

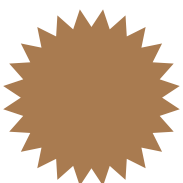


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Success of university inventions

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SUMMARY

Success of patented university inventions

The study investigates three questions on the success of patented university inventions in Germany. How successful are patented university inventions from a business perspective? How successful are patented university inventions from a societal perspective? What would be suitable measures to increase the success of patented university inventions?

To discuss the success from a business perspective, this study covers the number of patented university inventions, their profitability for universities as well as the effect of patents on third party funding and reputation. From 2002–2013, an average 2,300 patents based on university inventions were filed in Germany, which corresponds to 5.2% of all patents filed by German applicants. About one third of these patents were filed by universities (university patents) and about two thirds by other institutions like industrial companies (corporate academic patents). From 2010–2013, the number of patents filed by universities declined, as universities are trying to reduce their patenting costs. Analyses on the profitability of university patents show that in most cases the revenues generated by universities are significantly lower than the costs of patenting. However, discussions with university patenting executives indicate that many of them are not fully aware of this situation. Also, the fact that the share of university patents sold to companies – which is often less profitable than granting licenses – increased from 2002–2013 is rather surprising from a perspective of efficient use of public resources. Another positive effect of patented university inventions from a business perspective is their assumed effect on the acquisition of third party funding. The study cannot prove this effect on a quantitative level. However, the rationales described by several experts interviewed seem reasonable and serve as an argument for the success of patented university inventions.

To discuss the success of patented university inventions from a societal perspective, patent indicators based on bibliographic patent data and the effect of patents on the job market are analyzed. The analyses of patent indicators show that patented university inventions contribute significantly to technological advancement, as they receive on average more forward citations, are more general, and more radical compared to patents in general. An initial estimate of university patents on the job market shows that about 1,800 jobs are linked to university patents. Even though a direct link between these jobs and university patents cannot be proven, the number serves as an initial indication of the impact university patents have on the job market.

Combining the insights from a business and societal perspective, the use of public resources for the patenting of university inventions is a contentious topic, but seems to be reasonable. In order to increase the future success of patented university inventions, the study discusses improvement measures at the level of politics and university patenting institutions. At the politics level, additional performance indicators should be used to evaluate and manage patenting activities. Also, realistic expectations on the commercial success of university patents should be set and university patent executives should be enabled to make decisions based on a beneficial long-term perspective. At the level of university patenting institutions, decision criteria on when to patent university inventions should be adapted, also taking into account the societal effect of patenting university inventions. A promising lever to improve the commercial success of such patents would be to intensify collaboration among different university patent agencies. Additional measures could include clearly delineating the responsibilities of internal university patent bureaus and external patenting agencies as well as driving programs to increase awareness for protecting intellectual property at universities.

ARTICLE

Success of university inventions

A. Introduction and motivation

The present study investigates three questions on the success of patented university inventions in Germany. How successful are patented university inventions from a business perspective? How successful are patented university inventions from a societal perspective? What would be suitable measures to increase the success of patented university inventions?

Technology transfer of university inventions is one of the main tasks of universities next to research and education.¹ As many experts think that in most cases only patent protected university inventions will be successfully transferred to companies², the patenting of university inventions is a crucial topic for technology transfer.

In order to support the patenting of university inventions the German employee invention law (ArbnErfG) was modified in 2002. After the reformation of the law universities are able to file patents based on the inventions of their employees and exploit the patent rights. Also several public funded support programs were initiated and university patent agencies (Patentverwertungsagenturen) were established after 2002.³ As role model for a successful concept of university patenting, academic authors and other experts often refer to the Bayh-Dole Act in the USA.⁴ Since the Bayh-Dole Act in 1980, US universities were able to patent inventions of their research staff. This led to an increase of patents filed by US universities from 394 in 1980 to 4,797 in 2012.⁵ Revenues generated by US universities out of patent exploitation increased from about USD 100 mn in 1991 to USD 2.6 bn in 2013.⁶

In Germany the patenting of university inventions is largely financed by public funds and so it is of great interest from the perspective of universities, the government, and also tax payers to assess the success of patented university inventions.

¹ See § 2 (7) Hochschulrahmengesetz (HRG).

