Risk Tradeoff Analysis, Public Opinion and Nuclear Safety: A Spanish Case Study

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The 2011 nuclear accident at Fukushima-Daiichi nuclear power plant opened a heated worldwide debate over nuclear energy. Unfortunately, neither the previous nor current Spanish governments have publicized the evidence used to evaluate the merits of extending the lifespan of Spain’s own Garoña plant. This article uses the Garoña case for a twofold purpose. First, the article analyzes the accountability of Spain’s executive power decisions on potentially catastrophic industrial activities. The paper finds that the lack of appropriate information disclosure duties in Spain may allow the government to abuse its discretion on actions potentially damaging to human health and the environment. In addition, the paper uses risk tradeoff analysis to theorize how the Spanish government made its regulatory decision on Garoña. The analysis suggests that decisions made about Garoña involve a broad array of issues and interests that require a comprehensive, careful balancing of risks. The paper concludes that Spain needs urgent regulatory reform regarding transparency and access to information as well as the adoption of updated risk management theory for its regulation of technology.

Introduction: Fukushima and its Worldwide Reaction

Nuclear energy is generally considered a reliable and safe source of energy (OECD 2010:41). Nuclear power plants have been in operation for many years, and accidents are rare. However, a few catastrophic events in the last...
fifty years have made governments and the world populace aware of the potentially devastating nature of nuclear technology. In each case, human knowledge about nuclear energy was challenged by unexpected events. The 1979 Three Mile Island accident revealed unnoticed operational challenges, the 1986 Chernobyl accident human error in the testing of safety mechanisms, and the 2011 Fukushima incident vulnerabilities to natural disasters.

The nuclear accident at Fukushima-Daiichi nuclear power plant opened a heated debate about nuclear energy. The earthquake and tsunami that hit much of the eastern Japanese coast on March 11, 2011 disabled the plant’s reactor cooling system, which triggered leaks of nuclear radiation (World Nuclear Association 2012). The population thirty kilometers around the plant was evacuated, creating approximately 340,000 “nuclear refugees” (Goodman 2014). Soon after the accident, the Japanese government decided to shut off all its nuclear power plants, sparking speculations about a permanent phasing out of nuclear energy in the country. A few weeks later, German Prime Minister Angela Merkel announced that the German government intended to phase out nuclear energy by 2022 (Dempsey 2012).

In Spain, the debate about the use of nuclear energy took the form of a specific political decision. In the midst of one of the worst financial crises the country has ever experienced, the current government of President Mariano Rajoy had to decide the future of one of Spain’s nuclear facilities: the Garoña nuclear plant. The government had two options: confirm the closing of the 40-year-old Garoña nuclear plant as already determined by former Spanish President Jose Luis Rodriguez Zapatero, or keep the nuclear plant in operation beyond its projected 40-year lifetime, an unprecedented policy measure in Spain.

Zapatero’s decision to close the plant had proved an unpopular decision. In early 2012, unemployment rates in the Castilla y León autonomous area were near 20 percent (EUROSTAT 2014), and Garoña was a significant regional job provider (El Mundo 2014). Therefore, the Rajoy government’s decided to keep the plant open until late 2013, and allow the plant’s owner to apply for a renovation of the plant’s license of operation until 2019 (Boletín Oficial del Estado 2012:47,480). However, this governmental decision became inconsequential when the owner decided not to apply for a new permit, arguing that recent tax reforms had crippled
the plant’s profitability (Boletín Oficial del Estado 2013:51,384). The plant was disconnected from the grid on July 6, 2013. Still, the government has recently announced its intention to enact specifically tailored tax regulations that will allow the Garoña plant to reopen (El País 2013). Unfortunately, neither the previous nor current Spanish governments have made publicly available the information they used to assess Garoña nuclear plant’s future merit.

This article uses the Garoña case to discuss the uncertainties associated with regulatory measures taken on potentially catastrophic industrial activities. First, the paper describes two influential theoretical approaches to risk regulation. Second, the paper provides background on the Garoña nuclear plant and the recent policy decisions taken about its closing. Third, the paper analyzes these decisions following a general framework on Risk Tradeoff Analysis (RTA). The analysis suggests that there is an urgent need for transparency regarding risk-related public policy decisions in Spain. It also highlights the need for a careful balancing of risks on regulations that affect industrial activities with potentially catastrophic consequences.

