Illegal Immigration with Tariff Distortions

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Abstract

We develop a general equilibrium two-country model in which a home and a foreign countries trade many final goods, and legal immigration is restricted. International trade is distorted via tariffs imposed by both countries. Foreign migrants attempt illegally entry to the home country but face a probability of detection and arrest by border patrol of the home country. We focus on the relationship of commodity trade with illegal immigration. We examine how stricter border patrol affects the level of illegal immigration and trade. We establish conditions under which stricter border patrol and remittances from the host country reduce successful illegal immigration, and determine the welfare implications of these policy changes.

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**Keywords:** Illegal immigration, tariff policy, border patrol.

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1 Introduction

The European Union (EU) in 2007 is composed of 27 independent sovereign nations which are known as member states. EU forms a single market within which there are free circulations of goods, services, informations, capital and labor. EU as a customs union has tried to conclude preferential trade agreements (PTAs) with non-member countries given a common external tariff, for picking up one of PTAs in EU, the PTAs which were proposed between EU and the Mediterranean countries are aimed at combating non-trade issues such as illegal immigration, drugs et cetera. It is well known that 'There is also a very strong element of cooperation between members in non-trade policies, particularly in issues with regional spillover such as immigration, environment, development of poorer regions, foreign policy, and judicial matters' (Karacaovali and Limao (2008)). Broeders (2007) then showed that 'In European Union policy documents, figures of an annual inflow of 400,000–500,000 and an EU ‘stock’ of around 3 million irregular migrants are often noted, but exact numbers are unknown’, which is a central topic to this paper.

Considering the characteristics mentioned above in EU as a customs union, we might notice that a common tariff in EU causes a decrease in imports from outside EU, and hence a rise in illegal immigration mainly from the Mediterranean regions, if we suppose trades in commodities and factors are substitutes, invoking Mundell (1957). Therefore, given the common tariff-distorted trades in EU, trade and illegal immigration among trade partners could be substitutes. In other words, provided that there is a large income gap between EU and the Mediterranean countries, the common tariff would have prevented the distance in income from shrinking between them, which has produced illegal immigration between the two areas.

The facts in EU showed above motivate to introduce a two-country model of trade in goods and illegal immigration. We then model two small counties (North and South) and many traded goods to

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1The EU member countries in 2008 are as: Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

2We have had a lot of controversy on whether trade in commodities and factor movements are substitutes or complementaries between two countries as ; Purvis (1972), Markusen (1983), Svensson (1984), Markusen and Svensson (1985), Wong (1986) et cetera. However, observing the actual circumstances on trade in goods and illegal immigration between EU and outside EU, we might perceive the substitutability between trade in commodities and illegal immigration.
sketch illegal immigration between the two countries that trade each other with bilateral tariffs. Suppose North has superior production technologies to South, and the two countries impose bilateral tariffs, which yields factor-price inequalities between the countries where labor movements are disallowed. So, North is confronted with illegal immigrants who went beyond the border between North and South without being detected. A migration decision of them is generally characterized as a non risk-neutral behavior. We then examine how tighter border patrol by a host country (North) affects the number of illegal immigration from a source country, South, and welfare effects of a remittance by successful illegal migrant workers, given the tariff levels. As mentioned in Wong (1986), migrating workers would generally remit a portion of their earnings to the source country of illegal immigration.

Ethier (1986a, b) first introduced a one-small country model of illegal immigration in which a host country controls illegal immigration pressures, enforcing border patrol and employer sanctions. Consequently, there are many contributions of illegal immigration Bond and Chen (1987), Bandyopadhyay and Bandyopadhyay (1998), Djajic (1987, 1999), Gaytan-Fregoso and Lahiri (2000), Levine (1999), Friebel and Guriev (2006) and Guzman, Haslag and Orrenius (2008). Those previous contributions consistently assume risk-neutral behavior of a prospective illegal immigrant and a home firm against a host country’s immigration policies. Recently two papers, Friebel and Guriev (2006) and Guzman, Haslag and Orrenius (2008) focused upon the relationships between people-smugglers and attempted migrants. Friebel and Guriev (2006) introduced a two-country model of financial contract between a wealth-constrained migrants and intermediaries, recognizing the sociological evidence about the relation among them. They depicted the evidence surrounding illegal aliens in which these debt/labor contracts among them are enforced in the illegal sector of the host country than in the legal sector, but deportation policies by the host country cause them to have a difficulty in moving from the former to the latter, and hence few illegal migrants default on debt. Risks which intermediaries would bear are mitigated, which causes the intermediaries to be willing to finance the attempted illegal migrants. Hence, they conclude that stricter enforcement policies might not lessen but promote illegal immigration. Also, Guzman, Haslag and Orrenius (2008) showed a two-country, general equilibrium model in which a would-be migrant ille-

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3 See also Tapinos (2000) on six categories of clandestinity of unlawful aliens.
gally migrates into the host country in assistance with people smugglers, and then both work and save. They conclude that an enforcement technology by a host country’s government blurs, ceteris paribus, its efficiency with a smuggling technology, and successful migrant workers save a portion of their wages in the host country, from which capital stock in the host country is formed via savings. This paper suggests that the superior the smuggling technology is, the more the number of successful illegal migrants who pass through the frontier between the two countries is. Unlike those papers including recent ones, Woodland and Yoshida (2006) generalized behavior of an attempted illegal migrant to take non-neutral risk preferences into consideration when being faced with border control by making an attempt to cross the border between the two countries, using a two-country framework extended Ethier’s one small-country model.

