Why do active smokers take the risk of breaking the law in non-smoking areas? —Status quo evaluation of typical Chinese and German cities based on game-theoretical modeling

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Vorgelegt
von
Guang-Yi XU
aus
Sichuan

Dekan:	*Prof. Dr. Jörg Schlüchtermann*
Erstberichterstatter:	*Prof. Dr. Dr. Klaus Nagels*
Zweitberichterstatter:	*Prof. Dr. Dr. Dr. Eckhard Nagel*
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Abstract

The World Health Organization warns that COVID-19, air pollution, and climate change are the leading global public health threats. Meanwhile, tobacco is the single most preventable cause of death and a secondary component of air pollution, which leads to more than 8.2 million annual excess deaths worldwide. Over 10% of tobacco-related deaths result from passive smokers exposed to second-hand smoke. There is no safe level of exposure to second-hand smoke and applying a completely smoke-free environment is the only effective strategy for prevention. The research documented in the doctoral thesis applies game theory such as multi-player regular and extensive game models with actual case data in assessing the smoke-free law's effectiveness. It represents a structured comparison between the Peoples Republic of China and Germany regarding legislation, application, and enforcement.

The first research question is, "Are non-smoking areas 100% smoke-free in China and Germany?". It represents a prejudgment of the smoke-free status quo based on counterexample's within the two nations. The main research question is, "Why do active smokers take the risk of breaking the law in non-smoking areas?". It leads to simulations evaluating decision-making of the interactions between the active smoker and the other players from the perspective of policy regulators. The answers to these two questions aim to provide input for better smoke-free legislation with recommendations for China and Germany. New institutional economics explains how rules matter in game theory as a basis of theories and methods. Game theory served to structure the research program. Furthermore, it was deployed as a source of methods useful for framing the smoke-free game model along with the computation of Nash equilibria in this research. The calculation of typical 3-player strategic games uses a payoff matrix and computer-based Gambit software in the extensive game setup. The supporting theories are expectation, utility, and bounded rationality elements. The supporting methods are represented by logical analysis, field research, and comparative research. These means were applied throughout the entire process of game-theoretical model formulation and simulations. From a sequential perspective, the process was initiated for Hong Kong. Eventually, the results were used to form a universal comparative smoke-free game model for simulations focusing on the cities Shenzhen and Bayreuth.

The results show that the answer to the first research question is NO. Several counterexamples prove that both China and Germany have yet still to achieve a 100% smoke-free level. The answer to the main research question is tested repeatedly in every model simulation before concluding that the expected payoff for active smokers who choose to smoke is higher than the payoff of not smoking. For the ultimate goal of the smoke-free regulator, the balance ratios evaluating active smoking risk stand at -105.66% in Hong Kong, -88% in Bayreuth, and -15.84% in Shenzhen. Shenzhen is the best, but it still needs more effort to achieve the ultimate goal of eliminating active smoking. The monetary turning point in Hong Kong is HK$597.5, with an invalid range from 60.16% to 88.05%. Simultaneously, the turning point in Shenzhen is Y302 with valid or invalid for 39.6%, and €24 in Bayreuth with an invalid range from 40% to 97.6%. Applying the stated criteria, the compliance ranking is as follow: the latest smoke-free law in Hong Kong is the best, Shenzhen law 2013 version is the second, and Bavaria is the third. However, other criteria may need to be applied in further research in the context of effort aiming at reducing second hand smoking.

Keywords:Smoke-free, Non-smoking areas, Game theory, FCTC, WHO, Sino-German

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1 Background

Nowadays, World Health Organization (WHO) warns that the world faces multiple health challenges and threats endangering public health security. WHO (2019) reported that air pollution and climate change are the leading public health threats to global health. This report warns that air pollution has already become the most significant environmental risk to global health in 2019. 90% of people worldwide breathe polluted air every day. However, in 2020, the COVID-19 virus raced worldwide, rapidly emerging as one of the top killers on earth. It laid bare the inadequacies of health systems as the latest top public health threats. WHO (2020) stated that health services in all regions struggle to tackle COVID-19 and provide vital health care. Furthermore, it indicates that COVID-19 can spread with 'polluted air' in poorly ventilated and crowded indoor settings.

As a secondary component of air pollution, the problem of the tobacco epidemic is becoming even more severe than expected. WHO (2008) published its first special report on the global tobacco epidemic, recognizing tobacco as the single most preventable leading cause of death worldwide. The report stated that the tobacco epidemic had already killed 100 million people worldwide in the 20th century. Moreover, tobacco will kill one billion people during the 21st century. In 2008, this report estimated that tobacco caused 6 million deaths and will exceed 8 million a year by 2030. However, the latest newsletter from WHO (2021) confirmed that tobacco deaths exceed 8.2 million a year.

Moreover, tobacco is also the only legal consumer product that could harm everyone exposed to it and kill up to half of the smokers. Tobacco smoke is a carcinogen that could cause lung, oral, pharyngeal, laryngeal, esophageal, stomach, liver, pancreatic, kidney, bladder, and cervical cancer. Worldwide, smoking causes nearly 80% of male and 50% of female lung cancer deaths and 70% of lung cancer deaths. Moreover, the abovementioned health damage does not become evident until years or even decades. The tobacco-related disease and death epidemic has just begun and could worsen in the future.

Unfortunately, active smokers are the first but not the only ones sickened and killed by tobacco. Passive smokers are the victims of second-hand smoke (SHS) due to the collateral damage of active smoking. Non-smokers exposed to polluted air containing second-hand smoke face an increased risk of disease and death. Exposure to second-hand smoke contributes to illness, disability, and a range of fatal severe diseases. WHO (2008, 2021) estimated that second-hand smoke killed more than 603,000 people annually in 2008, but it doubled to 1.2 million in 2021, 10 years earlier than estimated.

Second-hand smoke is part of the tobacco epidemic, and the tobacco epidemic is a component of air pollution. This classification is also positioning second-hand smoke as part of the leading public health threats. This research focuses on policy design and application from the perspective of a smoke-free regulator. This research evaluates smoke-free regulation effectiveness by simulating real case counterexamples. The results would provide lessons and experience and aim to achieve smoke-free by reducing illegal active smoking in non-smoking areas. A similar approach could decrease exposure to SHS-related issues like tobacco leftover control. Furthermore, it may also provide a reference in the public health risk administration field, including exceeding gathering and wearing masks in regulated areas during the post-COVID-19 era.

1.1 Second-hand smoke (SHS) overview

Second-hand smoke (SHS) or environmental tobacco smoke (ETS) is a complex mixture of chemicals generated during the burning of tobacco products. When smoking a cigarette, the smoker inhales and exhales about half of the smoke while the other half floats around in the air. Passive smoking describes people's exposure to environmental tobacco smoke or second-hand smoke.

A special report on SHS and cancer by the American Society of Clinical Oncology (2013) showed that second-hand smoke contains more than 4000 chemicals, at least 250 of which are known to be harmful, and more than 50 cause cancer. Cigarette poisons and carcinogens include tar, nicotine, carbon monoxide, ammonia, formaldehyde, and hydrogen cyanide. Thus, the U.S. Environment Protection Agency (EPA) classified second-hand smoke as a Group A carcinogen.

The immediate effects of passive smoking are worth consideration. First, eye and nose irritation, which leads to coughing. Second, sore throat, headache, dizziness, and nausea. Third, adults with asthma can experience a significant decline in lung function when exposed to SHS. Fourth, there are measurable effects on the heart, even in short-term exposure. Thirty minutes of exposure is enough to reduce coronary blood flow.

The long-term effects of passive smoking are critical. First, cancers include lung cancer, nasal sinus cavity cancer, cervical cancer, breast cancer, and bladder cancer. Second, it affects the heart and blood vessels, which may lead to acute and chronic coronary heart disease. It increases the rate of atherosclerosis (hardening of arteries), and continual exposure to passive smoking doubles the chance of heart attack. Third, the environmental effect is an increased concentration of suspended particulate in the air.

There is no safe level of exposure to second-hand smoke. This fact is a significant finding by the International Agency for Research on Cancer (2004) and the U.S. Department of Health and Human Services (2006). Due to involuntary exposure to tobacco smoke, Even low levels of second-hand smoke can be harmful. The only way to protect non-smokers from second-hand smoke is to eliminate second-hand smoke. Separating smokers from non-smokers, cleaning the air, or ventilating buildings cannot eliminate exposure to second-hand smoke.

The report on the implementation of smoke-free environments for controlling the global tobacco epidemic by WHO (2009) indicated that around one in a hundred deaths worldwide are due to passive smoking, which kills an estimated 603,000 people in a year. Exposure to second-hand smoke was estimated to have caused 379,000 deaths from heart disease, 165,000 from lower respiratory infections, 36,900 from asthma, and 21,400 from lung cancer. Simultaneously, deaths from passive smoking in children skew toward poor and middle-income countries and deaths in adults spread across countries at all income levels.

Globally, about one-third of adults are regularly exposed to second-hand smoke. Öberg M. et al. (2011) analyzed the worldwide disease burden from second-hand smoke exposure in 192 countries. His analysis shows that 40 percent of children, 33 percent of non-smoking men, and 35 percent of non-smoking women were exposed to second-hand smoke worldwide. Second-hand smoke exposure contributes to about 1% of the total global disease burden and represents about 10%-15% of the disease burden caused by active smoking. Second-hand smoke exposure is also associated with health loss in quality of life among people who have never smoked. Moreover, higher levels of exposure result in a more significant reduction in quality-of-life measures.

The analytical data for the health effects assessment by the California Environmental Protection Agency (2005) shows that the principal contributor to second-hand smoke is side-stream smoke, which makes up 85% of second-hand smoke generated by burning tobacco products. In comparison, the smoker exhales the "main-stream smoke" directly, accounting for 15% of second-hand smoke. Other components of second-hand smoke include main-stream smoke emitted at the mouthpiece during puff drawing and the compounds diffused through the wrapper. The characteristics of second-hand smoke change as it ages and combines with other constituents in the ambient air. Primarily, it is three to four times more toxic per gram of particulate matter than main-stream tobacco smoke, and the toxicity of side-stream smoke is higher than the sum of the toxicities of its constituents. This estimation indicated that second-hand smoke exposure is more harmful compared to active smoking.

Moreover, according to a paper by Matt G. E. et al. (2011), second-hand smoke is also

closely connected to third-hand smoke. Tobacco smoke could spread from one room to another within a building, even if the doors to the smoking area were closed. These toxic chemicals from second-hand smoke contamination persist well beyond the period of active smoking. It would cling to rugs, drapes, clothes, food, furniture, and other materials, which could remain in a room for weeks and months, even after opening the windows or using fans for air filtering. Leftover tobacco products like filters can become a source of deposited chemicals. They will then recycle the smoke back into the room's air rather than remove it. Such tobacco toxins that build up over time, coating the surfaces of room elements and materials and smokers' belongings, are referred to as third-hand smoke. Thus, controlling second-hand smoke will also directly reduce the damage contributed by third-hand smoke.

In addition to a significant and growing health burden, second-hand smoke exposure imposes an economic burden on individuals and countries. Both for the costs of direct health care and indirect costs from reduced productivity. According to a report on implementing smoke-free environments published by the WHO (2009), economic costs related to second-hand smoke exposure in Hong Kong and elsewhere are similar to those in the United States. In China, Hong Kong Special Administrative Region, the cost of direct medical care, long-term care, and productivity losses attributable to second-hand smoke exposure is approximately USD 156 million annually. Economic studies on the cost of tobacco use have been conducted in some other countries. However, in most cases, these do not assess costs specifically related to second-hand smoke exposure.

1.2 WHO countermeasures overview

The World Health Organization Framework Convention on Tobacco Control (WHO FCTC) ratified "MPOWER" in a WHO (2008) report. "MPOWER" is the policy package intended to assist in the country-level implementation of effective interventions to reduce the demand for tobacco use.

"Monitor tobacco use and prevention policies" and "Protect people from tobacco smoke" are the first two policies connected to this research. The other four policies of MPOWER include the following:

- "Offer help to quit tobacco use"
- "Warn about the dangers of tobacco"
- "Enforce bans on tobacco advertising, promotion, and sponsorship"
- "Raise taxes on tobacco"

It is a fundamental human right for all people to breathe clean air. All non-smoking areas shall be 100% smoke-free because there is no safe level of exposure to second-hand smoke. Even brief exposure can cause severe damage to the passive smoker

since SHS also causes heart disease, cancer, and many other diseases. Any country, regardless of income level, could and shall implement effective smoke-free legislation. According to a guidebook making smoke-free cities published by the WHO (2011), only a total ban on smoking in public places protects people from the harms of second-hand smoke, helps smokers quit, and reduces smoking.

Centers for Disease Control and Prevention of the U.S. The Department of Health and Human Services (2008) also published a guideline of evaluation Toolkit for smoke-free policy. This research could be classified as smoke-free policy research focusing on enforcement effectiveness in its chapter: Compliance.

WHO (2003, 2008, and 2009) released a series of guidelines for the WHO FCTC and WHO Global InfoBase. Several alternative terms to describe the type of smoke are addressed by Article 8 of the WHO Framework Convention. The key definitions related to this research are selected, quote:

> " "Second-hand smoke": This term can be defined as "the smoke emitted from the burning end of a cigarette or from other tobacco products usually in combination with the smoke exhaled by the smoker".
>
> "Smoke-free air": The term is the keyword to the definition of smoke-free which represents the air that is 100% smoke-free. This definition includes, but is not limited to, air in which tobacco smoke cannot be seen, smelled, sensed or measured.
>
> "Smoking": The term should be defined to include being in possession or control of a lit tobacco product regardless of whether the smoke is being actively inhaled or exhaled.
>
> "Public places": While the precise definition of "public places" will vary between jurisdictions, it is important that legislation define this term as broadly as possible. The definition used should cover all places accessible to the general public or places for collective use, regardless of ownership or right to access.
>
> "Indoor" or "enclosed": Article 8 requires protection from tobacco smoke in "indoor" workplaces and public places. Because there are potential pitfalls in defining "indoor" areas, the experiences of various countries in defining this term should be specifically examined. The definition should be as inclusive and as clear as possible, and care should be taken in the definition to avoid creating lists that may be interpreted as excluding potentially relevant "indoor" areas. It is recommended that "indoor" (or "enclosed") areas be defined to include any space covered by a roof or enclosed by one or more walls or sides. Regardless of the type of material used for the roof, wall or sides, and

regardless of whether the structure is permanent or temporary.

"Workplace": This term is defined broadly as "any place used by people during their employment or work". This should include not only work done for compensation, but also voluntary work, if it is of the type for which compensation is normally paid. In addition, "workplaces" include not only those places at which work is performed, but also all attached or associated places commonly used by the workers in the course of their employment. These including, e.g., corridors, lifts, stairwells, lobbies, joint facilities, cafeterias, toilets, lounges, lunchrooms and also outbuildings such as sheds and huts. Vehicles used in the course of work are workplaces and should be specifically identified as such. Careful consideration should be given to workplaces that are also individuals' homes or dwelling places, for example, prisons, mental health institutions or nursing homes. These places also constitute workplaces for others, who should be protected from exposure to tobacco smoke.

"Public transport": This term should be defined to include any vehicle used for the carriage of members of the public, usually for reward or commercial gain. This would include taxis. "

(World Health Organization 2007, 3–4)

Moreover, WHO (2007) also released Guidelines to Article 8 of the WHO FCTC to help countries know how to protect their people from the risk of second-hand smoke with legislation and enforcement, quote:

"Effective smoke-free legislation should be clearly written and comprehensive. There should be no exemptions with clear responsibility for enforcement. The smoke-free law shall clearly define the act of smoking, specify all indoor areas covered, and mandate posting of clear and conspicuous signage. The government agency responsible for enforcement should be clearly defined, as should penalties for violations.

Enforcement is necessary once enacted, laws establishing smoke-free places must be well enforced. Administrators, managers or proprietors, rather than individual smokers, should bear primary responsibility for ensuring enforcement. Although maintenance of smoke-free places is largely self-enforced in the long-term, it may be necessary to increase the level of enforcement immediately after smoke-free laws are enacted. Once there is a high level of compliance, it is usually possible to reduce enforcement measures, with regular monitoring. "

(World Health Organization 2007, 1)

Meanwhile, WHO (2008 and 2009) stated in Article 4 of the WHO Framework Convention that strong political commitment is necessary to take countermeasures to protect all persons from exposure to tobacco smoke. The following essential principles and lines related to this research recommended by WHO are meant to guide the implementation of Article 8 of the WHO Framework Convention for all countries in smoke-free policy administration, quote:

> "Principle 1: Effective measures to provide protection from exposure to tobacco smoke, as envisioned by Article 8 of the WHO Framework Convention. This require the total elimination of smoking and tobacco smoke in a particular space or environment in order to create a 100% smoke-free environment. There is no safe level of exposure to tobacco smoke, and notions such as a threshold value for toxicity from second-hand smoke should be rejected, as they are contradicted by scientific evidence. Approaches other than 100% smoke-free environments, including ventilation, air filtration and the use of designated smoking areas (whether with separate ventilation systems or not), have repeatedly been shown to be ineffective. And there is conclusive evidence, scientific and otherwise, that engineering approaches do not protect against exposure to tobacco smoke.
>
> Principle 2: All people should be protected from exposure to tobacco smoke. All indoor workplaces and indoor public places should be smoke-free.
>
> Principle 3: Legislation is necessary to protect people from exposure to tobacco smoke. Voluntary smoke-free policies have repeatedly been shown to be ineffective and do not provide adequate protection. In order to be effective, legislation should be simple, clear and enforceable.
>
> Principle 4: Good planning and adequate resources are essential for successful implementation and enforcement of smoke-free legislation.
>
> Principle 5: Civil society has a central role in building support for and ensuring compliance with smoke-free measures, and should be included as an active partner in the process of developing, implementing and enforcing legislation.
>
> Principle 6: The implementation of smoke-free legislation, its enforcement and its impact should all be monitored and evaluated. This should include monitoring and responding to tobacco industry activities that undermine the implementation and enforcement of the legislation, as specified in

> Principle 7: The protection of people from exposure to tobacco smoke should be strengthened and expanded if necessary. Such action may include new or amended legislation, improved enforcement and other measures to reflect new scientific evidence and case-study experiences."
>
> (World Health Organization 2007, 2–3)

1.3 Similar research overview

In the literature review, there is plenty of research on what is second-hand smoke exposure, how harmful and dangerous it is, and what shall be done to achieve a global 100% smoke-free. Especially within the reference by the World Health Organization (2007, 2008, 2009, and 2011) mentioned above in previous research. However, there need to be more papers evaluating what has been done so far to prevent second-hand smoke exposure based on the policy recommended by WHO. Only a few papers aim to eliminate second-hand smoke exposure in public non-smoking areas similar to this research from policy formulation and optimization perspectives.

Ye, X., Yao, Z., Gao, Y., et al. (2014) assessed second-hand smoke exposure in different types of venues before and after the new smoke-free legislation implemented in Guangzhou, China, on September 1, 2010. This paper evaluated changes with a repeated cross-sectional survey of self-reported second-hand smoke exposure in different venues and homes.

Their results show that in full smoking ban areas, overall self-reported second-hand smoke exposure has declined significantly from 58.8% to 50.3% ($p<0.05$), with more significant drops in cultural venues, government offices, and commercial venues. Ye, X., Yao, Z., Gao, Y., et al. (2014) performed a quantitative vertical comparison of Guangzhou's smoke-free legislation in different locations before and after the version upgrade. This approach is similar to the vertical comparison researchers applied in Hong Kong and Shenzhen. It provides local first-hand data as a counterexample of 100% smoke-free China. However, expectably self-reported data may be less accurate than direct observation of a real case study applied by the researcher.

The article by Alan Shiell & Simon Chapman (2000) applied a similar methodology and keywords related to this research: passive smoking, game theory, tobacco control, prisoner's dilemma, and regulation. This research started with two alternative regulatory approaches to reduce workplace exposure to environmental tobacco smoke. These methods are voluntary, and self-regulation introduced by management or public health legislation bans smoking outright in enclosed places. In Australia, self-regulation has succeeded in restricting tobacco smoking in most indoor workplaces but has been a relative failure in the hospitality industry.

Insights from the game theory of 2-person regular form game analysis show why

reliance on the duty of care is unlikely to succeed even when establishment operators collectively support a non-smoking policy. Alan Shiell & Simon Chapman (2000) used plausible assumptions about the net costs of unilaterally introducing smoking restrictions and making good sense for society. Nevertheless, probably the least profitable option for an individual operator acting alone, the operators find themselves in the classic prisoner's dilemma. Suppose the policy restricts smoking in public places. In that case, game theory predicts that public health legislation banning smoking in enclosed places will be more effective than self-regulation and reliance on the duty of care.

Shen Shen & Jiang Min (2018) argued the tobacco industry that enjoys a monopoly, and the tobacco products share the characteristics of high margin, high revenue, as well as addictiveness and harmfulness. The Chinese tobacco industry has been in a system of state monopoly, which ensures stable development of the tobacco industry but has negative impacts on the tobacco industry market structure and market behavior.

This study aims to put forward relevant policy recommendations to improve relevant regulations and measures in the tobacco industry. It focuses on researching the causes and influences of Chinese tobacco regulation from the perspective of game theory. Then, it analyzes the existing problems within the tobacco industry in the decision-making model of good and bad tobacco companies or the government. It uses a 2-person table game payoff matrix and an extensive tree game similar to this research, informing the smoke-free game model in the first table game before transferring into the tree game.

Poutvaara, Panu and Siemers, Lars-H. R. (2007) formed a game-theoretical model for the social interaction between non-smokers and smokers using a sequential game. Then, they incorporated insights from social psychology and experimental economics to form an economic model. As a working paper at the Center for Economic Studies and Ifo Institute (CESifo), it stated that social norms affect human behavior. Moreover, non-smokers do not ask smokers to stop smoking and stay with them, even though disutility from smoking exceeds the utility of social interaction.

Overall, smoking is often unduly accepted when accommodating smoking as a social norm, even when smoking and non-smoking areas exist. Introducing smoking and non-smoking areas does not overcome this inefficiency, and this working paper concludes that smoking bans may represent a required but second-best policy. The game-theoretical approach applied in this working study is similar to the extensive sequential tree game smoke-free model in this research. However, it suggested that when smoking disutility exceeds social interaction utility, then non-smoker has no choice but to stay with an active smoker. Such an idea is absurd in the era of a universal smoking ban, and it is also unconvincing when calculating the utility balance without any actual case data.

The prisoner's dilemma is the perfect sample from the researcher's perspective. It

shows that the explicit steps of development start from the assumption to simulation, then from experiment to theory. The three research above applies game-theoretical modeling with variables without actual case data. The variables only represent players' unknown utility or payoff in a 2-person game. Such an approach is common in game-theoretical research but is maintained only as an assumption without practicality referring to the prisoner's dilemma.

In this research, smoke-free game-theoretical models combine strategic and extensive forms based on previous literature reviews. It will cross the threshold of assumptions in a game simulation by inserting three-dimensional data on health, satisfaction, and economics with proper reference.

This research is based on real cases instead of simply leaving alphanumeric characters for calculation. Also, the smoke-free game-theoretical models in this research are 3-person games from the beginning, even in the word description. The enforcer will join as a chance player before transferring to an extensive tree game. This approach is more advanced than the three similar pieces of research above and fits the reality of smoking bans already being enacted worldwide.

2 Questions, Design, and Goals

2.1 Research questions

First Question: Are non-smoking areas 100% smoke-free in China and Germany?

The first question aims to make prejudgments about the actual status quo of smoke-free legislation applications in China and Germany. There is no official report or statistics on smoke-free offenses in Bavaria, Germany. Meanwhile, a newsletter from Nanfang Daily by Mr. Du Xiaotian (2012) reported that no fine ticket was issued to any active smoker in Shenzhen, China, during the first version of the smoke-free law. However, no official record does not mean smoke-free violation does not exist. The potential counterexamples will prove that these illegal offenses exist in actual cases.

The keywords in the previous chapter to understand this first question in this section are non-smoking areas and 100% smoke-free. A non-smoking area is a place where people are not allowed to smoke. While smoke-free is equal to free of smoke, which describes an area where no smoke exists. 100% smoke-free in the first question related to the status quo evaluation before reaching the main question, and the keyword connected to the WHO standard is smoke-free air. WHO identifies that "smoke-free air" includes and is not limited to the air in which tobacco smoke cannot be seen, smelled, sensed, or measured.

If the answer to “Are non-smoking areas 100% smoke-free in China and Germany?” is YES. Then, no single case or record could be identified as a counterexample. No evidence shows that smoke has been seen, smelled, sensed, or measured within all non-smoking areas in China and Germany. The following research will evaluate how the current smoke-free regime succeeds within law enforcement and legislation design.

If the answer to “Are non-smoking areas 100% smoke-free in China and Germany?” is NO. Then, at least one case or record can be identified as a counterexample. Evidence shows that smoke has been seen, smelled, sensed, or measured within one or more non-smoking areas in China and Germany. The following research will use model simulation to evaluate why active smokers exist in these non-smoking areas and how to improve the current smoke-free law systems via the law enforcement and legislation design.

Main Question: Why do active smokers take the risk of breaking the law in non-smoking areas?

The smokers who actively break the law and smoke in restricted non-smoking areas are active smokers in this research. This illegal activity of active smokers is named active smoking. With field research, the researcher will record photographic evidence of the actual active smoking cases to prove that smoke has been seen, smelled, sensed, or measured within non-smoking areas in China and Germany. Besides, the literature review of the static report also provides several counterexamples.

The research then uses proper models to simulate how the legislation is working under the regime of smoke-free policy application and attempts to evaluate the behavior and consequences of active smoking. Specifically, the main question focuses on the decision-making process by active smokers who actively disobey smoke-free legislation and smoke in non-smoking areas. **Health is priceless for individual and social value compared to personal satisfaction and monetary income. Only when no one suffers any health loss, which is 100% smoke-free, achieves the Pareto optimum in a smoke-free game.** Smokers could also reduce social health loss attributed to active smoking by, e.g., switching to tobacco substitutes. Then, this would achieve Pareto improvement benefit to all other players better than previous decision-making results.

2.2 Research design

This research explores the foremost research questions with logical reasoning, quantitative analysis, and comprehensive comparison. First, using anti-smoking law enforcement data as a counterexample to prove that China and Germany did not achieve 100% smoke-free. Then, according to WHO standards, the answer to the first question is NO. Second, raising the main question that active smoking widely exists, the researcher introduces game-theoretical modeling based on laws related to smoke-free as game rules. The models simulate Hong Kong's smoke-free policy regime and aim to seek the reasons for its failure. Third, use Hong Kong as a particular case to generalize a universal smoke-free basic model for comparative research. Fourth, apply and analyze typical representative areas in other parts of China and Germany with the strictest smoke-free laws and counterexamples with this model. Finally, based on the result data, conclude the status quo of smoke-free law applications. Set risk standards for comparison ends with a turning point for a general active smoker to avoid illegal smoking offenses. Finally, discuss how China and Germany could cooperate and learn from each other to improve a 100% smoke-free environment based on the previous comparison.

Brief structural introductions for each chapter of this thesis are as follows:

Chapter 1 is the background that demonstrates the environmental status where the main research question appears. Then, how WHO responds to it with a literature review of similar research to explain the advantages of this research. The contents include a brief introduction to public health and the tobacco epidemic, a more

detailed review of second-hand smoke, WHO countermeasures, and similar research.

Chapter 2 separately lists the first and main research questions. They are "Are non-smoking areas 100% smoke-free?" and "Why do active smokers take the risk of breaking the law in non-smoking areas?" Design is the part that explains the planning and writing sequence of the paper. The goals are what the study aims to achieve.

Chapter 3 is the theories chapter that focuses on the theoretical basis connected to this paper. New institutional economics explains how rules matter in game theory application. The game theory contains a definition and description with the classification applied in this research, which is part of the combination of both a theory and a method. Summaries of the supporting theories applied in active smoking decision-making are utility and bounded rationality.

Chapter 4 is the methods chapter that explains the calculation of payoff matrices and computing Nash Equilibriums with Gambit software. They are the primary analysis tools in game-theoretical modeling and evaluation. Meanwhile, logical analysis, field research, and comparative research are the supporting methods for this research.

Chapter 5 is the chapter on the status quo of Non-smoking Areas in China and Germany. The researcher applies literature review and logical analysis to prejudge the status quo of non-smoking enforcement in China and Germany. Counterexamples prove China and Germany have not achieved 100% smoke-free.

Chapter 6 is the chapter that explains why Hong Kong is unique and focuses on the evolution of Hong Kong's smoke-free legislation. Moreover, the reason for choosing Hong Kong as the main research object is to build a universal smoke-free model for comparison. Additionally, the researcher collected information on how the Hong Kong smoke-free law evolved from 1982 to 2018, with detailed data on smoker reactions to policy upgrades.

Chapter 7 is the chapter that focuses on game-theoretical modeling based on Hong Kong. First, start with a draft standard game model in plus-minus preferences. Then, upgrading with economics, health, and utility degrees and inserting data with the enforcer as a chance player. Later, transform the model based on reality from a regular game into a computer-based extensive game. Eventually, develop a simplified tree game model with a basic and enhanced tree game model. The research also extends the basic model to an experimental reality model to simulate the interaction between the players and then refines the model for comparative research.

Chapter 8 is Model Application and Analysis in China. The chapter starts with data on tobacco use and the Tobacco Atlas for international comparison. The smoke-free laws section selected several cities in China with smoke-free law upgrades to preview for policy comparison. Then conduct a literature review in detail of old and new Shenzhen smoke-free legislation. Finally, the research analyzes the counterexample

recorded at Shenzhen university using a comparative model for further comparison.

Chapter 9 is Model Application and Analysis in Germany. The chapter starts with German data on tobacco use and Tobacco Atlas compared with China. The smoke-free law part is the literature review of the smoke-free laws in several states in Germany, especially for smoke-free legislation at the national level and in Bavaria. Counterexamples are the records from the Bayreuth youth hotel near the university campus and tracing cases at Bayreuth central train station. Finally, analyze counterexamples with comparative models that fit the actual case, ready to compare with Hong Kong and Shenzhen.

Chapter 10 is the Discussions chapter that summarizes previous research achievements and leads to a conclusion with a comparison between 3 regions. The summary starts with a smoke-free law overview and ends with three turning points. Extensive research has been conducted on the model's future application and experimental potential in a more advanced version. The 5-player final model is an upgrade for Hong Kong with possible policies in extensive research and stopping active smoking in simulation.

Chapter 11 is the Conclusions chapter that majorly demonstrates the contribution of research. This part explains what has been accomplished, compared to pre-studies, why using the current method, what the finding is, and why this is important. Then, draw a succinct conclusion fulfilling all three goals. The final sections are the limitations and outlook of the thesis for future research.

2.3 Research goals

Goal 1: Answer the first question: “Are non-smoking areas 100% smoke-free in China and Germany?” via literature review, data analysis, and logical implication.

Goal 2: Answer the main question: “Why do active smokers take the risk of breaking the law in non-smoking areas?” via literature review, data analysis, and comparative smoke-free model simulations based on Hong Kong as an example.

Goal 3: Apply the smoke-free game model based on Hong Kong to evaluate and compare counterexamples in typical Chinese and German cities. The comparison will provide results for cities to learn from one another for lessons and experiences in future smoke-free policy implications.

3 Theories

3.1 New institutional economics

Malcolm Rutherford (2001) stated that **new institutional economics is an economic perspective that extends economics by focusing on social and legal norms**. **Especially, rules are identified as institutions that underlie economics with analysis beyond earlier institutional and neo-classic economics.** New institutional economics applies more advanced mathematical tools with less value judgment than traditional ones. Besides, it is more suitable for a smaller range of exact incidents or cases that evaluate economic activities in an actual situation. **In this thesis, a confirmed case of smoke-free law application, especially the analysis of every round in a smoke-free game, is the right target for applying new institutional economics. Meanwhile, the smoke-free law's upgrade and evolution in Hong Kong are also research fields of traditional institutional economics.**

Institutions are usually equal to the rules of a society, which form the basic regime in a game-theoretical model. Institutions matter because they create the overall payoffs in a society. The research introduces this to describe and simulate the entire smoke-free law regime during players' decision-making process.

L. J. Alston (2008) stated in his textbook that new institutional economics incorporates the theory of institutions. These concepts include laws, rules, customs, and norms in economics. Furthermore, it is built, adapted, and extended based on neo-classic theory. Meanwhile, it also retains and builds on the fundamental assumptions of scarcity and competition, which are the basis of the choice theoretical approach that underlies microeconomics.

Rules exist from the beginning to the end in a game or real life. In the game-theoretical model, rules are the institutions equivalent to the law in human society. Institutions guide the lives of human beings in drastically different ways. Laws, culture, and political systems all create the environments of human actions under the rules. **The institution in this paper is the entire policy regime of the smoke-free law in non-smoking areas. These rules covered all the laws and legislation connected to smoke-free control when new institutional economics served as a theoretical basis.**

L. J. Alston (2008) suggested that new institutional economics has been one of the most successful fields in applied economics. Its contributions have been far-reaching, methodologically and substantively. It explains the underlying methodologies and identifies issues and questions for future research. Primarily, it **shows how results**

apply to decision-making in law, economic policy, management, regulation, and institutional design. This field is the reason for applying this theory in simulating smoke-free legislation.

Methodologically, Powell, W.W. and DiMaggio, P. J. (1991) reviewed that new institutional economics has developed valuable intersections with other **fields in economics. These research fields include game theory, law and economics, public choice**, managerial economics, and development economics. Substantively, the applications of new institutional economics **span many disciplines. It ranges from law to politics**, including **institutional design**, contracting, and business organization, which is suitable for smoke-free policy upgrades.

3.2 Game theory

Von Neumann, J. & Morgenstern, O. (1953) made a clear introduction of what constitutes a game, quote:

> "First, one must distinguish between the abstract concept of a game, and the individual plays of that game. The game is simply the totality of the rules which describe it. Every particular instance, at which the game is played – in a particular way – from beginning to end, is a play.
>
> Second, the corresponding distinction should be made for the moves, which are the component elements of the game. A move is the occasion of a choice between various alternatives, to be made either by one of the players, or by some device subject to chance, under conditions precisely prescribed by the rules of the game. The move is nothing but this abstract 'occasion', with the attendant details of description, – i.e. a component of the game. The specific alternative chosen in a concrete instance – i.e. in a concrete play – is the choice. Thus the moves are related to the choices in the same way as the game is to the play. The game consists of a sequence of moves, and the play of a sequence of choices.
>
> Finally, the rules of the game should not be confused with the strategies of the players. Exact definitions will be given consequently, but the distinction which we stress must be clear from the start. Each player selects his strategy – i.e. the general principles governing his choices – freely. While any particular strategy may be good or bad – provided that these concepts can be interpreted in an exact sense (...) – it is within the player's discretion to use or to reject it. The rules of the game, however, are absolute commands. If they are ever infringed, then the whole transaction by definition ceases to be the game described by those rules. In many cases it is even physically impossible to violate them."
>
> (Von Neumann, J. & Morgenstern, O. 1953, 49)

The previous classic statement already explains the most vital features of the game in game theory. In one sentence, **game theory is the science of decision-making interactions of rational players in different types of games**. This chapter focuses on the definition and description of game theory with a primary classification of different types of games from a theoretical viewpoint and a brief historical review.

For a clear definition of game theory by Sáiz M. E. (2007), a game is a **mathematical representation of a conflict situation**. The outcome depends on the mutual interaction between two or more rational players. **The definition of a player is a decision-maker in a decisional problem**: a person, a group, an animal, or whatever entity. Most significantly, a game differs depending on the number of players, and the most basic game can be classified as a two-person game. And, **in general, an N-person game when N > 2, like a three-person game for a smoke-free game**. Games have rules that **specify the actions the player can take, the information the player has available, and the consequences of the decisions**. Consequences usually affect the player and the other players, leading to a cooperative or competitive situation. **A game must also include payoffs or utilities representing the players' profits**. A set of alternatives describes the different actions or strategies a given player can choose in the feasible space of the game. From a direct quote from von Neumann and Morgenstern (1953), a move is the occasion of choice. The specific alternative to choose is the choice. A strategy defines a set of moves or choices a player will follow in a game. The strategy set is the set of strategies for all players to choose when playing a game.

Besides, Tomasz Goluch (2012) also stated a simple list of game theory formalism and assumptions, quote:

> "The purpose of this chapter is the systemization and detailing of game theory formalism, some assumptions on game theory is needed before start a game:
>
> 1. The rules of the game are precise, comprehensible and known to all players.
>
> 2. The players obey these rules.
>
> 3. There are two or an infinite number of players.
>
> 4. The game consist of moves performed at the same time (simultaneous game), or one at a time (sequential game); the number of moves is finite.
>
> 5. Each player has a set of strategies (finite or infinite). In theory, a game is restricted to choosing between strategies by each player. Choice of strategy can be a probability of selection among the subsets of strategies. What is means is that the player and their opponents do not know which strategy they will choose – this will be dictated by the chance or as a chance player for simulation.
>
> 6. After the game ends, each of the players get s certain result, its value

being numerical and described by means of payoff functions.

Moreover, games can be differentiated depending on:

1. Random situations: if there is at least one random situation that influences the outcome, then the game is a nondeterministic game. While in opposed to deterministic games, it is possible to foresee the outcome of the game when provided with strategies of all players.

2. Number of moves: It is one-step or simultaneous meaning the players make out decisions together in static games. In dynamic games, the decisions of players could be purely multi-staged or sequentially, and sometimes a combination of sequential and simultaneous.

3. Completeness of information: the minimal information a player should have is the knowledge of their own payoff function. This is called playing a game with hidden information. When a player knows the entire set of strategies (their own and other players'), as well as the position they occupy in a game, one can talk of a game with complete information. If the players additionally knows the payoff functions of other players, the history of random moves and their outcome (both their ant the other players'), one can talk of having complete information.

4. Cooperation elements: competition games are those where the win of one player has to be proportional to the loss of the other players. Cooperation games are those, in which players use their strategies to gain as much as possible, without worsening the condition of other players.

5. Payoff summation: The sum of competition game payoffs for all the players is usually 0 like chess, so it is named zero-sum games. In situation compete for a prize when the sum is a constant amount, it is named constant-sum games. For case like prisoner's dilemma when is payoff summation is not constant, it is named variable-sum games.”

(Goluch T. 2012, 7–9)

Referring to the Chinese version of the economic game theory by Shi-yu Xie (2017), the basic classification of game type for description verifies:

Cooperation elements: Non-cooperative or cooperative games

The number of players in total: two players or more

The number of strategies for each player: finite or infinite games

The process of the game: static games, dynamic games, or repeated games

Information set: Complete or incomplete, perfect or imperfect information

A smoke-free game, for example, is a non-cooperative 3-player finite static game with complete information.

In addition to this classification, static games could refer to strategic (normal) forms or table games. Dynamic games could refer to extensive form games, tree games, and multistage games. A payoff summation to describe whether it is a zero-sum, constant-sum, or variable-sum game is optional.

The following brief history of game theory development is selected and rewritten from the dissertation paper by Tomasz Goluch (2012). **According to U. Schwalbe and P. Walker (2001), the first person to break the ground on the game theory was Ernst Zermelo, who presented in 1913 with the first theory.** He proved that the outcome is a tie for one or both players in social games such as chess. The undisputed pioneer status in game theory history belongs to **John von Neumann and Oscar Morgenstern (1956). Their book on the theory of games and economic behavior in 1944** applied mathematical theory to economic applications and is an initial point of modern game theory. **John Nash Jr. (1950 and 1951) presented his three famous papers focused on equilibrium, including the non-cooperative games in 1950, the equilibrium points in n-person games in 1951, and the bargaining problem on Nash equilibriums in 1951**. In 1994, Nash and two mathematicians, Reinhard Selten and John Harsanyi, got the Nobel Prize in economics. It was a real breakthrough when his denominator Nash Equilibrium significantly contributed to the game theory.

Nowadays, game theory is no longer limited by mathematical perception but is widely applied in **economic**, physical, biological, anthropological, sociological, philosophical, information-technical, and **legislative research**.

Especially, Tomasz Goluch (2012) made a brief introduction about the game theory studies related to real-life situations like a smoke-free game, quote:

> "To estimate whether the game theory gives a true account of the behavior, as well as correctly estimates the modeled players, two approaches are used. It is possible to observe people in real situations and construct theories basing on these observations. These models can be used for statistical studies. The second approach tries to simulate the real-life situations with the simplified models. This type of research is called behavioral game theory. The drawback are that these have little reflection of the real-life situation, where the players motivation to win is the driving force."
>
> (Goluch T. 2012, 4)

Although the application of game theory in health economics is uncommon, this thesis applies game theory in health economics, especially in the smoke-free policy system. 'Rules of the smoke-free game' represent how institutions affect player strategies in simulating a smoke-free game-theoretical model.

Besides, game theory is also closely connected to Pareto efficiency according to Microeconomic Theory by Mas-Colell, A. Whinston, Michael D. and Green, Jerry R. (1995). Formally, an allocation is Pareto optimal if there is no alternative allocation, where improvements lead to at least one participant's well-being without reducing any other participant's well-being. Tomasz Goluch (2012) also stated, “A game where an alternative strategy may result in a gain for at least one, while guaranteeing no loss for others, is called Pareto optimal.” The new reallocation is a Pareto improvement if a transfer satisfies this condition. When no Pareto improvements are possible, the allocation is Pareto optimum

3.3 Utility

According to the selected explanation by John Hicks (1946), the **utility was initially considered a measure of preferences. It is the preference over some set of goods in economics. This set of goods, including services, equals something that satisfies human wants. It also represents the satisfaction experienced by the consumer of a specific good. In the simplest sense, economists consider utility to be revealed in people's willingness to pay different amounts for different goods.**

Geoffrey Jehle and Philipp Reny (2011) stated in their advanced microeconomic textbook that the concept of utility could also model worth or value. Its usage evolved significantly when it was initially introduced as a measure of pleasure or happiness within the theory of utilitarianism. The concept is an essential underpinning of rational choice theory in economics and game theory. This assumption is **vital because an economist cannot directly measure a specific good or service benefit, satisfaction, or happiness.** Instead, economists could apply this term and then devise ways of representing and measuring utility in terms of measurable economic choices.

In this paper, the researcher introduces this to precisely equal a certain good: the satisfaction of active smoking in a non-smoking area. Applying utility will evaluate how much the active smoker is willing to pay to take the risk of smoking in a non-smoking area. **Although the exact amount of utility may be difficult to value directly with price, the target and limitations of the smoke-free regulator are clear.** To evaluate the risk and then calculate the payoff economically, **the amount of the utility of active smoking is first set to be the highest fine from the regulator's perspective.** More theories could lead to this issue to better explain this value of satisfaction. These include rational expectation in economics, the anchoring effect in psychology, and government-guided prices, especially in China. **Simply speaking, since the highest fine is known to all players in the smoke-free game, this information will provide an anchor for decision-making. Moreover, it is a reasonable expectation to value the price of active smoking as an amount equal to the**

highest fine, as the price of this violation is pre-set by government guidance and present in every warning.

Usually, the fine for a smoke-free violation is a range of amounts instead of a certain number in specific Chinese or German cities. Active smokers with satisfaction equal to the highest fine is the ultimate goal of smoke-free regulation pre-set by a government-guided price. For example, the maximum penalty for a smoke-free offense in Hong Kong is HK$5,000. It means the ultimate goal of this smoke-free policy is to stop every active smoker with the satisfaction of violation equal to and lower than HK$5,000. This alternative solves the problem of uncertain satisfaction for the illegal active smoking offense.

Similarly, John von Neumann and Oskar Morgenstern (1953) made the first significant use of the expected utility theory. They applied expected utility in their formulation of game theory. Their work shows that several simple, appealing axioms, characterizing preferences over risky gambles and games, imply that the utility of a gamble should be the probability-weighted average of the utility of its possible payoffs and outcomes.

In game theory and decision theory, **the expected utility hypothesis concerns human preferences regarding choices with uncertain outcomes.** Schoemaker P. (1982) stated this assumption focuses on the expected utility model. In such gambling that the subjective value associated with an individual's gamble is, in fact: **the statistical expectation of that individual's valuation of the outcomes of that gamble**. The expected utility theory analyzes choices among risky projects with multiple, possibly multidimensional outcomes. **This sample indicated that applying utility to game theory in smoke-free model simulation is possible, and the satisfaction value of active smoking simulation based on this theory is appropriate.**

In finance, researchers also apply utility to generate an individual's price for an asset, called **an indifference price. The utility functions in this study will evaluate the risk measure of active smoking. This paper presents the difference in active smoking risk-level values based on the balance. It is the amount between the expected payoffs of breaking the law in a non-smoking area with the loss of satisfaction.**

3.4 Bounded rationality

The most critical and controversial assumption of game theory is that all players in each game are rational. John von Neumann and Oskar Morgenstern (1953) started this key assumption from their research on the theory of games and economic behavior. A definition for this rational is: **to implement the best available strategy to pursue well-defined objectives or preferences over the set of**

possible outcomes.

Rationality implies that the players know the strategies available to each player. The player has complete and consistent preferences over possible outcomes. They are aware of those preferences and can determine the best strategy for themselves and then flawlessly implement it. Then, this player is a human being with superb rationality.

In contrast, bounded rationality is about the idea of limited rationality when individuals make decisions, as stated by Esther-Mirjam Sent (2018). The limits include **the tractability of the problem, the cognitive limitations of the minds, and the time available to make the decision.** Gerd Gigerenzer and Reinhard Selten (2002) suggested that **decision-makers in this view seek a satisfactory solution rather than an optimal one**. This statement means that humans only sometimes undertake a complete cost-benefit analysis to determine the optimal decision but instead choose an option that fulfills their adequacy criteria.

In fact, smokers are irrational enough as they would make a lousy choice consuming tobacco when knowing its health risk. The researcher extends the field of **bounded rationality in this paper to the partly rational action of an active smoker, precisely the possible negative effect of addiction to nicotine.** This theory could also partly explain the action of non-smoking area managers when choosing to cooperate or to conflict.

Herbert A. Simon (1955) **proposed bounded rationality as an alternative basis for mathematical modeling decision-making** in economics, political science, and related disciplines and complemented rationality as optimization. Viewing decision-making as an entirely rational process by finding an optimal choice with given information. Therefore, **bounded rationality addresses the discrepancy between the human with assumed perfect rationality and the reality of human cognition.**

Olson, Jr. Mancur (1971) suggested that "some models of human behavior in the social sciences assume that humans can be reasonably approximated or described as "rational" entities." However, Gerd Gigerenzer and Reinhard Selten (2002) stated that: “many economic models assume that people are on average rational and can, in large enough quantities, act according to their preferences approximately.” The concept of bounded rationality in the following models revises this assumption.

In this research, the **decision-making process of an active smoker is rational as the other players in a smoke-free game**. The satisfaction of an illegal smoking offense represents the **bounded rationality of a smoker. Due to addiction to tobacco consumption, they may irrationally consider active smoking with an extremely high value**, unlike other players in the smoke-free game. This value will make this **irrational action by active smokers calculable in a smoke-free game model as a rational player.**

4 Methods

4.1 Game-theoretical model formation and computation

The game theory model formation and computation content in this method chapter are works of literature from the game theory textbooks. The following chapters will briefly introduce keywords and explain their connection to smoke-free because this research focuses on applying the smoke-free study method instead of innovation in the game theory itself.

4.1.1 Strategic (normal) form game

Game in a strategic (normal) form is the original form of the game model in classic game theory research, which appears at the start process of smoke-free model development status from the word description until the enforcer joins in as a chance player.

Martin J. Osborne (1994) stated that **a strategic game is a model of interactive decision-making in which each decision-maker chooses his plan of action once and for all, and these choices are made simultaneously**. A common interpretation of a strategic game is a model of an event that occurs once. All the players know the details of the game, and they are all rational. The players choose these actions simultaneously and independently. One strategic (normal) game consists of a finite number of players. A strategy set is assigned to each player. Finally, a payoff function assigns a specific payoff to each player depending on his strategy and the strategy of the other players**.**

The game theory textbook by Levent Koçkesen and Efe A. OK (2007) presents a more detailed statement about a game in strategic form, quote:

> "Formally speaking, we need exactly three objects to define a game in strategic form.
>
> A strategic form game is composed of:
>
> Set of players: N
>
> A set of actions: Ai for each player i
>
> A payoff function: ui : A→R for each player i
>
> In general, we name the players by integers and denote a generic player

by i, whom we call player i. However, this choice is arbitrary and one may choose to name the players differently. (...)

We interpret Ai as the set of all available actions (or strategies) to player i. That is, for player I "playing the game" means choosing an action from the set Ai. (...)

Given the action spaces of the players, we define the outcome space of the game as

$A = \times i \in N Ai = \{(a1, ...,an) : ai \in Ai, i = 1, ...,n\}$.

An outcome a = (a1, ...,an) is thus nothing but an action profile.

To be able to formulate the decision problem of a player in a given strategic environment, we need to know about the preferences of this individual. Payoff functions represent these preferences. The interpretation of a payoff function is identical to that of a utility function that you might have encountered in a microeconomics course. If ui(a1, ...,an) > ui(b1, ...,bn), then we understand that player i likes outcome a = (a1, ...,an) strictly better than the outcome b = (b1, ...,bn). The crucial observation is that the payoff of the player i depends not only on the action chosen by player i but also on the action choices of the rest of the participating players. As we have discussed before, this is a crucial element distinguishing a game theoretic decision problem from a single agent decision problem.

We should note that, at this level of generality, we treat a statement like ui(a) > ui(b) as purely ordinal, that is, without attaching any meaning to the difference ui(a)–ui(b). All we know in the formulation so far is how the individuals rank the outcomes, not how much "utils" they derive from them. (...)

Summing up, we define formally a game in strategic form as the tuple

$(N,\{Ai\}i \in N,\{ui\}i \in N)$.

(Note that the term "normal form game" is also used in the literature.) Thus, when we talk about a "game in strategic form" we have in mind a setup in which all this information is provided. In particular, if the game is played by only two players (so that N = {1,2}), we need exactly four pieces of information:

(A1,A2,u1,u2).

Therefore, if each player has finitely many actions available to him/her, then we can represent a 2-person game in strategic form by means of a *bimatrix*, (...)"

(Levent Koçkesen & Efe A. Ok 2007, 21–22)

The payoff function assigns each player a specific payoff depending on his strategy and the strategy of the other players. The number of players is limited to 2 if their sets of strategies consist of only a few elements. **The outcome of the payoff function can be represented in a payoff matrix showing the two players, their strategies, and their payoffs.**

The matrix representation of the game in the strategic form of each extensive type of game can be brought down to an equivalent strategic form. Simultaneously, the conversion in the other direction is not as apparent. **As the game is two-player, a matrix is the best presentation for the payoff function.**

The intersection of the strategy matrix forms the payoff value for both players. In constant-sum, two-player games, it is possible to limit the representation to one player's payoff only. This method will easily count the opponents' wins, and with zero-sum games, it will have an identical value but with an opposite sign.

4.1.2 The Prisoner's dilemma

The prisoner's dilemma is a classic strategic (normal) game example in game theory history, which clearly demonstrates theory development from the assumption to simulation and then experiment to theory, as mentioned in the previous chapter. This thesis uses a similar logic and process to simulate the real smoking offense of a smoke-free game by transferring it into a game model from case to data.

The prisoner's dilemma shows that two rational players might not cooperate even when it is their best choice, an absolute classic in game theory history. According to the literature review of Rapoport, Anatol & Albert M. Chammah (1965) and Chess, David M. (1988), this game was first framed and tested via experiments by Merrill Flood and Melvin Dresher at RAND in the early 1950s. Later, Albert W. Tucker formalized this game and named it prisoner's dilemma. The 3-stage formation process of the prisoner's dilemma is a redesign based on selections in this thesis.

The prisoner's dilemma starts with two criminals being arrested and imprisoned separately, meaning they are in solitary confinement and cannot communicate. Due to insufficient evidence, the police could not convict the two prisoners on the principal charge, but enough on a lesser charge. Then, the police offered the two prisoners the same bargain. The prisoners have only one chance to cooperate or defect. The results differ according to the rules and their final decisions.

The three rules offer to the prisoners:

- If both prisoners defect by betraying each other, they all serve two years in prison.
- If a prisoner betrays and another remains silent, the prisoner betrays will be set free, but the prisoner remaining silent serves three years in prison.
- If both prisoners cooperate by remaining silent, they will serve only one year on the lesser charge.

This stage is similar to smoke-free game formation when first setting the game rules by selecting lines from local smoke-free laws.

