shin-Ichi Kitasaka (1999) Market valuation and the q theory of investment, *The Japanese Economic Review*, 50, 191–211.

Pamp, O., Dendorfer, F. and P. W. Thurner (2018) Arm your friends and save on defense? The impact of arms exports on military expenditures. *Public Choice*, 177, 165–187. https://doi.org/10.1007/s11127-018-0598-1

Pigou, Arthur (1920) The Economics of Welfare, Macmillan Co., Limited, London.

Qiu, Qiqi and Junmin Wan (2021) Residential investments and housing prices in China, *CAES Working Paper*, Fukuoka University, WP-2021-012, 1-55, September 30. http://www.econ.fukuoka-u.ac.jp/researchcenter/workingpapers/WP-2021-012.pdf

Setter, Oren and Asher Tishler (2006) Introduction: Defense Research and Development in the 21st Century, *Defense and Peace Economics*, 17 (3), 165-167. https://doi.org/10.1080/10242690600644996

Stalenheim, Peter, Damien Fruchart, Wuyi Omitoogun and Catanlina Perdomo (2010) Military expenditure, *Stockholm International Peace Research Institute (SIPRI) yearbook*, *2009*, 175-211. https://web.mit.edu/stgs/pdfs/Ghoshroy%20course%20material/SIPRI%20Military%20Expenditure%20Data.pdf

Stockholm International Peace Research Institute (2022) Arms control and disarmament agreement, *SIPRI Yearbook 2022*, Annex A. https://doi.org/10.1093/sipri/9780192883032.003.0015

Stockholm International Peace Research Institute (2023), *SIPRI Yearbook 2023*. https://www.sipriyearbook.org/view/9780198890720/sipri-9780198890720-miscMatter-005.xml

Tobin, James (1969) A general equilibrium approach to monetary theory, *Journal of Money, Credit and Banking*, 1 (1), 15-29.

Von Furstenberg, George M., Michael C. Lovell and James Tobin (1977) Corporate investment: Does market valuation matter in the aggregate?, *Brookings Papers on Economic Activity*, 2, 347-408. https://doi.org/10.2307/2534406

Wan, Junmin (2019) The effective life and value of capital, *Center of Advanced Economic Studies (CAES) Working Paper Series*, Fukuoka University, WP-2019-016, 1-40, December 2.

http://www.econ.fukuoka-u.ac.jp/researchcenter/workingpapers/WP-2019-016.pdf

Wan, Junmin (2023) *q* theory with replacement investment, *Center of Advanced Economic Studies (CAES) Working Paper Series*, WP-2023-003, Fukuoka University, May 2, pp. 1-20. http://www.econ.fukuoka-u.ac.jp/researchcenter/workingpapers/WP-2023-003.pdf

Wan, Junmin and Qiqi Qiu (2022) Depreciation rate by industrial sector and profit after tax in China, *The Chinese Economy*, March, 55 (2), 111-128. https://doi.org/10.1080/10971475.2021.1930297

Wan, Junmin and Qiqi Qiu (2023) Industrial investments and housing prices in China, *International Review of Economics and Finance*, 84, 832-852, March. https://doi.org/10.1016/j.iref.2022.11.039

Wijeweera, Albert and Matthew J. Webb (2011) Military spending and economic growth in South Asia: A Panel Data Analysis, *Defense and Peace Economics*, 22 (5), 545-554. https://doi.org/10.1080/10242694.2010.533905

Yakovlev, Pavel (2007) Arms Trade, Military Spending, and Economic Growth, *Defense and Peace Economics*, 18 (4), 317-338. https://doi.org/10.1080/10242690601099679

Table 1a: Average q, Before-tax Marginal q and After-tax Marginal q of the top 1-5 defense companies

	Lockheed Martin Corp. U.S.			**Raytheon Technologies U.S.**			**Northrop Grumman Corp. U.S.**			**Boeing U.S.**			**General Dynamics Corp. U.S.**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994										0.575	0.864	0.660			
1995										0.568	0.251	0.327			
1996	2.212	1.886	1.249							1.980	1.152	0.932			
1997	1.119	1.638	1.099							2.145	-0.228	-0.115			
1998	1.497	1.472	0.887							1.377	0.877	0.627			
1999	1.271	1.084	0.349							1.566	1.846	1.345			
2000	1.166	1.081	-0.466							1.922	1.985	1.381			
2001	1.292	0.868	-1.022							1.883	2.460	1.785			
2002	1.747	1.184	0.511							1.484	2.411	0.307			
2003	1.589	2.044	1.066	1.006	1.522	0.422				1.246	0.439	0.460	1.280	4.809	3.291
2004	1.587	2.034	1.233	1.126	1.542	0.463				1.555	1.146	1.179	1.448	3.251	3.341
2005	1.809	2.820	1.724	1.194	1.814	1.045				1.696	1.631	1.637	1.506	3.733	3.767

2006	1.957	3.447	2.205	1.336	2.157	1.504				1.798	1.781	1.309	1.587	4.114	4.466
2007	2.126	3.703	2.481	1.246	2.664	2.950				2.408	3.823	2.672	1.659	6.695	4.456
2008	2.441	3.956	2.480	1.389	3.060	1.971	0.977	2.462	-0.968	1.843	2.415	1.633	1.574	7.079	4.765
2009	1.765	3.133	2.146	3.055	2.939	1.765	0.929	1.738	1.374	1.871	1.283	0.803	1.217	6.324	4.120
2010	1.651	2.843	2.030	1.509	2.501	1.586	1.008	1.994	1.669	2.081	2.838	1.888	1.233	7.036	4.680
2011	1.759	2.522	1.665	1.584	2.680	1.701	0.902	2.004	2.007	2.041	3.171	2.180	1.251	6.112	4.035
2012	1.766	2.730	1.690	1.900	2.558	1.708	1.190	2.859	2.142	1.738	3.016	1.864	1.191	1.129	-0.490
2013	1.736	2.739	1.812	1.436	2.286	1.530	1.239	2.679	2.106	1.868	2.882	2.014	1.270	5.427	3.468
2014	2.390	2.936	2.117	1.550	2.369	1.536	1.609	2.909	2.321	2.189	3.123	2.276	1.592	5.791	3.771
2015	2.894	2.682	2.052	1.491	1.760	1.837	1.781	2.404	2.213	2.184	3.095	2.153	1.684	6.495	4.591
2016	2.327	2.692	2.366	1.494	2.018	1.241	2.241	3.294	2.576	2.246	2.416	2.027	1.918	5.911	4.061
2017	2.734	3.155	0.918	1.627	1.918	1.073	2.742	2.930	2.259	3.302	3.404	2.715	2.268	6.627	4.556
2018	3.077	3.526	2.426	1.909	0.626	1.146	2.285	2.797	2.735	4.907	3.880	3.386	2.459	5.591	4.256
2019	3.222	4.121	3.005	1.476	0.871	0.981	2.215	2.635	1.379	4.315	-0.563	-0.181	1.802	5.405	4.121
2020	3.103	3.882	3.068	1.350	-0.274	-0.510	2.098	2.224	1.648	2.773	-3.491	-3.265	1.541	4.418	3.386
2021	2.704	3.860	2.672	1.258	0.640	0.499	1.898	1.817	3.569	2.504	-0.774	-1.144	1.620	4.176	3.268
2022	3.242	3.469	2.382	1.357	0.743	0.713	2.360	1.426	2.406	2.346	-1.030	-1.468	1.908	4.192	3.375

Source: Authors' estimations.

Table 1b: Average q, Before-tax Marginal q and After-tax Marginal q of the top 6-10 defense companies (cont.)

	BAE Systems U.K.			**AVIC China**			**L3Harris Technologies U.S.**			**Leonardo Italy**			**Thales France**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002							0.948	1.203	0.794						
2003							1.312	0.939	0.620						
2004							1.075	1.682	1.241						
2005							1.145	2.351	1.593						

2006							1.323	2.384	1.490	1.143	1.196	1.389	3.489	2.402	1.922
2007							1.456	3.094	2.249	1.186	1.398	0.697	3.808	4.424	3.903
2008							1.046	2.263	1.574	1.363	1.597	0.760	3.003	2.031	2.211
2009	1.257	0.414	-0.024				0.985	1.665	0.130	1.009	1.725	0.780	3.145	1.526	-0.725
2010	1.176	1.276	0.410				1.070	3.032	2.027	0.974	1.709	0.599	2.879	1.281	-0.361
2011	1.236	1.509	1.308				1.317	2.668	1.778	0.961	-0.229	-2.442	2.825	2.040	1.725
2012	1.323	1.674	1.168				0.913	2.032	0.067	0.941	1.132	-0.824	2.609	2.517	1.941
2013	1.381	0.423	0.107				0.880	1.845	0.301	0.917	0.972	0.076	3.221	3.013	2.125
2014	1.689	1.392	0.860				1.021	2.443	1.641	1.014	0.731	0.021	4.508	3.181	2.324
2015	1.720	2.052	1.390				2.568	1.300	0.910	0.990	1.217	0.531	5.551	2.911	2.155
2016	1.972	2.916	1.655				0.914	1.098	0.582	1.037	1.026	0.529	6.917	3.451	2.570
2017	1.696	1.390	0.901	0.704	1.578	0.860	0.852	1.876	1.147	1.116	1.022	0.336	7.583	2.702	1.887
2018	1.731	2.224	1.568	0.758	0.857	0.626	0.983	2.260	1.752	1.052	1.018	0.726	8.609	3.238	2.370
2019	1.501	1.855	1.642	0.729	4.025	2.824	1.034	2.902	2.475	1.077	1.340	0.956	7.853	2.003	1.554
2020	1.562	2.015	1.431	0.698	1.564	1.175	5.583	3.227	1.462	0.947	0.623	0.293	5.035	0.854	0.801
2021	1.624	2.333	1.868	0.831	2.009	1.602	1.599	2.147	0.836	0.950	1.118	0.720	5.490	1.866	1.744
2022	1.683	2.236	1.570	0.719	1.283	1.090	1.616	1.444	1.007	0.907	1.102	1.069	7.336	2.054	1.709

Source: Authors' estimations.

Table 1c: Average q, Before-tax Marginal q and After-tax Marginal q of the top 11-15 defense companies (cont.)

