# Preserving or escaping? On the welfare effects of environmental self-protective choices

Antoci, Angelo and Borghesi, Simone

University of Sassari, University of Siena

May 2010

# Preserving or escaping? On the welfare effects of environmental self-protective choices

*Angelo Antoci*
*University of Sassari*
*Email: angelo.antoci@virgilio.it*

*Simone Borghesi*
*University of Siena*
*Email: Borghesi@unisi.it*

May 3, 2010

In modern societies individuals often try to alleviate their personal damages from environmental degradation by increasing their consumption of private goods. Although this "self-protective" behavior is very frequent in industrial economies, insufficient attention has been paid to its economic and environmental consequences. In this paper we show that such a behavior can give rise to a self-reinforcing growth process in which environmental degradation increases economic growth and vice-versa, leading the economy on a welfare-reducing path. For this purpose, we first provide several examples of environmental self-protective choices to give a heuristic view of this phenomenon and then examine their effects through a two-islands evolutionary model that leads the reader beyond a purely intuitive understanding of the argument. Although the proposed model is deliberately very simple, it may provide some interesting insights on an aspect that has been mainly ignored in the literature so far.

**Keywords:** Self-protective choices; defensive expenditures; environmental degradation; negative externalities; economic growth.

**JEL Classification:** O1, Q2.

## 1. Introduction

The direct effects of environmental degradation on the agents' welfare are the object of a large debate among both scholars and politicians. Environmental degradation, however, may also condition individual consumption choices generating some perverse effects in terms of economic growth and welfare that have been mainly ignored so far. As a matter of fact, ecological depletion incentives behaviors that are perceived as individually rational, (that is, utility maximizing for the agents who carry them out), but that may reduce the welfare of the whole population at the aggregate level. The mechanism underlying these perverse effects may be briefly summarized as follows. In order to defend from environmental degradation, economic agents make self-protective choices through the consumption of some private goods which may satisfy the same needs that were previously met by free environmental goods. The production and consumption of these private goods may enhance, in its turn, environmental degradation, thus further increasing the incentive to produce and consume private goods as a self-protection device. The substitution of environmental with private goods may thus lead to a vicious circle that determines an undesirable growth path, along which economic growth comes along with a reduction of the individuals' welfare.

The present paper intends to show the strategic context underlying the mechanism described above through a very simple analytical model. For this purpose, the paper is structured as follows. Paragraph 2 introduces the notion of self-protective choices. Paragraph 3 discusses the related literature on the growth effects of the self-protective choices. Paragraph 4 describes and investigates the analytical model. Finally, paragraph 5 concludes discussing some policy implications that derive from the analysis.

## 2. Environmental self-protective choices

In the last decades several contributions in the literature (e.g. Hueting, 1980; Shibata and Winrich, 1983; Bird, 1987; Leipert and Simonis, 1988; Shogren and Crocker, 1991; López, 2003; Escofet and Bravo-Peña, 2007) have set forth the idea that environmental depletion may modify the prevailing consumption pattern, leading individuals to increase the consumption of private goods that alleviate the negative effects of environmental degradation.

In the industrial economies there exists a wide range of private goods and services that each agent can use as self-protection instruments against environmental degradation[1]. Some of the most typical and often-quoted textbook examples of such goods include air filters and water treatment plants, mineral water, double-glazing to reduce the acoustic damage from urban traffic, medicines against pollution-related diseases (e.g. asthma and skin diseases).

The environmental degradation of coastal areas next to urban centers, resulting from overbuilding and environmental-unfriendly activities taking place in the surrounding industrial areas, induces urban residents to implement further self-protective choices. As a matter of fact, coastal areas near to the place of residence enable individuals to enjoy environmental goods at low cost, the more so the closer is the coastal area. Its degradation, however, can motivate costly trips to less contaminated areas by car, boat or airplane, or the purchase of expensive holiday packages in some tropical paradise. Individuals are thus forced to pay for goods that were once freely available.

The examples mentioned so far can definitely be classified as environmental self-protective choices. This notion, however, can also be interpreted in a broader sense, including a much wider set of consumption choices that are partially (but not exclusively) caused by environmental degradation. Urban life provides several examples of these choices.

The increasing use of home entertainments, for instance, can be partially due to the shortage of environmental goods in the residential area (e.g. urban parks where children can play) that leads many individuals to spend more time at home rather than to do open-air activities. The same applies to the rising diffusion of fitness centers and swimming pools that derive in part from the shortage of urban parks where practicing open-air sports and of clean rivers where taking a bath, respectively.

