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Article

A Model of Bajaw Economy

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1. Introduction

Bajaw, or Bajau, inhabiting the ocean area surrounded by Philippines, Indonesia, Brunei, and Malaysia, who seem to have migrated from those countries, live on the sea, differently from our normal life on land. They are engaged mainly in fishery and transportation as the means of life, and it seems that they are a peaceful tribe with their own cultural value. They have been studied mainly from the cultural point of view, by Sociology and Cultural Anthropology[1]. However, in spite of the importance of their economic activities such as trade, smuggling, migrations, poaching, etc., which seriously affect the surrounding countries, they seem to have been overlooked in Economics, presumably because they are beyond the ordinary viewpoint of the nation state[2]. Indeed, it seems that they live in a nation with their own law structure, which is overlapped with the surrounding coun-

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1) See, *e.g.*, Stacey, *et al.* (2018), Nagatsu (2012).

tries. This paper try to present a theoretical model of Bajaw in a general equilibrium framework of Economic Theory.

To do this, I construct a two period model in which two islands and an ocean exist. A certain number of individuals live in each island, and no one live in the ocean. In the first period, each individual of the two islands decides independently whether he/she migrates to the ocean or not. After their migrations are completed, in the second period, each individual in the two islands produces an island specific good. A part of the good produced in the first island is exported to the second island, and vice versa, through the transportation by people live in the ocean. The transportation requires a certain fraction of the good as transportation fee which is consumed by the ocean people. In each island, the domestic good and the imported good are exchanged through competitive markets.

The main results of the paper are as follows. First, The increase in population will cause the increase in the output and the population of the other country as a spillover effect through the migration. Second, the decrease in the transportation fee, which can be attributed to the development of maritime technology, will cause the increase in the output and the population of each of the two countries as well as the increase in everyone's welfare. These results seem to be contrary to conventional view of Economics, and to suggest the necessity of new policy implementations based on a new framework for analyzing such an economic region.

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2) See, *e.g.*, Smith (1776), Ljungqvist and Thomas J. Sargent (2018), for the traditional view.

This paper is organized as follows. In Section 2, a model is described and definitions of equilibrium are given. In the following section, the effects of exogenous variables on the equilibrium are considered. Finally, in Section 4, some remarks are given.

2. Model

Environment

Let us consider a two period economy in which two islands exist in a ocean. There are n_1 agents and n_2 agents in the first and the second island, respectively. At the beginning of the first period, no agent lives in the ocean. In the first period, m_1 agents move to the ocean from the first island. Also, m_2 agents move to the ocean from the second island. At the end of the first period, $n_1 - m_1$ agents and $n_2 - m_2$ agents live in the first and the second island, respectively, and the total of $m_1 + m_2$ agents live in the third island. For simplicity, I assume that $m_1 + m_2 > 0$, because the trade never occurs between the two islands if $m_1 + m_2 = 0$. In the second period, each of $n_1 - m_1$ agents living in the first island produces one unit of apple, and each of $n_2 - m_2$ agents living in the second island produces one unit of banana. Also, $m_1 + m_2$ agents living in the ocean become transporter of the two goods from the first island to the second island, and vice versa. The transportation from the first island to the second island requires θ units of apple ($\theta < 1$) per one unit of apple, which is consumed by the transporters. Similarly, for the transportation from the second island to the first island, θ units of banana per one unit of banana, which is also consumed by the transporters[3]. Every individual i in the economy has an identical Cobb-Douglas type utility function $u(x^i, y^i) = (x^i)^{\alpha}(y^i)^{\beta}$, where x^i and y^i are his/her consumption of apple and banana, respectively. Below I first consider people's actions in the second period, and then consider those in the first period assuming that people know what will happen in the second period.

Market

There are two markets, apple and banana, at the second period in each of the first and the second island. Let p be the price of banana in terms of apple in the first island. Also let q be the price of apple in terms of banana in the second island. Suppose someone exports one unit of apple from the first island to the second island. Then he can sell $1-\theta$ units of apple in the second island, and will get $q(1-\theta)$ units of banana. Bringing the banana back in the first island, he can sell $q(1-\theta)^2$ units of banana, and gets $pq(1-\theta)^2$ units of apple by selling it in the first island. If $pq(1-\theta)^2$ is greater than one, then he will get $pq(1-\theta)^2-1$ units of apple for free, so that he exports an infinite amount of apple and import an infinite amount of banana, by which the markets are not cleared. If $pq(1-\theta)^2$ is less than one, which means the red ink in the trade, then he does not trade. If $pq(1-\theta)^2$ is one, then the agent gets no profit or loss from the trade, so that he may or may not be engaged in the trade. Below I assume that $pq(1-\theta)^2 \leqq 1$, which I call the non-arbitrage condition, is satisfied in equilibrium for p, q, and θ.

