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Firms in international trade under undesirable background risk

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GEP

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Abstract

This paper presents a mean-variance decision making approach in the context of a risk-averse exporting firm, for analysing its optimal production and exporting decision in the portfolio of sales towards domestic and foreign markets, under unfair background risk, such as greater chance of loss for the export credit insurance (possibly offered under non-proportional reimbursement), or unprecedented negative externalities imposed by the partner country's government on the home country's export policies. Then this paper traces out the comparative static responses of optimal export sales owing to the changes in distribution, size, or in the dependence structure of the background risk. Adaptation of the mean-variance decision-theoretic model helps obtaining all the results in terms of monotonicity and curvature properties of the marginal willingness of substitution between risk and return, with simple yet intuitive interpretations.

Keywords: Exports; Unfair background risk; Decision under risk; Mean-variance model; Risk aversion.

JEL Classifications: D21; D81; F41.

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1. Introduction.

There are a number of theoretical works that explored production and export decisions of exporting firms under exchange rate uncertainty using the standard von Neumann-Morgenstern expected utility representation (see, for example, Kawai and Zilcha, 1986; Viaene and Zilcha, 1998; Broll and Eckwert, 1999; to name just a few). Recently, Broll and Mukherjee (2017) offered firm-level decision-theoretic analysis for production allocation problem between the domestic and foreign markets under exchange rate uncertainty.

This paper, extends Broll and Mukherjee (2017) by answering another important-yet-unexplored question: analysing the optimal export decision of a firm producing for both domestic and foreign markets, owing to the changes in the background risk. Example of such background risk could be increased chance of loss for the export credit insurance offered under non-proportional reimbursement (Funatsu, 1986).[1] On the top of that, there might be instances of unprecedented macro shocks owing to the governmental policy objectives, such as the much discussed terms-of-trade (ToT hereafter) externality (see, for example, Ethier, 2007), and/or 'political externality' which prevents the exporting country's domestic government to assist the exporting firms, owing to the protectionist policies of the partner country's government (see, for example, Ethier, 2004; 2011; 2013; Ethier and Hillman, 2018). Therefore, this paper characterises the such various sources of risks as an aggregated "unfair" background risk[2], which may either be independent or dependent upon the exchange rate risk. The importance of an unfair background risk on an exporting firm's production allocation decision between domestic markets (with certain return) and international market

[1] As shown in Funatsu (1986), under non-proportional reimbursement, risk-averse and risk-neutral firm will always opt for partial coverage. Therefore, the firm will have to incur any loss additional to the sum insured amount.

[2] In this paper, we focus only on the unfair background risk in particular: since, either in case of higher possibility of loss under export credit insurance with non-proportional reimbursement option, or in case of political externality or ToT externality, the expected value of total profit always gets depressed being confronts with such risk.

(risky return) has first been explored in this paper, using a simple theoretical framework. However, we abstract from the hedging possibility of the firm.

This paper applies a two-moment decision model (i.e. mean – variance model), which has been acknowledged as a meaningful alternative model of risk preferences to the expected utility approach (Ormiston and Schlee, 2001; Epstein, 1985). The major advantage is its intuitive simplicity: everything can be comprehended in terms of the trade-offs between return and risk. This flexibility allows us to yield simpler and interpretable comparative static results of the tampering effect of unfair background risk on the exporting firm's decision problem. Such exercise would have been too complex in the expected utility framework.

This paper is organised as follows: section 2 illustrate the model, section 3 discusses the comparative static results of the changes in the distribution of background risk, section 4 traces out the impact of being confronted with an additional 'unfair' background risk, while the impact of change in the dependence structure between the two sources of risks has been illustrated in section 5. After that section 6 demonstrates the robustness of our generic results in the light of an example. Finally, section 7 concludes.