The next step of the prisoner's dilemma explains how to transfer a real case set into a game model. Since the rules for the two prisoners are informed, the payoffs of their decision-making are predictable. Then, it could be transferred into a game matrix in the word description to simulate this case is present below, as Table 1 shows as following:

Table 1. Prisoner's dilemma matrix via word description

Prisoner 2 / **Prisoner 1**	**Prisoner 2 keeps silent (*Cooperates*)**	**Prisoner 2 betrays (*Defects*)**
Prisoner 1 keeps silent (*Cooperates*)	Each serves one year	Prisoner 1 serves three years Prisoner 2 goes free
Prisoner 1 betrays (*Defects*)	Prisoner 1 goes free Prisoner 2 serves three years	Each serves two years

This stage is similar to the smoke-free game when using the word description to form the smoke-free game models in this thesis.

Watson, J. (2008) discusses the decision-making process in a prisoner's dilemma from the perspective of strategy, quote:

> "In the prisoners' dilemma, a player might be deterred from selecting D by the threat of his partner chastising him after play occurs. Certainly such considerations enter the minds of decision makers. As game theorists, we must insist that all such considerations be manifest in the payoffs. Suppose we have a setting like that portrayed by the prisoners' dilemma, except that the payoffs are in dollar terms. Further suppose that player 1 prefers not to play D for fear of retribution by his opponent after the game ends. If we were to draw the "actual" matrix describing this game, player 1's payoffs from selecting D should be less than those from selecting C (against each of player 2's strategies). The actual game,

in this case, is not a prisoners' dilemma. Indeed, if retribution were possible after the players choose between C and D, then we ought to model the option for retribution formally as a part of the game."

(Watson, J. 2008, 52)

Table 2. Prisoner's dilemma – payoff matrix

Prisoner 2 / **Prisoner 1**	**Prisoner 2 keeps silent (*Cooperates*)**	**Prisoner 2 betrays (*Defects*)**
Prisoner 1 keeps silent (*Cooperates*)	-1 -1	0 -3
Prisoner 1 betrays (*Defects*)	-3 0	**-2** **-2**

This stage is similar to smoke-free when importing real case data for model simulation and then preparing for computation in this thesis.

Table 2 presents the prisoner's dilemma that could transform into a simplified payoff matrix from the original case. Xie Shi-yu (2017) suggested solving the matrix by underlining each player's payoff and selecting the box with underlined numbers for both players, as shown in Table 2. Also, the box where the game ends, as a result, is in bold font in this matrix. This study uses this method to apply smoke-free law and transfer it into smoke-free game models.

Levent Koçkesen and Efe A. OK (2007) also present a simple statement about the prisoner's dilemma, quote:

"The problem of a player in a strategic game is to decide upon an action to take without knowing which actions will be taken by her opponents. Therefore, each individual has to form a conjecture regarding the action choices of the other players, and this is not always an easy task. But, in some cases, this difficulty does not really arise, because there is an optimal way of taking an action independently of the intended play of the others. We have in fact already encountered such a situation in the prisoners' dilemma. Indeed, taking the noncooperative action of confessing, C, is optimal for, say player 1, in the prisoners' dilemma no matter what player 2 is planning to do. In this sense, we say that there is an "obvious" way of playing the prisoners' dilemma for player 1 (and similarly for player 2): choosing C."

(Levent Koçkesen & Efe A. Ok 2007, 29)

Regardless of the other player's choice, defection is always better than cooperation, with a higher payoff. Thus, it is a dominant strategy. Defection is the only strong Nash equilibrium for both players in the game. The dilemma is that cooperation is in fact better outcome than defection. However, it is not the rational outcome as a result because of the choice to cooperate. Thus, from a self-interested perspective, it is irrational.

Tomasz Goluch (2012) also made a brief statement on the status of the prisoner's dilemma in the game theory research field, quote:

> "The situation itself can have both positive and negative outcome for the society. For example: mass fishing – the number of fish caught exceeds the market demand, however it is in everybody's interest not to reduce the catch. A preferred situation is when others limit their catch. A positive example of Prisoner's Dilemma is competition – the superfluous catch causes price reduction.
>
> There is a variety of methods that aim at Pareto-optimal outcome by influencing the players' behavior within the Prisoner's Dilemma. One such method is to ensure that one player is certain the other player will not betray then, and the other way around.
>
> Unfortunately, such situations are a rarity (unless the players will get a chance to win back the loss). Another method is reaching a conclusion on other players by observing previous games. This is called iterated prisoners' dilemma, and it requires multiple games to create a behavioral history."
>
> (Goluch T. 2012, 18)

Nowadays, as a model for many real-world situations, the prisoner's dilemma game also involves cooperative behavior. Watson, J. (2008) discussed the current status of prisoner's dilemma in the field of economics, quote:

> "The prisoners' dilemma is a widely discussed game and has proved to be a source of insight in the fields of economics, sociology, political science, international relations, and philosophy. In economics, it is ubiquitous. Settings in which workers interact to produce in a firm often have the same flavor, although the models are richer and more complicated. In the same vein are some models of international trade. So, too, are settings of industrial organization."
>
> (Watson, J. 2008, 53)

This insight could be the next direction for smoke-free games evaluating the future cooperation potential between the active smoker and the manager.

4.1.3 Extensive form game

When players move with turns in order, the game tree will be the ideal representation of a sequential game. In this paper, the active smoker will act first to choose whether he or she will start smoking or not before the passive smokers, non-smoking managers, and patrolling officers react. Thus, the game tree will be the primary form of a smoke-free game model in this paper.

The easiest way to present an extensive form game is using the game trees suggested by Levent Koçkesen and Efe A. OK (2007), which is a multi-person generalization of a decision tree. **The rules of an extensive form game describe the game when players execute their moves consecutively.** The extensive form provides a clear strategic interaction by specifying which player moves when doing what and with what information status.

Levent Koçkesen and Efe A. OK (2007) made a systematic introduction about a game tree, quote:

> "Game trees are made up of: **nodes, branches, information sets, player labels, action labels and payoffs**. **Nodes** are of two types: **Decision nodes** represent the points in the game at which players make a decision, i.e., choose an action, or a strategy in general. As any other tree, a game tree has a root and it is useful to distinguish the root, which we will call the **initial node**. From the other decision nodes (it is represented by an open circle whereas all the other nodes are represented by closed circles). To each decision node, including the initial node, one, and only one, player label is attached, to indicate who moves at that particular decision node. The second type of nodes is called **terminal nodes** and at these nodes the game is over and nobody takes any action anymore. To each terminal node a **payoff** vector is appended. From each decision node, one or more branches emanate, each branch representing an action that can be taken by the player who is to move at that node. Each such branch is labeled with the **action** that it represents. A branch either leads to another decision node or to a terminal node. The last component that we have to talk about is the **information sets.** Information sets tell us what the players know when they are making a decision. They are collections of decision nodes of a player that cannot be distinguished from the perspective of that player."
>
> (Levent Koçkesen and Efe A. Ok 2007, 86–87)

Tomasz Goluch (2012) also demonstrated a sample of a game tree, quote:

> "The structure of game tree consists of arches and vertices. The vertices

represent a position in a game, while the arc stands for the possible move of the player, which determines the next position in a game. **The uppermost vertex – the root (rooted tree) represents the base position.** We assume that within a given vertex, only one player can make a move. The vertices that do not generate vertices are terminals (leaves) and they represent the end of the round. Each such vertical contains a numerical vector with all players' payoffs. **When a game allows that two players move at the same time, we are dealing with a simultaneous game and the outcome is that one player does not know which vertices he's reached (incomplete information).** To report that we need so called information sets – represented by a dotted line joining verticles in one information set as it shows in Figure 1: (a) Optimal strategy with final payoffs (b) Wedial values counted via backwards."

(Tomasz Goluch 2012, 9)

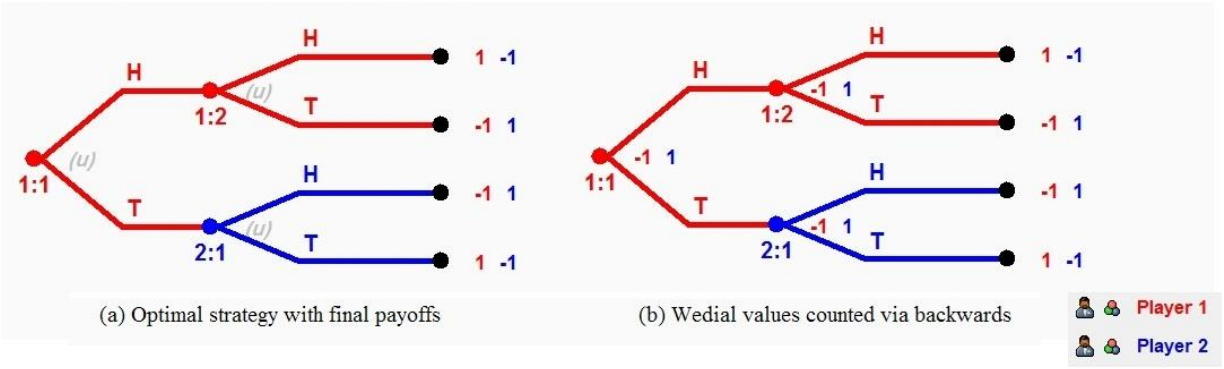


Figure 1. Sample tree game for sequential games

In strategic form games, the equilibrium concept in extensive form games, which is based on the idea that each player plays the best response to the play of the other players, started by Levent Koçkesen and Efe A. OK (2007). The difference is that it requires the strategies to be optimal at every single step in the game. Using the backward induction equilibrium is an algorithm as one of the recommended methods applied in Gambit software. After this process, it generates a recommendation of an active choice at every decision node. With the property that every player follows recommendations based on computation, their strategies would be optimal, at every decision-making node, as a possible move during gameplay. This method will also result in a path of play called the backward induction outcome.

A game modeled at that structure could also represent a reversed sequence by using backward induction, as suggested by Tomasz Goluch (2012). The last move belongs to the 'other' player, which means that his rational decision will be the best option. These values can be assigned to the vertices one level up in the game tree and represent the player's move. The 'next' move (going backward) is Player 1's move, which chooses the best possible options from the set of new values. The alternative left by Player 2 is not beneficial for Player 1 (each move results in a loss), which proves the previous statement. If players simultaneously reveal their choices, they

only know the other player's choice once the game is over, and the decision cannot be altered. This method is depicted by merging the game vertices with the player as part of one information set.

4.1.4 Nash equilibrium

he Nash equilibrium was named after John Forbes Nash, Jr. It is a steady state of solution concept in a non-cooperative game involving more than one player. Each player knows the equilibrium strategies of all the other players. Moreover, no player has anything to gain by changing only his or her own strategy. The design of the Nash equilibrium concept aims to analyze the outcome of decision-makers strategic interactions.

The solution of the Nash equilibrium in a matrix game with the underlying method Xie Shi-yu (2017) has already been introduced in the prisoner's dilemma.

M. Elena Sáiz (2007) stated a word description of the definition for a Nash equilibrium: A Nash equilibrium is a profile of strategy choices such that every strategy of the players is the best reply to the strategies chosen by the other players. In the Nash equilibrium, no player has any incentive to deviate unilaterally from it.

Watson, J. (2008) stated the origin of Nash equilibrium in the textbook, quote:

> "The simplest notion of congruity is that the players are best responding in a setting of strategic certainty. In other words, the players coordinate on a single strategy profile. In such a case, the players' beliefs and behavior are consistent, with each player's belief about another player's strategy concentrated on the actual strategy that the other player uses. Because of these accurate beliefs, the players are best responding to each others' strategies. To say it differently, the players' strategies are "mutual best responses."
>
> The idea of mutual best response is one of the many contributions of Nobel laureate John Nash to the field of game theory. It is a simple, but extremely powerful, theory of behavior. Nash used the term equilibrium for this concept; we now call it Nash equilibrium."
>
> (Watson, J. 2008, 97)

The modern game-theoretical of Nash equilibrium is in terms of mixed strategies. John von Neumann and Oskar Morgenstern (1956) introduced the concept of the mixed-strategy Nash equilibrium. However, their analysis was only limited to zero-sum games. Furthermore, they showed that one mixed-strategy Nash equilibrium would exist. But only for zero-sum games with a finite set of actions.

A textbook by Martin J. Osborne (1994) proved that every finite strategic game has a mixed strategy Nash equilibrium. This textbook also provides a brief statement of Nash equilibrium as a steady state, quote:

> "The most commonly used solution concept in game theory is that of Nash equilibrium. This notion captures a steady state of the play of a strategic game in which each player holds the correct expectation about the other players' behavior and acts rationally. It does not attempt to examine the process by which a steady state is reached."
>
> (Martin J. Osborne 1994, 29)

The significant contribution of Nash (1951) focuses on non-cooperative games is the following:

- Define mixed-strategy Nash equilibrium for games with a finite set of actions.
- Prove at least one mixed-strategy Nash equilibrium exists in such games.

According to Nash (1951), "an equilibrium point is an n-tuple such that each player's mixed strategy maximizes his payoff if the strategies of the others are held fixed. Thus, each player's strategy is optimal against those of the others."

Levent Koçkesen and Efe A. OK (2007) also made a detailed introduction about mixed strategy equilibrium, quote:

> "In some situations a player may want to randomize between several actions. If a player chooses which action to play randomly, we say that the player is using a *mixed strategy*, as opposed to a *pure strategy*. In a pure strategy the player chooses an action for sure, whereas in a mixed strategy, the player chooses a probability distribution over the set of actions available to him or her. In this section we will analyze the implications of allowing players to use mixed strategies.
>
> The definition of a mixed strategy is: ai for player i, is a probability distribution over his set of available actions, Ai. In other words, if player i has m actions available, a mixed strategy is an m dimensional vector $(\alpha_i^1, \alpha_i^2, \ldots, \alpha_i^m)$ such that $\alpha_i^k \geq 0$, for all $k = 1,2, \ldots m$, and $\sum_{k=1}^{m} \alpha_i^k = 1$.
>
> Notice that not all actions have to receive a positive probability in a mixed strategy. Therefore, it is also possible to see pure strategies as degenerate mixed strategies, in which all but one action is played with zero probability. Once we allow players to use mixed strategies, the outcomes are not deterministic anymore. Therefore, we have to specify players' preferences over lotteries, i.e., over probability distributions

> over outcomes, rather than preferences over certain outcomes. We will assume that players' preferences satisfy the assumptions of Von Neumann and Morgenstern (1953). So that the payoff to an uncertain outcome is the weighted average of the payoffs to underlying certain outcomes, weight attached to each outcome being the probability with which that outcome occurs.
>
> In other words, we assume that for each player i, there is a payoff function ui defined over the certain outcomes $a \in A$, such that the player's preferences over lotteries on A can be represented by the expected value of ui. If each outcome $a \in A$ occurs with probability $p(a)$, then the expected payoff of player i is: $u_i(p) \equiv \sum_{a \in A} p(a)\, u_i(a)$."
>
> (Levent Koçkesen and Efe A. Ok 2007, 71–73)

In games with mixed strategy Nash equilibriums, the probability of a player choosing any particular strategy should be computed by assigning a variable to a specific strategy, representing a fixed probability of choosing that strategy.

Table 3 shows an example of the mixed strategy from Levent Koçkesen and Efe A. Ok (2007), which is a matching pennies game. Each of the two players chooses either Head or Tail. If their choices differ, Player 1 pays Player 2 one dollar; if their choices are the same, Player 2 pays Player 1 one dollar instead. In other words, Player 1 always loses one point to Player 2 if they play the same strategy. Player 1 wins a point if the two players play different strategies.

For the computation, the textbook recommends assigning Player 1 the probability p of playing Head and $(1-p)$ of playing Tail. Meanwhile, assign Player 2 the probability q of playing Head and $(1-q)$ of playing Tail.

Table 3. Payoff matrix of a matching pennies game

	Player 2 plays Head	**Player 2 plays Tail**
Player 1 plays Head	−1, 1	1, −1
Player 1 plays Tail	1, −1	−1, 1

The computing process of this matching pennies game is shown as follows:

E[payoff for player 1 playing Head] = $(-1)q + (+1)(1-q) = 1-2q$

E[payoff for player 1 playing Tail] = $(+1)q + (-1)(1-q) = 2q-1$

E[payoff for player 1 playing Head] = E[payoff for player 1 playing Tail]

$\Rightarrow 1-2q = 2q-1 \Rightarrow q = 1/2$

E[payoff for player 2 playing Head] = $(+1)p + (-1)(1-p) = 2p-1$

E[payoff for player 2 playing Tail] = $(-1)p + (+1)(1-p) = 1-2p$

E[payoff for player 2 playing Head] = E[payoff for player 2 playing Tail]

$\Rightarrow 2p-1 = 1-2p \Rightarrow p = 1/2$

Thus, a mixed-strategy Nash equilibrium in this matching pennies game: the best option is to randomly select a Head or Tail using an equal probability for each player. Similar to a smoke-free game, when the active smoker does not know who will be the one to spot or even stop active smoking, randomly and equally performing estimation for every situation could be an option. This settlement is the reason for applying a mixed strategy to set the possibility of a smoke-free game chance player enforcer. The possibility is first set to be 0.5 each and 1 in total or 0.25 each for four situations.

4.1.5 Subgame Perfect Equilibrium

Subgame perfect equilibrium is a generalization of the abovementioned backward induction equilibrium applied to extensive form games with imperfect information, which is applied in smoke-free tree games model computation with the recommended method tracing logic equilibrium.

To define subgame perfect equilibrium formally, first define a subgame with the statement in Levent Koçkesen and Efe A. OK (2007), quote:

> "A subgame is a part of the game tree such that
>
> 1. it starts at a single decision node,
>
> 2. it contains every successor to this node,
>
> 3. if it contains a node in an information set, then it contains all the nodes in that information set.
>
> We can now obtain a better insight into the difference between subgame perfect equilibrium (or backward induction equilibrium) and Nash equilibrium by using the language of subgames. We first have to distinguish between subgames that can be reached by a strategy profile

> and those that cannot be reached. A subgame can be reached under the strategy profile $s \in S$ if, when the strategy profile is implemented, the initial node of the subgame will actually be reached. Otherwise, we say that the subgame cannot be reached under the strategy profile s. A strategy profile $s*$ is a Nash equilibrium if every player plays a best response to the strategies of the other players in every subgame that can be reached under $s*$. In contrast, a strategy profile $s*$ is a SPE if every player plays a best response to the strategies of the other players in every subgame, i.e., even in those subgames that cannot be reached under $s*$. In other words, Nash equilibrium demands rationality in only those subgames that can be reached in equilibrium, whereas SPE demands rationality in every subgame, and this latter form of rationality is called sequential rationality."
>
> (Levent Koçkesen and Efe A. Ok 2007, 96–97)

4.1.6 Computer based game-theoretical modeling and computation

Gambit is the primary tool for game modeling, presentation, and computation in this paper, which takes the place of traditional matrix calculation of game models, especially after introducing the extensive game models.

This chapter focuses on how Gambit software operates. It is a selection from the user for a computer-based Nash Equilibrium computing process. This content is from Gambit software's official website (2020). Also partly from the technical guidebook by McKelvey, R. D., McLennan, A. M., & Turocy, T. L. (2002).

Gambit is a software tool for the computation of finite, non-cooperative games. It comprises a graphical interface for interactively building. It would analyze standard games in extensive or strategy form with several command-line tools for computing Nash equilibriums. It is a solution concept for analyzing games and a set of file formats for storing and communicating games to external tools. As third-party open-access software, it assures that different researcher could obtain the same result with the same game every time with Gambit and avoid manual computation errors.

The Gambit project was first founded in the mid-1980s by Richard McKelvey at the California Institute of Technology. The original implementation was written in BASIC, with a simple graphical interface. Later, The codes of Gambit was ported to C around 1990 with the help of Bruce Bell, then distributed publicly for later version in 1991 and 1992.

Gambit has a few limitations important in model applications, which do not affect the

smoke-free game output. Gambit is for finite games only. Gambit is for non-cooperative game theory only. Analyzing large games may become infeasible surprisingly quickly.

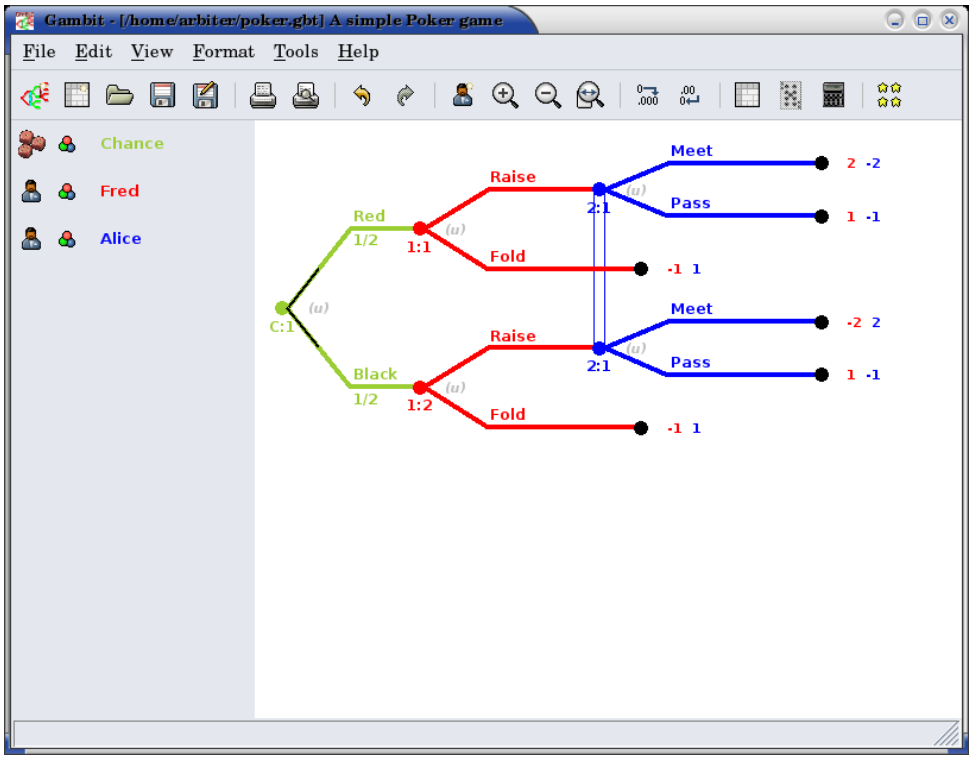


Figure 2. Sample game tree in Gambit: a simple one-card poker game[1]

Gambit software's official website (2020) demonstrated two principal panels that the frame presenting a game, usually the page similar to the smoke-free tree game model before computation in this research. The central panel to the right displays the game graphically. Figure 2 shows the game tree of a sample one-card poker game. To the left is the player panel listing the players in the game. In this sample, Fred and Alice are the players. The applicable information is in color to match the colors assigned to the players in the panel: Fred's moves and payoffs are in red, and Alice's in blue. Two additional panels are available besides the main one. The first one is that the toolbar controls the indication and elimination of dominant actions or strategies. The second one is that the interface handles the computation of the Nash equilibriums. Also, strategy profiles are presented in computing Nash equilibriums after the computation.

The Gambit software guides the options for computing Nash equilibriums in a dialogue. The methods for selecting a particular game depend on three criteria. These include the number of equilibriums to compute, whether the computation is ready to start on the extensive or strategic games,, and the game's details.

[1] Picture source: https://gambitproject.readthedocs.io/en/v15.1.1/_images/overview.png

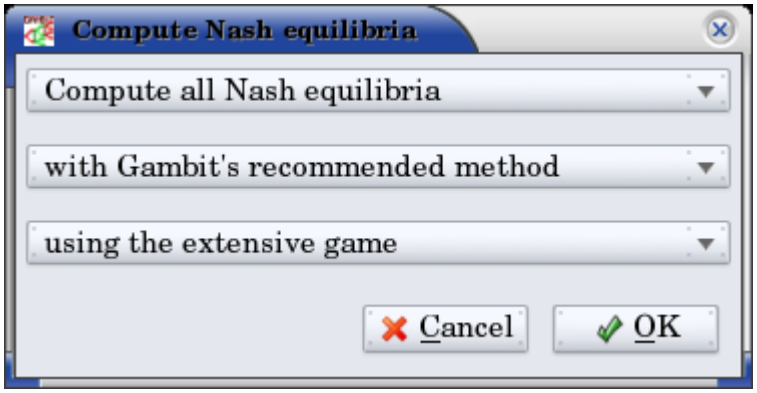


Figure 3. Sample menu of computing equilibriums in Gambit[2]

Figure 3 shows that the first step in finding equilibriums is to specify how much equilibrium is to be found, which is the same menu the researcher selected in smoke-free game computation at first. McKelvey, R. D., McLennan, A. M., & Turocy, T. L. (2014) stated that some algorithms for computing equilibriums adapt to finding a single equilibrium. Others attempted to compute the all equilibrium set. The first drop-down in the dialogue specifies how much equilibrium to compute. In this drop-down, options exist for as much equilibrium as possible and, for two-player games, all equilibriums. For some games, there exist algorithms that will compute as much equilibrium as possible relatively efficiently, but there are not guaranteed to find all equilibriums.

In the smoke-free comparative model, the researcher selects the option to find a single Nash equilibrium. It will first successively eliminate weakly dominated strategies. Eliminating weakly dominated strategies may eliminate some Nash equilibrium of the original game. Nevertheless, any Nash equilibrium with the reduced game will be equilibrium to the original game. So it is correct to select only one equilibrium when computing the smoke-free tree game. Alternatively, simplify this process of choosing the method to compute equilibriums in the second drop-down. Gambit automatic selection provides computation for any game with "recommended" methods. This selection includes the methods for computing one, at least one, and all Nash equilibriums. These methods are selected based on experience regarding the effectiveness and reliability of the methods generally similar in most games. For more control over the process, the researcher selected one of the appropriate methods for computing equilibriums from the second drop-down in the dialogue. This list only shows the appropriate methods for the game, given the selection of how much equilibrium to compute. When the computing is in progress, a new window appears in the middle of the screen. Figure 4 shows the number of equilibriums Gambit found with a payoff matrix within the progress screen of Gambit.

[2] Picture source: https://gambitproject.readthedocs.io/en/v15.1.1/_images/Nash.png

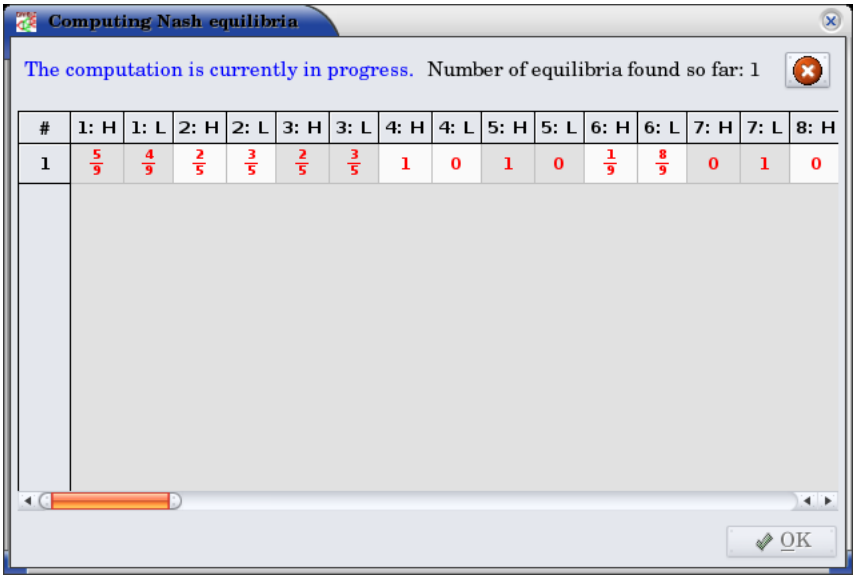


Figure 4. Sample computing progress window in Gambit[3]

After completing the computing equilibriums, the window similar to Figure 4 will disappear and switch back to the main window. A panel showing the list of completed equilibriums computation results is displayed automatically in the main window. Figure 5 shows this result window in Gambit. Thus, presenting the main window with the completed panel will effectively present the computation result in this paper.

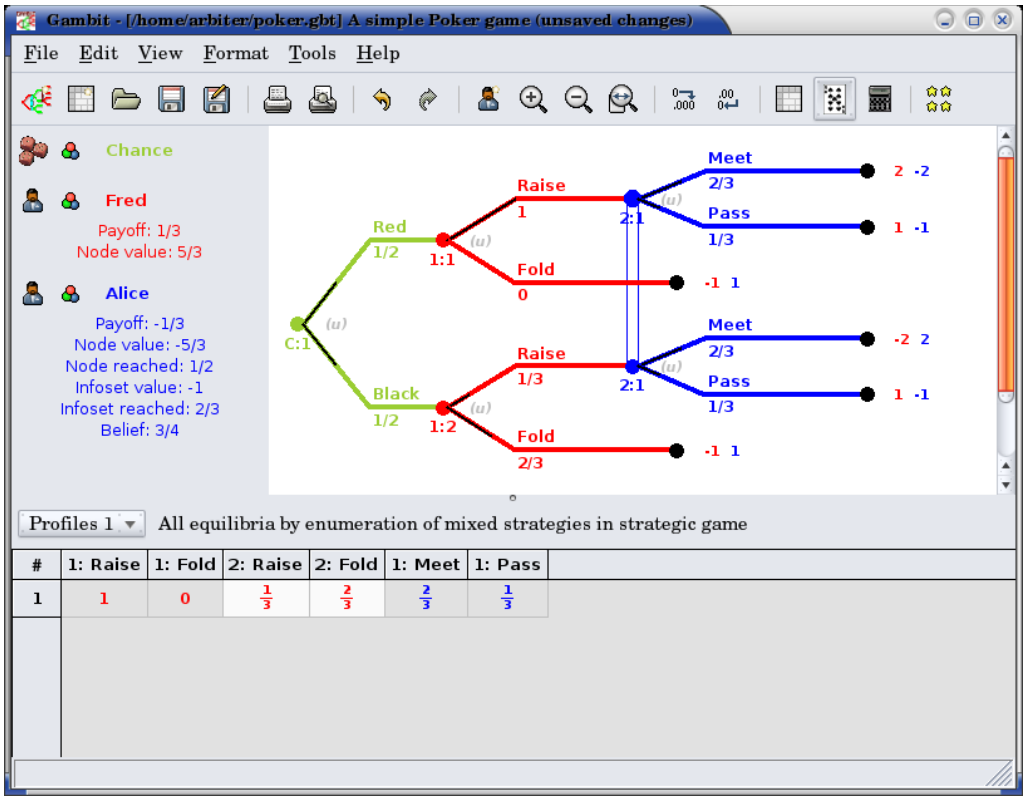


Figure 5. Sample completed equilibriums computation result panel in Gambit[4]

[3] Picture source: https://gambitproject.readthedocs.io/en/v15.1.1/_images/computing.png

This sample game has a unique equilibrium: Fred raises after Red with a probability of one and raises with a probability of one-third after Black. The other player Alice is at her only information set who plays meet with probability two-thirds and rises with probability one-third. Figure 5 shows Fred and Alice's payoffs on the screen's left side.

According to the Version 15.1.1 instruction from McKelvey, R. D., McLennan, A. M., & Turocy, T. L. (2014), this equilibrium is displayed in a profile panel table. This panel lists all equilibriums found if more than one equilibrium exists. The equilibriums computed are grouped by separate computational runs. Computing equilibriums using a different method or settings will add a second list of profiles. Briefly describe the method used to compute the equilibriums across the top of the profiles panel. The currently selected equilibrium is in bold font in the profile listing. The information about this equilibrium is displayed in the extensive game. The figure shows the probabilities of selecting each action below each tree branch.

For even moderate-sized games, the equilibrium computation can be a time-intensive process. The agent will compute quantal response equilibrium correspondence for extensive games like the smoke-free game.

Lastly, some may be interested in the detailed computation process. McKelvey, R. D., McLennan, A. M., & Turocy, T. L. (2002) explained how Gambit operates in the background for smoke-free games using Gambit as software tools.

Resolve is the identification name for the method applied to the smoke-free tree game, a 3-player extensive game in Gambit. It computes a branch of the logistic quantal response equilibrium correspondence for n-person extensive form games as described in [McKPal98] by McKelvey, R. D. & Palfrey, T. (1998). This technical guidebook is the extra literature written by the Gambit developer, which can be accessed in Richard McKelvey and Tom Palfrey's previous article as well.

McKelvey, R. D., McLennan, A. M., & Turocy, T. L. (2002) recommended a detailed description of this method, quote:

> “This algorithm returns the last point computed. This algorithm computes the principal branch of the logistic quantal response equilibrium correspondence. In this case taking the limit, as lambda goes to infinity, the quantal response equilibrium defines a unique selection from the set of Nash equilibrium for generic normal form games. Similarly, for extensive form games, it defines a selection from the set of sequential equilibriums. Therefore, in extensive form games, this algorithm can be used to compute approximations to a sequential equilibrium.”
>
> (McKelvey, R. D., McLennan, A. M., & Turocy, T. L. 2002, 210)

4 Picture source: https://gambitproject.readthedocs.io/en/v15.1.1/_images/beliefs.png

4.2 Logical analysis

According to the dictionary by Liddell, H.G. & Robert S. (1940), logic is the systematic study of valid rules of inference. It is originally from Greek means possessed of reason, intellectual, dialectical, and argumentative. It is mainly in research on the relationships that lead to the acceptance of one proposition (conclusion) based on a set of other propositions (premises).

According to Gensler, H.J. (2017), logic is the study of the classification of arguments and systematic analysis of logical forms. It is a systematic study of the validity of deductive inferences, the strength of inductive inferences, faulty arguments, and logical paradoxes. It is about the syntax and semantics of formal languages and the concepts of meaning, denotation, and truth.

In this research, the researcher transfers the smoke-free law into the rules of the game-theoretical model, applying logical analysis to simulate the possible options for each player and computing the payoff. These are just the same means of simulating and modeling a prisoner's dilemma before it became a theory. In the status quo chapter, using counterexample to estimate the smoke-free policy application in countries and regions is also an application of logical analysis to answer research question one.

With a precise classification of each phrase, the researcher applies logical analysis to analyze questions that need to be proven based on legislation or the rules. The action selection is based on investigation and logical analysis in the modeling forming process. Furthermore, one of the Gambit recommended computation methods proposed is tracing logic equilibriums. Also, when proving the questions, using counterexample to prove smoke-free is not realized in a particular city. These research processes are the applications of logical analysis in this paper, and the separated applications from the textbook by Gary Hardegree (2015) are listed as follows.

4.2.1 Arguments, Valid Arguments, and Argument Schemata

According to Ralph H. Johnson (2000), the trains of reasoning studied in logic are still arguments or argument schemata. Logic is the science of reasoning while reasoning has various applications, and the most important of these is argumentation. It is the process of logical analysis to determine what makes a valid or invalid argument or inference. It is convenient to see an argument as a sequence of sentences. This sentence includes the premises at the beginning and the conclusion at the end of the argument. An argument can contain several smaller steps and sub-arguments whose conclusions serve as the premises of the main argument. A valid argument is equal to if the premises of a valid argument are all true, then its conclusion must also

be true.

For example, in this paper, the first research question, "**Are nonsmoking areas 100% smoke-free in China and Germany?"** is a question aimed at judging the smoke-free status quo at the beginning of the research. **It could transfer to an argument: no smoke has been seen, smelled, sensed, or measured in all nonsmoking areas in China and Germany, then nonsmoking areas are 100% smoke-free in China and Germany. If the argument is proven invalid, move to the main research question.**

4.2.2 All, parts and some

Though linguistically similar in not including the whole or all, "part" and "some" are logically different. In this paper, the "part" means the cities with the strictest smoke-free practices (Hong Kong, Shenzhen, and Bayreuth). If they fail to achieve a 100% smoke-free city, the nations (China or Germany) representing the "all" also fail with insufficient enforcement effectiveness.

Suppes, P. (1957) stated that the phrases refer to different logical categories. "part" is relationally opposite to the "whole" and "some" to "all". They have different logical implications in that "part" precludes the possibility of the "whole". It is only a constituent of the "whole" and thus quite definite quantitatively and distinct from the "whole". "Some" is indefinite quantitatively and refers to "at least one, or a few, or even all". They have different truth values in those propositions with "some" and propositions with "all" form square of opposition, whereas propositions with "part" and propositions with the "whole" do not.

4.2.3 Counterexample

In logic, as stated by Gary L. Wise and Eric B. Hall. (1993), and especially in its applications to mathematics and philosophy, a counterexample is an exception to a proposed general rule of law.

In this paper, data, statistics, reports, newsletters, and photographs are all counterexamples to prove that the first research question, "**Are nonsmoking areas 100% smoke-free in China and Germany?" is invalid.**

The definition made a clear sample explaining what a counterexample is, quote:

> “For example, consider the proposition "all students are lazy". Because this statement claims that specific property (laziness) holds for all students, even a single example of a diligent student will prove it false. Thus, any hard-working student is a counterexample to "all students are lazy". More precisely, a counterexample is a specific instance of the falsity of a universal quantification (a "for all" statement).”
>
> (Definitions for counterexample – Freebase 2022)

Counterexamples usually argue that a specific philosophical position is wrong by showing that it sometimes does not apply. In mathematics, this term is also sometimes used in examples of the necessity of the entire hypothesis of a theorem by considering a case where a part of the hypothesis is not verified and where one can show that the conclusion does not hold.

4.2.4 Reduction to absurdity

In logic, reductio ad absurdum is the Latin for reduction to absurdity or argument to absurdity. It is a form of argument that attempts to disprove a statement by showing it inevitably leads to a ridiculous, absurd, or impractical conclusion. Or to prove one by showing that if it were not true, the result would be absurd or impossible, stated by Gensler, H.J. (2017). This way of logical thinking could trace back to classical Greek philosophy in Aristotle's Prior Analytics, according to the dictionary by Liddell, H.G. & Robert S. (1940). This technique has been used throughout the history in both formal mathematical and philosophical reasoning and debate.

In this paper, the **research applies the counterexample of the smoking offense to make the first question argument absurdity, showing that if it were not true.**

Two examples of arguments using reduction to absurdity are as follows for reference:

"The Earth cannot be flat. Otherwise, we would find people falling off the edge." This first example shows that it would be absurd to argue that the Earth is flat because it would lead to an impossible outcome since it contradicts the law of nature.

"There is no smallest positive rational number because if there were, it could be divided by two to get a smaller one." The second example is a mathematical proof by contradiction, arguing that denying the premise would result in a logical contradiction (there is a "smallest" number, yet there is a number smaller than it).

4.3 Field research

Field research or fieldwork collects information outside a laboratory, library, or workplace setting. The approaches and methods used in field research vary across research and disciplines. In this research, **field research majorly means independent investigation based on evidence collection with photos and sometimes interviews. This method avoids manual interference in smoke-free enforcement classification, especially in collecting counterexamples.**

Reyes-García, V. & Sunderlin, W.D. (2011) made a clear definition of field research, quote:

> **"Field research is a methodological approach to observe behavior under natural conditions.** Field research is traditionally contrasted to research conducted in laboratories or academic settings, or to research exclusively relying on existing, or secondary, data. In the social sciences, the collection of raw data in situ, often – but not exclusively – occurs in a geographical and cultural context not familiar to the person collecting the data. Differently from other methodological approaches, field research in the social sciences allows the researcher to engage in detailed observation and conversations to elicit information about the data being collected. There are many techniques and methods for data collection during field research (Bernard 1995), including:
>
> - Observation of events as they occur in natural settings sometimes expanded by means of a contextual inquiry. Observation can be naturalistic or participant, when the researcher engages in the observed activities;
> - Archival research or the study of information from already existing records, such as national census or local publications, but also personal documents;
> - Field experiments or experiments conducted in natural settings in order to understand causal relations among variables; and
> - Surveys or the collection of systematic data on people's actions, thoughts, and behavior through asking direct questions in natural settings. "
>
> (Reyes-García V. & Sunderlin W.D. 2011, 1)

Burgess, R. G. (1984) suggested that field research involves a range of well-defined, variable methods based on the researcher's needs. This measure includes informal interviews, **direct observation (especially in this thesis)**, group life participation, and collective discussions. Moreover, analyses of personal documents produced within the group, self-analysis, results from activities undertaken off- or online, and life histories. Although this method is generally aa category of qualitative

research, it may and often does include quantitative dimensions. The quality of results obtained from field research depends on the data gathered in the research field. The data, in turn, depend upon the field worker, his or her level of involvement, and ability to see and visualize information that other individuals visiting the study area may overlook. **When humans are the subject of study, protocols must be devised to reduce the risk of observer bias and the acquisition of too theoretical or idealized explanations of the workings of a culture. Participant observation, data collection, and survey research are examples of field research methods in contrast to experimental or lab research.**

4.4 Comparative research

Comparative research was first designed to compare different regions or cultures. It is a critical research methodology in the social sciences. As reviewed by Hantrais, L. (1999), the comparison is inherent in all science, including the social sciences, where comparative research has historically played a significant role in their development as a scientific disciplines.

Generally, **comparative research involves comparing two or more things and discovering something about one or all the indicators being compared.** One of the significant characteristics of comparative research is that **original data sets in different research objects may define categories differently or even not use the same categories. These techniques often use multiple disciplines in one or more studies. It is vital to design a correct method for such comparison**. Regarding the method, Antal, A. B., et al. (1987) stated that the majority agreement is that there is no methodology peculiar to comparative research. However, more research applies quantitative analysis instead of qualitative ones.

According to Social Policy and Socialism, written by Deacon Bob (1983), historical-comparative research involves comparing different time frames. The two main choices in this model are **comparing two stages at a time, either snapshots or time series, or just comparing the same thing over time to see if a policy's effects differ over a** while. Also, in comparative research, secondary analysis of quantitative data is relatively widespread, partly because of the cost of obtaining primary data for the country's policy environment. This study is generally an aggregate data analysis. Deutsch and Karl (1987) also suggested that comparing large quantities of data, especially government sourced, is prevalent.

Comparative research can take many forms, and the **two prominent essential factors are space and time**. Antal, A. B., et al. (1987) pointed out that cross-national comparisons are the most common. Although in most research, simple **comparisons within countries, contrasting different areas, cultures, or governments** are very constructive. Recurrent interregional studies apply to this

research. This field includes comparing similar or different countries or sets of countries instead of simply comparing one's own country to others or the whole world.

In this paper, the researcher applies **comparative research between China and Germany for a cross-national comparison of smoking epidemic statistics, smoke-free laws, smoking offenses counterexample, and smoke-free game models based on quantitative analysis.**

5 Counterexamples for Non-smoking Areas in China and Germany

To answer the first and starting research question: Are non-smoking areas 100% smoke-free in China and Germany? This paper will first estimate whether non-smoking areas in regions of China and Germany achieve this goal. The World Health Organization's smoke-free standards will be vital for status quo analysis and the following research.

The research starts with an assumption of the status quo. All the regions in China and Germany have reached the WHO standard at the beginning. This assumption is equal to 100% smoke-free in all non-smoking areas. No smoke has been seen, smelled, sensed, or measured, and the answer to the question is YES.

However, if any counterexample exists, such as law enforcement data showing active smokers exist by consuming tobacco products in a smoke-free area. Then, it means that smoke has been seen, smelled, sensed, or measured. This situation fit reduction to absurdity in logical analysis, this part and all-region in observation did not reach an entirely WHO smoke-free level. Thus, if the original hypothesis is an error, the proposition conclusion for the answer will be NO.

5.1 Counterexamples for non-smoking areas in Hong Kong SAR

Hong Kong has long-term annual data for smoking offense records, especially after applying the new smoke-free law in 2007.

The research turned real-time data of total enforcement figures against smoking offenses into Figure 6 from the Tobacco and Alcohol Control Office, Department of Health, Hong Kong SAR Government (2016).

This figure shows that Hong Kong has yet to reach the goal of being 100% smoke-free in most of the smoke-free areas. Offenses appeared from 2007 to 2015, even after a refined and complicated smoking ban in the entire city started in 2007.

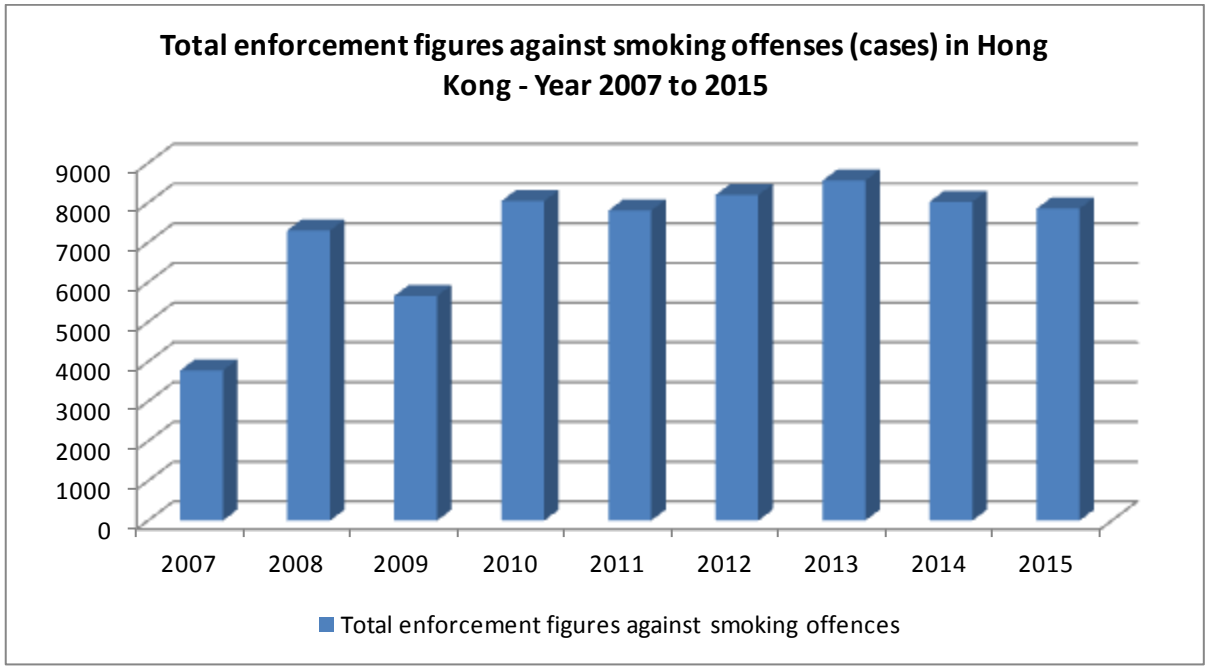


Figure 6. Total enforcement figures against smoking offenses in Hong Kong[5]

5.2 Counterexamples for non-smoking areas in other cities in China

Since the answer for Hong Kong, as part of China, to the first question is already NO. The answer for China as a country to the first question shall also be NO. More data from the WHO and newsletters make this assumption more convincing.

Data from the World Health Organization Western Pacific Region and the University of Waterloo, ITC Project (2015) show that smoking violation is common the important administrative cities. As located along the east side of China (as shown in Figure 7), including Beijing, Shanghai, and Guangzhou, had an extremely high percentage valued between 92% and 95% of smoking violations noticed in restaurants in 2008 before the implications.

The ratio of noticing active smoking in Chinese cities improved after they enacted their own smoke-free laws in 2008 and 2010. However, none of these cities achieved 100% smoke-free. The prevalence of smokers dropped dramatically from 67% to 77%, but none reached zero.

[5] Data source: https://www.taco.gov.hk/t/tc_chi/infostation/files/smokingstatistics_tc.pdf

Figure 7. Geographical map of China in English[6]

Previous literature by Ye, X., Yao, Z., Gao, Y., et al. (2014) also provides detailed violation data for Guangzhou. This assessment suggested that even in full smoking ban places, overall self-reported second-hand smoke exposure has declined significantly from 58.8% to 50.3% ($p<0.05$) but is still far from the goal of achieving 100% smoke-free in Guangzhou.

Meanwhile, a similar situation also appears in Shenzhen, the city next to Hong Kong, as marked with a red dot in Figure 7. Huang, S. (2014) reported that Shenzhen's smoke-free law was enforced for nine months, and more than 8,000 smokers were fined. These data were collected between March 1st and November 30th of 2014. The Shenzhen Municipal Public Security Bureau, the Urban Management Bureau, the City Transportation Commission, the Municipal Health Supervision Bureau, the Tourism Bureau of Style and Tourism Bureau, the City Market Authority, the Guangzhou

[6] Original picture source: https://e-politikk.no/images/verden/chinese_provinces_map1.jpg

Railway, and Shenzhen Airport are the eight law enforcement in this report. The law enforcement officers persuaded 90,417 smokers and punished 8,277 people with fines, and the total personal fines reached nearly 415,700 Chinese Yuan.

Thus, based on previous counterexamples among the cities in China, the answer for China to the first question is NO.

5.3 Counterexamples for non-smoking areas in Germany

Although Germany began smoke-free policy enforcement earlier than China and higher than other countries in the European Union (EU), 100% smoke-free is still challenging to achieve in Germany. The first counterexample came from the World Health Organization Western Pacific Region and the University of Waterloo, ITC Project (2015). This shows that 23% of active smokers were noticed after violating the law in restaurants in 2008. The same indicator was 86% in 2007. Moreover, a small inquiry by Wegner E.D (2016) shows 304 smoking offense cases in total recorded in Berlin from 2011 to 2015. This Kleine Anfrange in German (the written inquiry by Daniel Buchholz) presented a floating trend: 63, 68, 56, 60, and 57.

The German smoking ban also protects passive smokers from toxic smoke. The number of fines is relatively low and unstable compared to that in China. A newsletter by Dieter Schulz (2016) argued the effectiveness of being smoke-free when not punishing active smokers.

The news shows the process of how smoke-free enforcers deal with such cases when active smoke violates the smoke-free policy. It reported two violations, one in restaurants and one in a playhouse. The fines were initiated exclusively against the operators, not against the active smoking guests. 200 Euro (€200) was payable per violation in these 2 cases, according to this newsletter. In fact, it is a bad sample of regulating a smoke-free policy when no fine goes to the active smoker.

The newsletter also shows that the fine is not always equal to the amount in the smoke-free policy, selected from the same page by Dieter Schulz (2016), translate and quote:

> “In Schleswig-Holstein, both smokers and innkeepers face fines of up to €1000. The neighboring Mecklenburg-Vorpommern demands a record-breaking €10,000 penalty for illegal quagmires but only €500 to the state. Infringements of the non-smoking law were not established in the context of 'event-related controls'.
>
> In 2015, land management punished record-breaking ten violations

> during the past year. All fines (on average €100) were against the gastro-operators. The smoking guests went out on the tourist island tautly. In Itzehoe, it was just two detected violations in 2015, and each of which was punished with €88.50.
>
> In the self-proclaimed shopping center, which has a relatively lively gastro-scene, the number of smokers has remained relatively constant since the introduction of the smoking ban. Thus, in reality, the danger of being caught in the north is relatively small; the pressure of the local authorities is hardly noticeable. In the past year, 2015, the city of Kiel had only found three violations linked to a legal smoking ban."
>
> (Dieter Schulz 2016)

Based on these counterexamples, the answer for Germany to the first question is also **NO**.

In summary, the answer to "Are non-smoking areas 100% smoke-free in China and Germany?" is NO. At least one case or record has been identified as a counterexample in both China and Germany. They show that smoke has been seen, smelled, sensed, or measured within non-smoking areas in China and Germany.

According to the literature review and logical analysis, active smokers exist and play an essential role in breaking 100% smoke-free in all kinds of non-smoking areas. Thus, the main question appears: **"Why do active smokers take the risk of breaking the law in non-smoking areas?"**

6 Evolution of Hong Kong Smoke-free Legislation

Previous chapters prove that both China and Germany fail to achieve 100% smoke-free. This research now moves to the main question: **"Why do active smokers take the risk of breaking the law in non-smoking areas?"** Starting the simulation for active smoker behavior requests a city as a proper research object to evaluate active smoking.

According to data collection and logical analysis based on part and all, the researcher selected the regions with the strictest smoke-free policy levels in China and Germany as potential objects. Begin with Hong Kong because it was the city with the strictest smoke-free policy in 2007, which is the earliest in China. Hong Kong also has the most advanced reporting platform for smoke-free data accepted by WHO. Shenzhen is the following city with the strictest smoke-free policy in mainland China after 2009. The World Health Organization Western Pacific Region and University of Waterloo, ITC Project (2015) also indicated that Shenzhen has been applying the highest level of non-smoking policies in mainland China for different years.

In Germany, the most rigorous region is Bavaria, a typical state with the highest smoke-free level. Munich and Bayreuth are the reference cities to test whether there is a case of violation as a counterexample. Meanwhile, case data of Berlin and Beijing were selected as capital city samples for future research. The reasons for choosing Hong Kong as the specific object region for smoke-free research are listed in the following chapter.

6.1 Reasons to select Hong Kong as the primary sample for modeling

This paragraph explains the reasons for selecting Hong Kong as the primary sample for smoke-free game-theoretical modeling research among all the potential cities and regions.

