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Abstract

This paper examines the diversification motive for tariffs under trade-related uncertainty when there is incomplete international and domestic risk sharing. In the context of a two-country Ricardian continuum-of-sectors model with shocks to foreign technologies or preferences, tariffs allow a country to mitigate external risk by diversifying across sectors. Given sufficiently high risk and risk aversion, the optimality of tariffs depends primarily on a country's ability to diversify, rather than its market power, such that small countries gain most.

1. Introduction

It is generally accepted that there is a stronger economic rationale for larger countries to invoke protectionist international trade measures than for smaller ones. This supposition, which has received extensive attention in the literature on optimum tariffs and retaliation, stems from the premise that larger countries have greater market power over their terms of trade.[1] At the extreme, a positive tariff is never welfare improving for an archetypical small country according to the terms of trade argument.

This paper questions the conventional thinking on protection and country size. When the trade environment is uncertain, international and domestic risk-sharing is incomplete and commitments to production and trade must be made before uncertainty is resolved, second-best sectoral diversification considerations motivate tariff protection, in addition to the standard terms of trade rationale. Tariff protection allows a country to diversify into a broader range of sectors by shifting resources from exporting sectors to newly established import-competing sectors. This shift may be welfare improving when there is incomplete risk sharing because it allows a risk-averse country to reduce its exposure to trade-related risk. The diversification motive is particularly strong in small countries with high exposure to external risk, high degrees of risk aversion and large import shares.[2]

Empirical evidence shows that trade increases aggregate volatility in an economy, suggesting that such trade-related risk may be important. In a much-cited paper, Rodrik (1998) demonstrated that trade openness exposes economies to external

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shocks which increase aggregate risk. More recently, di Giovanni and Levchenko (2009) showed that the positive relationship between trade and overall volatility operates through sector-level volatility and specialization. Although aggregate risk cannot be domestically diversified, the literature on international finance shows that there is surprisingly little risk sharing across countries.[3] With incomplete international risk sharing, it is generally optimal for a single country to have greater diversification in production once uncertainty is introduced. Helpman and Razin (1978) established that optimal diversification in production can be achieved in a decentralized economy with households and firms provided that *perfect* domestic risk sharing occurs on a national stock market. Domestic risk-sharing, however, is very unlikely to be complete. Entrepreneurs typically have superior insight related to particular activities giving rise to asymmetric information. Further, in response to principal–agent issues, managers are likely to be induced to hold portfolios that are skewed toward their own firms. In the absence of perfect domestic risk sharing, the degree of diversification in production will be suboptimal.

Given the incomplete diversification of domestic and international portfolios, a thorough investigation of the diversification motive for protection is warranted. In this paper, we construct a model incorporating a Ricardian continuum of goods to rigorously connect country size with both the second-best diversification motive and the first-best terms of trade motives for protection. The model incorporates random disturbances to either foreign technologies or preferences.[4] We assume that agents are risk averse and, for clarity of analysis, focus on the extreme case where there are no stock markets. Hence, domestic as well as international risk sharing is inherently incomplete. Before uncertainty is resolved, a welfare maximizing government sets a non-cooperative import tariff and producers allocate labor across sectors in response. Constraints to trade policy formulation imposed by trade agreements are absent, and *ex-ante* trade policy and production decisions are irrevocable *ex-post*. After uncertainty is resolved, trade and consumption occur.

The model generates three key results. First, allowing for trade-related risk increases the welfare benefit of tariffs for any country. Greater risk and risk aversion heightens the incentive to impose tariffs. Consequently, a positive tariff is welfare improving for any country, regardless of how small. While a small country cannot improve its terms of trade, it can use a tariff to encourage sectoral diversification, which in turn increases expected welfare. Second, the welfare benefit of tariff-induced sectoral diversification *falls* with increased country size. Smaller countries gain more from diversification than larger ones as a result of their greater ability to diversify production using a tariff. For a larger country, the underlying extent of its diversification of production is attenuated by factor cost and product price increases associated with its terms of trade improvement. Third, with sufficiently high risk and risk aversion, the relationship between the welfare benefit of a tariff and country size is dictated primarily by a country's ability to diversify its production rather than its ability to affect the world price. In other words, the diversification effect can eclipse the terms of trade effect.

Earlier studies on resource allocation under trade-related uncertainty such as Turnovsky (1974), Eaton (1979), Helpman and Razin (1978), and Newbery and Stiglitz (1984) provide a key point of departure for our analysis. In a two-sector Ricardian model with *ex-ante* production and *ex-post* consumption decisions, Turnovsky (1974) showed that incomplete specialization of production may be optimal when terms of trade are uncertain. Eaton (1979) showed that when price is uncertain in a Heckscher–Ohlin framework, the *ex-ante* diversification of resources increases an economy's *ex-post* flexibility and may increase the optimal expected level of trade. Further Newbery and Stiglitz (1984) showed that free trade may be Pareto inferior to no trade when economies are risky and insurance markets are incomplete. This result is established in a two-country, two-sector model where prices play a key role in transferring and sharing risk. Our paper also complements the literature concerning the implications of trade-related risk for optimal trade policy. The general conclusion of this literature is that when markets for risk sharing are incomplete, trade policy instruments can be used to stabilize income or insure risk averse households. Batra and Russell (1974) showed that when production and consumption decisions are made *ex-ante*, terms of trade risk reduces expected welfare. Free trade is not optimal for a small country as a result and the government should subsidize or tax the consumption of traded goods, depending on which terms of trade are realized. In Cassing et al. (1986), the owners of both mobile and immobile factors benefit from a tariff *ex-ante* but differ in terms of the optimal size of a state-contingent tariff. To alleviate uncertainty in the terms of trade, the government should commit *ex-ante* to state-contingent tariffs specific to each group. Eaton and Grossman (1985) made a case for tariffs as a partial substitute for incomplete insurance markets. In the context of a specific-factors model where labor is mobile and capital is indivisible *ex-ante* and immobile *ex-post*, a tariff allows a small country to spread risk across individuals who differ in their *ex-post* incomes and so provide insurance.[5]

The most significant departure of this paper from the previous literature on trade under uncertainty is that we allow for variation in country size and examine the effect of varying size on the interaction of the diversification motive for tariff protection with the terms of trade motive.[6] Also, in contrast to the earlier literature that considered models with at most two risky sectors, this paper situates the analysis in a continuum of sectors model to enable a very natural discussion of the diversification of production.

The rest of the paper proceeds as follows. In section 2, we describe the basic two-country Ricardian model with a continuum of sectors and evaluate the economic rationale for trade protection when the trade environment is certain. In this setting, the relationship between the welfare impact of a tariff and country size is dictated entirely by a country's ability to influence world prices in accordance with the standard terms of trade motive. In section 3, we incorporate trade-related uncertainty into the model and examine the diversification motive for tariff protection and its relationship with the terms of trade motive. External risk is associated with random disturbances in foreign technology and foreign preferences. While the type of external risk affects the source of volatility in the terms of trade, it does not affect the welfare improvement associated with tariff protection. Section 4 concludes.

2. The Model

To provide a benchmark for our subsequent analysis in the presence of uncertainty, we begin by evaluating the welfare impact of a tariff under certainty in the context of the Ricardian model with a continuum of commodities introduced by Dornbusch et al. (1977). The world is endowed with L^W units of labor which is divided across two countries, Home and Foreign. Let $h \in (0, 1)$ represent Home's share of world labor or "size." As a result, Home's and Foreign's labor endowments are $L = hL^W$ and $L^* = (1 - h)L^W$. Throughout, we use an asterisk to denote the Foreign country. In the limit as $h \downarrow 0$, Home becomes an archetypical (ultra) small country, while in the other limiting case as $h \uparrow 1$, Home becomes ultra large. Within each country, labor can be employed over a continuum of sectors indexed by $z \in [0, 1]$, where each sector produces a distinct commodity.