2. The Model.

This paper studies a firm that serves both the domestic market and a foreign country market, facing a downward sloping residual demand curve at home and abroad. Denoting the random spot exchange rate (expressed in units of the home currency per unit of foreign currency) as $\tilde{e}$, price schedule of the exportable x as (in units of foreign currency) $p(x)$; price schedule of the product y sold in the domestic market as (in units of domestic currency) $p(y)$; concave revenue functions in both home and foreign markets (in units of their respective currencies) as $R(x)$ and $R(y)$. $\tilde{Z}$ denotes the background risk, entering 'passively' the profit function as uncertain frictions to trade, whereas $\beta > 0$ is used to scale the background risk up or down.

$$\tilde{\pi} = \tilde{e}R(x) + R(y) - C(x + y) + \beta\tilde{Z}. \quad (1)$$

For any random variable $\widetilde{W}$, the mean and variance are denoted by respectively, μ_W and v_W. For the pair of random variables $\tilde{e}$ and $\tilde{Z}$, $\text{Cov}(\tilde{e}, \tilde{Z})$ denotes their covariance. The variance and mean of final profit can then be written respectively as

$$v_\pi = v_e R(x)^2 + \beta^2 v_Z + 2\beta R(x)\text{Cov}(\tilde{e}, \tilde{Z}) \quad (2)$$

$$\mu_\pi = \mu_e R(x) + R(y) - C(x+y) + \beta\mu_Z = \mu_{\pi_e} + \beta\mu_Z \quad (3)$$

Where μ_{π_e} is the mean of the final profit without background risk.

Since the final profit is a linear function of the random variables, correlation (or covariance) serves as the most appropriate parameters to characterize how the dependence structures between the between the exchange rate risk and the background risk would affect the profit-risk (see, for example, Embrechts et al., 2002).

The preference function of the firm is $U = U(\mu_\pi, v_\pi)$, with $U_\mu(\mu_\pi, v_\pi) > 0$, $U_v(\mu_\pi, v_\pi) < 0$. In other words, we are assuming that the preference of the exporter satisfies non-satiation and the exporter is risk-averse[3], wherein the indifference curves in (μ_π, v_π)-space are upward-sloped.

The marginal rate of substitution (MRS) between risk and return is defined by

$$S(\mu, v) = -\frac{U_v(\mu_\pi, v_\pi)}{U_\mu(\mu_\pi, v_\pi)}.$$

$S > 0$ is the two-parameter equivalent to Arrow–Pratt measure of absolute risk aversion (or, equivalently, risk attitude). This measures the willingness to pay for a reduction in risk in terms of expected return.

The firm solves the following problem:

$$\max_{(x, y \geq 0)} U(\mu_\pi, v_\pi) \text{ s.t. (2) \& (3)} \quad (4)$$

[3] Recent empirical evidence (see, for example, Nakhoda, 2018) states on the fact that the prospective exporting firms of developing countries tend to accumulate long-term secured loans in the period prior to their entry into the export market. This also implies that the exporters are generally risk-averse.

The interior solution[4] for (x^*, y^*) holds if and only if

$$U_\mu(\mu_\pi^*, v_\pi^*)\big(\mu_e R'(x^*) - C'(x^* + y^*)\big) + U_v(\mu_\pi^*, v_\pi^*)(\partial v_\pi(x^*)/\partial x) = 0 \quad (5)$$

and

$$U_\mu(\mu_\pi^*, v_\pi^*)\big(R'(y^*) - C'(x^* + y^*)\big) = 0 \quad (6)$$

From (6) we obtain

$$R'(y^*) = C'(x^* + y^*) \quad (7)$$

since $U_\mu(\mu_\pi^*, v_\pi^*) > 0$. This demonstrates the fact that the total amount of production of the firm, $x^* + y^*$, is independent of the firm's attitude towards risk and of the probability distribution of the random marginal export revenue. However, the allocation of production between domestic supply and exports depends on the firm's risk preferences.