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3) The transporters are assumed to behave competitively, so that their profits become nought under a constant marginal cost of transportation.

Utility Maximization

Each agent i in the first island, given one unit of apple as his initial endowment, is assumed to maximize his utility subject to the budget constraint, which is represented by

$$x^i + p\, y^i \leqq 1,$$

where x^i and y^i are his consumption of apple and banana, respectively. Note that under the non-arbitrage condition, the agent's budget constraint is not affected by whether he trades or not. Let x^{i*} and y^{i*} be the solution for the problem. Then he supplies $1-x^{i*}$ units of apple and demands y^{i*} units of banana. As for each agent j in the second island, given one unit of banana as his initial endowment, is also assumed to maximize his utility subject to the budget constraint, which is represented by

$$q\, x^j + y^j \leqq 1,$$

where x^j and y^j are his consumption of apple and banana, respectively. Let x^{j*} and y^{j*} be the solution of this problem. Then he supplies $1-y^{j*}$ units of banana and demands x^{j*} units of apple.

For those who live in the ocean, they consume certain fractions of traded goods which are determined by the markets in the first and the second island. Let X and Y be the amount of apple and banana, respectively, traded between the first and the second island. Then people in the ocean consume total of θX units of apple and θY units of banana. For simplicity, I assume that the people consume equally. That is, each individual s in the ocean consumes $\theta X/(m_1+m_2)$ units of apple and $\theta Y/(m_1+m_2)$ units of banana.

Market Clearing

Given p, let $X^S(p)$ and $Y^D(p)$ be the aggregate supply of apple and the aggregate demand for banana, respectively, in the first island. Since there are $n_1 - m_1$ agents in the first island, we have $X^S(p) = (n_1 - m_1)(1 - x^{i*})$ and $Y^D(p) = (n_1 - m_1)y^{i*}$. Also, given q, let $X^D(q)$ and $Y^S(q)$ be the aggregate demand for apple and the aggregate supply of banana, respectively, in the second island. Since there are $n_2 - m_2$ agents in the second island, we have $X^D(q) = (n_2 - m_2)x^{j*}$ and $Y^S(q) = (n_2 - m_2)(1 - y^{i*})$.

Case 1: $pq(1-\theta)^2 = 1$

Suppose $pq(1-\theta)^2 = 1$. Then the trades take place, and all the apples supplied in the market of the first island are exported to the second island with the depreciation rate of θ. Therefore the total amount of apple supplied in the second island is given by $(1-\theta)X^S(p)$. For the apple market in the second island, the market clearing condition is given by

$$(1-\theta)\ X^S(p) = X^D(q),$$

or, equivalently,

$$(1-\theta)(n_1 - m_1)(1 - x^{i*}) = (n_2 - m_2)x^{j*}.$$

Similarly, the total amount of banana supplied in the first island is given by $(1-\theta)Y^S(q)$. Therefore, the market clearing condition is given by

$$(1-\theta)Y^S(q) = Y^D(p),$$

or, equivalently,

$$(1-\theta)(n_2 - m_2)(1 - y^{i*}) = (n_1 - m_1)y^{i*}.$$

Case 2: $pq(1-\theta)^2 < 1$

Suppose $pq(1-\theta)^2 < 1$. Then no trade occurs, and all the apples produced in the first island are consumed in the first island. Therefore, the apple markets to be cleared, we have

$$X^S(p)=X^D(q)=0,$$

or, equivalently,

$$1-x^{i*}=x^{j*}=0.$$

Similarly, for the banana markets to be cleared, we have

$$Y^S(q)=Y^D(p)=0,$$

or, equivalently,

$$1-y^{i*}=y^{i*}=0.$$

Equilibrium

By using the above setup, I define a second-period equilibrium as follows.

Definition. Given n_1, n_2, m_1, m_2 and θ, a second-period equilibrium is prices, (p^*, q^*), and an allocation $(x^{i*}, x^{j*}, y^{i*}, y^{j*})$, that satisfy the following condition.

