Should Countries Worry About Immiserizing Growth?

by

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Abstract

In the presence of tariff protection, Johnson (1967) showed that factor accumulation in a two-good, two-factor model could reduce a country's real income if it is biased sufficiently toward production of the tariff-protected good. This paper examines the exact conditions under which immiserization could occur in models with more than two goods or factors. In general, adding more goods beyond two seems to reduce the likely of immiserizing growth. This paper also examines how a country's tariff structure affects the likelihood that it would suffer immiserization. In general, immiserization is more likely the further apart, i.e. the greater the degree of tariff dispersion. This result provides an additional rationale for adopting a uniform tariff structure.

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I. Introduction

International trade theory has pointed out at least two situations under which factor accumulation or technical progress could reduce a country's real income. The first, attributed to Bhagwati (1958), occurs when factor accumulation is biased toward a country's export sector. This will deteriorate the country's terms of trade; if this effect is sufficiently large, then factor accumulation could reduce welfare. The second situation, attributed to Johnson (1967), occurs when factor accumulation takes place in the presence of tariff protection at unchanged terms of trade. Johnson showed that if the factor accumulation is biased sufficiently toward the tariff-protected sector, it could indeed reduce real income.

Until now, the exact conditions that need to be satisfied in order for Johnson-type immiserization to occur have not been well known. There have been a few papers in the literature that examined the conditions under which Johnson-type immiserization would occur, but they relied on specific cases and model structures. For example, in the context of the standard two-good, two-factor model of international trade in which all factors of production are intersectorally mobile, Bertrand and Flatters (1971) and Martin (1977) derived the conditions for immiserization if the import good is capital intensive, however, their analysis did not extend beyond two goods. In the context of the specific factors' model, Miyagiwa (1993) analyzed the condition for immiserization with two goods and three factors and concluded that if the tariff rate exceeds the capital-ratio in the import sector, the economy *may* suffer immiserization. The results derived in this paper show that it is possible to be more precise about the conditions necessary for immiserization.

This paper presents exact conditions that must be satified in order for factor accumulation to immiserize a country in the presence of protection. In particular, the conditions presented below apply regardless of the number of goods, factors, or tariff-protected goods. The results show that the addition of more than one tariff-protected good in the specific factors' model reduces the likelihood that a given pattern of factor accumulation could leave a country worse off. The results also show that a given increase in the supply of a factor of production will be more likely to reduce welfare, or "immiserize" the recipient country: (i) the smaller the growing factor's share in national income; and (ii) the larger the share of total output attributable to the tariff-protected sectors. The final section of the paper reports how increases the supplies of factors of production would affect real income for twenty countries, using simulation techniques.

This paper also examines how a country's tariff structure affects the likelihood that it might suffer immiserizing growth. It turns out that in the context of the specific factors' model, immiserization is more likely the greater the degree of tariff dispersion. Thus, a more uniform tariff structure would reduce the likelihood that it would suffer immiserizing growth, in the sense of Johnson. There is a literature that has argued that there are benefits from adopting a uniform tariff structure on political economy grounds (see for example Balassa (1989 and Harberger (1990))[2], so the results from this paper provide additional reasons why it may be beneficial for countries to move toward a more uniform tariff structure.

[2] These arguments are refuted to some degree by Panagariya and Rodrik (1993).

II. The Model

This section presents the conditions under which factor accumulation could immiserize a country in the presence of protection. Suppose there is one export good (denoted by E) and two imported goods (denoted by M1 and M2), each subject to an ad-valorem tariff (t_{Mj}). The framework easily generalizes to allow for *n* imported goods, but for simplicity, the section below will consider the case of two imported goods. The budget constraint for the economy is:

$$G(P_E, P_{M1}, P_{M2}, V) + t_1 P^*_{M1}(E_{M1} - G_{M1}) + t_2 P^*_{M2}(E_{M2} - G_{M2}) = E(P_E, P_{M1}, P_{M2}, U) \qquad (1)$$

where $G(P_E, P_{M1}, P_{M2}, V)$ is the economy's GDP function, $E(P_E, P_{M1}, P_{M2}, U)$ is the expenditure function, P_j and P^*_j are the domestic and world prices of good j respectively, V is the vector of the economy's factor endowments, and U is the consumer's utility level. A subscript next to the expenditure or GDP function represents partial differentiation with respect to that variable. The terms $t_1 P^*_{M1}(E_{M1} - G_{M1})$ and $t_2 P^*_{M2}(E_{M2} - G_{M2})$ measure tariff revenue on imports of good 1 and 2 respectively.

