Erasmus University Rotterdam

Erasmus School of Economics

Bachelor Thesis BSc Economics and Business Economics

The Effects of Generative AI on Venture Capital Investment Decisions: An Empirical Study

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Research question: how has the emergence of generative artificial intelligence affected venture capital investment decisions in Germany?

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Abstract

Generative artificial intelligence has captivated the public's attention since OpenAI's release of ChatGPT in November 2022, with the startup's technology holding the potential to significantly boost global productivity. This paper investigates how the emergence of generative artificial intelligence has affected venture capital investment decisions in Germany. A baseline ordinary least squares regression model found that the average deal size investing in a German AI company has decreased by 22% since the release of ChatGPT and a Difference-in-Differences model refines this figure to a 34% decrease. However, the latter study suggests the presence of spillover effects due to ChatGPT's release having an identical effect on non-AI firms as well. Although the models show that deal sizes in German AI firms have been increasing over time, it also suggests room for growth in the industry, as investments in AI firms are 13% lower, on average, compared to investments in non-AI firms. Moreover, a Poisson regression model revealed that the monthly investment rate in German AI startups have increased by 62% on average after the release of ChatGPT. This increased investment rate in AI firms, combined with the lower deal sizes in AI and non-AI firms, suggests that ChatGPT catalyzed a shift in investment behavior towards risk-aversion: spreading investments, smaller in size, across a greater number of firms.

Table of Contents

Introduction

The release of OpenAI's ChatGPT towards the end of 2022 has put a spotlight on generative artificial intelligence; an overnight sensation that was, in truth, the product of incremental innovations in the broader field of artificial intelligence. Generative artificial intelligence was labelled as a disruptive innovation soon thereafter which "will have a significant impact across all industry sectors" (Chui et al., 2023).

As venture growth remains a primary objective for startups to increase their competitiveness and establish themselves (Struckell et al., 2022), this report shifts its focus towards investments in AI firms. The AI investment landscape "has grown dramatically" (Tricot, 2021) even in the years before release of ChatGPT. Since then, activity has been "largely concentrated in North America, reflecting the continent's current domination of the overall AI investment landscape" (Chui et al., 2023). However, it is now critical to redirect the focus into Europe, Germany specifically, to see if investment is used as a vessel to foster innovation within the country. Therefore, this paper formulates the following research question: *how has the emergence of generative artificial intelligence has affected venture capital investment decisions in Germany?*

There could be several mechanisms that can motivate a relationship between the emergence of generative artificial intelligence and venture capital investment decisions. For example, investors who have become aware of the new potential of artificial intelligence (AI) could be more/less inclined to invest in other startups in the AI space. Similarly, investors may be willing to invest in riskier AI startups, seeking to replicate the OpenAI's success. On the other hand, the increased attention in the AI industry could significantly prompt profit-seeking entrepreneurs to enter the market and saturate the market, making investors reluctant to invest in such startups. Nonetheless, the hypotheses that formulate below predict that the effect of investors seeking to capitalize on the disruptive technology, encapsulated by McKinsey Global Institute's previously mentioned statement regarding the "rush to throw money at all things generative AI" (Chui et al., 2023), overpowers any possible reluctance to invest.

H_1: *The average investment rate in German AI companies increased after the release of ChatGPT*

H_2: *The average deal size investing in German AI companies increased after the release of ChatGPT*

The institutional setting in Germany differs greatly not only compared to the United States, but also compared to other EU countries. Being Europe's economic powerhouse (Rao, 2023), Germany's approach to AI with respect to its innovations and investments not only influences its own industries but also has widespread implications for countries around Europe that may follow suit. This paper aims to provide context for Germany as it navigates through the new age of AI industrialization. Despite the EU's newly appointed AI Act (European Commission, 2024) which applies to all its member states, Germany has shown initiative to invest in artificial intelligence in its AI strategy, deployed in 2019 (Federal Government of Germany, 2020). These underscore the importance of analyzing AI developments in such a country.

1.1. Impact

The impact that generative artificial intelligence (GAI) can potentially have on the economy has ranged from modest (Acemoglu, 2024) to major (Briggs et al., 2023; Chui et al., 2023), with the potential of "[adding] trillions of dollars in value to the global economy" (Chui et al., 2023) and boosting global productivity. The former phenomenon is motivated by the belief that the complexity of future tasks will dampen the impact GAI can have on productivity (Acemoglu, 2024). However, Chui et al. (2023) argues that since "productivity growth, the main engine of GDP growth over the past 30 years, slowed down in the past decade", GAI has the potential to stimulate productivity growth. Moreover, Briggs et al. (2023) outlines how GAI has the potential to create not only higher productivity, but major labor cost savings and job creation that can significantly further economic growth. Regardless of its impact on the overall economy, on a firm level, AI has been shown to significantly boost process efficiency in those that adopt the technology (Tan et al., 2024; Pavlou, 2006); this is has only been furthered with the emergence of GAI which can enable SMEs and especially startups to gain a competitive advantage (Gupta, 2024).

1.2. Challenges

AI presents several challenges from an adoption perspective, German firms not only need to acquire the necessary skilled labor to deploy the technology and adapt their IT infrastructure (Streim & Hecker, 2021; Destatis, 2024), but also account for various ethical consideration as well (Gupta et al., 2024; Tan et al., 2024). Moreover, the EU's release of their AI Act in 2023 has only amplified the ethical factors (European Commission, 2024). Nonetheless, Salgado-Criado et al. (2024) discusses how VCs could act as a mediator that enforces digital governance and addresses the risks associated with the emerging AI technologies. This sheds new light on a VC's role, which the EU has the potential to largely benefit from given the high amount of public uncertainty regarding AI (Hoffmann & Nurski, 2021).