The labor requirements per unit of output z in Home and Foreign are $a(z)$ and $a^*(z)$. Sectors are ranked in terms of diminishing Home-country advantage, so that the relative Foreign-to-Home labor requirements, $A(z) \equiv a^*(z)/a(z)$, are continuous and decreasing in z. It proves useful to specify $a(z)$ and $a^*(z)$ as follows:

$$a(z) = \begin{cases} 1 & \text{if } z \in [0, \alpha] \\ e^{z-\alpha} & \text{if } z \in (\alpha, 1] \end{cases} \quad \text{and} \quad a^*(z) = \begin{cases} e^{\alpha-z} & \text{if } z \in [0, \alpha] \\ 1 & \text{if } z \in (\alpha, 1] \end{cases}. \tag{1}$$

Consequently, Home has an absolute advantage in $z \in [0, \alpha]$ while Foreign has an absolute advantage in $z \in (\alpha, 1]$. For convenience, we define units of output such that it takes one unit of labor to produce one unit of z in whichever country has the lowest labor requirement. To ensure that there is no inherent productivity advantage or disadvantage to larger country size in a free-trade environment, we assume $\alpha = h$. This implies that the relative Foreign-to-Home labor requirements are $A(z) = e^{h-z}$.[7]

Home produces commodity z if its unit labor costs do not exceed Foreign's unit labor costs adjusted for Home's tariff t. This requires $\omega \le (1 + t)A(z)$, where $\omega \equiv w/w^*$ is the relative wage in Home vs Foreign. Assuming for simplicity that Foreign always trades freely, it produces z if $\omega \ge A(z)$. It follows that for a given value of ω, there exist critical sectors ζ and ζ^* determined by the *relative cost* schedules: $C(\zeta, \omega) \equiv \omega - (1 + t)A(\zeta) = 0$ and $C^*(\zeta^*, \omega) \equiv \omega - A(\zeta^*) = 0$ Since $A(z) = e^{h-z}$, the critical sectors which define the production and trade patterns are given by:

$$\zeta^* = h - \ln\omega \quad \text{and} \quad \zeta = h + \ln(1+t) - \ln\omega. \tag{2}$$

Consequently, $\zeta = \zeta^*$ if $t = 0$, but $\zeta > \zeta^*$ if $t > 0$. Home produces in $[0; \zeta]$ and imports in $(\zeta; 1]$; Foreign produces in $[\zeta^*; 1]$ and imports in $[0; \zeta^*)$; and commodities in the range $[\zeta^*; \zeta]$ are nontraded.

We assume the utility function of a representative agent is given by:

$$u = U(X) = \frac{e^{(1-\beta)\ln X}}{1-\beta}, \quad \text{where} \quad \ln X = \int_0^1 b(z)\ln c(z)dz. \tag{3}$$

The per-capita consumption of commodity z is $c(z)$ and the constant expenditure share on good z is $b(z) \ge 0$, where $\int_0^1 b(z)dz \equiv 1$. For future reference when we introduce uncertainty, the utility function is strictly concave in the general consumption level X and in each $c(z)$ provided that $\beta > 0$. Likewise, the utility function is concave in $\ln X$ and in each $\ln c(z)$ provided that $\beta > 1$.[8] The respective demand functions are:

$$c(z) = \frac{b(z)y}{p(z)} \quad \text{and} \quad c^*(z) = \frac{b^*(z)y^*}{p^*(z)}. \tag{4}$$

where y and y^* are the per capita incomes and $p(z)$ and $p^*(z)$ are the domestic prices of z in Home and Foreign. Given that we normalize wages such that $w^* = 1$ and $w = \omega$, prices depend on whether the good is domestically produced or imported as follows: $p(z) = \omega a(z)$ if $z \in [0, \zeta]$ and $p(z) = (1 + t)a^*(z)$ if $z \in (\zeta, 1]$, while $p^*(z) = \omega a(z)$ if $z \in [0, \zeta^*)$ and $p^*(z) = a^*(z)$ if $z \in [\zeta^*, 1]$. Assuming Home's budget shares are uniform across goods, we obtain $b(z) = 1$ from the adding-up property. We also initially assume that preferences in Foreign are identical so that $b^*(z) = 1$.

In equilibrium the excess demand for labor in Home is zero such that $L\int_0^{\zeta} c(z)a(z)dz + L^*\int_0^{\zeta^*} c^*(z)a(z)dz - L = 0$, which simplifies to:[9]

$$[1+t-tV(\zeta)][1-h]V^*(\zeta^*)+\omega hV(\zeta)=0, \tag{5}$$

where $V(\zeta) \equiv \int_{\zeta}^{1} b(z)dz$ and $V^*(\zeta^*) \equiv \int_0^{\zeta^*} b^*(z)dz$ are the fractions of income spent on imports by Home and Foreign respectively. Using (2) and recognizing that $V(\zeta) = 1 - \zeta$ and $V^*(\zeta^*) = \zeta^*$, the equilibrium ω can be determined by the *labor market* schedule:

$$F(\omega) \equiv [1+t[h+\ln(1+t)-\ln\omega]][1-h][h-\ln\omega]-h\omega[1-h-\ln(1+t)+\ln\omega]=0. \tag{6}$$

If ω is below (above) its equilibrium level, then $F(\omega) > 0$ ($F(\omega) < 0$) and labor is in excess demand (supply).

Given the equilibrium relative wage ω determined by (6), the equilibrium critical sectors ζ and ζ^* solve (2). Under free trade where $t = 0$, it follows that $\omega = 1$ and $\zeta = \zeta^* = h$.[10]

Proposition 1. *Starting from a free trade equilibrium, Home's tariff affects the trading equilibrium as follows:* $[d\omega/\omega]/dt = h$, $d\zeta/dt = 1 - h$ *and* $d\zeta^*/dt = -h$.

The Appendix provides proofs of all propositions. As Figure 1 shows, Home's tariff t increases its relative wage ω and in so doing, improves Home's terms of trade. This relationship between t and ω, which can be described as the *terms of trade effect* of tariff protection, rises monotonically with h and thus is stronger for larger countries. Home's tariff also has a net positive impact on the critical sector ζ. As ζ rises, Home diversifies into a broader range of sectors and so reduces its exposure to trade. This relationship between t and ζ, which we refer to as the *diversification effect* of tariff protection is stronger for a smaller countries. As h rises, the diversification effect falls because it is eroded by the improvement in the terms of trade: $d\zeta/dt = 1 - [d\omega/\omega]/dt$.

