

Alleviation of Bird-window Collisions: The Evaluation of Current Economic Approaches with Extension to an Innovative Policy

Xinran Wang^{1*†}, Shuhe Jin^{1†}, Ziran Wei^{2†}

¹*Shenzhen College of International Education, Shenzhen, China*

²*High School Affiliated to Shanghai Jiao Tong University, Shanghai, China*

^{*}*Corresponding Author. Email: karen_wang_xinran@126.com*

[†]*These authors contributed equally to this work and should be considered co-first authors.*

Abstract. Bird-window collisions have become the second largest anthropocentric factor causing bird loss. Specific environmental issues incorporate these economic problems, including market failures, challenges in valuing birds, and problems involving different stakeholders. Various economic policies have been designed and implemented to address the issues, including educational policy, market-based policy, certification programs, and the Toronto Green Standard. This paper focuses on the analysis of different economic problems and the evaluation of current existing policies. We also propose an innovative solution to alleviate bird-window collisions based on the limitations of the policies. With the certification program as our policy foundation, we further incorporate tax exemption and punishment oriented to individuals and corporations. However, the resolution we suggest requires further completion and extra experiments to fill the remaining gaps.

Keywords: Bird-window collisions, economic policy, fatality rate, alleviation of bird-window collisions

1. Introduction

Bird loss has become a significant environmental problem in today's world. Since 1970, nearly 3 billion birds have died in North America [1]; we have lost one-fourth of the birds. Also, bird biodiversity is decreasing: 159 recorded bird species have gone extinct [2].

Currently, bird-window collisions are considered a significant source of mortality in North America, only below feral cats [3]. The transparency and reflectivity of glass windows often mislead the birds, as they often reflect open areas or habitats, which causes an illusion to the birds that they can fly through [4]. Also, the artificial lights inside the windows often attract and disorient nocturnally migrating birds in large cities, resulting in a higher susceptibility of birds to collisions with windows [5]. Klem speculated that around 50% of bird-window collisions are fatal, often caused by severe trauma like broken bones, internal bleeding, and damage to vital organs [6]. A conservative estimate is that the bird death toll caused by bird-window collisions in Canada and the

United States exceeds 1 billion every year, with Canada accounting for 16 to 42 million and the US accounting for 365 to 988 million.

The deficiency in public awareness of bird-window collisions also aggravates bird loss. This is because bird-window collisions often go unnoticed by house owners, and the birds do not die immediately after the collisions. A study found that among 29 collisions, only 2 left a carcass under the windows; the rest flew away [7]. Nevertheless, they still died elsewhere because of the severe injury the collisions caused. The Predators, like cats and raccoons, will spot the opportunity and prey on those injured birds when they lose the ability to escape. It gives house owners the illusion that no bird collisions are happening around their houses [7]. Under such a scenario, deficient public awareness can pose a hurdle when governments try to alleviate the problem with policies, as the citizens have yet to realize the issue's importance.

Thus, this paper focuses on what new economic policy could be implemented to reduce bird-window collisions based on the evaluation of current policies.

We analyze some current policies that reduce bird-window collisions, each with merits and limitations. For example, taxation on traditional windows without bird-friendly designs is unfeasible for households because they are not liable but feasible for commercial buildings. The Toronto Green Standard (TGS) is a mandatory program that mandates bird-friendly treatments for all new constructions. However, it mainly targets new constructions, which leaves most of the existing buildings without bird-safe strategies, and most developers only meet the minimum TGS mandatory requirements due to insufficient incentives. The problem that all the policies have in common is that people need more incentives to retrofit their windows and contribute to mitigating bird-window collisions.

This paper proposes a new policy framework to address the incentives problem compared to previous literature work and points out further research directions aiming to solve bird-window collisions. We combine the policy of certification programs and marker-based approaches, aiming to motivate households and corporations through rewards and punishments. Also, we suggest that future researchers focus on and do experiments on whether our policy is practical and how the value of subsidies and taxes should be set.

2. Economic problem

2.1. Market failure

Birds are public goods from an economic perspective [8]. Samuelson [9] defined public goods as non-rivalrous and non-excludable goods. This means that one using the good cannot prevent others from using it, and one's usage will not decrease the product's value. Birds fit in the definition due to ecotourism, such as bird-watching activities and listening to birds singing [8]. Everyone has equal unrestricted access to the benefits brought by the birds and cannot prevent others from enjoying them. Thus, birds, with the characteristics of non-rivalry and non-excludability, belong to public goods.