1.3. Academic Relevance

This study adds valuable data and insights towards the growing discussions on the intersection between AI and finance. Tricot (2021) examined VC trends in AI, a publication upon which this study largely builds from as it was published prior to the release of ChatGPT and does not have a follow-up study despite industry's large disruption. The author found that AI startups in the EU that attracted the most VC investments were in media/marketing, business support, and financial services. Additionally, the AI sector began showing signs of maturity as valuations and median deal sizes for startups have been increasing the years leading up to 2022 (Tricot, 2021). In light of the dramatic change in the AI sector since the publication of Tricot's (2021) insights on VC trends, this study aims to add updated commentary and offer new findings on what the VC landscape currently looks like in the age of generative AI. Moreover, by focusing on Germany specifically, this report will provide additional context to a critical player in the EU's AI startup space given that, "within the EU, AI firms based in Germany and France accounted for about two thirds of VC investments" (Tricot, 2021).

1.4. Social Relevance

The pace of artificial intelligence finding industry applications across the globe in recent years has made it increasingly important to understand how firms in countries around the world manage to keep up with its rapid developments. Moreover, with an emphasis on the artificial intelligence industry being forward-looking, it is vital to investigate the progress that has been made so far, and what catalyzed such progress.

The McKinsey Global Institute outlined that, currently, there is a "rush to throw money at all things generative AI" (Chui et al., 2023). This highlights the importance of analyzing not only what is attracting such investment, but also what developments these funds are being allocated towards. This can shed light on potential growth sectors in the Germany's economy that GAI can help catalyze. Moreover, exploring VC trends after the release of ChatGPT can highlight ethical considerations that may need to be accounted for in future policies, as there is a growing concern that the current state of the EU AI Act fails to address the core issues of AI (Hacker, 2023).

1.5. Structure

The research question will be tackled from two lenses: analyzing the effect of ChatGPT's release on (1) the average deal size and (2) the frequency of VC investments in German AI companies. Studies 1 and 2 will investigate the former aspect and through ordinary least squares regression and difference-in-differences models respectively while Study 3 will examine the latter through a Poisson regression model by testing for any differences in the number of deals in a pre- versus post-ChatGPT era. This paper follows by discussing implications, opportunities for further research, and concluding remarks on the findings of this paper.

Data

2.1. Data Source & Cleaning

The raw data was sourced from Preqin, a leading data provider on private investments including venture capital, private equity, and funds. Using in-house filters, the sample is limited to more than a ten-year time window, ranging from January 1, 2013, to May 1, 2024. The deal location was set to the 27 EU countries in companies under the industry "vertical" labelled artificial intelligence; this classification spans across all industries and identified 10,649 deals under these criteria as of May 18, 2024. Firms that fall under this "vertical" are defined as *"companies that design and provide computer systems that perform tasks that would normally require human intervention/intelligence"* (Preqin, n.d.).

The data cleaning and analysis was primarily achieved using the Python libraries Pandas, NumPy, and StatsModels on a Jupyter Notebook and Matplotlib was used to visualize the data and results. To clean the data, deals that did not disclose their deal size were excluded (removing 2,153 deals) and deals that were either abandoned or rejected were excluded (removing 5 deals). Finally, deals under the stages "Secondary Stock Purchase", "Merger", or "Add-on" were excluded (removing 70 deals); Tricot (2021) follows the similar methods and does so under the motivation that these deals do not inject funds into the start-ups themselves, but are secondary market transactions between two investors instead. Finally, deals that did not target startups headquartered in Germany were excluded which yielded a final sample of 635 deals.

An additional "Industry Cluster" variable was added to indicate if the startup falls under one of the three main types of AI firms: Technology & Innovation, Healthcare & Pharmaceuticals, and Financial & Professional Services (See Appendix 1 to view the exact cluster specifications).

Moreover, 14 different deal stages were found in the data, which included Pre-seed to Series G funding rounds as well as grants, angel investments, and venture debt among others. Funding rounds associated with more mature stages of a startup's development (Series E/F/G), are significantly fewer in numbers than earlier stages (Pre-seed/Seed) as the deal size increases significantly as the firms become more mature. To account for this, these funding rounds have been aggregated into 5 different round stages: Seed, Series A, Series B, Series C+, Unspecified Round. Appendix 2 outlines how each funding round was converted into one of the five aggregated round stages by investigating the average deal size of a given round.

2.2. Exploratory Data Analysis

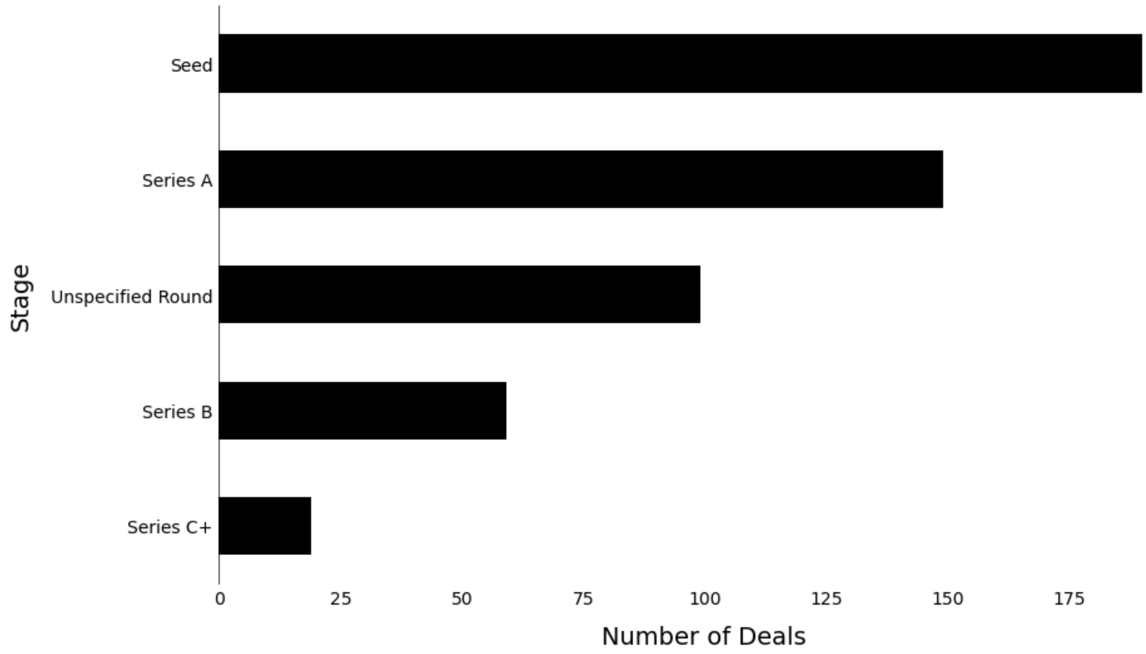
Table 1 below outlines an overview of the data. It is important to note that 635 German AI startups involved in 34 different industries (grouped into 4 industry clusters) and 25 different investor types are included in the data. This strengthens the representativeness of the sample as it covers a wide range of actors on both sides of a venture capital deal: both the investor and targeted AI startup.