Similarly, the choice of using the car in town instead of, say, going by bicycle or on foot may respond to several non-environmental needs (e.g. moving faster and cover

---

[1] See Leipert (1989), Leipert and Simonis (1989), Garrod and Willis (1999), United Nations (1993, 2003), for alternative classifications of the environmental defensive expenditures generated by these self-

longer distances, protecting from bad weather conditions, expressing ones' social status and so on). But it may also be determined by ecological reasons: the higher the urban air pollution level, the higher the incentive to go by car to reduce one's exposure to the air pollutants released by the traffic. This paradoxically increases urban traffic and air pollution in its turn, thus reinforcing the decision to go by car. Therefore, the production and consumption of private goods that are used as self-protection devices can contribute to further enhance environmental degradation. Air conditioners provide another paradigmatic example of this process. These devices are used to defend from global warming by cooling the interior of homes and offices, but give off heat to the exterior, thus generating an increase in the external temperature that tends to encourage their use even further. As these examples show, the choice of using private goods to defend from environmental degradation may generate further environmental degradation and can lead to a final outcome in which their use is above the socially optimal level.

Another self-protective choice that can further increase environmental degradation is the one involving a house move to an area outside a degraded urban centre. This choice -that is generally motivated by both economic reasons (the search for less expensive houses) and environmental reasons (traffic noise, urban air pollution, desire for greater living spaces)- has led to an increasing extension of the towns over time with a consequent invasion of the countryside. This phenomenon, often indicated with the term *urban sprawl*, may end up increasing the problems that originally induced people to flee away from town, such as the reduction of green and public areas, the traffic congestion with the consequent increase of polluting emissions and of the time spent commuting to work (cf., for instance, Ciscel, 2001; Antoci et al., 2008). Environmental degradation, therefore, may encourage the urban sprawl which may raise environmental degradation in its turn and extend the ecological problems to the new residential areas. If so, the agents that move away from town in search of better living conditions could be potentially worse-off at the end of the day, as they have to face higher traveling costs and lower leisure at disposal, without enjoying any significant improvement in the surrounding environmental conditions.

---

protection instruments, namely, goods and services that agents can purchase to protect from the deterioration of the environment they live in.

Even the migration flows across different countries or regions can partially respond to ecological needs and thus be interpreted as self-protection choices. As a matter of fact, many migration flows are motivated not only by economic reasons (such as the desire to find a better job and better living conditions), but also by environmental degradation and ecological catastrophes that create the need to escape from the country of origin. This ecological motivation has gradually become so important that a specific term, i.e. the "environmental refugee" (Myers, 1997; Bates, 2002), has been coined in the literature to identify these migrants. Many environmental refugees are likely to come from developing countries where most of the population cannot afford to protect from environmental degradation and is therefore more vulnerable to ecological problems (such as the loss of the land's fertility due to its pollution and over-exploitation that compels poor farmers to leave their sites). The migration flows of the environmental refugees, however, are partially independent of the income level in the country of origin since deep ecological problems can hit both developed and developing countries. For instance, in the long run the rise in the sea level deriving from global warming might flood coastal lowlands in both developing countries (e.g. Bangladesh or the Maldives), and in developed countries (e.g. Netherlands or New York city; see Yin et al., 2009).

## 3. Self-protection choices as engine of welfare-reducing economic growth

The above examples suggest that self-protection choices may drive the economy towards undesirable outcomes. This intuitive result has been analytically proved by a few contributions in the theoretical literature on this argument. Shogren and Crocker (1991), for instance, showed that if individuals are not able to coordinate their self-protection choices and if such choices generate further environmental degradation, then the Nash equilibrium level of self-protection in the economy is higher than optimal. The authors, however, limit their analysis to a static game-theoretic context and so do not analyze the possible implications that self-protection choices may have on economic growth dynamics. The idea that environmental negative externalities may promote economic growth via self-protection choices was first introduced in an economic growth model by Antoci and Bartolini (1999, 2004) who showed in an evolutionary game context that negative externalities can fuel an undesirable economic growth path, along which agents' welfare is negatively correlated with aggregate output of private goods. Antoci and Borghesi (2010) have extended the analysis of Antoci and Bartolini (1999, 2004) from a single-population to a North-South evolutionary context with two populations of interacting agents in order to analyze possible undesirable feedback effects due to the interaction between self-protection choices of the two hemispheres. Bartolini and Bonatti (2002, 2003), Antoci et al. (2005, 2007) and Antoci (2009) (among the others) obtained similar results in neoclassical growth models. In such framework, they proved that environmental degradation may promote the accumulation of physical capital and/or technological progress, but the consequent increase in private consumption can turn out to be welfare-reducing.

