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Patenting and the Gender Gap: Should Women Be Encouraged to Patent More?

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Abstract The commercialization of academic science has come to be understood as economically desirable for institutions, individual researchers, and the public. Not surprisingly, commercial activity, particularly that which results from patenting, appears to be producing changes in the standards used to evaluate scientists' performance and contributions. In this context, concerns about a gender gap in patenting activity have arisen and some have argued for the need to encourage women to seek more patents. They believe that because academic advancement is mainly dependent on productivity (Stuart and Ding in American Journal of Sociology 112:97–144, 2006; Azoulay et al. in Journal of Economic Behavior & Organization 63:599–623, 2007), differences in research output have the power to negatively impact women's careers. Moreover, in the case of patenting activity, they claim that the gender gap also has the potential to negatively affect society. This is so because scientific and technological advancement and innovation play a crucial role in contemporary societies. Thus, women's more limited involvement in the commercialization of science and technology can also be detrimental to innovation itself. Nevertheless, calls to encourage women to patent on grounds that such activity is likely to play a significant role in the betterment of both women's careers and society seem to be based on two problematic assumptions: (1) that the methods to determine women's productivity in patenting activities are an appropriate way to measure their research efforts and the impact of their work, and (2) that patenting, particularly in academia, benefits society. The purpose of this paper is to call into question these two assumptions.

Keywords Gender-gap · Patenting · Commercialization of science

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Introduction

Over the past four decades there has been a significant transformation in the culture and practice of science. Increasing relationships between industry and universities, a growing salience of intellectual property rights, and modifications in both institutional and individual expectations about the reward system and the meaning of public science constitute some of those changes (Kleinman and Vallas 2001; Owen-Smith and Powell 2003; Rhoten and Powell 2007; Vallas and Kleinman 2007, Colyvas and Powell 2007). Of particular significance to the reconfiguration of academic science was the passing of the Bayh-Dole Act of 1980 (Sampat 2006; Mowery and Ziedonis 2002; Colyvas and Powell 2007; Rhoten and Powell 2007; Berman 2008). Bayh-Dole created a uniform federal patent policy that allowed universities to retain property rights to any patents resulting from federally funded research and to license these patents on an exclusive or non-exclusive basis. It thus encouraged universities and individual researchers to patent and commercialize inventions that resulted from public funding. The new law led academic institutions to set-up technology transfer offices, triggered the creation of start-up companies, and promoted private funding for clinical studies. Indeed, when Congress passed the Bayh-Dole Act in 1980, universities generated fewer than 250 patents annually, about 25 universities engaged in technology transfer, and ties between industry and academic researchers were relatively uncommon (Henderson et al. 1998; Brody 2006; Fabrizio 2007; Sterckx 2011; Sampat 2006). The number of US patents obtained by universities increased almost 16-fold between 1980 and 2004 (Sterckx 2011). About 300 technology transfer offices exist today, nearly a tenfold increase from before the enactment of the law, and more than 4,500 for-profit firms have appeared as a result of patents made under Bayh-Dole (Loewenberg 2009).

Due, at least in part, to the influence of the Bayh-Dole act (Mowery and Ziedonis 2002; Sampat 2006; Colyvas and Powell 2007; Berman 2008), the commercialization of academic science has come to be understood as economically desirable for institutions, individual researchers, and the public (Kieff 2001; Loise and Stevens 2010; Schnittker and Karandinos 2010; Smith and MacFadyen 2010; Seltzer et al. 2010; Zycher et al. 2010), and is encouraged by governmental agencies such as the NIH (Hamburg and Collins 2010). Not surprisingly, commercial activity, particularly that which results from patenting, appears to be producing changes in the standards used to evaluate scientists' performance and contributions (Whittington and Smith-Doerr 2008; Ding et al. 2006; Slaughter and Rhoades 2004; Whittington and Smith-Doerr 2005).

In this context, concerns about a gender gap in patenting activity have arisen (McMillan 2009; Ding et al. 2006; Rosser 2009; Sidhu et al. 2009; Stephan and El-Ganainy 2007). The fear is that differences in research output have the power to negatively affect women's careers, be detrimental to innovation itself (Rosser 2009), and reduce the sorts of innovations that are produced (Rosser 2009). Society is thus adversely impacted. Given these concerns, some have argued for the need to encourage women to seek more patents (Rosser 2009; Murray and Graham 2007; Whittington and Smith-Doerr 2008).