From Eq. 5 we obtain

$$\{\mu_e R'(x^*) - R'(y^*)\}/(\partial v_\pi(x^*)/\partial x) = S(\mu_\pi^*, v_\pi^*) \quad (8)$$

The term $\{\mu_e R'(x^*) - R'(y^*)\}$ in Eq. 8 is merely the risk premium of the firm for the risky activity of exporting. This is always positive owing to the assumption of risk aversion.

Therefore, from Eq. 8, we would always have, $(\partial v_\pi/\partial x) > 0$, which implies that in this scenario with no hedging possibilities, exporting is risky.

Also, we are going to ascertain that an upscaling of background risk would aid to the overall riskiness of the exporting activity, i.e.

$$(\partial v_\pi(x^*)/\partial \beta) = 2\big[\beta v_Z + \mathrm{Cov}(\tilde{e}, \tilde{Z})R(x^*)\big] > 0, \quad (9)$$

which always holds true if $\mathrm{Cov}(\tilde{e}, \tilde{Z}) > 0$. However, in the literature of trade policy interventions, this assumption speaks the reality: a depreciation of the exporting

[4] Corner solution in this scenario, as demonstrated in Broll and Mukherjee (2017), would entail the possibility of zero exports ($x^* = 0$), which is not the focus of this paper.

country's currency (which is reflected by an increase in $\tilde{e}$ in our framework) encourages to export more and consequently increases the possibility of incurring more loss owing to the availability of only partial coverage of the export credit insurance policies; or encourages the bilateral trading partner's government to implement more protectionist trade policies, which would increase the risk of facing political and/or ToT externalities.

3. **Perturbation in the distribution of the background risk**.

Implicit differentiation of Eq. 8 with respect to (w.r.t. hereafter) μ_Z, we obtain

$$\operatorname{sgn}\left(\frac{\partial x^*}{\partial \mu_Z}\right) = -\beta \operatorname{sgn} S_\mu(\mu_\pi^*, v_\pi^*) \tag{10}$$

Similarly, totally differentiating Eq. 8 w.r.t. v_Z, we obtain

$$\operatorname{sgn}\left(\frac{\partial x^*}{\partial v_Z}\right) = -\beta^2 \operatorname{sgn} S_v(\mu_\pi^*, \sigma_\pi^*) \tag{11}$$

From Eq. 10 we find $\frac{\partial x^*}{\partial \mu_Z} > 0$, if and only if $S_\mu < 0$, while Eq. 11 yields $\frac{\partial x^*}{\partial v_Z} < 0$, if and only if $S_v > 0$. The condition $S_\mu < 0$ directs to the DARA (decreasing absolute risk aversion) preference structure, whereas $S_v > 0$ establishes the "variance vulnerability" property of the preferences (which means, in the present context, the exporting firm will export even lesser when the higher background risk aids to the overall riskiness of the export market, compared to the scenario under only exchange rate risk). The readers are advised to see Eichner and Wagener (2003; 2009; 2012) in this context.

Therefore, we arrive at the following proposition.

Proposition 1.

1. *A risk-averse firm will optimally export more (less) under higher (lower) expected value of $\tilde{Z}$ if and only if the preference are DARA.*
2. *A risk-averse exporting firm may optimally export less under higher background risk if and only if its preference is 'variance vulnerable'.*

In short, (a) higher expected $\tilde{Z}$ causes an increase in exports if the firm's willingness to accept risks decreases in expected profit and (b) higher volatility of $\tilde{Z}$ makes the firm to sell relatively more domestically if its willingness to accept risks intensifies when the profit-risk is escalated.