In 2005, Lam T. H (2005) and his research teammates from the Hong Kong University Public Health Institute finished unique research on death and economic loss attributed to second-hand smoke. The research became the reference for the Hong Kong government in the 2007 smoking ban, and the team updated the research in 2014. This result is also approved in the WHO (2008) yearbook on tobacco control, which is almost equal to similar research in the USA. The WHO suggested that this result is reliable and suitable for international comparative research. These essential data about second-hand smoking health and economic loss are rare and vital. There was no similar city-level research in mainland China or Germany in 2015. These data

support the research on the basis of the smoke-free game model within health degrees. Otherwise, the research could not be initiated without one of the most critical pixels of decision-making.

Hong Kong has been collecting long-term data on smoking trends since 1928, when its first smoking ban occurred. It is the longest and first in modern Chinese history among all potential regions for sample research. The data include not only the raw numbers of offenses and the total number of enforcement but also collected detailed data according to the place of offense from 2007. It also stored comparative data before, during, and after the new smoke-free policy application.

The online reporting platform for smoking-related data in Hong Kong is clear and accessible. Unlike other cities in China, viewing and downloading statistical data and reports on smoking directly from government websites, as suggested by Jeff PM Lee (2016), is common in Hong Kong for tobacco control. Especially after 2007, the government announced constant data on the total number and composition of smoke-free enforcement annually on the Hong Kong tobacco control committee website. Better compared to waiting for a newsletter or a small inquiry in mainland China and Germany.

6.2 Smoke-free legislation evolution and its milestones in Hong Kong

This research will form and simulate a smoke-free legislation regime with the game-theoretical model in the following chapters. The first step is understanding the regulations and laws at the literature level. This process helps illustrate the game's rules, which could also be considered the institution of game modeling.

6.2.1 Evolution of Smoking (Public Health) Ordinance

"Chapter: 371 Smoking (Public Health) Ordinance" is the primary legislation for smoking control in Hong Kong enacted by the Hong Kong SAR government (2012). After being rewritten and upgraded several times, it now has 11,458 words and 20 pages. The first update for this chapter was on 13 August 1982, and the latest update was on 9 February 2012. The latest significant upgrade via the Smoking (Public Health) Bill 2005 was for implementation on 1 January 2007. The law designated the entire city as a non-smoking area from this date, except for some exempt regions.

As a comprehensive law chapter on smoking, the content of the Smoking (Public Health) Ordinance includes, quote:

> “To prohibit smoking in certain areas; to provide for the display of a health warning and other information on packets or retail containers of

tobacco products; to restrict tobacco advertising; to restrict the sale or giving of tobacco products; to provide for the appointment, powers and duties of inspectors for the enforcement of certain provisions of this Ordinance; and to provide for incidental and related matters."

(Hong Kong SAR government 2012, 1)

Unlike other law documents filled with direct lines, the first section of Chapter: 371 Smoking (Public Health) Ordinance is a long list. It contains each part that has changed over the past 30 years. Furthermore, the first part of this document is preliminary, with interpretation as the central section, which lists the essential keywords used in the ordinance both in English and traditional Chinese. The updated information is also listed, followed by every word with an explanation. Take some phrases related to this research, for instance, quote:

"**Indoor (室內)** means

(a) having a ceiling or roof, or a cover that functions (whether temporarily or permanently) as a ceiling or roof;

and

(b) enclosed (whether temporarily or permanently) at least up to 50% of the total area on all sides, except for any window or door, or any closeable opening that functions as a window or door; **(Added 21 of 2006 s. 4)**

Manager (管理人), in relation to a no smoking area or a public transport carrier, means

(a) any person who is responsible for the management or is in charge or control of the no smoking area or public transport carrier. And includes an assistant manager and any person holding an appointment analogous to that of a manager or assistant manager; or

(b) in the case where there is no such person in relation to any premises, the owner of the premises; (Replaced 21 of 2006 s. 4)

No smoking area (禁止吸煙區) means an area designated as a no smoking area under section 3; (Replaced 9 of 1992 s. 2. Amended 93 of 1997 s. 2; 21 of 2006 s. 4)

Public place (公眾地方) means

(a) any place to which for the time being the public are entitled or permitted to have access, whether on payment or otherwise;

or

(b) a common part of any premises notwithstanding that the public are not entitled or permitted to have access to that common part or those

premises; **(Added 21 of 2006 s. 4)**

Restaurant premises (食肆處所) means any premises on or from which there is carried on—

(a) a factory canteen or restaurant within the meaning of section 31(2) of the Food Business Regulation (Cap 132 sub. leg. X);

or

(b) any other trade or business the purpose of which is for the sale or supply of meals or unbottled nonalcoholic drinks (including Chinese herb tea) for human consumption on the premises. (whether or not it is carried on by a person who is the holder of a licence under the Hawker Regulation (Cap 132 sub. leg. AI));

(Replaced 21 of 2006 s. 4)

Smoke (吸煙、吸用) means inhaling and expelling the smoke of tobacco or other substance."

(Hong Kong SAR government 2012, 2–4)

The second part of the Smoking (Public Health) Ordinance is the no-smoking areas, which identified prohibiting smoking in certain designated areas. **"No person shall smoke or carry a lighted cigarette, cigar or pipe in a no-smoking area."** is the standard to identify a smoke-free offense.

One phrase that closely connects to this research is the changing role of the manager (管理人 in Chinese). Especially in a no-smoking area or a public transportation carrier also during each update of the smoke-free policy. The definition of the manager of the premises is any person responsible for managing the statutory no-smoking area or public transport carrier. It includes the assistant manager and any person holding an appointment analogous to a manager.

The responsibility of managers in statutory no-smoking areas is to place no-smoking signs in a prominent position at first. This aim to remind the public that the premises are statutory non-smoking areas. Managers should maintain such signs in good order or be fined HK$15,000. In 2007, the Smoking (Public Health) Ordinance empowered the manager of a no-smoking area to enforce the relevant law. The manager will ensure no active smoking on the premises, but there is no extra supervision for the manager to apply these countermeasures, quote:

"The manager of a no smoking area or any person authorized in that behalf by any such manager may, in respect of any person who appears to be contravening subsection (2)-

(a) after indicating that the person is smoking or carrying a lighted cigarette, cigar or pipe, as the case may be, in a no smoking area in contravention of subsection (2), require the person to extinguish the lighted cigarette, cigar or pipe;

(b) where the person fails to extinguish the lighted cigarette, cigar or pipe, require him-

(i) to give his name and address and to produce proof of identity; and

(ii) to leave the no smoking area;

(c) where the person fails, as required under paragraph (b)-

(i) to give his name and address and to produce proof of identity; or

(ii) to leave the no smoking area,

remove him from the no smoking area by the use of reasonable force if necessary and detain him and call for the assistance of a police officer to assist in the enforcement of this section.

(4) Where a person is, under subsection (3), required to leave a no smoking area, removed from a no smoking area or detained, he shall not be entitled to a refund of any admission fee or money paid by him for entry into the premises or building in which the no smoking area is situated.

(5) For the avoidance of doubt, it is declared that subsections (1) and (1AB) apply to any premises that are owned or occupied by, or under the management and control of, the Government. (Added 21 of 2006 s. 5) ”

(Hong Kong SAR government 2012, 5)

Figure 8 shows the decision route of a non-smoking manager facing a smoking offense. It is the basis for the game tree options composition, similar to the prisoner's dilemma research process when transforming a case into a model.

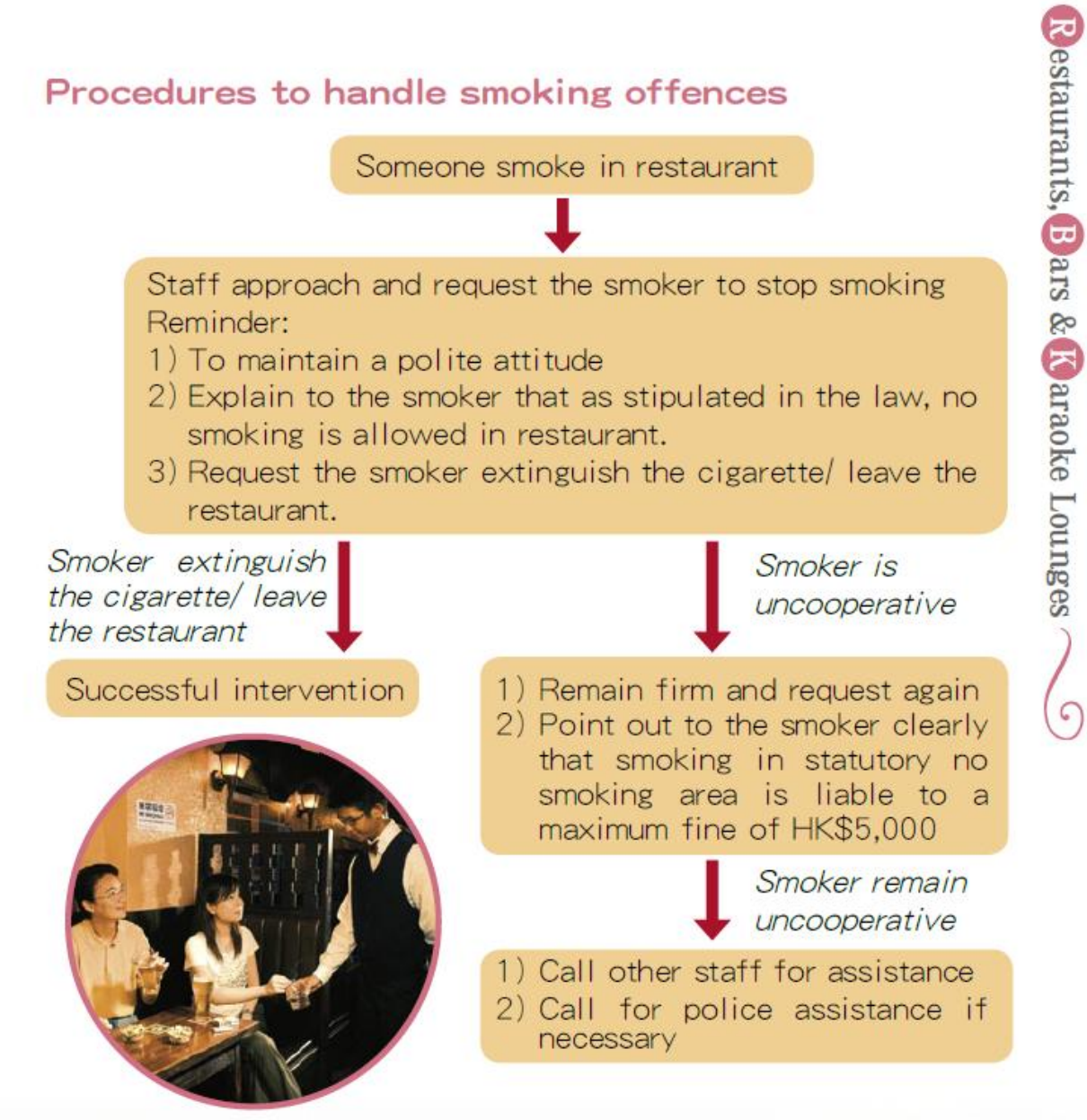


Figure 8. Procedure for a manager to handle smoking offenses in Hong Kong[7]

Part 5 Supplementary, Section 19 Transitional provisions relating to the Smoking (Public Health) (Amendment) Ordinance in 2006. Schedule 1 Public Transport Carriers Where Smoking is prohibited. Schedule 2 Designated No Smoking Areas and Exempt Areas. All these parts list every regulated non-smoking area which fits the principle WHO requested in detail. Part 1 quote:

7 Screenshot source: Page 14.
https://www.taco.gov.hk/t/sc_chi/downloads/files/Smoke_free_rest_guidelines_eng.pdf

"Designated No Smoking Areas

Item Type of area

1. Any cinema, theater or concert hall.

2. Any public lift.

3. Any escalator.

4. Any amusement game center.

5. Any child care center.

6. Any school.

7. Any specified educational establishment.

8. Any approved institution.

9. Any place of detention.

10. Any place of refuge.

11. Any reformatory school.

12. Any hospital.

13. Any maternity home.

14. Any public pleasure ground other than a bathing beach.

15. The following areas within any bathing beach-

(a) any part of the waters set aside for the sole use of swimmers under section 10 of the Bathing Beaches Regulation (Cap 132 sub. leg. E) (which includes any beach raft and any other thing on the surface of or above those waters);

(b) the shore covered with sand or stones, together with any structure, showering facilities or natural feature on such shore; and

(c) any area specified under section 107(3) of the Public Health and Municipal Services Ordinance (Cap 132) to be used as a barbecue area, camp site or children's play area.

16. The following areas within any public swimming pool-

(a) any swimming pool;

(b) any sidewalk immediately adjacent to the swimming pool;

(c) any diving board or other apparatus or facility adjoining the swimming pool; and

(d) any spectator stand.

17. The following areas within any stadium-

(a) any pitch;

(b) any running track;

(c) any sidewalk immediately adjacent to the pitch or running track; and

(d) any spectator stand.

18. The Hong Kong Wetland Park designated under section 24(1) of the Country Parks Ordinance (Cap 208).

19. An indoor area in-

(a) any shop, department store or shopping mall;

(b) any market (whether publicly or privately operated or managed);

(c) any supermarket;

(d) any bank;

(e) any restaurant premises;

(f) any bar;

(g) any karaoke establishment;

(h) any mahjong-tin kau premises;

(i) any bathhouse;

(j) any massage establishment;

(k) any residential care home;

(l) any treatment center; or

(m) any communal quarters (as defined in Part 3).

20. An indoor area in a workplace or public place to the extent that it is not an area described in any other item in this Part. ”

(Hong Kong SAR government 2012, 15)

Sometimes, a lawsuit against active smokers will lead to these updates in Hong Kong based on experience and lessons, according to documents collected by Hong Kong Legislative Council (2005). As recalled in this section, restaurants or food premises are smoke-free regulated areas. Nevertheless, at first, the Smoking (Public Health) Ordinance is designed for the indoor area only. The law enforcer once accused an active smoker of breaking the law on restaurant premises. However, this active smoker argued that he was smoking at the table outside the restaurant, which is not in the indoor area. Later after this law case, one more line to explain indoors is added as a lesson from this case. Enclosed (temporarily or permanently) at least up to 50% of the total area on all sides, except for any window or door or any closeable opening that functions as a window or door (Added 21 of 2006 s. 4.).

On 1 September 2009, the Hong Kong SAR government (2009) enacted the Chapter: 600 Fixed Penalty (Smoking Offenses) Ordinance. This new chapter is one of the significant changes to the fine for committing an active smoking crime in the regulated non-smoking area. It is an 11-page additional law with 5,333 words. Before 2010, the maximum fine was 5,000 HK dollars. However, the actual fine is much lower, according to documents released by Hong Kong Legislative Council (2008). Few law-breakers paid that much because the enforcer have to wait for the court to decide the actual amount of the fine. The court takes time to process simple progress to confirm the crime, and the fine is usually less than HK$1,000. Now, the implementation of the smoking offense "Fixed Penalty

(Smoking Offenses) Ordinance" sets the penalty fixed. Any members of the public in a non-smoking area smoking violation will be a fixed penalty of HK$1,500.

Although the fine is fixed, the highest potential smoking penalty remains HK$5,000. According to the remaining lines in Chapter 371, any person who contravenes section 3 or 4 commits an offense and is liable on summary conviction to a fine of HK$5,000.

Besides, any person who fails to give his name and address is liable on summary conviction to a fine at level 3, which is HK$10,000. This line also applies to producing proof of identity when required and under section 3(3) or 4(2). Moreover, a person who gives a false or misleading name or address commits an offense.

Fixed Penalty (Smoking Offenses) Ordinance also shows the form of the penalty in the regulation documents, which is unique and not included in the attachment page of other cities' regulations for smoke-free. This line is a typical sample for other regions to learn about fixed penalty regulation.

6.2.2 Hong Kong Smoke-free Milestones Review: 1982-2013

1982

The start of the Chapter: 371 Smoking (Public Health) Ordinance.

1983

First established statutory no-smoking areas:

Public lift and lower part of land public transport ban smoking;

Lifts have become a smoke-free area for the first time in China.

1992

Expand statutory no-smoking areas:

Cinemas, theaters, concert halls, public lifts, amusement game centers, and public transportation are now statutory non-smoking areas.

1998

Expand statutory no-smoking areas:

Shopping malls, department stores, supermarkets, and banks were statutory no-smoking areas. The Airport Passenger Terminal Building Authority may specify the range of non-smoking areas. All restaurants, schools, tertiary institutions, and

vocational training centers will be set at various designated places in non-smoking areas.

2001

The Hong Kong SAR government formally established the Department of Health Tobacco Control Office.

2005

China is to become one of the signing parties to the World Health Organization Framework Convention on Tobacco Control, and Hong Kong is responsible for expanding the relevant measures to fulfill.

Hong Kong is changing with China becoming a member of the WHO Framework Convention on tobacco control.

2006

Amendment to the Smoking (Public Health) Ordinance:

Council adopted the draft "2006 Smoking (Public Health) (Amendment) Ordinance" to achieve comprehensive indoor smoking in public places.

2007

Expand statutory no-smoking areas, and the revised Smoking (Public Health) Ordinance came into effect on 1 January 2007;

All restaurants, indoor workplaces, markets, public satisfaction grounds, and other public places are statutory non-smoking areas.

2009

Expand statutory no-smoking areas:

The smoking ban extended to fashion exempted category six places, including bars, clubs, nightclubs, bathhouses, massage establishments, and mahjong-tin Kau playing music venues. Also, the smoking ban was extended to cover the first phase of 48 buildings has public transportation facilities.

2010

Part of open public transport facilities into statutory no-smoking areas:

Smoking extended to 129 open-air public transport facilities and the other two covered public transport facilities.

2012

Amendment statutory no-smoking areas:

Nine open public transport facilities are now statutory non-smoking areas. Adding another 13 statutory non-smoking areas due to environmental change that plan to make changes in a range of non-smoking areas.

6.3 Detailed comparative data on smoking behaviors in Hong Kong

To answer "Why do active smokers take the risk of breaking the law in non-smoking areas?" the research also applies detailed comparative data as part of the background to evaluate active smoking and active smoker. These data may not be calculated in the game model but will provide references on Hong Kong's active smoking behaviors during the year of the smoking-ban policy upgrade.

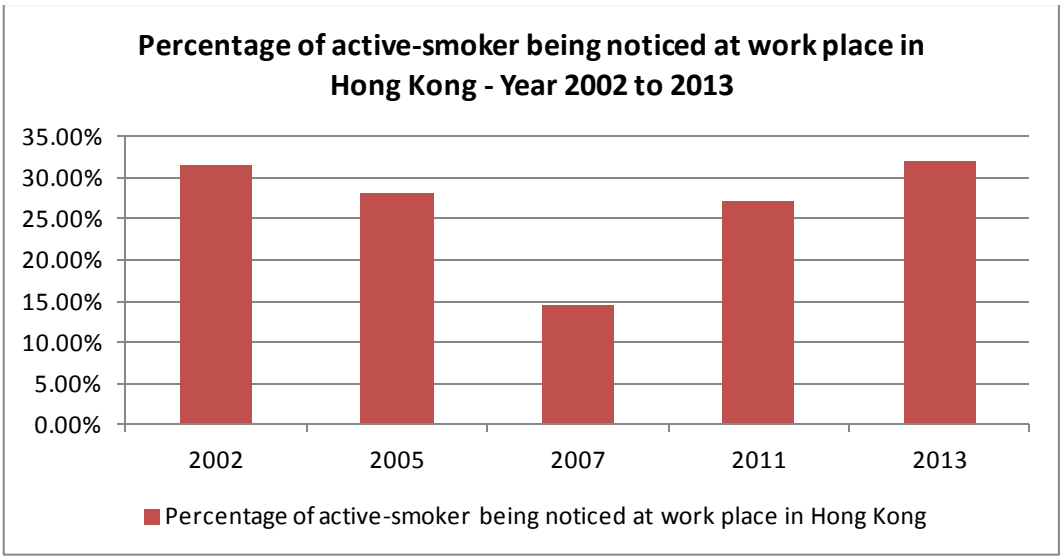


Figure 9. Percentage of active smoker noticed at work place in Hong Kong[8]

Figure 9 shows that before the renewed smoking ban came into action in 2007, the number of active smokers was around but lower than 30% in 2005. While in the workplace compared to the data in 2002. During the 2007 smoking ban, active smokers were less than 15% in workplaces, with a dramatic decrease. Four years after the 2007 smoking ban, active smokers recorded within three meters of the workplace heightened to roughly 27% compared to 2011. It was almost the same rate in 2005, pointing out that the smoke-free policy effectiveness is not improving as expected. Six

8 Data source: Census and Statistics Department, Hong Kong SAR. Thematic Household Survey Report, No.36, No.48 and No.53.
https://www.censtatd.gov.hk/en/data/stat_report/product/C0000047/att/B11302532013XXXXB0100.pdf.
https://www.censtatd.gov.hk/en/data/stat_report/product/C0000047/att/B11302482011XXXXB0100.pdf.
https://www.censtatd.gov.hk/en/data/stat_report/product/C0000047/att/B11302362008XXXXB0100.pdf

years after the 2007 smoking ban, active smokers recorded within three meters of the workplace reached 32% in 2013. The number is higher than the rate in 2002, suggesting the smoke-free policy effectiveness is even worse.

These data indicated that active smokers existed before, during, and after the 2007 smoking ban. The rate of active smoking offenses in indoor areas is declining but lifting in outdoor areas, which directs the selection of non-smoking area sample in-game model more focusing on outdoor areas.

Another fact shown in the charts is that the way smokers consume tobacco products is not changing with the 2007 smoking ban. According to data released by the same series of Hong Kong statistic reports, 81.2% of smokers did not change their way of smoking even during 2007 when the smoking ban came into force. Furthermore, 88% of smokers did not change their way of smoking in 2010, which is even higher compared with 2007.

This background data indicates that the current smoking ban regime is not enough to lead and change the behavior of active smokers. In this paper, nicotine addiction represents the bounded rationality of smokers in the model base on the fact as an explanation.

According to the American Cancer Society (2012), nicotine is an addictive drug like heroin and cocaine, and it keeps people coming back for more. Anyone who starts smoking or using tobacco in other forms can become addicted to nicotine. Although other cigarette substances cause cancer, nicotine is an addictive substance in tobacco. Nicotine is physically and psychologically addictive. Both of these addictions may begin from the first cigarette. Cigarettes contain additives to strengthen tobacco's addictiveness, and many people cannot quit smoking despite repeated attempts. Although the physical effects of nicotine are pleasant, significant psychological effects do not cause any noticeable "high" sensation. The primitive and unconscious brain receives a false "reward" from the effects of nicotine. The brain responds to this "reward" by developing a robust primitive response: nicotine addiction. Uptake receptor growth causes a chemical imbalance in the brain, making the user feel depressed and anxious when nicotine levels are low. The brain attempting to compensate for the release of so many "reward" chemicals is the cause.

7 Game-theoretical Modeling base on Hong Kong Smoke-free Law

In this chapter, the researcher set Hong Kong as the primary sample to evaluate smoke-free legislation applications on behalf of the regulator. The upgrades of smoke-free game-theoretical models are similar to the approach when developing the prisoner's dilemma theory for evaluation during framing and simulating.

Developing a smoke-free game-theoretical model starts with a confirmed case record of a counterexample in Hong Kong as the basis of model simulation fundamental research. Then, form the most straightforward standard game to simulate the choice and payoff of an active smoker in words as a draft model. After the second step, fill in the options with the data selected and calculate via health, economic, and satisfaction degrees as a basic model. Next, apply a tree game with enhanced interaction between the players as an advanced model. Finally, the process ends with a tree game simplified model suitable for cross-nation comparative research.

According to previous research on smoke-free policy, the smoke-free law is technically valid in all kinds of smoke-free areas. Thus, the smoke-free model in this chapter is general instead of specific. Viewing the game from the perspective of a smoke-free regulator means that the information is complete and perfect, considering all indicators. Furthermore, the government focuses more on monitoring and stopping active smokers without any special requirement or prerequisite, which could apply to any non-smoking area in future research with adjustments according to actual case data.

7.1 Counterexample in Hong Kong for Gambit modeling

For the background of this counterexample, the researcher witnessed and recorded this actual case of a smoking offense at Hong Kong Polytechnic University in 2007. At that time, Hong Kong had passed a new smoking ban throughout the entire university, including all indoor and outdoor areas as statutory non-smoking areas.

According to the campus map of Hong Kong Polytechnic University shown in Figure 10, the areas in white are the teaching buildings classified to be indoor non-smoking areas in the university. The areas in light brown color are the outdoor (playground and garden) or both indoor and outdoor (sidewalk between the buildings with a roof) regulated non-smoking areas. The researcher witnessed a smoking offense between the sidewalks of the P Building and the Q Building. One man smoked a cigarette near the chair facing the street and then walked away. Figure 10 shows the location of this smoking offense with a yellow arrow.

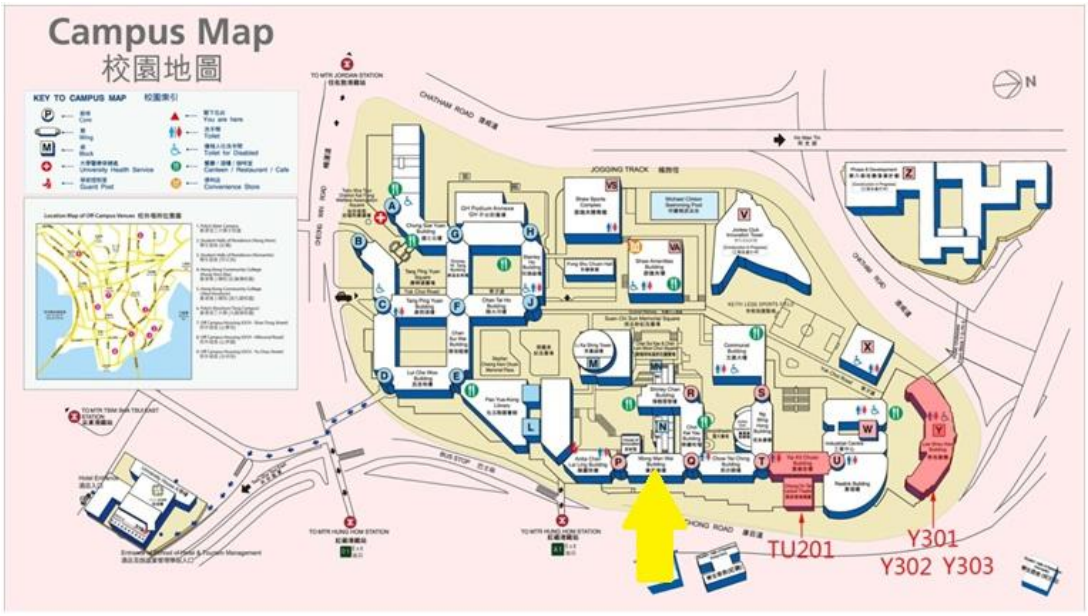


Figure 10. Campus map of Hong Kong Polytechnic University[9]

In fact, the signs and posters for smoking ban information have been evident at the Hong Kong Polytechnic University since 2007, but active smokers still exist in such a strict smoke-free area. Figure 11 shows a welcome poster at the Hong Kong Polytechnic University entrance clear for every visitor entering the university. It also highlighted that the maximum penalty for a single smoking offense was HK$5,000 in 2007.

Figure 11. Welcome poster of No Smoking and a maximum penalty of HK$5,000[10]

[9] Original picture source: https://www.polyu.edu.hk/cdo/images/Campus_Map/CampusMap.jpg

In fact, the signs and posters for smoking ban information have been evident at the Hong Kong Polytechnic University since 2007, but active smokers still exist in such a strict smoke-free area. Figure 11 shows a welcome poster at the Hong Kong Polytechnic University entrance clear for every visitor entering the university. It also highlighted that the maximum penalty for a single smoking offense was HK$5,000 in 2007.

Figure 12. “Smoking on campus is strictly prohibited” signs[11]

The research set **"Why do active smokers take the risk of breaking the law in non-smoking areas?"** as the primary research question. Now, the researcher starts the transformation of this actual case into a general smoke-free model to simulate the decision-making process based on a similar analytical procedure of the prisoner's dilemma.

Significantly, the manager of the non-smoking area, in this case, will be the security officer patrolling the Hong Kong Polytechnic University campus. The model covers non-smoking areas that have both indoor and outdoor areas, and the location where the real case occurred is a semi-open non-smoking area according to the classification by Hong Kong smoke-free law.

[10] Original photo source:
http://photo.blog.sina.com.cn/showpic.html#blogid=3e4504dc01000704&url=http://s10.sinaimg.cn/orignal/3e4504dc44c4072b74ca9

[11] Original photo source:
http://photo.blog.sina.com.cn/showpic.html#blogid=3e4504dc01000704&url=http://s12.sinaimg.cn/orignal/3e4504dca51982863d37b
http://photo.blog.sina.com.cn/showpic.html#blogid=3e4504dc01000704&url=http://s6.sinaimg.cn/orignal/3e4504dc9ea0a4daeda55

7.2 Game in words instead of numbers—the draft smoke-free model

Before introducing a computer-based game-theoretical model, the research forms the most straightforward regular game to simulate the choices and payoffs of active smoker and other players in words instead of numbers. This formation will set the draft and basis of the model before further research, following a similar route to developing a prisoner's dilemma. Thus, all the strategic games in draft modeling are non-cooperative 3-player finite static games with complete information if with no further notification.

Three major players in a typical smoke-free game are: active smoker, passive smoker, and manager (responsible for the non-smoking area);

Each player has two options on a single table, and they will decide simultaneously, representing the situation when all players gather together. One table represents different active smokers' choices when deciding whether to smoke or not at first. Another table represents whether passive smoker or managers will stop active smoker or not. All players are rational and will choose the best option with the highest payoff as their preference.

Three dimensions affect payoff, including Health, Satisfaction, and Economics. Especially,:

"-Health" means the health economic loss attributed to active or passive smoking.

"-Fine" means that the enforcer witnesses and punishes the smoke-free law-breaker with a fine.

"-Income" means the manager receives an extra income loss or penalty.

The first table only accounts for the health dimension, which means it will only consider changes in health in this game-theoretical draft model, as shown in Table 4.

Table 4. Smoke-free game-theoretical model (health)

Smoking?	**Yes**	**No**
Active smoker	**-Health***	0
Passive smoker	-Health	**0***
Manager	-Health	**0***
P.S. * represents the preference of a specific player		

Table 4 shows that all players will suffer health and economic loss when the active smoker consumes tobacco products like a cigarette in a non-smoking area. In contrast, all the players will win when the active smoker decides not to smoke.

Strangely, the preference of this smoker is In contrast to the computation of the payoff matrix, which is specially indicated using asterisk when data is unknown. In reality, active smokers will still choose to smoke in many cases while ignoring an all-win result. Active smokers prefer to smoke and lose health instead of not smoking like the others. This decision-making is different from the result of direct calculation in the payoff matrix but exists in reality. The researcher discovered and named this "all-win or all-lose" as a particular case in game theory that applies to smoke-free analysis. Moreover, an active smoker has the privilege to set the winning status of all game players in this case. The researcher named such a player the "key player" in game theory, similar but more vital than the destructor.

Although almost every active smoker is aware of the harm of smoking nowadays, in the actual cases proven by data and records, active smoker did exist with a preference to start smoking in a non-smoking area irrationally. The explanation for this behavior is that active smokers may get satisfaction from easing their need for nicotine. Simultaneously, the passive smokers and managers are at health risk with the decision of active smoker. This situation is another type of bounded rationality in this research. Later, adding satisfaction to the smoke-free game-theoretical model to be the second dimension. This arrangement applies the effect of such irrationality in a game when all the players are considered to be rational.

Table 5. Smoke-free game-theoretical model (health and satisfaction)

Smoking?	**Yes**	**No**
Active smoker	**-Health +Satisfaction***	-Satisfaction
Passive smoker	-Health	**0***
Manager	-Health	**0***
P.S. * represents the preference of a specific player		

Table 5 shows the smoke-free draft model (health and satisfaction) depicts the situation fits the reality and makes the payoff matrix calculable. All players still suffer health and economic loss when the active smoker starts smoking in a non-smoking area. According to this design, satisfaction added to the active smoker option in this model shall be higher than health loss to simulate a "rational" active smoker. This arrangement will make the program work, and the researcher will test several models after filling the data for a recheck. Another situation appears when the smoker chooses not to smoke, all the players except the active smoker will play without any health loss. Still, the active smoker now faces the loss with minus satisfaction.

After introducing the satisfaction dimension, the standard game is now playable and makes sense. Then, the research will apply the economic balance to the model as the third dimension. Table 6 shows the completed smoke-free draft model with health,

satisfaction, and economic degree. This model is with three significant indicators affecting all the players during game play.

Table 6. Smoke-free game-theoretical model (health, satisfaction and economic)

Smoking?	**Yes**	**No**
Active smoker	**-Health +Satisfaction (-fine) ***	-Satisfaction
Passive smoker	-Health	**0***
Manager	-Health (-income)	**0***
P.S. * represents the preference of a specific player		

When the active smoker decides to smoke in a non-smoking area, he or she will take the risk of being witnessed and punished by a smoke-free enforcer. So the fine is shown in brackets "()" as this is a possible incident, not a confirmed fact. The manager also risks losing future income if the active smoker is confirmed with an offense of smoke-free law. In some regions, like Shenzhen, this may also lead to a fine for the manager. Alternatively, even worse, the cost of long-term income by canceling the permit to do business. The income loss of the manager is also in brackets since the possibility of this incident will not be 100%. If the enforcer fails to identify the active smoker in time, the result will remain the same as the smoke-free game-theoretical model in Table 5.

Now, the game model is transferred into a combination of two normal game matrices in the strategic form of a table. These matrices will make the table fit the way of the classical game-theoretical model and easy to calculate in the future. This table is similar to previous work by Alan Shiell & Simon Chapman (2000) with a 2-person normal form game analysis. Other researchers stop with a single statement about the prisoner's dilemma at this stage. Similar to the current research level, the research also marks all current indicators using letters of the alphabet in table 7.

The health loss for different players is named as Hs for the smoker, Hp for the passive smoker, and Hm for the manager. The satisfaction for the active smoker is now Sa in the table. The possibility of the enforcer catching the smoker is now Pc, and the violation fine is Fv. This violation would lead to income loss for the smoker alone, excluding the manager. This arrangement is done because most public places are non-smoking in the status quo.

Furthermore, there are no options for the smoker to choose another place without a smoking ban during smoke-free game play. When Pc is multiple with Fv, it shows an uncertain fine by the enforcement with possibility. It also separately represents different strategies of active smokers and their payoffs. For other players, choose to

stop or not to stop the smoker with payoffs after active smoking. Especially, the preference of a specific player will no longer add an asterisk to express possibility without a formula. Moreover, the final results will be listed in bold font for the following models. The sample payoff matrix for all dimensions is in Table 7:

Table 7. Payoff matrix of smoke-free game ((health, satisfaction and economic)

Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	[-Sa-Hs-Pc×Fv, -Hp, -Hm]	[-Sa-Hs-Pc×Fv, 0, -Hm]
Leave smoker alone	[-Sa-Hs-Pc×Fv, -Hp, 0]	**[Sa-Hs-Pc×Fv, 0, 0]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[-Sa, 0, 0]	[-Sa, 0, 0]
No need to leave alone	[-Sa, 0, 0]	[-Sa, 0, 0]

Table 7 shows the payoff matrix of the smoke-free draft game. Square brackets in each selection represent the payoff for the players when selecting specific options. The first is the loss of the active smokers. The second is the loss of the manager of the non-smoking area. Moreover, the third is the loss of passive smokers. Technically, all players in this game will attempt to avoid minus health loss. This selection is the strategy to achieve Pareto optimum if smokers choose not to smoke. Only active smokers suffer -Sa, the satisfaction lost without active smoking, while others do not have to bear any health loss.

However, a smoke-free game is a collaborative decision-making process when the manager and passive smoker tend to leave the active smoker alone with inaccurate simulation. According to the formula, as other researchers did, if Hp and Hm are both greater than 0, both players will avoid this bad option with health loss. This "all-win or all-lose" case may not make sense in mathematical processing but already **presents an ending situation similar to the prisoner's dilemma. The manager and passive smoker want the opposite player to stop active smoking while leaving the smoker alone unstopped.**

Furthermore, a smoker should stop smoking if they are stopped when -Sa-Hs-Pc×Fv < -Sa. However, since the passive smoker and manager both tend to leave the smoker alone when the equilibrium stops at **[Sa-Hs-Pc×Fv, 0, 0].** This situation will happen when Sa-Hs-Pc×Fv > -Sa, which equals Sa > (Hs+Pc×Fv) / 2 as well. Nevertheless, due to Sa, the over-estimated satisfaction of active smoking with bounded rationality, the smoker will refuse to choose not to smoke in reality. Smoker

still tends to active smoking Even when there are -Sa when being stopped, -Hs due to active smoking and chance get caught and punished by an enforcer, Pc×Fv. This draft design leads to another version of the chance player following modeling development, and it is only suitable for static table games in early research.

This formula matrix is where others stop with a statement of the prisoner's dilemma and end their research publishing with alphabetic formulas. The research only makes this a draft model because it does not connect with the actual case data. What are the exact amounts of health loss? How did the writer evaluate satisfaction when it is uncertain? When will the enforcer successfully stop active smoking? None of these questions could be answered by simply using the alphabetic formula and what the researcher explores. It reaches its limit and cannot move forward to simulate one natural round of smoke-free game play. The research will now fill in the data step by step to frame a calculable payoff matrix. Then develop a basic model that starts by inserting actual case data of health economic loss.

7.3 All-win or all-lose in health degree—importance of key player

To fill in the data with the health and economic loss of the players in the payoff matrix, the researcher collects and calculates the original database on local research. It was conducted by the Hong Kong University Public Health Institute and announced by the Chairman of the Smoking and Health Committee in 2005. All strategic games in basic modeling are non-cooperative 3-player finite static games with complete information, which are similar to previous ones if with no further notification.

Lam T. H (2005) presented his first comprehensive assessment of the costs of tobacco in Asia. Later, McGhee S. M. et al. (2006) published this research focusing on Hong Kong's cost of tobacco-related diseases, especially including detailed data on passive smoking. Their work shows that 6,920 deaths were caused by smoking annually in Hong Kong, of which 1,324 were attributed to second-hand smoke exposure. This number is about 20 deaths per day, which is higher than SARS, a severe virus incident that once happened in Hong Kong. Smoking also costs 5.3 billion HK dollars in health and economic loss. Specifically, 28% of health service expenditure and 26% of the total loss of productivity was due to second-hand smoke exposure, equaling 0.15 billion Euro.

Since one offense is usually linked to one active smoking, the researcher designed a smoke-free game model for one cigarette a round in a play. The research will need to estimate per cigarette health economic loss for an active smoker and a passive smoker. Based on the research of McGhee S. M. et al. (2006), the researcher designed the estimated per cigarette health based on the death attributed to smoking and SHS because they are the basis for calculating life loss and productivity loss in previous research. The researcher also collected data from a report by the Hong Kong tobacco control office (2014) on smoking and health based on local statistics sources. The

data showed **that Hong Kong smokers consume 13 cigarettes on average per day, which is the reference for dividing the total daily health economic loss for estimation.**

For the currency exchange rate, 1 Chinese Yuan (￥, CHY, Yuan) is equal to approximately 1.16 Hong Kong dollars (HK$, HKD). Meanwhile, 1 Euro (€) is equal to 8.88 Hong Kong dollars in this research as a reference. All the data processed in the Hong Kong game-theoretical model will be in HKD to reduce the effect of currency floating. This measure is also preparing for further international comparison using the ratio. Later, the researcher will discuss the experimental way of estimating local per-cigarette health loss when lacking data, using Shenzhen as an example.

To calculate per cigarette health economic loss, the total health economic loss of active smokers is 3.869 billion HK dollars, which is 83% of the total health economic loss. Then divide the number by the 5,596 deaths in total that led to active smoking. It is 691,386.70 HK dollars per year for one person killed by active smoking. Then, divide 365, and the daily expected health economic loss for an active smoker will be 1,894.21 HK dollars. **Since Hong Kong smokers consume 13 cigarettes per day on average, the estimated health and economic loss per cigarette of active smoking are 145.93 HK dollars, according to deaths attributed to active smoking.**

For passive smokers, the total health economic loss attributed to second-hand smoking is 1.431 billion HK dollars, which stands for approximately 27% of the total annual health loss. Then, divided by the total number of deaths that led to second-hand smoke exposure 1,324, it is 1,080,815.71 HK dollars per year for one person dead by exposure to second-hand smoke. The daily expected health economic loss for a passive smoker is estimated to be 2,961.14 HK dollars. **Cooperated with the estimation, same as the active smoker, 13 cigarettes per day are applied in this calculation to simulate lifetime second-hand smoke exposure. The estimated health economic loss per cigarette exposure to second-hand smoking is 227.78 HK dollars. This number is 56.16% higher than the estimated health economic loss per cigarette of active smoking. The finding of this estimation is also a piece of evidence to prove that passive smoking is more harmful compared to active smoking. Moreover, this estimation will help evaluate the per-cigarette health loss for non-smokers in cities without related data.**

Although most active smokers and passive smokers know that active smoking and passive smoking are harmful, they may not know the exact per-cigarette health loss in actual cases. In this research, related information is hypothesized as a piece of common knowledge to all the players with adequate public propaganda to ensure complete information in both static games and dynamic games. This selection is because the work of McGhee S. M. et al. (2006) is the basis for upgrading the current Hong Kong smoke-free law. Furthermore, it was published to the Hong Kong public before 2007 and is constantly being referenced by the Hong Kong SAR government.

Now fill in the estimated per cigarette health economic loss into the matrix. When an active smoker starts smoking, there is a $-146 health economic loss. The manager and passive smoker will pay more for $-228 in health economic loss. The smoke-free game-theoretical model in the health dimension is shown in Table 8.

Table 8 is the basic smoke-free health data game model upgraded payoff matrix. The smoker is estimated to get -146 HK Dollar health economic loss per cigarette in every play when deciding to start smoking in a non-smoking area. If the Manager or Passive smoker tries to stop the smoker in person, they will face -228 HK dollars in health economic loss per cigarette every time. If Managers or Passive smokers leave the smoker alone, avoiding direct contact with the smoker to reduce the health risk, they will not be affected by second-hand smoke. Since the smoker tends to choose to smoke, while rational Managers and Passive smokers try to leave the smoker alone to reduce health risks, the final result will stay where the box is marked in bold font.

Table 8. Payoff matrix of the smoke-free game (health with data)

Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	[$-146，$-228，$-228]	[$-146，$0，$-228]
Leave smoker alone	[$-146，$-228，$0]	**[$-146，$0，$0]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[$0，$0，$0]	[$0，$0，$0]
No need to leave alone	[$0，$0，$0]	[$0，$0，$0]

When managers or passive smokers "Leave smokers alone" in an indoor area, e.g., a restaurant, the health loss will increase. In the real cause of a static game, all the players must gather together and make decisions simultaneously. When applying this to a smoke-free game, the health loss for the manager and non-smokers will be fixed. This situation occurs when they are close to the smoker and have nowhere to hide. They must stay in the same position during the gameplay and cannot avoid health risks due to exposure to second-hand smoke. The payoff matrix will turn into the form shown in Table 9. Payoffs for every player will be the highest loss once active smoking begins.

Moreover, the matrix shown in Table 9 demonstrates the simplest strategy for each player in smoke-free gameplay. It clearly shows an "all-win or all-lose" particular case in game theory researcher discovered and named with the data as well. The active

smoker should be considered the key player who has the privilege of setting the status of all game players. Especially this is only limited to indoor areas but not every situation in the following models.

Table 9. Payoff matrix of the indoor smoke-free game (health with data)

Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	**[$-146，$-228，$-228]**	**[$-146，$-228，$-228]**
Leave smoker alone	**[$-146，$-228，$-228]**	**[$-146，$-228，$-228]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[$0，$0，$0]	[$0，$0，$0]
No need to leave alone	[$0，$0，$0]	[$0，$0，$0]

In addition, according to the calculation of previous basic health data, the game model shows the characteristic of **variable-sum games similar to prisoner's dilemma**. If with no extra explanation, all the following games with data will be variable-sum games with no further notification.

7.4 Estimating satisfaction of active smoking with hypothesis

As planned in the draft model, the research will then introduce the satisfaction with active smoking into the basic smoke-free game-theoretical model in the health dimension to make the matrix calculable in the mathematic program.

Originally, bounded rationality was the theory trying to explain the reason for errors when individuals make decisions. Their rationality is limited by: the decision problem's tractability, their minds' cognitive limitations, and the time available to make the decision. In smoke-free game-theoretical modeling, the researcher identified nicotine addiction as a particular cause of bounded rationality to the active smoker. This addiction affected their decision to the smoke-free gameplay to evaluate their satisfaction with active smoking. Except in this setting, an active smoker remains a rational player in the smoke-free game. This application is an upgrade of bounded rationality theory in smoke-free game practice.

According to the utility theory and rational expectation, the researcher set a

hypothesis that satisfaction with active smoking is equal to a certain amount of fine. From the perspective of a smoke-free regulator, this is the government-guided price presented to all players in a smoke-free game. In the following models, the satisfaction of law-breaking active smokers is first equal to higher than the payoff of health loss in a smoke-free game. This estimation is based on the kind of "rational" active smoker with this bounded rationality due to nicotine addiction. This design is a solution to calculating irrational game players' decisions in a game-theoretical model with rational players. Setting the satisfaction of active smoking higher than the payoff of health loss is accessible. Still, the hard part is how much exactly in the economic and mathematical degree to simulate the estimated satisfaction with active smoking.

The research applied utility as an essential underpinning of rational choice theory in economics and game theory: since one cannot directly measure benefit, satisfaction, or happiness from a good or service. **According to this theory, the research first selects the highest fine for smoke-free offenses to represent the amount of satisfaction for active smoking as it is the 'ultimate goal' for smoke-free regulation. The highest fine is the standard price of smoking violations valued by the government and smoke-free law. This information is known and acknowledged by the active smoker and all other players in the smoke-free game. Everyone knows this is the highest price for a violation before they make any decision. This information is obvious in every non-smoking sign or notification in non-smoking areas location in Hong Kong.**

In 2007, Hong Kong renewed its Chapter: 371 Smoking (Public Health) Ordinance. The highest fine for an active smoker witnessed to be carrying a lighting tobacco product was HK$5,000. This fine is to estimate the satisfaction of active smoking in Hong Kong during 2007–2009 at first. Then, the researcher changes the amount of active smoker payoff by filling in the satisfaction dimension. When either a manager or a passive smoker stops an active smoker, the active smoker will lose the estimated satisfaction of HK$5,000. The new payoff will be $-5,146 in this situation, combined with previous health economic costs. When the active smoker chooses not to smoke, the new payoff will be $-5,000, for they lose the satisfaction of smoking. When no one stops active smokers, the payoff will be the balance between health and economic losses and estimated smoking satisfaction, which equals $4854.

Table 10 shows the new matrix with two dimensions after adding the data. The matrix in Table 10 with health and satisfaction dimensions now makes sense in the calculation. Without monitoring or punishment by an enforcer like a police officer, an active smoker will choose to start smoking as their dominant strategy. They face the risk that the manager or a passive smoker might stop the smoker in person. It may force the active smoker to lose both the satisfaction of active smoking and their health status since he already started smoking before others stopped him. As the model shows, the manager and the passive smoker will suffer $-228 health economic loss when stopping the active smoker in person. Thus, both the manager and passive smoker will expect the other player to stop the active smoker. They will then both choose to leave the active smoker alone. In the previous smoke-free game matrix, this payoff will result from a dilemma at the end of the game at the box marked in bold

font.

Table 10. Payoff matrix of the smoke-free game (health and satisfaction)

Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	[$-5,146, $-228, $-228]	[$-5,146, $0, $-228]
Leave smoker alone	[$-5,146, $-228, $0]	**[$4,854, $0, $0]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[$-5,000, $0, $0]	[$-5,000, $0, $0]
No need to leave alone	[$-5,000, $0, $0]	[$-5,000, $0, $0]

In brief, the finding in this section indicates that the existence of active smokers is the interactive decision process among all the players during the smoke-free gameplay under the rule of the smoke-free game.

7.5 Insert economic degree to form the complete basic model

The third step to complete the basic smoke-free game-theoretical model will be inserting the economic dimension based on the game matrix structure in the previous model.

The penalty from the smoke-free enforcer issued to an active smoker is the most important economic factor in smoke-free game-theoretical modeling. A different situation to represent whether an active smoker has or has not received the penalty means an extra table in the current model, so the basic model in the table version will only insert one same penalty as an example in the following research.

Another fact is that the penalty amount is valued at HK$5,000 at maximum from 2007 to August 2009 in Hong Kong smoke-free law. However, the actual fine will have to be decided by the court instead of the smoke-free enforcer. This process takes time, and usually, the penalty will be lower than HK$1,000. This reality could be why Chapter 600 was enacted in September 2009 to enforce a fixed-base penalty of HK$1,500 instead of HK$5,000 at the maximum.

The researcher simplifies this situation in actual cases by setting the

penalty of active smoking in non-smoking to a specific amount. This amount will first be set at HK$1,500 in the basic model to simulate the smoke-free game after September 2009. This arrangement is the status quo in Hong Kong when the fine is fix-based, but the highest penalty remains HK$5,000. Even now, it maintains the ultimate goal of smoke-free control in Hong Kong. The enforcers now join the game as chance players. Due to page limitations, some economic factors have also been listed or considered for this basic model but are not included formally in the final model.

In 2005 before the new smoke-free policy came into action, there was a debate on the obligations of the manager because the manager has been empowered as the enforcer. However, there is no regulation to ensure this extra responsibility. In the draft version of the 2007 smoking ban, according to documents collected by the Hong Kong Legislative Council (2005), managers will also receive a penalty if they fail to stop the active smoker. It is a similar penalty for proper maintenance of smoke-free signs valuing HK$15,000, but the council deleted this line after debates in the formally published version due to rejections. Table 11 shows the payoff matrix of the complete basic model – part 1.

Table 11. Payoff matrix of the basic smoke-free game model – Part 1

Enforcer witness and punish the active smoker		
Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	[$-6,646, $-228, $-228]	[$-6,646, $0, $-228]
Leave smoker alone	[$-6,646, $-228, $0]	**[$3,354, $0, $0]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[$-5,000, $0, $0]	[$-5,000, $0, $0]
No need to leave alone	[$-5,000, $0, $0]	[$-5,000, $0, $0]

Another example is the present and future loss in income due to penalties for active smokers. Research suggested no direct income decline effect on businesses like game centers and restaurants after the 2007 smoking ban. This part of income changes is also hard to calculate, for it also affects the income received from passive smokers with changes in smoke-free policy. The price of one cigarette is also removed from the

model, for it only stands for less than 1% of the total payoff.

As the chart shows in Table 11, this is the first part of the completed version of the 3-dimensional smoke-free game theory basic models in table form when the enforcer witness and punish the active smoker.

If the enforcer fails to witness active smoking, the matrix is shown in Table 12. It is almost identical to the matrix of 2-dimensional smoke-free game models in the previous paragraph. The end of gameplay will still remain in the same position as marked in bold font. However, if the Enforcer witnesses and punishes the active smoker, the payoff will include the economic loss of penalty, which is $-1,500 HK dollar in each situation. When the active smoker is stopped, it is valued at $-6646 HK dollars. If both the manager and passive smoker leave the active smoker alone, it is valued at $3,354.

Table 12. Payoff matrix of the basic smoke-free game model – Part 2

Enforcer fail to witness active smoking		
Active smoker – Smoking		
Manager / Passive smoker	Stop smoker in person	Leave smoker alone
Stop smoker in person	[$-5,146, $-228, $-228]	[$-5,146, $0, $-228]
Leave smoker alone	[$-5,146, $-228, $0]	**[$4,854, $0, $0]**
Active smoker – Not Smoking		
Manager / Passive smoker	No need to stop	No need to leave alone
No need to stop	[$-5,000, $0, $0]	[$-5,000, $0, $0]
No need to leave alone	[$-5,000, $0, $0]	[$-5,000, $0, $0]

Combining part 2 shown in Table 12, it seems evident that active smokers will tend to choose the situations not witnessed by the enforcer based on the matrix calculation. However, no player could control this factor during this smoke-free game, partly linked to the reports from players except active smokers. Thus, the chance player is an explanation and solution to such a simulation in the following models.

For a chance player in game-theoretical modeling, the distinct possibility of each chance is vital. However, the possibility of an enforcer to witness and punish the active smoker is usually unknown in the different regulated areas. Furthermore, it

remains uncertain when active smokers and other players arrive in an unfamiliar area in the actual case. This situation already has the characteristics of incomplete information, but during the design of the basic model, the research will first set the information to be complete. Solve with the simplest pre-set value in the simulation for an active smoker only as an estimation on behalf of the government policymakers.