	HII U.S.			**Leidos U.S.**			**Booz Allen Hamilton U.S.**			**Dassault Aviation Group France**			**Elbit Systems Israel**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															
2006															

2007													1.888	0.917	0.651
2008										3.593	6.691	5.748	1.355	1.573	1.290
2009										1.578	5.540	3.897	1.378	0.801	0.752
2010										1.619	8.406	4.505	1.454	1.267	1.191
2011							0.977	1.859	0.495	1.656	6.090	3.750	1.476	0.615	0.478
2012				0.804	2.644	1.891	1.040	2.339	1.450	2.114	7.320	4.668	1.085	1.145	0.962
2013	1.145	1.443	0.735	0.870	0.725	0.725	1.388	2.575	1.265	2.394	8.477	5.954	1.169	1.419	1.134
2014	1.461	1.776	0.917	0.770	-1.110	-1.675	1.712	2.759	1.389	2.555	4.583	4.629	1.284	1.514	1.100
2015	1.541	1.889	0.993	0.937	2.040	1.542	2.124	3.040	1.543	3.269	5.232	4.717	1.408	1.638	1.262
2016	1.842	2.882	1.885	1.920	1.704	1.005	2.284	3.005	1.986	2.815	3.798	3.900	1.578	1.806	1.442
2017	2.083	2.669	1.451	1.458	0.996	0.648	2.531	3.226	1.679	2.976	5.299	4.377	1.860	2.008	1.513
2018	2.196	2.912	2.560	1.613	1.564	1.213	2.638	3.134	1.838	3.499	5.060	5.625	2.075	1.754	1.250
2019	2.137	1.943	1.450	1.859	2.024	1.480	3.190	3.405	2.370	3.222	8.649	5.761	1.768	1.578	1.122
2020	1.855	2.071	1.804	2.325	1.944	1.225	3.738	3.420	2.464	4.113	2.956	2.082	1.573	1.479	1.080
2021	1.864	1.130	1.198	1.800	1.817	1.188	3.213	3.315	2.678	6.376	4.934	3.657	1.604	1.770	1.162
2022	1.488	0.999	1.024	1.678	1.647	1.037	3.075	2.206	1.504	5.059	2.904	3.516	1.637	1.426	1.069

Source: Authors' estimations.

Table 1d: Average q, Before-tax Marginal q and After-tax Marginal q of the top 16-20 defense companies (cont.)

	CACI International U.S.			SAIC U.S.			Rheinmetall Germany			Ultra Electronics U.K.			KBR U.S.		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995										1.040	2.721	0.777			
1996										0.959	4.186	2.691			
1997										0.975	4.859	2.969			
1998										1.072	5.059	3.195			
1999										0.886	5.048	3.281			
2000										0.969	7.404	4.936			
2001										1.155	6.479	4.535			
2002										1.055	5.591	3.727			
2003	2.750	2.065	2.065							1.113	5.080	3.534			
2004	3.660	3.535	2.149							1.036	4.984	3.821			
2005	2.129	2.810	1.587							0.830	2.822	2.091			

2006	2.034	2.678	1.512							0.847	3.271	2.726			
2007	1.814	2.249	1.211							0.857	3.389	2.691			
2008	1.357	2.004	1.025							0.947	3.008	2.320			
2009	1.220	2.234	1.158							3.964	2.303	1.709			
2010	1.267	2.144	1.172							5.457	1.309	1.018			
2011	1.258	2.556	1.466							6.278	4.142	3.428			
2012	1.191	3.009	1.680							4.715	3.644	3.008			
2013	1.182	2.734	1.531				1.028	0.293	0.080	5.863	3.795	2.861			
2014	1.560	1.953	1.205				1.190	0.295	0.081	6.458	2.312	0.347			
2015	1.159	1.559	0.976	2.166	4.692	2.757	1.169	1.011	0.588	2.280	2.159	0.818			
2016	1.505	2.100	1.132	3.089	2.496	1.287	1.226	1.164	0.709	1.979	2.601	1.677			
2017	1.335	2.024	1.115	2.252	2.706	1.471	1.297	1.198	0.784	1.821	1.750	1.406	1.104	2.040	3.328
2018	1.529	2.336	2.065	2.432	2.891	2.022	1.426	1.298	0.887	1.597	1.916	0.943	1.560	3.454	2.065
2019	1.559	2.080	1.462	3.077	2.386	1.486	1.406	1.389	0.960	1.777	2.821	2.250	1.335	1.770	0.988
2020	0.869	2.452	1.722	1.734	1.588	0.983	1.157	0.136	0.002	2.021	3.175	2.516	1.383	0.257	-0.325
2021	1.735	2.348	1.991	1.938	1.377	0.745	1.209	1.756	0.959	2.381	3.133	1.980	1.728	0.890	0.069
2022	1.660	1.978	1.462	1.655	1.789	1.080	1.587	2.086	1.527	3.428	-2.984	-4.279	1.729	1.317	0.737

Source: Authors' estimations.

Table 1e: Average q, Before-tax Marginal q and After-tax Marginal q of the top 21-25 defense companies (cont.)

	Israel Aerospace Industries Israel			**Saab Sweden**			**Perspecta U.S.**			**Babcock International Group U.K.**			**Hindustan Aeronautics India**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000										1.056	1.462	1.531			
2001										0.796	-0.310	-0.310			
2002										0.984	0.075	-1.272			
2003										1.432	1.768	0.744			
2004										1.237	2.799	2.036			
2005										4.030	3.242	1.760			
2006										1.800	2.583	1.649			

2007										2.254	3.522	2.516			
2008										3.360	3.589	2.284			
2009										1.477	2.586	1.439			
2010										1.787	2.888	2.108			
2011				1.003	2.035	1.534				2.728	2.487	1.707			
2012				0.868	1.469	1.118				1.517	2.065	1.063			
2013				0.935	1.087	0.600				1.909	2.059	1.511			
2014				1.268	1.555	1.095				2.088	2.300	1.856			
2015				1.439	1.629	1.202				2.664	2.609	1.972			
2016				1.567	1.507	0.986				1.472	1.842	1.518			
2017				1.654	1.995	1.337	0.532	1.895	0.306	1.356	2.098	1.593			
2018				1.607	1.918	1.156	4.303	0.497	0.344	1.120	2.028	1.562	1.300	2.932	1.827
2019				1.337	1.667	1.149	2.165	1.926	0.756	0.941	1.111	0.793	1.264	2.616	1.640
2020	1.620	1.518	1.107	0.650	0.679	0.563	1.232	0.908	0.142	1.091	-0.481	-0.876	1.274	3.197	2.377
2021	2.596	1.995	1.307	1.198	1.222	0.857	0.779	-4.912	-5.099	0.779	-4.912	-5.099	1.398	3.073	2.329
2022	1.466	1.539	1.153	1.416	1.272	0.887	1.183	1.045	0.773	1.183	1.045	0.773	2.049	3.604	3.504

Source: Authors' estimations.

Table 1f: Average q, Before-tax Marginal q and After-tax Marginal q of the top 26-30 defense companies (cont.)

	Mitsubishi Heavy Industries Japan			**Hanwha Aerospace South Korea**			**TransDigm Group U.S.**			**ManTech International Corp. U.S.**			**ASELSAN Turkey**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															

2006															
2007															
2008	1.123	2.948	0.862				1.143	2.680	1.192						
2009	0.941	2.768	1.982				1.111	2.727	1.324						
2010	1.011	4.067	1.564				1.434	2.714	1.222	1.658	5.254	3.055			
2011	1.002	1.724	2.588				2.201	2.868	1.014	1.123	3.130	1.835	0.819	2.661	1.075
2012	1.015	2.818	2.458	0.891	1.576	0.969	1.685	2.666	1.238	0.834	2.373	1.319	1.451	3.035	2.268
2013	1.050	1.940	1.867	0.655	1.442	0.693	2.032	2.420	0.978	0.771	0.439	-0.121	1.413	1.031	1.326
2014	0.916	1.517	1.536	0.781	2.253	1.340	2.443	2.571	0.850	0.722	1.921	0.958	1.458	1.590	1.811
2015	0.914	2.881	1.467	0.744	2.476	0.540	2.730	2.819	1.174	0.889	1.822	1.097	1.687	0.740	0.778
2016	0.785	2.381	-0.451	0.737	3.153	1.495	2.595	2.614	1.209	1.052	1.947	1.207	1.607	2.402	2.357
2017	0.940	2.182	1.796	0.892	3.847	2.381	2.321	2.434	0.982	1.172	1.913	2.224	2.200	2.526	2.987
2018	0.932	2.293	1.885	1.030	3.892	3.692	3.048	2.983	1.725	1.447	1.572	1.145	2.144	3.774	3.933
2019	0.905	2.030	2.008	0.827	2.114	1.122	3.606	2.658	1.228	1.704	1.828	1.505	1.165	3.021	3.188
2020	0.951	1.629	1.135	0.702	1.692	1.304	3.081	1.834	0.732	1.735	1.710	1.304	1.316	1.354	1.638
2021	0.933	1.685	0.219	0.797	2.448	1.406	3.148	1.647	0.662	1.941	1.843	1.352	1.141	1.006	1.709
2022	1.090	1.682	1.600	1.637	2.053	3.025	2.979	2.070	0.809				1.528	1.065	1.751

Source: Authors' estimations.

Table 1g: Average q, Before-tax Marginal q and After-tax Marginal q of the top 31-35 defense companies (cont.)

	Bharat Electronics India			**LIG NEX1 South Korea**			**BWX Technologies U.S.**			**Hensoldt Germany**			**Vectrus U.S.**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															

2006															
2007															
2008															
2009															
2010															
2011															
2012							0.659	3.425	2.150						
2013	1.398	3.401	4.631				0.502	5.228	3.242						
2014	1.659	4.207	4.330				0.706	0.554	0.159				1.484	1.807	1.094
2015	2.375	4.986	5.062				0.386	1.857	1.185				1.319	1.860	1.442
2016	2.505	5.237	5.027				1.034	3.616	2.775				1.237	2.066	1.153
2017	2.578	5.983	5.085				0.903	4.152	1.994				1.349	2.051	2.951
2018	2.329	5.747	4.034				0.829	3.466	2.861				1.390	2.251	1.641
2019	2.141	6.810	4.417	1.049	0.190	0.043	4.013	3.730	3.024	1.127	0.000	0.033	1.436	2.033	1.342
2020	2.054	5.871	3.884	1.107	0.842	0.814	3.725	3.985	3.379	1.562	0.376	-0.354	1.710	1.572	1.353
2021	2.690	6.409	4.187	1.092	1.145	1.330	3.069	3.230	3.199	1.335	0.000	0.310	1.323	1.708	1.267
2022	3.086	6.196	4.447	1.519	2.252	1.631	2.704	3.022	2.328	1.518	0.873	0.431	3.419	1.465	-0.366

Source: Authors' estimations.

Table 1h: Average q, Before-tax Marginal q and After-tax Marginal q of the top 36-40 defense companies (cont.)