(i) if $p^*q^*(1-\theta)^2=1$, then

$$(1-\theta)(n_1-m_1)(1-x^{i*})=(n_2-m_2)x^{j*}$$

and $(1-\theta)(n_2-m_2)(1-y^{i*})=(n_1-m_1)y^{i*}$,

(ii) if $p^*q^*(1-\theta)^2<1$, then

$$1-x^{i*}=x^{j*}=0$$

and $1-y^{i*}=y^{i*}=0$.

Proposition 1. For given n n_1, n_2, m_1, m_2 and θ, there is a second-period equilibrium such that

$p^*=[k/(1-\theta)][(n_1-m_1)/(n_2-m_2)]$, $q^*=\{1/[k(1-\theta)]\}[(n_2-m_2)/(n_1-m_1)]$,

$x^{i*}=1/(1+k)$, $y^{i*}=[(n_2-m_2)/(n_1-m_1)](1-\theta)[1/(1+k)]$,

$$x^{j*}=[(n_1-m_1)/(n_2-m_2)](1-\theta)[k/(1+k)],\ y^{j*}=k/(1+k),$$

where $k=\beta/\alpha$.

Proof of Proposition 1. Trivial.

Note that each individual's utility level may be different each other in the above equilibrium. The utility level of each individual in the first island, $u(x^{i*}, y^{i*})$, that in the second island, $u(x^{j*}, y^{j*})$, and that in the ocean, $u(x^{s*}, y^{s*})$, are given, respectively, as follows.

$$u(x^{i*}, y^{i*})=[1/(1+k)]^{\alpha+\beta}\ \{[(n_2-m_2)/(n_1-m_1)](1-\theta)\}^{\beta},$$

$$u(x^{j*}, y^{j*})=\{[(n_1-m_1)/(n_2-m_2)]\ (1-\theta)\}^{\alpha}\ [k/(1+k)]^{\alpha+\beta},$$

and $u(x^{s*},\ y^{s*})=\theta^{\alpha+\beta}\{[(n_1-m_1)/(m_1+m_2)][k/(1+k)]\}^{\alpha}\ \{[(n_2-m_2)/(m_1+m_2)][1/(1+k)]\}^{\beta}$.

Migration

In the first period, each individual decides whether he/she migrates from the island where he/she lives to the ocean or not, based on the correct expectations on the second period and the other individuals' decisions on the migration, given all other people's decisions, whether he/she migrates to the ocean or not. Let us consider an individual i, who lives in the first island. Let m_1^{-1} and m_2 be the number of individuals other than individual i who decide to migrate to the ocean from the first island and from the second island, respectively. Given m_1^{-1} and m_2, if he/she decides to stay in the first island, then his utility is given by $u(x^{i*},\ y^{i*})=[1/(1+k)]^{\alpha+\beta}\{[(n_2-m_2)/(n_1-m_1^{-1}-1)](1-\theta)\}^{\beta}$. If he/she decides to migrate to the ocean, then his/her utility is given by $u(x^{s*}, y^{s*})=\theta^{\alpha+\beta}\{[(n_1-m_1^{-1}-1)/(m_1^{-1}+1+m_2)][k/(1+k)]\}^{\alpha}\ \{[(n_2-m_2)/(m_1^{-1}+1+m_2)]\ [1/(1+k)]\}^{\beta}$. He/she decides to stay if the former is greater than the latter, and to migrate if the former is less than the latter. If the former is equivalent to the latter, he/she is indifferent between "stay" and "migrate". In this case, for simplicity, I assume that he/she stays in the first island. We can see that the latter is greater than the former when m_1^{-1} and m_2 are relatively small compared with n_1 and n_2. According to the increase in m_1^{-1}, the former increases and the latter decreases, and for some sufficiently large m_1^{-1}, the former becomes greater than the latter.

As for an individual j who lives in the second island, let m_1 and m_2^{-1} be the number of individuals other than individual j who decide to migrate to the ocean from the first island and from the second island, respectively. Given m_1 and m_2^{-1}, if he/she decides to stay in the second island, then his utility is given by $u(x^{j*}, y^{j*}) = \{[(n_1 - m_1)/(n_2 - m_2^{-1} - 1)](1-\theta)\}^{\alpha}[k/(1+k)]^{\alpha+\beta}$. If he/she decides to migrate to the ocean, then his/her utility is given by $u(x^{s*}, y^{s*}) = \theta^{\alpha+\beta}\{[(n_1 - m_1)/(m_1 + m_2^{-1} + 1)][k/(1+k)]\}^{\alpha}\{[(n_2 - m_2^{-1} - 1)/(m_1 + m_2^{-1} + 1)][1/(1+k)]\}^{\beta}$. We can see a similar result to the first island concerning to his/her decision on migration.