² Quote from an expert report of multiple research institutes to the German Federal Ministry of Education and Research: „in der Regel sind Forschungsergebnisse und Erfindungen aus öffentlichen FuE-Einrichtungen nur über den Weg der Patentierung in die Wirtschaft transferierbar“ Bundesministerium für Bildung und Forschung (1996), p 28.

³ See Kraßer (2002), p 2 f.

⁴ See Hülsbeck (2011), p 25.

⁵ See United States Patent and Trademark Office (2015). The values published in the annual report of the Association of University Technology Managers (AUTM) are approximately 7 % higher than the values published by USPTO. As the deviation is not relevant for the present study the reasons for the deviation are not further analyzed.

⁶ For data on 1980 see Hoeren (2005), p 132, for data on 2013 see Flanigan (2014), p 18.

The present study contributes to academic literature by providing so far non-existing insights on the success of patented university inventions from both a business but also societal perspective. Based on these insights suitable measures to increase the success are described. The target audience of this study consists of researches in the area of university technology transfer, executives from university patenting institutions, and responsible persons in politics for university policy and technology transfer.

B. Existing research and contribution of the present study

Existing research regarding the success of patented university inventions only addresses parts of relevant questions for the topic. In the following, an overview of the existing relevant literature is shown and it is described how the present study contributes to the academic literature in the respective areas:

- I. Parameters of university invention patenting
- II. Success from a business perspective
- III. Success from societal perspective
- IV. Measures to increase the success of patented university inventions
- V. Further topics regarding technology transfer in Germany and other countries

I. Parameters of university invention patenting

Existing research on parameters of university invention patenting covers legal, structural, and further topics of patenting of university inventions in Germany.

Literature on legal topics especially focusses on the impact of the ArbNErfG reform as well as proposals for changing the law in the future.⁷ Structural topics include the organizational setup of university patenting institutions, success of the execution of state funded support programs, and the creation of university spin-offs related to patented university inventions.⁸ Further areas of relevant research include the necessity to strengthen awareness for intellectual property rights among university researchers and the motivation of researchers to file patents.⁹ The insights of the present study contribute to the existing literature by suggesting approaches to further improve the parameters

⁷ See Bergmann (2006); Fuhrland & Weber (2011), p 92 f.; Hausberg et al. (2001); Hochschulrektorenkonferenz (1997), p 6; Hoeren (2005); Kraßer (2002); Roessler (2012), p 22 f.

⁸ See Bagdassarov (2012); Becher (1996); Blind et al. (2009); Bundesministerium für Bildung und Forschung (2004); European Commission (2013); Harhoff (2014); Hemer et al. (2006); Hemer et al. (2010); Kesting (2012); Kulicke et al. (2014); Prognos (2010); Prognos & Boehmert and Boehmert (2010).

⁹ See Erdmann (2008); Geuna & Nesta (2006); Hoeren (2005); Hülsbeck (2011); Kulicke et al. (2014), p 92 ff. and 137 f.; Schibany et al. (2008).

for patented university inventions both on the level of politics and university patenting institutions.

II. Success from a business perspective

Studies on the success from a business perspective assess the number of filed patents based on university inventions¹⁰, revenue of universities from patent exploitation¹¹, the impact of patents on university third party funding¹², and the impact on the reputation of universities¹³.

Regarding the number of filed patents from university inventions, various publications with different results do exist.¹⁴ The main reason for the differences of the results are different methods for identifying the respective patents as well as different data sets used.¹⁵ A comprehensive overview about the existing findings is not available. The present study contributes to the academic literature by providing an overview about the magnitude of available patents from university inventions in Germany.

The amount of existing research on the revenue of universities from patent exploitation is surprisingly small. Most existing research relates to activities linked to the “SIGNO” program - a German state funded initiative to support patenting of university inventions.¹⁶ However publications only assess the revenues generated and do not provide a full picture of profitability including the costs related to the patenting of university inventions. The present study contributes to academic literature in comparing the revenues and costs related to the patenting of university inventions.

Furthermore insights on the impact of patents on university third party funding are only rarely available in existing academic literature.¹⁷ Authors describe that cause and effect of patents filed by a university and the amount of third party funding acquired can hard-

¹⁰ See European Commission (2013), p 93 ff.; Expertenkommission Forschung und Innovation (2012), p 54 f.; Kulicke et al. (2014), p 64 ff.; Schmoch (2007), p 6.