Differently from the aforementioned studies in this line of research that focus mainly on the analysis of the possible dynamic regimes emerging from the models, the objective of this contribution is to present a very simple model that may help to understand the basic self-enforcing mechanism on which the above cited literature is based, avoiding the technicalities which may undermine the understanding of the basic forces at work. For this purpose, we will set forth a paradigmatic example based on a simple two-islands model that can convey the basic idea described above to a broad and interdisciplinary audience of both economists and non-specialists. To keep things as simple as possible, in this model we will deliberately neglect the regeneration process of natural capital as well as the accumulation of physical capital and technological progress. This simple context thus allows us to focus purely on the coordination problems that may emerge from individuals' self-protection choices.

## 4. A paradigmatic example: a "two-islands" model

To illustrate the substitution mechanism described above let us consider a population of individuals who live and work in an island that we will call A. To defend from the environmental degradation of island A, each individual has the possibility of buying a boat (or, equivalently, a cruise ticket or an airplane ticket) that can be used to move to an uncontaminated island B. In order to buy the boat, agents have to work and produce more. We assume that the consequent increase in the production activity tends to raise the environmental degradation of island A. It follows that as the number of individuals that decide to self-protect increases, the environmental degradation of A (and thus the incentive to go to B) also increases. When the share of individuals that decide to go to B is high enough, the environmental quality of A becomes so low that everyone will desire to move to B. If so, the community of island A as a whole will end up in an undesirable situation since it can no longer enjoy free access environmental goods.

The strategic framework described above can be summarized as follows. Let us indicate with *x* the share of individuals that decide to go to B and with 1-*x* the share of those remaining in A. We will denote with $W_B(x)$ and $W_A(x)$ the welfare of the agents that go to B and of those that stay in A, respectively. We assume that the individual welfare $W_i(x)$ ($i$ = A, B) is a strictly decreasing function of *x*: the higher the number of individuals that make defensive expenditures to protect from environmental degradation in A (e.g. purchasing a boat or an expensive holiday package to go to B), the higher the environmental degradation of both islands, which reduces the correspondent welfare levels. Thus, for instance, the use of boats to move from A to B may end up polluting also the sea at B. The same applies to air pollution in B due to the increase of cars and airplane traffic provoked by mass tourism.

In this context, one can distinguish two possible cases depending on whether $W_A(x)$ decreases more or less rapidly than $W_B(x)$ as *x* increases. In the first case, an increase in the number of individuals that self-protect affects island A more than B, in the second case the opposite holds. We will omit the case in which the two curves $W_A(x)$ and $W_B(x)$ decrease at the same rate since in that case the agents' decision trivially depends on the initial position of the curves.

**Scenario 1: self-protective choices affect island A more than B**

In this scenario, we can further distinguish three possible cases according to the relative position of the curves $W_A(x)$ and $W_B(x)$ in the (*x*, *W*) plane: (i) $W_B(x)$ lies always above $W_A(x)$ (see fig. 1), (ii) $W_B(x)$ lies always below $W_A(x)$ (fig.2) or (iii) the curves $W_A(x)$ and $W_B(x)$ cross in the (*x*, *W*) plane (fig.3).[2]

In the first case, the welfare of going to B is always higher than that of staying in A, whatever the share of agents *x* that decide to move to B, while in the second case the opposite applies.

Let us assume that there exists a given learning mechanism underlying individual choices that tends to spread the most remunerative strategy among the agents of the population (such as in to the so-called *replicator dynamics*, see Weibull 1995). If so, in the two extreme cases described above all individuals will end up making the same choice. In other words, variable *x* will either go to 1 (everyone moves to B) or to 0 (everyone stays in A), whatever the initial share $x_0$ of agents that decide to move to B (see figures 1 e 2, respectively).

If the two extreme cases described above do not apply and the curves $W_A(x)$ and $W_B(x)$ cross in the (*x*, *W*) space (fig.3), then there exists a value of *x*, $\bar{x}$, such that for every $x < \bar{x}$ the welfare of the individuals that move to B is lower than that of the agents that stay in A, whereas for every $x > \bar{x}$ the opposite holds. In this case, a "bistable dynamics" emerge from the model (see the arrows in fig.3): if the initial share $x_0$ is less than the threshold level $\bar{x}$, then all individuals will stay in A; vice-versa, if $x_0$ is larger than $\bar{x}$. If $x_0$ is just equal to $\bar{x}$, then the two choices provide the same welfare level and no individual will have any incentive to modify her choice.