As shown above, in case we model illegal immigration between two countries, we should not miss distorted trade in commodities which might provide some motives for attempted migrants, based upon the substitutability between trades in goods and factors. Those literatures have lack of commodity trade which is a key factor to yield illegal immigration. Nevertheless, some papers, Gaytan-Fregoso and Lahiri (2000, 2002) and Kahana and Lecker (2005) groped in each model of trade in goods and illegal immigration whose migration decision has no risky behavior against border controls for some policy proposals to lessen illegal immigration, e.g., a reduction in bilateral tariffs, foreign aid and so on. Woodland and Yoshida (2007) modeled, at the same time, flows in commodities and illegal immigration between two countries where a non risk-neutral migration decision of a would-be migrant who goes across the frontier between a host country and a source country of illegal immigration was assumed, referring to Woodland and Yoshida (2006). They examined how a proportional reduction in bilateral tariffs would affect illegal immigration and the two countries’ welfare.

Hence, our two-country model of illegal immigration given the bilateral tariff levels will be presented, since an introduction of the bilateral tariffs prevents trade in goods between the countries, and hence promotes illegal immigration arrestable by an immigration department in the host country, assuming the substitutability between trade in commodities and labor in the countries. A migration decision of the attempted migrant is considered based on expected utility maximisation in a manner similar to...
Woodland and Yoshida (2006). Although our model shares a foundation stone with Woodland and Yoshida (2007), unlike this paper we will pay our attention to behavior of the attempted illegal occurred by the assumption of the substitutability given the bilateral tariffs. Hence, our model has not yet been constructed, looking back the previous researches on illegal immigration. We then examine how tougher border controls have influences upon illegal immigration and the welfare of two countries, and how remittances of successful illegal migrants do them.

2 The Model

2.1 Introduction

We introduce a model of illegal immigration in which there are two small countries (North and South) and many traded commodities. Assuming good 1 to be the numeraire, the world price vector is \((1, \pi)\).

We assume that legal immigration is disallowed but that there is illegal immigration from South to North due to higher wage rates in North, perhaps due to a superior technology or factor endowments. We further assume that the two countries impose import tariffs and that tariff revenues in each country are transferred to its legal residents in a lump-sum manner. The domestic prices for non-numeraire goods are denoted \(P = \pi + T\) and \(p = \pi + t\), where \(T\) and \(t\) are the specific tariff rates.

The representative legal resident of the host country, North, has expenditure function \(E(P, G, U)\), where \(P\) is the domestic price vector (for non-numeraire goods), \(G\) is the government public good supply and \(U\) is the level of utility. Illegal residents have expenditure function \(\tilde{e}(P, G, \tilde{u})\). The expenditure function for the residents of South is given by \(e(p, u)\). The expenditure functions have the properties that they are increasing, concave and linearly homogeneous in prices and increasing in utility levels. As is well known, the partial derivatives denoted by \(E_P(\cdot), -E_G(\cdot)\) and \(E_U(\cdot)\) are, respectively, the compensated demand functions for non-numeraire goods, the marginal willingness to pay for the government good and the marginal cost of utility (inverse of the marginal utility of income). Similar interpretations apply to the partial derivatives \(\tilde{e}_P(\cdot), -\tilde{e}_G(\cdot)\) and \(\tilde{e}_u(\cdot)\) of the expenditure function for illegal immigrants, and to the partial derivatives \(e_p(\cdot)\) and \(e_u(\cdot)\) of the expenditure function for South residents.
The technology in North is specified through the revenue function \( R(P, L, I) \), where \( L \) is the amount of home labour used and \( I \) is the number of illegal residents (and their labour supply). In South the revenue function is \( r(p, l) \), where \( l \) is the amount of home labour used. The revenue functions have the properties that they are increasing, convex and linearly homogeneous in prices and they are increasing, concave and linearly homogeneous in factor inputs.\(^4\) As is well known, the partial derivatives of the revenue function denoted by \( R_P(\cdot) \), \( R_L(\cdot) \) and \( R_I(\cdot) \) are, respectively, the (net) supply functions for non-numeraire goods, the wage rate for domestic labour and the wage rate for the labour of illegal immigrants in North. Similar interpretations apply to the partial derivatives \( r_p(\cdot) \) and \( r_l(\cdot) \) of the revenue function in South.

The North government employs labour to produce the public good and to patrol borders to detect illegal immigrants. These employments are denoted by \( L^G \) and \( L^B \) with total government employment being \( L^\theta = L^G + L^B \). The output of the public good is \( G(L^G) \), while the probability of detection of an illegal immigrant at the border is \( g(L^B) \). The detection probability function obeys the restrictions \( g' > 0, g'' < 0 \). This means that the employment of more labour resources in border patrol raises the probability of detection, but with decreasing marginal returns.

The number of citizens (legal residents) in North is \( \bar{L} \), while employment of citizens in the private sector is \( L = \bar{L} - (L^G + L^B) = \bar{L} - L^\theta \). In South, employment is \( l = \bar{l} - I \), where \( \bar{l} \) is the number of citizens.

Because it is assumed that residents of South have a lower standard of living than residents of North and legal immigration is not permitted, there is an incentive for residents of South to contemplate illegal immigration to North. If they remain in South their income, and hence their level of utility, \( u \), will be known with certainty. However, an attempt at illegal immigration entails the possibility that they will be detected at the border and deported. Accordingly, their expected utility depends upon the utility, \( \tilde{u} \), received upon successful migration, obtained with probability \( 1 - g \), and the utility, \( u - k \), they receive upon detection and deportation, which occurs with probability \( g \). If this expected utility exceeds the utility obtained from staying in South, residents of South will attempt to migrate illegally. This attempt will reduce the expected gain. Equilibrium will be established when the expected gain in utility from

\(^4\)It is assumed that the factor inputs include capital but, since capital is not changed in the analysis, reference to capital inputs is subsumed.
illegal immigration is zero; at the margin South residents will be indifferent as to whether to attempt
migration or not. Accordingly, in equilibrium the indifference condition $(1 - g(L^B)) \bar{u} + g(L^B) (u - k) = u$
will be satisfied.