Table 1: Descriptive Statistics

Metric	**Statistic**
Total Deals	635
Median Deal Size (USD millions)	5.63
Number of Industries	34
Number of Industry Clusters	4
Number of Investor Types	25

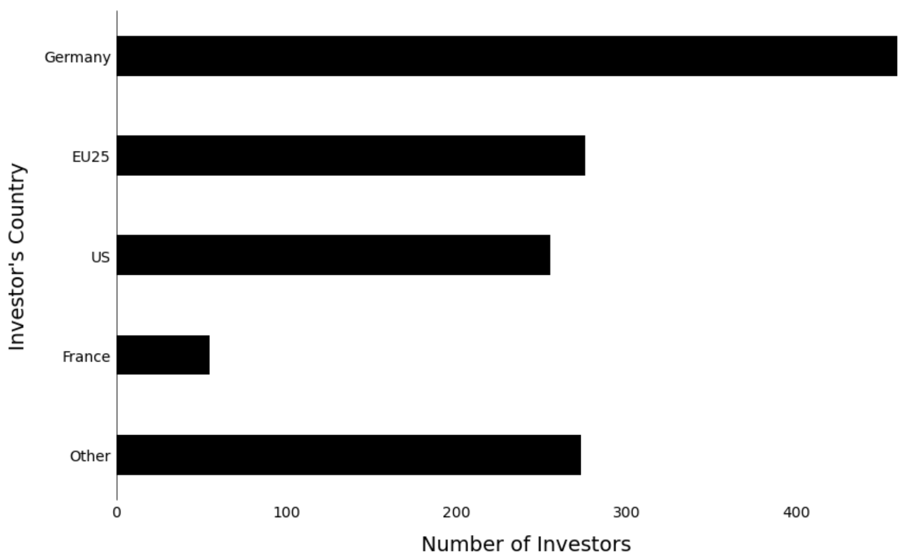
Figure 1 below visualizes the number of deals every deal stage has. The figure outlines how less investors are willing to fund a given deals as the deal increases in its size; this phenomenon is captured in the bar graph below as there are 190 Seed investments compared to just 19 Series C+ investments in German AI firms.

Figure 1: Venture capital deals in German AI firms, by funding round



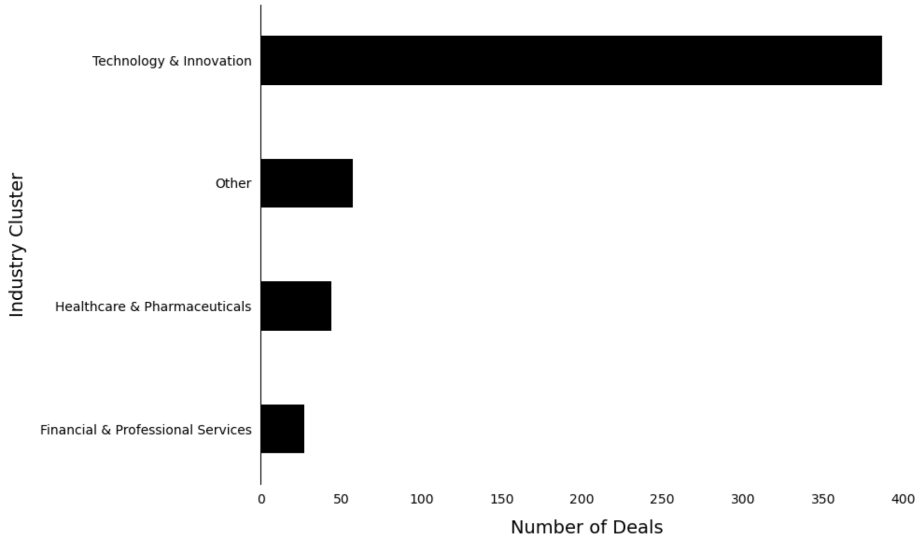
Investor composition also plays a significant role in determining a deal's outcome, as Nahata (2008) found that the reputation of a VC can affect a startup's success in exiting as well as the speed in which they access public markets. Moreover, Mäkela & Maula (2008) state that local investors invest prior to foreign ones. The authors find that local investment is then followed by foreign investment as the presence of the former holds significant signaling value. Figure 2 displays this by visualizing which country each investor is from, keeping in mind that multiple investors can back a single deal. The figure below supports the findings of Mäkela & Maula (2008) by showing that German startups are largely funded by investors in their own country.