The Concept of Disaster and Its Links to Regulation

Disaster research is a relatively new discipline. Its origin may be found in the post-World War II studies of social science and anthropology (Dynes 1970). However, disaster research has evolved swiftly, spurred by the ever increasing complexity of technology-related disasters. As the number of risks rises, layers between those risks become more intense, complex and difficult to measure, triggering unexpected and sometimes catastrophic effects. Take the example of the Chlorofluorocarbons (CFCs): the invention of CFCs improved quality of life by providing a safe way to keep our groceries refrigerated, but could destroy Earth’s ozone layer. In a similar example, toxic chemicals used against locust infestations in Africa in the early 21st century had serious negative health effects on humans (Quarantelli et al. 2006:16–17). Implicit in this line of thinking is the argument that technological innovations such as the use of chemicals, genetic engineering, or nuclear power will always have both benefits and drawbacks.

This point of view is consonant with Charles Perrow’s seminal theory of “normal accidents” in complex systems. Perrow’s theory is based on the following idea:
Catastrophes have always been with us. In the distant past, the natural ones easily exceeded the human-made ones. Human-made catastrophes appear to have increased with industrialization as we built devices that could crash, sink, burn, or explode (Perrow 1984:11).

The Chernobyl crisis is a good example of Perrow’s normal accidents theory. The plant’s meltdown occurred while the operators were testing safety protocols (Quarantelli et al. 2006:25). Perrow suggests that we should be cautious about these highly interactive technologies because tightly coupled and complex technologies will lead to failures with disastrous consequences.

From Normal Accidents Theory to Risk-Risk Balance
Avoiding potentially catastrophic technologies has an important caveat: regulations aimed at eliminating the risks associated with any dangerous activity such as nuclear energy can potentially and unexpectedly generate or increase other risks. For example, a global phasing out of nuclear energy could lead to greater reliance on carbon-based energy production, increasing the concentration of Greenhouse Gasses (GHGs) in the atmosphere. Hence, an assessment of the unintended negative consequences of actions taken to reduce risks must be conducted in order to evaluate the most convenient action.

Graham and Wiener developed the risk tradeoff analysis theory (RTA) in the mid-1990s. Instead of scrapping policies or banning the use of technological innovations, the authors proposed an in-depth analysis of each potentially risky regulation or policy (Graham & Wiener 1995:4–6). They identified several “key factors” necessary to evaluating risk-risk tradeoffs. These include: (1) magnitude (probability), (2) degree of population exposure (who or what is affected by the risk, levels of doses, and public perceptions of the risk), (3) certainty (including information sharing), (4) type of adverse outcome, (5) distribution, and (6) timing.

The authors conclude that risk assessment may be greatly improved by the development of “risk-superior . . . technologies and ways of organizing activities.” Graham and Wiener propose to enrich the work of the regulatory process at the bases of these decisions instead of just banning technologies or abandoning regulatory measures that may have positive
outcomes. In the following section, we will consider the analysis of a specific risk tradeoff, the decision of either closing or keeping in operation a Spanish nuclear facility that has reached its projected lifetime.

**Case Study: The Santa María de Garoña Nuclear Plant.**
Spain’s international isolation under General Franco’s regime (1939–1975) significantly limited Spain’s access to energy sources, and constituted a serious hurdle to the nation’s industrialization. This fact led the dictator to seriously consider nuclear energy as an energy alternative (RNE 2010). Thanks to Franco’s gradual alignment with U.S. foreign policy interests, Franco’s regime was invited to join President Eisenhower’s Atoms for Peace program, the first large-scale effort to expand civil use of U.S. nuclear technology (Puig 2005:215). Spain opened its first nuclear plant in 1968. Commissioned in 1971, Santa María de Garoña is currently the oldest and smallest of Spain’s nuclear plants (Segoviano-Monterrubio 2011:35).

Operation permits in Spain have a maximum validity of ten years, and Spanish regulations require that in order to renew a permit, all nuclear plants must conduct an in-depth Periodic Safety Review (Ministry of Energy 2009). Additional requirements are imposed in case the owners of a plant request a permit to continue operating the plant past its designed lifetime (Consejo de Seguridad Nuclear 2009).