Nevertheless, calls to encourage women to patent on grounds that such activity is likely to play a significant role in the betterment of both women's careers and the good of the community seem to be based on two problematic assumptions: (1) that the methods to determine women's productivity in patenting activities are an appropriate way to measure their research efforts and the impact of their work, and (2) that patenting, particularly in academia, benefits society. The purpose of this paper is to call into question these two assumptions. Although the patenting gender gap appears to exist both in industry and in academia, the focus of this paper will be on academic research.

The Gender-Gap in Patenting Activities

In the last four decades, the presence of women in science, technology, engineering and mathematics (STEM) fields has increased significantly. In the US today, for instance, half of all MD degrees and 52% of PhDs in life sciences are awarded to women, as are 57% of PhDs in social sciences (Ceci and Williams 2011). In other science and engineering fields; however, women's share of doctorates is lower. In mathematics and statistics and the physical sciences, for instance, women receive 27% of PhDs, and only 18% of engineering doctorates are awarded to women (NSF 2007). Moreover, women's share of full-time tenured or tenure-track faculty positions in science and technology has increased slowly from just under 10% in 1979 to 28% in 2006 (Burrelli 2008). In the US, women hold only 19% of full professorships and are more likely to be assistant and associate professors (Burrelli 2008). In the European Union, the proportion of women among full professors in STEM fields is only 11% (European Commission 2009). Also, while there has been an increase in women's participation in professional associations and editorial boards, women's representation is still seriously lacking in a variety of specialties (Morton and Sonnad 2007; Jagsi et al. 2008; Robinson et al. 2010; European Commission 2009; Butcher 2011). Similarly, the rate of advancement of women into positions of leadership in academic medicine is slower than would be predicted by their numbers in medicine and the sciences for the past decades (Carnes et al. 2008; Zhuge et al. 2011; Reed et al. 2011; European Commission 2009).

Awareness of gender disparities in the scientific and technological professions has also called attention to gender differences on research productivity. Studies suggest that such productivity, which has most often been measured as counts of refereed journal articles, is, on average, greater for male researchers than for their female colleagues (Braisher et al. 2005; Jagsi et al. 2006; Kelly and Jennions 2006; Symonds et al. 2006; Schrager et al. 2011; Sidhu et al. 2009). Recently, indicators of commercial activity related to technology transfer and patenting are increasingly being used to evaluate scientists' productivity and contributions (Whittington and Smith-Doerr 2008; Ding et al. 2006; Slaughter and Rhoades 2004; Whittington and Smith-Doerr 2005). And here also, recent studies have found that, even when the gender gap is declining, male scientists have higher patent counts through their careers than female scientists (Whittington and Smith-Doerr 2005; Whittington and Smith-Doerr 2008; Ding et al. 2006; Stephan and El-Ganainy 2007; McMillan 2009; Frietsch et al. 2009). For instance, in a study of 4,227 scientists who had at least 5 years of post-graduate publishing experience in academic institutions, only 5.65%

of women held patents, but 13% of male scientists did. Additionally, the 431 males who had patented accumulated a total of 1,286 patents, while the 51 women patenters produced only 91 patents (Ding et al. 2006). Similarly, others have found that in academia, the percentage of men involved in patenting is more than double the percentage of women (Whittington and Smith-Doerr 2005). In another study aimed at evaluating how the organization of scientists' work settings may influence enduring disparities between men and women in science, the authors found that academic women's predicted probability of patenting is 43% that of men (Whittington and Smith-Doerr 2008).

Assessment of scientists' research output is essential for making decisions on recruitment, tenure and promotion, and on awards and honors considerations. Measuring the number of articles, citations, and now patents is a common practice to evaluate researchers' productivity. Hence, women's limited involvement in patenting can have adverse consequences for their careers and reputations.