Figure 2: Venture capital deals in German AI firms, by investor country



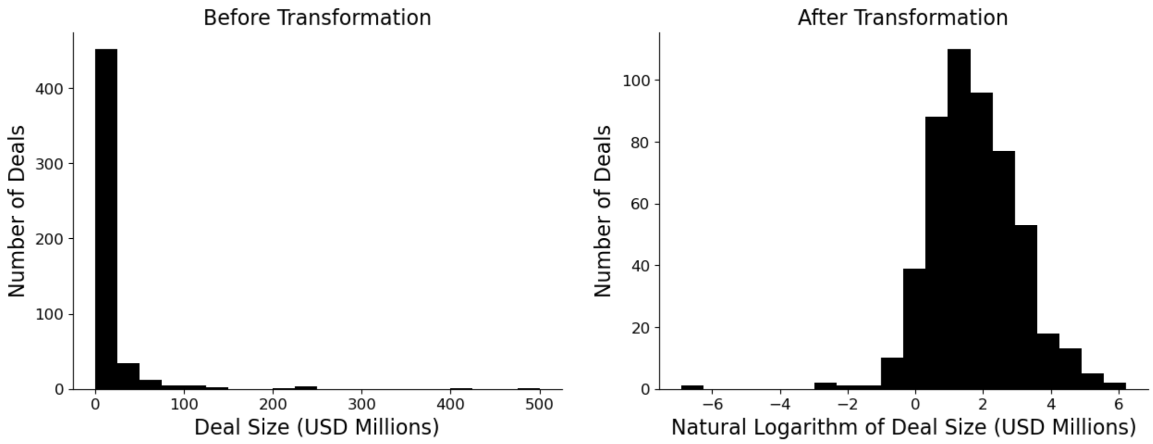
The industry in which a startup operates could also largely determine the deal size or attention a startup can acquire. Therefore, the models deployed in this paper aim to account for this by including an additional variable that controls for an AI startup's industry. The figure outlines how most of the AI startups fall under the Technology & Innovation cluster, followed by Healthcare & Pharmaceuticals, which correspond to the technology's most prominent application areas.

Figure 3: Venture capital deals in German AI firms, by industry cluster



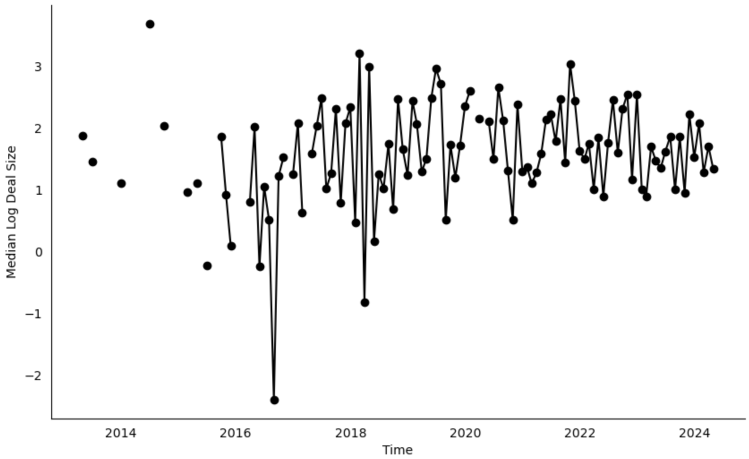
The size of a venture capital deal can range greatly, however, as explained and illustrated Figure 1, it is known that the most popular deals are those in the earlier stages of a startup's development and smaller in funding amount. The histogram on the left hand side in Figure 4 verifies this; the distribution of deal sizes heavily exhibits a positive skewness. In order to deploy many of the models used in this analysis, the data must assume a normal distribution. Therefore, applying the natural logarithm to each deal size aims to approximate a normal distribution, the result of which is found on the right hand side of Figure 4.

Figure 4: Normalizing the distribution of deal sizes



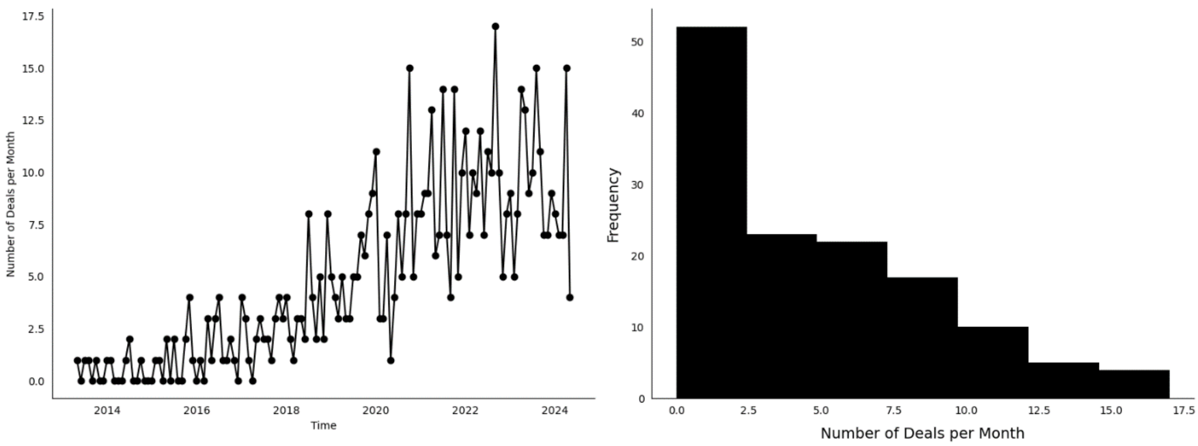
To give an overview of what the following studies will entail, Figure 5 below outlines the median deal size investing in German AI companies over time. The figure shows that the median investment size in German AI companies fluctuates greatly over time, with a slight upward trend from 2016 onwards. However, the size of a deal can be influenced by several factors, which is why the models in Studies 1 and 2 aim to isolate the effects that ChatGPT may have on deal sizes.

Figure 5: Median deal investment sizes in German AI companies over time



Deals were also aggregated by month in order to see the investment rate, which will be formally tested in Study 3. The graph on the left in Figure 6 below suggests that the number of deals per month has been increasing from 2017 onwards until 2023. It is important to note that data on recent deals (2024) is likely incomplete due to time lags between a deal's finalization and its addition to the Preqin dataset; this may explain the sudden drop in the most recent month. The graph on the right in Figure 6 visualizes the distribution of deal counts by month, displaying a positive skewness in the data, with most months only having two to five deals investing in a German AI company.