Totally differentiating (1) gives the welfare effect of a change in factor endowments, *dV:*

$$dU\left[E_U - t_1 P^*_{M1} E_{M1U} - t_2 P^*_{M2} E_{M2U}\right] = \left[G_V - t_1 P^*_{M1} G_{M1V} - t_2 P^*_{M2} G_{M2V}\right] dV \qquad (2).$$

Using equation (2), an increase in the endowment of factor *k* will lead to immiserization if:

$$\left[G_k - t_1 P^*_{M1} G_{M1k} - t_2 P^*_{M2} G_{M2k}\right] < 0 \qquad (3).$$

Using some basic duality results (see Dixit and Norman (1980) and Woodland (1982)), equation (3) can be written:

$$w_k < t_{M1} P^*_{M1} \frac{\partial X_{M1}}{\partial V_k} + t_{M2} P^*_{M2} \frac{\partial X_{M2}}{\partial V_k} \qquad (4)$$

where w_k is the return to factor k. Putting equation (4) into elasticity form gives:

$$1 < \frac{t_{M1}}{(1+t_{M1})} \eta_{M1k} \frac{\alpha_{M1}}{\beta_k} + \frac{t_{M2}}{(1+t_{M2})} \eta_{M2k} \frac{\alpha_{M2}}{\beta_k} \qquad (5)$$

where α_j is the share of sector j's output in national income, β_i is the share of factor i's income in national income, and η_{jk} are the elasticities of output j with respect to a change in the endowment in factor k—the standard Rybczynski elasticities.

An alternative condition that must be satisfied in order for immiserization to occur can be derived by exploiting some well-known duality results. Using the reciprocity relationships (Samuelson (1953)), i.e. $\frac{\partial X_j}{\partial V_i} = \frac{\partial w_i}{\partial P_j}$, equation (4) can be expressed as:

$$w_k < t_{M1} P_{M1}^* \frac{\partial w_k}{\partial P_{M1}} + t_{M2} P_{M2}^* \frac{\partial w_k}{\partial P_{M2}} \tag{6}$$

since $\frac{\partial X_{M1}}{\partial V_k} = \frac{\partial w_k}{\partial P_{M1}}$, or:

$$1 < \frac{t_{M1}}{(1+t_{M1})} \varepsilon_{kM1} + \frac{t_{M2}}{(1+t_{M2})} \varepsilon_{kM2} \tag{7}$$

where ε_{kj} is the elasticity of factor price *k* with respect to a change in the price of output *j*—the Stolper-Samuelson elasticity.

In the general case of *n* import goods subject to tariffs, the condition for immiserization can be expressed in the following alternative ways:

$$1 < \frac{1}{\beta_k} \sum_{j=1}^{n} \frac{t_j}{1+t_j} \eta_{jk} \alpha_j \text{ , for each factor } k \tag{8}$$

$$1 < \sum_{j=1}^{n} \frac{t_j}{1+t_j} \varepsilon_{kj}, \text{ for each factor } k \qquad (9).$$

In these formulae, the summation extends over the number of imported goods subject to a tariff (j).

III. Some Results

This section lays out some results that follow from the equations (8) and (9). Unfortunately, results depend on model structure, i.e. number of goods and factors, so a number of cases need to be examined. Throughout the remainder of the paper, the case of more goods than factors will not be analyzed, given the tendency to specialize under these circumstances.

A. The "Even" Case

Consider the case where the number of goods equals the number of factors and suppose the endowment of some factor *k* increases, while all other endowments remain unchanged. Using equation (8), immiserization will occur if the sum of Rybczynski terms, appropriately weighted by tariff rates and output shares, exceeds one. Other things equal, this will be the case the higher the tariff rate on the good whose output increases, the higher the share of output of that good in aggregate income (GDP), and the smaller the share of the expanding factor in national income—the more "unimportant" it is in the terminology of Jones and Scheinkman (1977).