2.2 Model Specification

The model comprises the budget constraints for the legal residents of North and of South, the budget
constraint of illegal immigrants from South residing in North, and the equilibrium condition for the illegal
immigration decision. The endogenous variables are the utility levels for the three types of individuals
and the level of successful illegal immigration. The model may be expressed as

\[ R(P, \overline{L} - L^0, I) - IR_I(P, \overline{L} - L^0, I) + T' M - E(P, G(L^G), U) \overline{L} = 0 \]  

\[ (1 - \alpha) R_I(P, \overline{L} - L^0, I) - e(P, G(L^G), \bar{u}) = 0 \]  

\[ r(p, \overline{I} - I) + \alpha IR_I(P, \overline{L} - L^0, I) + t' m - e(p, u) (\overline{I} - I) = 0 \]  

\[ (1 - g(L^B)) \bar{u} + g(L^B) (u - k) = u, \]

where $P = \pi + T$, $p = \pi + t$, $R_L = R_L(P, \overline{L} - L^0, I)$ and import vectors $M$ and $m$ are given by

\[ M = \overline{L} E_P + I \bar{e}_P - R_P \]  

\[ m = (\overline{I} - I) v_p - r_p. \]

These four equations (substituting out imports) determine the four endogenous variables $U$, $u$, $\bar{u}$ and $I$.
The exogenously given policy parameters of interest are $L^B$, $\alpha$, $T$ and $t$.

The first equation describes the budget constraint of the citizens of North. The sum of the first two
terms is the income of the citizens of North, comprising revenue from the production sector minus the
payments to illegal immigrants. The third term is the tariff revenue, which is distributed to citizens as
a lump sum payment. The final term is total expenditure. Thus, the first equation states that total
expenditure by the citizens of North equals income plus net tariff revenue distributed in lump-sum form.
The second equation equates expenditure by a representative illegal immigrant to the wage earned from employment minus remittances sent back to South. The third equation states that total expenditure by the residents of South comprises revenue from the production sector plus remittances received from illegal immigrants in North plus the net tariff revenue accruing to the government and distributed in a lump-sum form to residents. The final equation requires that the expected utility for a prospective illegal immigrant is equal to the certain utility attained by remaining in South and so is the equilibrium condition for illegal immigration as explained by Woodland and Yoshida (2006).

It is instructive and useful to note that the last equilibrium condition may be re-written as

\[ \tilde{u} = u + hk, \]  

where \( h \equiv g/(1 - g) \) is the odds of being caught at the border in the attempt at illegally immigrating. This states that the utility level obtained upon successful immigration, \( \tilde{u} \), is to be greater than the utility attained by not attempting illegal immigration, \( u \), by the amount \( hk \). An increase in the odds of being caught and/or the penalty \( k \) will make this required utility wedge larger.

\textsuperscript{5}The equilibrium condition for the North citizens may, alternatively, be expressed as

\[ R(P, \bar{L} - L^g, I) - IR_1(P, \bar{L} - L^g, I) + R_L L^g + BS - E(P, G(L^G), U) \bar{L} = 0, \]

where \( BS \) is the government’s budget surplus. The sum of the first three terms is the income of the citizens of North, comprising revenue from the production sector minus the payments to illegal immigrants plus earnings of public servants. The fourth term is the government net budget surplus assumed to be distributed to citizens as a lump-sum payment. The budget surplus is, in turn, determined as \( BS = T^m - R_L L^g \), equal to the net tariff revenue minus the cost of paying government employees. Using this equality, we can simplify the first equilibrium condition and so rewrite the system of equilibrium conditions as in the text.
2.3 Equilibrium Conditions

The equilibrium conditions (suppressing mention of $G$ in the first two, since it remains fixed) may be re-written as

\begin{align*}
E(P,U) &= Y \equiv [R(P,L,I) - IR_I(P,L,I) + T'M] / \bar{L} \\
\tilde{c}(P,\tilde{u}) &= \tilde{y} \equiv (1 - \alpha)R_I(P,L,I) \\
\epsilon(p,u) &= y \equiv [r(p,l) + \alpha IR_I(P,L,I) + t'm] / l \\
\tilde{u} &= u + hk, 
\end{align*}

where it is recalled that $P = \pi + T$, $p = \pi + t$, $L = \bar{L} - L^0$ and $l = \bar{l} - I$, and that $M$ and $m$ are given by (5)and (6), and $h \equiv g/(1 - g)$.

The first three equations determine the utility levels of the three agents and therefore may be used to obtain the three indirect utility functions expressed in terms of the prices they face and their incomes $Y$, $\tilde{y}$ and $y$. These three indirect utility functions are denoted as $V(P,Y), \tilde{v}(P,\tilde{y})$ and $v(p,y)$.

2.4 Comparative Statics Equations

Now consider the model expressed in equations (8)-(11) in which each country imposes tariffs on its trade. The complications of having tariffs in the model are three-fold. First, domestic prices are affected by tariffs. Second, income depends upon the tariff revenue generated and returned to legal residents in lump sum form. Third, the policy instruments available to governments include the tariff vectors. A particular complication is that imports depend on utilities and, especially, the imports of North depend upon the utilities of legal and illegal residents. Each of these complications has to be taken into account in computing the comparative statics solutions.