	QinetiQ U.K.			**Korea Aerospace South Korea**			**Parsons Corp. U.S.**			**Curtiss-Wright Corp. U.S.**			**Austal Australia**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000										0.572	2.328	1.835			
2001										0.533	1.974	2.646			
2002										0.993	2.082	1.511			
2003										0.855	1.834	1.072			
2004										1.063	1.791	1.049			
2005										1.082	1.827	0.993			

2006										1.611	1.737	0.998			
2007										1.934	1.840	1.069			
2008	1.696	0.917	0.567							1.576	1.687	0.933			
2009	1.610	1.327	0.974							1.230	1.408	0.792			
2010	0.958	-0.130	-0.328							1.183	1.427	0.848			
2011	1.117	0.497	0.045							1.328	1.372	0.924			
2012	1.294	3.924	2.789							1.266	1.068	0.756			
2013	1.408	-1.524	-1.675							0.952	1.253	0.735			
2014	1.726	0.405	-0.219							1.201	1.457	0.879			
2015	1.795	2.324	2.219							1.193	1.785	1.102			
2016	2.454	1.733	2.449							1.577	1.920	1.178			
2017	2.494	2.899	2.681							2.045	1.964	1.299	0.704	1.578	0.860
2018	1.953	2.711	2.653							2.187	2.165	1.598	0.758	0.857	0.626
2019	1.855	1.520	1.507	1.784	1.987	1.229				2.245	2.347	1.789	0.729	4.025	2.824
2020	1.780	1.577	1.350	1.438	0.871	0.466	2.049	1.058	0.586	1.727	1.466	1.020	0.698	1.564	1.175
2021	1.650	1.190	1.332	1.493	0.325	0.356	1.800	0.708	0.343	1.733	1.909	1.331	0.831	2.009	1.602
2022	1.792	1.249	0.953	1.878	0.834	0.698	2.221	1.140	0.593	1.988	2.111	1.467	0.719	1.283	1.090

Source: Authors' estimations.

Table 1i: Average q, Before-tax Marginal q and After-tax Marginal q of the top 41-45 defense companies (cont.)

	Mercury Systems U.S.			Cobham U.K.			Aerojet Rocketdyne U.S.			Maxar Technologies U.S.			AAR Corp. U.S.		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991				0.592	0.987	0.823									
1992				0.626	1.130	0.861									
1993				0.603	0.902	0.702									
1994				0.565	1.115	0.650							1.382	0.713	0.292
1995				0.549	1.128	0.836							1.322	0.708	0.295
1996				0.557	1.794	1.346							1.671	0.931	0.466
1997				0.547	2.130	1.447							2.167	1.161	0.621
1998				0.767	2.153	1.480							2.188	1.467	0.813
1999				0.703	1.962	1.290							1.357	1.391	0.759
2000				1.046	1.721	0.786							1.031	1.192	0.588
2001				0.917	1.668	0.594							0.937	0.654	0.310
2002				0.790	1.329	0.588							0.768	-1.304	-0.950
2003				0.837	1.600	-0.164							0.645	-0.015	-0.178
2004				0.783	1.719	1.222							1.029	0.302	0.060
2005				0.774	1.298	0.928	1.377	-3.983	-3.898				1.203	0.475	0.216

2006				0.628	2.007	1.572	1.827	-0.899	-0.797				1.755	0.903	0.494
2007				0.672	1.682	1.337	1.659	0.468	1.403				1.492	1.080	0.671
2008				1.181	0.955	0.711	1.430	0.535	0.041				1.219	1.336	0.742
2009				0.650	1.323	0.857	1.429	1.388	1.138				0.860	0.874	0.484
2010				0.692	1.117	0.743	1.554	0.801	0.148				0.981	0.765	0.382
2011				0.557	1.211	0.869	1.449	0.856	0.066				0.915	0.925	0.483
2012				0.652	1.152	0.833	1.826	-0.145	-0.072				0.876	0.738	0.383
2013	0.817	-1.476	-0.800	0.668	0.504	0.364	2.737	0.206	2.664				0.784	0.598	0.268
2014	1.144	-0.499	-0.784	1.124	0.212	0.106	1.721	0.199	-0.498				0.851	0.722	0.361
2015	1.496	1.283	0.713	0.811	0.032	-0.101	1.687	0.315	-0.153				0.564	-0.066	0.055
2016	3.019	1.470	1.225	0.903	-2.160	-2.204	1.602	0.895	0.168				0.877	0.496	0.361
2017	2.887	1.094	0.739	0.706	0.336	0.263	1.705	0.961	-0.076	2.496	0.773	0.377	1.151	0.591	0.421
2018	2.980	1.137	0.992	0.612	0.425	0.281	1.854	2.280	1.153	1.375	-1.614	-1.813	1.552	0.677	0.575
2019	3.789	1.604	0.979				2.039	1.879	1.113	1.245	0.516	0.191	1.351	0.742	0.636
2020	3.176	1.579	1.492				2.085	1.989	1.139	2.430	0.004	0.553	1.402	0.329	0.191
2021	2.388	1.136	0.870				1.904	2.121	1.189	1.056	0.379	0.099	0.960	0.956	0.297
2022	1.943	0.331	0.114				2.185	1.349	0.688	1.964	0.027	-0.363	1.482	0.950	0.644

Source: Authors' estimations.

Table 1j: Average q, Before-tax Marginal q and After-tax Marginal q of the top 46-49 defense companies (cont.)

	Kratos D & S Solutions U.S.			**Patria Finland**			**Chemring U.K.**			**UNAC Russia**		
Year	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q	Average q	Before-tax Marginal q	After-tax Marginal q
1991												
1992												
1993												
1994												
1995												
1996												
1997												
1998												
1999												
2000												
2001												
2002												
2003												
2004												
2005												

2006												
2007												
2008												
2009												
2010	2.339	0.921	0.578									
2011	2.211	0.393	-0.323									
2012	1.004	-0.417	-0.959									
2013	1.003	0.154	-0.315									
2014	1.082	0.053	-0.777									
2015	0.843	-0.055	0.240									
2016	1.103	-0.263	-0.885				0.566	2.048	0.349			
2017	1.529	-0.171	-0.607	0.488	1.530	1.170	0.567	0.930	0.191			
2018	1.751	0.439	-0.050	0.514	1.982	1.597	0.731	1.207	-3.559			
2019	2.650	0.511	0.168	0.823	0.255	0.160	0.861	2.348	0.831	1.342	-0.649	-1.401
2020	2.394	0.347	0.943	0.682	1.084	0.921	1.314	2.628	1.201	1.327	0.791	-4.178
2021	2.435	0.267	-0.019	1.362	1.774	1.570	1.495	1.709	1.408	1.660	0.853	-0.519
2022	1.517	-0.024	-0.334	1.218	1.537	1.309	1.663	1.827	1.625	1.663	1.827	1.625

Source: Authors' estimations.

Table 2: Summary statistics of the 49 listed DBI firms

	Obs.	Median	Mean	Std. Dev.	Min	Max
Average $q_{(t)}$	651	1.4145	1.6843	1.0145	0.386	8.609
Before − tax Marginal $q_{(t)}$	651	1.902	2.0647	1.6419	-4.981	8.649
After − tax Marginal $q_{(t)}$	651	1.2235	1.3899	1.3954	-5.099	6.086
[Average $q_{(t)}$−1] Price Index for Investment in Fixed Assets	651	0.4145	0.6843	1.0145	-0.386	7.609
[Before − tax Marginal $q_{(t)]}$ Price for Investment in Fixed Assets	651	0.902	1.0647	1.6419	-5.981	7.649
[After − tax Marginal $q_{(t)]}$ Price for Investment in Fixed Assets	651	0.2235	0.3899	1.3954	-6.099	5.086
Investment in Fixed $\text{Assets}_{(t)}$/Net Value of Fixed $\text{Assets}_{(t-1)}$	651	0.182	0.2367	0.1795	0	1.162
Before − tax Profit on Fixed $\text{Assets}_{(t)}$/Net Value of Fixed $\text{Assets}_{(t-1)}$	651	0.08	0.0904	0.0846	-0.235	0.669
After − tax Profit on Fixed $\text{Assets}_{(t)}$/Net Value of Fixed $\text{Assets}_{(t-1)}$	651	0.054	0.0593	0.0711	-0.24	0.59
Year	657	2006	2013.4	6.7833	1991	2022

Source: Authors' estimations based on data from each firm's balance sheets and cash flows.

Table 3a: Determinants of investments in the 49 listed military firms (reduced form and adjustement cost model)

(Panel estimation with fixed effetc and robust standard errors (FE))

Independent Variables	Dependant variables		
	= Investments in Fixed Assets / Net Value of Fixed Assets		
Average q	0.00924	0.0175	0.0131
	(0.0237)	(0.0197)	(0.0176)
year		-0.00347	
		(0.00222)	
Constant	0.216***	7.196	0.177***
	(0.0385)	(4.493)	(0.0338)
y1991			-0.00291
			(0.0353)
y1992			0.0106
			(0.0356)
y1993			-0.00805
			(0.0354)
y1994			0.0177
			(0.0475)
y1995			0.189
			(0.167)
y1996			0.0809
			(0.0897)
y1997			0.260**
			(0.127)
y1998			0.208
			(0.132)
y1999			0.117
			(0.0776)
y2000			0.0944
			(0.0613)
y2001			0.0745
			(0.0529)
y2002			0.0932
			(0.0838)
y2003			0.0791
			(0.0578)
y2004			0.00876
			(0.0328)
y2005			0.0427
			(0.0339)
y2006			0.0304
			(0.0249)
y2007			0.142**
			(0.0566)
y2008			0.0565*
			(0.0306)
y2009			0.0538
			(0.0440)
y2010			-0.00775

			(0.0359)
y2011			0.0699
			(0.0441)
y2012			0.0194
			(0.0362)
y2013			-0.00899
			(0.0257)
y2014			-0.0380
			(0.0276)
y2015			-0.0203
			(0.0254)
y2016			-0.000228
			(0.0246)
y2017			0.0230
			(0.0322)
y2018			0.0315
			(0.0259)
y2019			0.0740**
			(0.0281)
y2020			0.0501*
			(0.0269)
y2021			0.00667
			(0.0142)
y2022 (excluded)			-
Observations	688	688	688
R-squared	0.002	0.019	0.106
Number of firm	49	49	49

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3b: Determinants of investments of the 49 listed military firms (reduced form and adjustement cost model)

(Panel estimation with fixed effetc and robust standard errors (FE))

Independent Variables	Dependant variables = Investments in Fixed Assets / Net Value of Fixed Assets		
Before-tax Marginal q	0.0244*	0.0233**	0.0214*
	(0.0129)	(0.0115)	(0.0120)
year		-0.00163	
		(0.00214)	
Constant	0.186***	3.480	0.179***
	(0.0267)	(4.283)	(0.0321)
y1991			-0.0346
			(0.0297)
y1992			-0.0236
			(0.0287)
y1993			-0.0378
			(0.0304)
y1994			-0.0141
			(0.0433)
y1995			-0.00373
			(0.0381)
y1996			0.0526
			(0.0832)
y1997			0.232*
			(0.119)
y1998			0.174
			(0.121)
y1999			0.0679
			(0.0681)
y2000			0.0496
			(0.0472)
y2001			0.0528
			(0.0515)
y2002			0.0696
			(0.0892)
y2003			0.0732
			(0.0617)
y2004			-0.0199
			(0.0328)
y2005			0.0213
			(0.0351)
y2006			-0.000386
			(0.0282)
y2007			0.105*
			(0.0590)
y2008			0.0166
			(0.0306)
y2009			0.0309
			(0.0479)

y2010			-0.0387
			(0.0365)
y2011			0.0489
			(0.0427)
y2012			-0.00458
			(0.0407)
y2013			-0.0259
			(0.0239)
y2014			-0.0508*
			(0.0270)
y2015			-0.0407*
			(0.0238)
y2016			-0.0152
			(0.0246)
y2017			-0.00162
			(0.0331)
y2018			0.0163
			(0.0264)
y2019			0.0515*
			(0.0264)
y2020			0.0525*
			(0.0279)
y2021			0.00199
			(0.0133)
y2022 (excluded)			
Observations	651	651	651
R-squared	0.039	0.043	0.130
Number of firmid	49	49	49