In the case of only two goods (an export and an import good) and two factors (labor and capital) the condition for immiserization is particularly simple. For example, suppose that the import good is capital intensive. Using the formula for the elasticity of the rental rate on capital as a result of change in the price of imports (see Woodland (1982)), together with equation (9), an increase in the capital stock will lead to immiserization if:

$$t > \frac{\theta_{LE}}{\theta_{LM}} - 1 \qquad \text{or} \qquad (1+t) > \frac{\theta_{LE}}{\theta_{LM}} \tag{10}$$

where θ_{ij} is the cost share of factor i in a unit of good j. This is the same condition as derived by Martin (1977). However, formulae (8) and (9) are more general. Equation (10) reveals the magnitude of the tariff rate that would be required to generate immiserization, given factor intensities. If the import good is capital intensive, then the chances of immiserization are greater: (i) the lower the cost share of labor used in the export sector (the lower is θ_{LE}); and (ii) the higher is the cost share of labor in the import sector (the higher is θ_{LM}). Alternatively, immiserization is more likely the lower the degree of capital intensity of the import sector.

In general, for immiserization to occur, the factor growth must cause the output of the tariff protected good to expand, that is, η_{jk} must be positive. Using equation (8), the condition for immiserization is:

$$t > \frac{\beta_k}{[\eta_{Mk}\alpha_M - \beta_k]} \tag{11}$$

provided $(\eta_{Mk}\alpha_M - \beta_k) > 0$, or $\eta_{Mk} > \frac{\beta_k}{\alpha_M}$. The probability that factor growth will immiserize is greater the smaller is β_k and the larger is α_M. Thus, in the 2x2 case, immiserization is always possible because one of the η_{jk} will be greater than one, while it may not be possible in the (nxn) case.

When the number of commodities and factors exceeds two, immiserization may no longer be possible. Consider an increase in the supply of factor k in a model with three goods (two import goods, M1 and M2, and one export good, E) and three factors. Using equation (9), for immiserization to occur, either ε_{kM1} or ε_{kM2} must be greater than one. In other words, at least one of the tariff-protected goods must be a "natural friend" of factor k. Jones and Scheinkman (1977) showed that in the (nxn) case, every factor has a "natural enemy"—a factor whose real return declines as a result of some commodity price change—but not necessarily a "natural friend". Thus, in the (nxn) case, immiserization may not be possible because the factor whose supply has increased must have a "natural friend" and it must be one of the tariff-protected goods.

B. The "Uneven" Case: The Specific Factors Model

What can be said about the likelihood of immsierizing growth when the number of factors exceeds the number of goods? In the specific-factors model, it is possible to take advantage of some clear-cut results regarding the relationship between endowment and output changes on the one hand and factor and commodity price changes on the other.

1. The Two-Good, Three-Factor Case

The case of two sectors (import and export) and three factors (a specific factor in each sector plus a mobile factor) gives clear-cut results. By using equation (11) for example, the condition for growth in the specific factor *k* used in the import sector M to immiserize is:

$$t > \frac{1}{\varepsilon_{kM} - 1} \qquad (14).$$

where t is the tariff rate on the imported good and ε_{kM} is the elasticity of the return to the specific factor used in the import sector from an increase in the price of the imported good. In the specific factor's model, it is well-known that $\varepsilon_{kM} > 1$. Thus, in this simple structure, immiserization is always possible from an increase in the supply of a specific factor in the tariff-protected sector.

Under this model structure it is possible to solve for the *exact* condition for immiserization. Using equation (11), this condition is:

$$t_M > \frac{\theta_{KM}}{\theta_{LM}} + \frac{\sigma_M \lambda_{LM} \theta_{KE}}{\sigma_E \lambda_{LE} \theta_{LM}}, \text{ or } \qquad (1 + t_M) > \frac{1}{\theta_{LM}} + \frac{\sigma_M \lambda_{LM} \theta_{KE}}{\sigma_E \lambda_{LE} \theta_{LM}} \qquad (15).$$

Miyagiwa (1993) correctly stated that if the tariff rate exceeded $\frac{\theta_{KM}}{\theta_{LM}}$, then capital accumulation "may" reduce welfare. Equation (15), however, gives the exact condition that must hold for immiserization. It reveals that growth in the factor specific to the import sector will be more likely to lead to immiserization: (i) the lower the value of θ_{KM} relative to θ_{LM}; (ii) the smaller the magnitude of σ_M and the larger the value of σ_E; and (iii) the smaller is λ_{LM} relative to λ_{LE}.[3]

Comparing equations (12) and (15), the magnitude of the tariff rate needed to generate immiserization is in general, higher in the specific factor's model compared to the all factor's mobile model. In a sense, all else equal, it is more difficult to generate immiserization in the specific factor's model. Note from equation (15), the tariff rate needed to produce immiserization in the specific factor's model depends on the elasticities of substitution between labor and capital in the two sectors, while in the all factors mobile model, it does not. This is because in the specific factor's model, a change in factor supplies will alter factor prices.