Taking Foreign's zero-tariff policy as given, Home's government can choose to impose a tariff to improve its representative agent's welfare. The indirect welfare function is:[11]

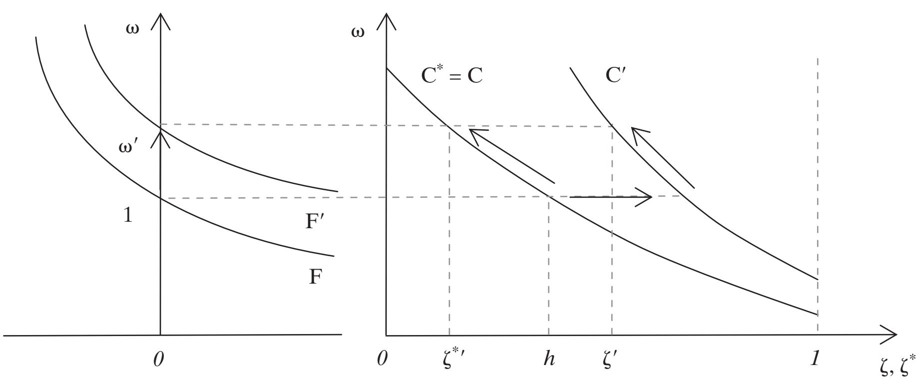

Figure 1. The Impact of Home's Tariff

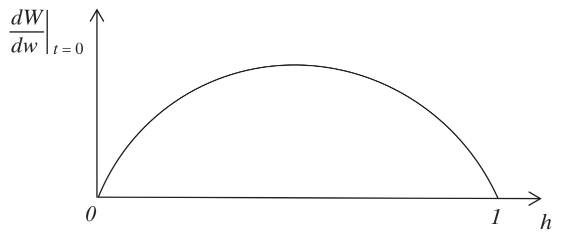

Figure 2. Welfare Impact of a Tariff Under Certainty

$$W = W(\omega, \zeta, t) = \frac{e^{(1-\beta)\ln X}}{1-\beta}, \tag{7}$$

where $\ln X = (1-\zeta)\ln\omega + \zeta\ln(1+t) - \ln(1+t\zeta) - \int_0^{\zeta}\ln a(z)dz - \int_{\zeta}^{1}\ln a^*(z)dz.$

Home's free-trade welfare is $W = 1/(1-\beta)$, which is invariant to country size. Starting in a free trade equilibrium, Home's tariff t affects W as follows:

$$\left.\frac{dW}{dt}\right|_{t=0} = \frac{\partial W}{\partial\omega}\frac{d\omega}{dt} = (1-\zeta)\frac{d\omega/\omega}{dt} = (1-h)h. \tag{8}$$

Under certainty, the welfare impact of a tariff depends solely on the terms of trade effect. The direct effect of t on Home's welfare, $\partial W/\partial t$, is zero in the neighborhood of free trade because the tariff distortion is initially infinitesimally small. Further, in the absence of uncertainty, Home's tariff does not cause a diversification effect on welfare. Since Home's and Foreign's unit labor costs are equal at the margin, we obtain $\partial W/\partial\zeta = 0$.

Figure 2 plots (8) and shows that deviating from free trade is welfare improving for any country of size $h \in (0,1)$. Further, the welfare benefit of a tariff rises with h at first and then falls as h approaches one. Relative country size matters for two reasons. First, as Home becomes larger and wields more market power, its tariff has a greater impact on its terms of trade. Second, as Home becomes larger relative to Foreign, it imports over a smaller range of sectors and thus its return from any given improvement in its terms of trade is diminished. This second effect becomes predominant when h is close to one.

3. Uncertainty

The key question is how the introduction of trade-related uncertainty modifies the relationship between the welfare impact of a tariff and country size. We first investigate external risk associated with random disturbances in foreign technology in in the next subsection and then consider uncertainty in foreign demand in the subsequent subsection.

Uncertainty in Foreign Technology

Suppose Foreign's unit labor requirements are subject to a technological shock $s_i^* > 0$ such that $a_i^*(z) = s_i^* a^*(z)$ and so the relative Foreign-to-Home labor requirements are $A_i(z) = s_i^* e^{h-z}$. For simplicity, assume that there are only two states of nature ($i = 1, 2$), which occur with equal probability such that $\pi_i = 0.5$. Let the state-contingent technological shocks be given by $s_1^* = e^{-r}$ and $s_2^* = e^r$, where $r > 0$ measures the degree of technological risk. By design, the geometric mean is equal to one such that $\bar{s}^* = \sqrt{s_1^* s_2^*} = 1$ corresponds with the certain technology. Since $s_2^* > 1$ and $s_1^* < 1$, Home's relative competitiveness improves in state 2 and worsens in state 1. An increase in r spreads s_1^* and s_2^* further apart while preserving the mean and so increases uncertainty. Home is unable to influence the degree of risk and takes r as given.

We characterize uncertainty in terms of a geometric mean preserving spread (GMPS) rather than an arithmetic mean preserving spread (AMPS) to ensure that results are insensitive to the choice of numeraire (Flemming et al., 1977).[12] When a geometric mean is used as the certainty equivalent, the measure of risk attitude should be defined in terms of the utility of the logarithm of the general consumption level X (Flemming et al., 1977). An individual exhibits risk aversion with respect to a GMPS if $U''(lnX) < 0$. Simple differentiation reveals that risk aversion with respect to a GMPS requires $\beta > 1$ rather than $\beta > 0$ for an AMPS. Consequently, we will now assume $\beta > 1$.[13]

The timing of decisions is as follows. Prior to uncertainty being resolved, Home's government sets a non-cooperative tariff $t \geq 0$ and producers allocate labor across sectors and commit to producing ranges of commodities for domestic consumption and export. The government and the producers have the same expectations about the future relative unit labor requirements. Both *ex-ante* trade policy and production decisions are irrevocable; neither can be revised *ex-post*. Trade and consumption are carried out after the random disturbance is observed.

In this scenario, the sectors ζ and ζ^* are determined prior to uncertainty being resolved and so, can be treated as parametric when the *ex-post* state-contingent relative wages are determined. Further since expenditure shares associated with Cobb–Douglas tastes are constant and identical across countries, Home's and Foreign's fractions of income spent on imports are constant: $V(\zeta) \equiv \int_\zeta^1 b(z)dz = 1 - \zeta$ and $V^*(\zeta^*) \equiv \int_0^{\zeta^*} b^*(z)dz = \zeta^*$ when $b(z) = b^*(z) = 1$. The market-clearing condition (5) thus implies that the state-contingent relative wages ω_i are equal to the certainty wage $\bar{\omega}$ given by:

$$\bar{\omega}(\zeta, \zeta^*) = \frac{1-h}{h}\frac{\zeta^*}{1-\zeta}[1 + t\zeta]. \tag{9}$$

While the relative wage is constant under foreign technological uncertainty, the prices of Foreign's goods vary such that $p_i^*(z) = s_i^* a^*(z)$ and $p_i(z) = (1+t)s_i^* a^*(z)$.[14]

Given the GMPS modeling of uncertainty, $\bar{\omega}$ is the *ex-ante* relative wage, which guides the production and trade decisions made prior to the resolution of uncertainty. Updating (2) to link the critical sectors with $\bar{\omega}$ yields:

$$\zeta^* = h - \ln \bar{\omega} \quad \text{and} \quad \zeta = h + \ln(1+t) - \ln \bar{\omega}. \tag{10}$$

By construction, the *ex-ante* production and trade decisions associated with (9) and (10) are the same as in the certainty equilibrium. In correspondence with the certainty equilibrium, $\zeta = \zeta^* = h$ and $\bar{\omega} = 1$ under free-trade. Consequently, Proposition 1 continues to summarize the impact of Home's tariff on the certainty-equivalent trading equilibrium, which underlies the *ex-ante* production and trade decisions.