4. Impact of an increase in the unfair background risk.

Let us now incorporate the possibility that the background risk is "unfair", i.e. $\mu_Z < 0$. Given this, implicitly differentiating Eq. 8 w.r.t. β yields

$$\operatorname{sgn}\frac{\partial x^*}{\partial \beta} = -\operatorname{sgn}\left[\underbrace{S_\mu \frac{\partial \mu_\pi^*}{\partial \beta}}_{ME} + \underbrace{\frac{S(\mu_\pi^*, \sigma_\pi^*)}{(\partial v_\pi(x^*)/\partial x)}\left(\frac{\partial^2 v_\pi(x^*)}{\partial x \partial \beta}\right)}_{CE} + \underbrace{S_v \frac{\partial v_\pi(x^*)}{\partial \beta}}_{VE}\right] \tag{12}$$

where, we have,

ME > 0, (by the assumption of DARA);

CE > 0 as and when $\mathrm{Cov}(\tilde{e}, \tilde{Z}) > 0$.

VE > 0, as and when $\mathrm{Cov}(\tilde{e}, \tilde{Z}) \geq 0$ (variance vulnerability).

Hence, $\frac{\partial x^*}{\partial \beta} < 0$ unambiguously as and when $\mathrm{Cov}(\tilde{e}, \tilde{Z}) \geq 0$.

Therefore, similar to Eichner and Wagener (2012), the impact of an addition (with initial $\beta = 0$) or increase in the background risk on the optimum export can be classified into a "mean effect" (ME), a "correlation effect" (CE), and a variance effect (VE).

Therefore, when the risk-averse exporter is confronted with an increase in the *dependent and unfair* background risk, in the form of, say, an increased chance of loss in the amount excess of the coverage (i.e., $\mathrm{Cov}(\tilde{e}, \tilde{Z}) > 0$), $\frac{\partial x^*}{\partial \beta} < 0$ holds unambiguously if and only if $S_\mu < 0$ and $S_v > 0$ hold simultaneously.

However, Eichner (2008, Proposition 2) shows that both DARA and the variance vulnerability (i.e. $S_\mu < 0 < S_v$) properties lead to infer that an agent with mean-variance preference is "risk vulnerable". This leads us to state the following proposition.

Proposition 2. *A risk-averse exporting firm will optimally reduce exports and increase domestic sales being confronted to a dependent unfair background risk if and only if it is risk vulnerable.*

It is interesting to note from Eq. 12 that even when the risk-averse exporting firm is confronted with an increase in the *independent and unfair* background risk (i.e. $\mathrm{Cov}(\tilde{e},\tilde{Z}) = 0$ and consequently, $CE = 0$), in the form of, say, a disruptive technology shock, optimal export falls if and only if the exporter is "risk vulnerable".

Therefore, as the willingness to pay for reduction in exports decreases in (expected) profit and increases with profit-risk, then an increase in unfair and independent background risk has a tempering effect on the marginal willingness to sell for the export market. In other words, even when the two sources of risks are stochastically independent, the background risk can still be indirectly controlled via more domestic sells and less exports.

5. Change in the dependence between background risk and the exchange rates.

Now, let us move on to trace out the implications of change in the dependence structure between the exchange rate risk and the background risk.

Implicit differentiation of Eq. 8 w.r.t. yields

$$\mathrm{sgn}\left(\frac{\partial x^*}{\partial \mathrm{Cov}(\tilde{e},\tilde{Z})}\right) = -\mathrm{sgn}\left[\frac{1}{2}\left(\frac{1}{v_e R(x^*)+\beta \mathrm{Cov}(\tilde{e},\tilde{Z})}\right)\left(\frac{v_\pi(x^*)}{R(x^*)}\right) + \varepsilon_v\right] \quad (14)$$

where $\varepsilon_v = \left(\frac{\partial S}{\partial v_\pi}\right)\left(\frac{v_\pi}{S}\right)$ is the elasticity of risk aversion w.r.t. v_π. We have utilised Eq. 8 and substituted $\frac{\partial^2 v_\pi(x^*)}{\partial x \partial \mathrm{Cov}(\tilde{e},\tilde{Z})} = 2\beta R'(x^*)$ and $\frac{\partial v_\pi(x^*)}{\partial \mathrm{Cov}(\tilde{e},\tilde{Z})} = 2\beta R(x^*)$.