But more is at stake than women's careers when patenting activities by women are limited; it can also be detrimental to society. Patent rights allow returns from research and investment, and thus many argue that such rights are needed in order to enhance the development and application of science. Patents are thought to be good for the community as they promote new scientific and technological applications and serve as catalysts for economic growth (Kieff 2001; Loise and Stevens 2010; Schnittker and Karandinos 2010; Seltzer et al. 2010; Smith and MacFadyen 2010; Zycher et al. 2010). Thus, women's limited role in commercial activities such as patenting could be detrimental to innovation and economic activity. Additionally, some evidence suggests that men and women tend to focus on different types of scientific and technological advances. For instance, some studies have shown that patents obtained by women often involve technologies related to reproduction, children, and the home (Macdonald 1992; Thimmesh and Sweet 2000). If it is the case that women would focus on different research and development projects than men typically do, then a reduced participation of women in patenting might also limit the sorts of questions addressed and the types of innovations that are produced (Rosser 2009).

Solving the Gender-Gap: Encouraging Women to Patent?

Because of the presumed detrimental consequences that women's lack of participation in patenting activities can have for their careers and for the common good, some have argued that it is important to encourage women to patent more (Rosser 2009; Murray and Graham 2007; Whittington and Smith-Doerr 2008). In order to do so, it would be necessary to determine barriers that prevent or discourage women from patenting and to propose and enact mechanisms that will be likely to overcome those barriers (Stephan and El-Ganainy 2007; Murray and Graham 2007; Hunter and Leahey 2010; Leahey 2006).

However, although removing obstacles to women's advancement is clearly a worthy and necessary goal, it is not clear that encouraging women to increase their participation in patenting can improve women's careers or contribute to the good of the community. The belief that more patenting by women can accomplish these aims is grounded on two problematic assumptions: (1) that the methods to determine women's productivity in patenting activities are an appropriate way to measure their research efforts and the impact of their work, and (2) that patenting in academia benefits society. In what follows I call into question these two assumptions.

Measuring Women's Productivity

The majority of studies that have found differences in productivity between men and women assess the number of articles published or the number of patent applications (Kaufman and Chevan 2011; Fox 2005; Sidhu et al. 2009; Frietsch et al. 2009; Jagsi et al. 2006; Whittington and Smith-Doerr 2005; Prpic 2002; Heckenberg and Druml 2010). But, although calculating productivity as the number of articles or patents applications might be an easy task, it is clear that this measure indicates nothing about the quality of the articles or the patents (Loscalzo 2011; Ding et al. 2006). Indeed, particularly in the case of patenting activity, patent counts as a proxy for innovation or knowledge development are a severely limited measure because of the very large variance in the significance or value of individual patents (Hall et al. 2005).

Quantifying the quality of scientific research has proven to be a complicated undertaking and one that appears to be far from gender neutral. Hence, some evidence suggests that simply measuring quantity of articles, and now patents, might not be an adequate way to measure the impact of scientists' work and that it might in fact disadvantage women (Ding et al. 2006; Long 1992; Whittington and Smith-Doerr 2005; Symonds et al. 2006; McMillan 2009). For instance, in some of the studies that have been conducted to assess a gender gap in publishing productivity, a few of them have evaluated not only quantity of publications but have also used some measure of quality—e.g. number of citations or journal impact factor (Ding et al. 2006; Murray and Graham 2007; Long 1992; Symonds et al. 2006; Penas and Willett 2006). These more complex studies have found that although women tend to have both a lower total publication count, and a lower publication count per year, their papers are more substantive and they are cited similarly or even more frequently than papers by male scientists who publish more papers. Furthermore, some studies have found that the gender gap in average journal impact factor actually favors women (Ding et al. 2006; Symonds et al. 2006). Thus, at least some studies point to the fact that in spite of the different rates in publication, there is no evidence that women do less important work based on standard measures of scientific impact.

But if assessing the impact of scientists' publications is a complex activity, more so is to evaluate that of patenting activities (Hall et al. 2005). Clearly, as in the case of publishing, the number of patents tells us nothing about their relevance, quality, or impact. It is important to remember that the main motivation for encouraging scientists to patent is that this type of commercial activity presumably promotes and facilitates innovation and can lead to economic activity and other public benefits. Because the trend to commercialize research and to use patenting activity as a measure for academic productivity and promotion is relatively recent, fewer studies have been conducted assessing gender differences in patenting activity. But, as in the case of publishing, the studies that have been conducted suggest that, when focusing exclusively on the number of patents, there is a gender gap. However, when more complex factors, such as the generality and originality of the patents are assessed, for instance, studies have found that there are no substantial differences between men and women (Whittington and Smith-Doerr 2005; McMillan 2009). Furthermore, although as has been noted, women patent less than men do, some studies have shown that patent citations are similar for men and women (Whittington and Smith-Doerr 2005) and that women's patents are valued more highly than those of men or those resulting from joint work between men and women (McMillan 2009). Additionally, according to some studies, in spite of the gender gap in the number of patents, the work that is commercialized by women appears to be more applicable to a wider variety of technological fields (Whittington and Smith-Doerr 2005).