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3c: Determinants of investments in the 51 listed military firms (reduced form and adjustement cost model)

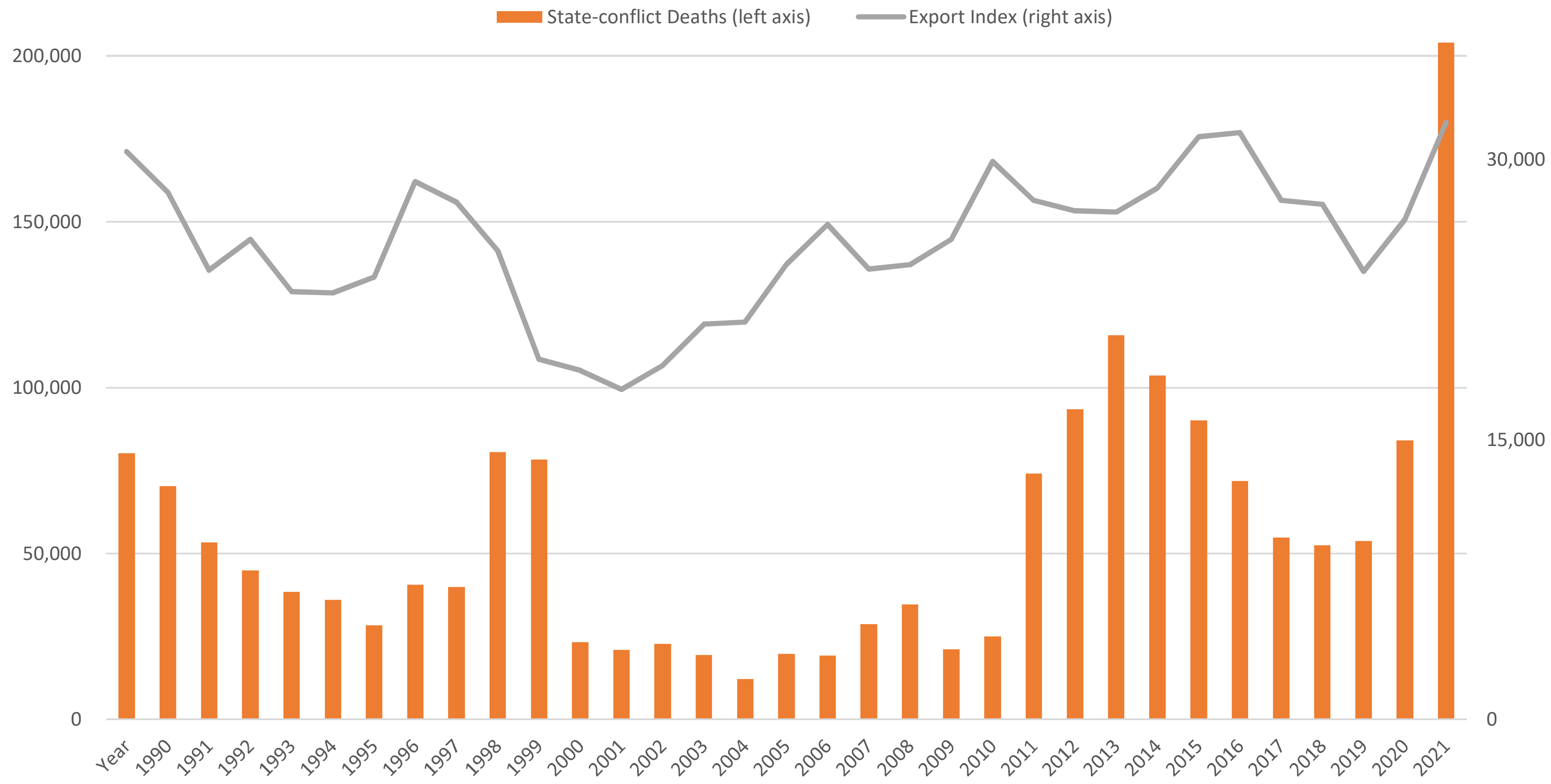
(Panel estimation with fixed effetc and robust standard errors (FE))

Independent Variables	Dependant variables = Investments in Fixed Assets / Net Value of Fixed Assets		
After-tax marginal q	0.0321***	0.0312***	0.0289***
	(0.0114)	(0.0106)	(0.0103)
year		-0.00183	
		(0.00225)	
Constant	0.192***	3.871	0.180***
	(0.0159)	(4.527)	(0.0260)
y1991			-0.0379
			(0.0298)
y1992			-0.0250
			(0.0296)
y1993			-0.0394
			(0.0306)
y1994			-0.0102
			(0.0441)
y1995			-0.00278
			(0.0388)
y1996			0.0549
			(0.0866)
y1997			0.237*
			(0.123)
y1998			0.179
			(0.126)
y1999			0.0700
			(0.0769)
y2000			0.0520
			(0.0549)
y2001			0.0521
			(0.0541)
y2002			0.0806
			(0.0944)
y2003			0.0779
			(0.0608)
y2004			-0.0192
			(0.0335)
y2005			0.0257
			(0.0356)
y2006			-0.00265
			(0.0276)
y2007			0.104*
			(0.0583)
y2008			0.0271
			(0.0310)
y2009			0.0412
			(0.0460)

y2010			-0.0265
			(0.0356)
y2011			0.0575
			(0.0429)
y2012			0.00501
			(0.0384)
y2013			-0.0229
			(0.0217)
y2014			-0.0439
			(0.0265)
y2015			-0.0367
			(0.0233)
y2016			-0.0104
			(0.0242)
y2017			0.000800
			(0.0323)
y2018			0.0171
			(0.0257)
y2019			0.0530**
			(0.0260)
y2020			0.0561*
			(0.0281)
y2021			0.00249
			(0.0127)
y2022 (excluded)			
Observations	651	651	651
R-squared	0.052	0.057	0.141
Number of firmid	49	49	49

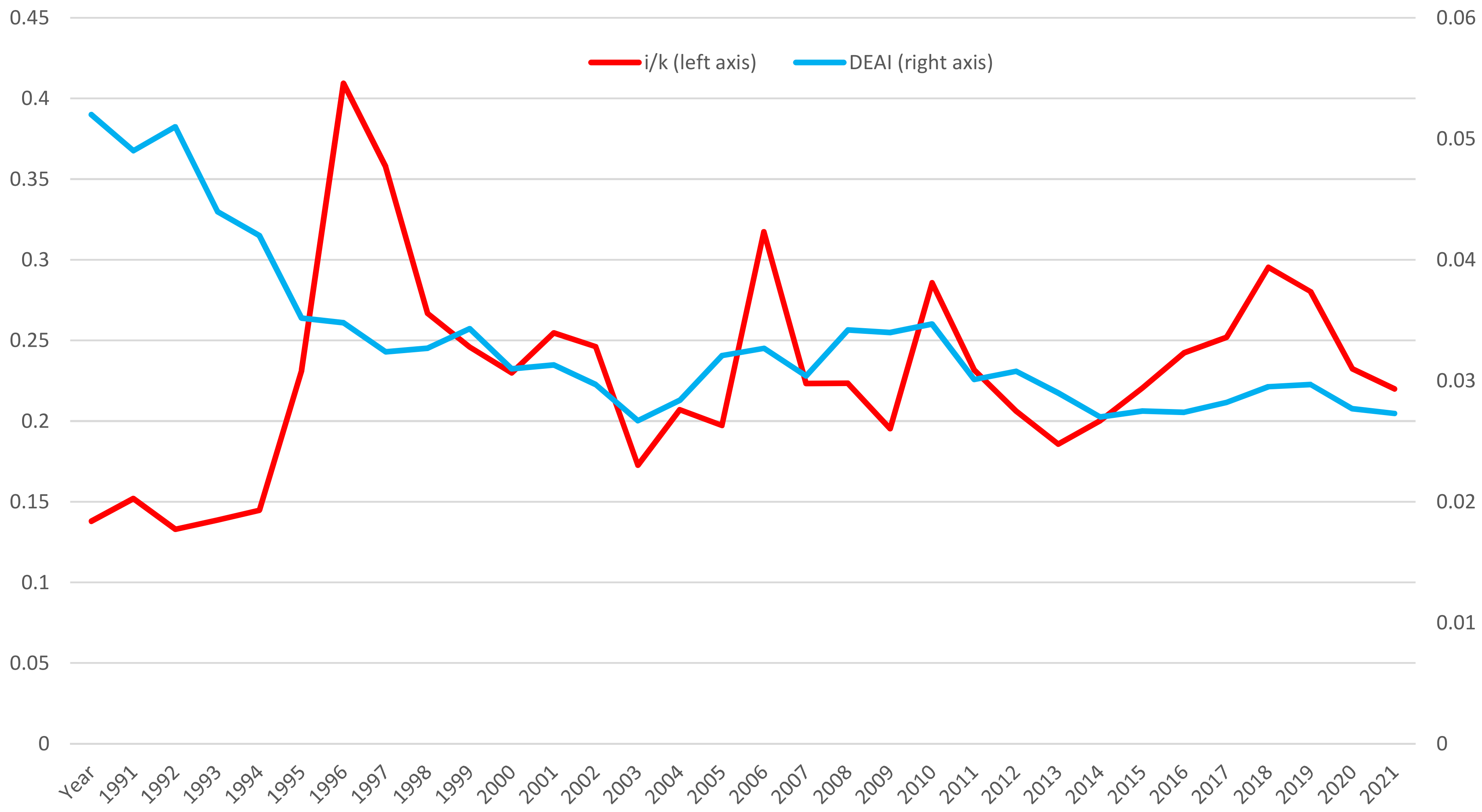
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1: State-conflict Deaths and Export Index in the World