¹¹ See Kulicke et al. (2014), p 74 ff.; Prognos & Boehmert and Boehmert (2010), p 120 ff.

¹² See Bundesministerium für Bildung und Forschung (2004), p 57; Bundesregierung (2011), p 9; Crespi et al. (2011), p 18; Fahrenberg et al. (2013), p 51; Geuna & Nesta (2006), p 794; Grimpe & Fier (2010), p 9; Gulbrandsen & Smeby (2005), p 944 f.; Hemer et al. (2010), p 25; Henderson et al. (1998), p 122; Hülsbeck (2011), p 25; Kulicke et al. (2014), p 143.

¹³ See Bundesministerium für Bildung und Forschung (2004), p 57; Bundesregierung (2011), p 9; OECD (2003), p 3 Kurzfassung.

¹⁴ See amongst others Dornbusch & Neuhäusler (2015), p 22; DPMA (2007), p 18, (2013), p 89; Projektträger Jülich (2014).

¹⁵ Also described in Glauber et al. (2014b), p 3.

¹⁶ See Kulicke et al. (2014); Prognos & Boehmert and Boehmert (2010). According to an expert interviewed, approximately 80% of exploited patented university inventions are covered by the SIGNO data.

¹⁷ See amongst others Bundesministerium für Bildung und Forschung (2004), p 57; Bundesregierung (2011), p 9; Crespi et al. (2011), p 18; Fahrenberg et al. (2013), p 51; Geuna & Nesta (2006), p 794; Grimpe & Fier (2010), p 9; Gulbrandsen & Smeby (2005), p 944 f.; Hemer et al. (2010), p 25; Henderson et al. (1998), p 122; Hülsbeck (2011), p 25; Kulicke et al. (2014), p 143.

ly be distinguished.¹⁸ In order to enrich the existing academic insights the present study summarizes findings from relevant publications and synthesizes insights from expert interviews.

III. Success from societal perspective

Most existing research on the success from a societal perspective focusses on analyzing “quality” indicators of patents based on university inventions.¹⁹ Further dimensions of societal impact are mentioned by several authors but are not discussed on an in-depth level.²⁰

The most established way in academic research to assess patent “quality” is to analyze indicators based on bibliographic data like citations to other patents, lifespan of the patent protection, and size of the patent family.²¹ Analyses of this bibliographic data allow deriving insights on the technological importance of patents.²² Most existing research on patent indicators of university inventions focusses on patents from universities outside of Germany.²³ The present study contributes to academic literature by analyzing patent indicators for university inventions from German universities. The study also analyzes patent indicators that are relevant for assessing the societal impact of patents but are not used in existing research of patented university inventions so far, including inventions from international universities.

Existing research on the societal impact other than based on patent indicators is relatively rare. Authors mention the positive societal effect related to the creation of new jobs, increased taxes through the adoption of new technologies by companies, and technologies that would not be available without university patenting.²⁴ However the societal effect is not quantified in the existing literature so far.²⁵ The present study contributes to

¹⁸ See Geuna & Nesta (2006), p 794; Henderson et al. (1998), p 122.

¹⁹ See Czarnitzki et al. (2011b); Hall & Harhoff (2012); Hall et al. (2005); Harhoff et al. (1999); Harhoff et al. (2003); Mowery & Ziedonis (2002).

²⁰ See Cuntz et al. (2012), p 6; Ledebur (2006), p 269; Carlsson & Fridh (2002), p 201 f.; Mazzoleni (2006).

²¹ See Czarnitzki et al. (2011b); Hall & Harhoff (2012); Hall et al. (2005); Harhoff et al. (1999); Harhoff et al. (2003); Mowery & Ziedonis (2002).

²² For describing the technological importance of patents authors often use the expressions „importance“ (Hall et al. (2005), p 19; Hülsbeck (2011), p 26; Mowery & Ziedonis (2002), p 405), „quality“ (Mowery & Ziedonis (2002), p 399 ff.), „value“ (Hall et al. (2005), p 19; Harhoff et al. (2003), p 1343 ff.; Lissoni & Montobbio (2015), p 145), „social value“ (Czarnitzki et al. (2011b), p 763), „private value“ (Czarnitzki et al. (2011b), p 763), „value of innovations“ (Trajtenberg (1990), p 172) „technological importance“ (Czarnitzki et al. (2011b), p 763), as well as the German expressions „Wichtigkeit“ (Hülsbeck (2011), p 26) and „ökonomischer Wert“ (Hülsbeck (2011), p 64). In the present study these expressions are summarized as „technological importance“.