[3] It can readily be shown that $\theta_{KM} = \frac{\beta^{KM}}{\alpha_M}$. Equation (10) showed that the possibility of immiserizing growth would be greater the smaller is β^i and the larger is α_j. Both of these situations are consistent with a smaller value for θ_{KM}.

There are two further results from using this structure. First, growth in the supply of the factor specific to the export sector cannot immiserize, since output of the tariff-protected good must contract and the factor-price elasticity must be negative. This is consistent with the conclusion of Srinivasan (1983). Second, if the supply of the mobile factor increases, immiserization is not possible, since the factor-price elasticity is less than one. These results imply that short run (with a specific factor), if the mobile factor is labor, immigration cannot immiserize the recipient country, provided the terms of trade remain unchanged.

2. Three-Goods and Four Factors

In the specific factor's model, if there are more than two goods, immiserization is still possible, however, there is a sense in which it becomes more difficult to achieve. Suppose there is one export good and two tariff-protected goods (refer to them as M1 and M2). An increase in the supply of factor *k* will immiserize if:

$$1 < \frac{t_{M1}}{(1+t_{M1})}\varepsilon_{kM1} + \frac{t_{M2}}{(1+t_{M2})}\varepsilon_{kM2} \text{, for an increase in the supply of factor k} \qquad (16).$$

If the supply of the factor specific to the first import sector (M1) increases, then $\varepsilon_{kM1} > 1$ and $\varepsilon_{kM2} < 0$. With more than one tariff-protected sector, all factor-price elasticities are negative, except for the factor-price elasticity of the factor whose supply has increased. As in the case of just one tariff-protected good, growth in the factor specific to the export sector cannot immiserize.

As in the two-good case, an increase in the supply of the mobile factor cannot lead to immiserization. From equation (11), if the mobile factor is labor, then in order for immiserization, the following condition must hold:

$$1 < \frac{t_{M1}}{(1+t_{M1})}\varepsilon_{LM1} + \frac{t_{M2}}{(1+t_{M2})}\varepsilon_{LM2}, \tag{17}$$

where ε_{Lj} is the elasticity of the return to the mobile factor (the wage rate) with respect to a change in the price of good j. It can easily be shown that the right-hand side of equation (17) is less than one, given that each $\varepsilon_{Lj} < 1$. Thus, even with more than one imported good, an increase in the supply of the mobile factor cannot lead to immiserization.

C. Tariff Structure and Immiserizing Growth

This section examines how a country's tariff structure affects the likelihood that it might suffer immiserizing growth in the context of the specific factors' model. It turns out that there is a sense in which adopting a uniform tariff structure would reduce the chances that a country could suffer immiserization.

Specific Factor's Model: Two imported Goods and One Export Good

Consider the specific factor's model with two imported goods subject to tariffs. This is the simplest structure to investigate questions surrounding tariff structure. Then, from equation (10), an increase in the supply of the specific factor used in the first import sector will lead to immiserization if:

$$1 < \frac{1}{\beta^{KM1}}\left[\frac{t_{M1}}{1+t_{M1}}\left[\frac{\theta_{KM1}(\sigma_E\lambda_{LE}\theta_{KM2}+\sigma_{M1}\lambda_{LM1}\theta_{KE}\theta_{KM2})}{\lambda_{KM1}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2}+\lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}+\lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]}\right]\right]\alpha_{M1}$$

$$+\frac{\sigma_{M2}\theta_{KM1}\theta_{KE}}{\beta^{KM1}\lambda_{KM1}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2}+\lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}+\lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]}\left[\frac{t_{M1}\lambda_{LM2}\alpha_{M1}}{(1+t_{M1})}-\frac{t_{M2}\theta_{LM2}\lambda_{LM1}\alpha_{M2}}{(1+t_{M2})}\right]$$

(18).

It is obvious from equation (18), that all else equal, a higher tariff on the first imported good (t_{M1}), relative to the tariff on the second imported good (t_{M2}), will increase the chances that the economy would be worse off from an increase in the supply of the factor specific to the first import sector.