The comparative statics equations may be obtained as follows. Differentiating equations (8)-(11), we
get that

\[ \overline{\text{LE}}_U dU + \overline{\text{LE}}'_P dT = -IR_{II} dI - (R_L - IR_{II}) dL^B + (R'_P - IR_{IP}) dT + M' dT + T' dM \quad (12) \]

\[ \tilde{e}_u d\tilde{u} + \tilde{e}'_P dT = (1 - \alpha) R_{II} dI - (1 - \alpha) R_{II} dL^B - R_I d\alpha + (1 - \alpha) R_{IP} dT \quad (13) \]

\[ le_u du + le'_P dt - e dI = \left[ -r_l + \alpha(R_l + IR_{II}) \right] dI - \alpha IR_{II} dL^B + IR_I d\alpha + r'_P dt + \alpha IR_{IP} dT \]

\[ + m' dt + \ell' dm \]

\[ d\tilde{u} = du + \lambda dL^B, \quad (14) \]

where the changes in imports are

\[ dM = (\overline{\text{LE}}_{PP} + \overline{\text{LE}}_{PP} - R_{PP}) dT + \overline{\text{LE}}_{PU} dU + I\tilde{e}_P d\tilde{u} + (\tilde{e}_P - R_{PI}) dI + R_{PL} dL^B \]

\[ = S_{PP} dT + \overline{\text{LE}}_{PU} dU + I\tilde{e}_P d\tilde{u} + (\tilde{e}_P - R_{PI}) dI + R_{PL} dL^B \quad (16) \]

\[ dm = (le_{PP} - r_{PP}) dt + le_{PU} du + (r_{PL} - e_P) dI \]

\[ = s_{PP} dt + le_{PU} du + (r_{PL} - e_P) dI, \quad (17) \]

where

\[ S_{PP} = \overline{\text{LE}}_{PP} + I\tilde{e}_{PP} - R_{PP} \quad (18) \]

\[ s_{PP} = le_{PP} - r_{PP} \quad (19) \]

are the net substitution matrices in North and South, and where \( \lambda = kg'/(1 - g)^2 > 0. \)
Using all these equations, the comparative statics equations may be re-expressed as

$$L(E_U - T'EP_U) dU = -[IR_{II} + T'(R_{PI} - \tilde{c}_P)] dI - (R_L - T'R_{PL}) dL_B$$

$$+ [T'S_{PP} + I\tilde{c}_P'] dT + IT'\tilde{c}_P'_{pu} d\tilde{u}$$

(20)

$$\tilde{c}_u d\tilde{u} = (1 - \alpha)R_{II} dI - (1 - \alpha)R_{II} dL_B - R_I d\alpha + [(1 - \alpha)R_{IP} - \tilde{c}_P'] dT$$

(21)

$$l(e_u - t'c_{pu}) du = [e - r_l + \alpha(R_l + IR_{II}) + t'(r_{pl} - e_p)] dI - \alpha I R_{II} dL_B + IR_I d\alpha$$

$$+ t's_{pu} dt + \alpha IR_{IP} dT$$

(22)

$$d\tilde{u} = du + \lambda dL_B.$$  

(23)

Combining the first two rows of the comparative statics equations, we can obtain the “reduced form” for the utility change for North’s legal residents, and further re-express the equilibrium conditions as

$$L\hat{E}_U dU = [IT'\tilde{c}_y(1 - \alpha)R_{II} + T'(\tilde{c}_P - R_{PI}) - IR_{II}] dI$$

$$+ [T'R_{PL} - (R_L - IR_{II}) - IT'\tilde{c}_y(1 - \alpha)R_{II}] dL_B$$

$$+ [T'S_{PP} + IT'\tilde{c}_y(1 - \alpha)R_{IP} + IR_{II}] dT - IT'\tilde{c}_y R_I d\alpha$$

(24)

$$\tilde{c}_u d\tilde{u} = (1 - \alpha)R_{II} dI - (1 - \alpha)R_{II} dL_B - R_I d\alpha + [(1 - \alpha)R_{IP} - \tilde{c}_P'] dT$$

(25)

$$\hat{l}\tilde{c}_u du = [e - r_l + \alpha(R_l + IR_{II}) + t'(r_{pl} - e_p)] dI - \alpha I R_{II} dL_B + IR_I d\alpha$$

$$+ t's_{pu} dt + \alpha IR_{IP} dT$$

(26)

$$d\tilde{u} = du + \lambda dL_B.$$  

(27)

where $\tilde{c}_y = (\tilde{c}_{pu} / \tilde{c}_u)$ is the income effect on consumption for an illegal immigrant and where $\tilde{c}_u \equiv e_u - t'e_{pu} > 0$ and $\hat{E}_U \equiv E_U - T'EP_U > 0$ under Hatta normality. Alternative expressions for these Hatta normality terms are provided by $\tilde{c}_u \equiv e_u(1 - t'e_{pu}/e_u) = e_u(1 - t'c_y)$ and $\hat{E}_U \equiv E_U (1 - T'EP_U/E_U) = E_U (1 - T'C_Y)$, where $c_y = \epsilon_{pu}/e_u$ and $C_Y = E_{pu}/E_U$ are the income effects on consumption for foreign and home residents respectively.
The final comparative statics equation, using the others, becomes

\[0 = d\bar{u} - du - \lambda dL^B\]

\[= \{\bar{c}_u^{-1}(1 - \alpha)R_{II} - l^{-1}\bar{c}_u^{-1}[e - ri + \alpha(R_I + IR_{II}) + t'(r_{pl} - e_p)]\} dI\]

\[= \{\lambda + \bar{c}_u^{-1}(1 - \alpha)R_{II} - l^{-1}\bar{c}_u^{-1}\alpha IR_{II}\} dL^B - \{\bar{c}_u^{-1}R_i + l^{-1}\bar{c}_u^{-1}IR_{I}\} d\alpha\]

\[+ \{\bar{c}_u^{-1}[(1 - \alpha)R_{IP} - \bar{c}_p'] - l^{-1}\bar{c}_u^{-1}\alpha IR_{IP}\} dT - l^{-1}\bar{c}_u^{-1}t's_{pp} dt\]

\[= C_I dI + C_B dL^B + C_A d\alpha + C_T dT + C_t dt, \quad (28)\]

where

\[C_I = \bar{c}_u^{-1}(1 - \alpha)R_{II} - l^{-1}\bar{c}_u^{-1}H \quad (29)\]

\[C_B = -\{\lambda + \bar{c}_u^{-1}(1 - \alpha) - l^{-1}\bar{c}_u^{-1}\alpha I\} R_{II} \quad (30)\]

\[C_A = -\{\bar{c}_u^{-1} + l^{-1}I\} R_I < 0 \quad (31)\]

\[C_T = \bar{c}_u^{-1}[(1 - \alpha)R_{IP} - \bar{c}_p'] - l^{-1}\bar{c}_u^{-1}\alpha IR_{IP} \quad (32)\]

\[C_t = -l^{-1}\bar{c}_u^{-1}t's_{pp} \quad (33)\]

and \(H = e - r_i + \alpha(R_I + IR_{II}) + t'(r_{pl} - e_p)\). The solution for the change in illegal immigration, obtained from (28), is

\[dI = -C_I^{-1} [C_B dL^B + C_A d\alpha + C_T dT + C_t dt]. \quad (34)\]