Reformulating (7), Home's indirect expected welfare function is:

$$\bar{W} = \sum_i \pi_i W_i = \frac{1}{1-\beta}\sum_i \pi_i \mathrm{e}^{(1-\beta)\ln X_i}, \quad \text{where} \tag{11}$$

$$\ln X_i = (1-\zeta)(\ln\bar{\omega} - \ln s_i^*) + \zeta\ln(1+t) - \ln(1+\zeta t) - \int_0^{\zeta}\ln a(z)dz - \int_{\zeta}^{1}\ln a^*(z)dz. \tag{12}$$

Under free trade, expected welfare simplifies to:

$$\bar{W} = \frac{\sum_i \pi_i R_i}{1-\beta} = \frac{R}{1-\beta}, \quad \text{where} \quad R_i \equiv \mathrm{e}^{(\beta-1)(1-h)\ln s_i^*} \quad \text{and} \quad R \equiv \sum_i \pi_i R_i. \tag{13}$$

Here, $R = 0.5[\mathrm{e}^{(\beta-1)(1-h)r} + \mathrm{e}^{-(\beta-1)(1-h)r}] \geq 1$ is a measure of the perceived extent of risk. From (13), $R = 1$ and $\bar{W} = 1/(1-\beta)$ as in the certainty case, whenever: (i) risk *per se* is absent ($r = 0$) or (ii) the representative consumer is risk neutral ($\beta = 1$). Naturally when $r > 0$ and $\beta > 1$, the perceived extent of risk rises with the degree of risk ($R_r > 0$) and the degree of risk aversion ($R_\beta > 0$), but declines with an expansion of Home's production owing to larger size ($R_h < 0$, since $\zeta = h$). An increase in the perceived extent of risk R reduces expected welfare since risk aversion implies $\beta > 1$.

By anticipating the impact of a tariff on the underlying trading equilibrium, we can gauge the incentive for Home's government to implement a tariff:

$$\left.\frac{d\bar{W}}{dt}\right|_{t=0} = TE + DE, \tag{14}$$

$$\text{where} \quad TE = \sum_i \pi_i (1-h) R_i \frac{d\bar{\omega}/\bar{\omega}}{dt} = (1-h)hR, \tag{15}$$

$$DE = \sum_i \pi_i R_i \ln s_i^* \frac{d\zeta}{dt} = (1-h)rQ. \tag{16}$$

Here, $Q \equiv 0.5[\mathrm{e}^{(\beta-1)(1-h)r} - \mathrm{e}^{-(\beta-1)(1-h)r}] = R - R_2 \geq 0$ is a measure of the perceived spread of risk. With uncertainty, the impact on welfare can be decomposed into a terms of trade effect (TE) and a diversification effect (DE) of tariff protection. The terms of trade effect in (15) closely resembles the terms of trade effect in (8).

PROPOSITION 2. *The TE is single-peaked with $TE = 0$ in the limit as $h \downarrow 0$ or $h \uparrow 1$. Given $r > 0$ and $\beta > 1$, $\forall h \in (0,1)$ the TE is strictly increasing in: (i) the degree of risk in the foreign technology, r; and (ii) the degree of risk aversion, β.*

While uncertainty serves to accentuate the importance of the terms of trade improvement arising from a tariff, the real novelty lies in the DE, which was absent in (8).

PROPOSITION 3. *If $r = 0$ or $\beta = 1$, then $DE = 0$. If $r > 0$ and $\beta > 1$, then $\forall h \in (0,1)$ $DE > 0$ but in the limit as $h \uparrow 1$ $DE = 0$. Further, $\forall h \in (0,1)$ the DE is strictly decreasing in h, and strictly increasing in: (i) the degree of risk in the foreign technology r; and (ii) the degree of risk aversion β.*

The DE is rooted in imperfect risk sharing. In the current context where stock markets are absent, under free trade the critical sector ζ serves to equate the expected per-unit labor costs of Home with those of Foreign in accordance with (10) rather

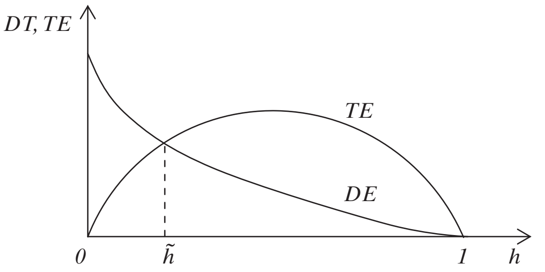

Figure 3. Welfare Impact of a Tariff Under Technological Uncertainty

than maximize expected welfare. Not only in this extreme situation but also in more general ones where risk sharing is incomplete, greater diversification in production reduces Home's exposure to risk and thereby increases its expected welfare such that $\partial\bar{W}/\partial\zeta > 0$.

In the presence of uncertainty in the foreign technology, as a result of the diversification effect there are benefits associated with tariffs even in the (ultra) small country case, which arises as $h \downarrow 0$. This prediction sharply contrasts the terms of trade motive, according to which the welfare maximizing optimal tariff for a small country is zero. Seen together, Propositions 2 and 3 imply that the greater the degree of trade risk or risk aversion, the greater the overall marginal benefit of implementing a tariff.

Figure 3 plots the relationships between country size and the TE and DE. The welfare benefit of a terms of trade improvement rises with h at first and then falls as $h \uparrow 1$ as under certainty but the effect is amplified under uncertainty. Since the DE is positive for all $h \in (0, 1)$ tariff-induced sectoral diversification increases expected welfare for any risk averse country when foreign technological requirements are uncertain. The DE is at its maximum in the small country case where $h \downarrow 0$ and it falls monotonically to zero as $h \uparrow 1$. As such, a small country gains most from sectoral diversification, with larger countries gaining less. This relationship between the welfare benefit of sectoral diversification and country size is solely driven by a country's ability to diversify across sectors using a tariff, which is greatest for a small country. Not surprisingly, the sub-interval of h over which the DE dominates the TE is wider when the risk of disturbances in foreign technological requirements is higher and/or risk tolerance is lower.

Proposition 4. *With uncertainty in foreign technology, there exists a unique critical country size* $\tilde{h}(\beta, r) \in (0,1)$ *such that: (i)* $DE > TE$ *when* $h < \tilde{h}$; *(ii)* $DE < TE$ *when* $\tilde{h} < h$; *and (iii)* $DE = TE$ *when* $h = \tilde{h}$. *Further,* $d\tilde{h}/dr > 0$ *and* $d\tilde{h}/d\beta > 0$.

Diversification always increases Home's expected welfare *ex-ante*, but may turn out to be a detrimental strategy *ex-post*. If state 1 is realized, the relative price of imports at the margin will be below the expected value of one. Accordingly, *ex-post* welfare would be higher if production was more specialized. The subjective weight placed on this "mistake" is low, however, since protecting risk averse agents from a price increase in the event of state 2 is relatively more important. *Ex-ante* sectoral diversification allows for hedging against the risk of a price increase and thereby provides "protection."

The diversification motive for tariffs examined in this paper relates to a portfolio diversification rationale for trade policy developed in Brainard (1991). Under this rationale, the government acts as an investor whose portfolio entails optimally diversified labor investments. To explain this rationale in the context of our model, we restate the DE as $DE = \sum_i \pi_i R_i \ln s_i^* d\zeta/dt = [\sum_i \pi_i R_i \sum_i \pi_i \ln s_i^* + \mathrm{cov}(R_i, \ln s_i^*)] d\zeta/dt$, where $\mathrm{cov}(R_i, \ln s_i^*)$ is the covariance between R_i and $\ln s_i^*$. Welfare improving diversification is achieved by using a tariff to shift labor from exporting sectors to newly established import-competing sectors. This shift changes the structure of Home's production by expanding the range of domestic commodities and contracting the range of exported commodities. Labor released from exporting sectors is fully absorbed by new sectors, and the fraction of labor reallocated this way equals $d\zeta/dt$.[15]

The safe investment of labor in new sectors aimed at domestic consumption is accompanied by an uncertain loss of return from reducing investment in exporting sectors. The expected net gain from the reallocation of labor is $\sum_i \pi_i \ln s_i^* = 0$, since $s_1^* = e^{-r}$ and $s_2^* = e^r$. Although there is not a positive net gain on average from the reallocation of labor, the diversification of labor investment is still welfare improving with risk aversion. This is because the foreign shock $\ln s_i^*$ and the perceived extent of risk R_i are positively related, i.e. $\mathrm{cov}(R_i, \ln s_i^*) > 0$. Diversification reduces Home's exposure to trade-related risk and so increases Home's expected welfare at the margin.

