Economic Theory and Minority Language

SPERLICH, Stefan Andréas, URIARTE, José Ramon

Reference


Available at:
http://archive-ouverte.unige.ch/unige:36602

Disclaimer: layout of this document may differ from the published version.
THE ECONOMICS OF LANGUAGE POLICY

Organisers: Bengt-Arne Wickström and Michele Gazzola

Workshop to be held on 26–27 July 2013 on the island of San Servolo in the Bay of Venice, Italy

ECONOMIC THEORY AND MINORITY LANGUAGE

Stephan Sperlich and José-Ramón Uriarte
ECONOMIC THEORY and MINORITY LANGUAGE

Stephan Sperlich,
Université de Genève
and
José-Ramón Uriarte
University of the Basque Country

June 2013

WORK in PROGRESS

Not to be quoted without permission
I. Introduction (to be completed)

The purpose of the present paper is to offer a theoretical explanation to the persistent gap that exists between the knowledge and the usage of a minority language.

To this end, we propose a model that describes the possible linguistic strategic behaviour of bilingual speakers in societies with two official languages. The explanation that our model offers is that this gap, its size and the level of use of the minority language, is not merely a statistical problem; that is, it is not determined only by the (relatively small) proportion of bilingual speakers. The model says that the gap is mainly due to a linguistic convention developed by the bilingual speakers in the long run. Indeed, the long run Nash equilibrium is an optimal partition of the bilingual population in two groups with different linguistic behaviours relative to the minority language.

This linguistic convention is understood, in our model, as an equilibrium concept with strong stability properties. In particular, the equilibrium is evolutionary stable.

The paper is structured as follows. ....

II. Type of Societies and Languages

Threatened languages are usually characterized by being spoken by minorities. We are going to consider a society with two official languages; let $A$ denote the language spoken by every individual of the society and $B$ denote the threatened language, spoken by the bilingual minority of the society.

Societies:

The present paper will only consider threatened languages in societies satisfying the following two general features:

1. The society has two official languages.

The type of societies we have in mind are democracies that at some point in their history have decided that the languages $A$ (known by every member of the society) and $B$ (known by a minority), and their related cultures have, by law, equal status, rights and priviledges.

2. The society has enough resources to design linguistic policies to insure the maintenance and public transmission of the minority language.

Thus, we shall be dealing with highly developed economies with resources assigned to schools, teachers, textbooks, editing houses, media, technologies
and institutions to support and promote the teaching and transmission of language B and its related culture.

**Languages in Contact:**
With respect to the languages, we will only deal with the case where A and B are linguistically very distant so that the conversations that take place during an interaction must be in one of the languages, either B, - this could only happen when all the participants in the interaction are bilingual-, or A. That is, we do not allow passive bilingualism.

**Some examples** of societies and languages which would satisfy these features are the Basque Country, Brittany, Canada, Ireland, Scotland and Wales. In the Basque Country, the languages are Basque and French in the French part, and Basque and Spanish in the Spanish part; in Brittany, Breton and French; in Canada, English and French. Irish, Gaelic (of Scotland) and Welsh compete with the *lingua franca*, English. Of course, there are other examples satisfying these two features.

**Pessimistic Views**
*In the societies we are studying, there is a major concern and pessimism in those who are involved in the design of language policy and the citizens in general about the persistent gap that exists between the knowledge of the minority language and its usage outside the education system.*

**Question:**
Why is it that having the political system, the legal instruments, -e.g. the Gaelic Language (Scotland) Act 2005, the Law of Normalization of Euskera’s Use",1982, The Welsh Language (Wales) Measure 2011 gave the Welsh language official status in Wales ) to promote and facilitate their use, the resources, the education system, the language policies, and what is more important, the people’s support and willingness to speak the language, there is such gap between knowledge and usage?

**III. Analysis restricted to the case of Basque:**
In the present paper we will be dealing with the case of Basque. But we
think our result could be extended to the other societies mentioned above.