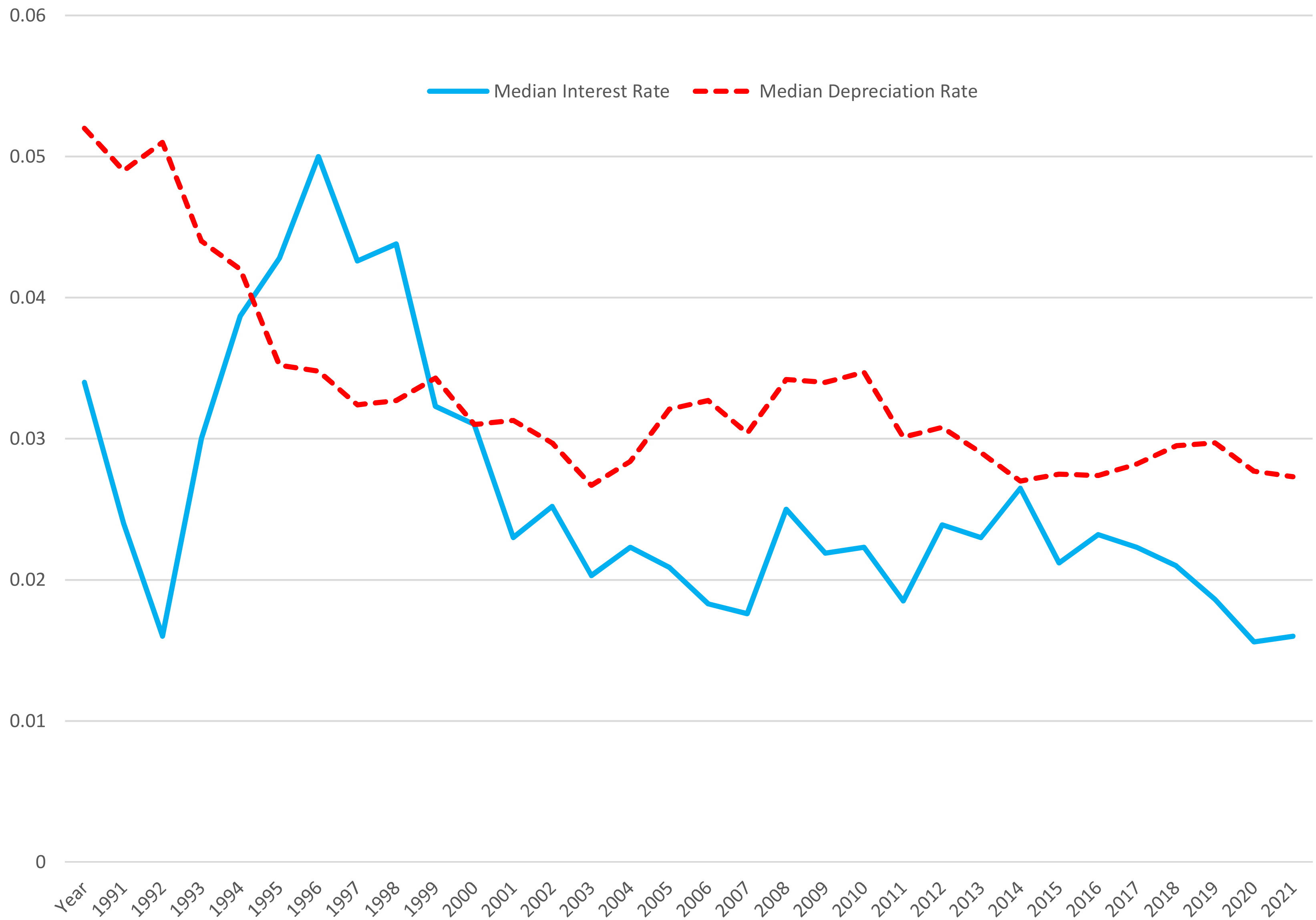
Source: Authors' drawing based on ``Our World in Data."
https://ourworldindata.org

Figure 2: Investment rate and depreciation rate

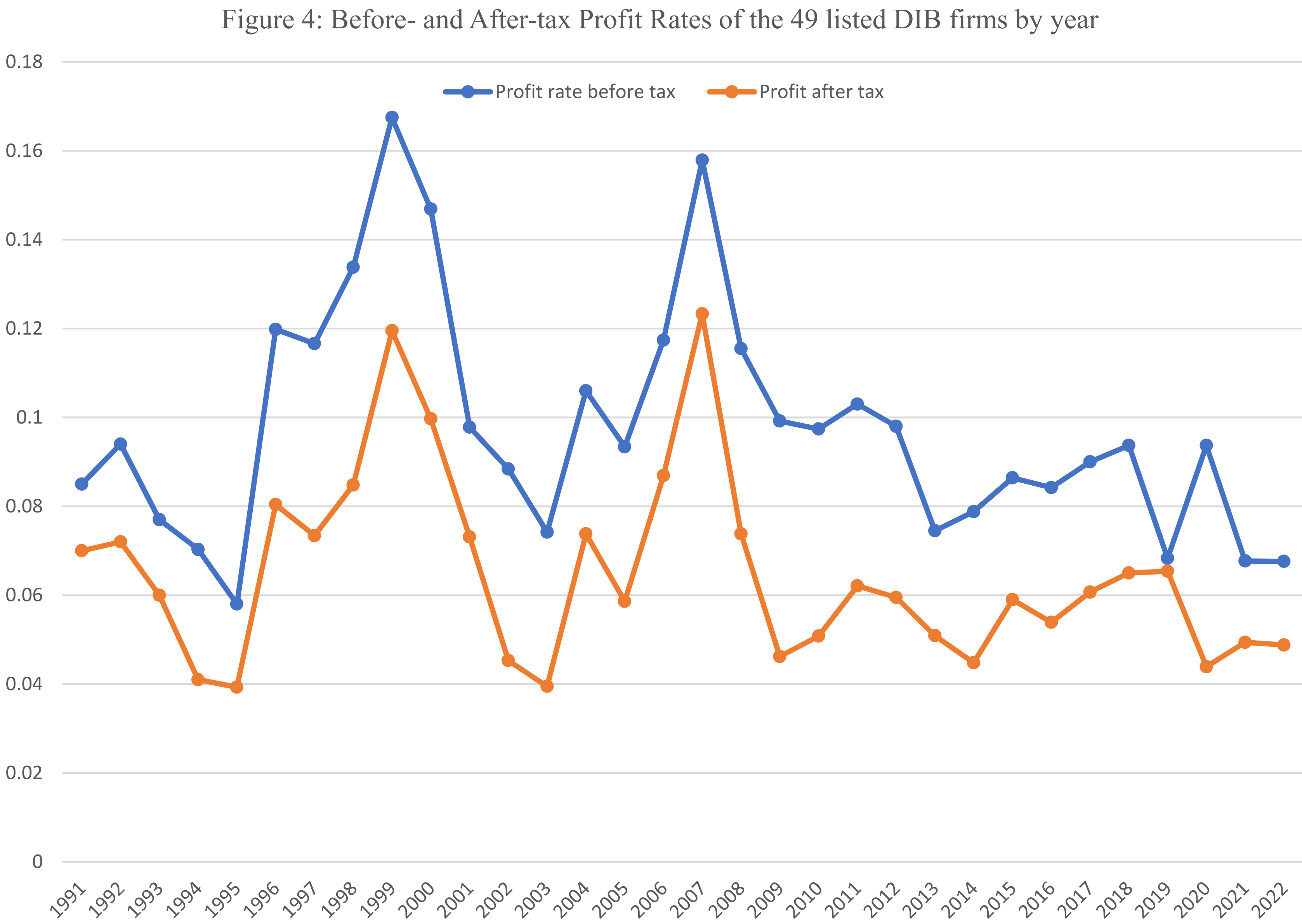


Source: Authors' estimations.

Figure 3: Median value of Depreciation and Interest Rates of the 49 listed DBI firms by year

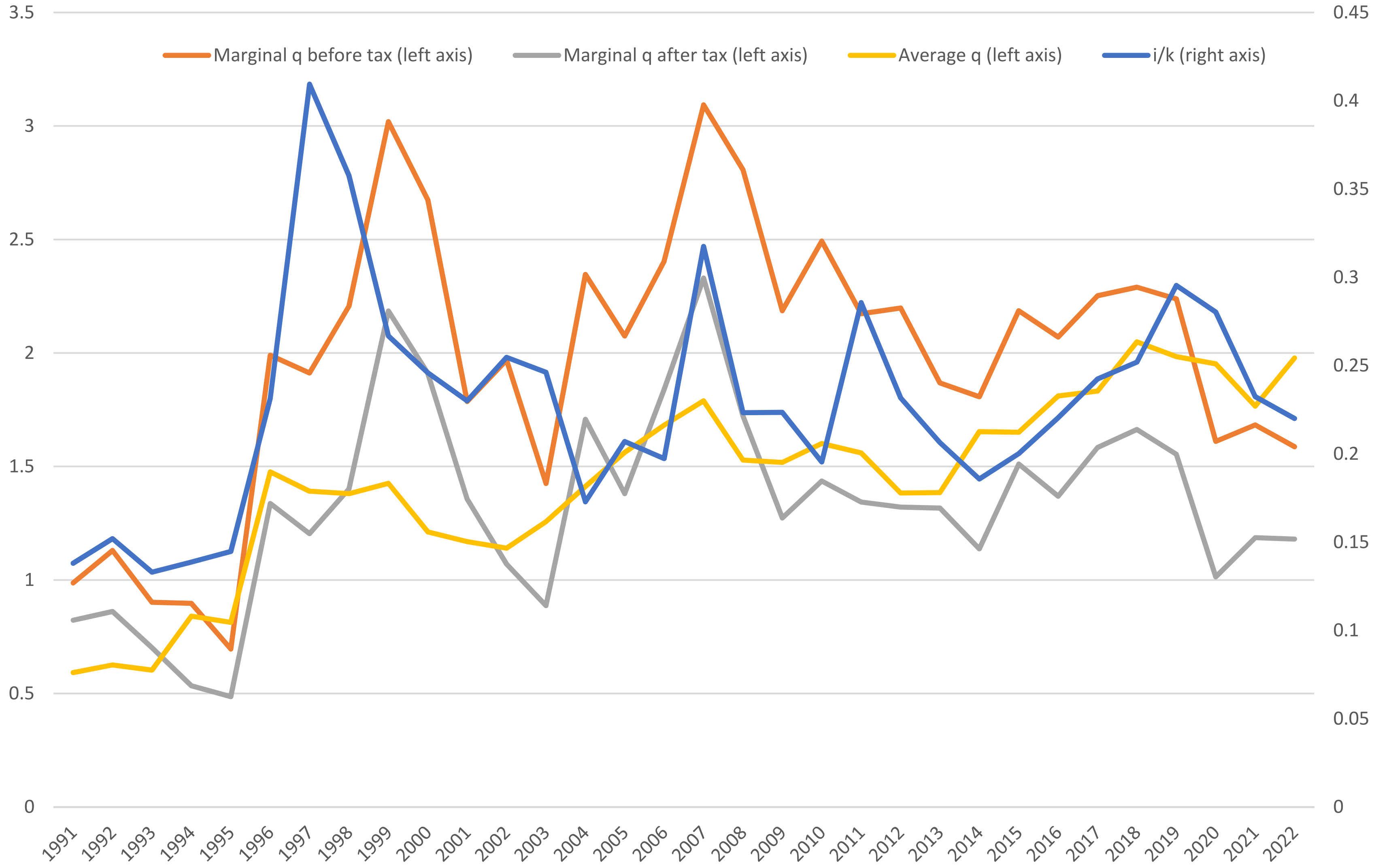


Source: Authors' estimations.