The severe mortalities of birds as public goods due to bird-window collisions is an example of market failure. Klem [10] tracked bird-window collisions of five clear windows in several new buildings across seven days. He collected a total of 13 collisions, and eight birds involved were dead, which was a 65% mortality rate. This experiment reveals a high mortality rate in bird-window collisions. However, people need more awareness about the severity and the importance of bird protection against collisions [8]. This lack of understanding is the phenomenon of information asymmetry. This implies their low incentives to contribute to the mitigation of bird-window

collisions. People only consider private costs when purchasing windows and designing houses, ignoring the external costs (see Figure 1) - bird mortalities [8]. The information asymmetry and the neglectfulness of external costs cause a failure to achieve social optimum and market failure.

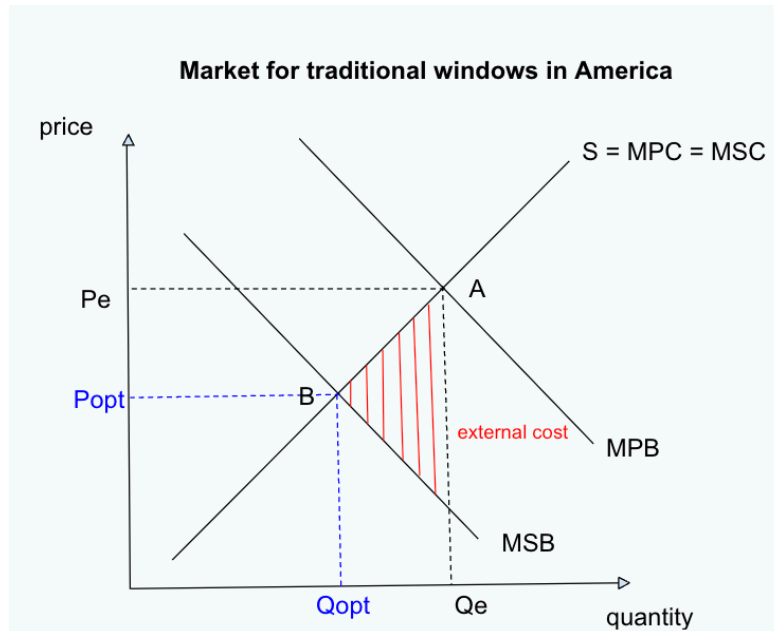


Figure 1: Graph presenting the external cost in the market for traditional windows in America

In addition, the mitigation process of bird-window collisions faces free rider problems [8]. Some people may have a "fluke mentality" that others are working to mitigate collisions, and they could benefit from the improved environmental quality due to the non-excludable features of public goods. Those people would not be actively participating in mitigation programs.

To design effective policies addressing the problems, we need tangible values for calculations and the stakeholders involved to take different actions, which will be further discussed in the following two sections.

2.2. Challenges in valuing birds

The birds' total economic value (TEV) measures the externality when human activities impact the ecology [8]. Therefore, knowing the TEV can help reach market equilibrium and eliminate market failure. TEV can be divided into direct use value, indirect use value, and non-use value. One example of the direct use value of birds is ecotourism, which is similar to birding tourism and the bird-watching industry. The indirect use value of birds refers to the ecological benefits provided by birds. For instance, they are vital in controlling pests, dispersing seeds, pollinating, etc. They are essential in maintaining ecosystem health and achieving ecological balance. A method called the cost of treatment methodology can be used to calculate the birds' indirect value using replacement goods like pesticides: the increase in pesticide investment when the bird population decreases by a number.

Measuring the willingness to pay for conserving the birds is difficult. This is because it is hard to measure the non-use value and some indirect value due to the long-term effects of the decreasing population of birds. Therefore, it can take much work to calculate the willingness to pay directly. Alternatively, one can examine the households' expenditures on bird-window collision mitigation

products to estimate the willingness to pay. Nonetheless, Warren [8] states that the value is likely to be highly understated because most people are unaware of the importance of bird collision and the impact it causes; hence, they may be only willing to spend a small amount on conserving the birds.

A study conducted by Kim et al. [11] estimates the willingness to pay for the conservation of bird species to avoid collisions using a choice experiment among 1000 participants. The results demonstrate that the average annual willingness to pay to alleviate birds' collision problems is 31 dollars per household. This study laid the foundation for policy design and implications [11].

2.3. Stakeholders analysis

2.3.1. Property developer

As the builders and sellers of house buildings, property developers are concerned with the projects' profit-earning ability. This conflicts with the implementation of bird-friendly windows or films to some extent.