²³ For example on the patent indicator of generality no relevant publications covering German patents based on university inventions are known. For international examples see Henderson et al. (1998), p 123; Hülsbeck (2011), p 26; Lissoni & Montobbio (2015), p 161.

²⁴ See Carlsson & Fridh (2002), p 201 f.; Cuntz et al. (2012), p 6; Ledebur (2006), p 269; Mazzoleni (2006), p 3 f.

²⁵ See Kulicke et al. (2014), p 8 Kurzfassung.

the academic literature by providing a first rough assessment of the number of jobs in companies related to the usage of patents filed by universities.

IV. Measures to increase the success of patented university inventions

Potential measures to increase the success of patented university inventions are mainly described in expert reports assessing the impact of state funded support programs²⁶ as well as academic literature on technology transfer²⁷. The present study contributes to the existing literature by providing additional insights derived from expert interviews both from a business but also societal perspective.

V. Further topics regarding technology transfer in Germany and other countries

Besides the publications described above relevant literature for the present study includes research on technology transfer in general²⁸, success of state funded support programs²⁹, and the necessity to file patents for technology transfer³⁰.

C. Research methods and data sources

In order to assess the success of patented university inventions qualitative and quantitative research methods are used. Qualitative Methods used include the integrative literature review³¹, 28 semi-structured experts interviews³², and the empirical-qualitative exploration³³. As quantitative method, the empirical-quantitative exploration³⁴ is used to analyze and describe data indicating the success of patented university inventions. Data sources for the quantitative analyzes include quarterly results reported within the SI-GNO-program³⁵, the OECD-patent database with patent indicators based on

²⁶ See Bundesministerium für Bildung und Forschung (2004), p 70 ff.; Harhoff (2014), p 62 ff.; Kulicke et al. (2014), p 255 ff.; Prognos & Boehmert and Boehmert (2010), p 159 ff.

²⁷ See Bagdassarov (2012), p 37 ff.; Hülsbeck (2011).

²⁸ See Crespi et al. (2006), p 3 ff.; European Commission (1995), (2007), (2013), p 5; Grimpe & Fier (2010); Hülsbeck (2011), p 1 f.

²⁹ See Harhoff (2014); Kulicke et al. (2014), p 49 ff.; Prognos & Boehmert and Boehmert (2010).

³⁰ See Crespi et al. (2006), p 24; Hellmann (2007); Mazzoleni (2006); Murray & Stern (2007).

³¹ See Cooper (1982), p 4.

³² See Bortz & Döring (2003), p 238 f. and p 386. Interview partners include executives from university patenting agencies, university inventors, academic researchers in the area of university patenting, representatives from politics, patent lawyers and additional experts on technology transfers.

³³ See Bortz & Döring (2003), p 386.

³⁴ See Bortz & Döring (2003), p 373.

³⁵ See Projektträger Jülich (2014).

bibliographic data³⁶, detailed data on patent exploitation from two selected universities³⁷, detailed data on patent exploitation from the Max Planck Society³⁸ as well as data from previously published expert reports and studies³⁹.

D. Findings on the success from a business perspective

To discuss the success from a business perspective, the present study covers the number of patented university inventions, their profitability for universities, as well as the effect of patents on third party funding and reputation of universities.

From 2002–2013, an average of 2,300 patents based on university inventions were filed in Germany, which corresponds to 5.2% of all patents filed by German applicants.⁴⁰ About one third of these patents were filed by universities (university patents) and about two thirds by other institutions like industrial companies (corporate academic patents). However, the number of patents filed by universities has been declining since 2010.⁴¹ According to experts interviewed, one explanation for the decline are the aspirations of some university patent agencies in recent years to reduce their costs in order to meet expectations on their financial performance in the short term.