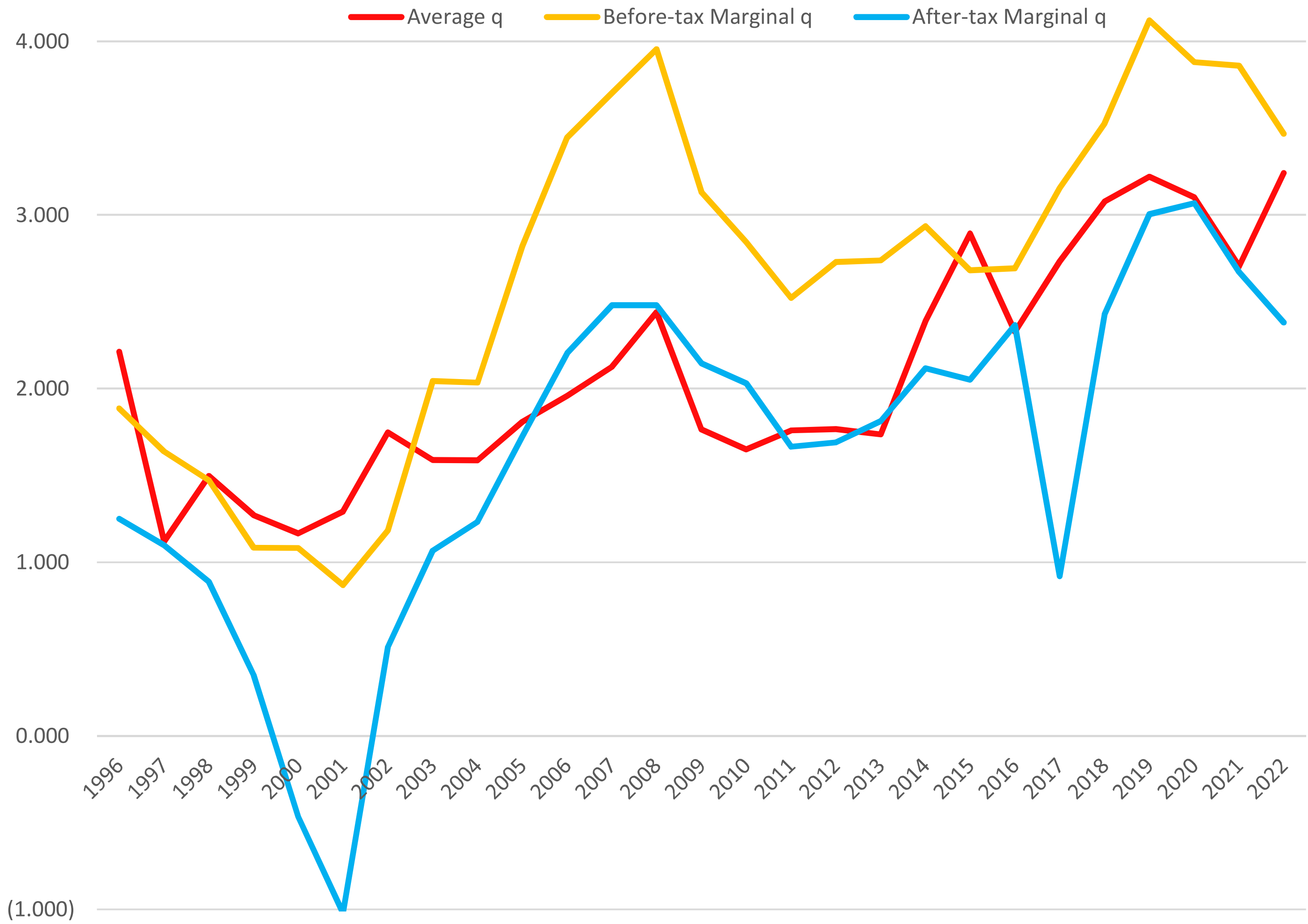
Source: Authors' estimations

Figure 5: Average *q*, Before- and After-tax Marginal *q* and ratio of investments to fixed assets of the 49 listed DIB firms by year



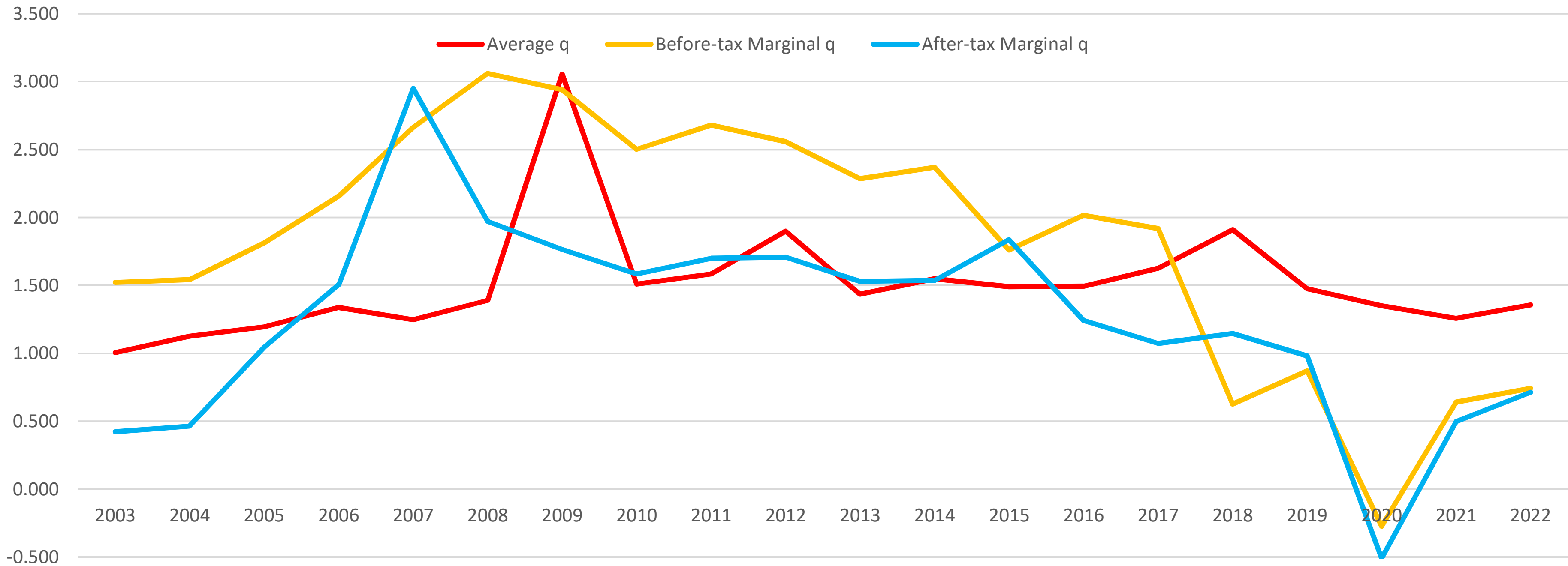
Source: Authors' estimations.

Figure 6: Average *q*, before- and after-tax Marginal *q* of Lookcheed for the period 1996 - 2022



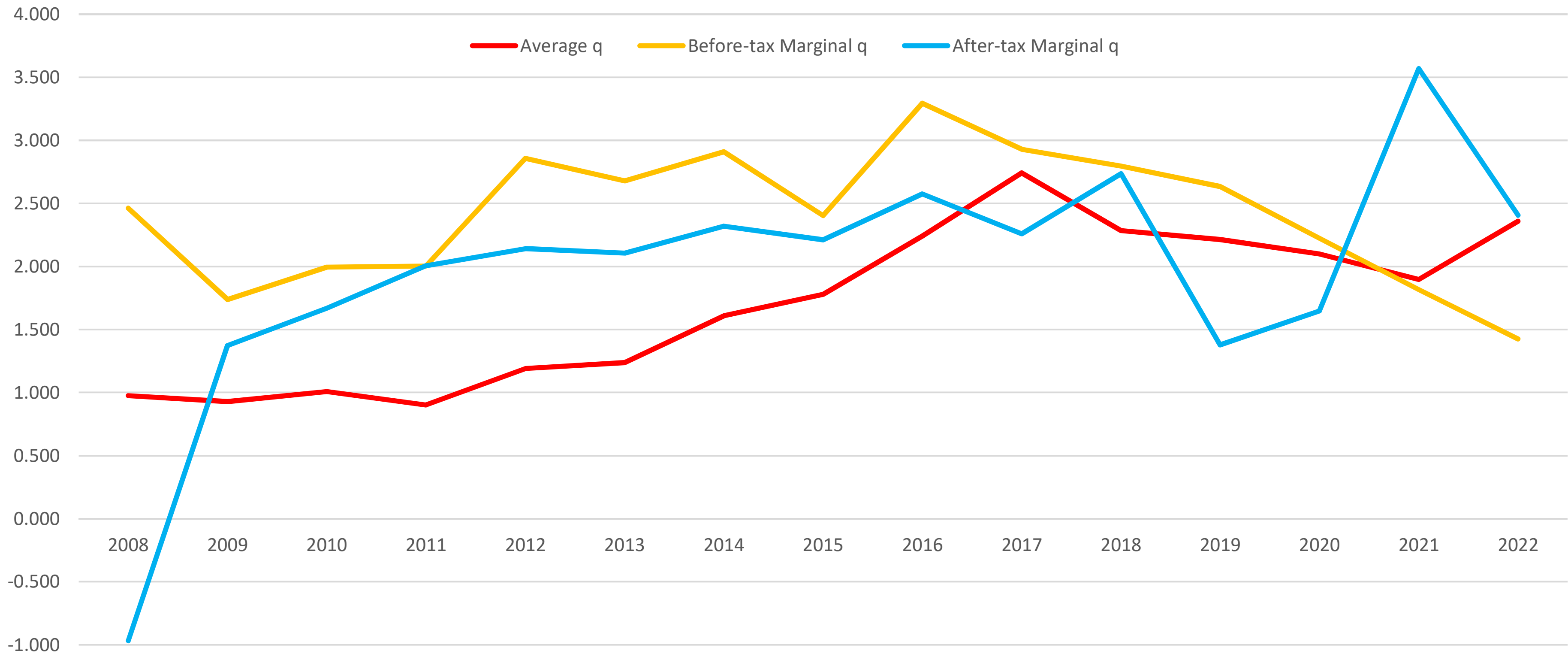
Source: Authors' estimations.