First and foremost, the bird-friendly materials might negatively affect the beauty and clarity of the outside window views. This might negatively affect consumers' willingness to purchase. A high-quality window view is essential in indoor life as people spend almost 87% of their lifetime in houses [12]. Based on the study that compares the different types of bird-friendly windows conducted by Brown et al. [13], although windows containing permanent and visible patterns like ceramic frits effectively prevent collision, people can also see these patterns. This visibility may lead to a poor view from the windows and varying personal preferences regarding the decorations. As a result, the blurred view of the windows might lead to dissatisfaction and reluctance, leading to lower sales levels and preventing property developers from adopting bird-friendly windows and materials.

Moreover, considering the higher costs of UV windows or films than traditional windows, property developers lack incentives to increase their cost burden to improve the bird collision pattern. Therefore, this results in a potential dilemma and difficulty alleviating the bird collision issues.

2.3.2. Residents

Residents of private houses are crucial stakeholders in ensuring the bird collision problem, but the deficiency in their awareness further aggravates the issue. Based on existing analysis and research, most bird-window collisions occur within residents' housing buildings. Machtans et al. [14] investigated the bird-window collisions for different buildings, including housing, low-rise, and high buildings. Houses were much higher than the other two, consisting of about 90% of all the collisions, while low-rising buildings were responsible for another 10% and high buildings only comprised about 1%. As the major contributor to the bird-window collision issues, most private households remained uneducated about the phenomenon and its corresponding solutions.

The current level of bird collisions is deficient, especially in homes [8]. Under such circumstances, low awareness could potentially prevent households from participating in voluntary actions regarding bird conservation. Moreover, residents might not fully comprehend the significance of government policies, leading to inefficiency and stagnation in resolving bird collision issues.

In addition, Warren [8] suggests that residents also lack awareness of access to products, costs, potential utility, and aesthetic perspectives. This appropriately explains the low public willingness to afford bird-friendly products, including glasses and films.

2.3.3. Company producing bird friendly-film

Companies that are responsible for the production of bird-friendly materials are also confronted with mediocre incentives to enlarge the scale of production. This is attributed to the lack of customer demand. As Warren [8] points out, the derived demands for its materials also remain comparatively low due to the low general awareness of bird-friendly materials. Kim et al. [11] conducted a choice experiment among 1000 participants to estimate the economic benefits derived from the conservation of bird species to avoid collisions. The results demonstrate that the average annual willingness to pay to alleviate birds' collision problems is 31 dollars per household. This quantity is insufficient for firms to enlarge the production scale and comprehensively alleviate the birds' collision issues.

3. Current policies and evaluation

3.1. Educational policy: Public Information Campaign (PIC)

3.1.1. Policy description

Warren [8] points out the lack of awareness and incentives to mitigate bird-window collisions among the public. To address the lack of awareness, he suggests implementing a public information campaign (PIC) in which people would learn about the importance of birds and bird protection. It aims to raise awareness to mitigate bird-window collisions and increase participation in programs to reduce collision rates. According to a survey by Warren [8], respondents welcomed this policy. 78% of respondents indicated agreeing or strongly agreeing with the policy, much higher than the secondary welcomed policy about providing incentives, with 61% supporting it [8].

3.1.2. Evaluation of the educational policy

Educational policies are effective in raising incentives. Sheng et al. [15] apply questionnaires to analyze citizens' attitudes toward preventing bird collision issues after introducing the problems of bird-window collisions. The results showed that most participants were willing to reduce the collision rate when having an overview of bird-window collisions [15]. This study reveals the importance of publicization of bird-window collisions and raising awareness to increase incentives among citizens. Educational policies to set up public information campaigns (PICs) would effectively fit the needs of this aspect.

Also, there are practically implementing examples of Public Information Campaigns (PIC). A good example is the "Lights Out! Texas" program in the state of Texas in the United States. The program publicizes the bird-window collision problem and activates citizens to take action by turning unnecessary lights off between 11 p.m. and 6 a.m. According to BBC [16], "Lights Out! Texas" effectively reduced bird-window collisions in Texas.

However, there was a lack of information to measure the intensity of implementation and whether people followed the program guidelines. Taking "Lights Out! Texas" as an example, it is difficult to observe whether participants follow the guidelines for turning off lights. Also, there was a lack of evidence to prove that the successful mitigation in Texas was due to the program instead of other factors. Warren [8] suggests that PIC survey participants ask about their willingness to contribute after teaching sessions.

3.2. Market-based policy: Taxes and subsidies

3.2.1. Policy description

Warren [8] considers market-based approaches to address the incentive and external costs problems, including taxing and subsidizing. He first raises the idea of taxing traditional windows, which would mislead the birds and increase collision rates. He aims to incorporate the external costs of bird mortality into the price of traditional windows to make them price uncompetitive. As a result, more stakeholders may replace traditional windows with bird-friendly ones to prevent being taxed. In addition, Warren [8] proposes the subsidy program methods. He considers currently existing bird-friendly products and hopes to use subsidies to reduce the price of the products. This may increase the stakeholders' willingness to pay for the products.