In Table I we present some important data about the Basque

**Table I (*)&**

Evolution of Knowledge ($\alpha$) and Street Usage (KE) of Basque in the Basque Country-Euskal Herria

<table>
<thead>
<tr>
<th>Year$^{(1)}$</th>
<th>$\alpha^{(2)}$</th>
<th>Year$^{(3)}$</th>
<th>KE$^{(4)}$</th>
<th>EI = KE/$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986$^{(4)}$</td>
<td>1989</td>
<td>10.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>22.30</td>
<td>1993</td>
<td>11.8</td>
<td>0.52915</td>
</tr>
<tr>
<td>1996</td>
<td>24.40</td>
<td>1997</td>
<td>13.0</td>
<td>0.52379</td>
</tr>
<tr>
<td>2001</td>
<td>25.40</td>
<td>2001</td>
<td>13.3</td>
<td>0.52362</td>
</tr>
<tr>
<td>2006</td>
<td>25.70</td>
<td>2006</td>
<td>13.7</td>
<td>0.53307</td>
</tr>
<tr>
<td>2011</td>
<td>27.00</td>
<td>2011</td>
<td>13.3</td>
<td>0.49259</td>
</tr>
</tbody>
</table>

(1) Years of the Sociolinguistic Survey (Inkesta Soziolinguistikoa) carried out by the Basque Government-Eusko Jaurlaritza.

(2) Knowledge of Basque (group age 16 years and over): it is given by the proportion of bilingual speakers $\alpha$.

(3) Years of the Street Usage (KE) measure carried out by the Cluster of Sociolinguistics- Soziolinguistikoa Klusterra.

(4) The Street Usage or Kale Erabiler (KE) measure.

(*)& The data correspond to all the geographical areas where the Basque language is spoken. Throughout history, the area has been called, Euskal Herria, which means, literally, the Country of the Basque; that is, the Basque Country.

**The Street Usage Measure of a Minority Language.**

In a society with two official languages, -A and B-, people who are interacting at a certain time and place could use either A or B or a mixture of both languages. Out of the total conversations that could be recorded at random, at a given time and place, one could count those conversations that used one of the two languages, say B, and the proportion of people who took part in them. From there one can deduce the proportion of the bilingual population of the observed place who use Basque in their interactions. This is called the street use measure - or Kale Erabiler (KE) - of language B.
Dividing the KE index of the given municipality by the proportion of bilingual speakers of that municipality, we obtain, the Efficiency Index (EI). A municipality with a high EI means that the proportion of the bilingual population who actually use language B in that municipality is high.

The methodology for measuring the street use of a minority language has been developed by the group Soziolinguistika Klusterra, who operates in the Basque Country; see Altuna and Barturen (2013).

Table I shows the KE index for the case of the Basque. We distinguish between the knowledge of the language and its use; the distinction is particularly in the case of minority languages whose use is socially constrained by the population of monolingual speakers of the dominant language A.

Two features of the KE index for Basque are worth mentioning:

(i) The data about the KE index of Basque shows the natural implication that the proportion of bilingual people interacting in Basque increases with the size of the bilingual population.

(ii) A striking feature of the KE index for Basque is that the gap between knowledge (K) and use (KE) of Basque is increasing.

Answer:
We want to provide an answer to this issue mainly using a model based on economic theory.

IV. A Model for the Usage of a Minority Language.

1. The experimental studies about language use and human communication, -which, according to Gallantucci and Garrod (2010), could be referred to as experimental pragmatics, whose research object is the spoken dialogue (e.g., Clark, 1996) and experimental semiotics which focuses on interactions without preestablished communicative conventions (e.g., Galantucci, 2005; Selten and Warglien (2007) ),- implicitly assume that the laboratory subjects share similar cognitive processes.

However, a bilingual speaker, taking part in real-life interactions, faces not only the common problem of satisfying his communicative needs; additionally, the bilingual speaker has a language coordination problem and so must take a decision upon the language, -either A or B- expected to be used in the interaction. Therefore, unlike the monolingual speaker, a bilingual speaker must solve simultaneously two problems: to maximize the commu-
nication effectiveness and efficiency and maximize his linguistic preferences.

As Selten and Warglien (2007), we want to emphasize the main economic factors of linguistic communication, not in general though, but for the case of the bilingual speaker. These are, on the one hand, the expected benefit derived from satisfying both communication needs and linguistic preferences and, on the other, the expected cost attached to the speech production in two active language systems (memory, word length, utterance length, frequency and other factors; see Frank and Goodman, 2012), plus the costs attached to the resulting language actually used in the interaction (more on this, below). In other words, in a linguistic communication situation, the bilingual subject faces more complex cognitive tasks than those faced by a monolingual speaker.

2. In the societies we are dealing with in the present paper, it is safe to say that bilingual speakers must face frequently language choice situations. Very often a bilingual participating in an interaction must decide which language will use with the interlocutor. Therefore, it is natural that the bilingual speakers build communicative conventions which will serve to minimize the efforts associated with linguistic communication.