Figure 6: Number of investments in German AI firms per month, over time & by frequency



Study 1: Baseline Models

3.1. Motivation & Model Specifications

An initial set of models, in the form of ordinary least squares (OLS) regressions, will serve as a baseline for the rest of the study. Its purpose is not to draw causal inferences, but to assist in answering the research question by testing for a relationship, if any, between the release date of ChatGPT and the average size of a deal investing in a German AI company. The dependent variable used will be the natural logarithm of a deal size in millions of USD, and the primary independent variable will be a binary indicator denoting whether ChatGPT was released at the time of the deal's finalization. Naturally, the log-linear model will leverage several control variables, detailed in Appendix 3. These control variables below, outlined in equations (2) and (3), include a series of dummy variables that account for the location of the investor, the funding round of the deal and the industry of the AI startup.

$$Ln(Deal\ Size)_i = \alpha + \beta_1 * ChatGPT_i + \beta_2 * Date_i + \varepsilon_i \quad (1)$$

$$Ln(Deal\ Size)_i = \alpha + \beta_1 * ChatGPT_i + \beta_2 * Date_i + \beta_3 * France_i + \beta_4 * Germany_i + \\ + \beta_5 * EU25_i + \beta_5 * US_i + \varepsilon_i \quad (2)$$

$$Ln(Deal\ Size)_i = \alpha + \beta_1 * ChatGPT_i + \beta_2 * Date_i + \beta_3 * France_i + \beta_4 * Germany_i + \\ \beta_5 * EU25_i + \beta_5 * US_i + \beta_6 * Series\ A_i + \beta_7 * Series\ B_i + \beta_8 * Series\ C\ plus_i + \beta_9 * \\ Unspecified\ Round_i + \beta_{10} * Financial_i + \beta_{11} * Healthcare_i + \beta_{12} * Technology_i + \varepsilon_i \quad (3)$$

3.2. Results

Looking at column (1) of the log-linear OLS model, the release of ChatGPT has a significantly negative effect on the average deal size of German AI companies. This suggests that, when controlling for time, VC deal sizes in German AI firms have, on average, decreased by 60% after the release of ChatGPT. However, there are several other factors that affect the size of a VC deal that are not accounted for in the baseline model (1).

Table 2: OLS Regression Coefficient Table on the Deal Size of German AI Companies

	Baseline (1)	(1) + Investor Location (2)	(2) + Stage, and Industry (3)
Constant	-241.34***	-205.63***	-243.33***
	(65.72)	(61.41)	(50.45)
ChatGPT	-0.60***	-0.50***	-0.22*
	(0.17)	(0.16)	(0.13)
Date	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Investor Country			
France		0.19***	0.27*
		(0.19)	(0.16)
Germany		-0.15	-0.21**
		(0.12)	(0.10)
European Union 25		0.30***	0.12**
		(0.07)	(0.06)
United States		0.93***	0.42***
		(0.12)	(0.10)
Deal Stage			
Series A			1.26***
			(0.11)
Series B			2.13***
			(0.15)
Series C+			2.61***
			(0.20)
Unspecified Round			0.30**
			(0.12)
Industry			
Financial &			0.46**
Professional Services			(0.21)
Healthcare			-0.18
			(0.19)
Technology &			0.05
Innovation			(0.14)
R-squared	0.02	0.17	0.47
Observations	635	635	635

Dependent variable: LnDealSizeUSD. Note: Standard errors in parentheses. Stars indicate significance: * p<0.1 ** p<0.05 *** p<0.01. Reference categories are as follows: Investor Country = "Other", Deal Stage = "Seed", Industry = "Other". Deals only involve German AI firms.

Model (2) found in column (2) of Table 2 adds a set of control variables that account for the country where the venture capitalist (investor) is headquartered in. Adding these control variables changed the ChatGPT coefficient from -0.60 to -0.50, further isolating the effect the effect of ChatGPT on the average deal size.

The final OLS model (3) in the final column of Table 2 controls for not only the date and investor location, but also the stage of the deal and the target firm's (startup's) industry. In all three models, the date of the deal's finalization has had a significant and positive effect on the deal size, suggesting that the size of a deal investing in German AI companies has marginally increased every day, on average, since 2013. Moreover, ChatGPT's coefficient has increased from -0.50 to -0.22. This suggests that the emergence of ChatGPT is associated with a significant 22% decreased in the average deal size of investments in German AI firms, conditional on time effects. The control variables in model (3) show that the location of the investor and, unsurprisingly, the deal stage, impacts the size of the deal as all control variables were found to be significant at least in the 10% level. The impact of the startup's industry on deal size has had mixed results. Whilst the deal size of German AI firms falling under the financial and professional services cluster appear to be, on average, 46% higher than other sectors, the deal size of German AI startups under the healthcare and technology & innovation cluster do not appear to differ significantly compared to other sectors.

3.3. Assumptions & Limitations to the Models

The OLS models presented in Table 2 do appear to have satisfied the normality assumption (seen in Figure 4), however, the OLS model (1) contained a highly negatively biased ChatGPT coefficient. This is evidenced by the coefficient increasing toward zero after more controls were added in models (2) and (3). However, even the final OLS model (3) does not control for all factors that affect both the release of ChatGPT and the size of an investment in German AI firms. Therefore, endogeneity persists in the final OLS model as well due to omitted variable bias. Although the control variables found in Table 2's models partially correct for this bias, the model still cannot draw casual inference. Moreover, measurement error could further bias the results. This is because the variable ChatGPT indicates 1 if the date of the deal's finalization is after the release of ChatGPT (November 30, 2022), however, venture capital deals take place over several months. As a result, several deals in November/December of 2022 likely were not influenced by the release of ChatGPT as the deal was initialized months prior to the release of the disruptive technology.

Study 2: Difference-in-Differences

4.1. Motivation & Model Specifications

The purpose of this research is to investigate if the emergence of GAI (proxied by ChatGPT's release) has affected venture capital investment decisions in Germany. Therefore, Study 2 expands on the OLS models in Study 1 by not only analyzing the effects that ChatGPT has on the deals investing in German AI companies, but non-AI companies in Germany as well. A Difference-in-Differences (DiD) design renders itself suitable for such a framework as this study will explore whether two groups (AI vs. non-AI companies in Germany) were affected differently by the emergence of GAI.