A moratorium to the construction of new nuclear plants has been in place in Spain since 1984 (World-Nuclear 2012). In 2009, the owners of the Garoña nuclear plant requested a renewal of its permit of operation for ten more years. At the end of that proposed extension, Garoña would have been in operation for forty-eight years. Also in 2009, the Nuclear Security Council (Consejo de Seguridad Nuclear) issued a report stating that the plant met all necessary requirements and recommended issuing the permit for Garoña while imposing a series of necessary improvements. However, the government granted only a five-year permit, and approved a plan to close Garoña by 2014. After the November 2011 general elections, the new government revisited its decision. The new government decided to allow Garoña to operate until 2019 following the recommendation of the Nuclear Security Council, and is actively supporting the plant’s restart.

Garoña has been at the center of a heated energy policy debate. Interest groups opposed to nuclear energy highlight the potentially catastrophic
consequences of a nuclear accident, particularly after the events of the Fukushima nuclear plant (El Mundo 2011). They also stress health concerns related with the levels of radioactivity emitted to the atmosphere by the normal operation procedures of all nuclear plants as well as environmental concerns related to the treatment, transport, and storage of nuclear wastes. On the other hand, proponents of nuclear energy stress Spain’s dependence on foreign sources of energy, the reliability of nuclear energy compared with renewable sources of energy, and the need to fulfill Spain’s commitment to reduce its GHG emissions by 2020 (Segoviano-Monterrubio 2011:6).1

Public opinion in Spain is against the use of nuclear energy (Centro de Investigaciones Sociologicas 2011:15). The anti-nuclear movement was particularly active during the seventies and eighties, forcing the government to cancel the operation of the already constructed Lemóniz nuclear facility2 (Angulo 1978; Mounfield 1985). A May 2011 poll by the Spanish Sociological Investigations Center (CIS) showed that 64 percent would oppose the construction of new nuclear plants, 52 percent thought that the potential costs of nuclear energy outweighed its benefits, and 1 out of 3 respondents believed that the risks of nuclear energy are underestimated (Centro de Investigaciones Sociologicas 2011:15).

The key factors of a Risk Tradeoff Analysis allow for a brief assessment of the decision to keep the Garoña plant in operation exceeding its projected lifetime, as well as its countervailing risk tradeoffs. Table 1 presents a summary of this assessment. The list is not exclusive, and is included here to help identify possible risk tradeoffs. The target risks column represents potential risks the government might try to avoid by keeping Garoña open. These range from the likelihood of increased unemployment rates in the short-term to the need to reduce GHG emissions. Each target risk is coupled with at least one countervailing risk. The countervailing risks represent the risks that may increase as consequences of taking the target risk-reducing measure.

1. The financial crisis in Spain may have the positive externality of helping Spain to reach its GHG emission reduction goals.
2. The conflict concerning the Lemóniz nuclear plant was much more than the opposition of the civil society to environmental or health risks. The conflict developed in the midst of the difficult Spanish transition to democracy after the death of General Franco, and was used by the Basque separatist movement to publicize their demands. The construction site suffered three terrorist attacks.
As stated previously, the key factors of a Risk Tradeoff Analysis include: (1) magnitude, (2) degree of population exposure, (3) certainty, (4) type of adverse outcome, (5) distribution and (6) timing.

**Magnitude**
Magnitude is the probability of an adverse outcome (Graham & Wiener 1995:30). Perception of magnitude highly depends on the way data are presented. Indeed, recent estimates suggest that, considering the total amount of years of operation of all active nuclear plants, a plant meltdown is only probable once every 20,000 years of reactor operation (Cohen 1990). However, if we just state that there have been three major nuclear accidents reported in the last thirty-five years and that some partial core meltdowns occurred before that (Fermi reactor in 1966, St. Laurent des Eaux A1 in 1969, Browns Ferry plant in 1974) the probability of a catastrophe seems higher.
Size of Population

In case of a nuclear accident, the size of the population affected will greatly depend on the geographical situation of the nuclear plant. The affected population will also depend on the nature of the nuclear failure, the meteorological conditions at the time of the accident, and other factors. Target risks including lifestyle changes and GHG emissions have the potential to affect a much greater number of people, and will only gradually develop over time instead of being concentrated in a catastrophic event.