As a result the linguistic behaviour of bilingual speakers is shaped by a repetitive, almost continuous, language decision-making and, what is common in human language, a tendency to the optimization - of the difference between benefits and costs-, guided by an economizing attitude and principles of least effort; see Selten and Warglien (2007).

3. Let us refer now to the information conditions under which the bilingual speaker’s choices are made. In the present paper, we are not interested in what happens with the use of minority languages inside the geographical areas where B is strong and widely used. Precisely, what we want to know is what happens outside those areas, in urban domains where the bilingual speakers are less known to each other. It is in the urban areas and in the economically most dynamic sectors of the society where the fate of the minority language is at stake. The highly economically advanced societies we have in mind are characterized by dramatic economic and technological changes that encompass a high mobility, both social and geographical, of the work force. As a consequence, bilingual people frequently participate in anonymous interactions; that is, without knowing the linguistic type of the interactive partner, whether monolingual or bilingual. Hence, the question is: which is the use bilingual speakers make of B in this kind of interactions?
It is worth mentioning, that the learning of $B$ by subjects belonging to families originally immigrant, and the language contact situation of $A$ and $B$ eliminate external signals of linguistic types. For instance, the accents, as signals that would reveal who speaks $B$ and who does not, are erased.

The modelling of this setting requires assuming that bilingual speakers make language choices under imperfect information. Therefore our analysis must make use of bayesian models. Iriberry and Uriarte (2012) proposed a bayesian game, the Language Conversation Game ($LCG$), to model the strategic use bilingual speakers make of the languages $A$ and $B$ under imperfect information.

The following set of assumptions formalizes some of the what has been said in the previous lines.

**Assumptions:**

- **A.0.** General assumption:
  (i) the society is a democracy, highly developed economically.
  (ii) the society has two official languages, denoted $A$ and $B$, which are, by law, equal (that is, they have equal rights and privileges).

  We add now a set of more specific assumptions:

- **A.1.** Imperfect information about the linguistic type of the speech partner. We assume, on the other hand, that the proportion of bilingual and monolingual speakers in the society, denoted $\alpha$ and $(1-\alpha)$, respectively, is common knowledge among all the agents in the society.

- **A.2.** Linguistic Distance: $A$ and $B$ are linguistically very distant, so that successful communication is only possible when the interaction takes place in one language.

  The next assumption capture the people´s support of language $B$.

- **A.3.** Language loyalty: Bilingual speakers prefer to speak $B$ and have payoff incentives (see A.4 below) to do so.

Let us refer now to the payoffs. In the present context, the payoffs could be assumed to be the net benefits that the speakers may obtain from satisfying their communication needs. First note that a monolingual speaker makes no language choices and will always get the payoff $n$:

$$n = \text{Communication benefit} - \text{Speech production cost} = b - c_1$$
A bilingual speaker might coordinate on the majority language $A$; in that case, we will assume that he will get, as the monolingual speaker, the payoff, $n$, because this was a voluntary coordination or choice. The bilingual speakers will get the maximum payoff, $m$, when they coordinate in their preferred language $B$; we will assume that $m > n$. Then $(n - c)$ would be the payoff to a bilingual speaker who, having chosen $B$, is matched to someone, monolingual (or bilingual), who uses language $A$ and, therefore, is forced to speak $A$; $c$ denotes the frustration cost felt by this bilingual speaker.

In short, we are making the following assumption about the payoffs:
- **A.4. Payoffs**: For a given proportion $\alpha < 1-\alpha$, we assume the following payoff ordering: $m > n > c > 0$.
- **A.5. Frustration Cost**: $c < (m - n)\frac{\alpha}{(1-\alpha)}$.

**Pure Strategies:**
Since the bilingual speaker must make his language choices under imperfect information about the linguistic type of the interlocutor, the strategies the bilingual speaker might think are available to him can be reduced to the following two:

$s_1$: *Use always $B$, whether you know for certain you are speaking to a bilingual individual or not. Use $A$ only when the speech partner reveals he is of the monolingual type.*

Playing strategy $s_1$ is equivalent to revealing your bilingual type to the interlocutor.

$s_2$: *Use $B$ only when you know for certain that you are speaking to a bilingual individual; use $A$, otherwise.*

When the bilingual speaker plays strategy $s_2$ it is equivalent to hiding his linguistic type.