With the simple structure of technology and preferences in our model, the relationships between country size and the impact of a tariff on expected welfare in (14) are clear cut.

Proposition 5. *With uncertainty in foreign technology, the welfare impact of a tariff is positive* $\forall h \in (0, 1)$. *There exists a unique cutoff risk* $\tilde{r}(\beta)$ *such that the welfare impact of a tariff either (i) falls monotonically with h from its maximum where* $h \downarrow 0$, *if* $r \geq \tilde{r}(\beta)$*; or (ii) rises with h initially and then falls, if* $r < \tilde{r}(\beta)$. *Further,* $d\tilde{r}/d\beta < 0$.

Figure 4 plots (14) as a function of h for sample values of $r \geq \tilde{r}(\beta)$ and $r < \tilde{r}(\beta)$. Naturally, the cutoff risk $\tilde{r}(\beta)$ is low when risk tolerance is low (i.e. β is high). If the risk of disturbances in foreign technological requirements r is high or risk tolerance is low so that $r \geq \tilde{r}(\beta)$, the diversification effect is sufficiently strong that the welfare benefit of a tariff falls monotonically from its maximum in the small country case (i.e. where $h \downarrow 0$) to zero as $h \uparrow 1$. Consequently, a smaller country gains more than a larger country from imposing a tariff across the full range of relative sizes. If, in contrast, risk r is low and/or risk tolerance is high so that $r < \tilde{r}(\beta)$, the diversification is sufficiently weak that the welfare benefit of a tariff initially rises with the relative size of Home and falls as h approaches one.[16]

Even if Home's technology is also subject to risk, our results would remain qualitatively unchanged provided that the there is greater uncertainty in the foreign

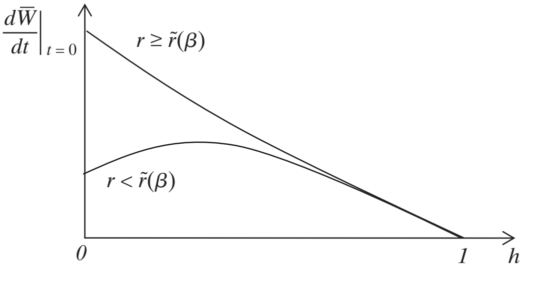

Figure 4. Welfare Impact of a Tariff Under Technological Uncertainty

technology, perhaps because Home residents have better information about their own technologies. In the less likely event that Home residents are better informed about the Foreign technology than there own, however, tariff induced diversification would expose Home to increased rather than decreased risk. In this case it can be shown that the relationship between country size and the diversification effect of a tariff on welfare is U-shaped with $DE < 0\ \forall h \in (0, 1)$ and $DE = 0$ as $h \downarrow 0$ or $h \uparrow 1$. Interestingly, if there is a sufficiently high degree of risk and/or risk aversion, the negative diversification effect can overpower the terms of trade effect such that the marginal damage associated with a tariff is smaller for smaller countries and there is less disincentive for smaller countries to impose tariffs.[17]

Uncertainty in Foreign Demand

Suppose now that the foreign technology is certain and that uncertainty is instead associated with random disturbances in foreign preferences. Whereas before Foreign's expenditures were uniform across all goods such that $b^*(z) = 1$, these expenditure shares are now subject to a demand shock $\delta_i^* > 0$ that displaces spending from imports to domestically produced goods or *vice versa*: $b_i^*(z) = \delta_i^*$ for all $z \in [0, \zeta^*]$ and $b_i^*(z) = [1 - \zeta^* \delta_i^*]/[1 - \zeta^*]$ for all $z \in (\zeta^*, 1]$.[18] As before, two states of nature i can arise with equal probability of $\pi_i = 0.5$. The state-contingent demand shocks are $\delta_1^* = e^{-\nu}$ and $\delta_2^* = e^{\nu}$, where the parameter $\nu > 0$ measures the degree of demand risk. The geometric mean is equal to one such that $\bar{\delta}^* = \sqrt{\delta_1^* \delta_2^*} = 1$ corresponds with the certain demand. Since $\delta_2^* > 1$ and $\delta_1^* < 1$, Foreign's budget share shifts away from its own domestic goods and toward imports from Home in state 2 and *vice versa* in state 1.[19] An increase in ν spreads δ_1^* and δ_2^* further apart while preserving the mean and so, increases uncertainty.

As under technological uncertainty, the sectors ζ and ζ^* are pre-determined prior to uncertainty being resolved. The *ex-ante* decisions on production and trade are guided by the certainty wage $\bar{\omega}$ given by (9), with ζ and ζ^* linked to $\bar{\omega}$ as in (10). Thus, the *ex-ante* production and trade decisions remain the same as in the certainty equilibrium. In particular under free trade, the *ex-ante* relative wage is $\bar{\omega} = 1$ and the ensuing critical sectors of both countries are commensurate with country size such that $\zeta = \zeta^* = h$.

Uncertainty in demand differs from uncertainty in technology in two important respects. First, import prices that Home faces are no longer state contingent since $p_i(z) = p(z) = (1 + t)a^*(z)$. Second, *ex-post* relative wages are no longer constant but depend now on the state of the world as follows:[20]

$$\omega_i(\zeta, \zeta^*) = \frac{1-h}{h} \frac{\delta_i^* \zeta^*}{1-\zeta} [1 + t\zeta], \quad i = 1, 2. \tag{17}$$

Using (10), we obtain $\omega_i = \delta_i^* \bar{\omega}$, which reduces to $\omega_i = \delta_i^*$ under free trade. Not surprisingly, Home's *ex-post* relative wage ω_i is greater than $\bar{\omega}$ in state 2 where Foreign demand for Home goods is unexpectedly high and *vice versa* in state 1.

While (11) continues to determine Home's expected welfare, the state-contingent general consumption level is now $\ln X_i = (1-\zeta)\ln\omega_i + \zeta\ln(1+t) - \ln(1+\zeta t) - \int_0^{\zeta} \ln a(z)dz - \int_{\zeta}^{1} \ln a^*(z)dz$. Hence under free trade, $\bar{W} = \sum_i \pi_i \rho_i/(1-\beta) = \rho/(1-\beta)$, where $\rho_i \equiv e^{(1-\beta)(1-h)\ln\delta_i^*}$ and $\rho \equiv \sum_i \pi_i \rho_i$. An increase in the perceived extent of risk, $\rho = 0.5[e^{(\beta-1)(1-h)v} + e^{-(\beta-1)(1-h)v}]$, continues to reduce expected welfare. Again, the perceived extent of risk rises with the degree of risk aversion or risk *per se*, but falls as the range of domestic production rises owing to larger country size. Thus, Home's expected welfare is reduced by either uncertainty in foreign demand or foreign technology.

We can continue to use (14) to summarize the impact of a tariff, but now the terms of trade and diversification effects on expected welfare are: $TE = \sum_i \pi_i (1-h)\rho_i [d\omega_i/\omega_i]/dt = (1-h)h\rho$ and $DE = -\sum_i \pi_i \rho_i \ln \delta_i^* d\zeta/dt = (1-h)v\theta$, where $\theta = 0.5[e^{(\beta-1)(1-h)v} - e^{-(\beta-1)(1-h)v}] = \rho - \rho_2 > 1$ is the measure of the perceived spread of risk. Since these expressions are structurally equivalent to (15) and (16), Propositions 2–5 also apply when foreign demand, rather than technology, is uncertain. Thus, the welfare improvement associated with tariff protection is not specific to the source of foreign uncertainty.[21]

4. Conclusion

This paper has focused on how the welfare incentive for countries to implement tariffs and deviate from free trade is affected by foreign risk and varies with country size.[22] A Ricardian continuum-of-goods model has been employed to show that sectoral diversification may provide a significant second-best motive for tariff protection when both international and domestic risk-sharing are incomplete, the trade environment is uncertain and commitments to production and trade are made before uncertainty is resolved. While diversification may end up being welfare-reducing *ex-post*, it increases expected welfare *ex-ante*. Clearly, increased production specialization, rather than diversification, would have been beneficial when domestic real income happens to be above its expected value. The relative importance of this concern, however, is low since with risk aversion, a welfare loss from a decline in real income is weighted more heavily than a gain from an equivalent increase in real income.