Data on enforcement figures against smoking offenses in 2008 shows that food premises stand for 17.07% of the annual total figures. While amusement game centers stand for 30.51%, other statutory non-smoking areas are only 21.56%. Nevertheless, in 2015, food premises only accounted for 6.61% of the total annual figures, amusement game centers decreased to 13.96%, and other statutory non-smoking areas skyrocketed to 46.26%.

Besides, the smoke-free law is designed to apply to every type of non-smoking area instead of a specific one. Different possible combinations exist within all non-smoking areas, and the model simulation will only request universal estimation. Thus, the solution in this basic model is to make a simple assumption considering all the situations above when not knowing the exact possibility of using a dichotomy. For the chance player enforcer, the possibility of success or failure to witness and punish the active smoker is the same. **This data means they are both valued at 50%, nearly 46.26% in reality, and this simplest solution will make up for further research.**

In fact, the actual number of total offenses and reporting cases was 46% in 2014, 44% in 2015, and 42% in the first quarter of 2016, on average in Hong Kong. While in the center-west district, the percentages are 28.38%, 27.48%, and 26.12%, which is entirely different. The source of the above data set is the Hong Kong Tobacco Control Office's (2016) feedback for the number of smoking offense fine is less than half of reporting case (关于违例吸烟检控数字不足一半的问题 in Chinese). Thus, the research will attempt to set the overall possibility of being caught around 40% or 50% to reflect this actual number in general for further model simulation.

To better understand this pre-set possibility, we could use the time enforcer reaches the smoking offense site to make a simulation. The possibility is set at 50%, equal to a specific patrolling simulation. That is catching one active smoker when smoking in a non-smoking area with three enforcers who can reach the site of the smoking offense in 5 min, randomly patrolling within one hour. If the possibility is set to be 40%, then it is equal to catching one active smoker with two enforcers who can reach a place of smoking offense in 6 min, randomly patrolling within one hour.

Take the previous smoke-free game model as an example. Before the active smoker decides whether they will smoke in the non-smoking area, **the payoff for their decision is $3,354×50%+$4,854×50%=$4,104**. The active smoker will choose the matrix with a higher payoff of $4,104 compared to -$5,000, which means that active smokers will start smoking in that situation.

The basic smoke-free game-theoretical model in the form of a standard game implied the possible reason for the existence of active smokers: the expected payoff of active smokers is higher than not smoking. Significantly, this is based on the active smoker's final node payoff result without pre-set conditions, which means the researcher will not know the result when the model is ready to run but only after the computation. Furthermore, this will be tested in every following model to recheck whether the same result is repeated in every simulation before drawing a conclusion.

Currently, the normal game model has reached its limit to further explore and evaluate the smoke-free game in this step. This model is only suitable for indoor non-smoking areas when all the players gather together, and the other players will witness the smoker 100% in each game. Another reason is moves of players in real smoke-free cases are in order with sequence instead of together in the normal form of the game at the beginning. The normal game models consider that every player moves simultaneously and only once, which could explain most indoor cases but not outdoor ones. The smoking offense is described as one-moment action according to the previous report of the Hong Kong Tobacco Control Office (2016).

However, the smoke-free law indeed covers all kinds of non-smoking areas, including outdoor and mixed ones. In a real counterexample, players will not decide the result simultaneously but will wait for the key player, the active smoker, to place their first move. Thus, the next chapter will explain how to transform the basic smoke-free static table-theoretical model into a dynamic tree game model based on the real cause of counterexamples.

7.6 Transferring smoke-free table game into tree game

Since the smoke-free static game model reaches its limit, the formation of the game-theoretical model will be transformed from a normal game into an extensive game. This aim is to fit the model to reality when active smokers act first in real situations. This chapter also upgrades the method of calculation from pure hand-marked artificial to computer-based automatic. The research uses Gambit software as the foremost tool to develop a basic smoke-free tree game model according to the previous research structure in the standard game.

Unlike the static game, the player in a smoke-free game will not be considered to make their decisions simultaneously but one by one, starting with the active smoker as the key player. The manager or the passive smoker will play the next move, which reflects that the active smoker noticed by the manager or the passive smoker in a real case. The order of the second movement between the manager and the passive smoker is equal to the situation in this basic tree game model.

Figure 13 shows a screen capture of every player's every move in different colors. The red player is an active smoker and starts the game with a move to decide whether to smoke or not. Then, the chance player simulated in the normal game represents the enforcer status in light green with a 50% chance each. Although chance players without payoff are usually player 0 listed at the start of the game, the enforcer does not need to punish the active smoker if they decide not to smoke. Besides, this is not yet a game of incomplete information, and the possibility of police catching the active smoker is also not isolated without connection to the passive smoker and manager. The equal possibility of enforcer is a compromise between actual data and estimation of a smoker in an unfamiliar area. Thus, the researcher moves the chance player representing the enforcer to appear in the second stage of smoke-free gameplay in this basic model.

Further rearrangement of the chance players will be placed accordingly to the model development. After the smoker's act, a player between the passive smoker and the manager will have to make a move to decide whether they will stop the smoker in person or leave the smoker alone. Finally, the remaining player will make their move to make a similar selection as the previous player did. The last two stages of the players' decision process represent the transference of information in the basic game model. For example, when a passive smoker informs the manager violation of active smoking, this information is complete in the basic game model, as mentioned previously.

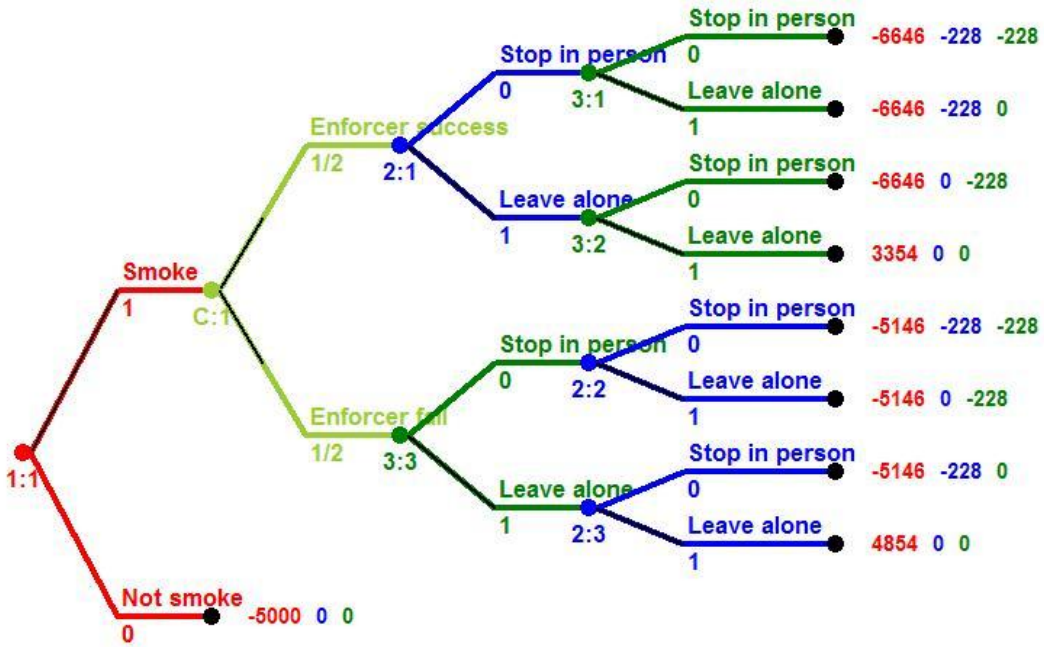


Figure 13. Tree graph of a transformed smoke-free tree game basic model

The tree game will end with a payoff based on the move of all players within the options provided in the game tree. Compared with the normal game, the lower part of the table representing active smokers who give up smoking is now summarized in one move with payoff values [$-5,000，$0，$0]. Furthermore, other trees covered the remaining matrix and payoffs according to different movements. Especially the second player will have 50% each to choose the two moves, but considering the replacement of the position between the second and third player mentioned before, the total possibility will reach 100% as predicted.

Figure 13 shows the payoff of the transformed smoke-free tree game basic model based on the previous normal game on the right side. The result has the same payoff matrix as the basic smoke-free game model combining Parts 1 and 2. The data are also shown in Tables 12 and 13 for the previous normal game. A presentation of the entire payoff matrix of every choice during the tree game modeling process will only appear at this time due to page limitations. This sample attempts to show that the data basis is the same, but the tree game model presents the order of player decisions more precisely and more realistically.

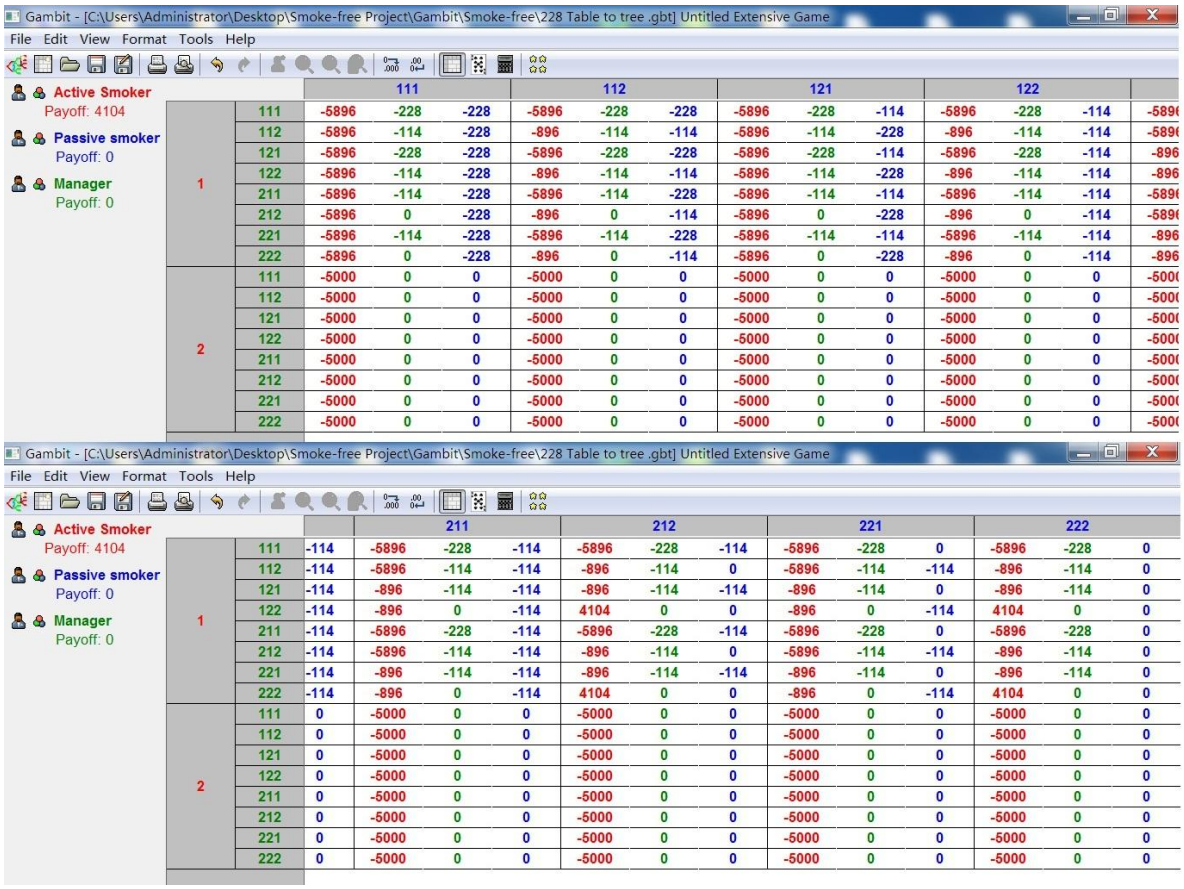


Figure 14. Reduced strategic representation of a transformed smoke-free tree game basic model

The payoff matrix shown in Figure 14 lists the processing status as a **reduced strategic representation of the game**. This presentation is an internal method of

Gambit to present an extensive game strategically by listing the feasible payoff for all players in different movements. For example, 111 represents the payoff when the move of an active smoker is to smoke, which is the first 1. The second 1 is a move of the passive smoker to stop the smoker in person. The third 1 is the manager's move to stop the smoker as well. Furthermore, the payoff is [$-6,646, $-228, $-228], the same value as presented in the basic game table.

Compared to the normal game in the modeling section, one advantage of the tree game is that the research does not have to repeatedly list [$-5,000, $0, $0]. A single move with one payoff will be sufficient to simulate the same situation that appears eight times in the normal game form when the active smoker is not smoking.

Figure 15 shows the real-time pre-calculation process of the basic smoke-free tree game model present on the main screen of Gambit. It is also marked as an active smoker in red, a passive smoker in blue, and a manager in green. Thus, the numbers in different colors represent the player's payoff in the order of active smoker, passive smoker, and manager.

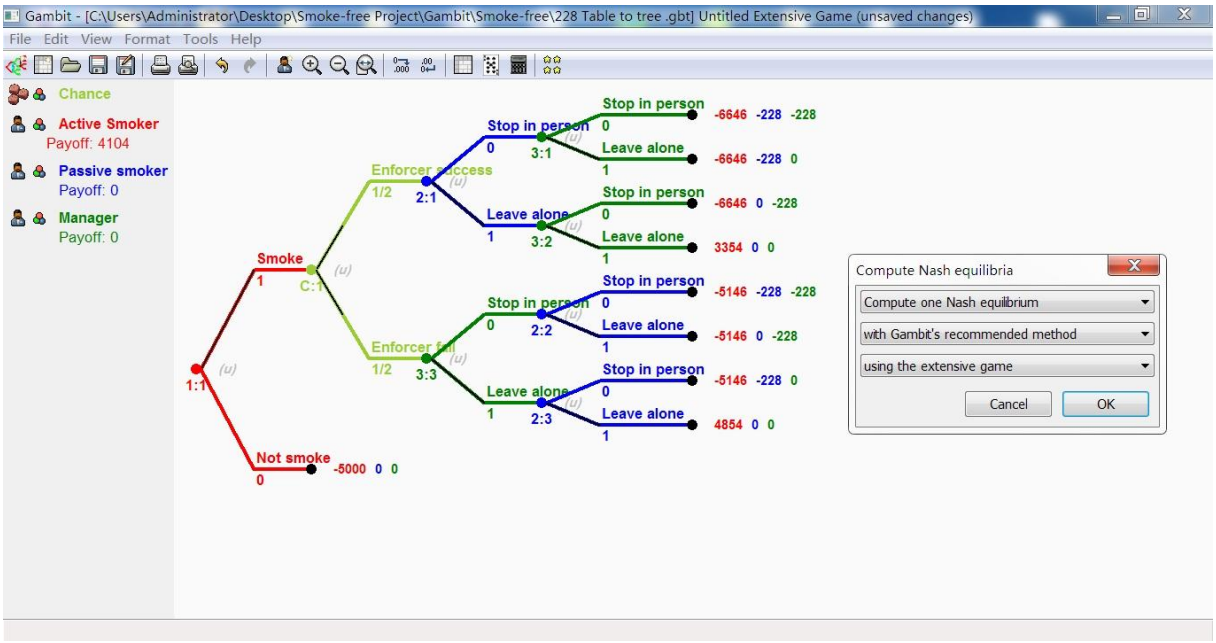


Figure 15. Pre-calculation status of a transformed smoke-free tree game basic model

Dynamic and static games differ because only one player can make a move in a single round. So there are two movement routes in this game: one starts with the passive smoker, and the other starts with the manager. In this tree game, the route starting with the passive smoker will always get the possibility for the enforcer to succeed in witnessing and punishing the active smoker, but not the route when that begins with the manager. The result will be the same when placing the passive smoker in the manager position. This situation indicates that the position of the chance player enforcer status should rearrange to fit the information set in a real case instead of a normal game simulation.

Figure 16 shows the computing process of the tree game presented in the middle of the window and then listed in the below output window as follows. This real-time screen capture shows that a single Nash equilibrium is successfully calculated using an extensive game process with the recommended method. Since the result will appear automatically on the main screen, the results in the following chapters will delete the capture of this window and only present the main screen capture instead.

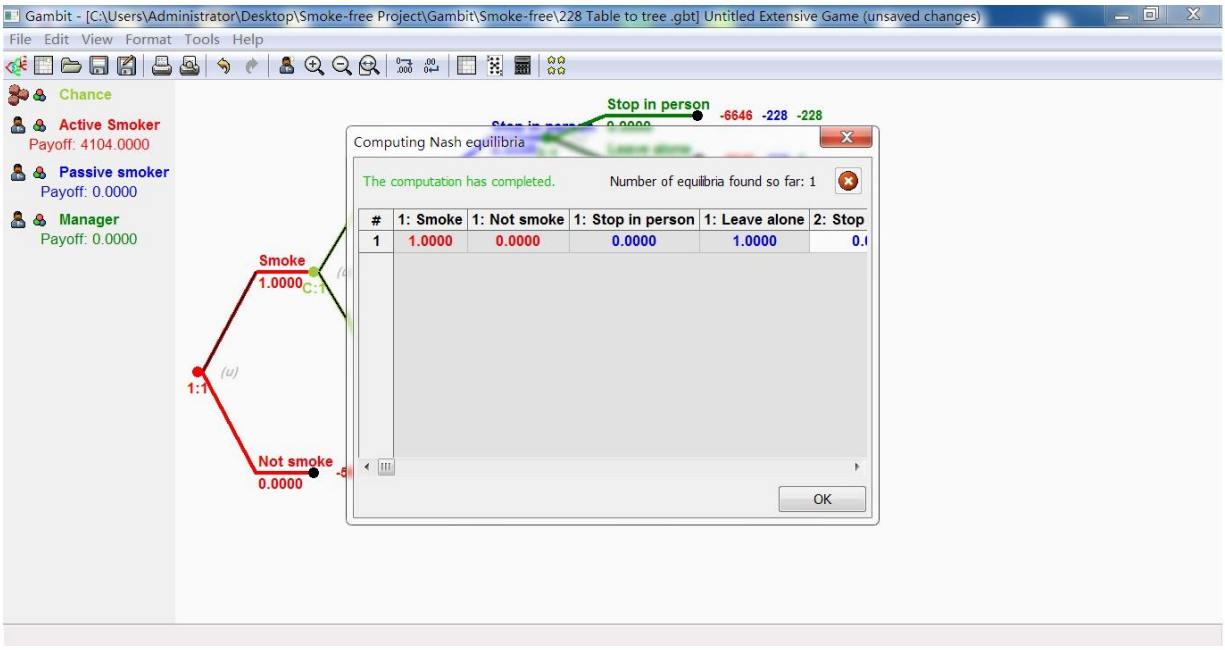
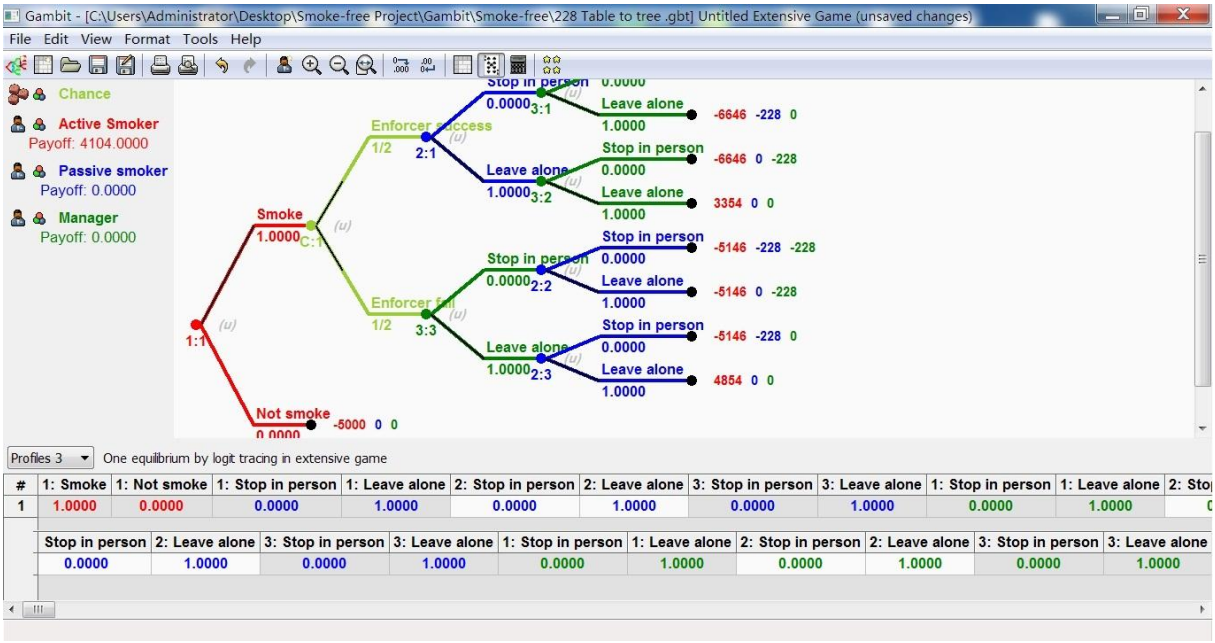


Figure 16. Computing Nash equilibriums of a transformed smoke-free tree game basic model

On the left side of Figure 16, the payoff stands for the reference to players before the game started. This presentation is because Gambit processed a computer-based simulation for the game from the beginning to the end in advance. The reference payoff for the active smoker to smoke is HK$4,104, and the value for both the passive smoker and manager is HK$0, the same payoff amount in the previous normal game model.

The player will use this expected payoff to play the game by comparing the expected payoff with the exact one. Choose this move if the exact payoff is higher than the estimated one. Otherwise, select another move whose payoff is higher than the estimated one. However, this is not the same payoff calculated in a normal game.



#	1: Smoke	1: Not smoke	1: Stop in person	1: Leave alone	2: Stop in person	2: Leave alone	3: Stop in person	3: Leave alone	1: Stop in person	1: Leave alone	2: Sto
1	1.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	

Stop in person	2: Leave alone	3: Stop in person	3: Leave alone	1: Stop in person	1: Leave alone	2: Stop in person	2: Leave alone	3: Stop in person	3: Leave alone
0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Figure 17. Result panel of a transformed smoke-free tree game basic model

This real-time screen capture is combined with two pictures to present the complete list. Figure 17 is the result list showing the best strategy among the possible options for each player. The active smoker's best strategy is to smoke at value 1 in the red number list. The passive smoker's best strategy is to leave alone a value of 1 in the blue number list. The manager's best strategy is also to leave the smoker alone as it is a value of 1 in the green number list.

This result panel marks the end of the transformation from a smoke-free basic static game to a one-shot dynamic game. The computation process seems more complex than the normal game, but it will become an advantage when more options and moves are inserted into the model.

Meanwhile, in the real smoke-free case, it has a different playing order in a sequential game. Due to the transference of information, the enforcer is the last to get the information about active smoking. Then, a chance player shall be listed at the end of the decision tree in a complete and perfect information game. Besides, the differences in the first witness of active smoking also affect tree structure based on the transference of information during the second stage of the dynamic smoke-free game. The kinds of characters represented in the multi-stage game model must define whether the transference of information is perfect or not.

Moreover, with different branches of a tree, subgames appear in the smoke-free game model calculated via backward induction in pursuit of subgame perfect Nash equilibrium. According to proof in the textbook by Martin J. Osborne (1994), every extensive finite game with perfect information has a subgame perfect equilibrium.

Thus, the researcher designed the following game-theoretical models considered as a non-cooperative 3-player finite dynamic game with complete and perfect information if with no further notification.

7.7 Enhanced model base on basic tree game model

As mentioned in the previous research, direct transformation from a static game to a dynamic game may lead to misunderstandings. The place of a chance player represents the status of the enforcer. Whether witnessing and punishing the active smoker successfully needs rearrangement. As suggested in the analysis, the researcher rearranged the position of the chance player enforcer status shall be d to fit the actual case. This transformation will be the first step in this chapter, as the process and aim are to keep the smoke-free upgrading model as detailed as possible in a realistic situation.

However, this model is only an enhanced model instead of a realistic one since the payoff data are abstract for key factors only. Further detailed data are complex to access or without statistics records for reference. The researcher considered a realistic model in the research plan but requested more resources and experiments to achieve it.

To rearrange the position of the chance player in the tree game model to illustrate a simulation based on a real case. Then, introducing another chance player represents the possibility for the passive smoker and manager to see the active smoker smoking. As the previous game model is processed, the possibility will remain the same for the two following players.

The chance player representing the status of smoke-free enforcer is now at the end of the game tree. This simulation fits the real case better than the previous model because the manager is responsible for calling the police if necessary. According to the Chapter: 371 Smoking (Public Health) Ordinance, the enforcer is at the end of the game. The police usually join the game after the other players decide, like in the actual case.

The computation process will be the same as in the previous tree model. The tree graph before and after computation with the Nash equilibriums result list is on the following page.

Figure 18 shows a tree graph of the game before computation in extensive gameplay. The researcher introduces the chance player of the first witness to replace the place of the enforcer when the intercept is a success or failure. This setting is a better simulation of a smoke-free game decision sequence, with the natural order of receiving the information in violation compared to the previous model.

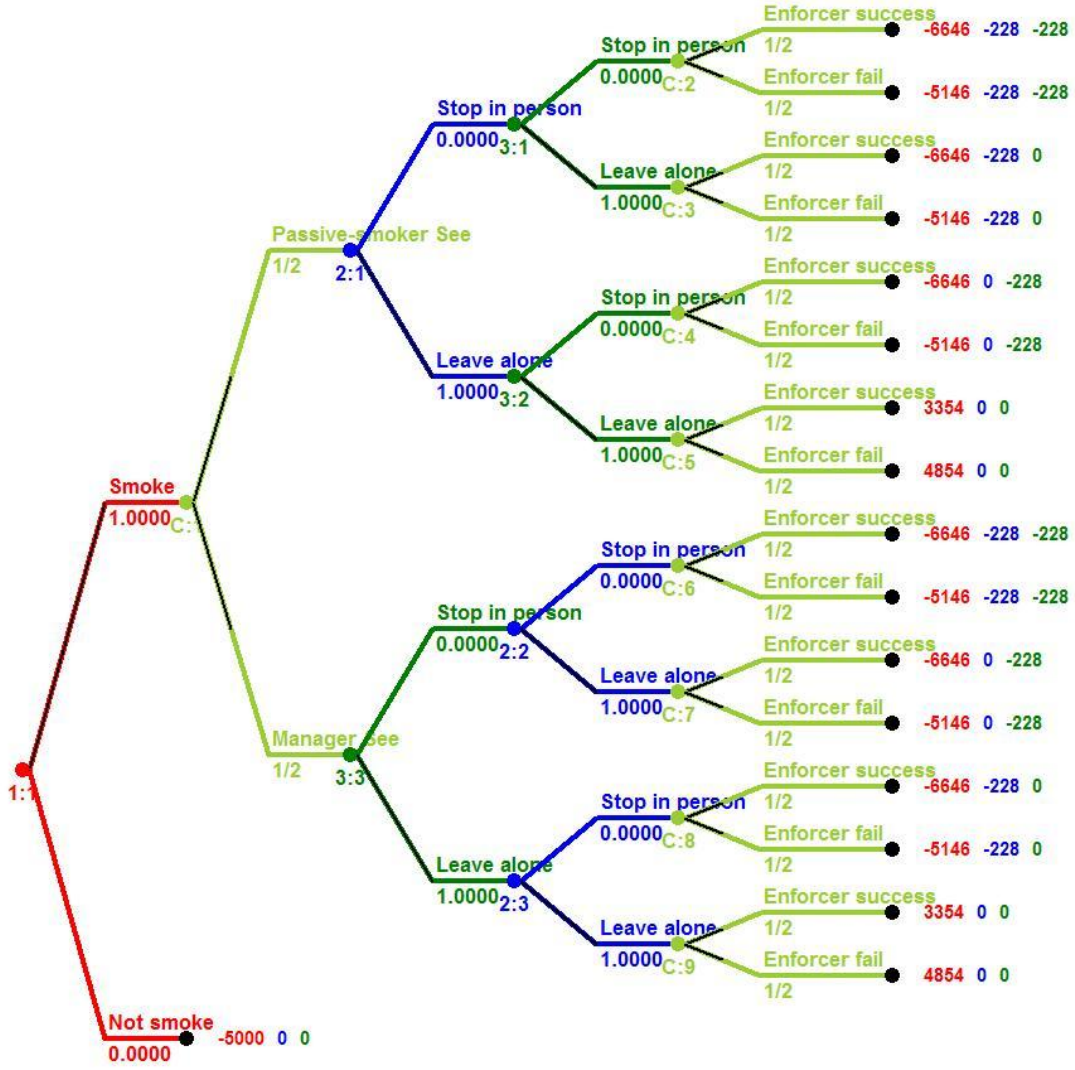


Figure 18. Tree graph of a redesigned smoke-free tree game basic model

According to the previous upgraded tree game graph shown in Figure 18, all the enforcer chance players are moved to the end with a payoff in a different situation. This time it covers 100% of all feasible movements for the three players. This real-time screen capture marked the best option with 1.0000 for every player: the active smoker's best option is still to smoke, as the red number shows. Passive smokers' best option is to leave alone no matter if the manager decides to stop the smoker or leave the smoker alone, with 1.0000 three times in blue. The manager's best option is identical to that of the passive smoker, so the final situation will still end with both following players leaving the smoker alone when the smoker takes the risk to start smoking.

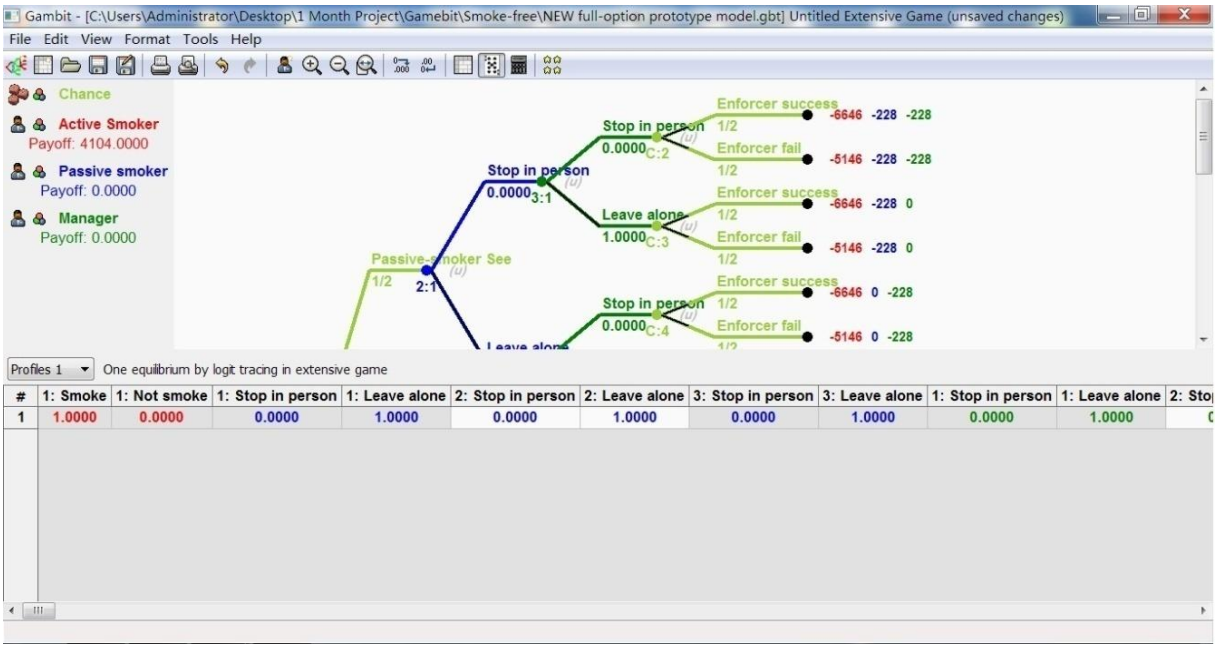


Figure 19. Result panel of a redesigned smoke-free tree game basic model

The above real-time screen captures in Figure 19 show the successful computation. A single Nash equilibrium is the result shown below the tree graph after the computation. **This time, the reference payoff of an active smoker is also HK$4,104, and the payoffs for the other two players are both 0, which fits the result calculated in the previous basic game. The balance between the expected payoff and the highest fine was HK$9,104. It stands for -182.08% compared to the loss of satisfaction, equal to the highest fine. This ratio indicates that the actual risk of a smoking offense is almost twice lower than the law-guided violation price. It is the indicator that clearly displays the risk of active smoking for Hong Kong's status quo in this model simulation.**

The next step is to develop an enhanced tree model based on the upgraded one. In the actual case, there are usually more than two options for each player, and the first chance player to witness active smoking will not only be the manager and the passive smoker.

In the improved tree model, the researcher added more moves to the two following players:

The options for passive smokers include stopping the smoker in person, leaving and informing the manager, calling the enforcer hotline directly, staying still at the exact location, and avoiding the smoker.

The options for the manager extended to: stop the smoker in person, leave the passive smoker to deal with the incident, call the enforcer hotline directly, stay still at the exact location and avoid the smoker.

These are the moves that happen in an actual situation, especially staying still at the exact location is a control option in the model. Usually, a rational player will only choose this move if it brings a loss in income.

Another change is introducing two new moves into the first chance player:

- **Enforcer witnesses active smoker directly;**
- **No one sensed the smoking.**

According to the tree game model graph shown in Figure 20, the best option with 1.0000 is only for the active smoker, who is smoking, colored in red. The best options for passive smokers are the same since they have the same payoff. Leave the smoker alone after informing the manager. According to this model simulation, there is a 33% chance that the passive smoker will call the enforcer hotline directly. Alternatively, in the second round of smoke-free gameplay, there is another 33% chance to avoid the smoker to eliminate second-hand smoke exposure.

The manager's moves are similar to passive smoker because the best option is to leave the active smoker to the passive smoker and then leave the smoker alone. The other 66% chance for the manager is equal to a passive smoker. This result is unreliable to fit the actual case due to insufficient data. These options have only two types of payoffs if there are no penalties to the manager when he fails to stop active smoking.

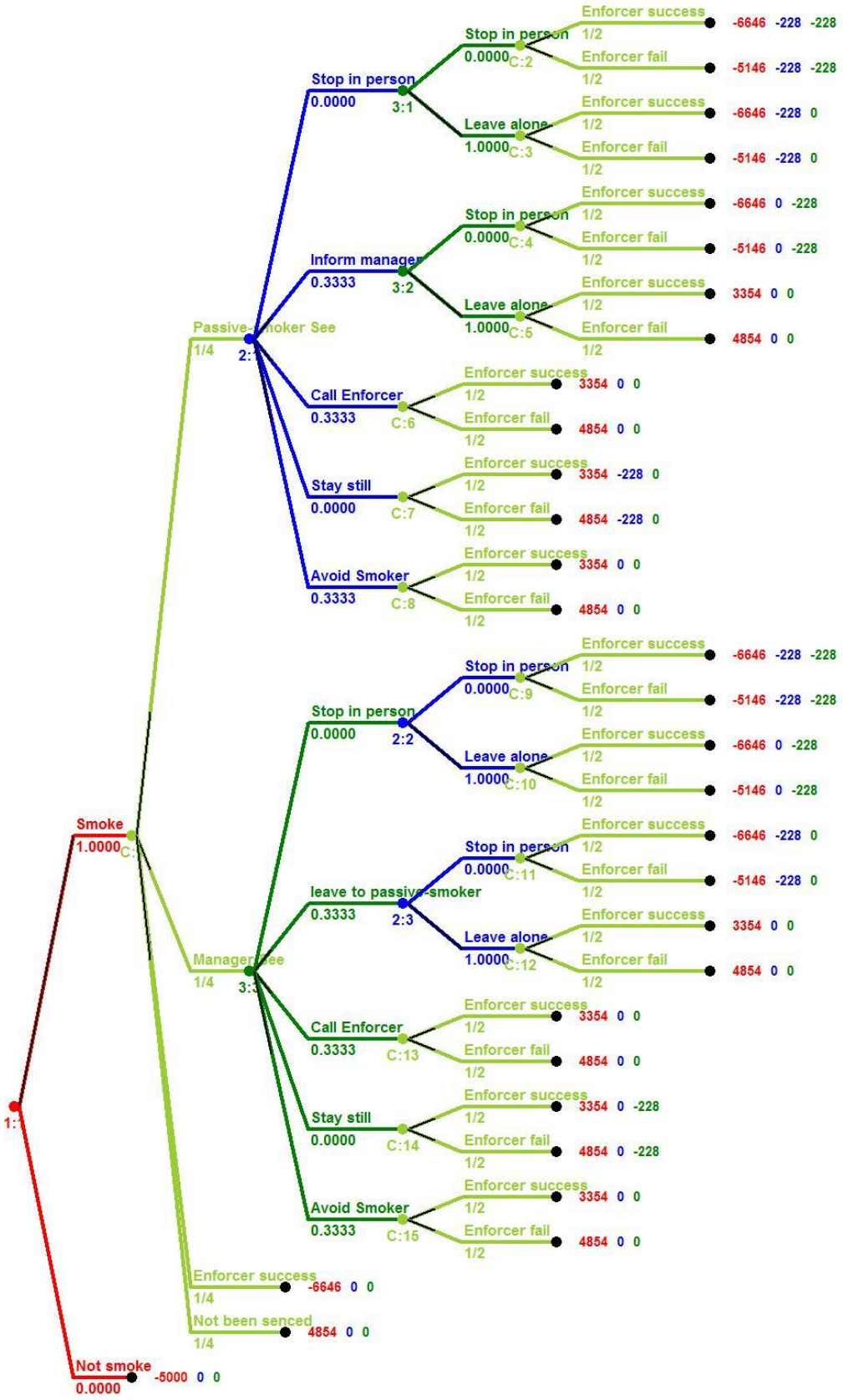


Figure 20. Tree graph of an enhanced smoke-free tree game model

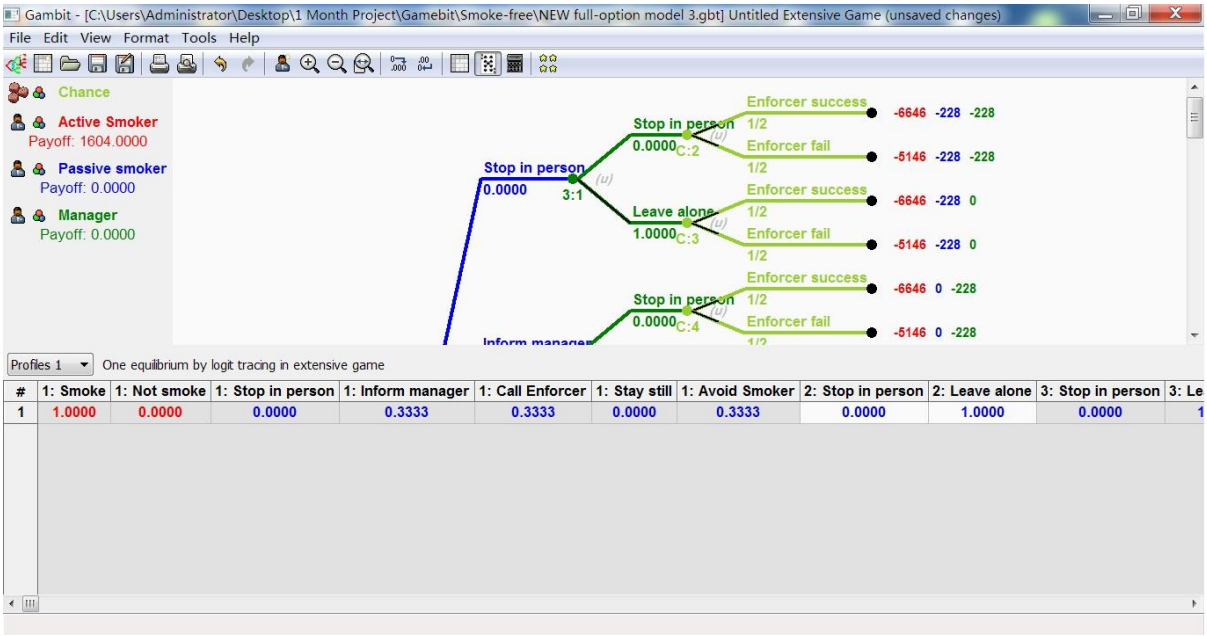


Figure 21. Result panel of an enhanced smoke-free tree game model

The screen captures in Figure 21 show that the computation is a success. A single Nash equilibrium is the result below the tree graph after the computation. **The payoff for an active smoker reduces to HK$1,604 in this model. Meanwhile, the payoffs for the other two players are both 0**. The expected payoff for the smoker is close to the penalty of HK$1,500. Once the expected payoff becomes lower than the penalty, active smokers' behavior might also change.

Smokeless tobacco products are added to the active smokers' list to further explore the game modeling options for active smokers. The satisfaction value of using second-hand smoke-free tobacco products is reduced by 50% compared with traditional tobacco products. This simulation is based on an assumption using dichotomy. When active smokers consume smokeless tobacco, their satisfaction is half lower than traditional tobacco products. Another option for the active smoker is to move to a smoking-permitted area. This move is a controlling factor testing whether smokers will obey the law when no health, economic, or satisfaction cost is requested to move to a place where smoking is allowed. The tree graph is pictured as follows in Figure 22:

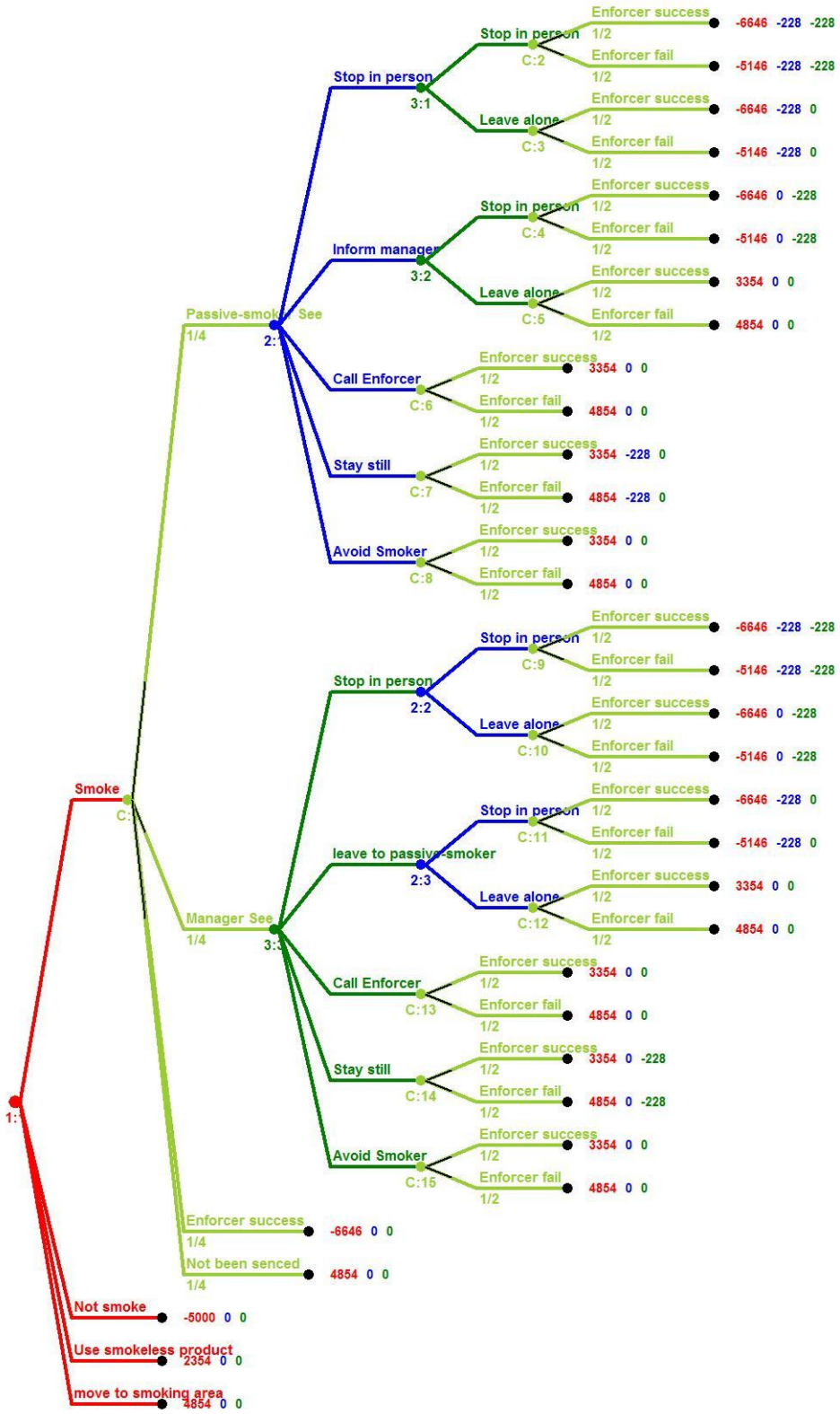


Figure 22. Tree graph of a multi-optional smoke-free tree game model

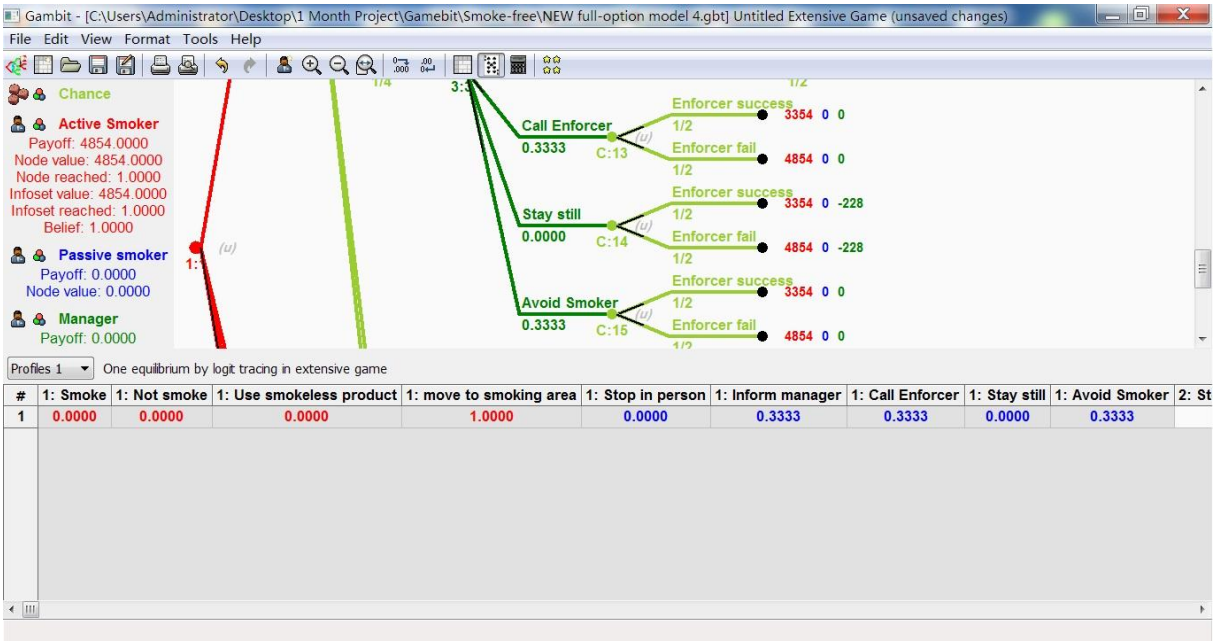


Figure 23. Result panel of a multi-optional smoke-free tree game model

The results of the enhanced tree game for the more active smoker option are in Figure 23. A single Nash equilibrium exists in this model. Active smokers will obey the law when no health, economic, or satisfaction cost is requested to move to a place where smoking is allowed when its payoff is higher than other options. Thus, **one reason for active smokers may be that the cost of moving to a smoking-permitted area is higher than the expected payoff of directly smoking**. Meanwhile, the smoker is not choosing smokeless tobacco as a move, which fits the actual case when active smokers will still break the law even when they could switch to smokeless tobacco.

The research tests raise the cost of active smokers when other players call the enforcer hotline directly. Still, it is uncertain how many possibilities shall be added for enforcers to succeed in a real case. **Due to insufficient data and maintaining the original data instead of extra setting, the payoff of avoiding and calling first remains equal in the following models as a primary preset value.**

7.8 Simplified model base on combined payoffs in enhanced model

The repeating payoff is always a problem in the smoke-free tree game model. The next step of the research is to simplify the current enhanced model, combine the move with a similar or even equal payoff, and develop a simplified model that is easy to compute. This simplified model simulates the fast decision process of an experienced active smoker, and the model is suitable for international comparative research in the following chapters.

According to the computation for one Nash equilibrium with the enhanced model, there are two-movement routes for the following players after the smoker makes his first move.

Figure 24 shows the computation process of the simplified tree game model based on the enhanced model pictured in the following pictures:

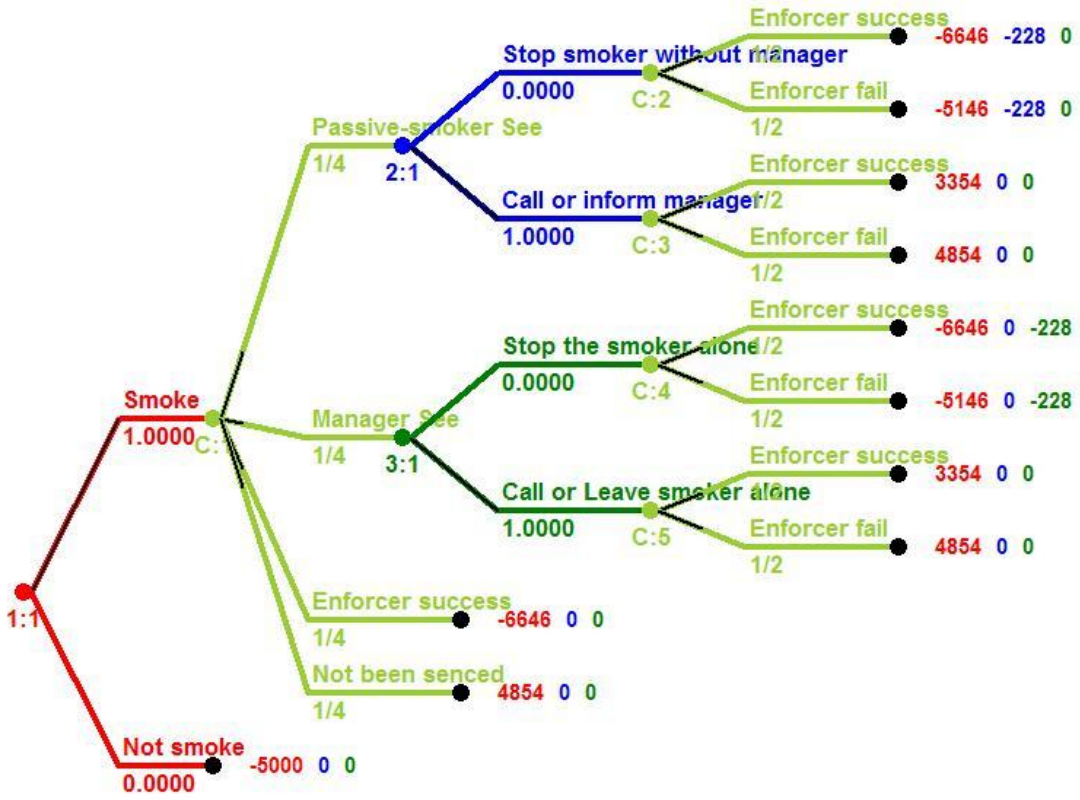


Figure 24. Tree graph of a simplified smoke-free tree game model

If a passive smoker notices an active smoker and decides to stop the smoker in person, the manager's best move is to leave the active smoker alone and let the passive smoker deal with the incident. Meanwhile, when the passive smoker decides to leave the active smoker alone, the manager will also make a move to leave the active smoker alone. Both have the same payoff when passive smokers call the enforcer hotline or avoid the active smoker without contact with other players. These are the two major movement routes when the passive smoker sees the active smoker first and makes their move earlier than the manager.

The manager will make a move similar to the passive smoker when they first see the active smoker. It is either stopping the active smoker without the help of others.

Otherwise, the two following players will choose to leave the active smoker alone together.

Figure 24 also shows a tree graph of the simplified tree game before computation. Considering the 25% chance player, it is still a matrix for a tree game instead of a strategic game. So the computation will still select tree game modeling.

According to the tree game model graph after the computation, the best option with 1.0000 is marked for the active smoker to smoke in red. The Passive smoker's best option is to avoid contact with the active smoker by calling the enforcer directly or leaving the smoker alone after informing the manager. The best move for the manager is similar to the passive smoker: they will leave the active smoker to the passive smoker to deal with by avoiding contact with this active smoker and calling the enforcer.