Observe that if *x* = 0 (that is, everyone stays in A) the individual welfare level is $W_A(0)$, while if *x* = 1 (namely, everyone moves to B) it is equal to $W_B(1)$. As figures 2 and 3 show, in the cases (ii) and (iii) above it is always: $W_A(0) > W_B(1)$. In other words, the agents are always better-off if they all stay at home rather than if they all go to island B. However, if the curves cross (fig.3), the dynamics of the model may lead the

[2] Notice that $W_A$ and $W_B$ have been represented as convex curves in the figures, so that the agents' welfare diminishes at a decreasing rate as *x* increases. The classification of the possible cases described above, however, depends only on the relative positions of $W_A$ and $W_B$ and is independent of the shape of the two curves.

agents to operate the opposite choice (i.e. they all go to B) that will make everyone worse-off. In fact, if the initial share $x_0$ is above the threshold level $\bar{x}$, going to B is individually perceived as the best strategy in response to the others' choices (i.e. $W_B(x) > W_A(x) \ \ \forall x_0 > \bar{x}$). As the self-protective choice spreads among the population, however, the whole community ends up on a socially undesirable outcome since the agents' welfare in $x = 1$ is lower than in $x = 0$. In this case, the choice of going to B gives origin to an undesirable social convention that represents a stable Nash equilibrium of the economy. Any departure from this equilibrium thus requires an external intervention in order to coordinate the individuals' choices. As a matter of fact, no agent has an incentive to stay in A if the others do not do the same.

A similar outcome may also occur when $W_B(x)$ lies always above $W_A(x)$ so that everyone wants to move to B (case *i* above). As fig.1 shows, although $W_B(x) > W_A(x)$ $\forall x$, we can still have $W_A(0) > W_B(1)$. Even in this case, therefore, the strategy selection process may thus lead the agents to choose $x = 1$ although the welfare level in $x = 1$ is lower than in $x = 0$. If so, the individually rational choice of moving to B produces a socially undesirable equilibrium at the aggregate level for the community as a whole.

**Scenario 2: self-protective choices affect island B more than A**

Let us now suppose that the impact of the self-protective choice is relatively higher on island B than on island A. Thus, for instance, the air pollution provoked by the airplane traffic from A to B can damage B relatively more than A. The same applies to the sea pollution caused by the increasing number of boats directed to B where the local ecosystem can be less resilient than in A (think, for instance, of tropical islands that become the target of mass tourism).

Like for Scenario 1, even in this case we can distinguish three possible sub-cases according to the relative position of the decreasing curves $W_A(x)$ and $W_B(x)$ in the (*x*, *W*) plane. If $W_B(x)$ is steeper than $W_A(x)$ but it always remains above $W_A(x)$, then $x$ will tend to 1 (see the arrows in fig. 4). Once again, however, it is still possible (though it is not necessarily the case) that after going to B all individuals will be worse-off at the end of the day, since the environmental quality of island B may get lower than the one they used to enjoy when they all lived on island A and none made self-protective expenditures (i.e. $W_A(0) > W_B(1)$, as in fig. 4).

If, on the contrary, $W_B(x)$ lies always below $W_A(x)$ and the former curve falls more steeply than the latter (fig.5), then all agents will prefer to stay at home, which leads to a socially desirable outcome since the agents' welfare is higher in $x = 0$ than in $x = 1$.

Finally, if the curves $W_A(x)$ and $W_B(x)$ cross at $x = \bar{x}$ (fig.6), we have $W_A(x) < W_B(x)$ if $x < \bar{x}$, while $W_A(x) > W_B(x)$ if $x > \bar{x}$. In other words, if the number of agents that decide to go to B is sufficiently low, going to B is the best strategy for each individual and the share of people that make this self-protective choice will increase. If, on the contrary, the number of individuals that move to B becomes "too high" (above the threshold level $\bar{x}$), it is preferable to stay at home rather than go to B where beaches are now also crowded and polluted, which is what originally induced people to leave A in search of a better island.