In our model, tariff protection encourages the sectoral diversification of domestic production and in so doing, mitigates external risk and increases expected welfare. The diversification motive for tariff setting is particularly strong in small countries. Not only do small countries face higher exposure to external risk, but they also have a greater ability to diversify across sectors precisely because the protective effect of a tariff is not partially eroded by a terms-of-trade improvement. With sufficiently high risk and risk aversion, the diversification motive for tariffs has a predominant effect on the relationship between country size and the benefits of tariffs. The relationship between the welfare effect of a tariff and country size is no longer dictated primarily by a country's ability to affect the world price, but rather by its ability to diversify production across sectors.

The analysis in this paper suggests important avenues for future empirical work linking levels of protection with the degree of trade-related risk and country size. For countries of all sizes, it is predicted that the extent of protection should be increasing in the degree of risk. The relationship between tariff protection and country size, however, depends critically on the degree of risk. Tariff protection should (i) fall monotonically with country size *when risk is high*, in which case the diversification motive dominates the terms of trade motive, or (ii) initially rise with country size and then fall *when risk is low*, in which case the terms of trade motive is dominant. While Amin and Haidar (2013) find that restrictive "trade facilitation" measures increase with country size suggesting that the terms of trade effect may be dominant, their analysis does not consider uncertainty and includes only one aspect of protectionism, albeit an increasingly important one. Consequently, one senses that there could be more to the story of protectionism, country size and risk.[23]

Appendix

Proof of Proposition 1

Differentiating (6) with respect to t and ω and evaluating the result at $t = 0$ and $\omega = 1$, we obtain $F_t = h(1 + h - h^2)$ and $F_\omega = -(1 + h - h^2)$. It follows from the implicit function theorem that $[d\omega/\omega]/dt = -F_t/[\omega F_\omega] = h$. Then from (2) we obtain $d\zeta/dt = 1 - [d\omega/\omega]/dt = 1 - h$ and $d\zeta^*/dt = -[d\omega/\omega]/dt = -h$.

Proof of Propositions 2 and 3

To help establish that the terms of trade effect remains single-peaked under uncertainty, note that $dR/dh = -\psi_0 Q \leq 0$ and $dQ/dh = -\psi_0 R < 0$, where $R = 0.5[e^{\psi} + e^{-\psi}]$, $Q = 0.5[e^{\psi} - e^{-\psi}]$, $\psi \equiv [1 - h]\psi_0 > 0$, and $\psi_0 \equiv [\beta - 1]r > 0$. Differentiating $TE = Rh(1 - h)$ we find:

$$\frac{dTE}{dh} = \tilde{K}R - \tilde{J}Q = \left[\frac{\tilde{K}}{\tilde{J}} - \xi\right]\tilde{J}R \quad \text{and} \tag{A1}$$

$$\frac{d^2TE}{dh^2} = -\left\{2 + [1-2h]\psi_0\xi - \left[\frac{h}{1-h}\right]\left[1 - \frac{\xi\tilde{K}}{\tilde{J}}\right]\psi^2\right\}R, \tag{A2}$$

where $\tilde{J} \equiv h\psi$, $\tilde{K} \equiv 1 - 2h$, $\xi \equiv \dfrac{Q}{R} = \dfrac{e^{2\psi} - 1}{e^{2\psi} + 1}$.

From (A1), $dTE/dh > 0$ in the limit as $h \downarrow 0$ and $dTE/dh < 0$ as $h \uparrow 1$, which implies at least a single peak since the TE function is continuous and smooth. For any h^* where the TE function is stationary, it must be the case that $\tilde{K} = 1 - 2h^* > 0$ or $h^* < 0.5$. Assessing (A2) where $h = h^*$ and $\tilde{K}/\tilde{J} = \xi$ yields:

$$\frac{d^2TE(h^*)}{dh^2} = -\left\{2 + [1-2h^*]\psi_0\xi - \left[\frac{h^*}{1-h^*}\right][1-\xi^2]\psi^2\right\}R < 0. \tag{A3}$$

To establish that the slope of the TE function is diminishing at any point at which it is equal to zero such that (A3) is negative, we observe that $h^*/[1 - h^*] < 1$ and

$$[1-\xi^2]\psi^2 = \frac{[2\psi]^2}{e^{2\psi} + e^{-2\psi} + 2} < \frac{[2\psi]^2}{e^{2\psi}} < 1. \tag{A4}$$

Over the restricted domain where $\psi \geq 0$, the function $[2\psi]^2/e^{2\psi}$ achieves a unique maximum of 0.541 at $\psi = 1$. Since the TE function is continuous and smooth, the fact that (A3) is negative implies that there is exactly one stationary point h^*, which is a unique interior maximum falling on the sub-interval (0,0.5). As h rises, once dTE/dh becomes negative it must remain negative because it is continuous and cannot again rise to zero.

Next, we show that the diversification effect declines monotonically in country size. Differentiating $DE = rQ(1 - h)$ with respect to h, we obtain $dDE/dh = -r[Q + (1 - h)\psi_0 R]$ and $d^2DE/dh^2 = r\psi_0[2R + \psi_0 Q] > 0$. Consequently, $dDE/dh < 0$ for all $h \in (0, 1)$.

Finally, when $\beta > 1$ and $r > 0$, (i) $R_r > 0$ and $Q_r > 0$; (ii) $R_\beta > 0$ and $Q_\beta > 0$. Hence, the risk-related results in Proposition 2 follow immediately from (15) and those in Proposition 3 follow immediately from (16).

Proof of Proposition 4

Since $r > 0$ and $\beta > 1$, we have: (i) $TE = 0$, $dTE/dh > 0$, $DE > 0$ and $dDE/dh < 0$ as $h \downarrow 0$; and (ii) $TE = 0$, $dTE/dh = -1$, $DE = 0$ and $dDE/dh = 0$ as $h \uparrow 1$. Since the TE and DE functions are both continuous in h, they must cross at least once on the interval (0, 1). Further, $TE - DE = 0.5[(r + h)e^{-\psi} - (r - h)e^{\psi}](1 - h)$, which is equal to zero when $H(h; r, \beta) \equiv e^{-2\psi} - [r - h]/[r + h] = 0$ where $\psi \equiv [1 - h][\beta - 1]r$. We note that H is continuous and H_h is strictly positive. Since $H(h; r, \beta) < 0$ in the limit as $h \downarrow 0$ and $H(h; r, \beta) > 0$ in the limit as $h \uparrow 1$, there exists a unique $\tilde{h}(r, \beta) \in (0, 1)$ that sets H equal to zero. Consequently, $H \geq 0$ and $TE{-}DE \geq 0$ when $1 > h \geq \tilde{h}(r, \beta)$; but $H < 0$ and $TE{-}DE < 0$ when $0 < h < \tilde{h}(r, \beta)$. We next find that $\tilde{h} < r$ because $H > 0$ when $h = r$ and $H_h > 0$. Also since $\tilde{h} < r$, the condition $h \geq r$, which is sufficient for $TE{-}DE > 0$, is consistent with the condition $h > \tilde{h}$, which is necessary for $TE{-}DE > 0$. Finally, $d\tilde{h}/dr = -H_r/H_h > 0$ and $d\tilde{h}/d\beta = -H_\beta/H_h > 0$ since $H_h > 0$, $H_\beta < 0$, and $H_r < 0$.