This study introduces a control group into the sample (Described in Appendix 4) composed of deals investing in non-AI companies in Germany over the same time period as the sample of German AI companies in Study 1 (which serve as the treatment group). By doing so, the model can isolate the impact that GAI has on AI companies given the effects that GAI may have on non-AI companies, which was not accounted for in the first OLS models. Another advantage that DiD models have over OLS models are that they can be used to get closer to causality rather than association. This is because control groups found in DiD models can serve as a counterfactual, assuming that the control and treatment groups have parallel trends before the intervention.

The first DiD model found in equation (4) includes a new binary variable indicating if a company is directly involved in AI (the treatment group) or not (the control group). Moreover, an interaction term between AI Company and ChatGPT was included to see if the emergence of GAI affected the deal sizes of German AI companies differently compared to non-AI companies. Moreover, the second DiD model in equation (5) expands on equation (4) by adding the same control variables found in Study 1 that account for multiple time-invariant factors such as the investor's location, the deal round as well as the target company's industry.

$$Ln(Deal\ Size)_i = \alpha + \beta_1 * ChatGPT_i + \beta_2 * AI\ Company_i + \beta_3 * AI\ Company \times ChatGPT_i + \beta_4 * Date_i + \varepsilon_i \quad (4)$$

$$Ln(Deal\ Size)_i = \alpha + \beta_1 * ChatGPT_i + \beta_2 * AI\ Company_i + \beta_3 * AI\ Company \times ChatGPT_i + \beta_4 * Date_i + \beta_5 * France_i + \beta_6 * Germany_i + \beta_7 * EU25_i + \beta_8 * US_i + \beta_9 * Series\ A_i + \beta_{10} * Series\ B_i + \beta_{11} * Series\ C\ plus_i + \beta_{12} * Unspecified\ Round_i + \beta_{13} * Financial_i + \beta_{14} * Healthcare_i + \beta_{15} * Technology_i + \varepsilon_i \quad (5)$$

4.2. Results

The baseline DiD model (4) in Table 3 below found the coefficient of ChatGPT to be significant and negative, suggesting that the venture capital deal sizes have decreased on average by 52% after the release of ChatGPT. The model's significant and negative AI Company coefficient suggests that venture capital investments in German AI companies are 61% lower than German non-AI companies. However, the statistically insignificant interaction term between the AI Company and ChatGPT coefficients found that there was insufficient evidence to conclude that the deal sizes of German AI companies were affected any differently than non-AI companies.

Model (5) found in Table 3 includes control variables that account for the investor's location, deal stage, and the target firm's industry on top of the date which was included for in Model (4); controlling for these factors, the effects of ChatGPT's introduction on the deal size changed from -52% to -34%, indicating that Model (4)'s ChatGPT coefficient was negatively biased. Model (4)'s AI Company coefficient appears to also be negatively biased as the coefficient increased from -0.61 in Model (4) to -0.13 in Model (5), suggesting that the deal sizes investing in AI companies are 13% lower than non-AI companies. Nonetheless, Model (5) did not find a significant coefficient to accompany the interaction term between AI Company and ChatGPT, suggesting that the deal sizes of AI companies in Germany were not affected differently than non-AI companies in Germany.

Table 3: Difference-in-Differences Coefficient Table on the Deal Size of German Companies

	Baseline DiD Model (4)	**(4) + Controls (5)**
Constant	-246.54***	-297.79***
	(13.54)	(10.27)
ChatGPT	-0.52***	-0.34***
	(0.05)	(0.04)
AI Company	-0.61***	-0.13**
	(0.08)	(0.07)
AI Company * ChatGPT	0.12	0.09
	(0.16)	(0.12)
Date	0.00***	0.00***
	(0.00)	(0.00)
Investor Country		
France		0.09
		(0.07)
Germany		-0.27***
		(0.03)
European Union 25		-0.10***
		(0.04)
United States		0.25***
		(0.04)

Deal Stage		
Series A		1.12***
		(0.31)
Series B		1.92***
		(0.37)
Series C+		2.82***
		(0.04)
Unspecified Round		0.46***
		(0.04)
Industry		
Financial & Professional Services		0.13***
		(0.04)
Healthcare		-0.15***
		(0.04)
Technology & Innovation		-0.17***
		(0.03)
R-squared	0.04	0.47
Observations	8,946	8,775

Dependent variable: LnDealSizeUSD. Note: Standard Errors in parentheses. Stars indicate significance: * p<0.1 ** p<0.05 *** p<0.01. Reference categories are as follows: Investor Country = "Other", Deal Stage = "Seed", Industry = "Other". Deals only involve German firms. Difference in observations between the models due to certain deals not disclosing the target firm's industry.

4.3. Threats to Causality

The main threat to the casual interpretation of the DiD models is that the parallel trends assumption does not hold. This assumption states that the deal sizes of AI companies and non-AI companies in Germany would have changed the same way, had the release of ChatGPT not taken place. However, it is very likely that AI companies and non-AI companies have several observable & unobservable differences that aren't controlled for in the DiD models above. Because of this, the control group used in the models do not represent a suitable counterfactual for AI companies, meaning that the DiD models cannot draw casual inference regarding ChatGPT's effect on the investments in German AI companies. Moreover, the treatment in Table 3's models is set to ChatGPT's exact release date which is problematic because VC deals typically take months to fully materialize; meaning that the sharp threshold may not be best suited for this use case. Additionally, other interventions that could have impacted the average deal size investing in a German AI company were not controlled for in these DiD models. For example, the EU's AI Act (European Commission, 2024) could significantly affect the average deal size in the same observed time that the DiD model operates in. The effects of such interventions could be inadvertently captured in the ChatGPT and AI coefficients, rendering them as biased estimators. These threats alone severely limit the validity of the DiD models' findings.