Similarly, an increase in the supply of the specific factor used in the second import sector will lead to immiserization if:

$$1 < \frac{1}{\beta^{KM2}}\left[\frac{t_{M2}}{1+t_{M2}}\left[\frac{\theta_{KM2}(\sigma_E\lambda_{LE}\theta_{KM1}+\sigma_{M2}\lambda_{LM2}\theta_{KE}\theta_{KM1})}{\lambda_{KM2}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2}+\lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}+\lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]}\right]\right]\alpha_{M2}$$

$$+\frac{\sigma_{M1}\theta_{KM2}\theta_{KE}}{\beta^{KM2}\lambda_{KM2}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2}+\lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}+\lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]}\left[\frac{t_{M2}\lambda_{LM1}\alpha_{M2}}{(1+t_{M2})}-\frac{t_{M1}\theta_{LM1}\lambda_{LM2}\alpha_{M1}}{(1+t_{M1})}\right]$$

(19).

From (19), all else constant, the chances of immiserization resulting from an increase in the supply of the specific factor used in the second import sector will be greater the higher the tariff rate in the second import sector (t_{M2}), relative to the tariff on the first imported good (t_{M1}).

The results demonstrate that if it is unknown which sector is likely to experience an increase in the supply of its specific factor, then a uniform tariff structure would lessen the chances that the country would be worse off.[4] This issue does not arise in the case of an increase in the supply of the mobile factor, as immiserization is not possible in this case.

The above argument hinges, among other things, on the fact that in the specific factors' model, an increase in some commodity price will raise the real return to the specific factor used in the production of the good whose price has risen and reduce the real return of all the other specific factors. In other words, ε_{KM1} and ε_{KM2} have opposite signs. In an nxn model, this will not necessarily be the case. For example, Jones and Scheinkman (1977) show that in the case of three goods and three factors, the Stolper-Samuelson elasticity of some factor's return with respect to two commodity-price changes might be positive, but less

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[4] Anderson and Neary (2005) have shown in a different context that welfare is a decreasing function of the *generalized* variance of a country's tariff structure.

than one. Thus, greater tariff dispersion will increase the likelihood of immiserization in the specific factors' model, but not necessarily in the mobile-factors model.

IV. Country Examples

While the previous sections established some general conclusions regarding the likelihood of immiserization induced by factor accumulation in the presence of tariffs, it could not cover all possible cases and model structures. Therefore, this section uses simulation techniques to assess empirically how different types of factor accumulation would affect welfare for a group of low-income countries that have higher than average degrees of tariff dispersion, as measured by the standard deviation of tariff rates.

The methodology uses a computable general equilibrium model for twenty countries. The model structure for each country is the same, but the parameters and benchmark data vary to capture the particular circumstances of each country. The model structure is the specific-factor's model discussed in section B. For each country model, there are five sectors: two exportable goods, two importable sectors, and a nontraded good. The two export and import sectors can be thought of as primary products (agriculture and raw materials) and manufactured goods. Each of the five goods is produced by using a sector-specific factor (i.e. capital), a factor that is mobile across all five sectors (i.e. labor), and domestic and imported intermediate inputs. The terms of trade are taken as given, but the price of the nontraded good is determined endogenously. In each country, a representative consumer is assumed to possess a cobb-douglass utility function over all five goods. Equilibrium is determined when a set of factor prices and price for the nontraded good is found that is consistent with market clearing. The individual country models are benchmarked to data contained in the GTAP database, version 6, for production, trade flows, and protection.[5]

Each country model is used to determine the welfare effect of six types of factor accumulation: an increase in the amount of capital that is specific to all five sectors, plus an increase in the supply of the mobile factor, labor. The change in welfare is measured by the equivalent variation. For simplicity, the experiments simulate the welfare impact of one percent increases in each of these six factor of production. The results are reported in Table 2.[6]

Of the twenty countries examined, only one, Tunisia, would experience a decline in welfare as a result of factor accumulation, and this occurs as a result of an increase in capital specific to the first import sector—imports of primary products such as agriculture, raw materials, and minerals. This result largely stems from the large dispersion in Tunisia's tariff structure: the tariff rate on primary products is 41.2 percent, while the tariff on manufactured goods is 11.8 percent. While all other countries gain as a result of capital accumulation specific to both import sectors, the magnitude of these gains is generally lower than the gains from other types of factor accumulation—export-biased or labor biased. Every country gains

[5] GTAP is the Global Trade Analysis Project and it includes a global economic model and database. Documentation of the database can be found in Dimarmaran and McDougal (2006).