3.2.2. Evaluation of the market-based policy

Although taxing could sometimes be effective, it may not successfully affect people's choices regarding the types of windows. Taxing could be effective if people find bird-friendly windows more worthwhile or choose other substitutes benefiting bird-window collisions [8]. However, this effect is limited because bird-friendly windows or films are likely more expensive than traditional ones [8]. The initial higher prices of bird-friendly windows offset the effect of taxation on traditional windows. Thus, it is undetermined whether the bird-friendly windows or the traditional windows with taxation would be more expensive, which leaves doubt on whether the consumers would change their choices from traditional windows to bird-friendly windows.

Subsidizing, especially retrofits, could be very useful in motivating customers to buy existing bird-friendly products. However, Warren [8] establishes concerns about free-rider problems. Citizens who bought bird-friendly products before the implementation of the subsidy policy cannot benefit from the rebates. They would complain and ask for extra rebates, increasing many government costs.

Considering practical tryouts about taxing and subsidizing policies, there are difficulties in fixing the values of tax and subsidy and motivating people to join. This considers external costs and benefits the policies bring, which are related to the values birds being rescued could bring. However, the intangible values of birds are difficult to convert into tangible values (more specifically mentioned in 2.1.2), imposing extra difficulties. Also, a lack of people's awareness about bird-window collisions would cause a lack of incentive for them to buy bird-friendly windows even if they have a lower price than before due to the subsidy. The practical problems contribute to the lack of realistic examples of implementing market-based approaches.

Therefore, although market-based methods could positively influence bird-window collision problems, their significant limitations regarding undetermined prices, free rider problems, and practical problems leave us doubting their usefulness.

3.3. Certification program

3.3.1. Policy description

Certification programs aim to mitigate bird-window collisions by incentivizing stakeholders [8]. The programs set up design standards for housings to diminish bird-window collisions, and certificates would be given to households that achieved the standards [8].

One example of the certification program is Leadership in Energy and Environmental Design (LEED), a universally pervasive green building rating system established by the U.S. Green Building Council (USGBC) [17]. It provides a framework for energy-efficient and sustainable buildings. There are four levels of certification: Certified (40-49 Points Earned), Silver (50-59 Points Earned), Gold (60-79 Points Earned), Platinum (80+ Points Earned). 2011, the LEED program adopted "Pilot Credit SSpc55: Bird Collision Deterrence (BCD)" [18]. This credit was moved into the Innovation Catalogue in 2022. It involves requirements for interior and exterior lighting. This reduces light pollution and night bird-window collisions. Also, it requires all the building facade materials with a threat factor below 30. The material threat factor database provided by America Bird Conservancy (ABC) can be used directly to calculate Bird Collision Rating (BCR).

3.3.2. Evaluation of the certification programs

Ogden [19] points out that biodiversity conservation is not LEED's priority. LEED focuses more on energy, water, and materials than on biodiversity. It can be seen from the fact that the BCD credit is only worth 1 point among the 113 credits in the credit library. Also, Ogden [19] mentions that in LEED, there is a conflict between extensive glazing for natural sunlight to reduce electricity use and birds' safety. Extensive glazing is detrimental for birds, for no doubt, and a 'Daylight' credit in the LEED credit library is worth 2 points. Building developers will be more likely to gain Daylight credit rather than BCD credit.

3.4. Toronto green standard

3.4.1. Policy background and description

Toronto Green Standard (TGS) considers bird protection to be one of its sustainable goals. Supported by FLAP (Fatal Light Awareness Program) and other stakeholders, the City of Toronto published the TGS, a set of sustainable green building requirements and guidelines, in 2006. In 2007, "Bird-friendly Development Guidelines" were added under the Ecology category of the Tier 1 requirement. Tier 1 is the mandatory requirements that all new constructions need to meet. Tier 2-4 provide more voluntary, advanced guidelines but with financial incentives. TGS has undergone several updates, the latest version of version 3 in 2018 [20].

The "Bird-friendly Development Guidelines" in Tier 1 continue improving techniques that reduce bird-window collisions. For instance, the spacing of visual markers (e.g., glass etchings, films) decreased from 100-2800 mm in Version 2 to less than 100mm in Version 3. The smaller spacing between patterns is more effective in preventing collisions.