Notice that this is not an argument that women's work in science is better than men's. This is an argument that calls into question the gender neutrality of standard ways of measuring scientific productivity and that points out that these standard measures actually disadvantage women. If one cares to measure aspects other than quantity, one might find that no gender gap exists in women's patenting activities. Equally important, the argument calls attention to what is presumably significant about patenting scientific work. That is, the success of patents in promoting innovation, advancing economic activity, and ultimately contributing to improving the common good. It is difficult to see why simply counting patents should be thought of as an appropriate measure of significance. And if it is not, then we have no reasons to view the fact that there is a gender gap in patent counts as problematic.[1]

Moreover, encouraging women to be more active in their patenting activities might actually harm rather than help their careers. After all, structural factors that are beyond women's control might prevent then from being as productive, in a purely quantitative sense, as men. Indeed, if evidence from publishing productivity is any indication, although the gender gap in this aspect has been narrowed in the last four decades, it has proven difficult to eliminate (Jagsi et al. 2006).

It seems then that if we are concerned with women's ability to receive appropriate recognition for their work, then it might be more appropriate to encourage academic institutions to measure the impact of scientists in more nuanced ways. Factors other than publication record and number of patents, such as teaching, mentorship, collaboration, or participation in activities essential to academia, should be adequately valued. Furthermore, as mentioned earlier, when evaluating patenting activities, it is important to take into account what the goals of such activities are. Innovation and other public benefits are aims of those activities, but it is not clear that patents are either necessary or sufficient to achieve such goals (Rafferty 2008; Sampat 2010; Mowery and Ziedonis 2002). If so, then it is important to assess the effect of women's scientific work on innovation and the community rather than

[1] Of course, to the extent that number of patents is used to evaluate scientists' careers, this would be a matter of concern. But it seems that the appropriate response in this case would be to eliminate this criterion rather than to simply accept it and encourage women to patent more.

simply focusing on evaluating patent numbers. Relevant aspects that we would do well in evaluating include whether gender differences exist in types of patents, the impact of those patents, the effect of women's work on patent applications even if they are not the patent holders, and the contribution of women's work to research, development, and public health improvement independently of patenting activities.

Benefits to Society

A second problematic assumption that also grounds calls for women to increase their patenting activities is that our current patent system is necessary to encourage new discoveries and promote investment in science and technology (Kieff 2001; Loise and Stevens 2010; Siepmann 2004), both activities that contribute to society. Presumably, patent rights allow returns from research and investment and thus are needed in order to enhance the development and application of science. Patents thus benefit the community because they promote new scientific and technological applications and serve as catalysts for economic growth. Persuading women to patent then is thus thought to contribute to these goals. Moreover, if as mentioned earlier, men and women tend to focus on different types of scientific and technological advances, encouraging women's participation in patenting will presumably expand the sorts of innovations that are produced (Rosser 2009).

However, whether patents in academia do indeed serve to promote innovation, contribute to economic growth, and ultimately benefit society is not completely clear. And this is so for a variety of reasons. First, some evidence suggests that patenting and licensing activities may increase secrecy and thus may operate to delay access to new knowledge rather than as a mechanism that encourages sharing and distribution of new knowledge. For instance, some studies have shown that patenting activities among scientists are likely to result in publication delays, withholding of data at scientific meetings, and in hindering the sharing of research results with other researchers (Blumenthal et al. 2006; Campbell and Bendavid 2003; Grushcow 2004; Murray and Stern 2007; Penin 2010; Nelson 2004). Data withholding can affect the rate of discovery in negative ways, deter productive relationships between scientists, and might hamper the quality of education of new scientists. Moreover, more and more patents are being filed not only for downstream products but also increasingly for research tools (Geiger and Sá 2008; Holman 2006). These upstream research tools can serve as discovery instruments in a variety of research projects or they can cover fundamental biological processes—such as particular signaling pathways for instance (Garber 2006). Secrecy in these cases can result in a restricted access to such research tools and thus stifle scientific knowledge and technological innovation (Sterckx 2011; Holman 2006).