To provide an intuitive explanation of this result consider, for instance, the well-known case of the Phi-Phi islands that are located in Thailand. In the year 2000 one of these uncontaminated islands (Phi-Phi Leh) was the backdrop for the movie "The Beach" with the movie star Leonardo di Caprio. Following the release of the movie, there was a dramatic increase of tourism on the Phi-Phi islands that became one of the most requested destinations from travel agencies all over the world. However, the increase of tourism and of the local population (previously made up only of a few fishermen) led to the construction of many buildings with the consequent depletion of the original environment. In this case, therefore, if the number $x$ of tourists that move to Phi-Phi islands causes a high environmental degradation of the islands, then moving to Phi-Phi islands is no longer convenient and people would be better-off staying at home and enjoy the nearby beach rather than buying an expensive holidays to a famous beach that is however depleted and crowded as well. A similar reasoning can be obviously applied to many other popular resorts that have experienced increasing environmental degradation in the last few years due to the large tourist flows from all over the world.

Differently from what happened under Scenario 1, in this case $x$ will tend to the meeting point $\bar{x}$ whatever the initial share $x$ of self-protecting individuals, so that $\bar{x}$ represents a stable Nash equilibrium of the economy. Notice that since $0 < \bar{x} < 1$, at the equilibrium one can observe heterogeneous choices within the population (some people decide to go to B and others to stay in A) and the distribution of the choices among the agents tends to remain constant over time (the equilibrium being stable). As fig. 6 shows, it is: $W_A(0) > W_A(\bar{x}) = W_B(\bar{x})$. In other words, although everyone would be better-off staying at home, the dynamics that emerge from the strategy adoption process leads away from $x$ = 0 towards the stable equilibrium $x = \bar{x}$, so that when $x < \bar{x}$ the community moves along a welfare-reducing path.

## 5. Conclusions

The analysis developed above has shown how a community may end up in a "private consumption trap" characterized by high self-protective consumption, high environmental degradation and low welfare level. A way out from this trap may occur only if a sufficiently high share of individuals simultaneously stop self-protecting, namely, consuming private goods as substitute for the depleted environmental goods.

In this context, therefore, an intervention of the Public Administration to coordinate the agents' choices seems highly desirable. Environmental policies should incentive individuals to preserve and enjoy the free access local environment they live in rather than replacing its benefits by escaping from it via self-protective choices. When introducing ecological interventions policy-makers should examine how many opportunities individuals have to enjoy their spare time without facing any cost. This issue seems particularly relevant for managing large urban centers. As a matter of fact, environmental problems due to interactions among the agents are particularly evident in the urban areas characterized by high human density and high production density. This explains why most self-protective choices occur in large cities. On the one hand urban centers offer a wide range of different ways to spend one's spare time, but on the other hand almost none of these ways can be enjoyed for free. This tends to damage relatively more the poorest families of the population that cannot afford many of the costly self-protection activities that can be found in town.

**References**

Antoci, A., 2009. Environmental degradation as engine of undesirable economic growth via self-protection consumption choices. Ecological Economics 68, 1385-1397.

Antoci, A., Bartolini, S., 1999. Negative Externalities as the Engine of Growth in an Evolutionary Context. Working paper No. 83.99, FEEM, Milan.

Antoci, A., Bartolini, S., 2004. Negative externalities and labor input in an evolutionary game. Environment and Development Economics 9, 1-22.

Antoci, A., Galeotti, M., Russu, P., 2005. Consumption of private goods as substitutes for environmental goods in an economic growth model. Nonlinear Analysis: Modelling and Control 10, 3-34.

Antoci, A., Galeotti, M., Russu, P., 2007. Undesirable economic growth via economic agents' self-protection against environmental degradation. Journal of The Franklin Institute 344, 377-390.

Antoci, A., Borghesi, S., Galeotti, M., 2008. Should we replace the environment? Limits of economic growth in the presence of self-protective choices. International Journal of Social Economics 35, 283-297.

Antoci, A., Borghesi, S., 2010. Transferring negative externalities: feedback effects of self-protection choices in a two hemispheres model, in Nonlinear Dynamics in Economics, Finance and Social Sciences, Bischi G., Chiarella C., Gardini L. (Eds), Springer Verlag, Amsterdam.

Bartolini, S., Bonatti, L., 2002. Environmental and social degradation as the engine of economic growth. Ecological Economics 43, 1-16.

Bartolini, S., Bonatti, L., 2003. Undesirable growth in a model with capital accumulation and environmental assets. Environment and Development Economics 8, 11-30.