An analysis of data on the profitability of university patents between 2002–2013 shows that the implied costs for patenting university inventions exceed the revenues generated through patent exploitation in most cases. For about one third of filed university patents licensing or similar technology transfer agreements with companies are closed. About two thirds of university patents are not used by companies and so do not generate any revenues for the universities.⁴² On average, revenues of approximately EUR 6,800 are generated per filed university patent.⁴³ This amount is significantly lower than the average amount necessary to cover the implied patenting costs (EUR 43,000 per patent⁴⁴).

Furthermore, the analysis of detailed revenue data from two selected universities shows that for 84% of patents filed the generated revenues are lower than the EUR 43.000 nec-

³⁶ See OECD (2014a). January 2014 version of the database.

³⁷ The universities requested to not publish their names.

³⁸ See Max-Planck-Innovation (2014).

³⁹ See Centrum für Hochschulentwicklung CHE (2014); Dornbusch & Neuhäusler (2015), p 11 ff.; Glauber et al. (2014a); Harhoff (2014); Kulicke et al. (2014).

⁴⁰ Based on data provided by Dornbusch & Neuhäusler (2015), p 22; DPMA (2007), p 18, (2013), p 89; Projektträger Jülich (2014).

⁴¹ See Dornbusch & Neuhäusler (2015), p 22.

⁴² Based on data provided by Projektträger Jülich (2014).

⁴³ Based on data provided by Projektträger Jülich (2014).

⁴⁴ See Fleuchaus & Braitmayer (2002), p 655. $42.857 \text{ EUR} = 30.000 \text{ EUR} / (1 - 0,3 \text{ compensation for employees})$. The value of EUR 30,000 does not include any costs and besides the costs of filing and maintaining patent protection. For example personell costs of employees from university patenting institutions are not included. A detailed definition of the closts included in the value of EUR 30,000 is not available in the original source mentioned in the publication.

essary to reach break-even.⁴⁵ Surprisingly, discussions with university patenting executives indicate that many of them are not fully aware of the fact that there is a significant gap between generated revenues and implied costs. However, when assessing the profitability of these patents it needs to be considered that for many patents licensing agreements are still ongoing and may lead to additional revenue in the coming years.

Another key finding of the present study is that the share of patents sold by universities increased from 6% in 2002 to 56% in 2013.⁴⁶ This fact is surprising as – according to the experts interviewed – patents exploited through licensing agreements generally generate higher revenues over their lifetime compared to patents sold. According to the experts interviewed, the main reason for this trend is the ambition of university patenting agencies to optimize their short term financial performance by preferring one-time revenues from sales compared to recurring (and in total higher) revenues from licensing agreements.

Besides generated revenues, another positive effect of patented university inventions from a business perspective is more successful third party university funding.⁴⁷ The present study cannot prove this effect on a quantitative level. However, experts interviewed validated that patents filed by a university are perceived as signal that the university's researchers are able to successfully develop technologies with business potential. Nevertheless, it can be questioned whether the filing of a patent by a university is required in order to achieve the positive reputation effect. The effect could also be generated by transferring the intellectual property rights to companies and let them file the patent. In this case, no patenting costs for the universities would occur.

E. Findings on the success from a societal perspective

To discuss the success of patented university inventions from a societal perspective, patent indicators based on bibliographic patent data and the effect of patents on the job market are analyzed.

An assessment of patent indicators based on bibliographic data shows that patents based on university inventions generally receive a higher number of forward citations and have higher values for indexes on generality and radicality.⁴⁸ The high values on the number of forward citations and generality indicate the high importance for future patents. High values for the index on radicality indicate that patented university inventions

⁴⁵ The universities requested to not publish their names.

⁴⁶ Based on data provided by Projektträger Jülich (2014).

⁴⁷ See amongst others Bundesministerium für Bildung und Forschung (2004), p 57; Bundesregierung (2011), p 9; Carlsson & Fridh (2002), p 4; Crespi et al. (2011), p 18; Fahrenberg et al. (2013), p 51; Geuna & Nesta (2006), p 794; Grimpe & Fier (2010), p 9; Gulbrandsen & Smeby (2005), p 944 f.; Hemer et al. (2010), p 25; Henderson et al. (1998), p 122; Hülsbeck (2011), p 25; Kulicke et al. (2014), p 143.