Second, upstream patenting activities can also give rise to what has been called the "tragedy of the anticommons," where a variety of owners each have a right to exclude others from a patented product (Heller and Eisenberg 1998). Hence, if researchers want access to multiple patented products in order to create a single downstream product, e.g. a diagnostic test, they must obtain the agreement of all the upstream patent owners in order to proceed with the project. Such "patent thickets" increase the risk that agreements will fail or that transaction costs will become too high, hence effectively creating an underuse of resources that can slow the pace of downstream biomedical innovation (Heller and Eisenberg 1998; Rai 1999; Sterckx 2011; Holman 2006; Van Overwalle 2010; Gold et al. 2010).

Third, patenting activities could have significant effects on the academic research agenda, as research funding and efforts might emphasize commercial research areas over scientific disciplines and questions less likely to result in patentable technologies (Geuna 2001). Although the evidence on the relationship between commercial interests, such as those that result from patenting activities, and shifts in the research agenda is ambiguous, some studies have called attention to changes in the research orientation of individual academic researchers who engage in patenting activities (Krimsky 2003; Brody 2007). Researchers who engage in patenting seem to be more likely to move the direction of their research toward questions and research areas of commercial interest and value (Fabrizio and Di Minin 2008; Larsen 2011; Azoulay et al. 2007; Jensen and Webster 2011).

If this is so, it might be that patenting activities could have a serious effect on the types of medical interventions that are likely to be produced by skewing biomedical research toward products that yield high profits rather than to global priority health needs in both developed and developing countries (Angell 2004). For instance, although malaria, pneumonia, diarrhea, and tuberculosis account for 21% of the global disease burden, they receive only 0.31% of all public and private funds devoted to heath research (Currat et al. 2004). We lack medicines and vaccines for some of the most common infections affecting the world's one billion poorest people (Bethony et al. 2011; Cohen et al. 2010; Hotez and Brown 2009). Indeed, even in industrialized nations there is a considerable scarcity of needed drugs. For instance, many common infections are now associated with high levels of drug resistance (Noskin et al. 2007), and nonetheless, development of new antimicrobials has not been forthcoming (Kresse et al. 2007; Hamad 2010). The expenses to develop these drugs are considerable, they are used for very short periods, and unlike other types of drugs, antimicrobials quickly become obsolete because their use leads to greater resistance (Kresse et al. 2007). Moreover, in the context of the belief that patents result in significant financial rewards, scientists might discard, or fail to develop, cheaper and harder to patent or unpatentable treatment and diagnostic methods. Indeed, for many diseases, the problem is not only one of scarcity of adequate medicines but also a lack of adequate research into prevention strategies (Colagiuri et al. 2006). For instance, tobacco and alcohol use, unhealthful diets, and lack of physical activity constitute key risk factors for chronic diseases such as cardiovascular disease cancer, diabetes, and lung diseases that are the largest cause of death in the world (Yach et al. 2004). Research on patentable drugs or medical treatments is unlikely to do much to help a significant portion of the population affected by these diseases.

A fourth factor that calls into question the benefit of patenting activities to the community is related to the effect that such activities might have on the objectivity of scientific research. Patenting activities contribute to conflicts of interests for both individual researchers and institutions (Krimsky 2003; Brody 2007; Angell 2000). As mentioned earlier, since the early 1980s academic patenting and licensing activities in biomedical and engineering fields have significantly increased.

Although there is disagreement about whether Bayh-Dole has truly fostered new discoveries, increased university profits, contributed to bringing more biomedical products to the market, or brought benefit to patients (Geiger and Sá 2008; So et al. 2008; Blumenthal et al. 2006; Gold et al. 2010), there is little doubt that the commercial activities encouraged by the Bayh-Dole Act have created conflicts of interests for both individual researchers and institutions.