The language attached to each profile of pure strategies is shown in the language matrix shown below. Notice that the preferred language $B$ will be used in the conversation whenever there is, at least, one bilingual speaker using strategy $s_1$. But if both play strategy $s_2$ they will talk in their less preferred language.

\[
\begin{array}{c|cc}
    & s_1 & s_2 \\
  \hline
  s_1 & B & B \\
  s_2 & B & A \\
\end{array}
\]
The Language Matrix: it shows the language associated to each pair of pure strategies played by two bilingual speakers. Since players have imperfect information about the type of the opponent, they might use either \( B \) or \( A \) in the interaction. That is, if both bilingual speakers hide their type by choosing \( s_2 \), then they will use their less preferred language \( A \) in the interaction. In the other three cases they will use their preferred language \( B \), because at least one speech partner is revealing the bilingual identity.

V. The Equilibrium

Iribarri and Uriarte (2012) show that the LCG has a mixed strategy Nash equilibrium, \( x^* \), with strong stability properties. If we interpret the LCG as a game played by the population of bilingual players, denoted \( N \), this equilibrium could be interpreted as an optimal partition of the bilingual population \( N \). (A formal proof of this result is shown in the Appendix). The optimal partition of \( N \) might be called a linguistic convention built, in the long run, by the bilingual speakers. Indeed, the language strategy played by each group in the partition is the following:

1. the subpopulation \( Nx^* \) consists of bilingual speakers who reveal their bilingual type by playing the pure strategy \( s_1 \).
2. the subpopulation \( N(1 - x^*) \) consists of those who hide their bilingual type by playing the pure strategy \( s_2 \).

The language used under each strategy profile is shown in the Language Matrix. \( B \) will be spoken whenever there is at least one bilingual speaker who plays \( s_1 \); if both speakers play \( s_2 \), then they will use language \( A \).

Hypothesis

In Table I it is distinguished between those who know the minority language (that is, the proportion \( \alpha \) of bilingual speakers) and those who actually use it (that is, the KE measure of Table I). The distinction between knowledge and use of the minority language \( B \) is well captured by the LCG. What matters is what happens in the Nash mixed strategy equilibrium, \( x^* \); and there we know the precise number of those who have the knowledge of the minority language \( B \), have the incentives to speak it, but use \( A \) instead when they interact between them. They are the bilingual speakers in group \( N(1 - x^*) \). The equilibrium tells us as well the number of bilingual speakers who actually use always \( B \) when they interact with other bilingual speakers: those in group \( Nx^* \). All this leads us to the following hypothesis:
The optimal fraction of bilingual speakers who play \( s_1 \), the mixed strategy Nash equilibrium \( x^* \), could be thought of as a theoretical representation of those bilingual speakers who, in real situations, do use B in their interactions with other bilingual speakers and are captured by the KE measure of each sociolinguistic zone \( i \) with a specific proportion \( \alpha_i \) of bilingual speakers.

Question:
If the theoretical representation of the bilingual speakers who use B (whenever they are matched to other bilingual speakers) is \( x^*(\text{the equilibrium proportion of bilingual speakers who play } s_1) \), which of the two strategies is most likely to be used in equilibrium by the bilingual players?

Indeterminacy of \( x^* \):
The model only tells us that the equilibrium is an interior point of the unit interval: \( x^* \in (0, 1) \). So we must look outside the model we have used so far, to look for some information that might tell us about the relative size of \( x^* \) (and therefore, of \( Nx^* \)). In the next lines we make use of some cognitive theories that might serve to answer the above question.

V.1. The cognitive features attached to playing strategy \( S_1 \):
1. Using \( S_1 \) is a way of revealing the bilingual type of the player; that is, by using B the player reveals to the speech partner that he is bilingual. This may occur when the bilingual speaker starts the conversation, or when the bilingual must answer to an interlocutor who has started the dialogue using A; in the latter case, the bilingual would show his preference for B by switching the language of the dialogue from A to B. If the interlocutor is monolingual, then, as mentioned previously, he will suffer a frustration cost and get the minimum payoff of the game: \( n - c \). If the interlocutor is bilingual, then the switch to B would be accepted and both would get the highest payoff: \( m \).

2. Most importantly, strategy \( s_1 \) forces the speech partner to reveal his type too. Hence, either the partner is bilingual as well and agree with the switching from A to B and so they get aligned in language B, or, what happens more frequently, the partner is monolingual, and must confess the lack of knowledge of B and excuse himself. The latter is an embarrassing situation.
3. Strategy $s_1$ could be perceived by the interlocutor (hearer) as a *Face Threatening Act* because he is being inquired about his knowledge of one of the official languages of the community. If the interlocutor happens to be a bilingual speaker, then the face threatening is felt marginal. It is only when the interlocutor is monolingual that the face threatening feeling could be strong... The hearer’s positive face is threatened because the inquire might be felt as an implicit criticism for various reasons:

a. for excluding the bilingual speaker from the use of $B$.