Murphy [21] points out that despite the improvements made in Version 3, the requirements regarding bird-friendly measures in Tier 1 are still not practical enough. According to FLAP, the recommended spacing between visual markers is not more than 50 mm. Additionally, Tier 1 allows bird-friendly treatments either on the interior or the exterior of the glass surface. In contrast, the standard of FLAP is to only apply the visual markers on the exterior since birds can see them more clearly.

The implementation of mandatory Tier 1 is stringent. Before the developer can begin the construction work, he/she should submit the site plan application to the City planning division. The planners and urban designers will then check whether the application meets the minimum city development requirements. As long as any Tier 1 requirements are not indicated in the application,

the developer has to resubmit the modified version until it meets all the minimum requirements of Tier 1 before the Notice of Approval is given.

Murphy [21] states that these guidelines are still ineffective for the following reasons. First, the decline in population does not show a sign of stopping. Second, the guidelines only apply to new constructions; the existing ones are primarily untreated by any visual markers or Non-reflective glass, continuing to cause bird-window collisions. Last but not least, most of the citizens, not only in Toronto, haven't realized that the paramount reason for protecting biodiversity is to keep the Earth what it was: a habitable homeland for humans. Each species that we push to the brink of extinction also pulls us closer to that point.

3.4.2. Further development of the TGS

In the paper "Birds, Buildings, People: Are Birdsafe Guidelines Enough?" Murphy [21] mainly discusses version 3 of TGS, published in 2018. However, the latest Version 4 came out in 2020, which updates some requirements. In version 4, Tier 1, the spacing of patterns requirement for all new constructions is 50 mm (horizontal and vertical), corresponding to the standard of FLAP. In Version 3, only low-rise residential constructions (less than four stories) have a maximum spacing of patterns of 100 mm (both horizontal and vertical); the other constructions (mid to high-rise residential; non-residential; all the city-owned development projects) have a maximum spacing of patterns of 50 mm (both horizontal and vertical). The adjustment might not be significant, but in Canada, residential structures are estimated to cause 90% of the total annual mortality of birds [14], and low-rise buildings are more susceptible to bird collisions. Therefore, this slight adjustment may play a role in further reducing the bird-window collisions.

One adjustment regarding bird-friendly glazing areas is worth pointing out. In Version 3 Tier 1, the low-rise residential needs to treat 85% of all the exterior glazing within 12 meters above the grade of the building or to the height of the surrounding tree canopy with bird-friendly designs. It means that if the surrounding tree canopy is less than 12 meters, then the owner can apply bird-friendly glazing only to the height of the tree canopy. The requirements for the rest of the construction are the same, except that the treated building height is 16 meters or above. In version 4, all construction needs to apply bird-friendly designs to treat 85% of all the exterior glazing within 16 meters above the grade of the building or to the height of the surrounding tree canopy, whichever is greater. The owner must apply more bird-friendly glazing if the surrounding tree canopy is more than 16 meters. It potentially extends the bird-friendly treatment areas of the building.

One of Murphy's [21] concerns was resolved in the Version 4. He indicated that Tier 1 of Version 3 allowed visual markers to be applied to the interior or exterior of glass glazing. In contrast, the FLAP standard applies them only to the exterior surface. This issue is resolved in the newest Version 4, which clearly states that visual markers should be applied to the first surface of the glass, aligning with FLAP's standard.

Moreover, Murphy's [21] paper does not mention the exterior lighting requirement in Tier 1. Since the artificial lights in the city constantly lure many nocturnal migratory birds, these lightings often increase the risk of bird-window collision and affect birds' migratory behaviors. In version 3, the exterior fixtures of all the new constructions must have the Dark Sky Fixture Seal of Approval, a lighting certification that reduces glare and night sky pollution. Specifically for city-owned constructions, rooftop and exterior lighting must be turned off from 11 p.m. to 6 a.m. In Version 4, except for low-rise residential, rooftop and exterior lighting of all other constructions must be turned off from 10 p.m. to 6 a.m. [20]. Requirements for Dark Sky Compliance of exterior fixtures stayed the same.

TGS is gradually approaching a more enhanced set of requirements and guidelines that prevent bird-window collisions, and some of Murphy's [21] concerns are resolved in the latest Version 4. However, there are still some problems and potential uncertainty. First, Version 4 only targets new constructions, so Murphy [21] held that the TGS is ineffective and needs improvement. Moreover, although Murphy [18] didn't mention the citizens' incentives in following the requirements, we believe that if the citizens lack the incentives to protect the birds, they will only meet the minimum standards of the requirements in Tier 1, not to mention even checking on Tier 2-4. Also, the existing constructions will ignore the birdsafe guidelines. Lastly, no studies have examined its effectiveness since the version was released two years ago. Hence, whether the new Version effectively alleviates the issue of bird-window collisions is still unknown.