Certainty in Risk Estimates

The availability of the data necessary to assess completely different kinds of risks may greatly distort the execution of an accurate RTA. The FCC case is a clear example of this situation. At the time CFC’s started to be commercialized, they were considered a non-toxic, non-reactive compound that could be widely used as a household refrigerant. At that time, the damaging effects of CFC’s on the ozone layer were unresearched.

In the Garoña case, expert groups may be able to accurately assess the ageing of the structures and the security of the building that contains the nuclear reactor. Even when quantitative data are not available or very limited, subjective technical judgments may also be obtained from experts. However, these assessments usually fail to take into account all possible effects of a policy measure. The assessment of Spain’s nuclear facilities’ vulnerability to terrorist attacks exemplifies this problem. In Spain, the assessment of national security implications of nuclear energy is in the hands of the National Center for Critical Infrastructure Protection (Centro Nacional para la Protección de Infraestructuras Críticas) created in 2007. In 2011, the WikiLeaks affair revealed that although the Spanish Government had conducted security assessments of its nuclear facilities in the aftermath of the 2004 Madrid terrorist bombings, U.S. government officials were worried about the overall security of Spanish nuclear facilities (Wikileaks 2009). These fears were confirmed when Greenpeace activists managed to breach the perimeter of Spanish nuclear facilities in 2007 and again in 2011. Had these actions been taken by terrorist cells instead of peaceful protesters, the consequences for national security could have been tragic.
Type of Adverse Outcome
Countervailing risks will often be different in character from target risks. Building on the national security example, actions taken to reduce the risk of suffering a terrorist attack may increase the chances of suffering civil and human rights violations. In this regard, human perceptions of risk may greatly influence decision-making since “[S]ome risks are felt to be controllable and voluntarily assumed, while others seem uncontrollable by the individual” (Graham & Wiener 1995:32).

Distributional Considerations
Which sector of the population will suffer the effects of the risk? Are there any “environmental justice” concerns? In the case of nuclear facilities, it would be relevant to know what were or are the criteria used to determine the location of a nuclear plant. Given the dangers posed by the normal operation of a nuclear plant, there is common agreement that plans should be situated away from highly populated areas. However, nuclear crises always affect a considerable amount of people (Aoki 2012). In the case of Garoña, the plant is less than 100 km away from some medium-sized Spanish cities, such as Logroño, Vitoria, and Burgos and less than 200 km away from the wine regions of Rioja and Ribera del Duero, significant economic drivers of Spain’s agricultural sector.3

Timing of risks
Improvements in technology and scientific knowledge may decrease overall risks. Using once again the CFCs example, the process of phasing out CFCs initiated by the Montreal Protocol in 1988 was initiated because—at that time—American chemical corporations were in an advantageous situation to commercialize CFC substitutes (Wiener 1999:687). Similarly, human ingenuity and scientific research might increase the safety of nuclear facilities, or even find alternative sources of energy that will make nuclear facilities unprofitable. The shale gas boom has changed

3. We must stress that nuclear crisis are extremely dependent on variable. Referring to the Chernobyl crisis, Perrow wrote: “but more important is the luck that the USSR had with the weather that night. The radioactive cloud rose slowly to several thousand feet in the still air before dispersing. Had a wind carried it over nearby Kiev, many more thousands could have died.” (Perrow 1999, 279).
the picture of energy generation in just a few years. Shale gas extraction technology provides availability to abundant sources of natural gas, cutting down the costs of building new gas-powered electricity plants relative to nuclear plants.

Sources of Risk Tradeoffs
The previous section has presented a set of topics that—under a Risk Tradeoff Analysis perspective—should be assessed to take into account both the target and the countervailing risks associated with a regulatory decision. The following paragraphs will in turn identify some sources of risk tradeoffs in the specific regulatory measure of keeping the Garoña nuclear plant in operation.

Heuristics
One of the largest problems is an imbalance of heuristics. Keeping Garoña operational may address the immediate problem of unemployment and energy security but may also increase the risk of a nuclear accident. Closing Garoña may immediately reduce nuclear insecurity but also increase unemployment, forcing Spain to default on its international GHG emission reduction target. Seeking increased political support, decision makers may take a short-term, reactive decision—namely keeping the plant in operation, thus avoiding the political cost of being seen as job-killers—instead of a long-term preventive decision such as closing the plant while subsidizing the creation of a renewable energy industry cluster in the region.