Once this solution is obtained, the solution for the remaining endogenous variables (changes in utility levels) can be obtained by substituting this solution into the other comparative statics equations and evaluating the right hand sides.

The sign of \(C_A\) in (31) is unconditional. However, the signs of the other coefficients appear ambiguous in general. To help resolve some of the coefficient signs, we make some further assumptions. First, in Appendix A it is shown that a sufficient condition for Hicksian stability of the model is that \(C_I < 0\) provided that Hatta normality is a maintained hypothesis. Second, it is also shown the Appendix A that a sufficient condition for \(C_I < 0\) is that \(H > 0\). Thus, the condition \(H > 0\) is, under Hatta normality,
sufficient to guarantee Hicksian stability. Accordingly, we will henceforth assume that

\[ H \equiv e - r_l + \alpha(R_l + IR_I) + l'(r_{pl} - c_p) > 0. \]  

(35)

This sign restriction will be referred to as Condition A.

In the following, the sign of \( R_{II} = \partial R_I / \partial L = \partial R_L / \partial I \) will play an important role. In general, this term can be of either sign and so we will sometimes invoke one of two sign conditions. These are (i) Condition B that \( R_{II} < 0 \), and (ii) Condition \( B' \) that \( R_{II} > 0 \). Condition B is interpreted to mean that inputs of legal and illegal labour in North production are substitutes; an increase in \( L \) will raise the marginal product of \( I \), and vice versa. Condition \( B' \) means that the two inputs are complements in production.

Having set up the model equations and assumptions, we now proceed to determine the comparative statics properties of the model.

3 Effects of Tighter Border Patrol

Our first task is to consider the consequences of the government of North increasing the resources devoted to the detection of illegal immigrants at the border.

3.1 Effects on Illegal Immigration

Consider the effect of an exogenous change in the amount of labour, \( L^B \), North devotes to border patrols. From equation (34), it is clear that

\[ dI/dL^B = -C_I^{-1}C_B, \]

(36)

where \( C_I < 0 \) (assumed to ensure Hicksian stability, as noted above) but where the sign of \( C_B \) is ambiguous in general. That is, the sign of \( C_B \) cannot be determined without further conditions. It is noted that \( dI/dL^B \geq 0 \) according to whether \( C_B \geq 0 \). The normally expected result that \( dI/dL^B < 0 \) occurs if, and only if, \( C_B < 0 \). To aid the ensuing analysis, let \( C_B \) be written in a compact form as \( C_B = \{-\{\lambda + \gamma R_{II}\}, \) where \( \gamma \equiv \hat{c}_{u}^{-1}(1 - \alpha) - l^{-1}\hat{c}_{u}^{-1}\alpha I. \)
If there are no remittances \((\alpha = 0)\), then \(\gamma = \tilde{c}_u^{-1} > 0\). In this case, \(C_B\) is negative provided \(R_{IL} > 0\) (meaning that legal and illegal labour are substitutes in production) since \(\lambda > 0\). Accordingly, in this case an increase in the labour resources devoted to border patrols leads to a decrease in the level of successful illegal immigration.

**Proposition 1:** Assume that there are no remittances back to South \((\alpha = 0)\) and that Conditions A \((H > 0)\) and B’ \((R_{IL} > 0)\) hold. Then a tighter border patrol reduces successful illegal immigration.

More generally, we observe that the sign of \(C_B\) depends crucially upon the signs of \(\gamma\) and \(R_{IL}\) since \(\lambda > 0\). Accordingly, we consider Condition C that

\[
\gamma \equiv \tilde{c}_u^{-1}(1 - \alpha) - \tilde{c}_u^{-1} H^{-1} = \tilde{c}_u^{-1} - \alpha(\tilde{c}_u^{-1} + \tilde{c}_u^{-1} H^{-1}) > 0. \tag{37}
\]

This is satisfied, for example, if \(\alpha = 0\) (as noted above). However, if \(\alpha\) is sufficiently large then it seems possible that Condition C might not be satisfied. To get further insight, \(\gamma\) (Condition C) may be rewritten as

\[
\gamma = \tilde{c}_u^{-1} [\tilde{c}_u/\tilde{c}_u - \beta](1 - \alpha) > 0, \text{ where } \beta \equiv \alpha I/(1 - \alpha)l. \tag{38}
\]

Under our normality assumptions, the inequality will be satisfied if, and only if, the expression is square parentheses is positive, that is, \(\tilde{c}_u/\tilde{c}_u = \tilde{c}_u^{-1}/\tilde{c}_u^{-1} = \partial \tilde{v}/\partial \tilde{y} / \partial v/\partial y > \beta \equiv \alpha I/(1 - \alpha)l\). This means that the marginal utility of income for illegal immigrants \((\partial \tilde{v}/\partial \tilde{y} = \tilde{c}_u^{-1}\) (adjusting for tariffs) is greater than a critical number \(\beta\) that depends on the remittance proportion \(\alpha\) and the ratio \(I/l\) of immigrants to those who stay in South. The term \(\beta = (\alpha I/l)/(1 - \alpha)\) is interpreted as the ratio of remittances received per South resident to the income retained per immigrant.