3.5. Overall limitations

The review of the policies above shows that none are comprehensive enough and have some limitations. For the PIC, it is hard to measure the effectiveness of the educational campaigns because all the actions, like turning off lights from 11 p.m. to 6 a.m., that these campaigns encourage are entirely voluntary. Therefore, the organizations cannot know how many individuals participate, not to mention the impact of the PICs on reducing bird-window collisions.

Limitations for direct taxation and subsidies are apparent and non-negligible. First, taxation cannot be implemented in households because it is unfeasible to hold every private homeowner liable. Nonetheless, bird collisions with homes account for 90% of all collisions. Therefore, it should be addressed, but not with taxation. Subsidies may have the problem of free-riding, referring to some people purchasing bird-friendly films or windows at a higher price before the subsidy policy, causing complaints. However, the more significant problem is that if people are unaware of the benefits of saving the birds (direct value, indirect value, non-use value), they have no incentives to purchase bird-friendly products, even if they only have to pay a portion when there is a subsidy. That highlights the importance of education.

The issue with LEED is that it assesses the building's sustainable, economic, and social aspects instead of alleviating the pressing phenomenon of bird-window collision. Therefore, organizations like the U.S. Green Building Council (USGBC) should establish a new certification system that rates bird-friendly buildings. Another problem is that private households and corporations without an ESG sector are not incentivized to obtain the certification.

The main limitation of the TGS (Toronto Green Standard) is that it only targets new constructions. Although it has kept revising its requirements and guidelines and making positive adjustments, the target buildings -"new constructions"- stay the same. This means that most of the existing buildings still lack any birdsafe strategies, and the impact of TGS on the bird population is insufficient because the implemented range is limited. Moreover, most building developers only fulfill the minimum requirements because they are mandatory. Hence, they will not go beyond to achieve more since it is unnecessary. It reveals a fundamental problem: lack of incentive.

The major problem behind all kinds of policies is that the public lacks the incentive to protect birds. Mandatory policies can be somewhat effective but are inapplicable to households because homeowners lack liability. An excellent way to create incentives for citizens is to educate them about the importance of preserving birds and their potential value. The aim of educating people can be achieved through PICs, social media posts, news articles, etc.

4. Recommendations for solution

Based on the evaluation of existing policies, we meticulously devise an innovative solution to tackle the birds' collision issue. Our policy combines specific feasible actions and enhances the overall utility to tackle the main issue: the lack of incentives for both companies and households, which leads to the vast majority of bird collision issues and policy inflexibility in targeting households. Therefore, the overall goal is to create incentives for both parties to conduct voluntary actions while maintaining the sustainable and long-term implementation of the policy.

The core of our policy implementation is a devised certification program. Taking the LEED program as our basic foundation, we tailor the certification program to the bird collision standards for corporations and households. This might enhance the efficiency of bird protection due to the exclusive concentration on relevant details relating to bird collisions.

Via researching the potential arrangements and factors that may cause potential hazards to bird species, we separate the certification program into distinct levels, each representing the degree of configuration or adjustment that is friendly and safe for birds. Based on the level examined by staff via random inspection, the households and corporations will be given tailored rewards and punishments. As a result, it will probably boost their incentives to implement birds' friendly designs and decorations.

Households will be given a specific amount of property tax exemption based on the certification level for several reasons. Firstly, taxation is not feasible for individual households since consumers have few substitutes for traditional windows, which makes them price-inelastic despite the burdens of taxation [8]. Secondly, raising individuals' tax revenue for political reasons is generally not feasible: residents lack the flexibility to be coerced by the government with concerns about social pressure and political perspectives. Thirdly, subsidy-formed solutions might be more modest and efficacious than mandatory taxation policies that force residents via punishment. This might assure the successful policy implementation and latent results compared to compulsory taxation.

Based on preliminary considerations, individual households might be more likely to focus on preventing bird collisions since tax exemption offers long-term potential for households to save costs. With the educational campaigns and inspections, residents might gradually transform into long-term habits and continuously improve the current configuration and designs. In consequence, this can alleviate the birds' collision issue to a large extent since households account for 90% of the collision phenomenon [8].

Unlike households, corporations will be motivated by taxation punishments and reputation gain. Unlike households, compulsory policies are allowed for companies; thus, our policy applies taxation to them. Corporations should pay fines to the government if their designs do not fit the certification program standards. Despite the punishments, corporations can gain a reputation with the certifications from the program. The certifications prove the buildings to be outstanding in dealing with environmental problems - bird-window collisions, which highlights its accordance with the "green" standard. This positively impacts the reputation of firms [22]. A better reputation would attract more customers. This will increase the demand and raise firm sales, bringing extra profits.