Bates, D., 2002. Environmental refugees? Classifying human migrations caused by environmental change. Population and Environment 23, 465-477.

Bird, J., 1987. The transferability and depletability of externalities. Journal of Environmental Economics and Management 14, 54-57.

Ciscel, D.H., 2001. The Economics of Urban Sprawl: Inefficiency as a Core Feature of Metropolitan Growth. Journal of Economic Issues, 35(2), 405-413.

Escofet, A., Bravo-Peña, L. C., 2007. Overcoming environmental deterioration through defensive expenditures: field evidence from Bahía del Tóbari (Sonora, México) and implications for coastal impact assessment. Journal of Environmental Management 84, 266-273.

Garrod, G., Willis, K.G., 1999. Economic Valuation of the Environment, Edward Elgar, Cheltenham, UK.

Hueting, R., 1980. New Scarcity and Economic Growth. More Welfare Through Less Production?, North Holland , Amsterdam.

Leipert, C., 1986. Social costs of economic growth. Journal of Economic Issues 20, 109-131.

Leipert, C., Simonis, U.E., 1988. Environmental damage - environmental expenditures: statistical evidence on the Federal Republic of Germany. International Journal of Social Economics 15, 37-52.

López, R. E., 2003. Growth, Equity and the Environment: Elements for a Development Strategy for Latin America. Mimeo, University of Maryland at College Park, USA.

Myers, N., 1997. Environmental refugees. Population and Environment 19,167-182.

Shibata, H., Winrich, J. S., 1983. Control of pollution when the offended defend themselves. Economica 50, 425-37.

Shogren, J.F., Crocker, T.D., 1991. Cooperative and non-cooperative protection against transferable and filterable externalities. Environmental and Resource Economics 1, 195-213.

United Nations,1993. Handbook of National Accounting: Integrated Environmental and Economic Accounting. Studies in Methods, Series F, No.61, Sales No. E. 93 XVII.12, United Nations, New York.

United Nations, Commission of the European Communities, International Monetary Fund, Organisation for Economic Cooperation and Development, World Bank, 2003. Handbook for Integrated Environmental and Economic Accounting. United Nations, New York.

Yin, J., Schlesinger, M. E., Stouffer R. J., 2009. Model projections of rapid sea-level rise on the northeast coast of the United States. Nature Geoscience 2, 262-266.

Weibull, J. W., 1995. Evolutionary Game Theory. The MIT Press, Cambridge, USA.