**Proposition 2:** Assume that Conditions A \((H > 0)\) and B’ \((R_{IL} > 0)\) hold. Then a tighter border patrol reduces successful illegal immigration provided that \(\partial \tilde{v}/\partial \tilde{y} / \partial v/\partial y = \tilde{c}_u/\tilde{c}_u > \beta \equiv \alpha I/(1 - \alpha)l\) (Condition C).

Alternatively, consider Condition C’ that \(\gamma < 0\). Again, \(C_B\) is negative provided now that \(R_{IL} < 0\) (meaning that legal and illegal labour are complements in production) since \(\lambda > 0\). Accordingly, in
this case an increase in the labour resources devoted to border patrols leads to a decrease in the level of successful illegal immigration.

**Proposition 3:** If Conditions A \((H > 0)\) and B \((R_{IL} < 0)\) hold, then a tighter border patrol may increase or decrease successful illegal immigration. Illegal immigration will decrease if \(\tilde{e}^{-1}_u/\tilde{e}^{-1}_u = \tilde{e}_u/\tilde{e}_u < \beta \equiv \alpha I/(1 - \alpha)l\) (Condition C').

When can \(C_B\) be positive, which is required to obtain the unexpected result that greater border protection leads to an increase in the level of successful illegal immigration? Clearly, the requirement is that \(\lambda + \gamma R_{IL} < 0\) and, since \(\lambda = kg/(1 - g)^2 > 0\), this requires \(\gamma R_{IL}\) to be sufficiently negative. It is necessary that \(\gamma\) and \(R_{IL}\) are of opposite sign: if \(\gamma < 0\) then \(R_{IL} > 0\) is required, and if \(\gamma > 0\) then \(R_{IL} < 0\) is required.

### 3.2 Effects on Welfare

Now consider the utility effects of a tighter border patrol. From the above comparative statics equations (24)-(27), we obtain that

\[
\mathbb{E} \frac{dU}{dL} = [T'(\tilde{e}_P - R_{PI}) - IR_{II} \{1 - (1 - \alpha)T''\tilde{c}_y\}] dI/dL + [T' R_{PI} - (R_L - IR_{IL} \{1 - (1 - \alpha)T''\tilde{c}_y\})]
\]

\[
\tilde{e}_u d\tilde{u}/dL = (1 - \alpha) [R_{II} dI/dL - R_{IL}]
\]

\[
l\tilde{e}_u du/dL = HdI/dL - \alpha IR_{IL}
\]

\[
d\tilde{u}/dL = du/dL + \lambda.
\]

Consider first the simplest case where there are no remittances and there is free trade. In this case, it is known from Proposition 1 above that \(dI/dL < 0\) when \(R_{IL} > 0\), while the first equation immediately above becomes

\[
\mathbb{E} \frac{dU}{dL} = -IR_{II} dI/dL - (R_L - IR_{IL}).
\]

The effect on utilities is as follows. It is clear from the above equations that the utility \(u\) of South residents declines; lower successful migration means more labour and hence lower wages in South and
this income drop reduces welfare. The utility level $U$ of North residents goes down due to the indirect effect that fewer illegal immigrants have on the net income accruing to residents and due to the direct effect of having fewer Northern workers in the private sector if $\partial (R - IR_I) / \partial L = R_L - IR_{IL} > 0$ (which means that an increase in legal resident labour raises its income). Additional resources devoted to border patrols have to be paid for and this reduces incomes. Indirectly, the reduction in illegal immigrants raises the wage rates illegal immigrants attract and this is an additional cost to citizens. Overall, unless the term $IR_{IL}$ is sufficiently positive, citizens of North suffer a loss of utility when there is a reduction in the level of illegal immigration arising from stricter border patrol. The utility level $\tilde{u}$ of illegal immigrants in North goes up under our assumptions because fewer successful immigrants means higher wages for the successful ones and down because fewer North resident workers (due to more being employed as border patrol workers) reduces the wage rate for illegal immigrants (since $R_{IL} > 0$). The outcome is ambiguous in general, but welfare will increase unless $R_{IL}$ is particularly large. These results may be summarized in the following proposition.

**Proposition 4:** Assume that there are no remittances, there is free trade, and Conditions A ($H > 0$) and B ($R_{IL} > 0$) hold. Then a tighter border patrol reduces welfare of legal residents in North, if $\partial (R - IR_I) / \partial L = R_L - IR_{IL} > 0$, and the welfare of the residents of South. The welfare of successful illegal immigrants will rise if $R_{IL}$ is sufficiently small.

Relaxing the assumption that $R_{IL} > 0$, the results become a little more complicated. Assume that tighter border patrols do reduce the level of successful illegal migration. Illegal immigrants now certainly gain in welfare, since they now get higher wages directly as a result of North taking more labour from the private sector to increase border patrols. However, South residents now get larger remittances from their non-resident countrymen and the previous loss in welfare is mitigated and may, potentially, yield a welfare gain. North citizens are unaffected by the relaxation of the technology assumption to allow $R_{IL} < 0$ and they still suffer a loss in welfare. These observations yield the following proposition.

**Proposition 5:** Assume that Conditions A ($H > 0$) and B ($R_{IL} < 0$) hold, there is free trade, and a tighter border patrol reduces successful illegal immigration. Then, a tighter border patrol reduces welfare of legal residents in North if $\partial (R - IR_I) / \partial L > 0$, and increases the welfare of successful illegal
immigrants. The effect on the welfare of the residents of South is ambiguous. Their welfare falls if $-\alpha IR_{IL}$ is sufficiently small.

If the assumption that Condition B ($R_{IL} < 0$) holds is relaxed in this proposition, an alternative wording results. In this case, the utility of North citizens falls if $\partial(R - IR_I)/\partial L = R_L - IR_{IL} > 0$, the utility of illegal immigrants rises if $R_{IL} < 0$ and the utility of South residents falls if either $\alpha = 0$ or $R_{IL} > 0$.