Eq. 14 suggests that $\frac{\partial x^*}{\partial \mathrm{Cov}(\tilde{e},\tilde{Z})} < 0$, if and only if $\varepsilon_v > -\frac{1}{2}\left(\frac{1}{v_e R(x^*)+\beta \mathrm{Cov}(\tilde{e},\tilde{Z})}\right)\left(\frac{v_\pi(x^*)}{R(x^*)}\right)$.

Now, let us consider the RHS of this inequality. Let

$$\frac{1}{2}\left(\frac{1}{v_e R(x^*) + \beta \mathrm{Cov}(\tilde{e}, \tilde{Z})}\right)\left(\frac{v_\pi(x^*)}{R(x^*)}\right) = \frac{1}{2\Theta}$$

Then, it can easily be shown that

$$\Theta \in (0,1].$$

Therefore, whenever $\varepsilon_v > -0.5$, $\frac{\partial x^*}{\partial \mathrm{Cov}(\tilde{e}, \tilde{Z})} < 0$ will automatically hold true.

Hence, we can state the following proposition:

Proposition 3.

The firm will optimally decrease export and increase domestic supply whenever $\varepsilon_v > -0.5$ *holds*.

The condition $\varepsilon_v > -0.5$ guarantees that the degree of risk aversion, in relative terms, does not decrease "too strongly" owing to the increased chance of loss in the amount excess of the coverage, or the increased threat of deterrence by the partner country's government policies, coupled with the exchange rate risks.

6. A parametric example.

Let us exemplify the generic framework in terms of a specific preference function, say

$$U(\mu_\pi, v_\pi) = \mu_\pi^a - v_\pi^b \tag{15}$$

As demonstrated in Saha (1997), Eq. 15 allows us to have the most flexibility, since it does not require to presume any specific assumption on the pattern of risk-preference structure.

Hence, the expression for the MRS between risk and return for the exporting firm would become

$$S(\mu_\pi, v_\pi) = (b/a)\mu_\pi^{1-a} v_\pi^{b-1} \tag{16}$$

and the F.O.C. for exporting sales turns out to be

$$a\{\mu_e R'(x^*) - R'(y^*)\}\mu_\pi^{*\,(a-1)} - b\left(\frac{\partial v_\pi(x^*)}{\partial x}\right)v_\pi^{*\,(b-1)} = 0 \tag{17}$$

Given Eq. 17, we can come up with the following results equivalent to Propositions 1(a) – (b), 2-3.

Corollary (a). Comparative static effect w.r.t. $\boldsymbol{\mu_Z}$:

$$\operatorname{sgn}\left(\frac{\partial x^*}{\partial \mu_Z}\right) = \operatorname{sgn}\left[\beta a(a-1)\{\mu_e R'(x^*) - R'(y^*)\}\mu_\pi^{*\,(a-2)}\right] \tag{18}$$

Therefore, $\left(\frac{\partial x^*}{\partial \mu_Z}\right) < 0$ if and only if $(1-a) < 0$. However, as

$$S_\mu = \frac{b(1-a)}{a\mu_\pi^{*\,a}} v_\pi^{*\,(b-1)} \tag{19}$$

$S_\mu < 0$, whenever $(1-a) < 0$. In other words, $\left(\frac{\partial x^*}{\partial \mu_Z}\right) < 0$, if and only if the preference follows DARA, which has been argued in Proposition 1(a).