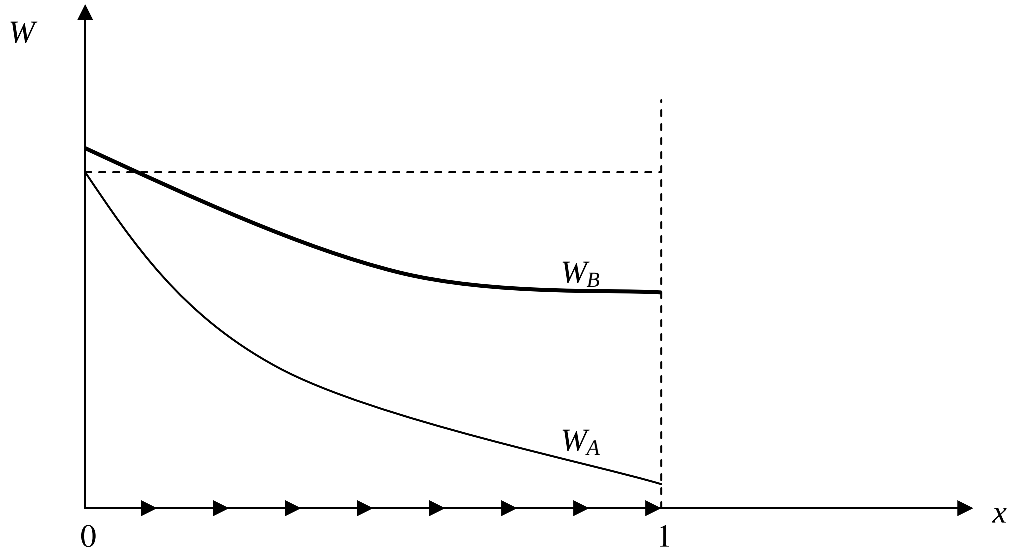


**Figure 1:** $W_A$ steeper than $W_B$ and all agents go to island B.

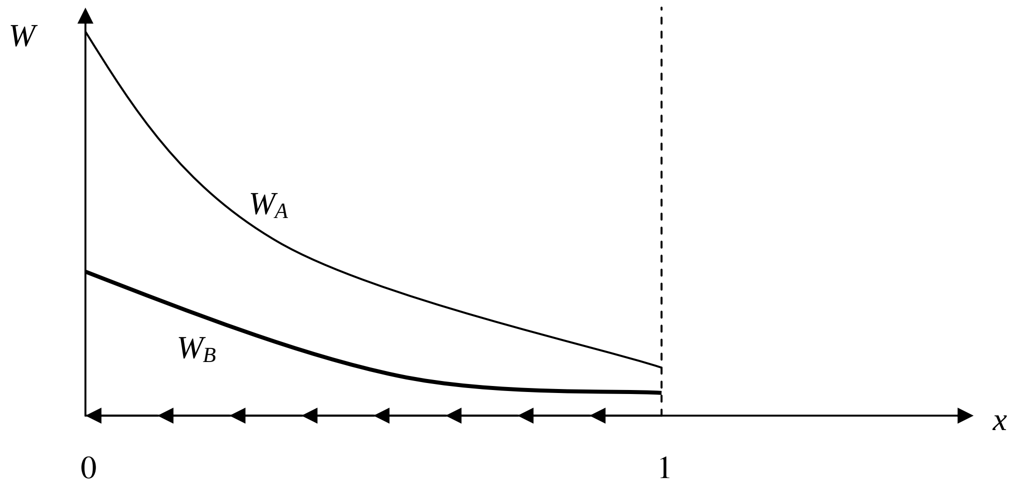


**Figure 2:** $W_A$ steeper than $W_B$ and all agents stay in island A.

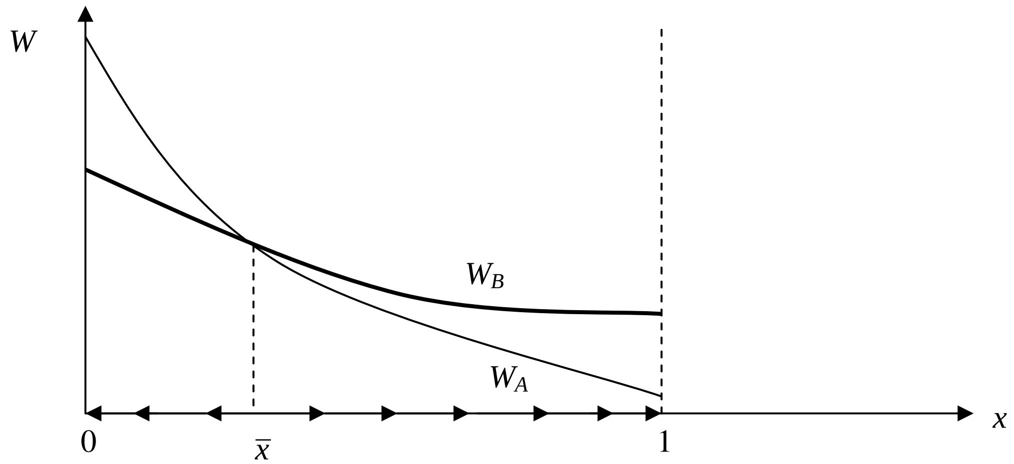


**Figure 3:** $W_A$ steeper than $W_B$; if $x$ is initially below (above) $\bar{x}$, then all agents stay in A (go to B).