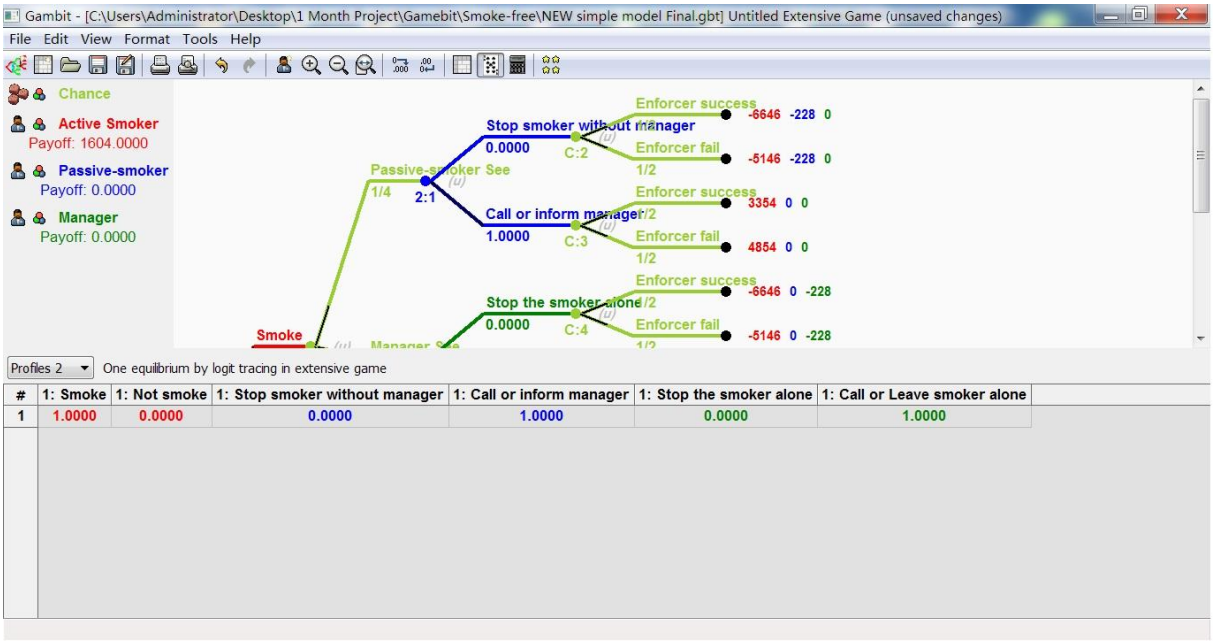


Figure 25. Result panel of a simplified smoke-free tree game model

The above screen captures in Figure 25 show that the computation is a success. A single Nash equilibrium is the result shown below the tree graph after the computation. **In this model, the payoff for the active smoker is also HK$1,604, and the payoff for the other two players is 0**.

This model is the end of exploring a simplified game tree model. This model may not be reasonably accurate compared to others, but it will be easy to calculate with less data requirement. This exploratory simplification simulates a fast-evaluate process for an active smoker. It could also apply in comparative studies, although this model is only a rough reference in analyzing a real case.

7.9 Experimental realistic model to final comparative model

At the very beginning, the research attempted to develop a model that could make the simulation practically close to the actual case. The researcher designed this model to be a sequential game-theoretical model with several rounds of active smoker feedback on other players' decisions. According to the previous enhanced model in the previous research, this model is named the realistic game model in working status.

The research first attempts to separate the manager's decision in the route of passive smoker stopping the active smoker into different rounds with an alternated payoff and add a response for the active smoker to continue or stop smoking. This decision of reacting to the passive smoker or the manager end and starts the next round. To reflect the difference in rounds, the health cost payoff for the passive smoker or the manager will be half only when stopping the smoker before they finish smoking. Moreover, the satisfaction loss of the smoker being stopped is also half the original amount in the second round. The drawback of this solution is the over-usage of dichotomy, causing more inaccuracy. Thus, this will not apply in comparative research. Part of the improved decision tree in working progress representing the interaction between the three-player is shown in the following Figure 26:

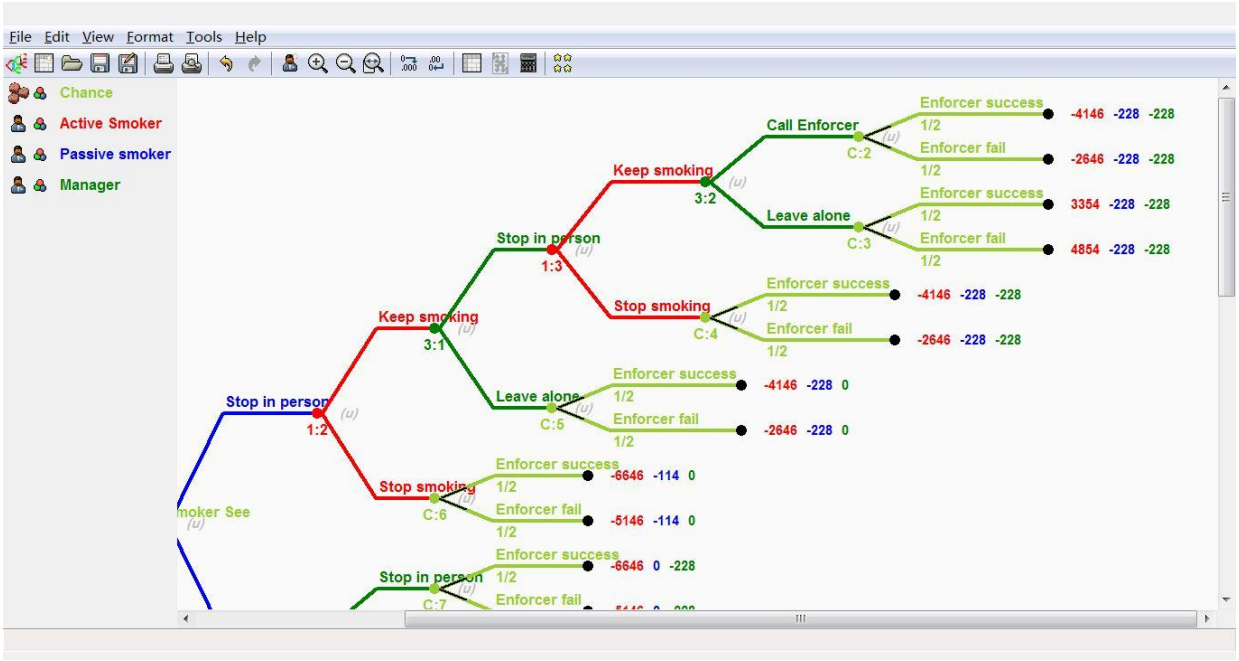
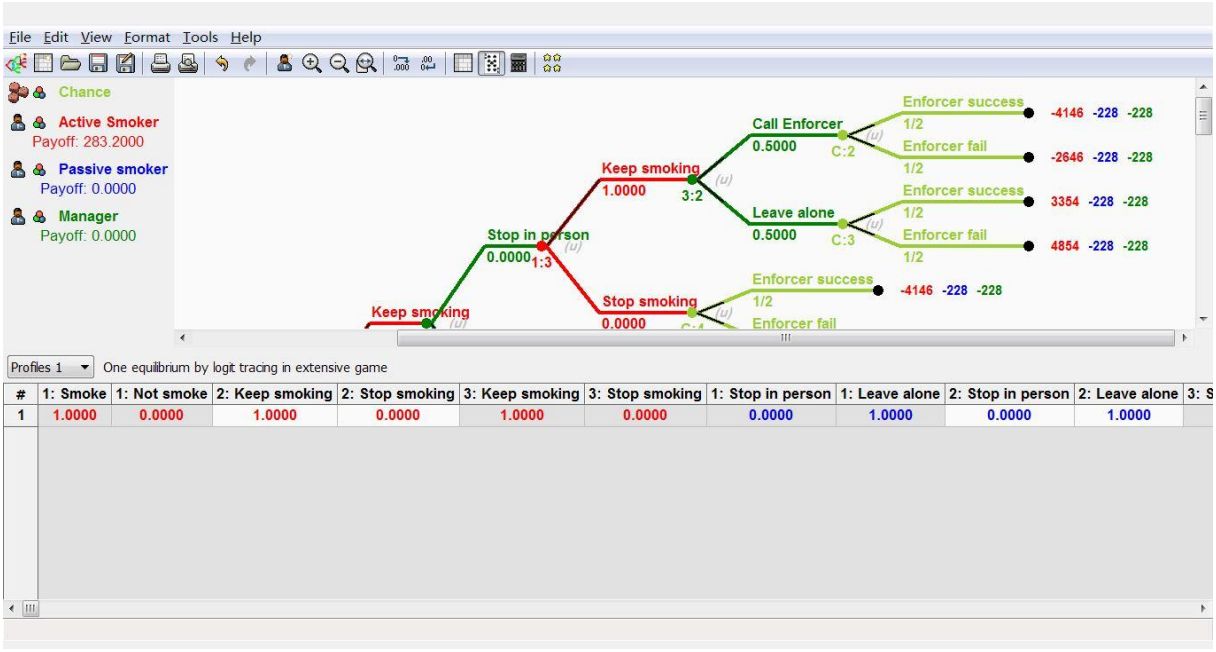


Figure 26. Part of tree graph for improved smoke-free tree game model

Figure 27 shows the computation result of this experimental improved game tree model as follows. The active smoker will move to smoke in the first and second rounds of decisions when stopped by passive smokers or managers, as shown in 1.0000 in this situation.



#	1: Smoke	1: Not smoke	2: Keep smoking	2: Stop smoking	3: Keep smoking	3: Stop smoking	1: Stop in person	1: Leave alone	2: Stop in person	2: Leave alone	3: S
1	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	1.0000	

Figure 27. Result panel for improved smoke-free tree game model

Since the game tree of this model will be too large for comparative research and the halved payoff is based on an assumption instead of evidence, the research halted the development of a further separated tree game model.

The research then attempts to remove the chance player for the enforcer at every end of the game and place the chance player only after the decision tree of calling the enforcer. The picture below shows the realistic model working in progress that part of the structure after reducing the decision tree for enforcer chance player without payoff, as shown in Figure 28.

In this model, the active smoker has the move to stop when persuaded by the passive smoker or the manager. These players' options will form a circle, start and recycle with the active smoker when the following players make their move, which attempts to simulate the interaction between the three players.

The researcher inserts the intention of smoking in this step since the payoff will differ based on the smoker's decision to stop during the gameplay before they finish consuming the cigarette. The researcher also introduces a penalty for the manager because the manager may not fulfill the responsibility to monitor active smoking when there is no positive payoff output.

Figure 28 demonstrates this sample of advanced realistic tree game models in the working state. This model reset the satisfaction with active smoking. Raise the possibility for the enforcer to catch the active smoker when receiving a call from the manager. Passive smoker has other means to react in this simulation of a case in reality.

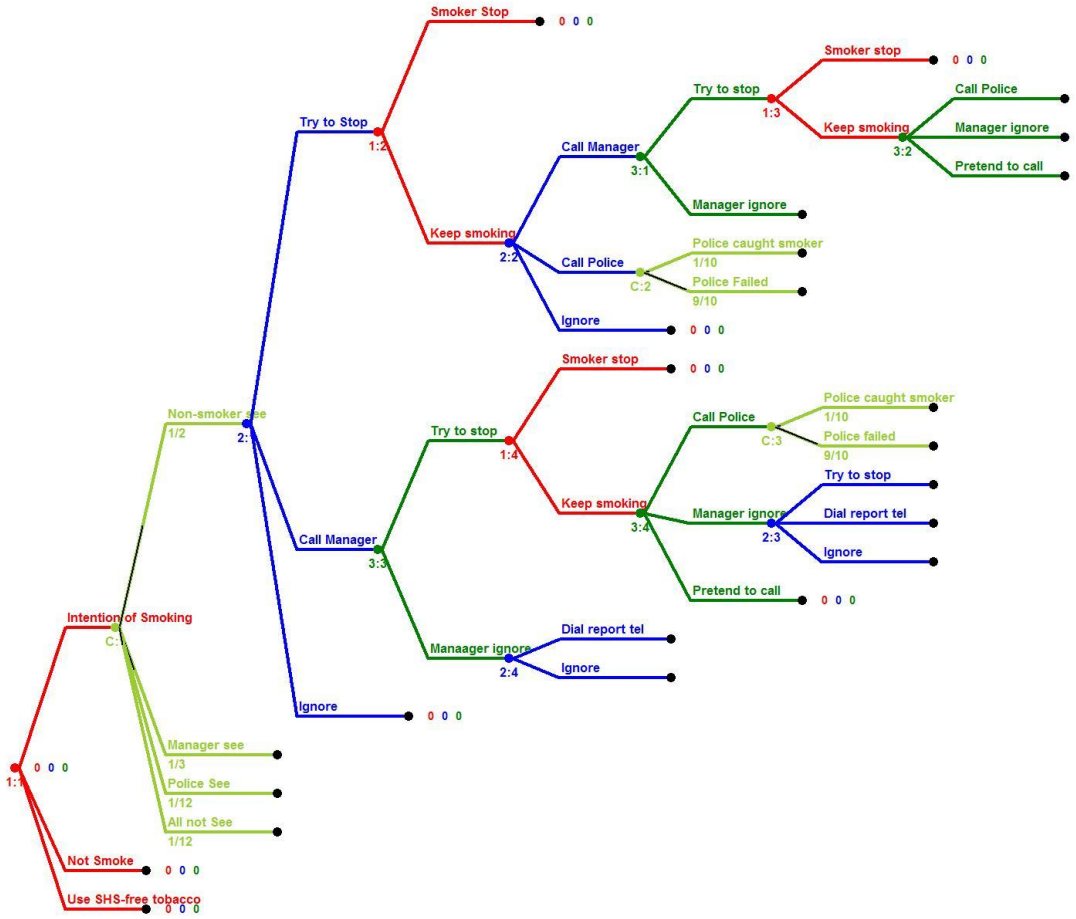


Figure 28. Sample tree graph of a realistic smoke-free tree game model

However, a shortcoming of using this realistic model is that the Nash equilibrium is complicated to calculate, even for a multi-core computer. Furthermore, the original data requested for the factors only suited a limited range of nonsmoking areas. Moreover, the amount of health loss attributed to active smoking will be further divided into different stages, causing more inaccuracy. Besides, there needs to be more output data due to insufficient statistical data for alternative factors in other cities in China and Germany. Thus, the researcher will not apply the realistic model in comparative research. This model's working status can be restored as a future research direction with more detailed data.

Fortunately, there is a legacy to enlighten further smoke-free gambit modeling with this experimental research, which is transforming the intention of smoking.

A smoker needs a series of preparations before consuming traditional tobacco products like cigars and cigarettes. The researcher defines it as the actions for the intention of smoking period. Take out a cigarette box, then match or lighter. Pull out a stick of cigarette, and then put it into the mouth. Finally, start the lighter and enlighten the cigarette.

The five steps except enlightening the cigarette are considered the period: the intention of smoking. It is time for active smoking before lighting a tobacco product. This period is essential because it is the watershed of a potential smoker and an active smoker, which decides the winning status of the tree game as a key player in the health loss degree. It will be complex and challenging to compute the Nash equilibrium when inserting the intention of smoking into the decision tree. Thus, the researcher transferred the intention to smoke into a chance player in the following model. It represents the situation when one of the players stops the smoker from showing the intention to smoke before the active smoker lights the cigarette.

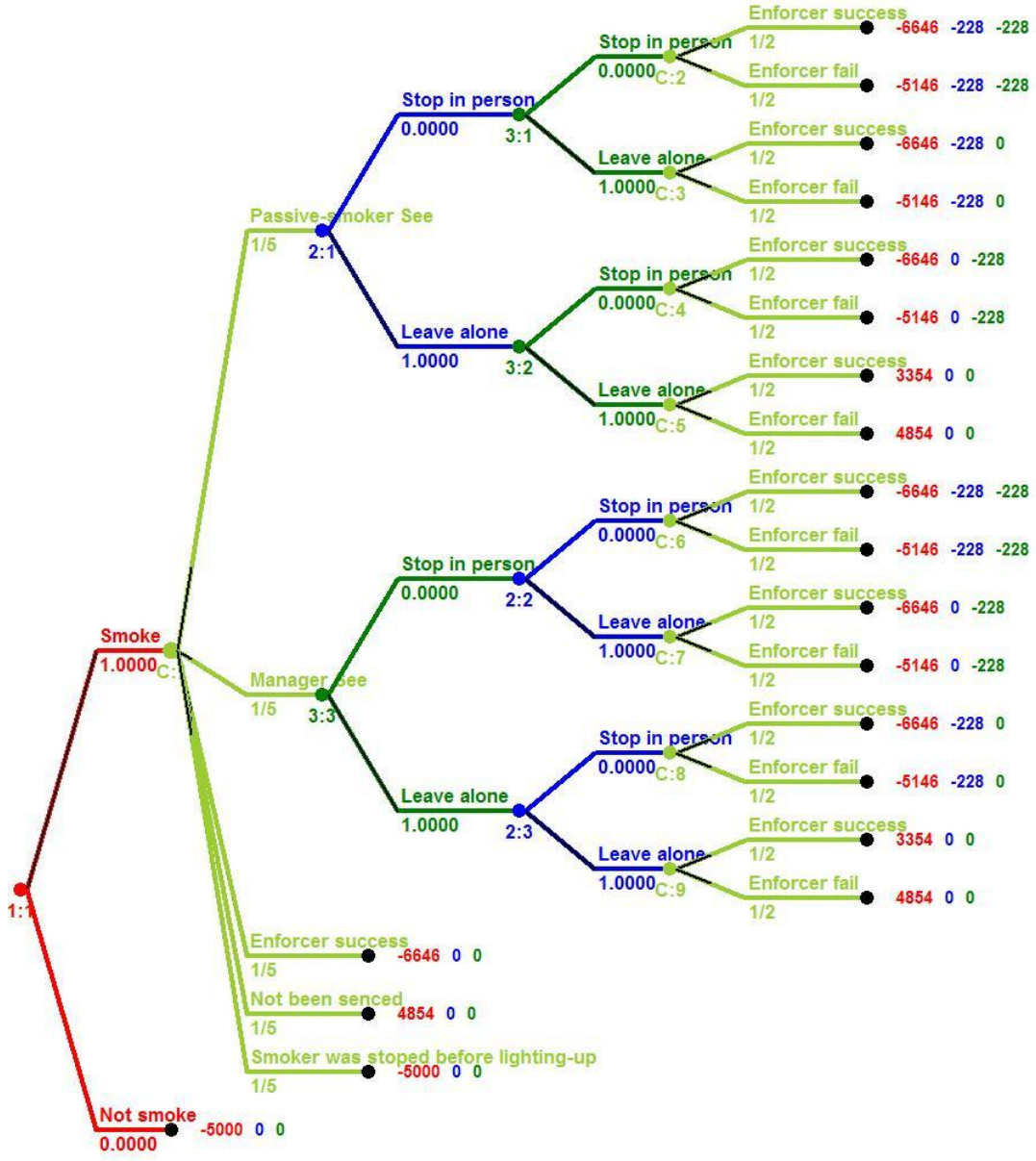
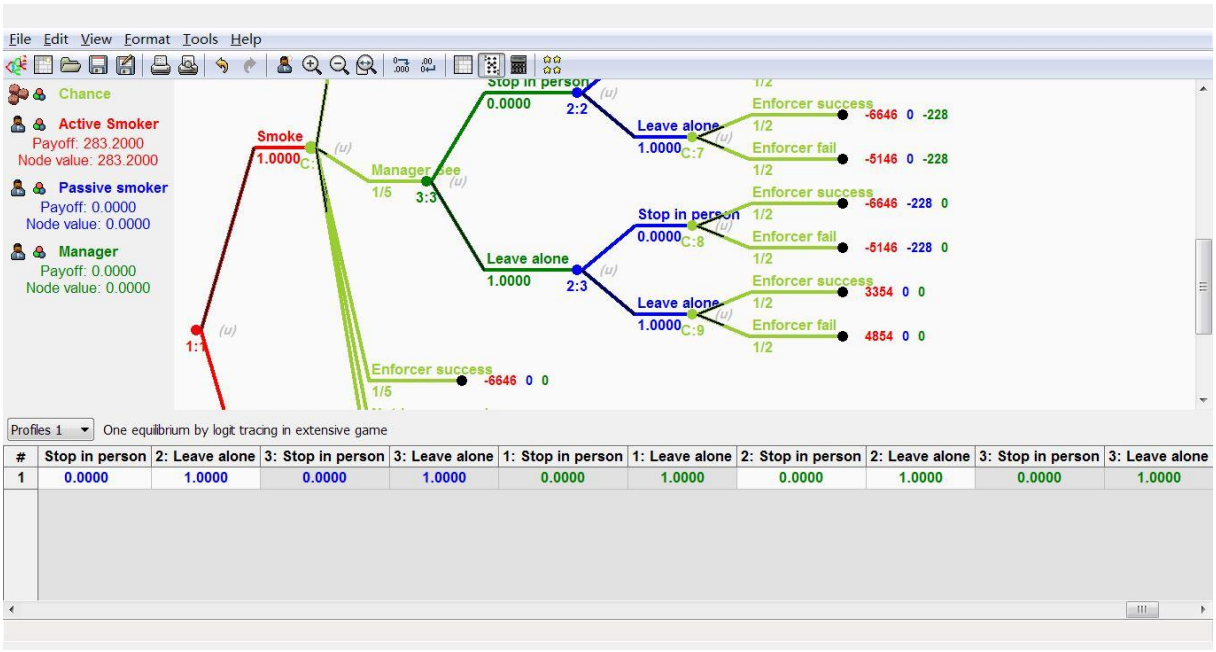


Figure 29. Tree graph of a comparative smoke-free tree game model

Figure 29 shows the structure of the game tree when transforming the intention of smoking into the chance player when the option is smoker was stopped before lighting up.

Figure 30 shows that one Nash equilibrium still exists with a successful computation process. This change only affects the matrix and payoff of the expected payoff in the computation process screen captures. **In this model, the possibility of being caught switches from 50% to 40%. The payoff for active smokers is reduced to HK$283, and the payoffs for the other two players are both 0. The balance between the expected payoff and the highest fine declined to HK$5,283. It stands for -105.66% of the highest fine. This ratio indicates that the actual risk of a smoking offense is slightly one time lower than the law-guided violation price.**



#	Stop in person	2: Leave alone	3: Stop in person	3: Leave alone	1: Stop in person	1: Leave alone	2: Stop in person	2: Leave alone	3: Stop in person	3: Leave alone
1	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Figure 30. Result panel of a comparative smoke-free tree game model

The gap between the intention to smoke and starting smoking exists in reality. However, it is usually hard to stop smoking in this short period. The only result of such a situation is the smoker losing satisfaction when there is no loss for other players as the first ones to make this move. The solution in this paper is to insert it as one of the chance players in the first selection tree instead of inserting a complete decision tree for the intention of smoking. This result panel is the end of the game-theoretical model development section. In future comparative research, the research will select the basic tree model and a comparative model to evaluate counterexamples in China and Germany.

8 Smoke-free Status quo and Gambit Model Application for China

8.1 Overview of tobacco related facts in China

The Chinese National Ministry of Health (2012) released the first-ever special report on China's smoking health hazards in May 2012. This report outlines the hazards of tobacco use, states the health consequences of second-hand smoke, and emphasizes the importance of smoking cessation. Currently, more than 300 million smokers in entire China account for nearly 33% of the total number of smokers worldwide. Since China signed the FCTC in November 2003 and ratified the FCTC in January 2005, also the year Germany joined the FCTC. "Smoke-free public places as part of the major national goal to increase life expectancy" is also written in China's 12th Five-Year Plan. This line in the law is an apparent notification that represents its importance to the Chinese central government.

Data released by the World Health Organization (2007) Global Adult Tobacco Survey (GATS) held in China shows that 28.1% of the population in China smokes, including 52.9% of men and 2.4% of women. 52.7% of smokers aged 20 to 34 started smoking daily before age 20. If the prevalence of tobacco use in If with no countermeasures, the future total number of tobacco-related deaths yearly in China may increase to 3 million by 2050.

According to statistics on mortality attributable to smoking in China by Gu D. et al. (2009), tobacco causes approximately one million deaths annually in China, which is around one in six of all such deaths worldwide. In other words, one Chinese dies approximately every 30 seconds because of tobacco use, equal to around 3000 people daily. Meanwhile, second-hand smoke is a significant challenge for tobacco exposure in China. The total population of China is more than 1.3 billion, with 0.3 billion smokers, and there are 0.74 Billion passive smoker at risk of second-hand smoke exposure. Public areas, workplaces, and families have the highest rate of second-hand smoke exposure, especially in public areas. In a typical week of observation, 70% of adults in China are exposed to second-hand smoke in one environment or another. Exposure to second-hand smoke kills approximately 100,000 Chinese people yearly, accounting for 10% of the annual deaths caused by tobacco.

The World Health Organization Western Pacific Region (2015) published a comparative report on China with 15 other countries in the International Tobacco Control Policy Evaluation Project (ITC Project). The report shows that China has the highest level of smoking in workplaces (70%). Second-highest level of smoking in restaurants and bars (82% and 89%, respectively). The lowest percentage of smokers with smoke-free homes (20%). Evidence from other countries demonstrates that if China were to implement a comprehensive national smoke-free law, enormous reductions in exposure to second-hand smoke in public places could be achieved. For

example, after France and Ireland implemented smoking bans covering restaurants and bars, smoking in these venues decreased to less than 5%.

According to the Chinese tobacco control report by the Ministry of Health (2007), direct tobacco use and second-hand smoke cause significant health risk factors for non-communicable diseases. In China, these consequences include heart disease, cancer, and lung or respiratory tract diseases. Half of the regular smokers in China will die prematurely as a result of their direct tobacco use. In China, the risk of developing lung cancer increases with the frequency and duration of smoking. Around 5.5 million Chinese deaths were by direct disease and illness related to tobacco use in 2005. Smoking is estimated to cause 10% of total cardiovascular diseases worldwide. While in China, 46% of deaths among men aged 30-44 years who die from cardiovascular are attributable to direct tobacco use or exposure to second-hand smoke. Smoking also increases the risk of communicable diseases such as tuberculosis and pneumonia.

Moreover, awareness of the health hazards of smoking and health warnings for tobacco use in China is lower than in developed countries. Only 25% of Chinese adults have a comprehensive understanding of the specific health harm attributed to smoking. Less than 33% of Chinese adults are aware of the dangers of second-hand smoke exposure. The WHO FCTC recommends that large and clear warnings appear on the front and back of tobacco packets. It should describe specific illnesses caused by tobacco with pictures or graphic health warnings that have a more significant impact than words alone. This measure is proven to be an effective means of increasing awareness of the harms of tobacco use. Unfortunately, health warnings on cigarette packs in China only show text warnings instead of graphic health warnings. Consequently, 63.6% of Chinese smokers who noticed the text warning label printed on cigarette packs did not have the thought to quit smoking. Specifically, this is also selected data according to the Global Adult Tobacco Survey (GATS) conducted in China by World Health Organization (2007).

Meanwhile, China also has the world's most enormous cigarette consumption, with relatively lower prices and taxes, according to World Health Organization Western Pacific Region (2015).

The Chinese consumed nearly 2.3 trillion cigarettes in 2009, accounting for more than 30% of cigarettes consumed worldwide. In comparison, Germany is ranked 9th with a percentage of cigarettes consumer around 2%. China's total number of smokers is also ranked first in the world. This number is higher than the combined number of the other four top tobacco-consuming countries: Indonesia, Japan, the Russian Federation, and the United States of America.

The affordability of tobacco products is among the most critical factors influencing smoking rates. The retail price of the most sold tobacco brand in China was US$ 0.74 (5 Chinese Yuan) in 2010, while the average cost of a packet of cigarettes in developed countries like Germany is much higher. Nearly 14% of the average annual per capita

income was required to buy 100 packets of the cheapest cigarettes in China in 2000. However, in 2010, the same number of cheapest cigarette packets could be purchased for less than 3% of the average annual per capita income.

Tobacco tax increases are among the most effective policies for reducing tobacco consumption. This measure may lead to higher retail prices for cigarettes, encouraging smokers to quit and increasing successful attempts at quitting. Meanwhile, it also reduces the number of cigarettes each smoker smokes and discourages prospective new smokers from quitting the habit. Thus, the WHO recommends that at least 70% of the retail price of cigarettes comes from excise taxes. Nevertheless, the effective rate of taxation as a proportion of the retail price of tobacco products in China is only around 40% for the most popular brand.

8.2 Tobacco Atlas China data for international comparison

The WHO published the first edition of the Tobacco Atlas in 2002. The American Cancer Society (2015) also published a report introducing the fifth edition of Tobacco Atlas. Later, it uploaded its database to the Internet and restored data on tobacco use by WHO standards. It is easy for international comparison based on country fact sheets and charts.

According to data by the American Cancer Society (2015) in Tobacco Atlas China, the tobacco-caused disease kills more than 1,384,200 Chinese yearly. Meanwhile, more than 8,937,000 children and 275,900,000 adults use tobacco daily. The death caused by tobacco separation via sex difference in China was 19.5% of Men and 11.9% of Women in 2010, which are higher than the average percentage in other middle-income countries.

A smoker in China would have to spend 1.7% of the national median income to purchase 10 of the cheapest cigarettes to smoke each day. While the combined revenues of the world's six largest tobacco companies in 2013 were 342 Billion U.S. dollars, which is 4% of the Gross National Income of China in the same year.

In 2013, the percentage of adults using tobacco daily was 45.3% for men and 2.1% for females. More men smoke in China than, on average, in middle-income countries. In contrast, fewer women smoke on average in China compared to other middle-income countries. There are 11,900,000 women who consume cigarettes each day in China. Moreover, the percentage of children using tobacco daily is 18% of boys and 0.5% of girls. More boys smoke in China than, on average, in middle-income countries. Even though fewer girls smoke on average in China compared to other middle-income countries, 225,200 girls still smoke cigarettes daily. These data are the signs of an ongoing and dire public health threat. In China, only 0.5% of adults currently using tobacco consume smokeless tobacco products. Fewer people use smokeless tobacco in China than in other middle-income countries. Nevertheless, 5,662,300 people are

still currently using smokeless tobacco. As a health threat similar to traditional tobacco product but good for a smoke-free environment, smokeless product sale in China is still at the starting point of a long-developing trend.

Besides, the current smoke-free policy in China is far from adequate, according to the records in the Tobacco Atlas database.

In the "Protect From Smoke" section, China only achieves Smoke-free Public Transport and Unknown status of All Other Indoor Public Places Smoke-free in the entire list. Smoke-free regulated areas and other locations are NO in the Chinese smoke-free policy. These areas include Smoke-free HealthCare Facilities, Smoke-free Universities, Smoke-free Indoor Offices, Smoke-free Restaurants, Smoke-free Pubs, and Bars & Funds for Smoke-free Enforcement.

The section offering help for smokers to quit smoking is also lacking in China. There are only NRT and/or some cessation services (neither cost-covered) for quitting solutions in China without a national quit line. In the Raise Taxes of tobacco product section, China only has 26% Retail Price as Excise Tax while the WHO Benchmark is 75% Retail Price for Excise Tax. Furthermore, in the Enforce bans on advertising section, the number of Bans on Forms of Direct Advertising in China is zero, within a possible seven bans. The number of Bans on Forms of Indirect Advertising is four of the possible seven bans. Finally, the Advertisement Ban Compliance Percent is only 10% self-rated compliance.

There is only one section in which China scored an entire point: Warning about the dangers to the whole population in a media campaign. China achieved all YES according to the WHO best practices in this section. China as a country ran a national anti-tobacco campaign in 2011 and 2012. The list of what China completed is separately shown in the following sentences:

- Become Part Of A Comprehensive Tobacco Control Program.
- Pre-Tested With The Target Audience.
- Target Audience Research Was Conducted.
- Aired On Television And/or Radio.
- Utilized Media Planning.
- Earned Media/Public Relations Were Used To Promote The Campaign.
- Process Evaluation Was Used To Assess Implementation.
- Outcome Evaluation Was Used To Assess Effectiveness.

8.3 Evolution of China Smoke-free legislation: Shenzhen as sample

There is no safe level for second-hand smoke exposure. Therefore, comprehensive smoke-free laws are crucial to protect the public's health. After China ratified the

WHO FCTC in 2005, the treaty required Chinese Parties to adopt laws or regulations to make all public places, workplaces, and public transportation smoke-free.

Details of local-level smoke-free initiatives in selected cities in China[2]

City	WHO FCTC compliant	Implementation date	Places covered	Penalties for violations
Beijing (*15*)	Yes*	1 May 2008; new law effective as of 1 June 2015	All indoor public places, workplaces and public transport without exceptions; some outdoor areas*	2000 to 10 000 CNY (US$ 322–1611) for managers; 50 to 200 CNY (US$ 8–32) for individuals*
Guangzhou (*16*)	No	1 September 2010	Selected public places, including indoor Government offices, schools and on all public transport; other indoor public places, including bars, karaoke establishments, restaurants, and waiting areas of public transport are covered by a partial smoking ban which allows for designated smoking rooms (DSRs); hotels are required to have designated smoke-free areas	10 000 to 30 000 CNY (US$ 4834) for employers and 3000 to 5000 CNY (US$ 483–806) for managers for serious, repeated violations; 50 CNY (US$ 8) for individuals
Harbin (*17*)	No	31 May 2012	All indoor public places, workplaces and public transport except hotels and restaurants where smoking is allowed in designated areas	Up to 30 000 CNY (US$ 4834) for serious, repeated violations for owners and managers; 200 CNY (US$ 32) for individuals
Shanghai (*18*)	No	1 March 2010; amendments to legislation are in process	Selected places, including schools, hospitals, libraries, arenas, Internet bars and museums, and on all public transport; some other indoor public places are covered by a partial smoking ban or have designated smoke-free areas, including hotels, restaurants, karaoke establishments and Government offices. No regulation on other indoor workplaces	2000 to 10 000 CNY for employers for repeated violations; 50–200 CNY for individuals
Shenzhen (*19*)	No	1 March 2014	All indoor public places, workplaces and public transport; but bars and other entertainment venues are exempt until 31 December 2016	30 000 CNY for managers for serious, repeated violations; 50–200 CNY for individuals
Tianjin (*20*)	No	31 May 2012	Selected public places, including indoor Government offices, schools, shopping malls, supermarkets and on all public transport; other indoor public places and workplaces, including bars, entertainment venues, hotels and restaurants, are covered by a partial smoking ban which either allows for DSRs or requires provision of smoke-free areas	5000 CNY (US$ 806) for employers and 500 CNY (US$ 81) for managers for serious, repeated violations; 50–200 CNY for individuals

*Beijing's law is only WHO FCTC compliant as of 1 June 2015, when the new legislation took effect. The information in Table 1 refers to the new law.
Source: ITC Project, University of Waterloo, unpublished table based on information in References (15-20), 2015.

2 All currency conversions for Table 1 and throughout this report were calculated using xe.com based on rates as of 23 June 2015 (1 CNY/RMB = US$ 0.16)

Figure 31. Comparison of detailed smoke-free laws among 6 Chinese cities[1 2]

12 Screenshot source: World Health Organization Western Pacific Region and University of Waterloo, ITC Project. Smoke-free policies in China: evidence of effectiveness and implications for action. Manila: World Health Organization Regional Office for the Western Pacific; 2015. Page 5

However, China does not have a national smoke-free law even now. Policy recommendations and Article 8 guidelines released by World Health Organization (2007) provide an effective way to protect all Chinese population from the harms of tobacco smoke. According to Yang G. et al. (2015), China lags behind other countries in implementing a national comprehensive smoke-free law and is still the only BRICS (Brazil, Russian Federation, India, China, and South Africa) country without a national smoke-free law.

From 2004 to 2014, more than a dozen cities in China implemented smoke-free initiatives. Figure 31 shows six cities with best practices and the strictest legislation across China with details information. The cities with smoke-free policy upgrades include Beijing, Guangzhou, Harbin, Shanghai, Shenzhen, and Tianjin. Initial evaluations of these local regulations have shown these initiatives' potential to reduce smoking. However, until 2014, none of these initiatives have been comprehensive (i.e., require 100% smoke-free areas without exceptions). Moreover, they had not yet exhibited the vigorous enforcement and public education campaigns necessary to increase their effectiveness. **Especially, Shenzhen became the city with the strictest smoke-free law in mainland China due to the coverage of almost all public areas and the highest penalty for violation after 2016.**

On 1 June 2015, Beijing enacted a new smoke-free law in China's capital. The Beijing smoke-free law requires all indoor and outdoor places in public, such as schools and kindergartens, to be 100% smoke-free. As the first comprehensive smoke-free law in China, The Beijing smoke-free law is fully compliant with Article 8 of the WHO FCTC, considered the most vital tobacco control law adopted in China first-ever since that period.

Tobacco Control Laws (2019) is an interactive website designed to access information about tobacco control legislation and litigation worldwide for visitors interested in tobacco control. The Legislation of Tobacco Control Laws is one of the U.S. projects led by the International Legal Consortium of Campaign for Tobacco-Free Kids in Washington, D.C. The website provides legislative reviews and policy fact sheets to assess how tobacco control measures from a growing list of countries. It also provides comparisons to the WHO FCTC and its associated guidelines. The smoke-free legislation summary for China is as follows, quote:

> “China became a Party to the WHO FCTC on January 9, 2006.
>
> Smoke-free Places: Smoking is completely prohibited in at least 28 indoor public places, including medical facilities, restaurants, bars, and most public transportation. Designated smoking areas are permitted in other specified places, such as long-distance transport. Sub-national jurisdictions have the authority to implement local smoke-free policies.
>
> Tobacco Advertising, Promotion and Sponsorship: Tobacco advertising is prohibited in mass media, public places, means of public transport,

and outdoors. Other forms of tobacco advertising are permitted, including through sponsored events and organizations, promotional discounts, and retailer incentive programs.

Tobacco Packaging and Labeling: Required warnings are text-only, use small type, and must cover no less than 35 percent of the front and back surfaces of cigarette packaging. Misleading terms such as "light" and "low tar" are prohibited on tobacco packaging, but other misleading packaging (e.g., colors, numbers, and symbols) is not prohibited.

Cigarette Contents and Disclosures: The law does not grant the authority to regulate the contents of cigarettes. The law does not require that manufacturers and importers disclose to government authorities information on the contents and emissions of their products.

Sales Restrictions: The law prohibits the sale of tobacco products via vending machines and near primary and secondary schools. Internet sales are restricted. There are no restrictions on the sale of single cigarettes or small packets of cigarettes. The sale of tobacco products is prohibited to persons under the age of 18.

E-Cigarettes: There is no national law restricting the sale; use; advertising, promotion and sponsorship; or packaging and labeling of e-cigarettes. Some sub-national jurisdictions have enacted laws restricting the use of e-cigarettes where smoking is prohibited and e-cigarette advertising, promotion and sponsorship.

Roadmap to Tobacco Control Legislation

In China, the National People's Congress, the highest state body, has not passed a comprehensive tobacco control law. Instead, there are several relevant laws and regulations that address tobacco use in China. In 1991, the Standing Committee of the National People's Congress passed the Law of People's Republic of China on Tobacco Monopoly (Tobacco Monopoly Law). For the purposes of managing the manufacture and business of tobacco products, increasing the quality of tobacco products, protecting consumers' interests, and ensuring state revenue. The law is concerned primarily with exercising monopoly control over tobacco commodities and operating a monopoly license system, although it also includes provisions regarding tobacco packaging. Further, the Tobacco Monopoly Law bans certain types of advertising of tobacco products (radio, TV and newspaper or periodicals). The State Council, the chief administrative authority, issued Regulations for the Implementation of the Tobacco Monopoly Law in 1997 (and subsequently amended), elaborating upon matters addressed in the law.

> The Advertising Law of the People's Republic of China (Advertising Law) was promulgated in 1994 and amended in 2015 to prohibit advertising in mass media, public places, means of public transport, and outdoors. The Ministry of Industry and Information Technology's Rules on Tobacco Monopoly Licensing include provisions banning the sale of tobacco products by Internet and vending machine.
>
> Several laws and regulations set forth China's smoke-free policies. These laws and regulations were issued by a variety of agencies and place restrictions on smoking in a broad range of public places. Such promulgations include: (1) Ministry of Health Rules on the Implementation of Public Places Sanitation Administration Regulations. (2) Law on the Protection of Minors (prohibiting smoking in places where minors gather, such as schools, dormitories, etc.). (3) Rules on the Prohibition of Smoking in Public Transport and Waiting Rooms (issued jointly by six agencies). (4) Civil Aviation Administration Rules on the Prohibition of Smoking in Civil Airports and Civil Aircraft. (5) State Council Regulations on the Administration of Business Premises for Internet Access Services (banning smoking in Internet cafes and public computer lounges).
>
> General packaging and labeling requirements are set forth in the Tobacco Monopoly Law (1991) and its accompanying implementing regulations (1997, amended in 2016). More specific requirements are contained in the Rules on Cigarette Package Labeling in the Jurisdiction of the People's Republic of China, which went into effect October 1, 2016. These new rules replace the Rules on Cigarette Package Labeling in the Territories of the People's Republic of China, issued in 2007."
>
> (Tobacco Control Laws 2019)

As the research sample in this chapter, the reasons for selecting Shenzhen are: Shenzhen city also passed a new version of a smoke-free law on 1 March 2014 before the Beijing smoke-free law. In fact, the former version of the Shenzhen law came into effect on 28 August 1998, even earlier than in Beijing on 1 May 2008. The new Shenzhen smoke-free is now becoming comprehensive and fully compliant with Article 8 of the WHO FCTC since 1 January 2017. The new version could now be considered the latest smoke-free laws representing China's highest level of legislation.

Moreover, Shenzhen is located on the southeast side of Guangdong in mainland China next to the Hong Kong special district. Shenzhen and Hong Kong are gradually developing a closer and inseparable cooperation relationship as twin cities. The two cities have many similarities in geography, population, language, stock markets, and healthcare compared to Beijing, located in northeast China. Thus, Shenzhen is selected in the research as the perfect comparative sample to apply Hong Kong smoke-free Gambit models developed in the previous research. Furthermore, this

part will also start with the literature review and translation of the Shenzhen smoke-free law in the following paragraph, as the researcher did for Hong Kong that first set the rules of the game in Shenzhen.

In the following part, the old version of the Shenzhen smoke-free law is translated and summarized for the research study. This old version represents the kind of smoke-free legislation that stays in writing without practice in a real case for smoke-free history lessons provided by China. As one of the earliest cities in China to introduce tobacco control regulations in this country, it had not issued a single ticket in the past 15 years till 2014, when the new version was passed, according to Mr. Du Xiaotian (2012). It only had a limited five pages of smoke-free law and a lack of clear identification compared to Hong Kong's smoke-free legislation. Moreover, this situation is similar to the current version of the smoke-free law in Bavaria. In order to have a better view of the translated Shenzhen smoke-free law, the researcher translated some of the critical chapters from simplified Chinese. Some important lines are in bold font quotes for reference in the following chapter. Furthermore, two versions of the same smoke-free law by the Shenzhen Government (1998 and 2013): **Shenzhen Special Economic Zone Smoking Control Ordinance**.

8.3.1 Shenzhen Smoke-free legislation version 1998

“Shenzhen Special Economic Zone Smoking Control Ordinance

Publication date: August 28, 1998 (Adopted at the 25th Meeting of the Standing Committee of the Second Shenzhen Municipal People’s Congress on August 28, 1998)

Article 1 These regulations were developed to protect people's health and **reduce the harm caused by smoking.**

Article 2 The following places are **nonsmoking places**:

(1) public offices and meeting rooms of state organs, enterprises, public institutions, and social organizations;

(2) nurseries, kindergartens;

(3) teaching places, student dormitories, and other places for youth activities at various educational institutions;

(4) various types of medical and health institutions in the waiting area, clinic area, and ward area;

(5) libraries, archives, exhibition halls, science and technology museums, museums, art galleries, and other types of exhibition halls;

(6) public transportation and elevators;

(7) theaters, concert halls, video rooms, and gymnasiums.

Article 3 The following places are **nonsmoking areas with part of the entire district**:

(1) song and dance halls, karaoke OK hall, game room, music cafe;

(2) shopping malls, financial industry, postal sector of the business hall;

(3) an indoor restaurant with more than 100 seats;

(4) public transportation waiting room, ticket office.

The direct operators or direct managers (from now on referred to as managers) of nonsmoking places in some areas shall clearly define the places as nonsmoking areas (rooms) and smoking areas (rooms) and set obvious nonsmoking and smoking-allowed signs.

Article 4 No smoking shall be prohibited for minors under the age of 18.

Article 5 A cigarette seller may not sell cigarettes to minors under the age of 18 or to women with evident pregnancy status.

Cigarette sellers must post or have posters of harmful smoking content on smoking in prominent locations where the cigarettes are sold.

Article 6 It is forbidden to publish tobacco advertisements using radio, film, television, computer information network, newspapers, periodicals, and other media.

Do not set outdoor tobacco ads. Before this ordinance's entry into force has been established, it should be December 31, 1999 removal.

Article 7 The **health administrative department of Shenzhen Municipal People's Government shall be the competent department in charge of smoking control and shall exercise the following powers in accordance with the provisions of these regulations:**

(1) to develop a plan to control smoking and organize the implementation;

(2) to organize publicity and education campaigns that smoking may endanger their health;

(3) to organize and coordinate the relevant administrative departments, social organizations, and trade associations to perform smoking control activities;

(4) conducting any inspection or punishment for any violation of these regulations.

The health administrative departments of the people's

governments in all districts shall be responsible for managing and punishing smoking control in their respective administrative areas.

Article 8 Public security, education, culture, news, urban management, other departments, and relevant social organizations and trade associations shall assist health administrative departments in performing tobacco control work.

News media such as radio, television, newspapers, and periodicals should periodically broadcast or publish public service advertisements to publicize that smoking is harmful to health.

Article 9 Nonsmoking **establishments or managers of nonsmoking places in some areas shall perform the following duties:**

(1) to establish a no-smoking management system.

(2) **to discourage smoking in this unit's nonsmoking areas or nonsmoking areas (rooms). If the discouragement is ineffective, they may be advised to leave the nonsmoking area. The nonsmoking area (room) could inform the police and ask for assistance.**

(3) a no-smoking sign shall be set in a conspicuous place where a no-smoking place or no-smoking area (room) is allowed. A place with audio and video equipment shall be given a no-smoking warning through a sound image device. In some areas, a non-smoking place smoking area (room) is set up as a qualified exhaust.

(4) no signs or articles of smoking articles and tobacco advertisements shall be placed in nonsmoking areas or nonsmoking areas (rooms).

Article 10 **Anyone in a no-smoking place and a part of a nonsmoking area (room) must abide by this ordinance and may not engage in smoking, and may exercise the following rights:**

(1) requires smokers to stop smoking immediately;

(2) requiring managers of on-site staff to stop smoking;

(3) report a violation of these regulations to the health administrative department.

Article 11 Administrative law enforcement personnel in the administrative department of public health shall discourage smoking in violation of these regulations. It imposes a fine of *20 Yuan* on them and advises them to leave the premises if the act of dissuasion is invalidated.

Article 12 Minors who violate Article 4 of these regulations shall be

ordered to be disciplined by their schools or health administrative departments.

Article 13 **Whoever violates the provisions of the first paragraph of Article 5 of these regulations will be punished with a fine. A penalty of 3,000 Yuan by the administrative department of health. Anyone who violates the provisions of the second paragraph of Article 5 of these regulations shall be ordered to make corrections and be fined 500 Yuan by the administrative department of health.**

Article 14 For those who violate the provisions of Article 6 of these regulations. These violators include advertisers, advertisement operators, and publishers ordered by the administrative department for industry and commerce. They shall stop publishing tobacco advertisements, have no illegal income, and impose on the parties concerned illegally. The income is more than twice but not more than five times the fine.

Article 15 The management and administration department that fails to perform its duties in violation of the provisions of Article 9 of these regulations shall be given a warning and ordered to make corrections within a prescribed time limit. Those who fail to correct within the prescribed time limit may be fined between 500 and 3,000 Yuan.

Article 16 Encourages the establishment of nonsmoking units, and the non-smoking government units are to be commended.

Article 17 No smoking and no-smoking signs shall be uniformly printed by the public health administration department, and a posting requirement shall be described.

Article 18 These regulations shall come into force on November 1, 1998."

Shenzhen Government (1998)

8.3.2 Shenzhen Smoke-free legislation 2013 (Selected)

"Shenzhen Special Economic Zone Smoking Control Ordinance

Publication date: October 29, 2013 (Adopted at the 25th Meeting of the Standing Committee of the Second Shenzhen Municipal People's Congress on August 28, 1998. **Adopted at the 25th Meeting of the Standing Committee of the Fifth Shenzhen Municipal People's Congress on October 29, 2013**)

Chapter II: Tobacco control sites

Article 8 No smoking is allowed in indoor workplaces, indoor public places, and public transportation except as provided in Article 9 of these Regulations.

The following outdoor places are nonsmoking:

(1) The outdoor area of education or place of activities that mainly provides education, teaching, and activities for minors;

(2) Outdoor teaching areas of schools and training institutions other than those specified in (1) above;

(3) Outdoor areas of parks, medical and health institutions, and social welfare institutions that mainly serve pregnant women and children;

(4) Other outdoor areas of nonsmoking spots such as medical and health institutions, cultural relics protection units, parks, tourist spots, and other places as provided in item (3).

(5) Stadiums, sports and fitness outdoor seating seats, competition venue area;

(6) According to the need to organize large-scale activities, the government temporarily creates new nonsmoking places;

(7) Other nonsmoking places stipulated by-laws, rules, and regulations.

Article 9 The following venues shall be restricted smoking places before December 31, 2016:

(1) bars, dance halls, and other places of song and dance entertainment;

(2) tea house, massage, bath (including sauna, spa, water, foot bath), and other leisure services.

Operators or managers restricting smoking places should set warning signs about the harmfulness of smoking in conspicuous places.

Operators or managers for restricting places of smoking shall designate or set nonsmoking areas (rooms) and shall set the identification of nonsmoking areas (rooms).

Article 10 **No smoking shall be restricted after the expiration of the period of smoking place**, and the municipal public health administrative department shall make a public announcement to the

public.

Encourage restrictions on smoking establishment operators or managers at the deadline for the self-prohibition of smoking.

Article 11 Place operators or managers setting up smoking spots should meet the following conditions:

(1) outdoor area;

(2) it shall not approach the central passage through which crowded areas and pedestrians must pass;

(3) complies with fire safety requirements;

(4) set a clear guide to the logo;

(5) configure an ashtray and other appliances containing soot, and set smoking warning signs of health.

Article 12 The municipal administrative department of public health shall, according to the provisions of these regulations, announce to the public the specific areas where smoking is prohibited and the places where smoking is restricted.

Chapter III: Measures for Controlling Tobacco

Article 13 Operators and managers of places where smoking is prohibited shall perform the following duties:

(1) Establishing a smoking ban management system, conducting tobacco control publicity and education, and equipping tobacco control inspectors;

(2) Smoking-related appliances or items with tobacco advertisements shall not be arranged;

(3) Setting a nonsmoking sign and a supervisory complaint telephone at the entrance of the nonsmoking place and other prominent places;

(4) **For smoking in a nonsmoking place, the staff of the place should be required to extinguish the ignited tobacco products. If it is not extinguished, they shall be advised to leave. The manager should report to the relevant department if the smoker disobeys the dissuasion and does not leave the site.**

Article 14 Smoking is prohibited in business places. If it must leave the place without listening to dissuasion, the operator will not be allowed to recover the expenses already spent. The payment shall not be refused if the service has been accepted but not paid.

Article 15 **Any individual or entity has the right to require smokers to stop smoking in a nonsmoking place. They have the right to require the operators and managers of the nonsmoking places to perform their tobacco control duties and complain to**

the relevant departments. The relevant departments shall investigate the complaints and verify the nonsmoking places.

Chapter V: Supervision and Management

Article 32 The municipal government shall establish a joint meeting system for tobacco control work by the municipal government organization. Mainly perform the following duties:

(1) To study and consider plans, policies, and programs for tobacco control work;

(B) Coordinate and solve the problems in tobacco control work;

(3) To supervise, inspect and evaluate the implementation of tobacco control work;

(4) Other issues related to tobacco control work.

Tobacco control is a joint committee managed by the city publicity, development of reform, finance, health, education, supervision, human resources, social security, transportation, sports tourism, market supervision, civil affairs, public security, urban management, economic and trade and information, technological innovation, housing Construction, ports, the rule of law, organ affairs management, the General Labor Union, the Communist Youth League, Women's Federation and other relevant departments.

The specific offices of the Joint committee on Tobacco Control are located in the municipal health administrative department and are responsible for the daily work.

Article 33 A system of regular meetings of the joint meeting shall be established. The joint meeting of tobacco control work shall hold a working meeting at least once a year. The joint meeting agreed on matters, and each member unit should organize the implementation.