Corollary (b). Comparative static effect w.r.t. $\boldsymbol{v_Z}$:

$$\operatorname{sgn}\left(\frac{\partial x^*}{\partial v_Z}\right) = -\operatorname{sgn}\left[\beta^2 b(b-1)\frac{\partial v_\pi(x^*)}{\partial x}v_\pi^{*\,(b-2)}\right] \tag{20}$$

Therefore, $\left(\frac{\partial x^*}{\partial v_Z}\right) < 0$ if and only if $(b-1) > 0$. However, since,

$$S_v = \frac{b(b-1)}{a}\mu_\pi^{*\,(1-a)} v_\pi^{*\,(b-2)} \tag{21}$$

$S_v > 0$, when $(b-1) > 0$. In other words, $\left(\frac{\partial x^*}{\partial v_Z}\right)$ is unambiguously negative when $S_v > 0$ (variance vulnerability); which is precisely the statement in Proposition 1(b).

Corollary (c). **Impact of facing $\boldsymbol{\Delta\beta > 0}$**.

Implicit differentiation of Eq. 17 and substituting values we obtain,

$$\text{sgn}\frac{\partial x^*}{\partial \beta} = -\frac{2b\mu_\pi^{*\,(1-a)}v_\pi^{*\,(b-1)}}{a}\text{sgn}\left[\underbrace{\frac{(1-a)\mu_Z}{2\mu_\pi^*}}_{ME} + \underbrace{\frac{R'(x^*)\text{Cov}(\tilde{e},\tilde{Z})}{(\partial v_\pi(x^*)/\partial x)}}_{CE}\right.$$

$$\left. + \underbrace{\frac{(b-1)[\beta v_Z + \text{Cov}(\tilde{e},\tilde{Z})R(x^*)]}{v_\pi^*}}_{VE}\right] \qquad (22)$$

Therefore, likewise the general scenario, here also we have ME > 0, VE > 0 and CE ≥ 0 (equality will arise in case of independent background risk, such as a disruptive technology shock), whenever $a > 1, b > 1$, or $S_\mu < 0 < S_v$. Hence, Proposition 2 is also satisfied: $\frac{\partial x^*}{\partial \beta} < 0$ under dependent or independent background risk to export, if and only if the exporter is "risk vulnerable".

Corollary (d). **Comparative static effect of $\Delta\text{Cov}(\tilde{e},\tilde{Z}) > 0$**

Implicitly differentiating Eq. 17,

$$\text{sgn}\left(\frac{\partial x^*}{\partial\text{Cov}(\tilde{e},\tilde{Z})}\right) = -\text{sgn}\left[\frac{1}{2}\left(\frac{1}{v_e R(x^*) + \beta\text{Cov}(\tilde{e},\tilde{Z})}\right)\left(\frac{v_\pi(x^*)}{R(x^*)}\right) + (b-1)\right] \quad (23)$$

This yields $\left(\frac{\partial x^*}{\partial\text{Cov}(\tilde{e},\tilde{Z})}\right) < 0$, if and only if $(b-1) > 0$. However, from Eq. 16, it can be easily checked that $(b-1) = \varepsilon_v$. Therefore, this implies $\varepsilon_v > 0 > -0.5$ holds true. Therefore, Proposition 3 is satisfied as well.

7. Concluding remarks.

For an exporting firm under uncertainty, tampering effect of unfair background risk on the exporting firm's decision problem regarding the relative quantity to be sold optimally abroad, vis-à-vis to the domestic market, is an immensely important but has been left unexplored. This paper has taken up the practically relevant case of dependent and unfair background risk, such as greater possibility of incurring losses under export credit insurance with non-proportional reimbursement scheme, or the threats of facing political or ToT externalities from the bilateral trading partner(s). The mean–variance decision – theoretic analysis considered in this paper provides plethora of astounding insights with clear intuitive appeal. The major advantage of this approach has been to yield all the comparative static results of optimal export sales in response to the changes in distribution, size, or in the dependence structure of the background risk in terms of monotonicity and curvature properties of the marginal willingness to substitute risk for return. Such analytical insights are quite novel in the literature of international economics. As a future direction, one can extend this analysis to explore the decision problem for a firm regarding how much to invest abroad optimally to acquire foreign assets.

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