Focusing on immediate problems may also lead decision makers to procrastinate in making the necessary decisions to reduce risks. Human beings tend to pose a higher value on immediate gratification and under-value future benefits (Ariely & Wertenbroch 2002:219). The range of examples is broad, including both individual decisions like brushing your teeth, and collective public policy decisions such as incentivizing low-income jobs instead of high education and scientific research. In the present case, the immediate benefits of maintaining the status quo may seem more rewarding to the rule maker than engaging in a challenging, complex energy transition. Bipartisan collaboration is needed to avoid this kind of short-sighted approach.
Bounded Oversight Roles
Concentration of competences in one single agency or institution is a limitation to a thorough Risk Tradeoff Analysis evaluation because “there is no individual or agency capable of processing all information needed for making the decision” (Graham & Wiener 1995:235). In the case of Spain, this problem is worsened for at least two reasons. First, in order to obtain a permit of operation, Garoña only needs to meet all technical requirements determined by the Nuclear Security Council. This ensures Garoña can be restarted without the authorization of the National Center for Critical Infrastructure Protection, which oversees the project’s equally important national security implications. Second, the political system in Spain determines that the executive branch always holds control over the legislative branch. This lack of balance between both branches of power promotes a concentration of decision making in the hands of the executive. This situation—when added to the lack of a Freedom of Information Act in Spain—provides the executive branch with a powerful incentive to abuse its discretion.

New-Old Bias
Traditional stakeholders in most industries raise entry barriers to potential newcomers. For example, coal producers and nuclear energy companies fight subsidies on renewable energy technologies and describe renewable energy as unreliable and expensive. Additionally, from a consumer’s perspective, a good-old energy provider could be viewed as more reliable than taking a leap of faith towards a new kind of energy production.

To date, Spanish nuclear facilities have operated without major accidents, and both industry lobbyists and governmental institutions have praised their reliability (Boletín Oficial del Estado 2013). Thus, a decision to close this nuclear facility or phase out nuclear energy in Spain could be seen as an unfair penalty to a highly specialized industrial sector that has been operating under the most stringent levels of security while raising doubts about alternative energy sources.

Behavioral Responses
Behavioral response to nuclear energy by different affected stakeholders is subject to change, particularly when comparing divergent interests. In
the balance between environmental protection and job creation, the latter usually becomes a stronger argument, particularly in times of dire financial circumstances.

Behavioral responses are also influenced by ethical considerations and by the overall balance that a society makes of its own strengths and weaknesses. The wave of U.S. environmental laws enacted in the sixties and seventies reflected both the increased concern Americans developed about the need for a healthy environment and confidence in technological entrepreneurship that followed the success of the Apollo XI space mission (Salzman & Thompson 2010:56). A similar approach may be identified in the recent German decision to phase out nuclear energy. The report, issued in May 2011 by the German Ethics Commission for a Safe Energy Supply, establishes Germany’s future general principles for energy supply and consumption:

Germany must follow the phase out path with new confidence in its own strengths and a consistent process of checks and controls. . . . Science in Germany is in an excellent position and can be expected to continue to provide innovative and efficient solutions for the energy transition. (German Ethics Commission for a Safe Energy Supply 2011:2–3).

Omitted Voices
A governmental public policy decision on a potentially catastrophic technology may leave some stakeholders out of the debate. The potential unheard voices are dispersed within societies and across national boundaries. The consequences of transboundary harm exemplify this issue. International law’s duties regarding potentially catastrophic consequences of nuclear industry are not stringent. States are obligated by the 1992 Rio Declaration (Principles 17 and 19) and 1991 Espoo Convention to communicate with neighboring states and follow an environmental impact assessment prior to the installation of any nuclear energy facility (UNECE 1991:310).

Notwithstanding this provision, States are not under obligation to repeat this process regularly. Thus, Garoña may be restarted without the need to inform Spain’s neighboring countries and without conducting a
new Environmental Impact Assessment (EIA). Needless to say, keeping a nuclear plant in operation longer than it is designed for may easily be defined as an activity that can significantly affect the environment, health, and security of a nation and its neighboring states. Garoña’s nuclear reactor has some relevant precedent that could strongly raise the regulators’ concerns. In 1996, one of the nuclear reactors that served as a model for building Garoña, Dresden 2 in Illinois, suffered what Charles Perrow has described as “the quintessential example of a system accident” because of the large set of equipment failures, false signals, and unexpected interactions the plant operators had to face (Perrow 1999:49). Moreover, Garoña’s reactor is a boiling water reactor identical to the one that failed at Fukushima’s power plant (Kanter 2011).