Proof of Proposition 5

The overall marginal benefit of Home's tariff t on its welfare starting at free trade is: $OE(h; r, \beta) \equiv d\bar{W}/dt|_{t=0} = Rh(1-h) + rQ(1-h)$, which is strictly increasing in both r and β given that initially $r > 0$ and $\beta > 1$. We obtain:

$$\frac{dOE(h)}{dh} = KR - JQ = \left[\frac{K}{J} - \xi\right] JR, \quad \text{and} \tag{A5}$$

$$\frac{d^2OE(h)}{dh^2} = -\left\{2[1-\kappa] + [1-2h]\psi_0\xi + \frac{\kappa\xi K}{J} - \left[\frac{h}{1-h}\right]\left[1 - \frac{\xi K}{J}\right]\psi^2\right\} R, \tag{A6}$$

where

$$J \equiv r + \psi h > 0, \quad K \equiv 1 - \kappa - [2-\kappa]h, \quad \xi \equiv \frac{Q}{R} = \frac{e^{2\psi} - 1}{e^{2\psi} + 1},$$

$$\kappa \equiv r\psi_0, \quad \psi \equiv (1-h)\psi_0 \quad \text{and} \quad \psi_0 \equiv (\beta - 1)r.$$

From (A5), a sufficient but not necessary condition for the overall marginal benefit of a tariff to decline monotonically in h over the interval (0, 1) is to have $K(0) < 0$, which arises whenever $\kappa > 1$ or $r \geq [\beta - 1]^{-0.5}$. Conversely, for the overall marginal benefit of a tariff to be stationary in h, such that (A5) is equal to zero at some h^{**}, it is necessary to have $K(h^{**}) > 0$, and thus $0 \leq \kappa < 1$. Further, it must be the case that $h^{**} < (1 - \kappa)/(2 - \kappa) < 0.5$. Assessing (A6) where $h = h^{**}$ and $K/J = \xi$ yields:

$$\frac{d^2OE(h^{**})}{dh^2} = -\left\{2[1-\kappa]+[1-2h^{**}]\psi_0\xi+\kappa\xi^2-\left[\frac{h^{**}}{1-h^{**}}\right][1-\xi^2]\psi^2\right\}R<0. \quad \text{(A7)}$$

To establish that the slope of the overall marginal benefit function is diminishing at any point that it is equal to zero, we observe that $h^{**}/(1 - h^{**}) < (1 - \kappa)$ and make use of (A4). Since the *OE* function is continuous and smooth, the fact that (A7) is negative implies that there is *at most* one stationary point. As h increases the overall marginal benefit of a tariff must eventually decline. Once (A5) becomes negative, it can never become positive because it cannot rise to zero. Consequently, the *OE* function must have a unique global maximum, which may either be a boundary maximum as $h \downarrow 0$ or an internal maximum at an h^{**} on a sub-interval $(0, [1 - \kappa]/[2 - \kappa])$.

The necessary and sufficient condition for a boundary maximum is that (A5) is less than or equal to zero when evaluated at $h \downarrow 0$ or $G(r, \beta) \equiv 1 - \kappa - r\xi_0 \leq 0$, where $\xi_0 \equiv Q_0/R_0 = [e^{2\psi_0}-1]/[e^{2\psi_0}+1]$. Since we have already seen that $\kappa \equiv [\beta-1]r^2 \geq 1$ is sufficient for a unique boundary maximum in *OE*, we now focus on the situation where $\kappa < 1$. It can be observed that $G_r < 0$ because ξ_0 increases as r and thus $\psi_0 \equiv [\beta - 1]r$ rise. Therefore there exists a unique $\tilde{r}(\beta)$, which solves $G(r, \beta) = 0$, such that $G \leq 0$ when $r \geq \tilde{r}(\beta)$ and $G > 0$ when $r < \tilde{r}(\beta)$. It follows that if $r \geq \tilde{r}(\beta)$, then $dOE/dh < 0$ when $h \in (0, 1)$. If $r < \tilde{r}(\beta)$, then $dOE/dh > 0$ when $h \downarrow 0$. As h rises, however, dOE/dh eventually falls to zero and becomes permanently negative. Further, $d\tilde{r}/d\beta = -G_\beta/G_r < 0$ since $G_\beta < 0$ and $G_r < 0$.

References

Amin, M. and J. I. Haidar, "Trade Facilitation and Country Size," *Empirical Economics* Online first December (2013), doi: 10.1007/s00181-013-0781-7.

Batra, R. and W. Russell, "Gains from Trade Under Uncertainty," *American Economic Review* 64 (1974):1040–48.

Brainard, S. L., "Protecting Losers: Optimal Diversification, Insurance, and Trade Policy," NBER working papers 3773 (1991).

Cassing, J. H., A. L. Hillman, and N. V. Long, "Risk Aversion, Terms of Trade Uncertainty and Social-Consensus Trade Policy," *Oxford Economic Papers* 38 (1986):234–42.

di Giovanni, J. and A. A. Levchenko, "Trade Openness and Volatility," *The Review of Economics and Statistics* 91 (2009):558–85.

Dixit, A., "Strategic Aspects of Trade Policy," in T. F. Bewley (ed.), *Advances in Economic Theory: Fifth World Congress*, New York: Cambridge University Press (1987): 329–62.

Dornbusch, R., S. Fisher, and P. A. Samuelson, "Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods," *American Economic Review* 67 (1977):823–39.

Eaton, J., "The Allocation of Resources in an Open Economy with Uncertain Terms of Trade," *International Economic Review* 20 (1979):391–403.

Eaton, J. and G. M. Grossman, "Tariffs as Insurance: Optimal Commercial Policy when Domestic Markets are Incomplete," *Canadian Journal of Economics* 18 (1985):258–72.

Flemming, J., S. Turnovsky, and M. Kemp, "On the Choice of Numeraire and Certainty Price in General Equilibrium Models of Price Uncertainty," *Review of Economic Studies* 44 (1977):573–83.

Grossman, G. M. and E. Helpman, "Protection for Sale," *The American Economic Review* 84 (1994):833–50.

Helpman, E. and A. Razin, *A Theory of International Trade under Uncertainty*, New York: Academic Press (1978).

Johnson, H. G., "Optimum Tariffs and Retaliation," *Review of Economic Studies* 21 (1953–54):142–53.

Kalemli-Ozcan, S., B. E. Sørensen, and O. Yosha, "Risk Sharing and Industrial Specialization: Regional and International Evidence," *The American Economic Review* 93 (2003):903–18.

Kennan, J. and R. Riezman, "Do Big Countries Win Tariff Wars?" *International Economic Review* 29 (1988):81–85.

Lewis, K. K., "Puzzles in International Financial Markets," in G. M. Grossman and K. Rogoff (Eds), *Handbook of International Economics*, 1st edn, vol. 3, chap. 37, Amsterdam: Elsevier (1995): 1913–71.

———, "What Can Explain the Apparent Lack of International Consumption Risk Sharing?" *Journal of Political Economy* 104 (1996):267–97.

Newbery, D. M. G. and J. E. Stiglitz, "Pareto Inferior Trade," *The Review of Economic Studies* 51 (1984):1–12.

Obstfeld, M., "International Capital Mobility in the 1990s," NBER working papers 4534 (1993).