[6] The choice of a one-percent increase is arbitrary. As is well known, if the magnitude of the increase in factor supply is large enough, the country must gain even with a distortion, provided specialization does not occur. As well, if the magnitude of the increase is small enough, the country must be worse off. See Johnson (1967).

Table 2. Welfare Effects of a One Percent Increase in Factor Endowments
(Welfare effects are in millions of 2001 U.S. Dollars; percent of GDP in parenthesis)

	Capital in First Export Sector	Capital in Second Export Sector	Capital in First Import Sector	Capital in Second Import Sector	Capital in Nontraded Sector	Labor Endowment
Albania	1.4	11.7	1.5	2.2	2.9	14.7
	(0.0)	(0.3)	(0.0)	(0.1)	(0.1)	(0.3)
Argentina	11.8	11.4	0.5	46.1	27.8	122.6
	(0.1)	(0.1)	(0.0)	(0.2)	(0.1)	(0.6)
Bangladesh	1.7	3.8	5.4	2.0	8.5	24.2
	(0.0)	(0.1)	(0.1)	(0.0)	(0.2)	(0.5)
Botswana	0.4	11.4	0.5	46.1	27.8	122.6
	(0.1)	(0.1)	(0.0)	(0.2)	(0.1)	(0.6)
Brazil	21.7	22.1	5.6	61.4	78.0	2506.2
	(0.1)	(0.1)	(0.0)	(0.1)	(0.2)	(0.6)
China	10.2	18.9	1.0	6.6	9.6	53.7
	(0.1)	(0.2)	(0.0)	(0.1)	(0.1)	(0.6)
Colombia	5.7	8.5	1.6	5.4	10.1	46.2
	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.6)
Egypt	0.5	0.1	0.0	0.5	0.3	0.8
	(0.2)	(0.1)	(0.0)	(0.2)	(0.1)	(0.3)
India	66.6	88.3	6.4	16.3	71.6	204.0
	(0.2)	(0.2)	(0.0)	(0.0)	(0.2)	(0.5)
Madagascar	9.2	0.9	1.4	4.2	4.6	25.0
	(0.2)	(0.0)	(0.0)	(0.1)	(0.1)	(0.5)
Malawi	1.8	2.5	1.3	1.3	0.6	9.1
	(0.1)	(0.2)	(0.1)	(0.1)	(0.0)	(0.6)
Morocco	29.2	65.1	3.1	8.7	39.8	180.9
	(0.1)	(0.2)	(0.0)	(0.0)	(0.1)	(0.5)
Mozambique	2.1	3.5	1.3	5.8	5.8	18.1
	(0.1)	(0.1)	(0.0)	(0.2)	(0.2)	(0.5)
Peru	6.9	7.3	3.1	9.4	7.2	16.6
	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	(0.3)
Philippines	8.9	6.5	4.3	11.6	9.6	19.9
	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	(0.3)
Romania	3.4	5.9	3.7	8.4	3.8	13.4
	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	(0.3)
Tanzania	19.3	4.8	1.0	12.2	8.2	43.4
	(0.2)	(0.1)	(0.0)	(0.1)	(0.1)	(0.5)
Tunisia	12.6	62.0	-1.4	13.0	9.9	84.8
	(0.1)	(0.3)	(0.0)	(0.1)	(0.1)	(0.4)
Vietnam	5.9	8.4	1.9	5.5	10.3	11.7
	(0.1)	(0.2)	(0.0)	(0.1)	(0.2)	(0.2)
Zambia	3.0	2.2	1.0	4.4	7.0	16.0
	(0.1)	(0.1)	(0.0)	(0.1)	(0.2)	(0.5)

Source: Author's calculations.

as a result of an increase in the supply of the mobile factor, labor, as expected.