Another side of the “omitted voices” debate concentrates on the level of information available to the public. As already mentioned, the lack of a transparency law in Spain is a significant limitation. Additionally, protocols for providing information to the public concerning anomalies in nuclear plants usually involve the need of several actors, and in the event of a crisis established rules of operation usually fail.

**Conclusions**

Technological progress has led to some negative consequences, such as chemical warfare, climate change, and nuclear fallout; however, human society has nevertheless reached new levels of progress.

Technology can both avoid and cause catastrophes. At a highly sophisticated level of human development, technological failures are inevitable. Our contemporary global society must face the difficult task of discriminating among new technologies in order to ensure that technological innovation develops under acceptable safety levels. But how “safe” is safe enough? The problem is that the adequate information needed to make such a decision is usually not available. In a classic example, our carbon-based Industrial Revolution was initiated by a small group of nations whose scientists managed to convert coal and oil into movement and electricity. These inventions carried the benefits of industrialization. However, the intensive use of fossil fuels also created a climate change problem of potentially catastrophic consequences that demands an extremely complex global response.
When taking the decision to issue a permit that will allow Garoña to be in operation for more than forty years, the assessment of risks, benefits, and interests (the risk tradeoff) becomes particularly relevant. Germany justified its decision to phase out nuclear energy by citing Fukushima as an example of nuclear energy’s unpredictable dangers. Parallel concerns seem to have also arisen in Spanish society where polls show broad opposition to nuclear energy. Many neighboring European countries have similar opinions. A recent poll conducted by Reuters news agency showed that 57 percent of French nationals were against the use of nuclear energy (Thomson Reuters 2012).

An adequate balance of risks may be performed in order to provide decision makers with holistic and detailed information. This includes not only technical reports about the performance of the plant and its components but also security assessments including costs and a review of alternatives that takes into account related industries that may be directly affected like tourism, agriculture, and urban development.

Political pressure, agency capture, and subjective assessments may greatly influence the decision making process. Political pressure from labor and nuclear industry interests may lead the government to decide that Garoña should be maintained in operation indefinitely, thus forcing the society to accept higher risks of nuclear disaster. On the other hand, political pressure from environmental groups and starry-eyed renewable energy researchers may lead the same government to close Garoña, thereby increasing the risk of losing energy independence, business opportunities and improvements the Spanish nuclear energy sector could achieve both at home and abroad.

Nuclear energy generation may seem to be a beneficial activity in the short term, but in the long term, the increased costs may greatly outweigh the benefits. For example, costs of waste management will keep increasing, especially if the German decision is successful and other countries follow suit. National security risks should not be underestimated, since the costs of a terrorist attack on a nuclear facility would be unbearable. Moreover, damages to other economic activities could result in economic losses extremely difficult to assess. Building off the example of the wine industry, nuclear fallout from Garoña could destroy forever booming wine
industries like Rioja and Ribera del Duero. These industries generate more jobs than the Garoña plant.

What Risk Tradeoff Analysis indicates is that in order to make the best decision, the decision maker must gather as much information as she can and from as many different expert voices as possible. It is important never to lose sight of the specific benefit we are expecting to obtain from the use of nuclear technology. Since we use nuclear technology to generate electricity, the main benefit is ultimately making electrons flow. In a country like Spain, there are many options for following Faraday’s footsteps. Wind power has been a successful example, a clean technology that the Spanish energy sector has been developing for quite a long time. Short-term goals and governmental procrastination may suggest that keeping nuclear plants in operation is the most convenient decision, but in the meantime, Spain will probably be losing the opportunity to become a world leader in alternative energy technology, wasting business opportunities. Furthermore, Spain would also be keeping the door open to a national security threat of unprecedented consequences. The low probability of such an outcome should not be used as an excuse for inaction. On the contrary, a decision to phase out nuclear energy in Spain could increase national security and, contemporarily, act as an incentive to technological entrepreneurship and research.

Bibliography