The member units of the joint meeting shall, according to the actual situation, formulate a tobacco control system in their own industry and this system and organize the implementation of tobacco control in this industry and this system.

Article 34 The health administrative department shall perform the following duties according to the law:

(1) To draft and organize the implementation of tobacco control programs;

(2) To organize, coordinate, guide, monitor, and evaluate tobacco control work in a unified manner

(3) Responsible for guiding, coordinating, deploying, and organizing health education on tobacco control and tobacco hazards;

(4) To organize medical and health institutions to perform smoking cessation medical services and provide counseling and guidance on

smoking cessation;

(5) Performing the duties of supervision and administration of tobacco control and law enforcement of the administration according to the provisions, except as provided in Article 35 of these regulations;

(6) Other responsibilities as prescribed by laws, rules, and regulations.

Article 35 The following departments shall, in accordance with the provisions of these regulations, be responsible for the publicity, education, daily management, and supervision of tobacco control work and shall punish those who violate the provisions of these regulations:

(1) The administrative department of transportation is responsible for the control of tobacco except for public transportation outside the train, its public places outside the train, and related public places and workplaces;

(2) Civil aviation and railway administration departments shall be responsible for tobacco control in public places and workplaces, such as public transportation and their waiting places such as civil aircraft, trains, and other places in accordance with the relevant state provisions;

(3) The cultural and sports tourism administrative department shall be responsible for tobacco control work in cultural places, sports venues, tourist attractions, and public places and workplaces within its jurisdiction;

(4) The administrative department of market supervision shall be responsible for the tobacco control work in the food service establishments, wholesale and retail establishments, and their workplaces;

(5) The public security department is responsible for the control of tobacco control in places such as school buses and Internet access service establishments, hotels, hotels, entertainment venues, dance halls, massages, bathing places, and their workplaces;

(6) The administrative department of city administration is responsible for the tobacco control work in public places and workplaces in the parks, subways, and areas under its jurisdiction;

Other relevant departments will assist the competent departments in publicizing, educating, supervising, and administering tobacco control.

Article 36 The health administrative department and the relevant administrative departments shall establish such systems as the route inspection and complaint handling of tobacco control and release the regulatory information to the public.

Article 37 The administrative department of health shall monitor and evaluate the tobacco control work and make it public to society regularly.

Monitoring and evaluation can be entrusted to third-party organizations or agencies.

Article 38 The municipal government shall set up a public telephone number of 12345 to call for the city's unified complaint of tobacco control. When the relevant department receives a complaint, it will accept it. Complaints against real names shall inform the complainant of the handling results within 15 working days from the date of acceptance.

Chapter VI: Legal Liability

Article 39 Those who, in violation of the provisions of these regulations, discourage smoking in places where smoking is prohibited and unobstructed by the operators. Managers of the premises shall be ordered to make corrections by the relevant departments under the provisions of Article 35 of the Health Administrative Department and these regulations. **A fine of 50 Yuan shall be imposed and confiscated on the spot. If no correction is made, a fine of 200 Yuan will be imposed. Where a case of obstruction of law enforcement is found, a fine of 500 Yuan shall be imposed.**

Where a minor has any provision of the preceding paragraph, the relevant department under the 35th article of this ordinance shall be given admonition education and ordered to make corrections according to the terms of reference.

Article 40 **Anyone who violates items 2 and 3 of Article 9 of these regulations shall be given a warning by the relevant department as prescribed in Article 35. Regulations are in accordance with the terms of reference, and shall be ordered to make corrections within a prescribed time limit. If it fails to make corrections within the prescribed time limit, it shall receive a fine of 20,000 Yuan.**

Article 41 When the establishment of a smoking point does not comply with the provisions of Items (1), (2), (4), and (5) of Article 11. The administrative department of health meets Article 35 of these regulations. Relevant departments, in accordance with the terms, are to be warned and ordered to correct within a time limit. If not corrected, overdue shall be imposed 20,000 Yuan fine.

The smoking point set does not meet fire safety requirements by the fire department of public security organs in accordance with the relevant laws and regulations be punished.

Article 42 Non-smoking place operator or manager may fail to perform a duty as prescribed in Article 13 of these regulations. The department of health administration and the relevant department, as prescribed in Article 35 of these regulations, shall give a warning. In accordance with the terms of reference, they are ordered to be corrected within a time limit. If not corrected, overdue shall be imposed 30,000 Yuan fine.

Article 43 Anyone who violates the provisions of Paragraph 1 of Article 16 of these regulations shall be warned by the administrative department of market supervision and shall be ordered to correct it within a prescribed time limit. If it fails to make the correction within the prescribed time limit, it shall be given a fine of 10,000 Yuan.

Anyone who violates the second paragraph of Articles 16, Article 17, or Article 18 (1) of these regulations shall be ordered to make a correction. The market supervision administrative department had to make corrections and imposed a fine of 30,000 Yuan.

Chapter VII Supplementary Provisions

Article 48 The term district government, referred to in these regulations, includes the administrative organ of the new district.

Article 49 The term smoking, as used in this ordinance, means holding a lit tobacco product.

Article 50 The term indoor, as used in these regulations, refers to all the buildings and structures within a building covered by a ceiling and surrounded by a total enclosed area of more than 50%.

Article 51 These regulations shall come into force on March 1, 2014."

Shenzhen Government (2013)

8.3.3 Comparison of Shenzhen smoke-free law between 1998 and 2013

In fact, the old version of the Shenzhen smoke-free law (1998) is only a 3-page short law with 1050 words. It is one of the earliest in China to introduce tobacco control regulations throughout the country, with a

precise amount of penalty for both institutes and individuals. However, the Newsletter covering its weak enforcement by Du, X. T. (2012). It reported that it had not issued a single ticket in the past 14 years until 2013. The reasons for this reality include the department's management function was not given this enforcement power, the main body of law enforcement being unclear, and the weak punishment. Therefore, health supervision in Shenzhen based on the old version meets the difficulties in law enforcement.

For a simple comparison between 2 versions of the smoke-free law in Shenzhen, the English version of the new one in 2013 better accounted for 5313 words for 11 pages. It raised the individual fine for a smoking offense from a fix-based 20 Yuan to a three-stage fine according to the reaction of active smoke. That is **50 Yuan at minimum, 200 Yuan for no correction, and 500 Yuan in case of obstruction of law enforcement**. **The fine for institutions also changes, from a floating fine between 500 Yuan and 3,000 Yuan to a fix-based 30,000 Yuan, similar to the Hong Kong fine issued to active smoker**. For nonsmoking areas, more outdoor districts are in the new version. The manager and other personnel in the nonsmoking area are empowered to stop smokers in both versions.

Nevertheless, the new one focuses more on supervising the manager for their responsibility in tobacco control instead of the smoker. The supervision management in the new version is a joint meeting of different government departments instead of one institute. The new version adds term explanations similar to the first chapter of Hong Kong's smoke-free law.

8.4 Analysis of a counterexample base on Gambit model

One counterexample of a smoking offense was witnessed and recorded with photographic evidence in mainland China in 2015 at Shenzhen University's teaching building for art.

According to the new city smoke-free law in Shenzhen, the entire teaching building for art shall be smoke-free indoors and outdoors. This regulation applies because the function of this area is education, and the law classified areas for education as nonsmoking areas. It is **the outdoor area of education** or place of activities that mainly provides education, teaching, and activities for minors. Furthermore, it includes **Outdoor teaching areas of schools and training institutions** other than those specified in the previous prescription.

Figure 32. Campus map of Shenzhen University with smoking offense indicator[13]

According to the campus map of Shenzhen university shown in Figure 32, the name of the teaching building for art is the letter G on this map. The dark orange buildings are indoor nonsmoking areas at the southwest corner of the campus map. The white sidewalk and 1F ground are the outdoor nonsmoking areas. The yellow arrow points out the location of the smoking offense in 2014.

This photo, Figure 33, is the entrance of the teaching building for art. A clear nonsmoking sign is on the sidewalk facing the main entrance. Every visitor to the teaching building for art will notice this reminder of the smoke-free policy at the university. There is no language difficulty since it is a nonsmoking sign with both words and graphics. Meanwhile, a plastic destination board of "H3" is on the left side of the photo. This H3 is a clue for evidence of a smoking offense in the next paragraph.

13 Original picture source: https://it.szu.edu.cn/__local/3/FA/75/4958ED0C5546501E96FD4370110_F10613BF_360C6.gif

Figure 33. Entrance to the teaching building with a non-smoking sign

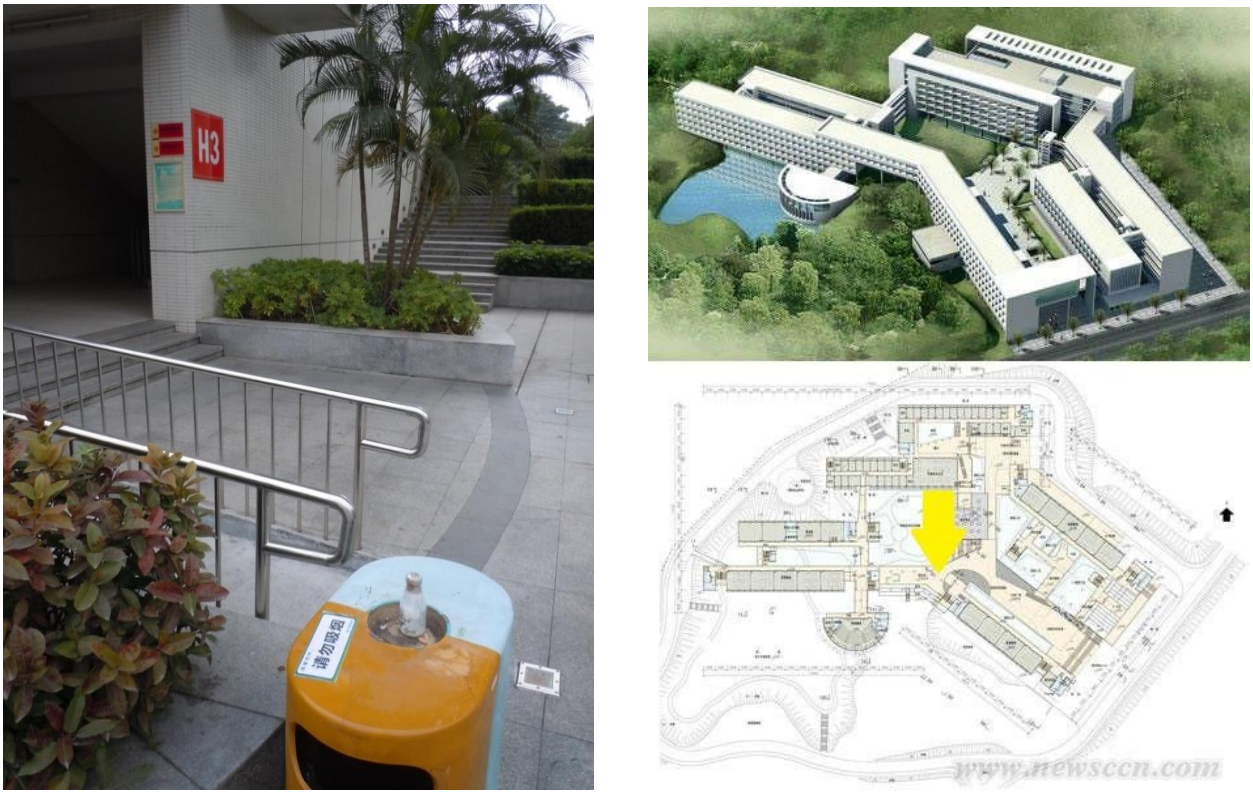


Figure 34. Photo and location of smoking offense on the map of teaching building for art[14]

[14] Right-side picture source: http://img6.ddove.com/upload/20160616/0950138801532.jpg

Figure 34 is the photo the researcher recorded as a counterexample of a smoking offense near another exit of the H3 building. It is on the other side of the same building that places the nonsmoking sign in the previous photo. The green box poster on the top of a trash can is **"Please do not smoke"**(请勿吸烟 in Chinese). The researcher found a cigarette left over on the top of a trash can with an empty bottle. This leftover evidence indicates an active smoker had offended the smoke-free law, and the smoke was seen and smelled in this case. The combined model and map of the teaching building for art are in Figure 34, with a yellow arrow pointing out where the smoking violation occurred as viewer reference information.

The following picture, Figure 35, shows the overview of the exact location where the counterexample took place from the third floor on the other side of the teaching building. The small garden near the pillars on the left side is the exit of the H3 building mentioned before with the smoking offense. The researcher added a yellow arrow pointing to where the trash was. This counterexample proves that the smoking violation can be seen even from the place taking the photo. This photo indicates that other players will notice the smoker quickly in this wide-open outdoor area.

Figure 35. Overview of smoking offense location from the other side

The researcher consulted this incident with the nonsmoking inspector for this smoke-free site. He was a security staff serving part-time as the manager of this nonsmoking area, standing at the teaching building entrance near the nonsmoking sign. The manager said he did not see anyone smoking in the nearby area when active smoking took place. Furthermore, the researcher confirmed there is only one security staff

patrolling around this entire teaching building of art. When asked the manager to call the enforcer via the hotline at 86-755-12345, he said it would be useless since the smoker had already gone away.

The background information is now adequate to combine the review of new smoke-free legislation and the situation description of the counterexample. The researcher will start by applying the Gambit model in previous research for evaluation.

Due to the currency difference, 1 Chinese Yuan (CNY) is equal to approximately 1.16 Hong Kong dollars, and the original data of health costs for second-hand smoke in the previous Gambit model, which is in Hong Kong dollars, is accepted by WHO. The researcher will transfer the health cost data from the Hong Kong dollar into the Chinese Yuan when applying it to the Gambit model. Thus, **the per cigarette health cost for an active smoker is HK$-146, which is around -126 Yuan, and the per cigarette health cost for a passive smoker is HK$-228, which is about -196 Yuan. For the price transformation reference of the Euro, one Euro equals 8.88 Hong Kong dollars, so one Euro equals 7.76 Chinese Yuan.**

This calculation is a compromise due to the lack of data and inaccuracy for Shenzhen on health loss attributed to tobacco. Compared to Hong Kong, **Chinese data exclude productivity lost attribute to tobacco from the beginning.** Furthermore, this arrangement is why the researcher chose to transfer Hong Kong's original data instead of using direct estimation based on a Chinese national analysis in 2014. The researcher will now provide an experimental way of estimating these data using original data collected from the WHO (2017) report as an example. According to this report naming smoking as a bill cannot afford, the direct and indirect health and life loss caused by tobacco in China is 350 billion CNY (57 billion US dollars). There were 1 million smoker deaths annually in 2014. Thus, it is 0.35 million health losses per person yearly in China. Chinese smokers consume 22 cigarettes daily, then combine with 365 days per year ready for division. The Chinese per cigarette health cost is 43.59 CNY for a smoker and 68.06 CNY for a passive smoker. The number of passive smokers refers to the Hong Kong ratio in the previous study. This calculation is due to the most straightforward estimated 10% of smoker loss in the WHO(2017) report, which is more inaccurate than in Hong Kong. Finally, the research use ratio of per capita gross domestic product (GDP) between Shenzhen and China for readjustment. According to the Chinese national and Shenzhen statistics bureau (2015), the national per capita GDP was 46,629 CNY per person in 2014, while 149,497 CNY per person in Shenzhen. Then, the readjusted per-cigarette health cost is 139.75 CNY for a smoker and 218.24 CNY for a passive smoker. This estimation of health loss only has a 10% balance between the direct currency transmission in the previous chapter, proving the previous estimation collecting data acknowledged by WHO is still valid for comparative research.

Meanwhile, satisfaction with active smoking will first set the highest fine for individual smoking offenses at the local price, which is 500 Yuan. The penalty is not fix-based like in Hong Kong, so the research will choose the first level to represent a

single smoking offense for the first time, which is 50 Yuan at minimum. In addition, the penalty for managers who fail to perform their duties in violation of the provision is 30,000 Yuan, which will be a new factor inserted into the Gambit model, starting with the basic one in the following model.

According to the applied basic tree model for Shenzhen's new smoke-free law, the payoff for a smoker not to smoke at the first move will be [￥-500，￥0，￥0]. This amount is approximately ten times lower compared to Hong Kong and partly reflects the economic status of mainland China. The 30,000 Yuan penalty for managers failing to perform their duties violates the provision. Then, insert these data into the model almost every time the enforcer witnesses and punishes the active smoker, except when the manager tried stopping the active smoker before the enforcer arrived.

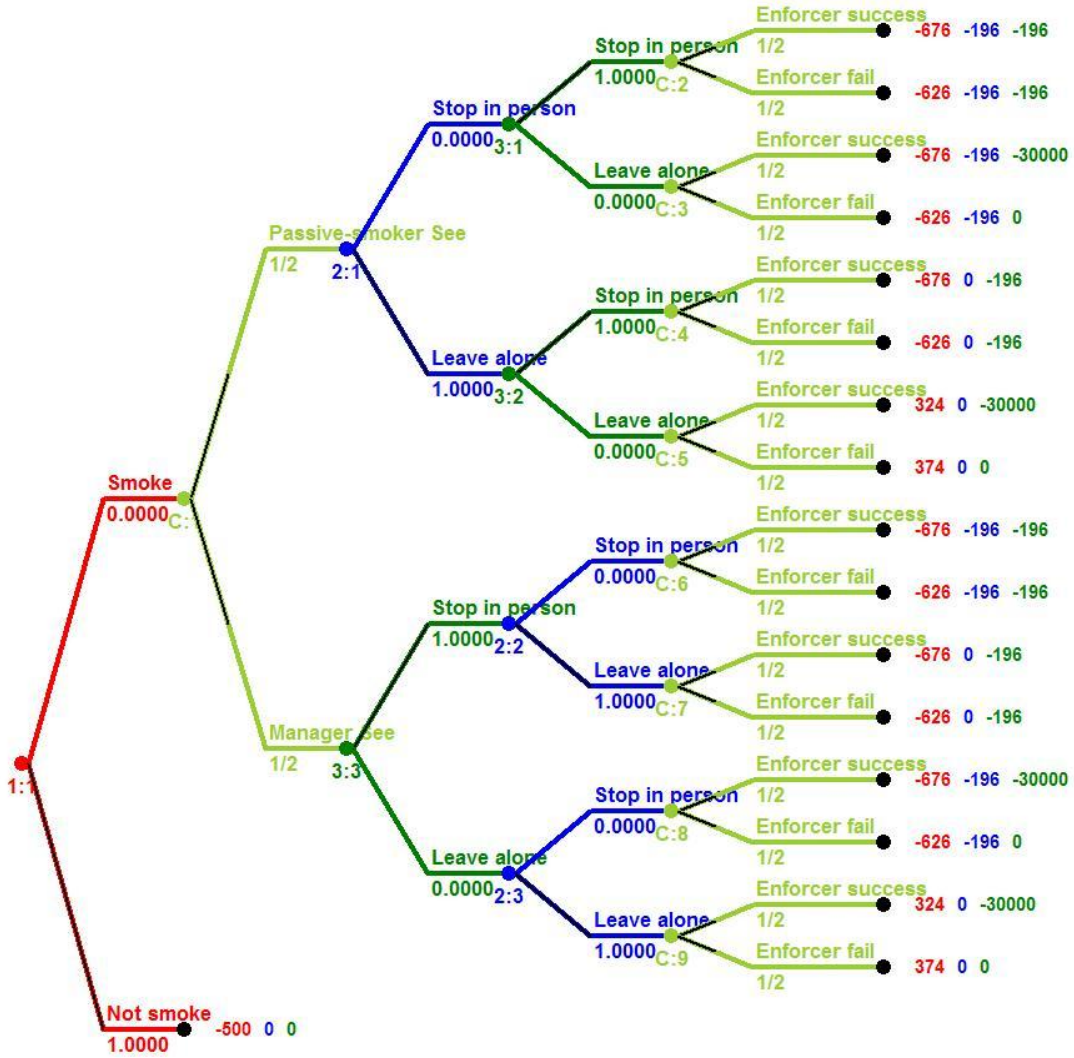


Figure 36. Tree graph of enhanced smoke-free tree game model for Shenzhen

The research will present a basic Shenzhen smoke-free game model before the comparative one. Figure 36 shows the tree graph of this analysis applied the basic tree model for Shenzhen.

According to the computation result in the below screen capture Figure 37, the player's movement under Shenzhen's smoke-free law has two differences compared with Hong Kong. The best strategy for active smoker in this basic smoke-free game is not to smoke, marked in red. Especially **this simulation result is the first and only time in the smoke-free game model that it achieves the ultimate goal. The expectative payoff of smoking ￥-651, which is lower than the highest fine, equals losing the satisfaction of the smoking offense valued at ￥-500 in a particular case. The balance between the expected payoff and the highest fine declined to ￥-150. It stands for just 30.2% of the highest fine. This ratio indicates the actual risk of smoking offense is 30% higher than the law-guided violation price based on Shenzhen's status quo in this model simulation. The law successfully stops the smoker with the satisfaction of smoking violation equal to the maximum penalty in simulation.** Another change in this basic model is manager's best option is to stop the smoker because of the penalty when the manager fails to perform his duties in violation of the provision. The decision route of the passive smoker has not changed, which is the same in Hong Kong to always leave the smoker alone.

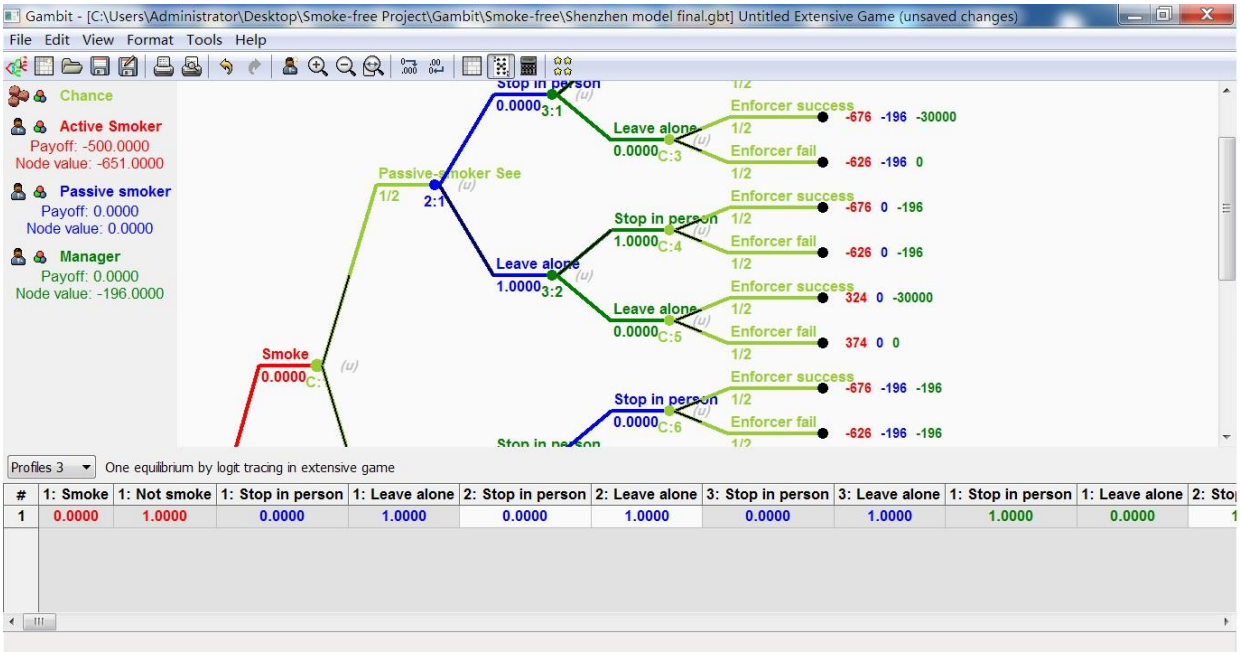


Figure 37. Result panel of basic smoke-free tree game model for Shenzhen

However, this ideal situation only happens when ignoring the chance when active smoker avoid being seen by others. Based on the logical analysis of reduction to absurdity, a counterexample happened, and an active smoker existed at Shenzhen University teaching building of art. Thus, other factors or options are missing in the basic model that differs from the actual case's situation.

Since only one security patrolled the entire teaching building, this would release the active smoker with less pressure from the security controlling the nonsmoking area. Meanwhile, the teaching building has no direct entrance outside the university wall. Even calling the police will not allow the enforcer to come in time, for one active smoker could finish one cigarette in 5-8 minutes. Then enforcer may be unable to come to the site when an active smoker violates the smoke-free law. Thus, it will be too high to estimate the possibility of managers seeing active smoker equal to 50%, as well as the possibility of enforcers.

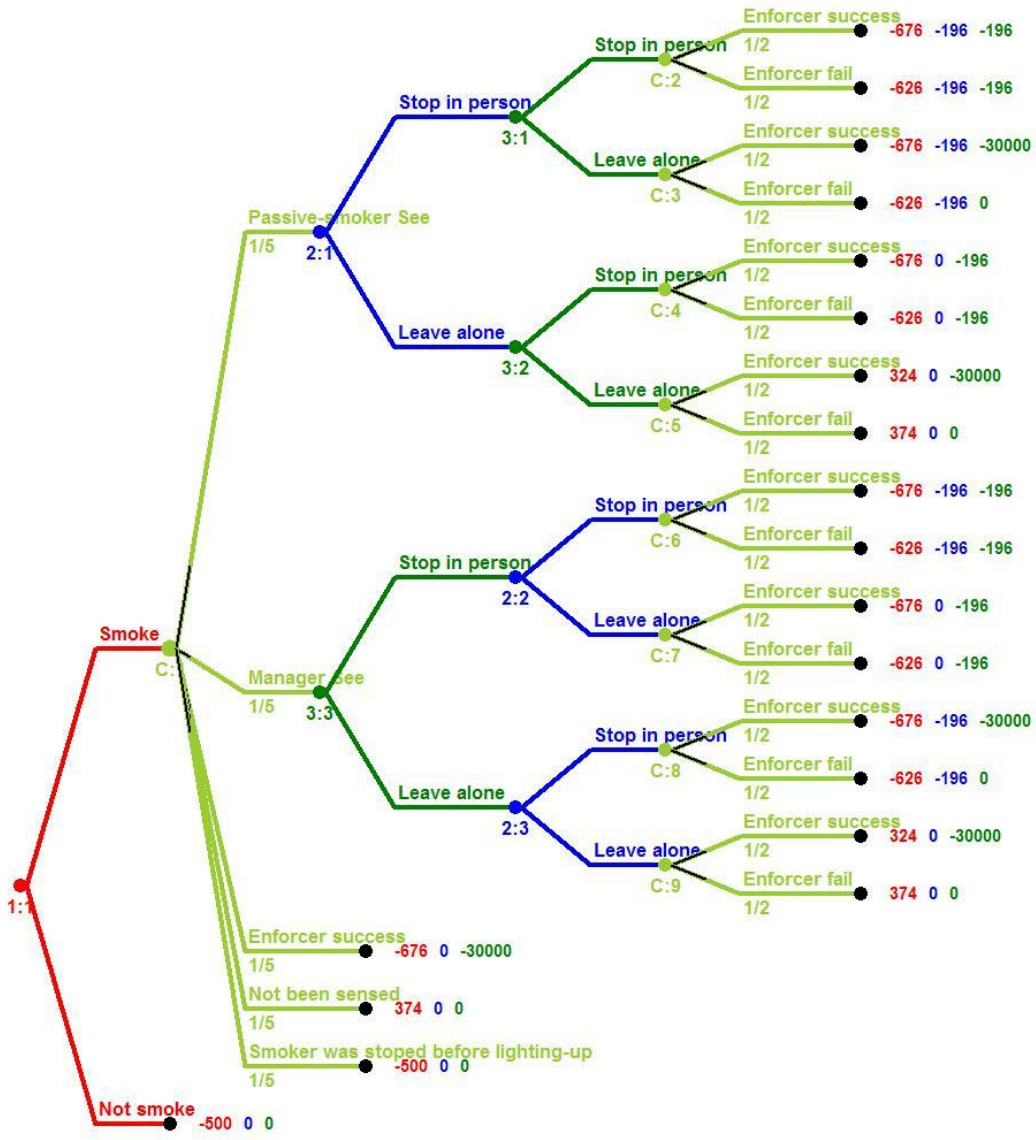


Figure 38. Tree graph of comparative smoke-free tree game model for Shenzhen

Figure 38 shows Shenzhen's graph of the comparative smoke-free tree game model. The research uses the comparative model instead of introducing similar chance player options in the first round of the enhanced game tree model. Then, observe if there are any changes to active smokers' expected payoff when setting the possibility of the manager witnessing at 20%. With the other four options in the first round, chance player and reduce the overall possibility to 40% like Hong Kong. It is equal to catching one active smoker with two enforcers who can reach a place of smoking offense in 6 min, randomly patrolling within one hour, or one enforcer in 12 min.

According to the computation result in the following screen capture Figure 39, **active smokers' best option in this improved option smoke-free game is now reset to not to smoke. The expectative payoff of smoking is ￥-420.8, which is now higher than losing the satisfaction of smoking ￥-500. The balance between the expected payoff and the highest fine declined to ￥79.2. It stands for -15.84% of the highest fine. This ratio indicates that the actual risk of smoking offense is only around 15% lower than the law-guided violation price based on the current model simulation. This result is still better than the ratio in Hong Kong assessed with a similar model, which accounted for 105.66%.** The manager's best option is to stop the smoker by reducing the expected penalty payoff, and passive smokers will still leave the smoker alone.

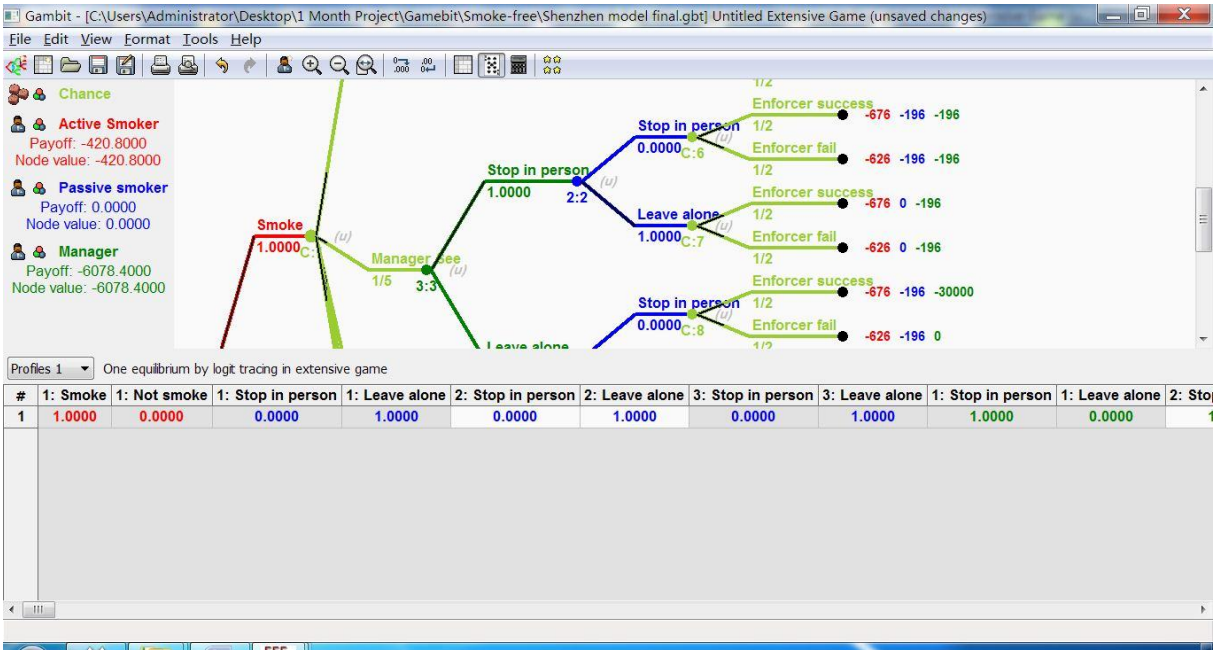


Figure 39. Result panel of a comparative smoke-free tree game model for Shenzhen

Finally, a particular stage of the game could be added at the end of each Shenzhen game tree when the enforcer catches the active smoker. That is to choose whether he or she will stop smoking and pay the ￥50 fine. Alternatively, keep smoking and then pay an extra fine of ￥200 or even, in the worst case, pay ￥500 when refusing to provide identification. For every rational active smoker, paying the ￥50 fine will be

much better than another strategy. Thus, this additional game stage on how to pay the minor fine is not in the current Shenzhen smoke-free game model for comparison with Hong Kong.

This chapter on the China overview and Shenzhen model will end now with the result of the improved comparative tree game model. The results fit the case under the new Shenzhen smoke-free law regulation in the previous output pictures. Furthermore, it is ready for comparative analysis with counterexamples recorded in Hong Kong and cities in Germany. Further advanced evaluation of smoke-free game situations facing incomplete or imperfect information in smoke-free game models will be considered in the discussion and excluded from comparative research.

9 Smoke-free Status quo and Gambit Model Application for Germany

9.1 Overview of tobacco related facts in Germany

In 2005, the World Health Organization published the Framework Convention on Tobacco Control (WHO FCTC), the legally binding for both China and Germany in smoke-free cooperation. Nevertheless, Germany still needs to implement several measures, according to WHO FCTC. In particular, considerable regular increases in the tax on tobacco and a comprehensive advertising ban. **Additionally, passive smoker protection in catering establishments continues to be patchy, with many exceptions. For these reasons, Germany ranked second to last in a ranking of tobacco control policies of the European countries by Luk Joossens & Martin Raw (2007, 2013) within the EU.**

German Cancer Research Center (Deutsches Krebsforschungszentrum in German), aka. DKFZ, released the latest statistics report on smoking 7 years ago. This report by German Cancer Research Center (2015) stated that in Germany, 121,000 people die from the consequences of smoking each year. It also shows that smoking is implicated in 13.5% of all German deaths. The death rate attributed to smoking is higher in the north of Germany than in the south. These regional variations reflect the variations in smoking behavior of the different German states.

The report led by the German Cancer Research Center (2005) also released the pollution level in Germany due to tobacco smoke. Each year, more than 170,000 newborn babies have already been exposed in the womb to the harmful substances contained in tobacco smoke. An estimated 8 million children and teenagers under 18 years old live in a household with at least one smoker. Among the adult population, more than 35 million nonsmokers are forced to inhale the harmful substances contained in second-hand smoke at home, at work, or in their leisure time. In the workplace alone, about 8.5 million nonsmokers are still exposed to second-hand smoke.

The latest data on regional and gender-specific tobacco use variations analyze how smoking trends have changed over time in the ITC Project (2010) report. This report shows the highest death rates among smokers of both genders in the German city-states of Bremen and Berlin, where 23% of men and 11% of women die from the consequences of smoking. The smoking-related death rates among men are lowest in the states of Baden-Württemberg at 17% and Bavaria at 18%. Furthermore, for women lowest rates are in Saxony at 4% and Thuringia at 5%. In comparison, smoking behavior in the age group between 25 and 69 years has remained largely stable since 2009. The smoking rates among young adults and minors have been dropping continuously ever since. Simultaneously, electronic inhalation products such as e-cigarettes and e-shishas have emerged on the market and created new

consumer trends. The cigarette has always been and continues to be a toxic mixture, and its consumption entails severe hazards to health, according to research in Germany. Illnesses caused by smoking include, above all, cancer and cardiovascular and respiratory diseases also in Germany. Specifically, cancer accounts for 52% of smoking-related deaths in men and 41% in women.

Dr. Katrin Schaller and Dr. Martina Pötschke-Langer (2008) published the first-ever calculation of the annual number of fatalities in Germany due to second-hand smoke. The result shows **that 3,301 nonsmokers die yearly from second-hand smoke exposure in Germany.** This death is a more significant number of fatalities than Germany's annual toll from illegal drugs, asbestos, BSE, and SARS combined. **Annually, second-hand smoke causes the deaths of an estimated 2,140 nonsmokers due to coronary heart disease, 770 nonsmokers due to stroke, 50 nonsmokers due to chronic obstructive pulmonary disease, and 260 nonsmokers due to lung cancer.** Approximately 60 infants die each year because of second-hand smoke in the household or from prenatal exposure to harmful substances because the mother smoked during pregnancy.

9.2 Tobacco Atlas Germany for international comparison with China

According to data released by the American Cancer Society (2015) in Tobacco Atlas Germany, tobacco and related diseases kill more than 128,000 Germans annually. This number equals 9.24% of the annual Chinese population killed by tobacco-caused disease. Meanwhile, more than 92,000 children (1.02% compare to China using the same indicator) and more than 17,991,000 adults (6.52% compare to China using the same indicator) continue using tobacco daily. The deaths caused by tobacco separated by a sex difference in German are 21.1% for men and 9.6% for women. Even though fewer men die on average in Germany than in other high-income countries, tobacco kills 1,698 men weekly. This percentage is 1.6% higher than in China. 9.6% of women's deaths were related to tobacco use in 2010. It is also lower compared to women dying on average in Germany and other high-income countries. Tobacco kills 758 women every week, which is 2.3% lower than that in China.

A smoker in Germany would have to spend 2.7% of the national median income to purchase 10 of the cheapest cigarettes to smoke each day. In contrast, a smoker in China would only have to spend 1.7% of the national median income to purchase 10 of the cheapest cigarettes to smoke each day. The combined revenues of the world's six largest tobacco companies in 2013 were 342 billion US dollars, equal to 9% of the Gross National Income of Germany. While this only accounted for 4% of the Gross National Income of China in the same year.

In 2013, the percentage of adults using tobacco daily was 45.3% of men and 2.1% of females in China. Meanwhile, 28% of men and 22,2% of females in Germany. These data indicate that the percentage of male smokers almost doubled in China compared with that in Germany, while the percentage of female smokers in Germany is ten

times higher than that in China. More men and women smoke in Germany than the average level in high-income countries. In contrast, more men smoke in China than the average level in middle-income countries. Fewer women on smoke on average in China compared to middle-income countries.

Moreover, the percentage of children using tobacco daily is 18% of boys and 0.5% of girls in China, while 4.5% of boys and 5.2% of girls in Germany. Even though fewer boys and girls smoke on average in Germany than in high-income countries, 44,000 boys and 48,400 girls smoke cigarettes daily. Compared to China, more boys smoke in China, on average, in middle-income countries. Even though fewer girls smoke on average in China compared to the average in middle-income countries, 225,200 girls still smoke cigarettes daily.

German's current smoke-free policy is also inadequate compared to China, according to the records in the Tobacco Atlas database.

In the "Protect from Smoke" section, Germany only achieves Smoke-free Government Facilities. China only achieves Smoke-free Public Transport. Both China and Germany get unknown status on All Other Indoor Public Places Smoke-free in an entire list of the smoke-free regulated area. All other locations in China and Germany are marked with NO in smoke-free policy, including Smoke-free HealthCare Facilities, Smoke-free Universities, Smoke-free Indoor Offices, Smoke-free Restaurants, Smoke-free Pubs, and Bars & Funds for Smoke-free Enforcement.

A section on offering help for smokers to quit smoking is also lacking in Germany. For quitting solutions, there are only NRT and/or some cessation services (neither cost-covered) in both China and Germany. Nevertheless, Germany has a national quit line when China does not. In the Raise Taxes on tobacco product section, China only has 26% of Retail Price as Excise Tax. While the WHO Benchmark is 75% and 57% in Germany, higher than in China.

In the Enforce bans on advertising section, the number of Bans on Forms of Direct Advertising in China is 0 of a possible seven bans, which is the same in Germany. The number of Bans on Forms of Indirect Advertising is 4 of a possible seven bans, which is also the same in Germany. The advertisement Ban Compliance percentage is only 10% self-rated compliance in China while it is 20% in Germany, higher compared to China.

China scored an entire point in Only 1 section, which is better than Germany. Warn about the dangers to the whole population in a media campaign with all YES compared to WHO best practice. In comparison, Germany missed one YES in Aired on Television and/or Radio.

9.3 German smoke-free legislation assessment: Bavaria as sample

At the national level, the no smoking law in Germany was updated at the end of July 2008 after the German Federal Constitutional Court upheld complaints against some parts of the smoking ban in Berlin's city-state and Baden-Wuerttemberg. Smoking will now be allowed in one-room bars, and clubs smaller than 75 square meters were not serving the food. According to a review by Stefan Kohler and Philipp Minkner (2014), the court gave Berlin and Baden-Wuerttemberg until the end of 2009 to draft new antismoking legislation. The judge's ruling sets a legal precedent for Germany because most states have similar antismoking laws. Although, it is most likely that all German states will review their laws and perhaps make some modifications. However, it is unlikely that the ban will lift smoking in many places.

Since September 2007, smoking has been prohibited in all federal government office buildings across Germany. These areas include courthouses, the German Parliament, and other federal buildings in Germany. Smoking is banned on public transportation as well. **Smoking at train stations is allowed only in designated smoking areas. Fines for violations range from €5 to €1,000.**

While it is up to the individual states to pass specific nonsmoking laws, the federal government has also done its part to reduce the number of places permitting smoking through legislation. An additional part of the German federal regulations is the ban on allowing minors to smoke in public. It is also against the law to sell tobacco products to minors. It fits cigarette machines in public areas with a device requiring a user to insert a German driver's license or a bank card in a slot before cigarettes can be purchased.

The smoke-free laws in different German states are apparently variable. Bavaria passed the strictest smoke-free law among the German states. Active smokers cannot smoke indoors at any bar or restaurant. In all states, even Bavaria, it is usually allowed to smoke outdoors: on terraces in beer gardens, and sometimes even in tents. Furthermore, in all states except Bavaria, the proprietor can permit smoking in a separate room, even well-sealed off from the main room. The states of North Rhine-Westphalia and Thuringia were the last ones to impose the ban. The federal government did not have this authority, so the states had to pass the ban individually. There are differences among smoke-free laws in other states of Germany as well.

Depending on the state, the smoking ban can also apply to other public buildings, such as schools, sports facilities, museums, airports, and hospitals. Penalties for violating the law also vary well. In Saxony, an active smoker can be fined up to €5,000, while in Hamburg and Thuringia, the maximum is €500.

Besides, all 16 states in Germany apply the mandatory smoke detectors policy,

according to the website: Smoke detectors save lives (2021). Although this policy is not only about smoke-free but also fire fighting, this is an advantage in Germany compared to China as a supporting law arrangement for smoke-free control.

The Tobacco Control Laws (2019) also provide a summary of smoke-free legislation in Germany that is easy to compare with China, quote:

> "Germany became a party to the WHO Framework Convention on Tobacco Control on March 16, 2005.
>
> Smoke-free Places: Under federal law, smoking is restricted in indoor workplaces and public places. Smoking areas may be permitted on means of transport where it is possible to have "physically separate units" (e.g., rail or passenger ships); however, smoking is prohibited on transport such as streetcars, trolleys, buses, and taxis. Sub-national laws apply at the state (Länder in German) level, and all 16 states have enacted laws restricting or banning smoking in places where states have authority. Sub-national laws may be more stringent than the national law.
>
> Tobacco Advertising, Promotion and Sponsorship: Tobacco advertising is prohibited on TV, radio, and in most print publications. Other types of print advertising, such as flyers, posters, signs, and outdoor advertising, are not covered under the law. Point of sale advertising and promotion and product display are also allowed. Other types of promotional activity - such as brand stretching, promotional discounts, gifts and prices, and retailer incentive programs - are not addressed in the law and therefore allowed. There are some restrictions on tobacco sponsorship and the publicity of such sponsorship.
>
> Tobacco Packaging and Labeling: For smoked tobacco products, one of two authorized text warnings must occupy 30 percent of the front of package, and one of 14 authorized text warnings must occupy 40 percent of the back of package. The front and back warnings must be rotated so that they regularly appear on the packages. However, the law does not specify how frequently the warnings are to be updated. For smokeless tobacco products, one text warning must occupy 30 percent of the front of the package. Misleading packaging and labeling, which could include terms such as "light" and "low tar" and other signs, is prohibited.
>
> Roadmap to Tobacco Control Legislation shows Germany's 16 states concluded a framework agreement in March 2007 with the federal government. The agreement required states to adopt smoking regulations in the areas where states have authority. This includes land, local institutions, educational facilities, healthcare facilities, cultural

institutions, sport facilities, hospitality venues and other public places. All 16 states have passed laws restricting or banning smoking in indoor public places.

At the federal level, smoking in indoor workplaces, indoor places, and public transport are governed by the Ordinance on Workplaces and the Law to Protect against the Dangers of Passive Smoking (also known as the Federal Non-Smoker's Protection Act). State laws may be more protective, but not less protective, than federal law.

The Provisional Tobacco Act regulates, among other things, advertising, promotion and sponsorship of tobacco products. The Act also authorizes, among other things, regulations regarding packaging and labeling. The Tobacco Product Ordinance (issued under the Food and Consumer Products Act) regulates packaging and labeling including health messages, and tar, nicotine, and carbon monoxide information. The Tobacco Ordinance (issued under the Food and Consumer Products Act) regulates allowable and prohibited substances in tobacco products. The Protection of Young Persons Act regulates numerous industries in relation to children and adolescents, including the sale of tobacco products, the prohibition on children and adolescents smoking in public places, and the sale of tobacco products through vending machines."

(Tobacco Control Laws 2019)

9.3.1 State-by-state summary of the German smoke-free laws

This list is a real-time online introduction to smoke-free laws as follows, quote:

"Bavaria (Bayern)

The smoking ban was started on January 1, 2008. It is the most comprehensive and severe of the German states. No smoking was allowed in adjoining, separated rooms and in party tents. (However, an exception has been made to allow smoking in the tents of the 2008 Oktoberfest, but later this exception was canceled as well.) **Smoking is not allowed in any public building, school, or hospital.** Exceptions are made for private parties or clubs. **Fines for violations range from €5 to 1,000, and the fines can be imposed on individuals and businesses.**

Baden-Württemberg

The smoking ban came into power here on August 1, 2007. Here, you are permitted to smoke in restaurants with separate smoking rooms and in

party tents. Don't light up in nightclubs and discotheque. Adult-age students and teachers are permitted to smoke in designated areas on school property. This included vocational schools and colleges. **Fines for individuals caught breaking the law can range from €40 to €150.**

Berlin

The smoking ban in public facilities, **including schools and hospitals**, started on January 1, 2008. However, adjoining rooms can be exempt. Fines started being levied on July 1, 2008. **Individuals can be fined up to €100, and businesses that break the law can be fined up to €1,000.**

Brandenburg

Smoking was banned in January 2008 in public places, schools, and other educational facilities, hospitals, retirement, and foster care homes. Smoking is permitted in restaurants, hotels, and cultural facilities in adjoining rooms providing that these areas are completely separate. There is no smoking allowed in discos. **Fines for individuals can range from €5 to €100, and businesses can expect fines ranging from €10 to €1,000.**

Bremen

The smoking ban became effective in schools and hospitals in August 2007 and was extended to include restaurants, discos, party tents, hotels, the harbor front area, and airports as of January 2008. Exceptions are made for traditional and special events. Separate smoking rooms are allowed in restaurants and discos that do not have a dance floor. **Individuals can be fined up to €500 and businesses up to €2,500.**

Hamburg

Smoking has been prohibited in all public facilities, including hospitals, schools, restaurants, and government offices in Hamburg, since January 2008. Designated smoking sections are the rule here for restaurants, provided that the rooms have appropriate ventilation devices. Party tents for special events are excluded from the ban. **Individuals can be fined anywhere from €20 to €200 and businesses from €50 to €500.**

Hessen

Hessen is a forerunner of non-smoking laws, been enforced here as early as October 2007 for restaurants and public facilities. Smoking is permitted only in Hessen in adjoining rooms provided that these are separate from non-smoking areas, and the same condition applies for party tents for special events. Businesses may construct "separate" rooms

without special construction permits until 2009. **Individuals can be fined up to €200 and businesses up to €2,500.**

Mecklenburg-Vorpommern

Here, the non-smoking ban took effect in August 2007. As of January 1, 2008, smoking has also been banned in restaurants. However, the restaurants can opt to provide a separate adjoining room if they wish. The same rule applies to government offices, hospitals, colleges/universities, foster homes, airports, and sports venues. **Individuals can be fined up to €500 and businesses up to €10,000.**

Niedersachsen

As of August 2007, the smoking ban became effective for restaurants, bars, and discos; restricted here again to separate onsite rooms. In this state, smoking is prohibited in public facilities such as schools, hospitals, and government offices.

Nordrhein-Westfalen

The New Year marked the implementation of the smoking ban, stretching to include restaurants, on July 1, 2008. Restaurants may provide separate smoking areas if the premises have enough rooms to provide this sort of arrangement. Smoking is not allowed in schools and educational institutions, or health facilities. Exceptions to the smoking ban here are party tents, special regional events such as Karneval and Schützenfeste, and special private parties and bars. **Fines range from €5 to €1,000.**

Rheinland Pfalz

Here the smoking ban came into effect on February 15, 2008. Hosts may designate separate (but smaller) rooms as smoking rooms. Small bars with only a main room and service only by the proprietor may allow smoking. Students of legal age may smoke in separate rooms and in smoking zones. **Individuals can be fined up to €500 and businesses up to €1,000.**

Saarland

This tiny state is the biggest exception to the general smoking ban in restaurants. In other words, smoking is allowed in small bars where the host/owner serves. In bigger restaurants, however, separate rooms must be provided. In party tents, the host/owner may authorize smoking. Smoking was prohibited in all public facilities, including government offices, schools, and hospitals, as of February 15, 2008. **Individuals can be fined up to €200 and businesses up to €1,000.**

Sachsen

The smoking ban took effect in Saxony on February 1, 2008 for public facilities. Smoking is allowed in bars if a separate room is provided. The discos were required to be smoke-free**. Violations here can be as high as the €5,000 Euro.**

Sachsen-Anhalt

January 1, 2008, the smoking ban for public buildings and restaurants took effect. Separate smoking rooms are allowed in hotels and restaurants. Smoking was not allowed in discos. **Individuals can be fined up to €500 and businesses up to €1,000.**

Schleswig-Holstein

As of January 1, 2008, smoking was prohibited in public facilities. Restaurants were required to designate a separate smoking area. **Individuals can be fined up to €400 and businesses up to €4,000.**

Thüringen

In Thüringen, the smoking ban began on July 1, 2008. Smoking is prohibited in pubs, discos, government offices, hospitals, schools, and cultural facilities. However, restaurants may authorize smoking in separate rooms. **Individuals can be fined up to €50 and businesses up to €500."**

(How To Germany 2018)

In fact, the nonsmoking areas also vary among the states in Germany. Figure 40 shows that the nonsmoking sign inside a red circle is completely prohibited, and the yellow one is only partly for active smoking prohibition. Railway stations, or train stations are the only nonsmoking area that altogether prohibits smoking all around the states of Germany. This situation led to the additional field research of counterexample at the train station in the following research besides the university campus. The research selected this place because it could represent the status quo of smoke-free law enforcement in cities, states, and nationwide.

	Administrative bodies, Courts	Prisons	Clinics	Asylums	Schools, Youth-houses, Kindergartens	High-schools	Gymnasiums, Indoor-pools	Museum, Theatre, Cinemas...	Discos	Restaurants	Malls	Airports	Railaway-stations
Baden-Württemberg	⊘	1 7	6	⊘	4	⊘	⊘	5	9	1 12			⊘
Bavaria	10		6 10	7 10	⊘	10	⊘	⊘	⊘	⊘		10	⊘
Berlin					⊘				⊘	1 12			⊘
Brandenburg	1	1 7	6	7	⊘	⊘	⊘	6	1	1 12	⊘		⊘
Bremen	⊘	7	⊘	⊘	⊘	⊘	⊘	⊘	9	1		⊘	⊘
Hamburg	⊘	7	⊘	⊘	⊘	⊘	⊘	⊘	⊘	12	⊘	⊘	⊘
Hesse	1	1 7	1	1	1	1	1	1	1	1 12		1	⊘
Mecklenburg-Vorpommern	⊘		⊘	⊘	⊘	⊘	⊘	⊘	⊘	1		3	⊘
Lower Saxony	⊘		⊘	6 10	7	⊘	⊘	10	⊘	1 12	⊘	10	⊘
North Rine Westphalia	⊘	2	6	⊘	⊘	⊘	⊘	⊘	⊘	⊘	13	14	⊘
Rhineland-Palatinate	⊘	1 2	⊘	1 7	⊘	⊘	⊘	⊘	9	1 11			⊘
Saarland		2	6 7	7	⊘	⊘	8	⊘	1	1		⊘	⊘
Saxony	⊘		⊘	⊘	⊘		⊘	⊘	⊘	1 11 12			⊘
Saxony-Anhalt	1	7	7	1	1	1	1	1	⊘	1	⊘		⊘
Schleswig-Holstein	⊘		⊘	7	7	⊘	⊘	⊘	1	1			⊘
Thuringia	1		⊘	7	⊘	⊘	⊘	⊘	9	1	⊘		⊘

Figure 40. Comparison of the smoke-free law in different states of Germany[15]

To better understand the German smoke-free laws, the researcher translated the national smoke-free regulation as follows for reference. This selection is essential because all states' smoke-free laws are under this draft structure of national smoke-free regulation. It indeed lists train stations as one of the significant smoke-free regulated areas but lets the states decide the fine according to their own smoke-free law.