Rodrik, D., "Why Do More Open Economies Have Bigger Governments?" *Journal of Political Economy* 106 (1998), 997–1032.

Turnovsky, S. J., "Technological and Price Uncertainty in a Ricardian Model of International Trade," *The Review of Economic Studies* 41 (1974):201–17.

Notes

1. For example, see Johnson (1953), Dixit (1987), Kennan and Riezman (1988).

2. There are, of course, many rationales for protection from imports. Political-economy considerations may be the most obvious and important motivation for protection (e.g. Grossman and Helpman, 1994). In the current context, it is possible that the counterbalance to lobbying efforts from import-competing sectors may be systematically weaker in smaller countries with fewer export sectors. While recognizing that the political motive for tariffs could be negatively correlated with size, our modeling strategy in this paper is to explore the link between country size and economic rationales for tariffs under uncertainty.

3. For example, see Obstfeld (1993), Lewis (1995), Lewis (1996) and Kalemli-Ozcan et al. (2003).

4. In effect, there is asymmetric information whereby agents in the Home country are better informed about domestic, as opposed to foreign, technologies and preferences.

5. In a Ricardian model with two risky exporting sectors, Brainard (1991) showed that trade policy can help achieve the socially optimal diversification of human capital investment. *Ex-post* protection redistributes wealth from winners to losers and so insures returns to human capital investment and encourages workers to diversify between the sectors *ex-ante*. The sectoral diversification motive for tariffs examined in our paper differs from the portfolio diversification rationale for trade policy developed in Brainard (1991). In Brainard (1991), optimal diversification is achieved by using state-contingent trade policy to protect losers *ex-post*, which is analogous to the insurance motive for trade protection made in Eaton and Grossman (1985). In our paper, in contrast, the government is diversifying its portfolio of production commitments *ex-ante*.

6. We thank an anonymous referee for helping us clarify the paper's contribution

7. This formulation of relative productivity represents an important first step in the construction of a free-trade equilibrium where the Home and Foreign wages are equal and the fraction of goods produced in Home always corresponds to its share of the world labor force. If instead $A(z)$ was independent of h, an increase in Home's relative size would depress its free-trade relative wage to allow it to be competitive over a larger range of goods. Having larger size connected with lower equilibrium relative productivity would unnecessarily complicate the interpretation of our results.

8. The utility function continues to be increasing in X and each $c(z)$ and generally well-behaved, even when $\beta > 1$ and the ordinal utility numbers are negative. When $\beta \to 1$, l'Hopital's Rule implies that the utility function takes on a standard logarithmic form, $U = \ln X$.

9. Using (4), we obtain $[[1 - V(\zeta)]y - \omega]h + V^*(\zeta^*)y^*[1 - h] = 0$. Home's per-capita income consists of wages and per capita tariff rebates: $y = \omega + T$, where $T = t\int_\zeta^1 p(z)c(z)dz/[1+t] = tyV(\zeta)/[1+t]$. Thus, $y = [1 + t]\omega/[1 + t - tV(\zeta)]$. Since Foreign's income consists of labor income such that $y^* = w^* = 1$, result (5) follows. The labor market clearing condition for Foreign is redundant by Walras' law.
10. The critical sectors coincide because all goods are traded under free trade. Figure 1 shows the impact of a Home tariff on the equilibrium starting from free trade. Since Home's tariff increases the relative price of imports, the $C(\zeta, \omega)$ schedule shifts out as ζ rises for every value of ω. Further, the increase in t and ζ at the initial ω would imply excess demand for Home's labor. Consequently, the equilibrium ω rises shifting the $F(\omega)$ schedule upward. Because a higher ω worsens the relative competitiveness of Home's production, ζ^* falls along the $C^*(\zeta^*, \omega)$ schedule and the increase in ζ is attenuated by the move along the new $C(\zeta, \omega)$ schedule.
11. To obtain this result, substitute (4) and $y = (1 + t)\omega/(1 + t\zeta)$ into (3).
12. In the context of terms of trade uncertainty, Flemming et al. (1977) show that an AMPS is an inappropriate measure of central tendency. When an arithmetic mean is used as the certainty price, the convexity-concavity property of the indirect utility function depends on the choice of numeraire. To avoid this problem, geometric mean should be used instead. Eaton (1979), Eaton and Grossman (1985), and Cassing et al. (1986) are the examples of studies where uncertainty is characterized as a GMPS.
13. Flemming et al. (1977) show that the coefficient of absolute risk aversion (ARA) with respect to a GMPS equals the coefficient of relative risk aversion (RRA) with respect to an AMPS minus one. From (3), the coefficient of RRA with respect to an AMPS is $-XU''(X)/U'(X) = \beta$, and the coefficient of ARR with respect to a GMPS is $-U''(\ln X)/U'(\ln X) = \beta - 1$.
14. As we will see shortly, these results change when foreign technology is certain and uncertainty is instead associated with random disturbances in Foreign's expenditure shares given by $b_i^*(z)$. In this scenario, the relative wage will vary (because $V^*(\zeta^*)$ in (5) will vary) but the prices of foreign goods will remain constant at $p^*(z) = a^*(z)$ and $p(z) = (1 + t)a^*(z)$. With less restrictive preferences, both the relative wage and product prices will vary under either type of uncertainty.
15. The contraction in the range of exported commodities frees $L^*c_i^*(\zeta)a(\zeta)(-d\zeta^*/dt) = Ld\zeta/dt$ units of labor while the expansion in the range of domestic production requires $Lc_i(\zeta)a(\zeta)(d\zeta/dt) = Ld\zeta/dt$ extra units of labor.
16. These result are suggested by Proposition 4, which stipulates that when r and/or β are higher (lower), the critical country size $\tilde{h}(\beta, r)$ is higher (lower) and, thus, the DE dominates the TE over a wider (narrower) range of h.
17. We thank an anonymous referee for suggesting the analysis of domestic uncertainty. Further details can be found in a supplement to this paper available from the authors.
18. Expenditure shares across the entire continuum continue to sum to one such that $\int_0^1 b_i^*(z)dz = 1$.
19. In state 2, $b_2^*(z) > 1$ for all $z \in [0, \zeta^*]$ and $b_2^*(z) < 1$ for all $z \in (\zeta^*, 1]$.
20. When reformulating (5) on a state contingent basis, it should be noted that Foreign's expenditure on imports is now $V_i^*(\zeta^*) = \delta_i^*\zeta^*$.
21. The risk-mitigating role of tariff protection generalizes to any type of uncertainty where the diversification of production reduces exposure to risk. Not all random disturbances meet this criterion, however. For example in (1), if $\alpha = h + \gamma_i$ where $\gamma_1 = -\gamma_2$, both the Home and Foreign technologies in the vicinity of the critical sector $\zeta = \zeta^* = h$ are subject to uncertainty. Thus, tariff-induced diversification of Home's production does not reduce risk, and there is not a favorable diversification effect on welfare.
22. As an anonymous referee points out, it is also interesting to consider the related but more mathematically challenging questions of how the height of a country's optimal tariff is affected by risk and varies with country size. It can be shown that the height of optimal tariff, t^o, is increasing in both the degree of risk r and the degree of risk aversion β. Further, if r and/or β

are sufficiently high, the diversification effect is prevalent in the sense that the optimal tariff is decreasing in country size h both in the limit as $h \downarrow 0$ and as $h \uparrow 1$. In contrast, if r and/or β are sufficiently low, the terms of trade effect prevails such that the optimal tariff initially increases in h in the limit as $h \downarrow 0$ but eventually falls in h as $h \uparrow 1$. Details can be found in a supplement available from the authors.

23. Indeed, preliminary empirical work available in a supplement from the authors suggests that the diversification effect may be dominant overall.