Since Tunisia was the only country for which factor accumulation would lead to immiserization, a further experiment was conducted. Starting from the initial set of tariff rates (41.2 and 11.8 percent), the model was used to simulate the impact of an increase in the tariff rate on the second import good, keeping the tariff rate on the first import good constant, so that both tariff rates were 41.2 percent. Then, starting from this new benchmark, the effects of an increase in the supply of capital specific to the first import sector were simulated. Relative to this new benchmark in which both tariff rates were equal, an infusion of capital specific to the first import sector still resulted in a reduction in overall welfare, however, the magnitude of the reduction was smaller than the reduction in welfare that occurred when the tariff rates were unequal. This results demonstrates that the dispersion in tariff rates contributed as least partly to the welfare loss that resulted from factor accumulation. It should be emphasized that even if tariff rates are equalized, immiserization is still possible, as shown by equations (18) and (19).

IV. Conclusions

This paper has presented a general condition that must be satisfied in order for factor accumulation to reduce real income in an economy with any number of tariff-protected goods. Prior literature had only identified the conditions for immiserization in special cases, such as two goods and two factors. This paper extended the analysis beyond two goods and studied how a country's tariff structure influences the chances that it might suffer immiserizing growth.

In “even” models, there is a sense in which the introduction of more than two goods reduces the chances of immiserization. This is because in (nxn) models, every factor must have a “natural enemy”, but not necessarily a “natural friend”. In the specific factors’ model, this paper has shown that immiserization is more difficult than in a model with all factors mobile. In the specific-factors model, factor accumulation biased toward a specific factor in a sector can lead to immiserization, but accumulation biased toward the mobile factor *cannot,* even in the presence of protection. This result is due to the fact that an increase in the supply of the mobile factor must raise outputs of all goods, unlike in the two-good, two-factor model. If the mobile factor is taken to be labor, then an increase in the supply of labor available to the economy, perhaps through immigration, *cannot* make the economy worse off in the short run, provided there is no change in the terms of trade. This conclusion is not valid in the long run when all factors can be thought of as mobile. In a model with all factors mobile, an increase in the labor supply could indeed lead to immiserization. This could explain differences in attitudes toward immigration in the short and long run.

The paper also investigated the role played a country’s tariff structure in influencing whether a country could suffer immiserizing growth. In the specific factor’s model, the paper shows that the farther apart the tariff rates are, i.e the greater the tariff dispersion, the greater the likelihood that a country will suffer immiserizing growth when it is unknown which specific factor will increase in supply. In a model in which all factor of production are mobile, this conjecture may not hold. The reason is that in the specific factors’ model, an increase in some commodity price must reduce the real return to every specific factor, except for the real return to the factor used in the sector whose price has risen. In a model in which all factors are mobile, the real returns to factors as a result of commodity-price changes are more difficult to pin down.

Ultimately, with more complicated model structures, whether factor accumulation will immiserize a country in the presence of tariff protection is an empirical question. Simulations for twenty countries with higher than average tariff dispersion revealed that only one would likely experience immiserizing growth. Overall, immiserizing growth of the "Johnson type" does not seem to be very likely, mainly because most country's tariff structures do not contain a degree of dispersion necessary to produce this outcome.

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Appendix

1. Mobile-Factor's Model: Two Goods, Two Factors

$$\hat{X}_E = \frac{-\lambda_{KM}}{(\lambda_{LM}\lambda_{KE} - \lambda_{LE}\lambda_{KM})}\hat{L} + \frac{\lambda_{LM}}{(\lambda_{LM}\lambda_{KE} - \lambda_{LE}\lambda_{KM})}\hat{K}$$

$$\hat{X}_M = \frac{\lambda_{KE}}{(\lambda_{LM}\lambda_{KE} - \lambda_{LE}\lambda_{KM})}\hat{L} + \frac{-\lambda_{LE}}{(\lambda_{LM}\lambda_{KE} - \lambda_{LE}\lambda_{KM})}\hat{K}$$

2. Specific-Factor's Model: Two Goods and Three Factors

$$\hat{X}_E = \left[\frac{\sigma_E\lambda_{LE}\theta_{KM}\theta_{KE} + \sigma_M\lambda_{LM}\theta_{KE}}{\lambda_{KE}(\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE})}\right]\hat{K}_E + \left[\frac{-\theta_{LE}\sigma_E\lambda_{LM}\theta_{KM}}{\lambda_{KM}(\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE})}\right]\hat{K}_M +$$

$$\left[\frac{\sigma_E\theta_{LE}\theta_{KM}}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{L} + \left[\frac{\sigma_M\lambda_{LM}\theta_{LE}\sigma_E}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{P}_E + \left[\frac{-\theta_{LE}\sigma_E\sigma_M\lambda_{LM}}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{P}_M$$