Note that it is said that languages are public goods. But, whenever a bilingual speaker interacts with a monolingual one, language $A$ will be used irrespective of the bilingual speaker’s preferences. Hence, it should said that majority languages are public goods. Minority languages face plenty of difficulties to satisfy the condition of non-excludability.

b. it could be understood, by the hearer, as questioning his efforts for the maintenance and transmission of $B$.

4. Strategy $s_1$ introduces *perturbations* in the process of dialogue alignment. Garrod and Pickering (2007) assume that the goal of dialogue is alignment; "interlocutors do not use language to encode and decode messages, but rather as a means by which they can align their mental states, so that they come to have the same ideas about the topic under discussion...( ). They understand dialogue as a joint activity, "like ballroom dancing or using a two-handed saw, and to assume that alignment follows from this inherently interactive process".

A bilingual interlocutor who forces the dialogue partner to confess whether he may or may not speak in $B$, might spoil the alignment process. After confessing his true type, the monolingual partner will be left in a state of doubts, conjecturing about how annoyed or aligned is his bilingual interlocutor. But it could also happen that both parties get equally affected and no alignment at all is produced.

5. Playing $s_1$ is equivalent to adopting the role of leader in solving the bilingual speakers’ language coordination problem for. See also Selten and Warglien (2007) about this role in the emergence of a common code.

6. *Time pressure plays a role as well.*

7. Lack of discursive models and lexical endowments in certain areas introduces difficulties for playing $s_1$.

V.2- The cognitive features attached to playing $S_2$:
Strategy $S_2$ is risk-free. It is adaptive in the sense that the strategy advice you to use the same language as your interlocutor. If you start the conversation, the strategy tells you to use the majority language $A$; if the interlocutor happens to be a bilingual who (plays $s_1$ and so) answers you in $B$, then you will switch to $B$ and get $m$. If the interlocutor is monolingual (or a bilingual who chooses to answer in $A$) you would get $n$. Thus, in terms of payoffs the minimum you get is $n$, but you might also get $m$ if you meet someone playing $S_1$.

This strategy does not introduce any perturbation in the dialogue alignment. It is also more polite than $S_1$, but, in terms of the language, if two bilingual players play $S_2$, they will not recognized each other and will talk in the language they prefer less (see the language matrix, above). Playing $S_2$ is adopting the role of hawks (see the matrix of expected payoffs in the Appendix); and when two hawks meet, they hurt each other.

**Corollary**

We conclude that the linguistic convention built by the bilingual population is based on a relatively higher proportion making use of strategy $S_2 : N x^* < N (1 - x^*)$.

Hence now we have a theoretical explanation for the data presented in Table I: it is more popular strategy $S_2$. This might explain the low level of use of Basque observed in table 1.

**VI. Conclusions**

To be written down.

**VII. References**


10.1093/oxfordhb/9780198568971.013.0026.


**Data:**
APPENDIX

Discussion of the Assumptions A1-A5
If we eliminate A.1 and assume perfect information and the rest of assumptions, one could expect that bilingual speakers would tend to coordinate in B. Assumption A.2 avoids the linguistic similarities between A and B assumed in Mira and Paredes (2005). If we assume language similarity, then conversations could take place using both A and B, bilingual speakers would not be forced to change necessarily from B to A, and there would not be any frustration cost. If, instead of A.5, we assume \( c \geq \frac{3}{4}(m - n) \), while keeping the rest of the assumptions, then it can be shown that the language used in equilibrium would be A (see Iriberri and Uriarte, 2012).

2. The Language Conversation Game (LCG)
Let us view now the LCG as a population game. To this end, let us assume that the bilingual population consists of a large, but finite number of individuals, who play a certain pure strategy \( s_i, (i = 1, 2) \), in a two-player game.

The members of the bilingual population play the LCG having \( S = \{s_1, s_2\} \) as their common strategy set. The interactions are modelled as pairwise random matching between agents of the bilingual population; that is, no more than two (randomly chosen) individuals interact at a time. The interactions take place continuously over time. Let \( N \) be the total population of bilingual speakers in the society, and \( x = \frac{N_1}{N} \) the proportion of bilingual agents playing the pure strategy \( s_1 \) at any point \( t \) in time (time dependence is suppressed in the notation). In this setting, a mixed strategy is interpreted as a population state that indicates the bilingual population share of agents playing each pure strategy. On the other hand, the payoffs of the game should not be interpreted as biological fitness, but as utility.