**Proposition 5a:** Assume that Condition A ($H > 0$) holds, there is free trade, and a tighter border patrol reduces successful illegal immigration. Then, a tighter border patrol reduces welfare of legal residents in North if $\partial(R - IR_I)/\partial L = R_L - IR_{IL} > 0$. It increases the welfare of successful illegal immigrants if Condition B ($R_{IL} < 0$) holds. It decreases the welfare of the residents of South if either $\alpha = 0$ or $R_{IL} > 0$.

Finally, we consider the welfare effects of tighter border patrol when the two countries impose import duties. To help the exposition, we continue to assume that stricter border patrol reduces the level of illegal immigration. This assumption relaxation only complicates the effect of tighter border patrol on the welfare level of North residents, since then

$$\vec{T}E UdU/dL^B = \left[T'(\vec{e}_P - R_{PL}) - IR_{IL} \{1 - (1 - \alpha)T'\vec{c}_y\}\right]dI/dL^B$$

$$+ \left[T'R_{PL} - (R_L - IR_{IL} \{1 - (1 - \alpha)T'\vec{c}_y\})\right].$$

If $T'\vec{c}_y > 0$, and we can assume that $1 - (1 - \alpha)T'\vec{c}_y > 0$, then the negative effect of reduced immigration is strengthened, because of less import duties due to lower consumption by illegal immigrants (income effect). Similarly, if $T'(\vec{e}_P - R_{PL}) > 0$ then the negative effect of reduced immigration is strengthened, because of less import duties due to fewer illegal immigrants (substitution effect). The last term (representing the direct effect of increased border patrol) in the above equation is also affected by tariffs. If $T'R_{PL} < 0$ and $R_{IL} \{1 - (1 - \alpha)T'\vec{c}_y\} > 0$, the direct negative tariff revenue effect of a reduction of North workers in the private sector upon welfare is also strengthened. Clearly, the signs of some of these terms are ambiguous in general without special assumption so the additional effects of tariffs can be to strengthen or weaken the previously determine welfare results.
4 Effects of More Generous Remittances

Consider the effect of an exogenous change in the proportion, $\alpha$, of an illegal immigrant’s income that is remitted back to South. From equation (34), it is clear that

$$dI/d\alpha = -C_A^{-1}C_A,$$  \hspace{1cm} (44)

where $C_A = -\{\tilde{e}_u^{-1} + \tilde{e}_u^{-1}l^{-1}I\} R_I < 0$ and $C_I < 0$ (as noted above). Thus, $dI/d\alpha < 0$, meaning that more generous remittances back to South residents reduces the incentive to illegally immigrate. Consequently, the level of successful immigration falls.

**Proposition 6:** Assume that Condition A ($H > 0$) holds. Then, more generous remittances from illegal immigrants to South residents (increase in $\alpha$) reduces successful illegal immigration.

The welfare effects of more generous remittances are as follows:

$$\mathcal{L}\mathcal{E}_d U/d\alpha = \left[T'(\tilde{e}_P - R_P) - IR_{II}\{1 - (1 - \alpha)T'y_{1}\}\right] dI/d\alpha - IT'y_{1}R_I$$  \hspace{1cm} (45)

$$\tilde{e}_u d\tilde{u}/d\alpha = (1 - \alpha)R_{II}dI/d\alpha - R_I$$  \hspace{1cm} (46)

$$l\tilde{e}_u d\tilde{u}/d\alpha = H dI/d\alpha + IR_I$$  \hspace{1cm} (47)

$$d\tilde{u}/d\alpha = du/d\alpha.$$  \hspace{1cm} (48)

Although the effect of more generous remittances upon illegal immigration is clear-cut, the welfare effects are ambiguous in general. It is seen from (46) and (47) that there are two opposing forces on the utility levels for citizens of South. The direct effects of more generous remittances are to reduce the welfare of illegal immigrants and to raise welfare of residents in South, but the indirect effects due to lower illegal migration are of the opposite signs. Fewer illegal immigrants mean higher wages for illegal immigrants but lower wages for South residents. Thus, it is not clear whether citizens of South (resident in South or North) gain or lose in welfare, but both lose or gain equally from (48).

If North is a free trader, the indirect effect on North citizens is to lower welfare. However, if North imposes tariffs on imports then the income of North citizens will depend upon what happens to tariff
revenue (which becomes income when distributed). The direct effect of more generous remittances is for illegal immigrants to spend less on commodities and this will reduce tariff revenue. On the other hand, fewer illegal immigrants mean higher wages for immigrants and this will raise spending on commodities, raising tariff revenue. The change in the number of immigrants may also change net imports and so affect the level of tariff revenue. In short, these effects do not go in the same direction and so citizens of North may experience higher or lower welfare in general.

5 Conclusions

The issue of illegal immigration and the appropriate policy response by source and destination countries is of vital interest. In this paper, we have investigated the role of various government policies in the determination of the level of illegal immigration and have also examined the welfare implications of these policies. In addition to the policy of the host country devoting more resources to border patrols, we have also considered the use of tariff reform as an indirect policy measure. More specifically, we have been concerned with the interaction between tariff distortions to trade, their reform and illegal immigration. This investigation has been undertaken in a general equilibrium model in which prospective illegal immigrants choose whether to attempt the broach of a border on the basis of expected utility maximization in the face of a probability of detection and deportation.