One of the most problematic effects of such conflicts is their ability to bring bias into the scientific research enterprise. Financial interests have the potential to bias a variety of scientific judgments from those related to the framing of research questions, to the choice of methodology and the interpretation of data, to the appropriate time to report data and publish scientific research (de Melo-Martin and Intemann 2009). Although the evidence about the effect of patents on the objectivity of scientific research is scarce (Mayer 2006), evidence exists of the impact on research of other commercial activities that also contribute to researchers' and institutional conflict of interest. For instance, a variety of studies have found that research receiving funding from commercial parties is significantly more likely to report positive outcomes than studies funded by not-for-profit organizations (Nkansah et al. 2009; Khan et al. 2008; Sismondo 2008; Ridker and Torres 2006; Bhandari et al. 2004). Obviously biased research is problematic for a variety of reasons including its lack of contribution to knowledge, the negative effects on the public's health, possible harms to the authority of science, and the threat to undermining public trust.

Finally, patenting activities might have negative effects on academic values such as openness, disinterestedness, and concern for the common good (Sterckx 2011). Of course, collaborations between universities and industry are not new, and neither is the fact of research sponsorship by governments, industries, or charities (Mirowski and Sent 2002; Rasmussen 2002; Kleinman 2003). Nonetheless, the current emphasis on the commercialization of scientific research raises legitimate concerns that traditional academic values might be seriously threatened. Even if it is the case that science has always had economic and political dependencies, it might be that the particular dependencies that are now being promoted might have profound impacts on scientific knowledge production (Mirowski 2011; Lave et al. 2010). Clearly, the problems mentioned earlier about restrictions on the dissemination of academic results, conflict of interest, and shifts in the research agenda towards profitable medical interventions to the detriment of public health needs all point out some possible consequences of violations of traditional academic values. But other aspects, such as the increasing separation of the research and teaching missions of the university, with teaching becoming more and more a secondary function (Lave et al. 2010) also call attention to ways in which traditional academic values might be undermined. Similarly, the ideal of knowledge as a common good used to benefit the community is being threatened by the increasing ownership of such knowledge and this threat can have detrimental effects on the role of universities in the critical transmission of knowledge and in education.

Of course, many of the problems just discussed are related to licensing activities rather than to simply the existence of patents. However, although before the Bayh-Dole Act university licensing was often non-exclusive, currently the vast majority of licenses granted under university patents are exclusive (Lemley 2008). Universities have strong incentives to grant exclusive rather than non-exclusive licenses because exclusive licensing royalty rates are almost always higher than non-exclusive rates. Moreover, the companies to which they license their research products often want exclusivity. Also, exclusive licensees often pay the cost of patent prosecution (Lemley 2008). Thus, although the Bayh-Dole Act requires neither that universities patent their research, nor that they do so exclusively, the increased emphasis on commercialization of research, and reductions in public funding for research makes potential negative effects of patenting activities more salient.

Conclusion

Few would deny that academic patenting can generate significant social benefits. However, if the concerns raised here are legitimate, as I believe they are, it seems that trying to reduce the gender gap in patenting by encouraging women to participate in such activities might fail to contribute to improving women's professional lives or to benefit society. As we have seen, using patent numbers as the criterion of evaluation might fail to adequately account for the true impact of women's scientific work. It takes for granted, without adequate assessment of the possible effects on women's lives and careers, the appropriateness of an evaluation criterion to which women must conform rather than encouraging a critical analysis of such a criterion. If my arguments here are correct, then at the least, an interest in women's careers calls for more complex empirical evaluations of their work.

Moreover, exhorting women to patent more presupposes that this activity will contribute to the good of society. Evidence is ambiguous about the benefits that patents might bring to society and a significant number of studies have called attention to the negative effects of patents. It might be that even if it is the case that patents provide an incentive to bring new products to market, alternative mechanisms might provide better incentives. A call for women to patent more might obscure the need to evaluate the role of universities in advancing knowledge and its benefits, the effects of commercialization on scientific research, and the importance of considering alternative solutions. The gender gap in patenting then might be one that needs to be closed not by providing incentives for women to patent more but by developing and encouraging strategies that promote technology development and transfer in ways that support scientific innovation, preserve academic values that are thought worthy, and ultimately contribute to the good of the community.

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