By using the above results, I define a Nash equilibrium as follows.

Definition. Given the second period equilibrium, the first period equilibrium is a pair (m_1^*, m_2^*) that satisfy

(i) $[1/(1+k)]^{\alpha+\beta}\{[(n_2 - m_2^*)/(n_1 - m_1^*)](1-\theta)\}^{\beta}$
$< \theta^{\alpha+\beta}\{[(n_1 - m_1^*)/(m_1^* + m_2^*)][k/(1+k)]\}^{\alpha}\{[(n_2 - m_2^*)/(m_1^* + m_2^*)][1/(1+k)]\}^{\beta}$

(ii) $\theta^{\alpha+\beta}\{[(n_1 - m_1^* - 1)/(m_1^* + 1 + m_2^*)][k/(1+k)]\}^{\alpha}\{[(n_2 - m_2^*)/(m_1^* + 1 + m_2^*)][1/(1+k)]\}^{\beta}$
$\leqq [1/(1+k)]^{\alpha}\{[(n_2 - m_2^*)/(n_1 - m_1^* - 1)](1-\theta)[1/(1+k)]\}^{\beta}$

(iii) $\{[(n_1 - m_1^*)/(n_2 - m_2^*)](1-\theta)\}^{\alpha}[k/(1+k)]^{\alpha+\beta}$

$< \theta^{\alpha+\beta}\{[(n_1 - m_1^*)/(m_1^* + m_2^*)][k/(1+k)]\}^{\alpha}\{[(n_2 - m_2^*)/(m_1^* + m_2^*)][1/(1+k)]\}^{\beta}$

(iv) $\theta^{\alpha+\beta}\{[(n_1 - m_1^*)/(m_1^* + m_2^* + 1)][k/(1+k)]\}^{\alpha}\{[(n_2 - m_2^* - 1)/(m_1^* + m_2^* + 1)][1/(1+k)]\}^{\beta}$

$\leqq \{[(n_1 - m_1^*)/(n_2 - m_2^* - 1)](1-\theta)\}^{\alpha}[k/(1+k)]^{\alpha+\beta}$

Note that in the above definition, the utility level of each individual becomes approximately the same in the equilibrium, if it exists, when n_1 and n_2 are sufficiently large. Other words, the existence of the ocean people not only enhances the trade but also equalizes the utility levels of people in the whole economy.

Numerical Example

Let $\alpha = \beta = 1/2$, $n_1 = n_2 = 500$, and $\theta = 1/2$. Then the first period equilibrium is given by

$m_1^* = m_2^* = 131.$

By using these values, the second period equilibrium is given by

$p^* = q^* = 2,$

$x^{i*} = 1/2, \; y^{i*} = 1/4, \; x^{j*} = 1/4, \; y^{j*} = 1/2.$

As for the people in the ocean, in the second period equilibrium, the consumption level is given by

$x^{s*} = y^{s*} = 369/1048 \fallingdotseq 0.352.$

3. Effects of Exogenous Shocks

In this section, I consider the effects of exogenous shocks, namely, the change in population of one country, say, n_1, and the transaction of the trade, θ, on the economy described above. Below I assume, for simplicity, that $\alpha = \beta$. Also I assume that n_1 and n_2 are sufficiently large, so that $u(x^{i*}, y^{i*}) = u(x^{j*}, y^{j*}) = u(x^{s*}, y^{s*})$ holds in the first period equilibrium. Finally I assume the first period equilibrium, $(m_1{}^*, m_2{}^*)$, and the second period equilibrium, (p^*, q^*) and $(x^{i*}, x^{j*}, y^{i*}, y^{j*})$, exist.

Under these assumptions, it is easily shown that the equilibrium values satisfy the following conditions.

(i)　$n_1 - m_1{}^* = n_2 - m_2{}^*$

(ii)　$u(x^{i*}, y^{i*}) = u(x^{j*}, y^{j*}) = (1/2)^{2\alpha}(1-\theta)^{\alpha}$,

(iii)　$u(x^{s*}, y^{s*}) = \theta^{2\alpha}(1/2)^{2\alpha}\{[(n_1 - m_1{}^*)/(m_1{}^* + m_2{}^*)\}^{2\alpha}$.