Figure 7: Average *q*, before- and after-tax Marginal *q* of Raytheon for the period 2003 - 2022



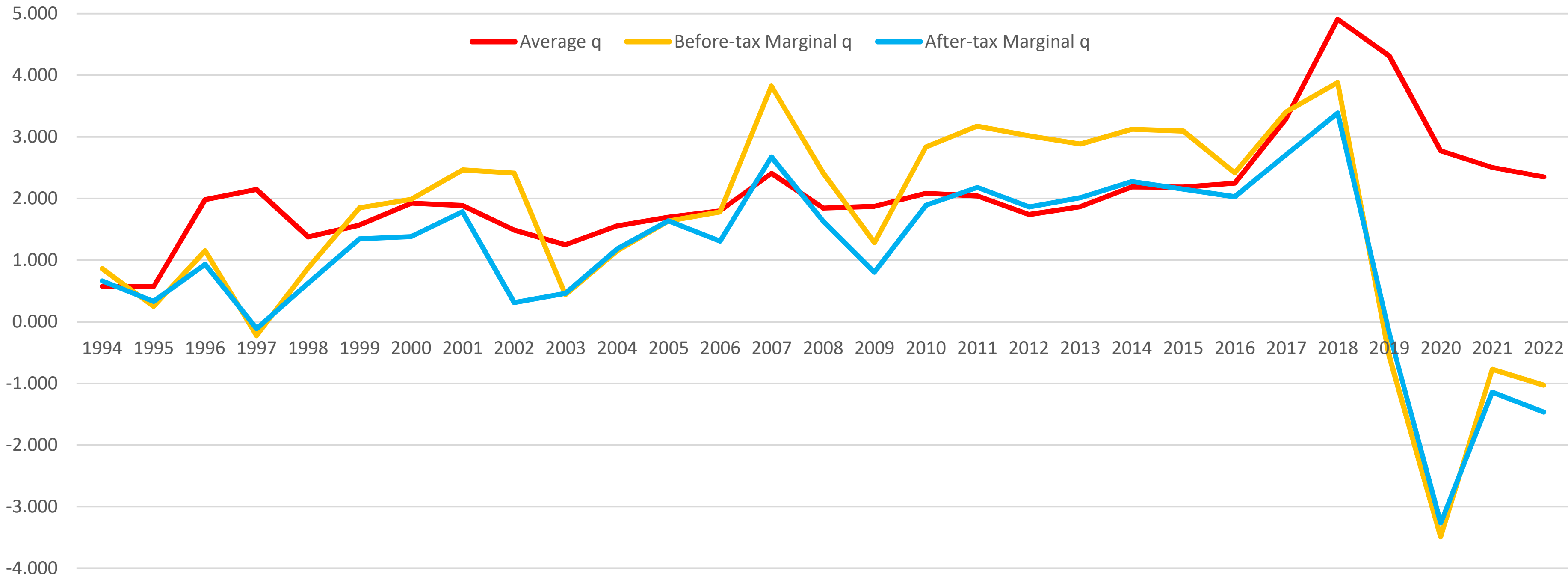
Source: Authors' estimations.

Figure 8: Average *q*, before- and after-tax Marginal *q* of Northrop Grumman for the period 2008 - 2022



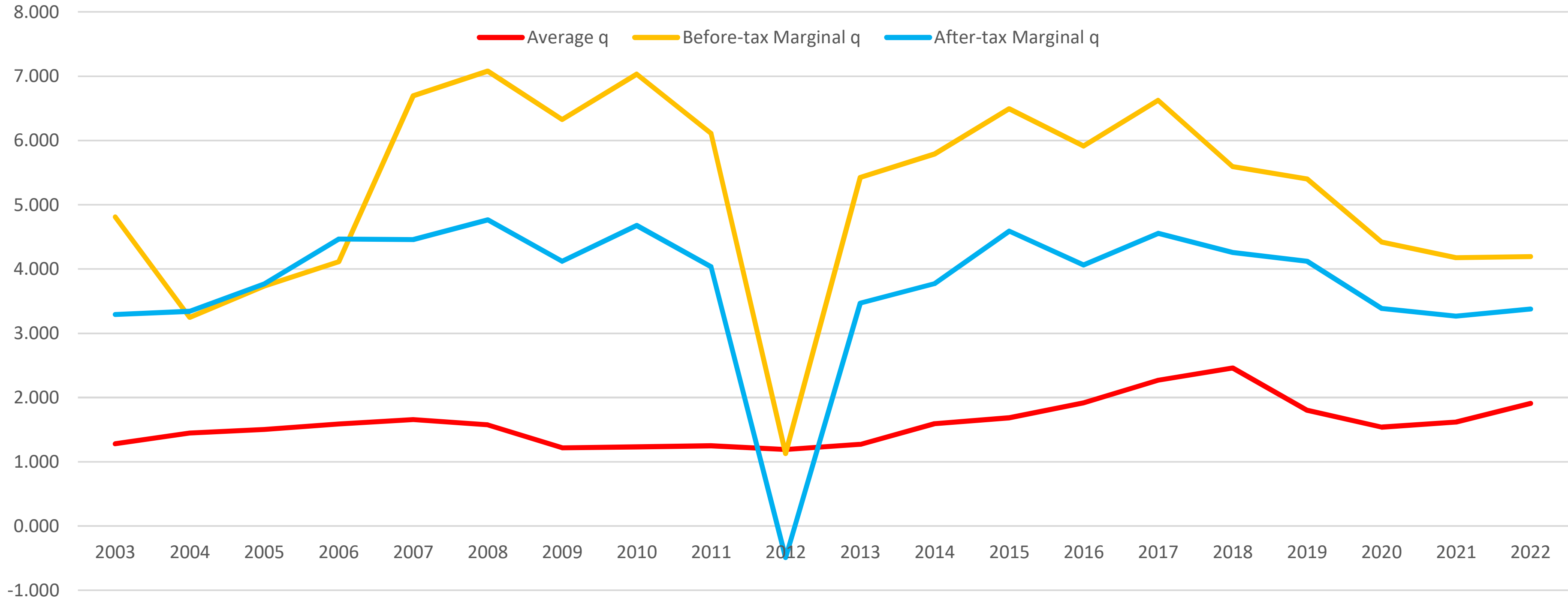
Source: Authors' estimations.

Figure 9: Average *q*, before- and after-tax Marginal *q* of Boeing for the period 1994 - 2022



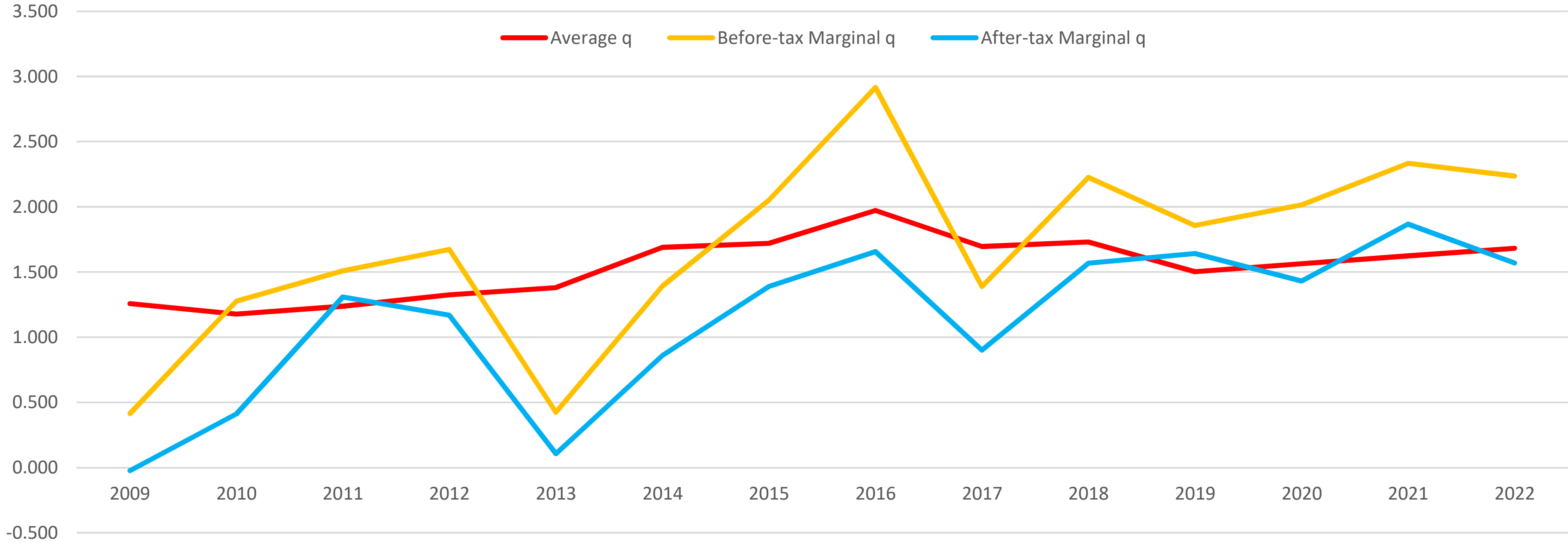
Source: Authors' estimations.

Figure 10: Average *q*, before- and after-tax Marginal *q* of General Dynamics for the period 2003 - 2022



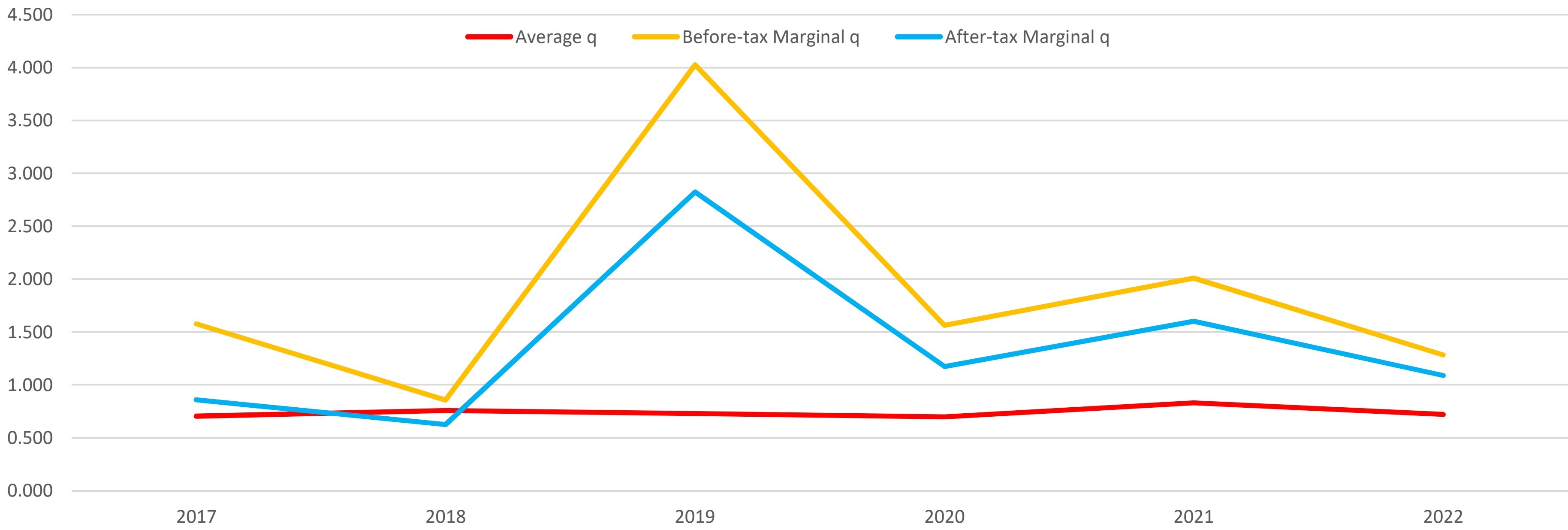
Source: Authors' estimations.