⁴⁸ Based on data provided by OECD (2014b).

are often especially new for the technology area compared to other patents.⁴⁹ These findings indicate that patents based on university inventions have a higher technological importance compared to patents in general.

Given the very high technological importance of patents based on university inventions and assuming that university inventions often do not make their way into companies without patent protection⁵⁰, the filing of patents by universities could be reasonable also if the patent exploitation is not profitable from a business perspective.

In order to assess the effects on the job market the study provides a rough estimate of the number of jobs linked to university patents. The calculation of the number of jobs is based on expert estimates concerning the revenues generated by companies using university patents and the average number of employees per revenue. This initial estimate shows that about 1,800 jobs are linked to university patents. Even though a direct link between these jobs and university patents cannot be proven, the number serves as an initial indication of the impact university patents have on the job market – an insight for discussion that is very relevant from a societal point of view but not yet available in academic literature.

F. Measures to increase the success

Combining the insights from a business and societal perspective, the use of public resources for the patenting of university inventions is a contentious topic, but seems to be reasonable. In order to increase the future success of patented university inventions improvement measures at the level of politics and university patenting institutions should be performed.

At the politics level, additional performance indicators should be used to evaluate and manage patenting activities. Financial performance indicators should include the share of patents generating at least as much revenue to cover the implied costs for patenting. Also a reporting of the financial success of patents in different technology areas would make sense in order to decide on focus technology areas for university patenting. Besides financial indicators, also non-financial indicators should be used for decision making on politics level. For example, the number of jobs created or the number of products related to patented university inventions. In addition, initiatives should be started at the politics level that foster the collaboration between different university patent institutions. This could allow a more effective usage of existing knowledge and

⁴⁹ See Squicciarini et al. (2013), p 53.

⁵⁰ Quote from an expert report of multiple research institutes to the German Federal Ministry of Education and Research: „in der Regel sind Forschungsergebnisse und Erfindungen aus öffentlichen FuE-Einrichtungen nur über den Weg der Patentierung in die Wirtschaft transferierbar“ Bundesministerium für Bildung und Forschung (1996), p 28.

networks. Additionally best practice processes should be shared between patenting institutions, e.g., for assessing the market potential of university inventions.

When assessing the performance of university patent institutions realistic expectations on the commercial success of university patents should be set by representatives from politics. In addition, managers of university patent institutions should be able to make decisions based on a beneficial long-term perspective instead of optimizing short-term financial performance. This issue could be addressed by providing a long-term funding guarantee for existing university patent institutions.

At the level of university patenting institutions, decision criteria on when to patent university inventions should be adapted, also taking into account the societal effect of patenting university inventions. Additional criteria for the decision could include an assessment if patent protection is necessary in order to transfer the technology to companies or if a spin-off based on the technology is planned.

A promising lever to improve the commercial success of patented university inventions would be to intensify collaboration among different university patent institutions. Additional measures could include clearly delineating the responsibilities of internal university patent bureaus and external patenting agencies as well as driving programs to increase awareness for protecting intellectual property at universities.

G. Limitations of work

When discussing the findings of this study limitations regarding the data sources and methods used should be considered.

Concerning the data sources used, limitations include the correctness and comprehensiveness of the databases. Especially insights on revenues generated by patented university inventions based on data provided by SIGNO rely on the available data quality. However, an expert interviewed estimates that 80% of existing university patents are covered by SIGNO data and the source provides the most accurate data available. Regarding the insights from patent indicators based on bibliographic data it should be noted that the analyses are based on a subset of patented university inventions as a comprehensive list of such patents is not available.

Limitations on the methods include especially that many insights are based on expert interviews conducted in the course of the study. The correctness and objectiveness of the information provided by the experts interviewed could be questioned. Also for some of the information provided by experts no quantitative proof of the facts is available. In

order to reduce the effect of potential incorrect information interviews with experts from different organizations (in total 28 interviews) were performed and insights were validated with quantitative facts wherever possible.

H. Areas for further research

Further studies in the area of patented university inventions should focus on further quantifying the success from a business but also societal perspective. Especially research on the success in different areas of technology would enhance the available knowledge and support decision making in politics, at universities, and at university patenting agencies. Also, an even more detailed analysis of the implied costs for university patenting would increase transparency on the actual cost-benefit of university patenting.

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