Effects of Population Growth

Suppose the population of the first island, n_1, increases to n_1'. According to this change, let $(m_1{}^{*\prime}, m_2{}^{*\prime})$ be the new equilibrium. Then we have the following proposition.

Proposition 2. Suppose n_1, increases to n_1'. Then in the new equilibrium, $m_1{}^{*\prime} > m_1{}^*$, $m_2{}^{*\prime} < m_2{}^*$, $n_1' - m_1{}^{*\prime} > n_1 - m_1{}^*$, and $(n_1' - m_1{}^*)/(m_1{}^{*\prime} + m_2{}^{*\prime}) = (n_1 - m_1{}^*)/(m_1{}^* + m_2{}^*)$.

Proof of Proposition 2. Trivial.

The above proposition says that the increase in the population causes the increase in the migration from the first island to the ocean and the decrease in the migration from the second island to the ocean, and the total number of people in the ocean, $m_1{}^{*\prime} + m_2{}^{*\prime}$, increases. The population growth shock in the first island will let the people move from the first island to the ocean, and also let some of the ocean people move to the second island. Other words, shock in the first island is transmitted to the ocean and the second island through migration.

Note that the population increase implies the increase in output. As the population increases by $n_1' - n_1$, the production of apple can potentially increase by the same amount. However, because of migration, realized increase in output is given by $(n_1' - m_1^{*\prime}) - (n_1 - m_1^*)$. The amount of $m_1^{*\prime} - m_1^*$ is spilled over to the ocean through migration. This spillover also cause another spillover from the ocean to the second island, and the production of banana in the second island increases by $m_2^* - m_2^{*\prime}$.

Effects of Transaction Shock

Now suppose that the transportation cost, θ, decreases to θ''. According to this change, let $(m_1^{*\prime\prime}, m_2^{*\prime\prime})$ be the new equilibrium. Then we have the following proposition.

Proposition 3. Suppose θ, decreases to θ''. Then in the new equilibrium, $m_1^{*\prime\prime} < m_1^*$ and $m_2^{*\prime\prime} < m_2^*$.

Proof of Proposition 3. Trivial.

In Proposition 3, θ can be regarded to represent the speed or transport capacity of boat owned by the ocean people. The decrease in θ implies that the boat gets faster or that the boat loads more. To put it differently, the marine technology is developed as θ decreases. Therefore the proposition says that the development of the marine technology will cause the decrease in migrations.

The decrease in migrations also implies the increase in production on the two islands. The utility level of people increases as a result of the decrease in θ. Thus, even if it seems irrelevant to the production, the marine technology development supports indirectly the production growth of each country.

４．Concluding Remarks

This paper has been considered Bajaw from the viewpoint of transportation and migration. Differently from traditional Economic theory, Bajaw people play not only the role of transporter but also that of shock absorber through migrations (see, e.g., Krugman *et al.* (2018) for traditional Economic theory). This seems to suggest that the research on such ocean people can introduce a new aspect of international cooperation on the economic growth. Also, it might be the case that the settlement policy for Bajaw people could weaken the economic sustainability of the surrounding countries. Finally, the specification of Bajaw people in this paper is not sufficient. Their another aspects such as fishery, smuggling, migrations, poaching, etc., should be done in the future.

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Summary

A Model of Bajaw Economy

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Bajaw, Ocean people emigrated mainly from Philippines, Indonesia, and Malaysia, and engaged in trade among those countries, have been studied in Sociology or Cultural Anthropology（*e.g.*, Stacy *et al.*（2018））, but not in Economics, in spite of the importance of their economic activities such as trade, smuggling, migrations, poaching, etc., that seriously affect the surrounding countries. This paper presents a theoretical model of Bajaw in a general equilibrium framework of Economic Theory. The model consists of two countries and one ocean tribe, in which two country-specific goods exist. The ocean people are emigrated from the two countries, and engaged in trade between the two countries, through collecting transportation fee. The main results are as follows. First, The increase in population and output will cause the decrease in the output and the population of the other country. Second, the increase in the transportation fee will cause the decrease in the output and the population of each of the two countries as well as the decrease in everyone's welfare. These results seem to be contrary to conventional view of Economics, and to suggest the necessity of new policy implementations based on a new framework for analyzing such an economic region.

Keywords: Bajaw, Economics, migration, trade, Equilibrium