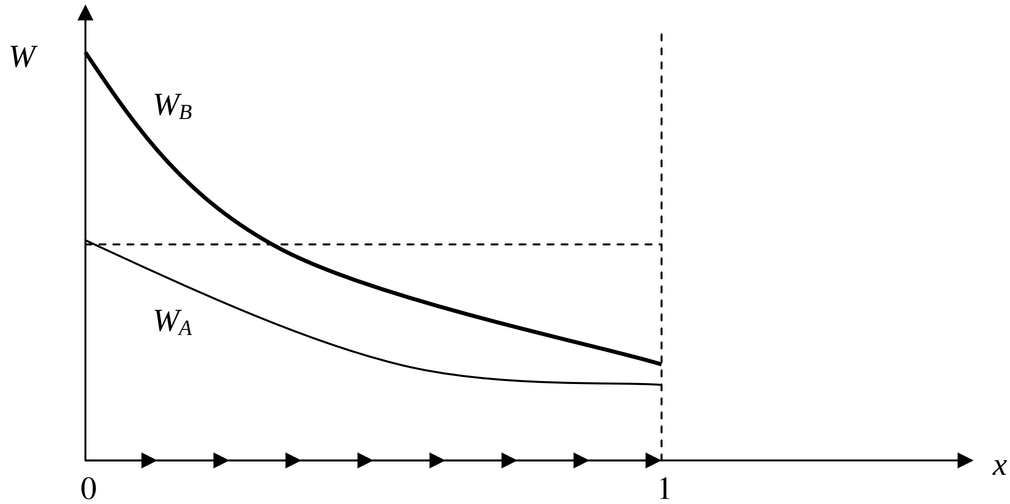


**Figure 4:** $W_B$ steeper than $W_A$ and all agents to go to B.

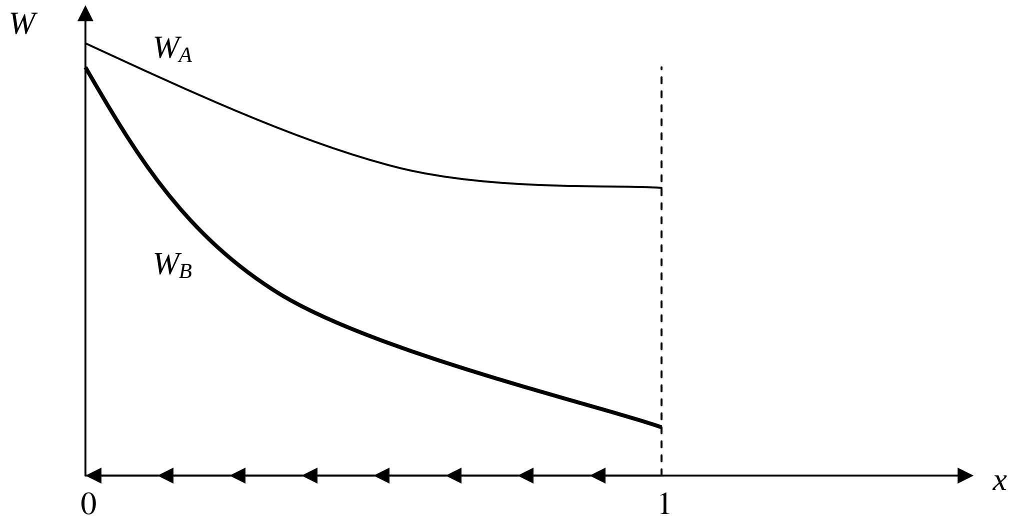


**Figure 5:** $W_B$ steeper than $W_A$ and all agents stay in A.

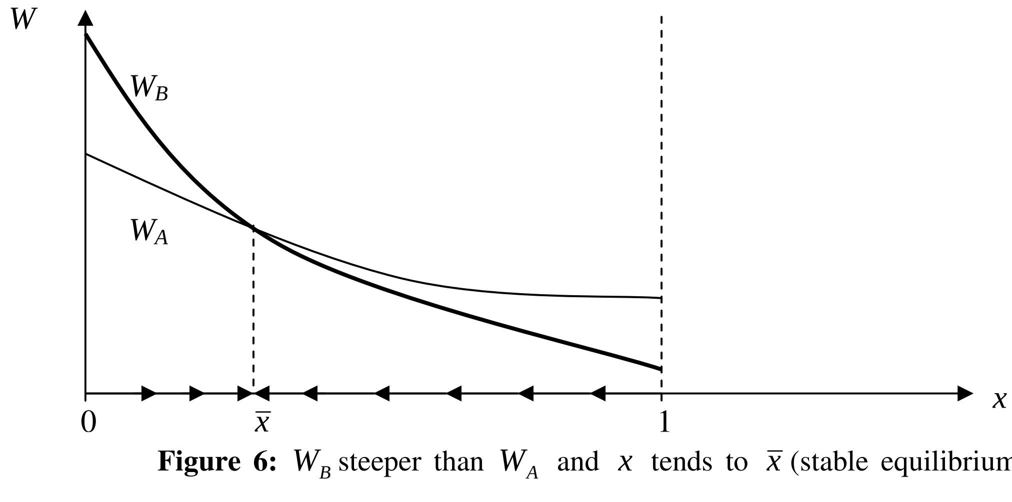


**Figure 6:** $W_B$ steeper than $W_A$ and $x$ tends to $\overline{x}$ (stable equilibrium) whatever the initial level of $x$.