Federal law in Germany is only effective if announced in the Federal Law Gazette (Bundesgesetzblatt). The federal states of Germany announce their laws and ordinances in a Law and Ordinance Gazette (Gesetz- und Verordnungsblatt). In the state of Saarland, an Official Gazette (Amtsblatt) fulfills this function. The researcher searched the respective gazettes of the federal republic and all 16 federal states for announcements of smoke-free laws through the Beck-Online law database. Officially announced changes to the smoke-free laws were considered until at least June 28, 2013, and at most until November 27, 2013.

The law on introducing a smoking ban in federal institutions and public transportation (Bundesnichtraucherschutzgesetz, or BNichtrSchG) is a German national law prohibiting smoking in federal and public transportation facilities by Federal Law Gazette (2007). After the inaction of this law, it became a primary part of the Mantle Act. The full name is the act protects against the dangers of second-hand smoke.

[15] Screenshot source: https://de.m.wikipedia.org/wiki/Nichtraucherschutzgesetze_in_Deutschland

Federal Law Gazette (2007) enacted the Law to Protect Against the Dangers of Passive Smoking after joining WHO FCTC. On July 20, 2007, it regulated smoking in federal facilities, public transportation, and public train stations. Later, with the Article 2 Amendment of the Workplace Ordinance. Also, Article 3 Amendment of the Protection of Young Persons Act, Article 5–7. In one sentence, the explanation of Article 1 is the same as BNichtrSchG on the same page.

The Federal Nonsmoking Protection Act entered into force on September 1, 2007. The law includes a general ban on smoking in all federal and federal constitutional bodies, in public transportation, and passenger stations of **public railways in fully enclosed spaces**. A violation of the ban is a gem. § five an administrative offense.

To better understand the German smoke-free law, the researcher translated it into English for comparative research, and the essential parts are also in bold letters like in previous chapters.

9.3.2 Law on introduction of a smoking ban in federal and public transport facilities

"Law on the introduction of a smoking ban in federal and public transportation facilities (Bundesnichtraucherschutzgesetz - BNichtrSchG)

BNichtrSchG

Date of production: 20.07.2007

Full citation:

"Federal Non-smoking Protection Act of July 20, 2007 (Federal Law Gazette I p. 1595)"

Footnote (+++ Text proof from: 1.9.2007 +++)

The G was called Art. 1 d. G v. 20.7.2007 I 1595 (PassivrauchSchG) by the Bundestag with the consent of the Bundesrat. It is a gem. Art. 7 Para. One of these G entered into force on 1.9.2007.

§ 1 Smoking ban

(1) Smoking shall be prohibited in accordance with paragraphs 2 and 3

1. in the federal and constitutional organs of the Federation,

2. within public transportation,

3. at passenger stations on public railways.

(2) The prohibition of smoking referred to in paragraph 1 applies in buildings and other fully enclosed spaces; it does not apply to rooms that serve residential or overnight accommodation

purposes and are left to the residents for their sole use.

(3) By way of derogation from paragraphs 1 and 2, the first half-sentence, the designated facilities, means of transport, and **stations may have separate and appropriately marked spaces in which smoking is permitted, provided that sufficient rooms are available**. Sentence 1 does not apply to the means of transport referred to in § 2 No. 2 letter b.

(4) The Federal Government shall be authorized by the ordinance to issue without the consent of the Bundesrat. More detailed provisions on the design and labeling of smoking rooms according to paragraph 3. in particular regarding the structural requirements regarding the size, location, design, and manner of their ventilation.

§ 2 Definitions

1. Federal agencies have within the meaning of this law are

a) Authorities, departments, courts, and other public institutions of the Federation,

b) Federal bodies, institutions, and foundations.

2. **Public transportation is within the meaning of this act**

a) the railway vehicles of the public railways used for the transport of persons according to § 3 Abs. 1 of the general railway law,

b) trams, trolleybuses, and motor vehicles used for the carriage of passengers, insofar as the carriage is subject to the provisions of the Passenger Transport Act or § 1 (4) (d), (g) or (i) of the Exemption Regulation;

c) Aircraft used for the commercial or installing carriage of passengers or professional sightseeing flights,

d) Passenger ships carrying passengers on scheduled flights.

3. **Passenger stations of the public railways are those according to § 3 Abs. 1 in connection with § 2 Abs. 3c Nr. 2 of the general railway Act.**

4. Spaces within the meaning of this law are

a) structurally separated units of a building,

b) spatially separated units of a means of transport.

§ 3 Obligations to inform

The smoking ban under § 1 must be <u>appropriately indicated</u>.

§ 4 Responsibility

The establishment of the smoking areas and the fulfillment of the obligation to inform under § 3 are the responsibility of the

owner of the house right or the operator of the means of transport.

§ 5 Penalty rule

(1) Offenders who smoke contrary to § 1 paragraph 1 act.

(2) Administrative offense may be punished with a fine.

(3) Administrative authorities within the meaning of Section 36 Subsection 1 No. 1 of the Act on Administrative Offenses are. Insofar as this law is executed by the Federation, the supreme federal authorities for themselves and their business as well as for the constitutional organs of the Federation respectively for the exercise of the house right authorized. Section 36 (3) of the law on administrative offenses applies accordingly."

(Federal Law Gazette 2007, 1595–1597)

9.3.3 Law for the protection of health

Bayreuth is a city in Bavaria that follows the smoke-free legislation in Bavaria State. Thus, the smoke-free regulation in Bayreuth should also be considered the strictest region in Germany, according to David Levitz (2010). The smoke-free law in Bavaria is a 3-page document named law for protecting health (GesetzzumSchutz der Gesundheit in German) by Bavarian Law and Ordinance Gazette (2007, 2010), which is Bayerisches Gesetz- und Verordnungsblatt in German. This law is the shortest in this research compared to current primary smoke-free laws in Hong Kong and Shenzhen. It has two versions, and the researcher selected the new one that came into action in 2010 and translated it into English for comparison.

"Law for protecting the health

(Health Protection Law - GSG)

Art. 1 Aim

The aim of this law is to protect the population from the health risks of passive smoking.

Art. 2 Scope of applications

This law applies to:

1. Public buildings:

a) buildings of the Bavarian State Parliament, including those used by the

political groups and members of parliament,

b) buildings by the authorities of the Free State of Bavaria, the municipalities and the municipal associations,

c) buildings of the other public law entities subject to the supervision of the Free State of Bavaria,

d) buildings of the courts of the Free State of Bavaria,

2. Facilities for children and adolescents:

a) schools and educational institutions,

b) school homes,

c) children's playgrounds, which are physically separated and dedicated by the bearer,

d) daycare facilities in accordance with the Bavarian law on education, upbringing, and care of children in kindergartens, other daycare centers, and daycare (Bayerisches Kinderbildungs- und -betreuungsgesetz - BayKiBiG) of July 8, 2005 (GVBl p. 236, BayRS 2231–1-A), amended by Article 117 of the Law of December 8, 2006 (GVBl p. 942),

e) other facilities and rooms where children are cared for all day or part of the day, in particular maternity centers, daycare, babies' clubs, shopping malls with childcare facilities,

f) youth hostels,

g) cultural and recreational facilities, according to no. 6, which are at least predominantly by children and adolescents and

h) other child and youth welfare services according to the Eighth Book of Social Law (SGB VIII) - child and youth welfare - (Article 1 of the Law of June 26, 1990, BGBl I p. 1163) in the version of the notice of 14. December 2006 (BGBl IS 3134), as amended by Article 2 (23) of the Act of February 19, 2007 (BGBl I p. 122),

3. Educational facilities for adults:

Adult education centers and other **adult education institutions, public universities**,

4. Healthcare facilities:

Hospitals, preventive and rehabilitation facilities within the meaning of Section 107 of the Fifth Book of the Social Code (SGB V) - Statutory Health Insurance - (Article 1 of the Law of December 20, 1988, BGBl I p. 2477), last amended by Article 38 of the Act of December 2, 2007 (BGBl I p. 2686), as well as comparable inpatient facilities that serve the purpose of medical care or the restoration of the health of patients, except the palliative care units,

5. Homes:

Student dormitories and homes in the sense of the Home Act (HeimG) in the version of the notice of November 5, 2001 (BGBl I p. 2970), last amended by Article 78 of the Ordinance of October 31, 2006 (BGBl I p. 2407), except the hospices,

6. Culture and leisure facilities:

Facilities serving the preservation, mediation, performance, and exhibition of artistic, entertaining, or historical content or works or recreational activities, as far as they are publicly accessible, in particular cinemas, museums, libraries, theaters, club premises,

7. Sports facilities:

Fixed facilities and facilities for the performance of sports,

8. Restaurants:

Restaurants in the sense of the restaurant act as amended on November 20, 1998 (BGBl I p. 3418), last amended by article 10 of the law of September 7, 2007 (BGBl I p. 2246),

9. Airports:

Airports include buildings or parts of buildings of commercial airports that serve public transportation and passenger handling.

Art. 3 Smoking ban

(1) Smoking is prohibited indoors in buildings, facilities, homes, sports facilities, restaurants, and airports mentioned in Art. 2. In facilities for children and adolescents (Article 2, No. 2), smoking is also prohibited on the grounds of the facilities.

(2) Smoking bans in other regulations or on the basis of powers associated with ownership or ownership remain unaffected.

Art. 4 Supervision

Free State of Bavaria, municipalities, and associations of municipalities as well as the other public law entities. Subject to the supervision of the Free State of Bavaria must work toward prohibiting smoking in private companies in which they are involved.

Art. 5 Exceptions

The smoking ban, according to Art. 3 Para. 1 does not apply:

1. in rooms that are used for private residential purposes and are left to the residents and their families for their sole use,

2. in designated areas of the police and public prosecutor's offices. Where interrogations are conducted, the interrogated person is allowed to smoke by the head or the interrogator on a case-by-case basis. The same applies in designated rooms of the courts for interrogations by the investigating judge or the investigating judge,

3. in artistic performances where smoking as part of the performance is an expression of artistic freedom.

Art. 6 Smoking room, smoking area

(1) By derogation from the first sentence of Article 3 (1), the person responsible (Article 7) may authorize smoking in an adjoining room for each building or facility. 2 Set 1 does not apply to institutions according to Art. 2 No. 2. **Except the facilities for outpatient and inpatient addiction therapy as well as education and integration assistance for adolescents and young adults** - as well as for facilities according to Art. 2 Nos. 6 to 8.

(2) In derogation from paragraph 1, sentence 1, in psychiatric hospitals, smoking may be permitted in any ward in an adjoining room; the same applies to psychiatric wards of somatic hospitals. Without prejudice to the first sentence of paragraph 1, the head of a correctional facility or a prison establishment may allow smoking in public areas. By way of derogation from the first sentence of paragraph 1, several smoking rooms may be set up in commercial airports and in those public buildings in which more than 500 employees work.

(3) If the room is to be marked as a smoking room, the smoking room must be structurally separated from the other rooms so that there is no constant air exchange.

(4) By derogation from Art. 3 Para. 1 sentence 2, the responsible person (Art. 7) may smoke in a designated subordinate area of the grounds for institutions for outpatient and stationary addiction therapy as well as education and integration assistance for adolescents and young adults allowed. Paragraph 3, sentence 1 applies accordingly.

Art. 7 Responsibility

Responsible for compliance with the smoking ban, according to Art. 3 Para. 1 and for fulfilling the labeling obligation according to Art. 6 Para. 3 sentence 1 are:

1. the President of the Bavarian State Parliament,

2. the head of the authority, the court, the institution, or the home,

3. the operator of the restaurant,

4. the operator of the airport.

In the event of a breach of the smoking ban, the controller (s) must take the necessary measures to prevent the continuation of the infringement or a new infringement.

Art. 8 Jurisdiction

For executing this law are responsible

1. concerning the buildings of the Bavarian State Parliament, the President of the Bavarian State Parliament,

2. otherwise, the district administrative authorities.

Art. 9 **Offenses**

(1) A fine *may be* imposed on persons who deliberately or negligently smoke in violation of a smoking ban, according to Article 3 (1).

(2) A fine *may be* imposed on persons who, contrary to the obligation laid down in the second sentence of Article 7. Fail to take the necessary measures to prevent the continuation of the infringement or a new breach of the smoking ban.

Art. 10 Come into effect

(1) This law will enter into force on January 1, 2010.

(2) At the end of July 31, 2010, the Act on the Protection of Health (Health Protection Act - GSG) of December 20, 2007 (GVBl p. 919, BayRS 2126-3-UG), as last amended by the law of July 27, 2009 (GVBl p. 384), ineffective."

(Bavarian Law and Ordinance Gazette 2010, 314–316)

According to a previous review of the law, the law of nonsmoking in Bayreuth is similar to the state law of Bavaria that set a smokeless environment via smoke-free law passed in the state on August 1, 2010. Moreover, the law on the Protection of Health (Health Protection Act GSG) adopted by the Volksbidid on July 4, 2010, entered into force. This situation is similar to China combining all the smoke-free laws while this one is on the state level, which is equal to the provincial level in China.

General information on the Protection of Health (Health Protection Act GSG) with enforcement instructions to the legal administration authorities:

The content of the smoke-free law in Bavaria includes a smoking ban in children's and youth facilities (Art. 2 No. 2 GSG), a smoking ban in restaurants (Art. 2 No. 8 GSG), a smoking ban in beer, wine, and grapes (Art. 2 No. 8 GSG), a smoking ban in sports facilities (Article 2 (7) GSG) and a smoking ban in public authorities (Article 2 (1) GSG).

The public buildings include all the buildings by the Bavarian-free State of Bavaria authorities. The municipalities and municipal associations and all buildings of the other legal entities are under public law governed by the auspices of the Free State of Bavaria within the meaning of Article 1 Bavarian Administrative Procedure Law (BayVwVfG) Free State Bavaria. However, it excludes, in particular, the buildings of the churches and other religious communities and the private companies (i.e., AG, GmbH) in which the state is involved. Article 4 of the Health Protection Act (GSG) applies to these companies.

The smoking ban in the aforementioned public buildings is independent of whether public transportation occurs or whether the offices are used as individual offices. A smoking room can be set up in buildings and completed buildings with up to 500 employees. Several smoking rooms can be set up in buildings with more than 500 employees. There is no legal obligation to set up a smoking room. The smoking room must be separated, so there is no constant air exchange with the rest of the building. Ventilation systems can help improve the room's air. Smoking areas are not allowed in the open space of a building, for example, in open courtyards. Authorities can regulate these areas, if necessary, for the rest of the outside areas and for visiting the smoking area.

However, a violation of the ban on smoking is impunity. There is no precise amount of penalty listed in the smoke-free law. The management must ensure the smoking ban is respected using organizational measures. Violations, on the other hand, may have consequences for work and service law. In the case of complaints to the authorities, the latter affects compliance with the smoking ban.

The county administrative authorities are responsible for enforcing the Health Protection Act (Art. 8 No. 2 GSG).

Smoking guests violate the law if they smoke intentionally or negligently against a smoking ban. The innkeeper can violate the health protection law in 2 ways: on the one hand, by smoking in the restaurant, and on the other hand, by not intervening when a guest smokes.

The assessment of whether the innkeeper has refrained from his duties of action or action depends on the individual case's overall circumstances. As soon as a guest violates the ban on smoking, the innkeeper must take the means to stop smoking. If necessary, he must call the competent authorities.

The general provisions of the regulatory offense law apply to regulatory issues. A statutory fine of 5 to 1000 Euro can be exhausted. Instead of the penalty procedure by the employees of the county administrative authorities levy of 5 to 35 Euro can be imposed for minor offenses. The revenues from fines and administrative fees are fully paid to the county administrative authorities in accordance with *Art. 7 Para. 2 FAG*.

The Health Protection Act does not specify regulatory controls' type, extent, and frequency. As a rule, event-related checks, for example, in the case of repeated complaints about the innkeeper or the guests of a particular establishment, will not be sufficient for smoke-free control in practice.

9.4 Gambit model application with counterexample in Bayreuth

Although Bayreuth represents the strongest level of smoke-free legislation in Germany, the researcher witnessed and recorded at least 3 counterexamples of smoking offenses in Bayreuth. Every violation of the smoking ban shall be fined according to the GSC in the previous chapter. However, in reality, the effectiveness of smoke-free is doubtful, with several counterexamples recorded via field research. Meanwhile, the house rules of the German railways (Deutsche Bahn) downloaded from **German railways (2015) show the company has a 40 Euro penalty for smoking in the station. However, according to field research, this notice is not clearly presented at the Bayreuth train station.**

Figure 41 shows a counterexample recorded at the Bayreuth youth hotel (Jugendherberge in German), and its location is where the yellow arrow is pointing on the map:

Figure 41. Part of the campus map for university Bayreuth includes youth hotel[16]

16 Original photo source: https://www.uni-bayreuth.de/de/universitaet/kontakt_campusplan/campusplan/campusplan-grafiken/Campusplan_1100px-jpg_de.jpg

According to Figure 41, the youth hotel is at the northeast corner of the campus land, right next to student apartment buildings (studentenwohnheime in German). It is part of the university entrance since it is part of the campus map for the university, and it is the walkway entering the university from Kreuzsteinbad.

Figure 42. Photo showing the entrance of the Bayreuth youth hotel in 2015

The researcher took a photo of the Bayreuth youth hotel entrance in 2015, which is shown in Figure 42. A trash can with a place for cigarette leftovers was next to the right side, directly at the entrance of the Bayreuth youth hotel. Technically, the entrance of the youth hotel is also a smoke-free ground of the youth hotel. Moreover, this case is contrary to the Health Protection Act (GSG) Section 2 Sub-Section 2, which requests that youth hotels' grounds be smoke-free.

Figure 43 is the photo showing many cigarette leftovers lying inside the plate above the trash can near the entrance of the youth hotel. These leftovers indicate the existence of active smokers and active smoking actions that should be prohibited.

Figure 43. Photo showing a trash can of the Bayreuth youth hotel in 2015

The research made records inside the youth hotel and found a notification in German and English posted in the hotel. A poster warned that the youth hotel's grounds should also be smoke-free. The place is shown in Figure 44, the photo inside the youth hotel with a yellow arrow.

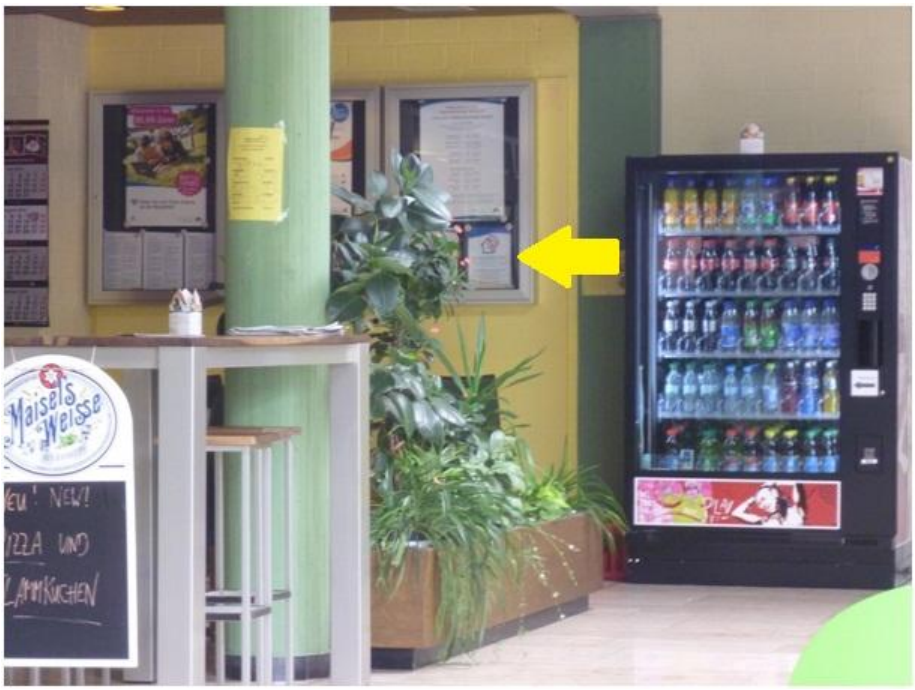


Figure 44. Photo indicating the location of non-smoking notification inside Bayreuth youth hotel

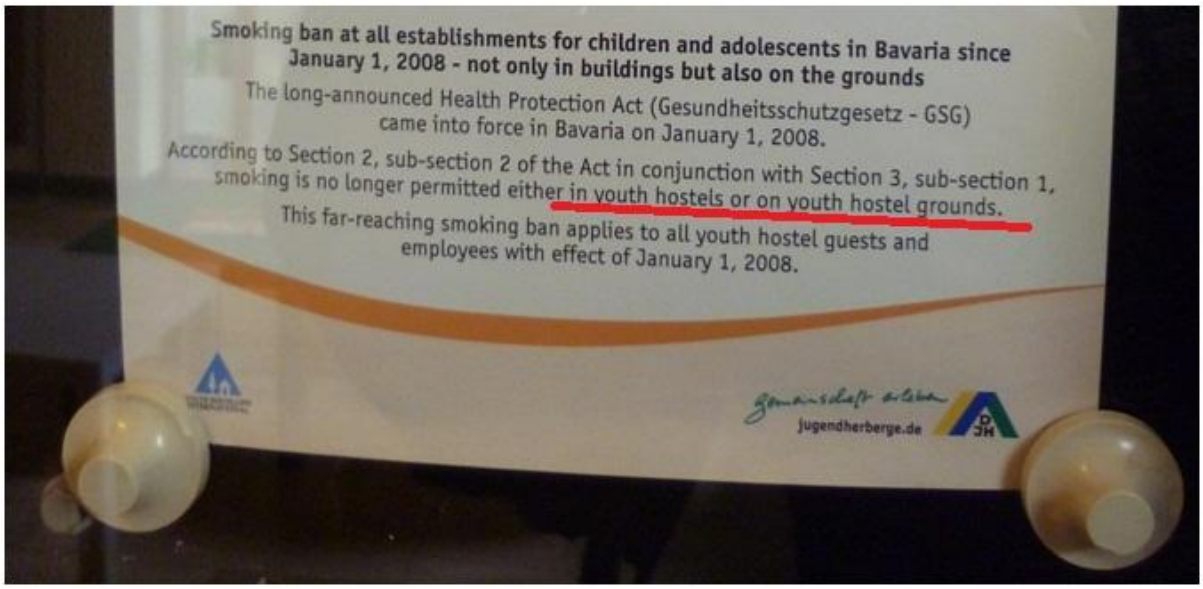


Figure 45. Part of the photo shows the non-smoking notification inside the Bayreuth youth hotel

Figure 45 shows the details of the non-smoking notification. The photo shows only the English part of this notice. The law in the red line shows that this location prohibits smoking, including on the grounds of the youth hotel.

Obviously, in this case, the manager of the non-smoking area and the youth hotel administrative staff did not fulfill their responsibility. While the law emphasizes explicitly protecting children and adolescents from avoiding the health risks of second-hand smoke. Besides, there is no precise amount of penalty in this notice explaining the law. Thus, evaluating this case with the smoke-free Gambit model will not be easy. This situation is because there is no exact penalty on this offense, no exact data for satisfaction or fine. **In this case, active smokers have no risk when they smoke in a prohibited non-smoking area: the Bayreuth youth hotel. Thus, the researcher decided to skip the enhanced model for Germany as the actual penalty is zero in this case. Another model simulation will be pointless unless it reflects the actual status quo.**

As an alternative sample for Bayreuth, the researcher found a counterexample suitable for evaluation by witnessing several times at Bayreuth Train Station from 2016 to 2021 in Bavaria, Germany.

According to the literature review, Bavaria has the strictest smoke-free law, which covers most indoor areas besides some outdoor areas, like the central train station. At the Bayreuth Hauptbahnhof (Hbf, which means main railway station in German), the researcher found black marks on the non-smoking sign at the north-west side of Bayreuth central train station, which is 20 meters away from the smoking area (marked in a yellow square).

The following Figure 46 photo shows one active smoker smoking outside a non-

smoking area instead of the yellow square in 2016. Another witness of an offense by a train station staff was in 2021 at the front entrance. The researcher had not posted photos about this case because it is similar to Figure 46, except this record was during the COVID-19 era when the smoking site was closed.

Figure 46. Photo of an active smoker outside the yellow square at Bayreuth train station

Another law-breaking situation is similar to the youth hotel here. When a police officer sees active smoker lighting or consuming a cigarette, police only ask the smoker to move into the yellow square. Nevertheless, not asking for a fine or registering the violator's name according to the smoke-free law. The managers here include the cleaning staff working at the train station, the train ticket seller, and the train driver companies with ticket checkers. They usually ignore such incidents, and some even violate the rules themselves. The researcher also witnessed that some train drivers would even break the law by finishing a cigarette before leaving the station.

According to Deutsche Bahn's notice, a €40 fine is for such incidents related to a smoking offense along the railway. Furthermore, this matches the range of penalties in the smoke-free law in Bavaria. The penalty was meant to be from €5 to €1,000 as a fine for individuals and institutions.

Since the manager of nonsmoking in the central train station failed to fulfill the duty to monitor and control tobacco use, the police officer became the only enforcer to stop active smoking action. Also, when interrupting and moving to the yellow square as the regular practice, the smoker will not hesitate to start smoking when there are no police around. This selection is because smoking is the action that fits his or her highest utility for the satisfaction of active smoking.

Figure 47. Photo of Bayreuth train station platform 2 with its edge

Figure 47 shows the Bayreuth train station platform 2 with its edge. This location is the place recorded where the smoking offense was along the railway. The shape of the edge will appear in the following picture.

Figure 48 shows a photo showing the railway of Bayreuth central train station at the stage with the exact location as the previous photo in Figure 47 shows. At least six cigarette leftovers near the railway. These indicate at least six smoking offenses of the smoke-free law in the train station in Bavaria. The research circled 3 of the most obvious ones in red for reference. Combining counterexamples in previous research, the effectiveness of the Bavaria smoke-free law is insufficient in practice due to lack of enforcement.

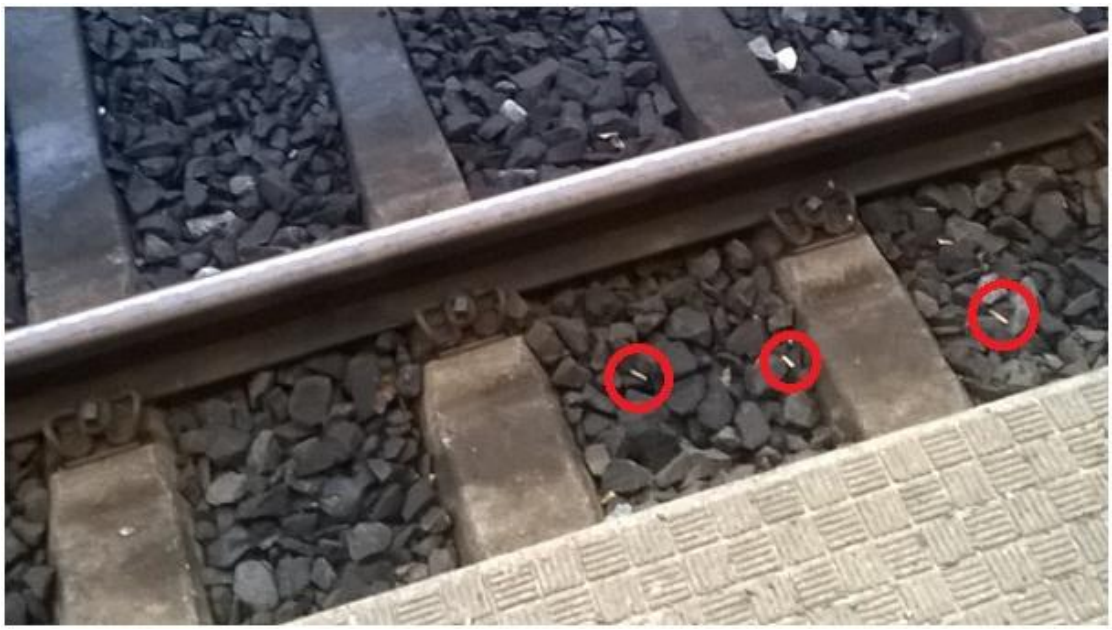


Figure 48. Photo of cigarette leftover near Bayreuth train station platform 2

Similar smoking offenses are not isolated incidents, but no statistical data report this issue. This photograph indicates that more smoking offenses may exist but are not stopped or controlled at the Bayreuth central train station.

The research also first selected the basic tree game model as it had been processed in Shenzhen to simulate the counterexample at the train station at Bayreuth and applied a model for the movements of all three players.

Due to the currency difference, one Euro used in Germany equals approximately 8.88 Hong Kong dollars. The original data of health costs for second-hand smoke in the previous Gambit model are valued in Hong Kong dollars as approved by WHO. The research will transfer the health cost data from Hong Kong dollars into Euro when applying it to the Gambit model. Thus, the per cigarette health cost for an active smoker is HK$-146, which is around €16, and the per cigarette health cost for a passive smoker is HK$-228, which is about €22.

Satisfaction with active smoking will first equal the highest fixed-base fine in Hong Kong. The individual smoking offense at local prices across German train stations is the same. It is €40 and suits the range of penalties, around €5 to €1,000 in Bavaria. However, since the police officer will only direct the active smoker to the yellow square in a real case, the penalty by the police officer will turn to zero in reality.

According to the applied basic tree model for Bavaria's smoke-free law, the payoff for a smoker not to smoke at the first move will be [€-40，€0，€0]. This amount is approximately the same as it is in Hong Kong. The payoff of an active smoker will only reduce when an officer or others stops since he or she could not finish smoking in these circumstances. While in other situations, active smoker could finish smoking with value without penalty. They are moved to a yellow square when witnessed by a police officer.

The research now applies a comparative tree model for the smoking offense incident at the Bayreuth train station.

The tree game demonstrating the decision map for Bayreuth train station is in Figure 49. The direct output from Gambit software is marking all best options with 1.0000 for every player. Active smoker’s best option is still to smoke, as the red number shows. Passive smokers' best option is to leave alone, whether the manager stops or leaves the smoker alone. It is also in blue with 1.0000 for three times. The manager's best option is identical to the passive smoker, so the final situation will still end with both following players leaving the smoker alone. The smoker will risk smoking, as the result panel shows in Figure 50.

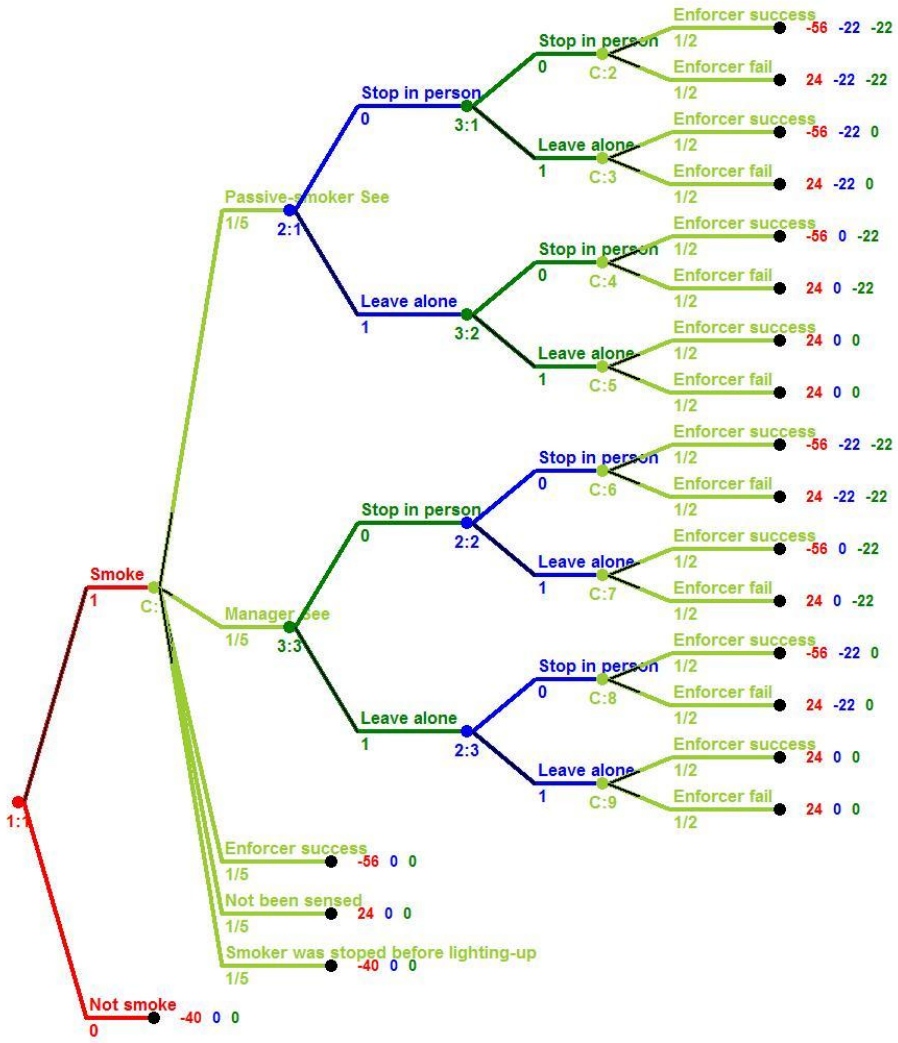


Figure 49. Tree graph of a comparative smoke-free tree game model for Bayreuth

The following real-time screen capture, Figure 50, shows that the computation is successful. A single Nash equilibrium results below the tree graph after the computation. **The expected payoff for active smoker is €-4.8. The payoff for the other two players is both 0, which is higher than the loss of €-40 according to the German railways individual penalty standard. The balance between the expected payoff and the highest fine declined to €35.2, 88% of the highest fine. This ratio is higher and better than -105.66% in Hong Kong but lower than -15.84% in Shenzhen. Based on the Bayreuth status quo in this model simulation, the actual risk of smoking offense is 88% lower than the law-guided violation price.** Active smokers with bounded rationality would definitely move to start smoking in this simulation since the only risk of the smoker taking this action is to be stopped before finishing the tobacco product.

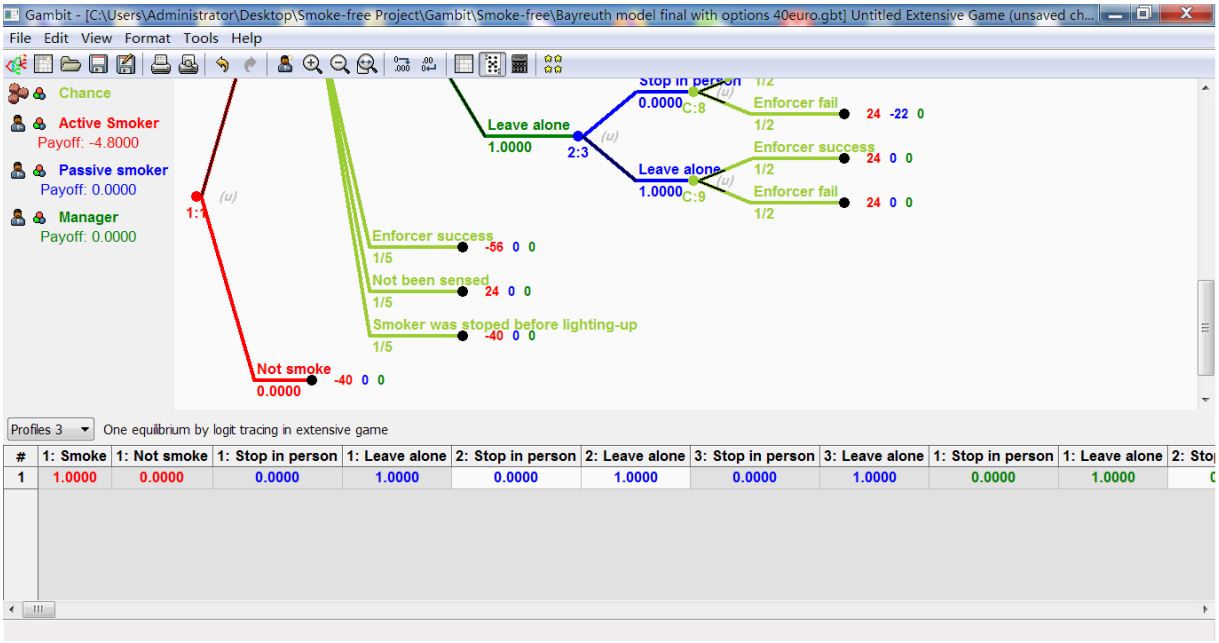


Figure 50. Result panel of comparative smoke-free tree game model for Bayreuth

In summary, this decision map in the comparative tree game model for a real counterexample in Bayreuth is similar but without a penalty compared to Hong Kong. Also, the manager of the nonsmoking area is not controlled compared to the one in Shenzhen. It is the one with the lowest enforcement effectiveness in simulation. However, the price of the penalty is more reasonable, with a higher risk compared to Hong Kong.

The lack of sufficient monitoring and precise penalty amount reduces the risk of an active smoking drop to almost zero. This missing information may lead to no smoking offenses in statistical reports, with smoking violations indeed existing. The record and analysis of counterexamples already show this in previous research.

However, what if the €40 penalty policy is in the condition of good enforcement and every active smoker violating the smoke-free law is fined €40 at the train station? The researcher now adds a €-40 fine to all situations when police succeed in the previous model. This new-theoretical situation is a simulation of a well-performing smoke-free law at the same train station when the police will stop active smoking and issue penalties. Theoretically, train station managers could also apply this rule. However, this new rule may lead to conflict among responsibilities when the manager and enforcer also have the right to issue a penalty. Thus, the €40 fine is limited to the police only. This player is an enforcer in the Bayreuth smoke-free game model simulation.

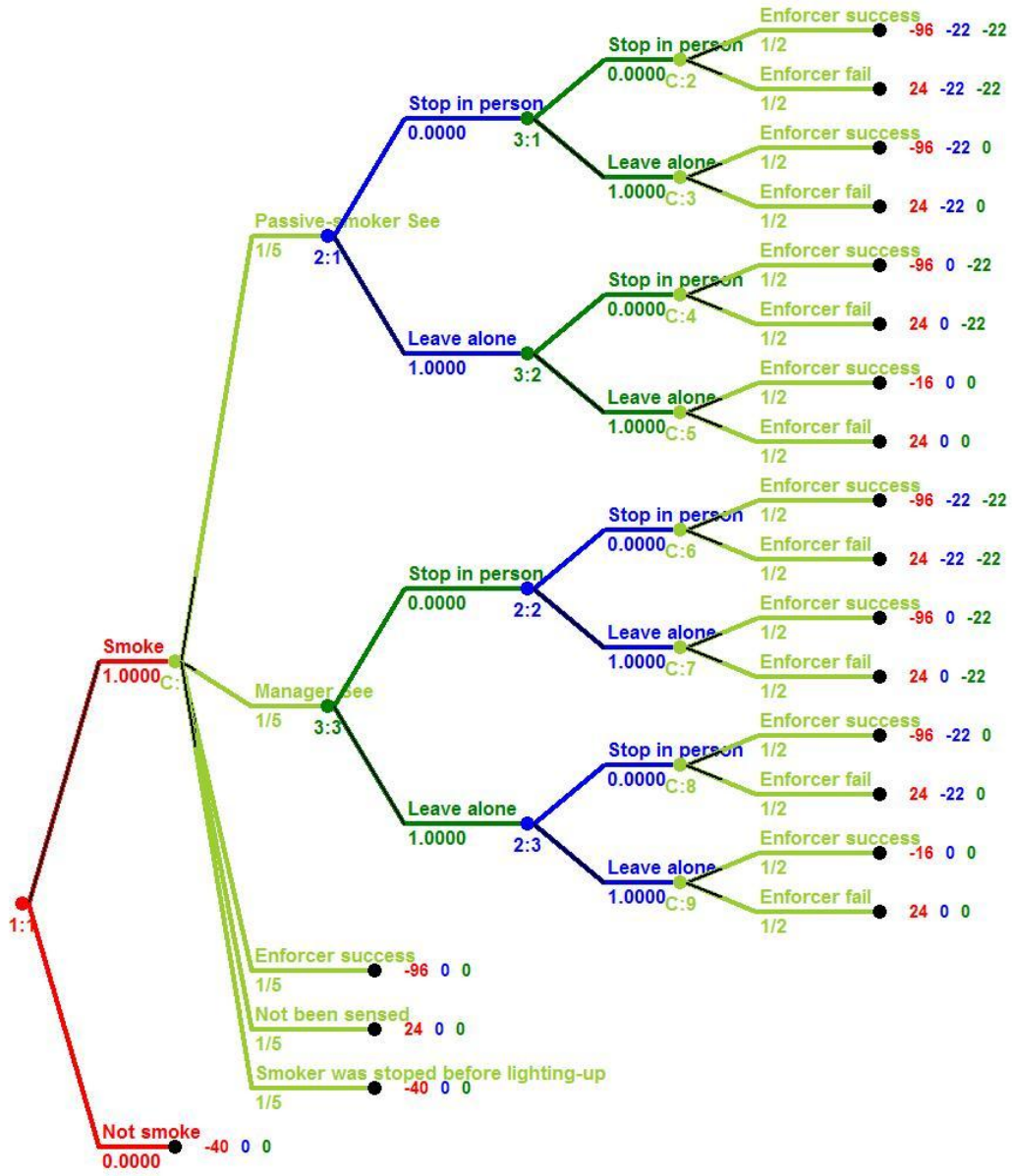


Figure 51. Tree graph of a comparative smoke-free tree game model for Bayreuth II

According to the tree game decision map in Figure 51 for Bayreuth train station, this direct output from Gambit software marked the best option with 1.0000 for every player. Active smoker's best option is still to smoke, as the red number shows. Passive smokers' best option is to leave alone, whether the manager stops or leaves the smoker alone. The result is 1.0000 three times in the blue routes. The manager's best option is identical to the passive smoker. Thus, the final situation will still end with both following players leaving the smoker alone when the active smoker faces an extra €40 as a penalty in the simulation.

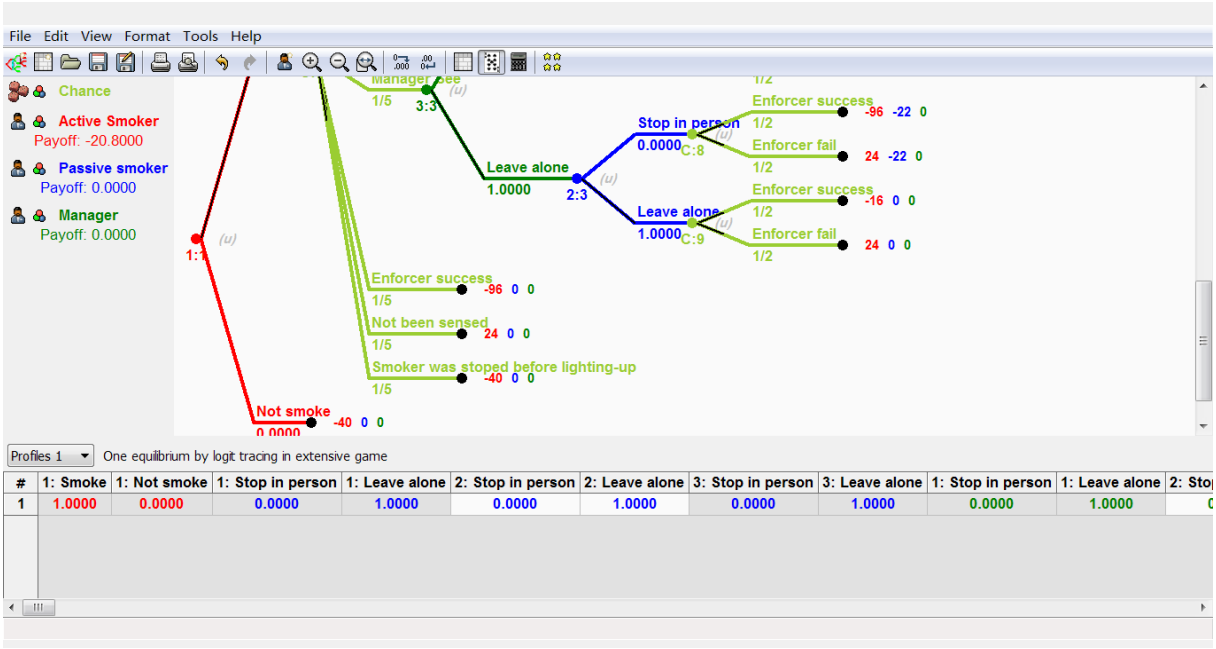


Figure 52. Result panel of comparative smoke-free tree game model for Bayreuth II

The above real-time screen capture in Figure 52 shows that the computation is successful as well. A single Nash equilibrium results below the tree graph after the computation. **The expected payoff of an active smoker is €-20.8. That is higher compared to the loss of €-40 according to the German railways individual penalty standard. Now balance between the expected payoff and the highest fine also declined to €19.2. It stands for -48% of the highest fine. This ratio indicates that the actual risk of smoking offense is less than half lower than the law-guided violation price based on the Bayreuth status quo in this model simulation.** The active smoker will still make the move to start smoking, but their risk will be higher compared to the previous model. The expectative payoff at the first node is still not enough for him or her to change their mind about avoiding illegal active smoking, according to the result based on the game model simulation.

10 Discussions

10.1 Risk expectation comparison

The decision-making route contains interactions between all players and the game's rules: the smoke-free law. With the computation of the game model based on current smoke-free laws among the three regions, the payoffs of smoking are all higher compared to the toughest fine for smoking offenses in simulation. This result leads to the consequence that potential smokers will take the risk of becoming active smokers instead of not smoking, considering the risk of penalty.

The results from previous computations are without preconditions in every model simulation. Payoffs for smoking at the first node are all higher than not smoking in Hong Kong, Shenzhen, and Bayreuth. **The balanced ratio between the expected payoff and the highest penalty in-game model indicates active smoking risk expectation. These ratios are -105.66% in Hong Kong, -88% in Bayreuth, and -15.84% in Shenzhen.** They all indicate that the actual risk of smoking offenses is lower than the law-guided violation prices. None of the cities achieved the ultimate goal of stopping the active smoker, with the satisfaction of smoking equal to the highest fine.

In previous research, the researcher set all satisfaction of active smokers for the violation to the same amount as the highest fine. However, in reality, not all active smokers are the targets of the ultimate goal of smoke-free regulation. Thus, the research reduces the satisfaction of smoking offenses refers to the formula before inserting the data. Furthermore, the research tests these data to pursue the comparative models of 3 cities for equilibrium at smokers' first choice. Then, successfully set the turning points for active smokers between smoking and not smoking when the **possibilities of both choices at the first node at 0.5 in the three cities. This ratio is a unique point for every city when the ratio of the previous risk expectation indicator is zero.**

Based on the computation for the comparative model of the Hong Kong status quo shown in Figure 53, the satisfaction value of the turning point for active smoking is HK$597.5 with a HK$1,500 fine as standard. The active smokers with a satisfaction lower than HK$597.5 will not smoke in the current simulation. This data means that active smokers with satisfaction levels of smoking offenses from HK$598 to HK$1,500 will not obey the smoke-free law in this model. Compared to the fix-base fine of HK$1,500, the invalid range of the current smoke-free law in Hong Kong stands for 60.16% of the total amount. When using the ultimate goal of HK$5,000 as the basis, the invalid ratio will rise to 88.05%.

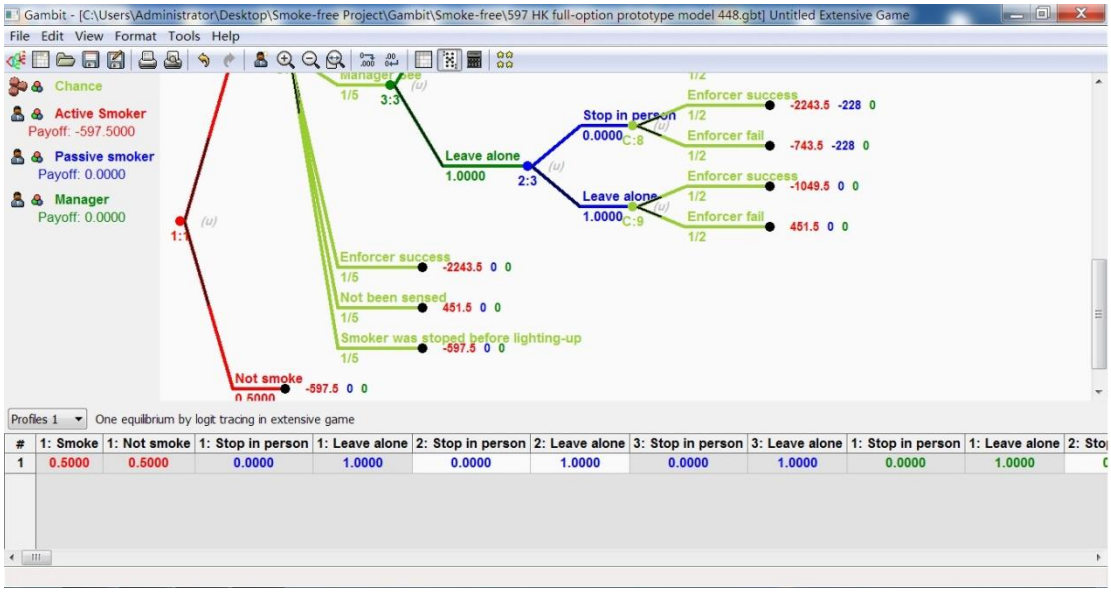


Figure 53. Result panel of comparative smoke-free tree game for Hong Kong turning point

Meanwhile, based on the computation for the comparative model of the Shenzhen status quo shown in Figure 54, the satisfaction value of the turning point for active smoking is ￥302 with only a ￥50 fine as standard. Active smokers with a satisfying amount lower than ￥302 will not smoke in the current simulation. This ratio covers the first and second stages of the Shenzhen smoke-free regulation penalty, valued at ￥50 and ￥200. This result means that active smokers with satisfaction levels of smoking offenses from ￥303 to ￥500 will not obey the smoke-free law. Compared to the highest fine of ￥500, the invalid range of current smoke-free regulations in Shenzhen stands for 39.6% of the total amount.