Study 3: Poisson Regression

5.1. Motivation & Model Specifications

Studies 1 and 2 analyze changes in the VC landscape investing in AI firms by testing for differences in the average deal size, however, another way to evaluate changes in the VC investment activity can be achieved by testing for differences in the investment rate**.** The next set of models leverage a Poisson regression model.

Such models differ from the standard OLS and DiD models as a Poisson distribution is especially useful for count data (Cox & Vladescu, 2023). Applying the Poisson regression model in equation (6) below would aid in answering whether the probability of observing *n* venture capital deals in German AI startups in a given month has changed after the release of ChatGPT. In other words, this model will test whether there has been a change in the number of deals per month in German AI startups after ChatGPT's release. Figure 6 suggests an upward trend in the investment rate in recent years, however, the Poisson regression model will aim to quantify such changes.

$$Deal\ Count_t = \alpha + \beta_1 * ChatGPT_t + \varepsilon_i \quad (6)$$

5.2. Results

Model (6) in Table 4 below suggests that the release of ChatGPT did significantly affect the rate of investment deals in German AI companies. This is evidenced by the statistically significant ($\alpha < 0.01$) coefficient of ChatGPT. To interpret the 0.62 coefficient, the figure must be exponentialized and converted into a percentage (Elhai et al., 2008), found in the equation below. This suggests that the expected number of deals per month investing in German AI firms have increased by 86.8% after the release of ChatGPT.

$$e^{0.6249} \approx 1.868 \Rightarrow +86.8$$

Table 4: Poisson Regression Coefficient Table of German AI Firm Deal Count

	Model on AI firm investments (6)	Robustness check: model on non-AI firm Investments (7)
Constant	1.60***	3.61***
	(0.05)	(0.02)
ChatGPT	0.62***	1.17***
	(0.09)	(0.02)
Pseudo R-squared	0.21	0.54
Observations	113	136

Dependent variable: DealCount (Number of deals per month). Note: Deals only involve German AI firms.

Standard Errors in parentheses. Stars indicate significance: * p<0.1 ** p<0.05 *** p<0.01.

5.3. Assumptions & Limitations to the Model

Regarding the Poisson regression, the count data's distribution required for such a regression is characterized by a positive skew, which is satisfied as seen on Figure 6. However, the data's mean deal count (5.62) does not equal the variance deal count (16.40): a critical assumption that has not been satisfied. Additionally, Model (6) in its current state only controls for time-varying factors, rendering the time-variant factors omitted since variables such as the investor country, deal stage and industry can no longer be used in the model. This is because single data points are no longer on a deal-level basis, but on a monthly basis instead. This explains the low pseudo R-squared of 0.21, suggesting that the Poisson regression model explains only 21% of the variation in the monthly deal count. Finally, the robustness check found in Model (7) of Table 4 found not only a significant coefficient, but a larger one compared to Model (6), which suggests that the investment rate in non-AI firms increased more than AI firms after ChatGPT's release. Therefore, the discrepancy between the mean and variance deal count, coupled with the lack of time-invariant control variables and counter-intuitive findings of the robustness check, significantly reduces the models' power.

Discussion & Future Research

6.1. Discussion & Implications

The two main findings from these studies are that (1) there is partial evidence that the investment rate in German AI companies have increased, supporting H_1 , and that (2) the average size of an investment in German companies has decreased after the release of ChatGPT, rejecting H_2 , with AI companies being affected no differently than non-AI companies.

Study 3 finds evidence that the monthly investments rate in AI startups have increased by 62%, supported by the Poisson Regression Model (6) in Table 4. Regardless of the model's power and lack of controls, this finding suggests that the VC landscape is flexible and responsive enough to allow such a quick influx of investments in German AI companies. This can be furthered by fostering more of an innovation culture for German startups, achieved by increasing their access to external funding through investing in the main startup hubs in Berlin and Munich, ultimately promoting collaboration and knowledge flows between startups and prospective founders.

Investors may perceive the AI market as more saturated and consequentially become more cautious in their investments in AI firms, evidenced by Study 1 and 2 which suggest that the average investment sizes in German firms decreased 34% after the release of ChatGPT. This decrease in the average investment size, combined with finding (1) showing evidence for an increased investment rate in AI firms, suggests that investors have shifted their risk-attitudes towards risk-aversion, representing the opposite effect H_2 had outlined. This behavior is characterized by spreading smaller investments in size across a wider range in firms.

Another explanation for such a phenomenon is that the previously mentioned inflow of new startups could have led to increased investments in younger firms, naturally decreasing the average investment size, *ceteris paribus*; this is because more AI firms are on the earlier stages of development and ask for lower funding amounts.

Model (5) found that the deal sizes of AI firms were affected by ChatGPT's release no differently than non-AI firms, this could be due to the increased uncertainty regarding the AI space and its growth potential. This is because the release of generative AI has set a new benchmark for the broader technology which investors may not be fully equipped to evaluate at this point in time, further supporting the notion that investors have become more risk averse.

Moreover, Studies 1 and 2 found that investments from German investors have, on average, lower deal sizes whilst deals other countries such as the US invest significantly higher sums of money. This represents the disparity in local versus foreign investor composition, in which the smaller (Seed) investments appear to be supported by local (German) investors whilst foreign investors are only willing to invest in the larger, more developed, AI companies. Policymakers can close this gap by providing incentives for foreign investors to not only invest in Germany's developed AI companies, but also to support its new wave of young AI startups.

Comparing the findings from these studies to the status quo established by Tricot (2021), who investigated AI's venture capital landscape in a pre-ChatGPT environment, highlights the disruptive effect that the technology had on VC investments. Tricot (2021) found that in the EU, deals investing in AI firms have been increasing over time, suggesting that the industry is maturing. While Studies 1 and 2 still support this notion, evidenced by the significant and positive Date coefficient in each OLS and DiD model, the studies also find the average deal size in AI firms are still significantly lower than non-AI firms (Model 5 in Table 3), implying that there is room for growth in the AI industry relative to other, more developed, ones.