Figure 11: Average *q*, before- and after-tax Marginal *q* of BAE for the period 2009 - 2022



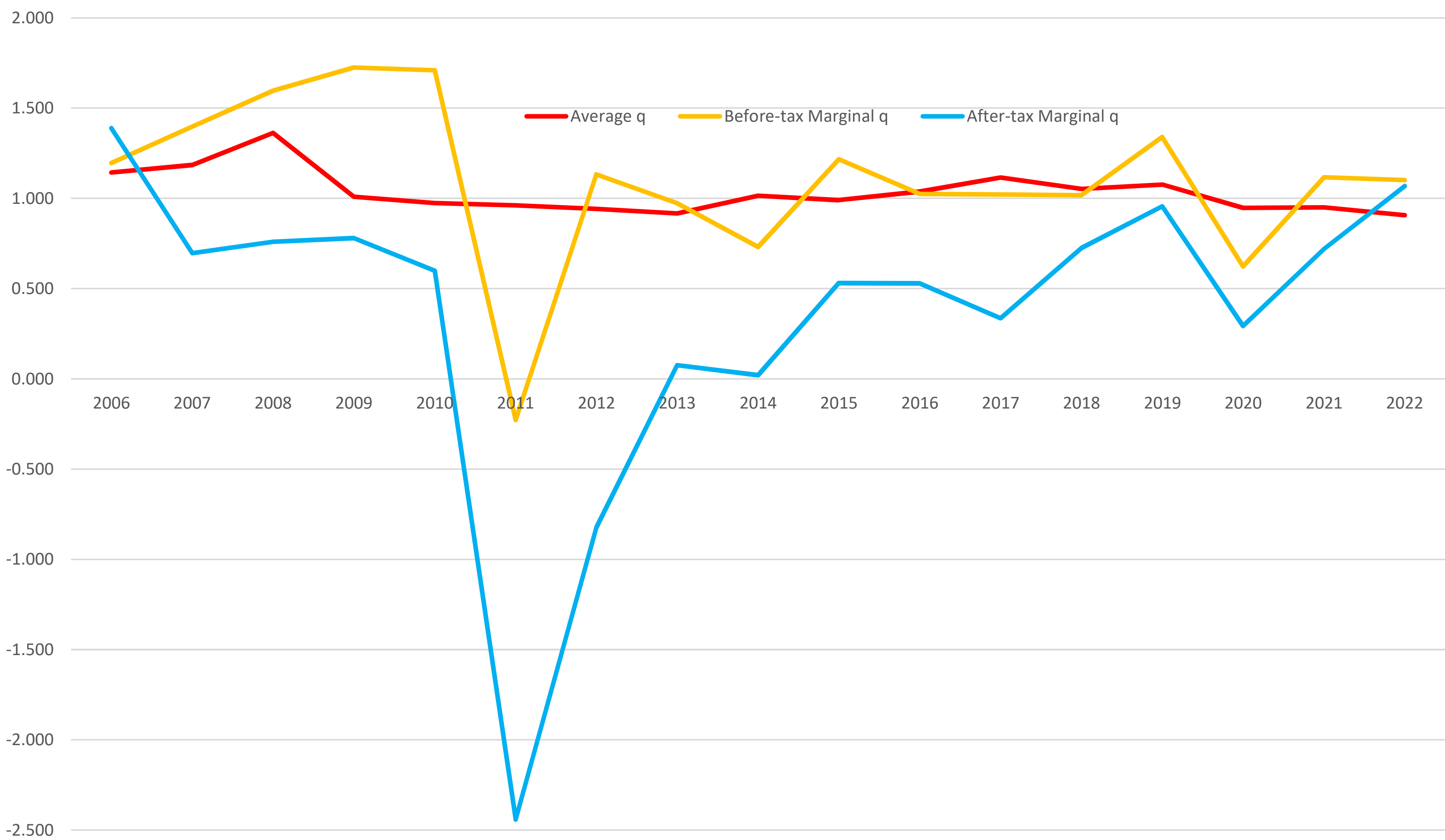
Source: Authors' estimations.

Figure 12: Average *q*, before- and after-tax Marginal *q* of AVIC for the period 2019 - 2022



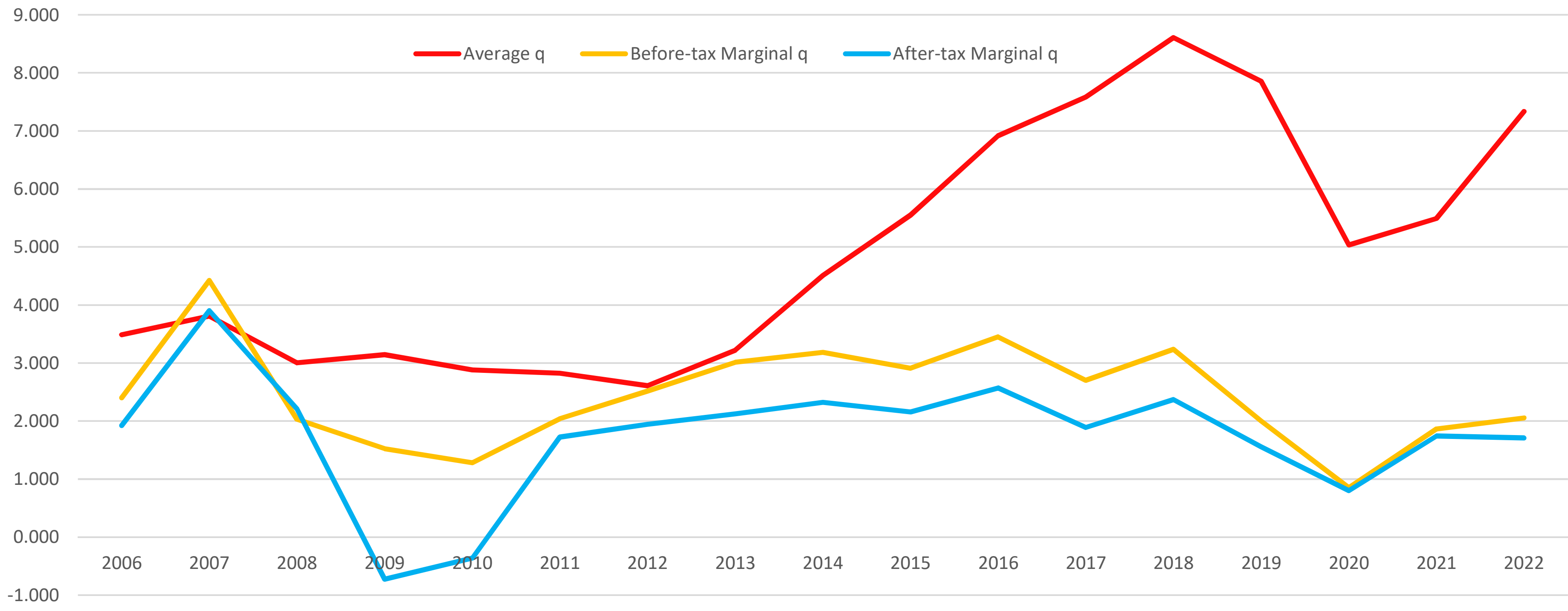
Source: Authors' estimations.

Figure 13: Average *q*, before- and after-tax Marginal *q* of Leonardo for the period 2006 - 2022



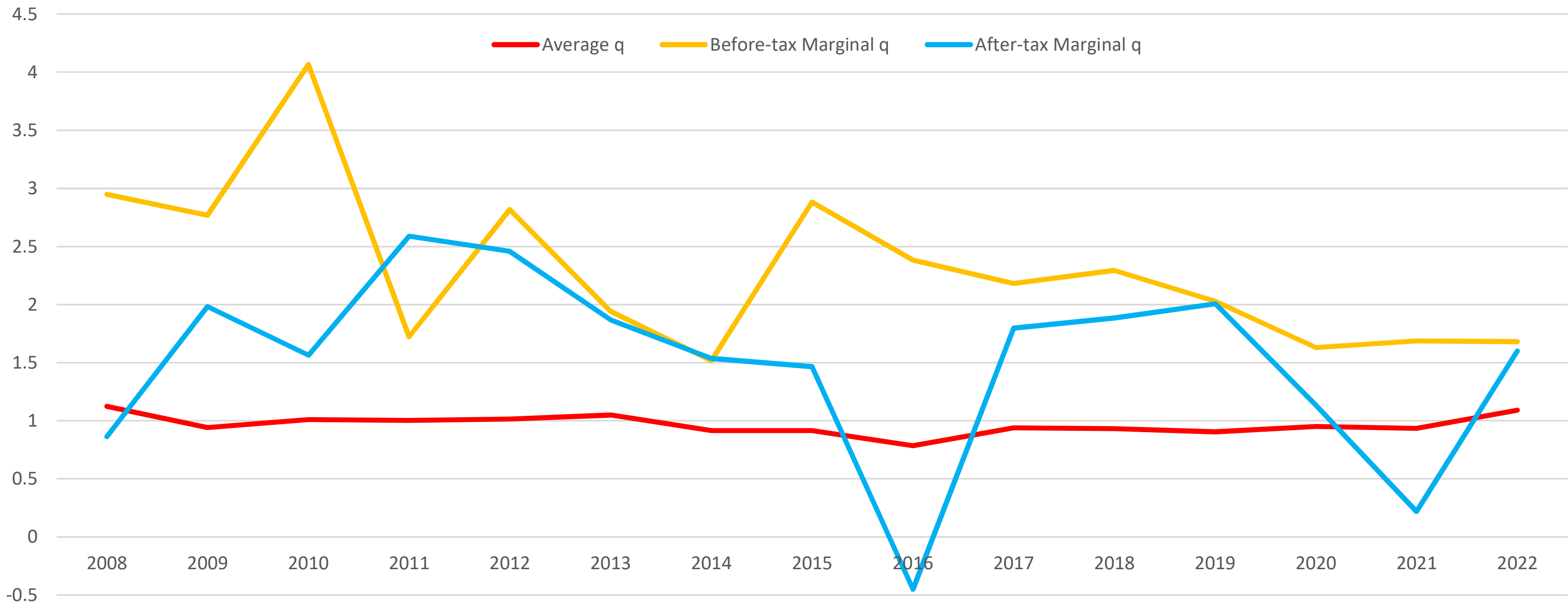
Source: Authors' estimations.

Figure 14: Average *q*, before- and after-tax Marginal *q* of Thales for the period 2006 - 2022



Source: Authors' estimations.

Figure 15: Average q, before- and after-tax Marginal q of Mitsubishi for the period 2008 - 2022



Source: Authors' estimations.