Program scorers regularly revalue the designs and give updated certifications with new rewards or punishments to ensure and sustain the design for mitigating bird-window collisions. During each period, scorers would randomly choose a day to visit the certificated buildings and evaluate them based on the newest situations to give the latest feedback. This random check would prevent stakeholders from only tackling the scorers, placing the bird-friendly products for examination, and removing them after the evaluation.

Our policy also has a sustainable mechanism for monetary flow to prevent extreme government debt. The program collects taxation revenue from corporations and uses it as a subsidy to reward individual households performing well in the certification program. This forms a money flow cycle to ensure a balance in the government budget—a balance of revenue from taxation and government spending on subsidies.

5. Conclusion

5.1. Summary

Our paper strives to identify the unresolved problem concerning the bird-window collision issues. With externality as our economic assumption model, we point out the market failure due to excessive traditional window usage and lack of incentives for corporations and households to adopt bird-friendly products. Based on analysis and research on three main stakeholders, including residents, property developers, and corporations, we evaluate the current policies from their applicability to potential disadvantages. Then, identifying the significant impediments and limitations, we combine and adjust the current policy to initiate an innovative certification program with tax exemption and punishment tailored for households and corporations.

5.2. Limitations

Our study does not fully account for certain factors that lead to the birds' collision issues. To be more specific, different seasons and regions may arouse different levels of collision rates. More detailed consideration can enhance the utility of our policy thanks to more focused targets and locations. In addition, different species also suffer from various degrees of fatality rates. Treating every species as a unity might ignore certain vulnerable groups and even approach extinction. Therefore, it might lead to unfavorable results and hazards based on our general assumption.

Our policy framework is set in an ideal form without sufficient data and experiments. Indeed, although tax exemptions or punishment might create specific long-term incentives, the degree of willingness and preference is still unknown. Specifically, if households remain unresponsive to the initiatives, bird collision issues may still exist and be aggravated further with consideration of long-term trends. Moreover, the uncertainty also impacts the feasibility of our tax exemption and punishment system, leading to more complicated policy implementation and adjustment.

Moreover, the framework could be more complicated to implement than we consider. We propose the program with random checks on the up-to-date building designs regularly, but this requires a large amount of labor effort in rechecking and scheduling for checking. Also, reducing property tax, a household reward, could cause political problems since the government primarily controls the property tax. There should be negotiations with the government to request permission to reduce the amount. Those practical problems could be severe obstacles preventing a successful framework implementation.

5.3. Future research implications

Some significant unsolved problems require further research and extra experiments to solve if the bird-window collisions need to be improved and made more effective.

First, the calculation problem of birds' values requires further choice experiments or other approachable methods. Non-use and indirect values with long-term effects should be converted to tangible costs for calculating birds' TEV. The TEV of birds is necessary for external costs—bird

mortality, which would be used to determine the external costs and benefits, which are used to fix the unit tax and subsidy.

In addition, the standards for the new bird-window collision certification program require further research and design. More specifically, the standards require consideration of a wide range of factors. More research should be done on what factors should be included and how much each factor should account for.

Last, the framework of our policy requires more precise completion. To prove the balance between revenue from taxation and government spending on subsidies in the government budget, extra simulations or research on the calculations and comparisons between the two should be conducted. Also, the practicability of the policy requires extra experiments to prove.