$$\hat{X}_M = \left[\frac{-\theta_{LM}\sigma_M\lambda_{LE}\theta_{KE}}{\lambda_{KE}(\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE})}\right]\hat{K}_E + \left[\frac{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}\theta_{KM}}{\lambda_{KM}(\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE})}\right]\hat{K}_M +$$

$$\left[\frac{\sigma_M\theta_{LM}\theta_{KE}}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{L} + \left[\frac{-\theta_{LM}\sigma_M\lambda_{LE}\sigma_E}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{P}_E + \left[\frac{\theta_{LM}\sigma_M\lambda_{LE}\sigma_E}{\sigma_E\lambda_{LE}\theta_{KM} + \sigma_M\lambda_{LM}\theta_{KE}}\right]\hat{P}_M$$

3. Specific-Factor's Model: Three Goods and Four Factors

$$\hat{X}_E = \left[\frac{\lambda_{LE}\sigma_E\theta_{KE}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}}{\lambda_{KE}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_E$$

$$+ \left[\frac{-\theta_{LE}\sigma_E\theta_{KM1}\theta_{KM2}\lambda_{LM1}}{\lambda_{KM1}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_{M1}$$

$$+ \left[\frac{-\theta_{LE}\sigma_E\theta_{KM1}\theta_{KM2}\lambda_{LM2}}{\lambda_{KM2}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_{M2}$$

$$+ \left[\frac{\theta_{LE}\sigma_E\theta_{KM1}\theta_{KM2}}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{L}$$

$$+ \left[\frac{\theta_{LE}\sigma_E(\lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1})}{\theta_{KE}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_E$$

$$+ \left[\frac{-\theta_{KM2}\lambda_{LM1}\sigma_{M1}\theta_{LE}\sigma_E}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_{M1}$$

$$+ \left[\frac{-\theta_{KM1}\lambda_{LM2}\sigma_{M2}\theta_{LE}\sigma_E}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_{M2}$$

$$\hat{X}_{M1} = \left[\frac{-\theta_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}\lambda_{LE}}{\lambda_{KE}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{K}_E$$

$$\left[\frac{\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}\theta_{KM1} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}}{\lambda_{KM1}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{K}_{M1}$$

$$+\left[\frac{-\theta_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}\lambda_{LM2}}{\lambda_{KM2}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{K}_{M2}$$

$$+\left[\frac{\theta_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2}}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{L}$$

$$+\left[\frac{-\theta_{LM1}\sigma_{M1}\theta_{KM2}\lambda_{LM1}\sigma_{M1}}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{P}_E$$

$$\left[\frac{\theta_{LM1}\sigma_{M1}(\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1})}{\theta_{KM1}\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{P}_{M1}$$

$$+\left[\frac{-\theta_{LM1}\sigma_{M1}\theta_{KE}\lambda_{LM2}\sigma_{M2}}{\left[\lambda_{LE}\sigma_E\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right]\hat{P}_{M2}$$

$$\hat{X}_{M2} = \left[\frac{-\theta_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\lambda_{LE}}{\lambda_{KE}\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_{E}$$

$$+ \left[\frac{-\theta_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\lambda_{LM1}}{\lambda_{KM1}\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_{M1}$$

$$\left[\frac{\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\theta_{KM2}}{\lambda_{KM2}\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{K}_{M2}$$

$$+ \left[\frac{\theta_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}}{\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{L}$$

$$+ \left[\frac{-\theta_{LM2}\sigma_{M2}\theta_{KM1}\lambda_{LE}\sigma_{E}}{\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_{E}$$

$$+ \left[\frac{-\theta_{KE}\theta_{LM2}\sigma_{M2}\lambda_{LM1}\sigma_{M1}}{\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_{M1}$$

$$+ \left[\frac{\theta_{LM2}\sigma_{M2}(\lambda_{KE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2})}{\theta_{KM2}\left[\lambda_{LE}\sigma_{E}\theta_{KM1}\theta_{KM2} + \lambda_{LM1}\sigma_{M1}\theta_{KE}\theta_{KM2} + \lambda_{LM2}\sigma_{M2}\theta_{KE}\theta_{KM1}\right]} \right] \hat{P}_{M2}$$