Our results concerning the effects of stricter border patrol are much clearer when there are no remittances and there is free trade. The relaxation of these two assumptions creates complications by adding dependencies between the budget constraints of the agents. Remittances clearly connect the budget constraints of the citizens of South, since the illegal immigrants reduce their disposable income and remit this reduction to residents of South; one thereby suffers a loss in welfare while the other benefits. The budget constraints of North citizens and the illegal immigrants are inter-connected, since the latter contribute to production but also extract income. Tariffs imposed by North further complicate this inter-dependency. The illegal immigrants contribute to tariff revenue through consumption and production. For example, their consumption of goods attracts import duties through import, while their contribution to production of dutiable goods reduces tariff revenue. As a result, the role of illegal immigrants in production and
consumption affects tariff revenue, which is distributed to North citizens. This complicates the effect of border patrol policy and also the effect of tariff reform, especially upon welfare of North citizens. Our paper highlights these effects.

**Appendix A: Stability**

In this appendix, we specify a dynamic adjustment model and derive the Hicksian stability conditions that are used in the text of the paper.

We consider the adjustment procedure

\[
\begin{align*}
\dot{U} &= \beta_1 \left[ R(P, \bar{L} - L^0, I) - IR_1(P, \bar{L} - L^0, I) + T'M - E(P, G(L^G), U) \right] \\
\dot{\bar{u}} &= \beta_2 \left[ (1 - \alpha) R_1(P, \bar{L} - L^0, I) - e(P, G(L^G), \bar{u}) \right] \\
\dot{u} &= \beta_3 \left[ r(p, \bar{l} - I) + \alpha IR_1(P, \bar{L} - L^0, I) + t'm - e(p, u) (\bar{l} - I) \right] \\
\dot{I} &= \beta_4 [\bar{u} - \bar{h}k - u],
\end{align*}
\]

where a dot over variables denotes the time derivative and the positive constants \( \beta_i \) (\( i = 1, \ldots, 4 \)) are the speeds of adjustment. The assumed adjustment mechanism implies that utilities will rise if income exceeds expenditure and that the level of illegal immigration with rise if the expected utility from attempted immigration exceeds the utility level obtained from not making the attempt.

Linearization of these differential equations around the equilibrium gives

\[
\begin{bmatrix}
\dot{U} \\
\dot{\bar{u}} \\
\dot{u} \\
\dot{I}
\end{bmatrix} =
\begin{bmatrix}
-\beta_1 \mathcal{L}(E_U - T'EP_U) & \beta_1 IT'P_{pu} & 0 & -\beta_1 [IR_{1U} + T'(R_{P1} - \bar{e}P)] \\
0 & -\beta_2 \bar{e}_u & 0 & \beta_2(1 - \alpha)R_{1U} \\
0 & 0 & -\beta_3 I(e_u - t'e_{pu}) & \beta_3 H \\
0 & \beta_4 & -\beta_4 & 0
\end{bmatrix}
\begin{bmatrix}
dU \\
d\bar{u} \\
du \\
dI
\end{bmatrix}
\]

where

\[
H = e - r_l + \alpha (R_l + IR_{1U}) + t'(r_{pl} - e_p).
\]

Let the coefficient matrix be denoted by \( J \), and the \( i \)th principal minor by \( J_i \). If \( J \) is a totally stable
matrix, then $J$ is a Hicksian matrix. This implies that (i) every principal minor of $J$ of even order is positive and (ii) every principal minor of $J$ of odd order is negative. Thus, the Hicksian sufficient stability conditions are that

\[
\begin{align*}
J_1 &= -\beta_1 \bar{T}(E_U - T'E_{PU}) < 0 \\
J_2 &= \beta_1 \beta_2 \bar{T}(E_U - T'E_{PU})\hat{e}_u - \beta_2 J_1 \hat{e}_u > 0 \\
J_3 &= -\beta_1 \beta_2 \beta_3 \bar{T}(E_U - T'E_{PU})\hat{e}_u l(e_u - t'e_{pu}) = -\beta_3 J_2 \hat{e}_u l(e_u - t'e_{pu}) < 0 \\
J_4 &= \beta_1 \beta_2 \beta_3 \beta_4 \bar{T}(E_U - T'E_{PU})K = -\beta_2 \beta_3 \beta_4 J_1 K > 0,
\end{align*}
\]

where

\[
K = \hat{e}_u H - l(e_u - t'e_{pu})(1 - \alpha)R_{II}.
\]

We find that

\[
\begin{align*}
E_U - T'E_{PU} &= E_U (1 - T'E_{PU}/E_U) = E_U (1 - T'CY) > 0 \\
e_u - t'e_{pu} &= e_u (1 - t'e_{pu}/e_u) = e_u (1 - t'c_y) > 0,
\end{align*}
\]

where $CY = E_{PU}/E_U$ and $c_y = e_{pu}/e_u$ are vectors of the income derivatives of the Marshallian demand functions for non-numeraire goods and the positive signs are the Hatta (1977) normality (or stability) conditions. Thus, the sign conditions on $J_1, J_2$ and $J_3$ for stability are automatically satisfied if Hatta normality is assumed. Stability condition $J_4 > 0$ will hold (under Hatta normality) if

\[
K = \hat{e}_u H - l e_u (1 - t'c_y)(1 - \alpha)R_{II} > 0.
\]

It is readily shown that $C_I$ appearing in the text of the paper is related to $K$ by the equation $C_I \hat{e}_u e_u (1 - t'c_y) + K = 0$. Thus, the sufficiency condition $K > 0$ may be equivalently expressed as $C_I < 0$. Finally, it is noted that a sufficient, but not necessary, condition for $K > 0$ $(C_I < 0)$ is that $H > 0$.

**Alternative approach to stability.** Assume that the utility budget constraints adjust instantan-
neously, but that the response of illegal immigration to differences in expected utilities is not instantaneous. Then, the adjustment model is

\[ \dot{I} = \beta_4 \left[ \tilde{u} - h \tilde{k} - u \right], \]

where the utility levels are determined by the three budget constraints. The differential approximation is given by

\[ \dot{I} = \beta_4 C_I dI \]

and the stability condition is that \( \beta_4 C_I < 0 \) or, equivalently, that \( C_I < 0 \).

References