2.1. Expected Payoffs
Let us consider a bilingual speaker who must decide, under imperfect information, which language is going to use in an interaction which is about to occur. Simplifying things, we could say that the bilingual speaker expects to be involved in two exclusive events: the bilingual speaker believes that with probability \( \alpha \) he is going to interact with another bilingual speaker, to
Both speakers are bilinguals

<table>
<thead>
<tr>
<th></th>
<th>$s_1$</th>
<th>$s_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_1$</td>
<td>$m, m$</td>
<td>$m, m$</td>
</tr>
<tr>
<td>$s_2$</td>
<td>$m, m$</td>
<td>$n, n$</td>
</tr>
</tbody>
</table>

Figure 1: The game expected to be played with probability $\alpha$ between two bilingual speakers. Notice that $s_1$ is weakly dominant, since $m > n > 0$.

Bilingual matched to a monolingual

<table>
<thead>
<tr>
<th></th>
<th>$s_1$</th>
<th>$s_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_1$</td>
<td>n-c</td>
<td></td>
</tr>
<tr>
<td>$s_2$</td>
<td>n</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: The game expected to be played with probability $1 - \alpha$ when a bilingual speaker meets a monolingual speaker. Note that $s_2$ is strictly dominant since $c > 0$

play the game described in Figure 2, in which, by A.4, strategy $s_1$ is weakly dominant. With probability $1 - \alpha$ the bilingual speaker expects to interact with a monolingual speaker, to play the game described in Figure 3, in which, by assumption A.4, $s_2$ is strictly dominant. The monolingual agent does not make choices and gets payoff $n$.

If a bilingual speaker chooses strategy $s_1$, then, no matter the choices of the other bilingual player, the expected payoff is $\alpha m + (1 - \alpha)(n - c)$; if the choice is $s_2$, then, against $s_1$, the expected payoff will be $\alpha m + (1 - \alpha)n$ and, against $s_2$, $n$. The resulting matrix of expected payoffs of the LCG played by two bilingual speakers will, therefore, be symmetric.

<table>
<thead>
<tr>
<th></th>
<th>$s_1$</th>
<th>$s_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_1$</td>
<td>$\alpha(m - n) - c(1 - \alpha), \alpha(m - n) - c(1 - \alpha)$</td>
<td>$\alpha(m - n) - c(1 - \alpha), \alpha(m - n)$</td>
</tr>
<tr>
<td>$s_2$</td>
<td>$\alpha(m - n), \alpha(m - n) - c(1 - \alpha)$</td>
<td>0, 0</td>
</tr>
</tbody>
</table>

Matrix of Expected Payoffs
2.2 Theoretical Prediction
Under the assumptions A.1-A.5, we get the following result.

**Proposition.** There exists a mixed strategy Nash equilibrium in which the bilingual population plays $s_1$ with probability $x^* = 1 - \frac{c(1-\alpha)}{\alpha(m-n)}$. This equilibrium is evolutionary stable, that is, $x^*$ is a language convention built by the bilingual population, and asymptotically stable in the associated one-population Replicator Dynamics.

Proof: Note that the LCG has the strategic structure of a Hawk-Dove Game (with $s_1$ as Dove and $s_2$ as Hawk). Thus, it has three Bayesian Nash equilibria: the asymmetric (and unstable) equilibria $(s_2, s_1)$ and $(s_1, s_2)$, and the symmetric mixed strategy equilibrium $(x^*, 1-x^*) = (1 - \frac{c(1-\alpha)}{\alpha(m-n)}, \frac{c(1-\alpha)}{\alpha(m-n)})$, with $x^* \in (0, 1)$. To see that the latter equilibrium is evolutionary stable, see Weibull [35]. The associated single population Replicator Dynamics is as follows:

\[ \dot{x} = [\alpha(m-n)(1-x) - c(1-\alpha)]x(1-x) \]

Notice that in $x^*$, $\alpha(m-n)(1-x) - c(1-\alpha) = 0$ and so $\dot{x} = 0$. We can see that for any $0 < x < 1 - \frac{c(1-\alpha)}{\alpha(m-n)}$, $\dot{x}$ increases toward $x^*$, and for any $1 > x > 1 - \frac{c(1-\alpha)}{\alpha(m-n)}$, $\dot{x}$ decreases toward $x^*$.