References

- [1] #BringBirdsBack. (n. d.). #BringBirdsBack. <https://www.3billionbirds.org/#:~:text=We've%20Lost%20One%20in%20Four%20Birds&text=Published%20in%20Science%20by%20researchers,including%20birds%20in%20every%20ecosystem>
- [2] The IUCN red list of threatened species. (n. d.). IUCN Red List of Threatened Species. <https://www.iucnredlist.org/search?query=burds&searchType=species>
- [3] Loss, S. R. , Will, T. , Loss, S. S. , & Marra, P. P. (2014). Bird-building collisions in the United States: Annual mortality and species vulnerability estimates. *the Condor*, 116(1), 8-23. <https://doi.org/10.1650/condor-13-090>. 1
- [4] Hager, S. B. , Cosentino, B. J. , Aguilar-Guemez, M. A. , Anderson, M. L. , Bakermans, M. , Boves, T. J. , Brandes, D. , Butler, M. W. , Butler, E. M. , Cagle, N. L. , Calderon-Parra, R. , Capparella, A. P. , Chen, A. , Cipollini, K. , Conkey, A. A. , Contreras, T. A. , Cooper, R. I. , Corbin, C. E. , Curry, R. L. , . . . Zuria, I. (2017). Continent-wide analysis of how urbanization affects bird-window collision mortality in North America. *Biological Conservation*, 212, 209-215. <https://doi.org/10.1016/j.biocon.2017.06.014>
- [5] Longcore, T. , Rich, C. , Mineau, P. , MacDonald, B. , Bert, D. G. , Sullivan, L. M. , Mutrie, E. , Gauthreaux, S. A. , Avery, M. L. , Crawford, R. L. , Manville, A. M. , Travis, E. R. , & Drake, D. (2013). Avian mortality at communication towers in the United States and Canada: Which species, how many, and where? *Biological Conservation*, pp. 158, 410-419. <https://doi.org/10.1016/j.biocon.2012.09.019>
- [6] Klem, J. (2010). AVIAN MORTALITY AT WINDOWS: THE SECOND LARGEST HUMAN SOURCE OF BIRD MORTALITY ON EARTH. In *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics* (pp. 244-251). <https://www.partnersinflight.org/wp-content/uploads/2017/03/Klem-Jr.-D.-p-244-251.pdf>
- [7] Sheppard, C. , & Lenz, B. (2023, January 14). Getting clear on birds and glass. <https://abcbirds.org/blog/truth-about-birds-and-glass-collisions/>
- [8] Warren, E. J. (2013). A clear threat to conservation: using public policy to reduce bird collisions with windows in homes. School of Public Policy Faculty of Arts & Sciences. https://summit.sfu.ca/system/files/iritems1/14361/etd7748_EWarren.pdf
- [9] Samuelson, P. A. (1954). The pure theory of public expenditure. *The Review of Economics and Statistics*, 36(4), 387. <https://doi.org/10.2307/1925895>
- [10] Klem, D. (1989). BIRD-WINDOW COLLISIONS. *The Wilson Journal of Ornithology*, 101(4), 606-620. http://www.windowcollisions.info/public/klem_collisions_1989.pdf
- [11] Kim, C. , Kim, J. , & Yoo, S. (2022). Economic benefits of preventing bird collisions in South Korea: findings from a choice experiment survey. *Environmental Science and Pollution Research*, 30(2), 2945-2957. <https://doi.org/10.1007/s11356-022-22343-y>
- [12] Lin, T. , Le, A. , & Chan, Y. (2022). Evaluation of window view preference using quantitative and qualitative factors of window view content. *Building and Environment*, p. 213, 108886. <https://doi.org/10.1016/j.buildenv.2022.108886>
- [13] Brown, B. , Antonopoulos, A. , Siddoway, S. , Hammes, K. , Kusakabe, E. , Bush, S. , & Utah Museum of Natural History. (2018). Bird Strike Prevention and Evaluation for the University of Utah. https://fcs.utah.edu/_resources/documents/bird-strikedocs/appendix2_brown2018greenfundsproposalexample.pdf
- [14] Machtans, C. S. , Wedeles, C. H. R. , & Bayne, E. M. (2013). A First Estimate for Canada of the Number of Birds Killed by Colliding with Building Windows. *Avian Conservation and Ecology*, 8(2). <https://doi.org/10.5751/ace-00568-080206>

- [15] Sheng, G. Q. , Ingabo, S. N. , & Chan, Y. (2024). Evaluating the impact of bird collision prevention glazing pattern design on window views. *Building and Environment*, 111657. <https://doi.org/10.1016/j.buildenv.2024.111657>
- [16] Farrell, R. (2024, April 25). Texas' skyscrapers are going dark to keep billions of birds safe. <https://www.bbc.com/future/article/20240410-how-switching-off-lights-stops-migrating-birds-collisions-with-buildings>
- [17] LEED credit library | U. S. Green Building Council. (n. d.). <https://www.usgbc.org/credits>
- [18] LEED projects save energy by saving birds | U. S. Green Building Council. (2020, April 20). <https://www.usgbc.org/articles/leed-projects-save-energy-saving-birds>
- [19] Ogden, L. E. (2014). Does Green Building Come up Short in Considering Biodiversity?: Focus on a growing concern. *BioScience/Bioscience*, 64(2), 83-89. <https://doi.org/10.1093/biosci/bit019>
- [20] Toronto, C. O. (2023, December 14). Toronto Green Standard. City of Toronto. <https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/>
- [21] Murphy, A. & COREView. (2019). Birds, buildings, people: Are birdsafe guidelines enough? In *Faculty of Environmental Studies [Thesis]*. <https://core.ac.uk/download/pdf/267805766.pdf>
- [22] Porter, M. E. , & Kramer, M. R. (2018). Creating shared value. In *Springer eBooks* (pp. 323-346). https://doi.org/10.1007/978-94-024-1144-7_16