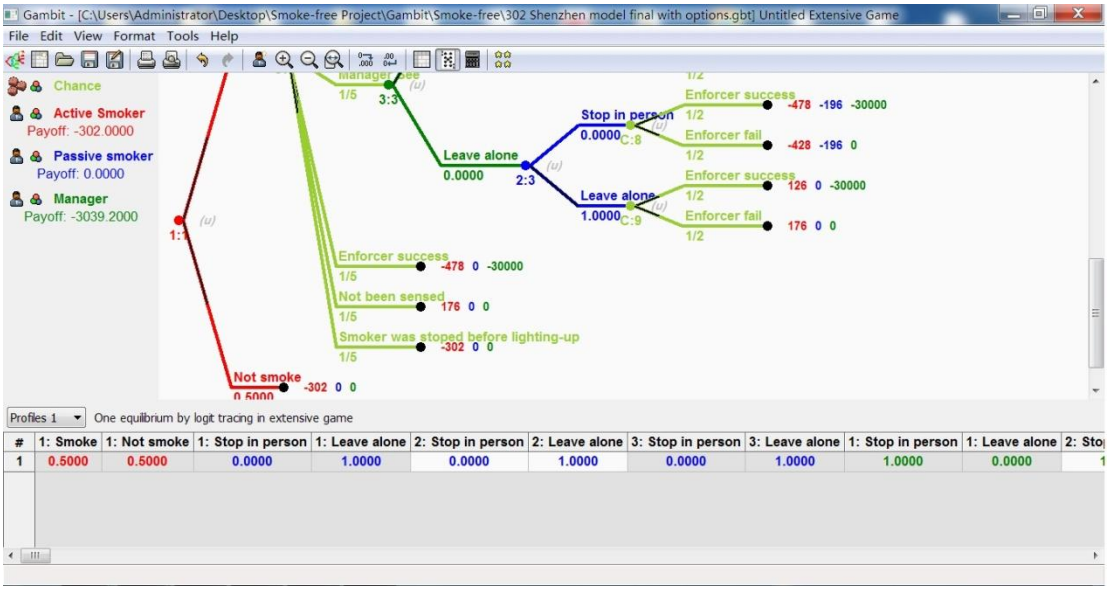
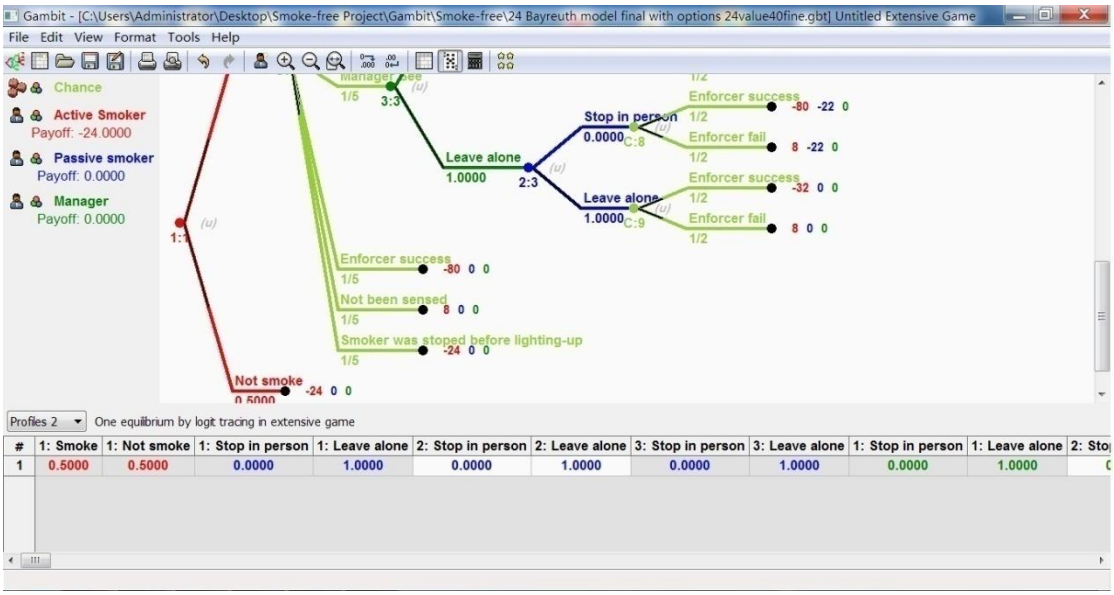


Figure 54. Result panel of comparative smoke-free tree game for Shenzhen turning point

Finally, Figure 55 shows a comparative model of Bayreuth train station with full enforcement of the €40 penalty. The satisfaction value of the turning point for active smoking was €24, with a €40 fine as standard. Active smokers with a satisfying amount lower than €24 will not smoke in the current simulation. This point means active smokers with the satisfaction of smoking offenses from €25 to €40 will not obey the smoke-free law. Compared with the substantial fine of €40, the invalid range of current smoke-free regulation in Bayreuth stands for 40% of the total amount, which is approximately the same ratio as the Shenzhen counterexample. However, if using the maximum penalty of €1,000 in Bavaria, the invalid range of current smoke-free regulation in Bayreuth increased to 97.6%, which is more severe than Hong Kong's status quo, with a maximum penalty of HK$5,000.



#	1: Smoke	1: Not smoke	1: Stop in person	1: Leave alone	2: Stop in person	2: Leave alone	3: Stop in person	3: Leave alone	1: Stop in person	1: Leave alone	2: Sto
1	0.5000	0.5000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	

Figure 55. Result panel of comparative smoke-free tree game for Bayreuth turning point

In summary, the turning point in Hong Kong is HK$597.5 vs. fines of HK$1,500 to HK$5,000, an invalid range from 60.16%–88.05%. The turning point in Shenzhen is ￥302 vs. fines for ￥50 to ￥500, valid at the first and second stages or invalid for 39.6%. The turning point in Bayreuth is €24 vs. fines from €40 to €1,000, with an invalid range from 40%–97.6%.

This study's second risk expectation indicator is these turning points and the invalid range of current smoke-free regulations. They indicate that all target cities with counterexamples still need improvement for current smoke-free regulations. These indicators demonstrate a precise range of effectiveness for smoke-free law applications. They also provide references and recommendations for a proper maximum penalty as the ultimate goal and better penalty arrangements in future smoke-free policy reform.

10.2 Legislation comparison

Comparative research of atlas data on tobacco use at the national level between China and Germany distinguishes between the two counties. Germany's annual deaths caused by smoking and passive smoking are less than 10% compared to China. More men but fewer women died of tobacco-caused diseases in Germany compared to China. While smokers pay more to buy tobacco products, fewer men and more women smoke daily in Germany than in China. The current smoke-free policy in German is better according to atlas standards but inadequate compared to China. German has only one more area fully protected from smoke compared to China. German has a higher rate of tobacco product tax compared to China but does not reach the WHO benchmark. German also has a national hotline addition compared to China.

Meanwhile, a comparison of smoke-free laws between China and Germany shows the improvement of Chinese smoke-free lawfully compliant with Article 8 of the WHO FCTC. Hong Kong achieved it in 2014, Beijing in 2015, and Shenzhen in 2017, but remained at the city or municipal level. The German smoke-free law first came into effect nationally in 2007. Then, Bavaria passed the toughest one at the state or provincial level in 2008. However, according to several counterexamples in this research, its enforcement and effectiveness are doubtful in actual case practice.

The smoke-free law in Shenzhen after 2017 is the strongest, with both penalties for active smokers and managers failing to perform duties of tobacco control. Meanwhile, Hong Kong has the highest fix-based fine among all three regions and represents the highest level of monitoring for active smokers. However, Hong Kong still needs a countermeasure to the manager's obligation in tobacco control. Bayreuth has the most minor and flexible penalty for active smokers. However, there is a substantial fix-base penalty in the train station, no enforcement for manager responsibility, or strict execution by the police force. Thus, Bayreuth is ranked third in non-smoking area supervision.

For direct comparison of the smoke-free law, the WHO suggests the more complex one in detail is better than the simple one in summary. Hong Kong is ranked first with a 20-page Chapter: 371 Smoking (Public Health) Ordinance with 11,458 words. Its 11-page additional law chapter 600, with 5,333 words, ranked second. The 11-page 2013-version of the Shenzhen Special Economic Zone to Smoking Control Ordinance is ranked third with 5,313 words. It is much better than its original version in 1998, which had only three pages and 1,040 words. German smoke-free law in Bavaria is ranked fourth with three pages and 1,290 words. The national smoke-free law of German is the last, with only two pages and 586 words. Besides, phrase lists, detailed smoke-free areas, and penalty classification are written clearly in the first three laws in Hong Kong and Shenzhen, while not in any law in Germany.

Details on the Sino-German legislation comparison are in the following paragraph:

- **National legislation:** Germany has one, but China has not.
- **Mandatory smoke detector installation:** All states in Germany apply this policy when China does not identify smoke detectors specifically.
- **Internal announcement of non-smoking areas**: Germany and China both do.
- **Legislation details:** Hong Kong is the best. Shenzhen is in second place. Bavaria cities are in third place.
- **Upgrade frequency:** Hong Kong government frequently upgrades smoke-free laws with additional lines and substitutive regulations. Shenzhen made one upgrade. Bavaria and Germany are not making upgrades after the first legislation.
- **Smoke-free phrase list:** Hong Kong and Shenzhen list all phrases in the first chapter of the law. In contrast, Bavaria and Germany missed this part.
- **Non-smoking area details:** Hong Kong has a more accurate one for every name of the non-smoking bus stop. Shenzhen has a general one with a precise classification. Bavaria only provides a succinct explanation. In contrast, the German national law misses this part.
- **No smoking district within the non-smoking area:** Shenzhen prohibits a smoking district at the entrance of the non-smoking area. Hong Kong also met this standard. While in Germany, there are yellow squares among non-smoking areas.
- **Penalty for specific violations:** Hong Kong and Shenzhen clearly distinguish the fines for active smokers and managers. While in Germany, the penalties are for both active smokers and managers, but usually only punish the managers.
- **Non-smoking penalty type:** Hong Kong is a fixed-based fine with a maximum penalty. Shenzhen is a three-stage fine. Bavaria had a more extensive range of fine grades from 5 to 1,000 Euro. Germany does not have a penalty type in its national law.
- **Signs of non-smoking fine:** Hong Kong and Shenzhen demonstrate the penalty for smoking within the non-smoking signs. While in Bavaria and Germany, it needs to be clarified.
- **Non-smoking law enforcement unit**: both Hong Kong and Shenzhen have special smoke-free enforcers patrolling frequently. Shenzhen also requests government and institutional officers to support the enforcement. While in Bavaria and Germany, this is the part-work for the police.
- **Law enforcement frequency:** Hong Kong enforcement has been relatively stable in offense after 2015. Shenzhen did not enforce this law before the upgrade. Now the enforcement is heavier than in Hong Kong. Bavaria is similar to Shenzhen before the upgrade.

10.3 Reciprocal learning

At the national level, China and Germany could learn from each other:

China should learn from Germany by passing national-level non-smoking legislation as soon as possible. China could apply a succinct national law similar to Germany. Then, combine it with current municipal or future provincial laws for a specific implementation. Three hierarchical levels of national, provincial, and municipal non-smoking legislation could be the best framework. China should also make mandatory smoke detector installations in every indoor non-smoking area learning from Germany. This status quo requires upgrades and matching existing fire control laws and fire-fighting facilities to join national non-smoking legislation. Although law enforcement is sufficient, the effectiveness of the penalty is not. Rising the level of penalty according to income level referred to Germany could be the next step for Chinese smoke-free legislation.

Germany should learn from China by clearly refining state smoke-free legislation, especially for fines. The penalty should be clear for specific violations and avoid confusion or false rational expectation. Currently, a smoke-free fine in Germany is mixed and usually punishes the manager instead of an active smoker. The above details on the Sino-German smoke-free legislation comparison show that the German one is weaker in several aspects. Simultaneously, in addition to strengthening smoke-free regulations, Germany should also implement law enforcement action. In Bavaria, avoiding the situation of Shenzhen's lesson without issuing a single fine for years may be the case. Law enforcement is insufficient, and the effectiveness of the penalty is questionable. Germany shall learn from China to enhance its enforcement according to smoke-free legislation with sufficient penalties for active smokers.

At the municipal or provincial level, Sino-German reciprocal learning could be:

The significant advantage of Hong Kong is that its non-smoking law is complete in detail compared to other parts of China and Germany. Hong Kong also releases smoke-free monitoring data online transparently and periodically. However, the effectiveness of the Hong Kong smoking ban could be better. Hong Kong's non-smoking law empowers managers with rights similar to enforcers, except for issuing a fine. However, there are no correlative obligations for these rights, and there is no risk of managers neglecting their duties. Hong Kong should learn from Shenzhen's latest upgrade, significantly strengthening the responsibility of its managers.

Shenzhen's advantage in non-smoking law is the compulsory requirements to managers with obligations for their rights. Every first violation will be tolerated with a severe penalty next time for active smokers and managers' neglect of duties. This measure is combing the compromise to difficulties in enforcement and humanistic concern in educating first-time violators. However, this policy is valid only when recording the identity of a first-time violator. Moreover, it could be difficult to

implant in EU countries like Germany. Shenzhen should learn from Hong Kong to present smoke-free monitoring data transparently and periodically.

The non-smoking law in Bavaria is elementary similar to that in Shenzhen before the upgrade. Smoke-free rights and obligations are distributed in different laws instead of combined in China. With less control over active smoking and managers, cities in Bavaria did not have smoke-free offenses data, but violations always existed. Bavaria should learn from Shenzhen and Hong Kong first to strengthen enforcement and clarify the penalty of violators to the manager's responsibility. Then, in the presence of the smoke-free monitoring data transparently and periodically.

10.4 Extensive research

Currently, the most severe problem in all smoke-free game practices in confirmed cases is insufficient managers. Also, there are insufficient law enforcement officers to patrol non-smoking areas worldwide.

Shenzhen passed one of the first non-smoking regulations across China in 1998, but no penalty tickets were issued in 14 years, as mentioned in a newsletter by Mr. Du Xiaotian (2012). It also explains the reason for this strange reality: only ten officers were working full-time at the Health Supervision Department for smoke-free law enforcement, while there was more than 10 million population in Shenzhen. Meanwhile, according to a document released by Hong Kong Legislative Council (2008), Hong Kong smoke-free enforcer team has 85 full-time officers. They are the primary enforcers of smoke-free laws when Hong Kong has less population than Shenzhen. The number of smoke-free law enforcers in Germany is unknown. According to current law, there are no full-time police officers for this special occasion.

Thus, insufficient smoke-free enforcers will be the expected status in almost every city. It is also a widespread problem in health economics and management. The following chapter explains possible improvements in extensive research from the perspective of a smoke-free legislator.

10.4.1 Empowering passive smokers

A feasible solution to enhance non-smoking area monitoring is to empower passive smokers with temporary authorization to be part of the smoke-free law enforcement team. In a real case, passive smokers tend to be the first ones to notice active smokers since there is usually one manager for a particular non-smoking area with more than one passive smoker at the same time. Portable devices are currently widely used, like

a smartphone, with the function of taking photos and uploading them online. Passive smokers already have a tool for recording smoke-free offenses as an extra enforcement power with a simple App. Theoretically, the lawmaker only should offer a small bonus compared to a full-time officer for the passive smoker to provide evidence of a smoking offense. Then, every passive smoker will become a potential enforcer in a non-smoking area for active smoking.

Some may argue about human rights issues and advocate that such measures violate privacy and do not apply to democratic countries or regions. However, it is In contrast to the universal declaration of human rights by United Nations (1948), quote:

> **"All human beings** are born free and equal in dignity and rights.
>
> Everyone has the right to life, liberty and the security of person.
>
> In the exercise of his rights and freedoms, everyone shall be subject only to such limitations as are determined by law solely. For the purpose of securing due recognition and **respect for the rights and freedoms of others** and of meeting the just requirements of morality, public order and the general welfare in a democratic society. "
>
> (United Nations 1948, 2–8)

Smoking harms health and may become vital to life in severe cases. So active smoking in a non-smoking area violates a non-smoker's right to life and security. Thus, active smokers could not violate non-smokers' right to life with health risks in the name of their right to freedom or privacy. Taking active smoking photos as evidence is only a tool to fight for the right to life and security for non-smokers. Similar to the case of refusing the policy and enforcement of mask-wearing. Also, in the name of freedom during the COVID-19 era.

Besides, democratic Taiwan in China has already applied this policy. The oriental daily website by the Chinese news web (2009) published a special report on smoke-free in Taiwan. The reward for each smoke-free violation photo is NT$10,000, which is about 2,432 Hong Kong dollars, and around 234 Euro for every photo of active smoking. These photos were the evidence for future monitoring of active smokers and dereliction of duty in the lack of managers. Of course, this policy requires additional technical support to provide a software platform on the mobile WAP or WWW website to transmit and manage this evidence. The government should also protect the private information of the whistleblowers who record active smoking. A similar application of these measures in China and Germany based on game-theoretical modeling analysis could upgrade the future smoke-free regulation.

10.4.2 Smokeless Tobacco and E-cigarette

Another way to stop potential smokers from becoming active smokers who harm the health of all players is by finding substitutes. This measure will offer more options for consuming tobacco products without smoke, such as snuff, nicotine stickers, nicotine gum, and nicotine soft drinks. It will be difficult for these non-traditional tobacco products to win in the competition with cigarettes since they currently have higher costs and less satisfaction. According to a report by WHO (2017), one patch of cigarette price is around 3–10 Yuan in China. Simultaneously, the price of each piece of nicotine patch could be 70–110 Yuan. Also, using alternative products compared with smoking cigarettes is considered less satisfying to active smokers. A solution to this event is setting different taxes for different tobacco products related to the tobacco business for production upgrading and government policy relevance. Respectively, this policy may affect the smoke-free game model by changing the integrated payoff of the active smoker's first movement.

Furthermore, direct the smoker to choose tobacco products that do not produce second-hand smoke in a non-smoking area. The application for this regulation upgrade in China and Germany based on game-theoretical modeling analysis could also be an upgrade in the future smoke-free regulation. Especially, E-cigarette is now spreading worldwide but still produces second-hand smoke. Thus, it also harms non-smokers and should be stopped and regulated in non-smoking areas.

10.4.3 Extra players in the smoke-free game

In previous research, the smoke-free game model focused on three major players: active smokers, passive smokers, and managers of non-smoking areas. The enforcers only participate in the smoke-free game as a chance player for the penalty for a smoke-free violation. In fact, there are six players in the integrated smoke-free game. The fourth player is the enforcers, whom the government employs to defend the smoke-free law. Meanwhile, the government could be considered a background player in the smoke-free game. The fifth background player, the government, is a different type of player than the others: government does not directly participate in a smoke-free game, so their payoff was excluded in the previous smoke-free game for three players. However, the government has the right to smoke-free legislation and the overall design of the entire smoke-free regulation. Other players' payoffs will entirely or partly convert into governmental expenditure or income during or after the smoke-free gameplay. Tobacco companies could also be an extra sixth player. However, they only receive income when active smokers consume a cigarette and pay part of their income as tax to the government in a single gameplay. Their influence in the smoke-free game model is relatively the smallest, which is why it was deleted in the previous game.

The government payoff in the smoke-free game as a background player is combined with income like active smoking fines, tobacco tax, and health loss attributed to all

the players in public expenditure. Indeed, active smokers could bring tobacco tax revenue and penalty when caught by the enforcer to the government. However, according to research by Lam T. H (2005), the expenditure of public hospitals stands for more than 80% of Hong Kong government funds. The health effects of active and passive tobacco use are generally in the cost of inpatient treatment when each patient pays only HK$100 per day during the treatment. Therefore, the economic loss of tobacco exposure, especially the loss of health care, is almost passed directly to the government. The income from penalty and tax will not be enough to cover the expenditure of health loss for the Hong Kong government's expected payoff even when the possibility for the enforcer to catch active smokers is set to be 50%.

Practically, previous research always stands on behalf of the policy-maker in the smoke-free game as the government. This position monitors and analyzes the entire active smoking game's decision-making path and outcome. The purpose of the policy-maker is to improve the current smoke-free policy design and stop the illegal behavior of active smokers. The previous three-player game model is the simplified version of 6 player game model. Their winning situation is equal when the active smoker decides not to smoke in the first stage instead of getting away with the penalty after active smoking.

10.4.4 Mandatory smoke detector installation

Directly reducing the likelihood of active smoking could be a possible solution, especially in indoor regulated smoke-free areas. Adding an electric smoke detector will erase the possibility of active smoking not being detected, which is enforced by the law in Germany. Although installing a smoke detector will not fully cover all the areas in indoor areas, the smoke will not slip out within the enclosed building. Once, there was a violation that indeed happened in a German office building where the researcher worked. One person was smoking underground in the garage, and firefighters came and checked after they detected smoke. This type of alarm device is becoming more and more popular and common in China as well. Future Chinese law could meet the exact requirements in Germany to promote the complete installation of indoor smoke alarm devices. Then, smoke monitoring will ensure 100% smoke-free indoors in China and German cities. A smoke detector network will monitor the indoor areas, and the enforcers will only arrive when there is a smoke-free violation. Enforcers will patrol the regulated outdoor areas, which could partly reduce the pressure of a human resource shortage.

Further research on this solution may involve the cost and payoff issues for installing extra smoke detectors in China. The researcher also considered the ratio of enforcer power rearrangement in a different type of regulated area. Moreover, collaboration with the fire department is vital to distinguish the event as a fire issue or a smoking offense issue.

10.5 Smoke-free upgrade for Hong Kong

This research uses a game-theoretical model to provide a reference for upgrading smoke-free regulation based on modeling. This chapter will present a final model with all possible improvements based on the Hong Kong status quo for better enforcement effectiveness. This model upgrade sets the risk expectation of active smoking to be less than zero after the computation without prerequisite. Furthermore, the additional game rules in this model are all mentioned in the previous chapter.

10.5.1 Upgrades of the final smoke-free model

- **Three rule upgrades in the final model for Hong Kong:**

The penalty for a non-smoking manager who neglects duties will be HK$15,000, similar to but half the amount in Shenzhen. This upgrade would lead to a -15000 in the manager's payoff if the police caught the violator, only when anyone informed the police in advance.

The bonus of HK$3,000 will be similar to but different compared to the "photograph and reward" in Chinese Taiwan. When a passive smoker or a manager decides to report active smoking to the police, he or she will get this bonus only after catching the violator. This bonus will only reward the first player for informing the police, and the enforcer will only pay once for this at the end. The payoff of passive smoker or manager will receive a +3000 in return for this bonus.

Cancel the rule of HK$5,000 maximum penalty with a fixed-base fine of HK$1,500. This change in the laws will set the satisfaction of active smoking equal to the highest fine.

- **For additional players, enforcers and governments will join the final smoke-free model:**

Besides, an enforcer now faces a health loss of HK$288 more than a chance player. This amount is the same as that for a passive smoker with every success when catching a violator. He or she will collect a fine from the violator and give a bonus to the first player to inform the police. The balance of the fines and bonus will be transmitted to the government.

The government serves as a background player regulating and monitoring the gameplay with the rules of a smoke-free game. The government will receive the

balance of the fine, a bonus from the enforcer, and half of the health costs for every player.

Temporarily, the model does not consider the payoff of the tobacco business as a player. The reason is that this smoke-free game is a program for a cigarette per round. The cost of a single cigarette, income and tax only stand for a minimal amount of less than HK$1 in the overall model. Thus, the current game model bypasses this player and the data.

- **Whether to report to the police or not, the probability of being caught is now different:**

More precise probability estimation is based on the feedback of the Hong Kong SAR Government, Hong Kong Tobacco Control Office (2016). The researcher selects the data for all regions in Hong Kong for estimation.

The probability of the police catching violators directly was 27.65%, 26.76%, and 29.99% from 2014 to April 2016. The average is 28.13%, and 28% is 0.28 in the model.

The probability of the police catching violators when informed in advance was rated 46.25%, 43.94%, and 42.04% from 2014 to April 2016. The average is 44.08%, and 44% is 0.44 in the model.

Other possibilities were correlatively reduced to 0.18 using impartial estimation.

- **Introducing e-cigarettes and smokeless tobacco as tobacco substitutes:**

The satisfaction is half of the active smoking replacing smokeless tobacco based on a dichotomy. The health loss of e-cigarettes remains the same as that of traditional cigarettes. Simultaneously, the health loss of e-cigarettes due to second-hand smoke is 15% compared to a cigarette. This arrangement is because it is the mainstream second-hand smoke, similar to cigarette reference.

The satisfaction of consuming smokeless tobacco is now a quarter of active smoking, with further dichotomization. The health loss of e-cigarettes is set to be half the number of regular cigarettes and e-cigarettes.

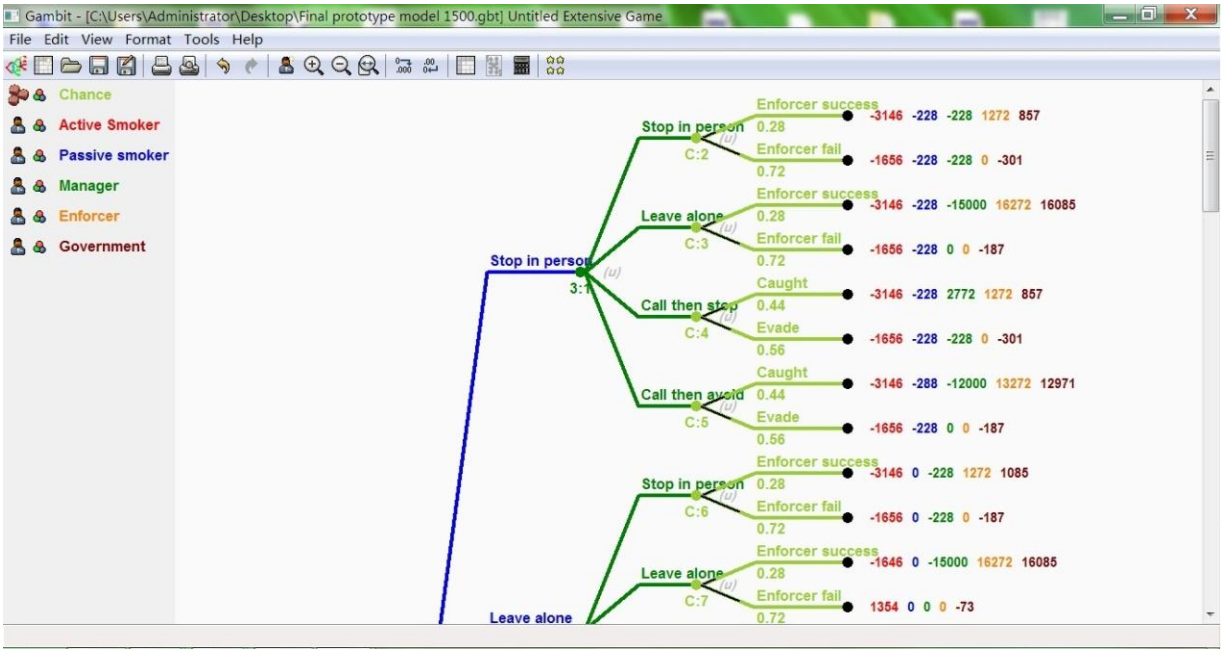


Figure 56. The top part of the final smoke-free tree game upgrade for Hong Kong

The top part of the final model is in Figure 56 due to the print limit. It presents the model with upgrades for all improvements mentioned in section 10.4.

The bottom part of the final model is in Figure 57 due to the print limit. It presents the model with upgrades for improvements mentioned in section 10.4.

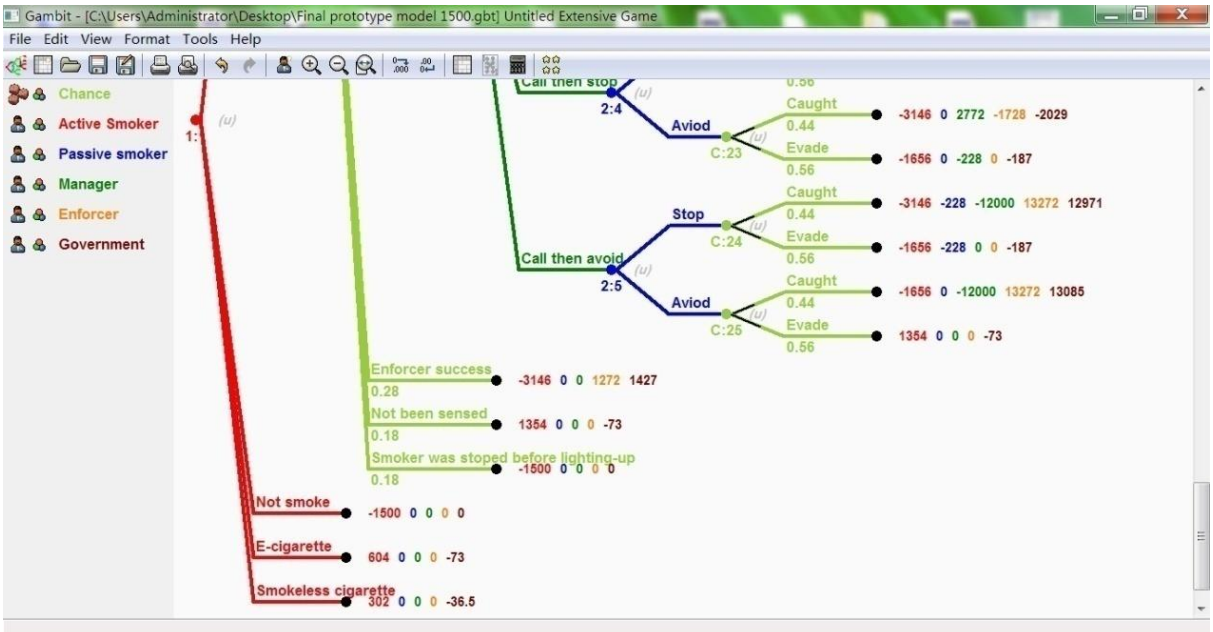


Figure 57. The bottom part of the final smoke-free tree game upgrade for Hong Kong

The researcher considers this mandatory smoke detector installation policy but is not applying it in this model. The smoke detector will sense the smoke in an indoor smoke-free area but not outdoors. It could replace not be sensed in the model when the non-smoking area combines indoor and outdoor non-smoking areas. Otherwise, it shall be a separate tree with a 100% chance of informing the police following the possibility of police catching the active smoker when being informed. Since the previous counterexample in Hong Kong is not an enclosed area, this feature is not in the final model at present.

10.5.2 Results of smoke-free final model

The real-time screen capture in Figure 58 shows that the computation is successful. The computation results in a single Nash equilibrium below the tree graph. The system-recommended method in this model is a simple subdivision in this computation. This method selection may cause inaccuracy in payoff calculation and the need to recheck manually.

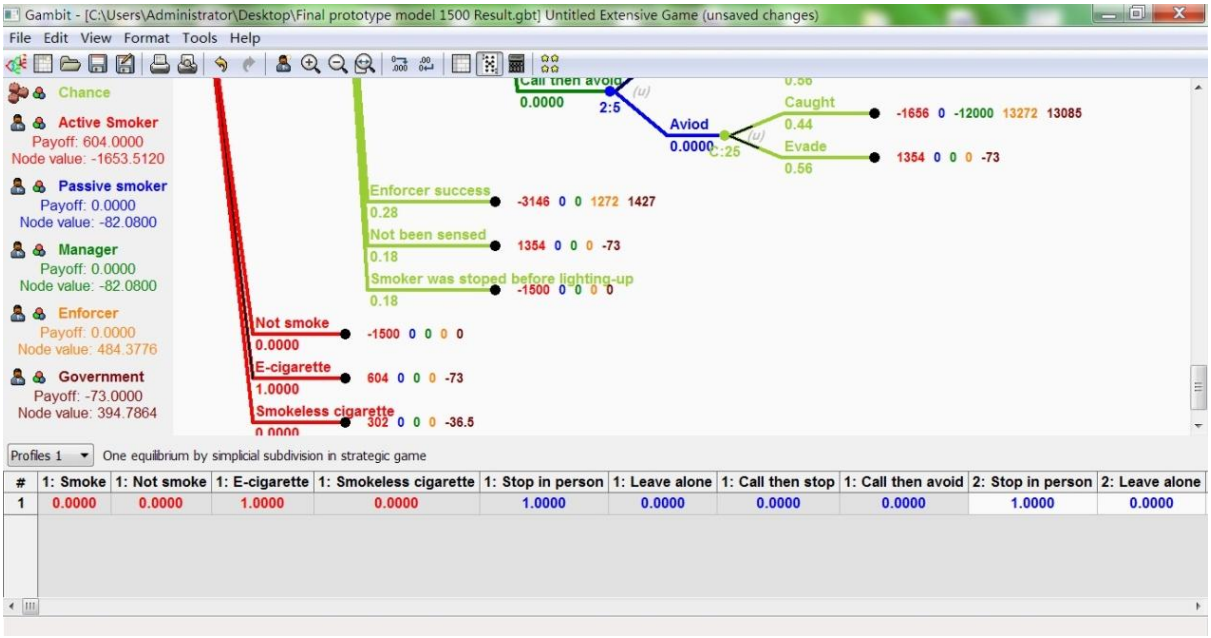


Figure 58. Result panel final smoke-free tree game upgrade for Hong Kong 1

The Nash equilibrium in this simulation ends without active smoking. Instead, the active smoker chooses an e-cigarette with a payoff of HK$603. It is the balance between satisfaction and health loss. Only health loss values of HK$73 are transmitted to the government. The payoff of active smoking is now minus HK$1,653.51, which is even lower than not smoking minus HK$1,500. This simulation indicates that this new rule of the smoke-free game will stop smokers from smoking with satisfaction under HK$1,653.51. The balance between the

expected payoff and the highest fine was minus HK$153.51. It stands for 10.23% compared to the loss of satisfaction, which equals the highest fine. This ratio indicates that the actual risk of a smoking offense is 10% higher than the law-guided violation price. This indicator indicates that the risk of active smoking now exists for the upgraded Hong Kong smoke-free law in this model simulation.

Significantly, the smokers would switch to tobacco substitutes after the upgrade and reduce social health loss attributed to active smoking. This improvement results in a Pareto improvement instead of a situation of Pareto optimum since the public sector should still bear the smoker's health loss. However, compared to the current Hong Kong smoke-free regulatory system in previous model simulations is much better.

For managers, upgrades encourage them to stop active smoking with a bonus and avoid higher penalties. For passive smokers, upgrades allow them to get a bounty when avoiding health losses. Simultaneously, law enforcers get a fine higher than health losses. For the government, this smoke-free upgrade model could operate within the balance of fines and bonuses to cover the expense of health loss in simulation.

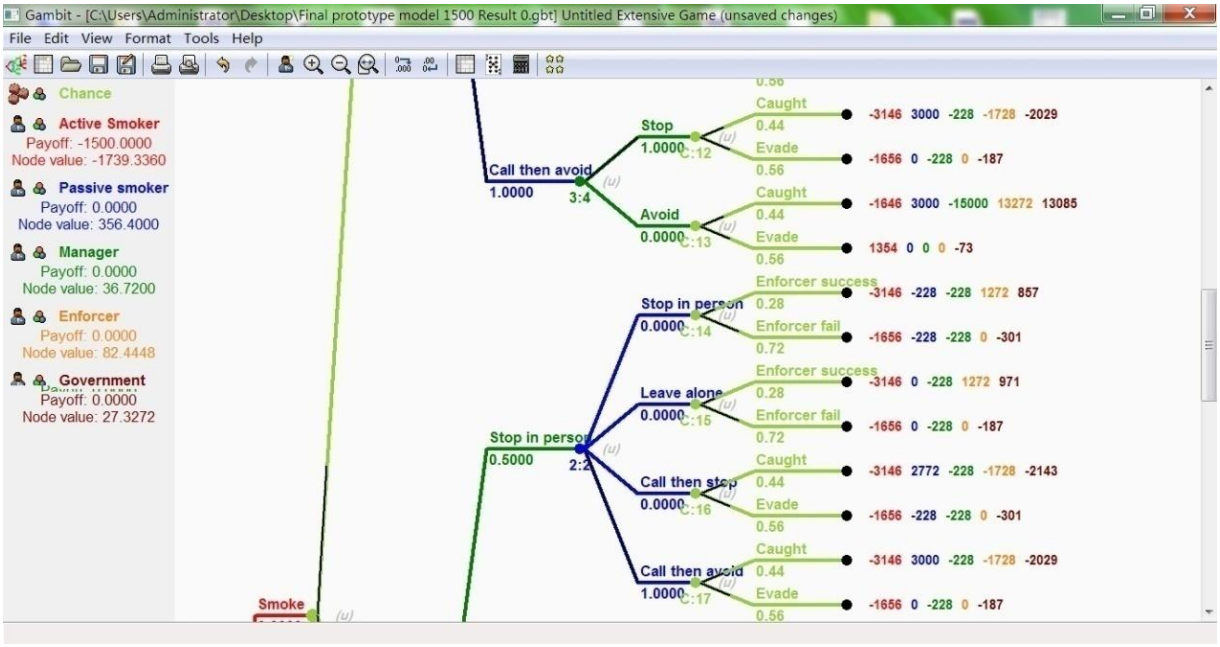


Figure 59. Result panel final smoke-free tree game upgrade for Hong Kong 2

The real-time screen capture in Figure 59 shows that the computation without tobacco substitutes is successful. This computation results in a single Nash equilibrium below the tree graph. The system-recommended method in this model is also a simple subdivision. The payoff of active smoking is now lower to minus HK$1,739.33 compared to HK$1,653.51. And the net payoffs of other players are also more balance in this simulation.

However, some strategies simply choose the first instead of the best. One problem occurs in Gambit modeling results: when there is a better strategy, the computation will ignore choices in another decision tree. This presenting method may be the reason causing payoff calculation inaccuracy and needs manual recheck.

11 Conclusions

11.1 Research contributions

The research uses the WHO report pre-evaluating the global smoke-free status quo. By positioning smoking problems in the category of air pollution, the research forms a level of three stages: passive smoking – tobacco epidemic – air pollution. This classification better identifies the position of non-smoking problems within public health threats from a global perspective. Unlike reports on tobacco by the WHO (2008, 2021) emphasizing coverage of policies, the research uses WHO estimations between 2008 and 2021 for quantitative comparison. The finding is that deaths from tobacco surpassed 8 million ten years earlier, and passive smoking deaths have already doubled. This finding is essential to make a more accurate judgment on the severity of the tobacco epidemic and the urgency of related smoke-free studies.

The research uses counterexamples to prove non-smoking areas are not 100% smoke-free in China and Germany, with cities including Hong Kong, Shenzhen, and Bayreuth. The counterexamples are findings collected from government offense data, reports, news, and photographic evidence. Compared to the pre-study by Kungskulniti, N. Charoenca, N. Peesing. J., et al. (2015), the research also uses fieldwork recording as a supporting method. Nevertheless, the aim of this chapter is a superficial judgment instead of the PM2.5 level in the pre-study. These findings set the basis for smoke-free game modeling. Furthermore, making correct judgments of the status quo by breaking the viewpoint that "no data means no offense" in Bavaria.

The research uses literature comparisons and application feedback to evaluate smoke-free regulatory systems in Hong Kong, Shenzhen, Bavaria, and Germany. The findings show that Hong Kong is the best but falls behind compared to Shenzhen, while Bavaria is similar to Shenzhen before the latest upgrade. This result shows that China's cities have better smoke-free enforcement than Germany, even without a national smoke-free law. The method is similar to the report by WHO Western Pacific Region and the University of Waterloo (2015), which mainly assesses whether regions are following the FCTC standard. In contrast, this research focuses on the details of the law and its enforcement.

The researcher learns from the theoretical development process through the prisoner's dilemma by Rapoport, A. & Chammah, A. M. (1965), then framed the design of smoke-free modeling. The researcher applies game theory in smoke-free because the decision-making of active smoking is based on the comprehensive elevation of the smoke-free law and all possible reactions of other players. This reference results in a series of smoke-free game-theoretical models, including word, table, basic, enhanced, simplified, comparative, and final models. The researcher innovatively uses utility combined with reasonable expectation, anchoring, and government-guided price to explain how to price satisfaction of active smoking in a

smoke-free game. Theoretically, the researcher expands the field of bounded rationality by Herbert A. Simon (1955). Tobacco addiction has become a new component of bounded rationality in smoke-free research. The consequences of these innovations are to program and compute irrational strategies of active smokers in the smoke-free game as rational players.

In static game modeling, the research simulates the situation when three major smoke-free players simultaneously make decisions in a game model. The researcher discovers and names a particular "all-win or all-lose" case in game-theoretical modeling limited to health degrees. The Health degree payoff matrix also has an opposite preference and leads to health loss for every player compared to computation results due to active smoking. This finding is important because health is priceless for individual and social value compared to personal satisfaction and monetary income. Only when no player suffers health loss will the Pareto optimum be achieved in smoke-free games. Next, the researcher identified the active smoker to be the key player. This phrase has a higher status compared to destructor by Xie, S. Y. (2017) describes the player who has the privilege of setting the winning status of Pareto efficiency for all game players. Compared to Alan Shiell & Simon Chapman (2000), the researcher uses actual case data to surpass the pre-study with formulas and letters to describe a possible prisoner's dilemma with an unequal equation. This research is an essential step from assumption to simulation before the experiment, similar to a serious game pre-study by M.E. Derksen et al. (2020) in game theory research.

Meanwhile, research uses per-cigarette health loss data to fit the reality of a smoke-free gameplay unit. These data originate from research by Lam, T. H. (2005) of Hong Kong, approved by WHO. Pre-study by Koronaiou, K. Al-Lawati, JA. Sayed. M. et al. (2021) showed that the percentage of second-hand smoke accounted for 20.4% of the total cost, different from 27.48% in Hong Kong. These percentages prove that simply using Chinese or German data will not make an accurate estimation, so the researcher still uses original data from Hong Kong for comparison. Another finding is that per cigarette health loss from second-hand smoke exposure is more harmful than active smoking data analysis. Other findings include that smoke-free games are variable-sum, and the existence of active smokers is the interaction of rules and all the players. Prisoner's dilemma appears in Hong Kong when passive smokers and managers expect the other players to stop being active smokers, similar to the tobacco industry pre-study by Shen Shen & Jiang Min (2018). The most important one is that: the expected payoff of active smokers who choose to smoke is higher than the payoff of not smoking. This research tests this finding to verify every time in every following model simulation.

Learning from Goluch T. (2012), the researcher uses Gambit to simulate the following models. The primary reason for choosing third-party software is that the calculation process is endorsed by the institute and could be repeated to avoid errors. It also simplifies the calculation process for a large amount of data in paper writing. The process of transforming a static model into a dynamic one is based on the fact that a smoke-free game occurs both indoors and outdoors. The researcher frames the decision trees based on a paper by Poutvaara, Panu, and Siemers, Lars-H. R. (2007)

but places active smokers at the center of the government's perspective. Because this is not a personal optimization for active smokers but in pursuit of Pareto optimum in smoke-free. The information set is also complete and perfect in a model similar to pre-study Poutvaara, Panu and Siemers, Lars-H. R. (2007). It represents the government monitoring smoke-free regulatory enforcement and works in an actual sequence when a smoke-free game is in reality. The dynamic model simulates the situation when players participate in decision-making sequentially under a certain probability of a mixed strategy smoke-free game. Moreover, it is an expectation of active smoking from the beginning to the end. Compared to the pre-study, it uses mixed strategies with actual case data, but the possibility remains framed impartially to simulate an unfamiliar non-smoking area for all players. Research then enhances the model with more options, including all possible situations the players could face, which is better for comparison. The research attempts to frame a realistic experimental model exploring players' interaction but stops due to insufficient payoff data. It leaves the legacy of inserting chance players simulating the period of the intention of smoking as an additional choice in smoke-free game-theoretical modeling. This outcome is a comparative game-theoretical model based on Hong Kong for further research in Shenzhen and Bayreuth.

For comparative research, the researcher applies similar game-theoretical modeling for a counterexample between China and Germany. They are based on local smoke-free penalty data and corresponding rules for general smoke-free games. All the expected payoffs of active smokers who chose to smoke are higher compared to the payoff of not smoking in 3 cities model simulations. Then, the researcher designed and calculated the balance ratios between the expected payoff and the highest fine to be the first risk expectation indicator. It uses the ratio to present the difference between the government-guided penalty and the real burden of active smoking. When this indicator is below zero, then the smoke-free regulation needs improvement. This process also explains why using local currency instead of dollars for comparison is similar to other research by McGhee, S. M., et al. (2006). The researcher designed the indicator in the ratio, which automatically avoids interference with currency differences except transferring per cigarette health loss.

For further research, the researcher tests, computes, and compares the turning points of 3 cities' active smokers to change behavior from smoking to non-smoking. The second risk expectation indicator evaluates the invalid range of current smoke-free laws in a general game simulation. Moreover, expanding the evaluation of smoke-free effectiveness to violators is lower than the ultimate goal. Finally, the researcher discusses possible upgrades for Hong Kong and frames the final 5-player model with these improvements based on further modeling. The final model upgrades successfully set risk expectations for active smoking to less than zero within the additional rules of the game. Smokers would switch to tobacco substitutes after upgrading the smoke-free law design in the simulation. Furthermore, the government could operate within the balance of fines and bonuses to cover the expense of health loss. These measures reduce social health loss attributed to active smoking as a Pareto improvement benefit to all other players much better than the status quo.

11.2 Research conclusions

The answer to the first research question: **"Are non-smoking areas 100% smoke-free in China and Germany?"** is **NO**. Active smoking decreased after the ban but never reached zero in China and Germany. The record of counterexamples in these regions proves that the three research cities are all not 100% smoke-free by WHO standards.

The answer to the main question: **"Why do active smokers take the risk of breaking the law in non-smoking areas?" is that: The expected payoff of active smokers who choose to smoke is higher than the payoff of not smoking.**

The implications of the smoke-free game model based on Hong Kong are successful in general evaluation and comparison of counterexamples in Shenzhen and Bayreuth. China must pass national non-smoking legislation to learn from Germany and enforce a statutory smoke detector network for all indoor areas. By learning from China, Germany should make clear refinements for every state-level smoke-free law and enhance smoke-free enforcement based on legislation.

This study completes the first exploratory, interdisciplinary, cross-national research that applies game theory to smoke-free enforcement effectiveness evaluation between China and Germany. Its significance is to promote the development and improvement of the worldwide non-smoking regulatory system through model simulation as the first successful sample.

11.3 Research limitations

The game-theoretical model evaluates players representing a single person for their status in the smoke-free game. However, one player may equal more than one passive smoker in reality. Then, they face a considerable number of health risks caused by active smoking. Additionally, when the enforcer stops the active smoker in person, he or she and the entire patrolling team may be at risk of second-hand smoke. The actual damage of second-hand smoke is underestimated in the current model compared to reality in the current model simulation.

The research focuses on the period when smokers decide whether to start active smoking until caught by police or evade this risk. A further penalty for active smoking is, in reality, under certain circumstances. Nevertheless, in the current simulations, there are no further or previous decision trees in the game model.

Complete and perfect information is an ideal state of game modeling, but this is uncommon in reality. General models simulate the actions of active smokers from the perspective of a smoke-free policy regulator. This design provides a better simulation of the consequences of the smoker's decision-making process at each node and prevents active smoking. However, this information set may have specific thought distortion and contradict reality from the beginning.

Hong Kong's health economic loss data, approved by WHO, only provides an international reference programming for the comparative model. Official smoke-free data on SHS health economic costs in Shenzhen and Bayreuth are missing. These cause inaccuracies in the simulation output and confine further comparison.

Possibility data for smoke-free real case locations are difficult to collect and measure without experiments. The research uses equalization or dichotomy to set possibilities, except for a few models in Hong Kong. This method could partly reflect how active smokers think, but it makes the model simulation for specific cases less reliable and needs readjustment after on-site data collection.

The continuous fieldwork is only limited to one location: Bayreuth train station. Except for one counterexample, cases in Hong Kong and Shenzhen were mainly selected based on literature reviews instead of first-hand information. Locations in these two cities have not continued tracking surveys for several years, i.e., in Bayreuth.

Research lacked the budget to experiment with smoke-free gameplay based on model simulation. The models stop at the stage from the assumption to the simulation without sufficient tests in a serious game experiment. Further assessment needs more tests and adjustment models to verify smoke-free games in reality.

11.4 Research outlooks

11.4.1 Implantation of current research

The research on the smoke-free game modeling processes may be applied to different levels of research fields. For research related to tobacco, the game model could provide references to cigarette leftover control, proper notification of smoke-free regulation, and the location of a legal smoking point or smoking room. For research related to health, the game model will be suitable for research on the control of not wearing masks in regulated public areas. It could also control overload gathering of people exceeding the legal number and illegal traveling without proper purpose. These are particularly helpful in the era of the COVID-19 pandemic after 2020. For

other research fields, the game model could connect to solve the problems of controlling electric waste dumping, illegal fishing and hunting, and free-riding of public goods.

The cigarette leftovers problem could be an example of this application. Germany has a strict waste classification and recycling system, but the control of cigarette leftovers is not as strict as other waste. The floor of Bayreuth's central train station, main bus station, and the university cafeteria is scattered with cigarette leftovers. Although this problem is not involved in previous research, it may lead to severe third-hand smoke pollution. Third-hand smoke is a type of residual harmful substance produced when second-hand smoke residue touches and stays in furniture, floors, trash, and other items. Cigarette leftovers everywhere are a significant source of third-hand smoke and need control. The cigarette leftover litter could play a similar role to that of the active smoker. Passive smokers with third-hand smoke are almost the same victims as passive smokers in smoke-free games.

Furthermore, the manager of the road or area is equal to the manager of the non-smoking site. Then, a similar game model could be formed based on previous research, and this model could reference policymakers' aims for better cigarette leftover control. An approach exists which is more extreme but enlightens others to think about how to solve the cigarette leftover problem. Interestingly, Japan does not have a litter box, but none will litter on the street because all garbage must be brought home to deal with in Japan. Japanese smokers should carry their ashtray no matter where it is, and this countermeasure stops cigarette leftover littering.

11.4.2 Further game-theoretical research

The smoke-free game information is not always perfectly transferred in a real case. Imperfect information in game theory refers to the situation when the previous players' previous moves are not observed when this player is on the stage to move. However, this was not the case in the previous smoke-free game model. The information about active smoking in a real case needs time to create and transfer. The time lag between information transformations causes players to need extra time to react. For example, when an active smoker decides to smoke till he or she lights up the tobacco product, the information confirms the violation of active smoking through this process in a real case. In Shenzhen, the statistical data Huang, S. (2014) reported that successful permission accounted for 90,417 active smokers to cancel an illegal move. No matter which player, stopping the active smoker before he lights up will make all players win the smoke-free game. The reason why stopped before light-up is introduced as a chance player at the second stage after the active smoker's first move. After the violation is confirmed, this information also needs time to be transferred to the enforcer. They have the authority to stop active smokers with a fine as a penalty instead of other players.

Imperfect information also appears if the enforcer is not patrolling the violation scene. The information may be missed when no one notices the active smoker or noticed by the manager who has a second level of enforcement to stop active smoking from deciding whether he or she will inform the enforcer right now. Passive smoker has no enforcement capability to stop active smoking by deciding whether they will inform the enforcer or the manager first. Providing channels like a hotline or mobile apps for passive smokers to report the violations will enable the confirmation of active smoking transfer faster to the enforcer. Player strategies during this type of time lag in the information transference could be the next project in further research.

Moreover, although each round of a smoke-free game is a one-shot game, it may become a repeated game for active smokers in particular situations. Repeated games analyze the situation when players consider their long-term payoffs and short-term gains. Moreover, this might lead the player to behave in ways different from how they would if the interactions were one-shot rather than long-term. For instance, when players do not detect active smoking, the active smoker finishes the first cigarette. This smoker may keep taking the risk of consuming another cigarette until one of the other players notices his violation of the smoke-free law. This situation could be considered a finitely smoke-free game repeated once, and it may keep repeating and turn into an infinite game theoretically.

Similarly, if the active smoker went through the entire smoke-free game and not being punished by the enforcer at the end, he or she may take the risk of repeating the same strategy for the next round of the smoke-free game. However, the original design of the smoke-free regulation was to stop active smoking instead of encouraging active smokers to keep violating the law and test for the best strategy to break the law. Repeated games are against the purpose of the smoke-free law, so it is not considered in previous research. At the same time, the models use a preset value of possibility to represent a universal situation of smoke-free gameplay. The policymaker is concerned more about the measures with adequate alert to the active smoker to prevent the first break of the smoke-free law and to stop the second violation after the first breaking window.

Finally, even when the smoke-free game is not repeated, an active smoker could improve his or her game strategy with several countermeasures. For example, the maximum penalty for active smoking is HK$5,000, listed on the smoke-free signs, and this is instant information to the potential active smoker to value the violation cost. When game theory considers anonymous information, the active smoker may not decide whether he or she will take the risk of smoking now before checking news or law documents online. After searching for the information, the active smoker may learn that the actual penalty must be decided in court before 2012, or the minimum fine is only HK$1,500. This process will affect the estimation process for active smokers about the cost of the violation. Additionally, the active smoker could use methods like fictitious play for learning in the frame of game theory. The smoking process only takes 5–8 min to complete. A potential active smoker could observe the surrounding circumstances to record the exact possibility of the appearance of other players in a specific non-smoking area. Then, the active smoker could improve his strategy with better possibility data in the first round. These represent the active

smokers' learning processes and the evolution of smoke-free game strategies in a specific area. Meanwhile, upgrading to a smoke-free law is relatively slow compared to individual adjustment and law design for a comprehensive set of non-smoking areas. Thus, game models in previous research use preset and impartial possibility data for every movement to represent the status when designing the smoke-free law without considering the circumstances of active smokers' learning and exact non-smoking area.

11.4.3 Feasible research for test-point experiment

According to the history of prisoner's dilemma, this classic game-theoretical model was first framed in RAND and tested with an experiment. The smoke-free game model also needs tests after previous research when proper conditions are available. In China, a test-point region would be selected for the experiment before this new policy officially comes into action, either in an institute or within an entire city. Ideally, university campuses could be the central fieldwork regions in feasible research for upgraded smoke-free policy experiments because they contain different types of non-smoking public places. These places include enclosed buildings, semi-closed stations, and all-open playgrounds, which could reflect multi-type smoke-free status in a specific district within the limited range of fieldwork.

In the selection phase, the researchers selected three university campuses for fieldwork from China and Germany. In China, Hong Kong and nearby Shenzhen are both in Guangdong. Research selected Hong Kong Polytechnic University and Shenzhen University since they are both non-smoking areas. Current research is already considering the differences in campus geographic characteristics and future cooperation for joint projects. Thus, the researchers selected a university in Bavaria, Germany. Guangdong and Bavaria are sister provinces, and Bayreuth University is a young and more modernized university with a precise range of the main campus and several external institutes. This selection is similar to that of Hong Kong Polytechnic University and Shenzhen University. Further fieldwork could collect more cases of smoke-free policy experiments in both nations by applying smoke-free university policy from China to Germany. Cooperation between universities in two nations to smoke-free policy upgrades will be another project of this research in the future.

12 Literature

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Appendix