6.2. Future Research

There are several ways in which the internal and external validity of the studies can be improved upon for future research. As the main limitation of each model is the lack of confounding variables, finding a more expansive dataset with more control variables can be the first way for the research to be conducted in the future. Moreover, finding a suitable control group for the DiD model would be the most effective way of drawing casual inference and building upon the findings of Study 2.

These pilot studies can not only be improved in their internal validity, but also in the range of factors which are investigated. For instance, these characteristics such as the average deal size or the number of deals could be analyzed on a state-level basis within Germany or, conversely, across other EU countries. Moreover, with Germany being an EU member, it is naturally affected by the EU's own AI Act which was not looked at in this paper.

This study can be built upon by connecting these findings with other areas of Germany's AI sector, particularly it's innovation output. By examining the correlation between Germany's AI patents/publications or startup inception rates and its venture capital landscape, a more holistic understanding of the country's AI sector would be achieved.

Conclusion

Overall, the emergence of ChatGPT's generative capabilities has affected the venture capital landscape within Germany. With a significant 62% increase in the average monthly investment rate in German AI firms after the disruptive technology's release, it is clear that AI has captured the attention of venture capitalists.

ChatGPT's release has also significantly decreased the average deal size investing in German firms by 34%. This is motivated by a redistribution of investor capital towards younger AI firms due to an influx of profit-seeking startups entering the market. The technology has not only put a spotlight on German startups in AI, but Study 3 finds evidence that supports the presence of spillover effects as well: decreasing the average deal size investing in *all types* of German firms by the same percentage after the release of the technology, making AI and non-AI firms identically affected.

The combination of the two findings above suggests that investors have adopted a risk-averse strategy when it comes to investing in AI, investing more in terms of volume (investment rate) but less in terms of magnitude per investment (investment size) due to the increased uncertainty that ChatGPT has instilled in investors.

As highlighted by the McKinsey Global Institute, there is a current "rush to throw money at all things generative AI" (Chui et al., 2023), however, the studies conducted in this paper show that investors are more cautious about what they throw their money at now than before OpenAI's technology was first released.

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Appendix 1: Startup industry clusters.

Industry of the startup identified in Preqin	Allocated Cluster
Financial Services	Financial & Professional Services
Business Support Services	Financial & Professional Services
Outsourcing	Financial & Professional Services
Marketing/Advertising	Financial & Professional Services
Insurance	Financial & Professional Services
Healthcare IT	Healthcare & Pharmaceuticals
Medical Devices & Equipment	Healthcare & Pharmaceuticals
Biotechnology	Healthcare & Pharmaceuticals
Healthcare	Healthcare & Pharmaceuticals
Pharmaceuticals	Healthcare & Pharmaceuticals
Healthcare Specialists	Healthcare & Pharmaceuticals
Software	Technology & Innovation
IT Infrastructure	Technology & Innovation
IT Security/Cybersecurity	Technology & Innovation
Internet	Technology & Innovation
Electronics	Technology & Innovation
Hardware	Technology & Innovation
Semiconductors	Technology & Innovation
Information Services	Technology & Innovation
Aerospace	Other
Power & Utilities	Other
Industrial Machinery	Other
Media	Other
Education/Training	Other
Environmental Services	Other
Automobiles, Other Vehicles & Parts	Other
Energy Storage & Batteries	Other
Real Estate Development & Operating Companies	Other
Heating, Cooling & Ventilation Equipment and Services	Other
Renewable Energy	Other
Materials	Other
Construction	Other
Travel & Leisure	Other
Agribusiness	Other
Food	Other
Packaging	Other
Consumer Products	Other
Logistics & Distribution	Other
Retail	Other
Consumer Services	Other
NaN	Other

Appendix 2: VC Deal Stage Category Conversion

Preqin Deal Stage Label	Median Deal Size (USD Millions)	Newly Allocated Stage Label
Unspecified Round	2.32	Unspecified Round
Angel	0.69	Seed
Grant	1.69	Seed
Seed	2.45	Seed
Venture Debt	5	Seed
Series A	8.285	Series A
Growth Capital/Expansion	18.24	Series B
Series B	21.86	Series B
PIPE	33.945	Series B
Series C	41	Series C+
Series D	114.04	Series C+
Series F	175	Series C+
Series G	176.47	Series C+
Series E	363.5	Series C+

Appendix 3: Description of control variables used in models.

Control Variable	Description
AI Company	A binary indicator denoting 1 if the target company is directly involved in artificial intelligence (Used only in Study 2)
Date	The date in which the deal is fully finalized
France	A binary indicator denoting 1 if the venture capitalist (investor) is headquartered in France
Germany	A binary indicator denoting 1 if the venture capitalist (investor) is headquartered in Germany
EU25	A binary indicator denoting 1 if the venture capitalist (investor) is headquartered in any EU country besides Germany & France
US	A binary indicator denoting 1 if the venture capitalist (investor) is headquartered in the United States
Series A/B/C plus	A binary indicator denoting 1 if the deal stage is classified under the respective round
Unspecified Round	A binary indicator denoting 1 if the deal stage was not disclosed in the data
Financial & Professional	A binary indicator denoting 1 if the startup's industry falls under the financial/professional services industry
Healthcare	A binary indicator denoting 1 if the startup's industry falls under the healthcare industry
Technology	A binary indicator denoting 1 if the startup's industry falls under the technology & innovation industry

Appendix 4: Control Group Data Cleaning

For Study 2, a control group was added in hopes of constructing a counterfactual in a set of Difference-in-Differences models. This control group included venture capital deals investing in non-AI companies headquartered in Germany, extracted from the same database Preqin and same time period as the sample of German AI companies used in Study 1 and 3.

The data cleaning method for the control group was identical to the method found in Section 2.1.. Deals that disclosed their deal size, were finalized (not abandoned or rejected) and invested in non-AI startups headquartered in Germany were included in this control group of 8,632 deals.